MediTERRA

16

INTERNATIONAL CENTRE FOR ADVANCED MEDITERRANEAN AGRONOMIC STUDIES
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
PRESSES DE SCIENCES PO

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ZERO WASTE IN THE MEDITERRANEAN
Natural Resources, Food and Knowledge

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CIHEAM

International Centre for Advanced
Mediterranean Agronomic Studies

Created in 1962, the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) is a Mediterranean organization which works for improving sustainable agriculture and fisheries, for ensuring food and nutrition security and for developing rural and coastal territories. The organization gathers thirteen Member States from both shores of the Mediterranean (Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia and Turkey) and works with several international and regional institutions.

CIHEAM is a space for intercultural dialogue, solidarity and sharing in which are discussed strategic development and cooperation issues in the Mediterranean. Research and dissemination of sustainable solutions for inclusive and responsible growth are the heart of its missions.

Its actions are the result of a "bottom-up" collaboration and are based on a holistic approach to development. With its Member States, its public and private partners, academic and research actors, CIHEAM strives to meet the four following challenges: combating all forms of waste; boosting sustainable agriculture and food; investing in new generations and fragile territories; preventing risks and managing tensions.

www.ciheam.org

Contact for the *Mediterra* Report

CIHEAM Headquarters
11, rue Newton – 75116 Paris – France
E-mail: secretariat@ciheam.org
Tel: +33 (0)1 53 23 91 00

Food and Agriculture Organization of the United Nations

The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations system with a mandate to raise levels of nutrition and standards of living for all people, to promote production, productivity and effective distribution of food and agricultural products, to ensure sustainable utilization and management of natural resources, and to contribute toward promoting world economy and eradicate poverty and hunger.

Within the framework of five Strategic Objectives, FAO works closely with Member Nations and a range of partners at national, regional and global levels to achieve these goals.

www.fao.org

FAO Headquarters
Viale delle Terme di Caracalla – 00153 Rome - Italy
E-mail: FAO-HQ@fao.org
Tel: +39 06 57051

Table OF CONTENTS

FOREWORD

The adoption of the 2030 Agenda marked the beginning of a new era with a strong commitment from the international community to promote a wide range of transformative and universal changes to achieve Sustainable Development, with local and regional specificities. The Sustainable Development Goals (SDGs) strive to provide inclusion and empowerment for all. The operationalization of this inclusive approach to growth and development relies on integrating the economic, social and environmental dimensions of development. Agriculture and food security play a key role in this regard. Indeed, they are at the heart of the 2030 Agenda.

The world, including the Mediterranean region, is faced with a number of challenges, such as inequalities, significant flows of distress migration and limited access to and poor management of natural resources, including water, land and biodiversity. Various forms of waste related to food, natural resources and knowledge are embedded in these challenges and pose significant obstacles for the achievement of sustainability.

In terms of food, the world produces enough today to feed the planet, but one third, representing 1.3 billion tons per year, is either wasted or lost in the supply chain, from initial agricultural production all the way to final household consumption.

Furthermore, continued increase in the use of natural resources such as water, land, forestry, biodiversity and fisheries, without paying sufficient attention to their depletion or environmental impacts, can lead to ecological crises and security threats. In the Mediterranean region, for example, wasting a precious resource like water may intensify such threats.

Additionally, the waste of human resources hampers development efforts. This happens, for example, in the form of unemployment, lack of access to education especially for girls, “brain drain” from developing countries, disappearance of local knowledge such as family farming practices and products, duplication of ideas without coordination and lack of synergies among relevant actors.

In this context, we are pleased to introduce the 2016 Edition of *Mediterra*, which addresses all of these waste challenges and presents innovative solutions while suggesting policy recommendations for the sustainable management of natural resources, food and knowledge in the Mediterranean.

For the first time ever, an Edition of *Mediterra* has been developed as a partnership between our two organizations: the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) and the Food and Agriculture Organization of the United Nations (FAO). The two organizations share the same vision of a prosperous Mediterranean region.

CIHEAM and FAO have collaborated for more than 35 years through joint knowledge generation, brokering dialogues and developing cooperation projects to empower small-scale farmers and fisher folk and develop capacities of different actors. More recently, they felt the need to renew their strategic partnership in response to the 2014 Algiers recommendation, adopted on the occasion of the 10th CIHEAM ministerial meeting, during which the Ministers requested “that FAO and CIHEAM examine the idea of defining a common strategic cooperation agenda designed to support agricultural, food and sustainable rural development in the Mediterranean”.

This 2016 Edition of *Mediterra* is an expression of the renewed strategic partnership between the two organizations. It represents an important step towards building consensus on innovations and inclusive policies needed to respond to the challenges faced by the Mediterranean region, particularly in terms of the triple wastes related to natural resources, food and knowledge. We believe that this new Edition of *Mediterra* contributes to fostering synergies in thematic areas of mutual interest. We hope that this joint piece of work will act as a catalyst for action towards achieving food security and sustainable development in the region, in collaboration with policymakers and all the other actors of the Euro-Mediterranean multilateral cooperation.

José **Graziano da Silva**
FAO Director General

Cosimo **Lacirignola**
CIHEAM Secretary General

ACKNOWLEDGMENTS

The joint CIHEAM-FAO Edition 2016 of *Mediterra* is the result of the willingness of the CIHEAM Secretary General and the FAO Director General to strengthen the partnership between the two organizations and build synergies in the field of research action and knowledge generation and sharing. At the end of 2014 this translated into a collaboration agreement which included co-direction, co-responsibility and co-funding of the 2016 Edition of *Mediterra*. Indeed this co-publication was possible thanks to the tremendous collaboration between the two organizations at many different levels.

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INTRODUCTION

Today as in the past, food security, and agricultural development as a whole, are major strategic issues for the planet. For public opinion, and those not closely involved in the sector, the food crisis of 2008 pointed to the key role played by food and agriculture in strategic global affairs. However, while such events can sometimes serve to raise the level of political and media awareness of agriculture, it should be remembered that food is an imperative everywhere and at all times. This is a story that is as old as humanity itself, and is not going to end any time soon. But a number of constraints are tightening their hold (shifts in demographics and food production, climate shocks), making this issue more of a structural challenge.

Against this background, the issue of agricultural losses and food waste has become a critical one. While there are various concerns about how the supply and demand of agricultural products will evolve in the years to come, the struggle to combat these losses and waste is proving to be one of the main pathways, both at local and global level, through which to tackle food insecurity. All countries face the same challenge – that of producing more with fewer resources and therefore having to husband these more effectively. The Mediterranean is no exception, not least because it remains prey to the dual problems of poor availability of land and water, forcing this already vulnerable region to be particularly careful of their management, so as not to increase future risks (see Chapter 1).

However, examining waste exclusively on the basis of production and poorly used resources runs the considerable risk of ignoring a deeply insidious and often neglected form of waste – that of human resources and knowledge related directly or indirectly to the agricultural and rural sector. The marginilization of some rural areas, which if addressed could make a significant contribution to local, national and regional development, and the unemployment that affects their communities, combined with the disappearance of knowledge and knowhow tested and accumulated over generations and lack of good governance – these are all resources that are being lost or at the very least, poorly used (see Chapter 14).

In its various dimensions (social and organizational, economic, technical and environmental), the question of waste should therefore be viewed from three separate, albeit complementary angles. Indeed, combining an analysis of natural resources, production and knowledge makes it possible to position the scope more globally in a perspective of sustainable development, where human beings are placed at the centre of the debate. That is the goal of Edition 2016 of *Mediterra*, a report jointly published by CIHEAM and FAO, which explores the issue of wastage using this three-pronged approach. A number of technical, social and environmental innovations aimed at limiting and avoiding such wastage enrich the discussions presented in this report.

Innovative in both form and content, this study is an invitation to embark on a cross-cutting and inter-sectoral exploration of the Mediterranean region, which is emblematic of agricultural, food and environmental issues on a global scale. Taking such an approach would seem to be critical in order to reach an understanding of the many interactions that can be harnessed, in an effort to reduce volumes of losses and waste. The report also offers some responses and insights for the implementation of participatory, political recommendations, so that wastage can be transformed into opportunities, creating pathways for development in the region, at a time when it is crucial to define the Mediterranean's place in the Global Development Agenda up to 2030, to which both FAO and CIHEAM are firmly committed (see Chapter 8).

Conserving natural resources

Food waste does not just mean losing a substance that is vital for humankind. It also means wasting precious natural resources (land, water, energy, forests, biodiversity) that are crucial to a sustainable food system. Unless a well functioning land base is maintained, with the water needed for agriculture, as well as forests to mitigate against climate change, inputs for and use made of sustainable energy in food production and transport, together with conservation of Mediterranean biodiversity, major determinants of food security will be disrupted. This land, this water, these forests, this pastureland and this biodiversity all serve as balancing factors for a humanity that is rooted in nature – one which does not need to be rendered sacred or dominated, but which must be handled carefully. Sound management of each of these resources is therefore both meaningful and decisive, and an integrated strategy to combat waste is essential, all the more given that scarcity and degradation are already making themselves felt.

Scarcity of natural resources is already causing tension and territorial instability in the Mediterranean region. Recent cases underscore the importance of this problem. It should be added that the region has gained notoriety as an example of conflicts over water. Leaving spectacular examples aside, the challenge of water is very real and its causes well known: poorly distributed between countries and territories, water is an increasingly coveted resource, especially in the light of population growth and the development of irresponsible tourism in some places, as well as climate change already under way in a region that is a hot spot of shifts in temperature and precipitation patterns. First and foremost, these tensions affect agriculture, for irrigation is often a major drain on this precious resource. However, resolving the water crisis in the Mediterranean will not be achieved by mobilizing increased volumes of this resource (see Chapter 3). After several decades of policy based on ensuring strong supply, which saw a sharp increase in the number of dams and large water infrastructures built and areas of land irrigated, indicators for withdrawals show that the renewal threshold has been exceeded in many places. The exploitation index of renewable natural resources (ratio between the volumes withdrawn and renewable water available) offers a particularly interesting indication of the current strain on this resource. Many Mediterranean countries now have an exploitation index of more than 50% and, in these cases, the prospects for improving supply are reduced. The scope for increasing water resources therefore lies more in limiting wastage. In the agriculture sector, large volumes of irrigation water are lost due to lack of appropriate techniques or modern infrastructure. Some of the water lost trickles into aquifers and may be used at a later date, but a considerable share evaporates. Developing more efficient irrigation systems will therefore involve deploying hydraulic engineering in the region. But what use will this be without social planning for water use, in the form of water users' associations, in an effort to establish collective management of a resource that is often poorly managed and subject to conflict over its use? In a region that invented social planning for water use through the Code of Hammurabi more than 38 centuries ago, right up to the water tribunals set up in Andalusia under Muslim Spain this is nothing new. But the forms of organization need rethinking, involving all users, with producers – men and women – first in line.

In terms of scarcity, it is noteworthy that the total volume of water used on the planet each year to produce food that is subsequently lost or wasted (250 km^3) is the equivalent of the annual flow of the River Volga (Russia), or three times the volume of Lake Geneva, between France and Switzerland. Naturally, this comparison should be treated with caution. With the problem of food insecurity largely overcome in terms of quantity, it is easy to lose sight of the fact that agricultural production can never be definitively guaranteed, especially when the issue of water is overlooked. It is worth bearing in mind that in order to obtain 1 kilogram of cereals, a staple food for human consumption, it takes 1,300 litres of water. In a Mediterranean region that has seen so many civilizations emerge, this wager on a new hydraulic revolution that can make the best of water resources without using any additional ones is by no means impossible. Indeed, there is clear evidence that the process has already begun. It would be a mistake to lose sight of the extraordinary resilience of Mediterranean societies and their time-honoured determination to innovate, despite the increasing constraints they face.

The problem of land is another issue that is frequently raised. The availability of hydroponic techniques is no reason to lose sight of the fact that land resources, like water, are crucial for agriculture. The situation is sufficiently worrying for the United Nations to have declared 2015 the International Year of Soils, following on from 2014, which was the International Year of Family Farming – an indication of the extent to which land constitutes a major pillar of the development of rural communitites. Nearly 1.3 billion hectares of land, the equivalent of 28% of the world's entire agricultural surface area, is currently used to produce food that is subsequently lost or wasted. To this waste of land should be added the whittling away of arable land by advancing urbanization, which is taking place throughout the Mediterranean.

While the countries of the northern shores could in theory offer new opportunities for agriculture, albeit at the expense of areas that are often extremely important to ecosystems, that is far from the case in North Africa and the Middle East. This is the only region in the world without reserves of arable land. Due to the aridity of some Mediterranean countries, substantial expanses of soil are very skeletal, making it extremely difficult to practise agriculture, particularly in the south and east of the region. While in the north, arable land accounts for almost one-third of countries' surface area, in the rest of the region the figure is barely 10%, with large expanses of desert that can at best be used for the movement of livestock. To be sure, a policy of actively supplying water has succeeded in turning round this natural disaster, transforming desert lands into arable land, but this conquest of the desert has reached its limit. What is more, here, as elsewhere, cultivated soils have been affected by erosion and salinization, causing desertification. Linked to overgrazing and steep gradients, coupled with bursts of intense rainfall typical of Mediterranean climates, this phenomenon requires that soil be treated with greater care (see Chapter 4). Another less visible process than urban competition, but one that has equally grave consequences and must therefore be taken seriously, is the salinization of agricultural land due to poorly designed irrigation systems (inadequate drainage, evaporation of water reserves in hot climates and concentration of salts). This fragility of agricultural land, both in terms of arable surface area and its productive capacity, shows that the best path clearly lies in combating agricultural waste. What is the point of increasing the area of arable land if the food produced from it is to end up being lost at the end of the chain?

Forests face many of the same issues as those linked to land and water. Mediterranean forests are extraordinarily diverse (there are almost 300 species, of which some 200 are endemic), equipped with a resilience developed over a long period of time. In often drastic conditions, these forests have set in place adaptation mechanisms that have enabled them to survive in often difficult Mediterranean landscapes. Their responses to environnemental stress are morphological (short leaves of persistent species, deep root systems, thick bark), phenological (early and rapid development of foliage) and physiological (tolerance of dehydratation, early photosynthesis, maintaining capacity for photosynthesis after long periods of drought). Particularly resilient, Mediterranean forests have a multi-functional dimension, even though use is often only made of their productive function. And among the services provided by forests, one of particular importance is the prominent role that they play in protecting soils, water catchment areas, water quality and biodiversity, as well as promoting climate change mitigation by sequestering CO_2 and improving microclimates. Yet despited all the major benefits they offer, forests are often subjected to all kinds of assault, starting with deforestation, especially due to urbanization and the development of agriculture and intensive timber trading. But it is fires that pose the greatest threat. It is hard not to equate this with waste, especially given that most fires are avoidable and that few have natural causes (such as lightning). Despite considerable efforts, the phenomenon appears to be spreading in the region, causing Mediterranean forests to become more fragile as a result, with 60 rare species at risk of extinction. Conserving forests and avoiding the waste of such a highly diversified resource is therefore an obligation (see Chapter 5).

The same is true of biodiversity on land and in the seas. Due to the variety of soils, landscapes and micro-climates found in different combinations, the Mediterranean has a remarkably rich range of diversity. The region hosts between 25,000 and 30,000 species of plants, of which more than half are endemic. Linked to the fact that vegetation established areas of resistance at the time of the ice age, this biodiversity of plants, but also animals, has been partly adapted by humans to fulfil their needs. As a result, the Mediterranean region has become a central point for disseminating living species throughout the world (breeds of goat and sheep and varieties of cereals, fruits and vegetables). Unfortunately, mainly man-made threats menace this biodiversity: the destruction of natural habitats, climate change, pollution and economic activities are all forms of waste brought about by human beings (see Chapter 6). Such biological diversity is also very marked in the Mediterranean Sea. Made up of maritime areas (Tyrrhenian, Aegean, Ionian, Adriatic) with particular biocoenoses, the Mediterranean hosts 7% of global marine species, including a number that are endemic. The wide range of life forms offers humans a diversified food source, which is now threatened by overfishing and pollution – both causes of waste at sea. While the concept of a blue economy based on a holistic and integrated vision of marine and coastal development is making headway, in the Mediterranean as elsewhere, there is a strong case for promoting operating practices for marine resources that are sustainable on three levels: ecologically, socially and economically. It is this approach that will assure the future of fisheries in the Mediterranean Sea, where the role of small communities of fishers is paramount (see Chapter 2).

Nor should energy waste be overlooked, given its critical contribution to agriculture. Foodstuffs produced and transported thousands of kilometres are never consumed, with a knock-on effect of susbstantial wasted energy. In addition, considerable greenhouse gas emissions are given off during the production and distribution of many foodstuffs. So just as there is a strong link between resource management and food, there can be no meaningful discussion on food unless the energy implications are taken into account. In a world whose limits are perceived in terms of resources, having once assumed that everything would last for a great deal longer, there is a more pressing need than ever to link these assets (energy and resources), in order to shape development policies that are sustainable. Against the backdrop of new climate initiatives that promote use of renewable energies, opportunities also exist for greater synergy between use of wind and solar energy in the food and agriculture sectors. In the Mediterranean, these developments herald promise for the future, so long as they are handled in an integrated fashion (specifically, through the water-land-energy nexus) and are implemented through inclusive, long-term policies (see Chapter 7).

Such discussions on wasted resources and the links between them are in keeping with the Sustainable Development Goals (SDG) that were drawn up in September 2015 by the United Nations, and which have confirmed and expanded on the development process launched in 2000 through the Millennium Development Goals (MDG). Some 17 objectives have now been established as part of this process to unify development programmes. The fight against resource waste goes straight to the heart of these objectives, often in a very direct manner. This is true of Goal 2 (zero hunger), Goal 6 (water), Goal 7 (energy), Goal 14 (life below water)and Goal 15, which concerns the protection of ecosystems. But this struggle can also make an indirect contribution to achieving certain objectives, starting with the first of them, which aims to fight poverty. This brings us back to the initial observation on the need to place the human and social dimension at the centre of initiatives designed to make development more sustainable. Suffering, frustration and injustice are major factors in the evolution of socio-political dynamics. Reducing inequalities and pursuing inclusive policies are proving to be strategic approaches for checking the process of social decomposition that could affect some countries.

Reducing food waste

According to FAO, about one-third of all food produced worldwide each year is lost or wasted. That represents a total of almost 1.3 billion tonnes. The wastage involves food destined for human consumption, which is lost at all stages of the food system. Such phases act in different ways and at varying levels, according to their place in the food supply chain and the geographical location, as well as the social and economic conditions that prevail. Developing countries are the worst affected by food losses as part of agricultural production (during harvest, transport and storage of foodstuffs produced), while higher income countries are mainly affected by food waste at retail and consumer level (in households and catering). Such polarization of the problem highlights the extent to which inequalities cause dysfunctions: on the one hand there is under-development, which hampers investment in infrastructure, and on the other, there is abundance (often unevenly distributed), which drives wastage.

Due to population growth and socio-economic changes, global food demand could rise by between 40 and 70% by 2050. In the light of this forecast, global agricultural production will need to increase by about 60%. That is a massive challenge, which will require a variety of solutions, both agronomic and technical, but also logistical, social, organizational and political. Within this range of responses, reducing food loss and waste is an approach that merits consideration, offering a real pathway for improving the efficiency and sustainability of agriculture and food production systems. It is a strategy that needs to be implemented on different territorial levels (see Chapter 9). Indeed, the problems vary widely, depending on the countries and supply chains involved. There will always be quantities of fruit and vegetables wasted during the transport phase, as these are fragile products. But it may be more difficult to accept that wheat, which is much easier to handle, should also be wasted. Or that, as happens far too often, part of harvests are lost due to lack of effective storage facilities and inadequate infrastructures in some countries.

A growing awareness is burgeoning and this must be spurred on. For example, in European societies, the fight against food waste has become an issue that has prompted strong public and citizens' protest in recent years. On all sides of the Mediterranean, there is a growing awareness that paying closer attention in this regard will not only result in personal savings, but will also make an indirect contribution to the state of the planet. Behaviour changes are emerging, especially in times of economic recession, and as they become more widespread they can help to build greater food security (see Chapter 13). In this context, it is worth considering the potential contribution of the Mediterranean diet in the complex debate on the fight against food waste. If this is really to be considered a sustainable pattern of consumption in every sense of the word, it is clear that reducing agricultural and food losses will also have to involve this famous diet, which continues to be one of the living emblems shared by all Mediterranean societies (see Chapter 10).

Large-scale retailsector is also working to change its rules on unsold products and use-by dates for products on the shelves, making a much clearer distinction between expiry dates and best-before dates. This growing awareness on the part of consumers and agrifood chain operators is therefore a collective movement worth highlighting (see Chapter 11). In the rest of the Mediterranean region, there is less recognition of food waste than there is in the north, and to date it has barely been translated into a legal framework. However, certain sectors of society (schools and universities, environmental associations, businesses) are starting to catch on. The issue is now a strong factor in innovation policies rolled out both by private economic operators and national and international public institutions (see Chapter 12).

There can be no doubt that a drastic reduction in food waste, either post-harvest or during consumption, offers a more effective and sustainable lever for development of the planet. It also represents a critical opportunity for farmers. Post-harvest losses automatically translate into loss of income for them, since they have lower quantities available for sale. For a long time, this aspect was overlooked. It is to be welcomed that the issue has now been accorded a higher place on the international agenda and that strategies have been set up by a number of countries and regional and local authorities. The G20 ministerial meeting on agriculture, held in Istanbul on 8 May 2015, underscored the importance of the subject in its communiqué. The Turkish authorities naturally focused strongly on this issue, given their current efforts to reduce wastage of bread in the country, with highly encouraging early results. Other governments in the Mediterranean region have adopted policies seeking to reduce agricultural losses and food waste. FAO has made this a priority in its Strategic Framework, and has assigned it as one of its three regional priorities for countries of the Middle East and North Africa, along with support to small-scale and family agriculture and increasing resilience to crises. CIHEAM has also become more actively engaged on the issue, convinced of the need to combine strategies for combating wasted natural resources and agricultural output with steps to prevent loss of knowledge and knowhow.

Feeding knowledge

The transfer of knowledge from one generation to the next, through good practices adapted to local conditions, is proving just as effective a strategy in the 21st century as it was in the past. But this transmission should not be exclusively vertical. It should be shared on the scale of landscapes, countries or even regions. In the Mediterranean, the challennges are such that there is a real need to promote good practices, exchange experiences and listen to how people use other techniques.

Knowhow is effective at the moment it is passed on to new generations, but it will become even more valuable if it is shared collectively and allowed to develop over time. The accumulation of top-down research that is never really shared, the duplication of ideas without any coordination and the lack of synergy between stakeholders – these are all facets of the same problem: wasted knowledge. Given the particular challenges posed by climate change, every solution counts and these can offer courses of action for farmers or fishers living on the other side of the Mediterranean, who observe the good practices of others and nearby innovations.

To feed the planet, it is important to nourish women and men with the ideas and knowledge that research can generate. But if these are to be used to the full, they must be integrated into training systems, which will need to become the receptacle through which knowledge is disseminated as it accumulates, without which it may well simply disappear. If there is to be sustainable food security in the world, it will be critical to combat this type of waste as well as the others! And when talking of new knowledge, let us not forget traditional knowhow, which deserves more attention, given its potential for offering solutions in some situations. This is especially true in the fight against climate change, as rural communities have long since learned how to deal with weather related events (see Chapter 15).

More broadly, local solutions need to be made more widely known, and modern communication technologies can help to catalyse this diffusion. That means nourishing knowledge through greater sharing of experiences, knowhow and ideas. A circular economy of knowledge represents a valuable tool to help combat difficulties, scarcities and threats. To put it another way, societies' primary source of resilience is often their knowledge, together with their ideas and experiences. Aside from combating wasted knowledge, there is a strong case for observing human action. People invent responses to problems that arise and in doing so accumulate knowledge, which settles over time and spreads to other areas. Women and men are protagonists of solutions that can overcome under-development. This positive vision of human activity on the state of the planet focuses firmly on people's ingenuity, which is capable of reversing trends, creating and finding local solutions and adapting them to respond to global challenges. Acknowledging this, the proposal can be organized around three pillars: economic, environmental and social approaches, supported by innovation, an important component of all three. In this sense, innovation means two things. First and foremost, the capacity of human beings to bring about change, advance scientific progress, nourish knowledge and make historic shifts, which can sometimes generate giant leaps for humanity. Implementation of the SDGs at local level must take into account the specific cultural, social, economic and geographical features of societies. Innovation for development is necessarily local and distinctive. There is no magic bullet solution. It is crucial to adapt to local realities if knowledge is going to be effectively aligned with practices, needs and the constraints of a situation for which an action needs to translate into a tangible result to improve people's lives (see Chapter 17). Each territory can therefore invent its own model (or models), at its own pace, with its own actors, difficulties and stories.

At a time when it is important to bear in mind the central role of human security in strategies for sustainable development, and therefore to play close attention to the coherence between the various social, economic and environmental pillars (which are catalysed by innovation and human ingenuity), it is critical to promote and support producers, in their diversity, taking account of their specific characteristics and their needs. In the Mediterranean, as elsewhere, it would be dangerous to build a future in which the human and social dimension of producers was diminished. There are a great many producers in this region. Their faces and territories are not necessarily well known and supported by public opinion and policies. But there will be no sustainable development of towns without development of rural areas, and there will be no dynamics in these outlying areas without producers becoming organized and unless there is participation by local communities.

No quantitative or qualitative improvement of agricultural output – crucial for all local development – can be lasting without the involvement of men and women farmers and their organizations. These are driving forces for proposals and vectors for change when it comes to helping to shape producers' activities in the best way possible. Despite their economic and social value and their right to participate in the decision-making process, farmers – especially men and women smallholder family ones – are too often excluded from local governance. While their presence is indispensable to the implementation of coherent development policies that are in line with local conditions, their voice is not sufficiently heard. This trend must be reversed if there is to be real progress on the path to sustainable, responsible and inclusive development (see Chapter 16).

Initiatives under way aimed at improving the organization and collective management of supply chains risk failing in their objectives if farmers are not sufficiently involved, as full partners, in the development of institutional frameworks, including legislation and the drawing up of regulations and agricultural policies. The agricultural cooperative movement shows the extent to which producers are capable of playing a leading role in the dynamics of governance, in this case at local level.

There is a similar pattern for the transfer of knowledge and knowhow. There continue to be insufficient exchanges between producers and the world of research, given the challenges of food insecurity, access to natural resources and conservation of biodiversity. It is an error not to draw more inspiration from the inventiveness shown by producers and for research institutes not to take adequate account of existing good practices. A farmer's land is an open-air laboratory. The solutions that he or she puts into practice are the fruit of careful analysis and seek to draw benefit from the constraints and opportunities offered. Transmitted locally, this skilful adaptability gives producers unrivaled expertise, to which researchers would do well to attribute greater value, and do more to disseminate further afield.

It is equally important to encourage producers to consider diversifying their activities and to offer them a central place in initiatives designed to make rural life more attractive. That would enable young people living in rural areas to make career plans there and feel that they have a place in society. It cannot be stressed enough that for today's young people, the rural exodus seems the only escape route possible. In search of work, essential services and leisure activities, they move to the cities, while the world of agriculture grows progressively older. In the Maghreb, the average age of farmers is now more than 50, and fewer and fewer people are taking up the mantle. Public policies must overcome a double fissure between cities and rural areas. As well as an economic and social divide, there is also a generational one, which is becoming progressively wider. Taking account of the needs and aspirations of the new generation in these places will be achieved more than anything else by giving value to an agriculture sector that is in a state of flux – one that is increasingly rooted in the digital economy, but is able to absorb traditional knowledge, technical innovations and social development (including the feminization of agriculture), so as to take on a definitive role in the future.

It is clear that agriculture alone cannot supply all the needs of rural communities, who are often made vulnerable by poverty, unemployment or geographical isolation. But a public policy that integrates long-term agricultural development, mindful of the women and men who depend on it, can help to create a virtuous cycle in the Mediterranean region. Such considerations mainly concern agriculture. However, although their sphere of action may be different, the fisheries and forestry sectors are also threatened by the same dangers of scant social recognition and erosion of knowledge. Given their contribution, firstly to food security and secondly to climate change, this report would be wrong to ignore them.

All this points to a need to reposition issues linked to agricultural and rural development at the centre of the very wide and extremely complex topic of migration and human mobility in the Mediterranean region. Substantial numbers of people are currently on the move, against a backdrop of social and territorial distress. The management of humanitarian emergencies, where the issue of food is a central one, is an essential factor, which requires a simultaneous medium and long-term response. FAO and CIHEAM both regularly highlight the acute strategic importance of this challenge in the region and are working to develop concrete programmes that can help to advance inclusive development (both in social and spatial terms) in the Mediterranean.

Mediterra 2016: an invitation to overcome waste

The subject of waste in its various dimensions (resources, loss of food and knowledge) is an important issue for the Mediterranean. In order to improve the food security of communities in this region, improved natural resource management, reduction of agricultural losses and the adaptation of knowledge to primary needs are all strategic levers for concrete and pragmatic action. It is for this reason that CIHEAM and FAO have decided to form a partnership to carry out a cross-cutting analysis of such forms of waste, with results of discussions presented in this edition 2016 of the *Mediterra* regional report. This three-dimensional vision of waste – whose strands are complementary and interwoven – and of innovations to combat it, are at the core of CIHEAM's Strategic Agenda 2025. This seeks to give priority to its mission of Mediterranean development in the years to come through a focus on four pillars (combating waste, strengthening food and nutrition security, inclusive development and risk management/preventing tension). The same vision is central to FAO's Strategic Framework through a focus on five pillars (eradication of hunger, making agriculture, forests and fisheries more productive and sustainable, reducing rural poverty, setting in place more open and efficient food systems, increasing the resilience of livelihoods to threats and crises) and to one of the regional initiatives for North Africa and the Near East.

Readers will find the report structured around these three dimensions. The first part reviews each of the resources for which waste is a real issue and calls for an analysis in the particularly constrained circumstances of the Mediterranean. The second focuses on food losses and waste (both land and sea-based), exploring both the extent of the problem and a promising pathway for improving food security and, as a spin-off, resource management. The third part concentrates on the erosion of knowhow, due to poor knowledge dissemination, exploring the risk this poses of collapsing agricultural models and the rediscovery of new systems of knowledge and innovation.

While the report places the spotlight on this triple waste, it also looks carefully at the innovations and inclusive policies that are attempting to address the issue. Indeed, the study aims to shed light on these issues, in order to promote discussion and serve as a catalyst for action. We are firmly convinced of the need to pursue this path, working together with all actors in multilateral Euro-Mediterranean development, as well as with political decision-makers wanting to invest in the post-2015 development agenda. In this region, implementation of the agenda will rely to a large extent on agriculture, fisheries, forestry and food or, to put it another way – and at the deliberate risk of repetition – on human beings and social dynamics, above all else.

ABSTRACTS

CHAPTER 1

Combined with the effects of climate change, urbanisation, economic, social and demographic transformations exert even greater pressure on the already threatened natural resources. At global level as well as in the Mediterranean, the management of water, land, forest and biodiversity is more than ever essential to meet the Sustainable Development Goals by 2030. This chapter addresses the state of natural resources at global level while stressing the necessity to struggle against waste and losses of natural resources but also the need for cooperation, social and organisational innovation at different levels.

CHAPTER 2

Effective management that ensures the sustainable exploitation of living marine resources is crucial for the biological, environmental and socioeconomic vitality of Mediterranean fisheries. This chapter reviews the characteristics of the sector's management in the region and highlights challenges it faces, such as the reduction of discards and bycatch and the struggle against illegal, unreported and unregulated fishing. Current management efforts, such as the implementation of species prohibitions, gear selectivity measures, and fisheries restricted areas, are discussed, together with the legal framework and compliance mechanisms that support their application. Ongoing challenges and future action, both to better manage the resource and to improve sustainable livelihoods in the sector, are presented.

CHAPTER 3

While Mediterranean agriculture suffers from water scarcity coupled with great yield and knowledge gaps with a permanent wastage of food and resources, future scenarios of water availability seem to validate the fact that multi-level action and measures are to be necessarily implemented to guarantee food security. In this perspective, this chapter addresses the key components of water resources management in order to contribute to a holistic understanding of the problems and the corresponding adequate solutions. The latter are a combination of technological and managerial interactions within the water-food-energy nexus that may only be addressed correctly after the identification of the sectorial gaps. For this purpose, this chapter sums up problems and solutions in the form of water policy recommendations, an indispensable starting point to achieve sustainable food security.

CHAPTER 4

This chapter analyses the status of land resources in the Mediterranean with a special focus on the Middle East and North Africa. The scarcity of natural endowments, limited options to increase cultivation and climate change threatening scenarios could increase the region's reliance on imported food. Consequently, sustainable land management becomes a strategic priority. The region must protect its limited productive lands and implement land use policies based on the biophysical potential, social and economic considerations and focused on the needs of farmers. In order to reverse the current land degradation trend and reduce the waste of arable land, a plan of actions and solutions should be provided to policy makers at different levels.

CHAPTER 5

The human pressure exerted on Mediterranean forests for millennia has resulted in highly humanised ecosystems, which are considered as complex socio-ecological systems. The unsustainable use of forest resources has both led to land abandonment and overexploitation that, combined with climate and socio-economic changes, is creating conditions for an accelerated degradation of forest resources. In order to avoid the waste of forest resources and preserve their multifunctionality, innovative approaches to sustainable forest management are strongly required.

CHAPTER 6

The Mediterranean area is a major centre for biodiversity that plays a key role in food security and nutrition and serves as a source of income and other services on which people depend for their livelihoods and welfare. This chapter provides an overview of the diversity of plant and animal resources in the Mediterranean region, including both wild and domestic species and focusing on crosscutting issues. Given the intensification of agriculture, tourism and demographic growth threatening these resources, as well as the challenges of increased food demand and climate change, this chapter highlights the importance and recalls the crucial need for a reasonable management of plant and animal resources and identifies possible solutions. The conventions and agreements on biodiversity signed by the majority of Mediterranean countries should be translated into national policies and strategic plans promoting the integration of agro-ecosystem approaches. The overview also reveals the need to better strengthen the institutional framework and capacities, particularly in the southern Mediterranean countries, and enhance the collaboration between existing organisations and programmes in the region.

CHAPTER 7

Northern Mediterranean countries are usually more energy efficient than southern and eastern Mediterranean countries. This also applies to the use of renewable energy, where mature and cost-effective technologies exist. Combining energy efficiency with an increased use of renewable energy would reduce the dependency of agriculture on fossil fuel and thus contribute to the reduction of GHG emissions. However, this requires improvements in policy measures and institutional settings, and the use of a water-energy-food nexus approach. Currently, there is international support to promote both improved energy efficiency and increased use of renewable energy in the region. Such support should also be adequately provided for the agri-food sector.

CHAPTER 8

While the 2030 Agenda is intended as a global framework, not much discussion has taken place yet to consider what the new Agenda could mean for a region such as the Mediterranean, given its unique features, particular challenges and fragmented political integration. Despite the progress made to achieve the MDGs in the region, several challenges remain to both ensure food security and reverse the degradation of natural resources. The waste of these resources is a serious constraint to sustainable rural and agricultural development while the loss of local knowledge associated to the environment is closely related to their depletion. This chapter outlines the main challenges faced by Mediterranean agriculture and natural resources in the framework of the 2030 Agenda towards the Millennium Development Goals (MDGs), highlighting critical improvements to be made and gaps to be filled with respect to the new Sustainable Development Goals (SDGs). It then specifically focuses on the main regional initiatives aimed at rural and agricultural sustainability, before an in-depth discussion on what it could mean and what it would take to implement the 2030 Agenda for Sustainable Development in the Mediterranean at regional, national and local levels.

CHAPTER 9

Given the existing food security and increased resource scarcity challenges, the issue of food loss and waste (FLW) has become very important for the international agenda as it has far-reaching social, economic and environmental implications. FLW are of particular concern in the Mediterranean area. Their reduction is therefore widely acknowledged to contribute to abating interlinked sustainability challenges such as food insecurity, climate change and water shortage. This chapter focuses on the connections between FLW and sustainable development, food security and nutrition and sustainable food systems while highlighting their main economic and environmental implications. The list of the main drivers and causes and their extent along the food chain enable a comparative analysis of FLW of different agro-food product. The opportunities and challenges for FLW reduction and prevention are also addressed. This chapter also gives insights into the legal framework and the institutional environment for FLW reduction in the Mediterranean. Coordinated action and a systemic and holistic approach fostered by a comprehensive policy addressing efficiently and effectively the FLW issue are necessary. Organisation and governance of the agro-food chain must also be improved. As such, the CIHEAM and the FAO have a crucial role to play in the harmonisation and coordination of regional initiatives.

CHAPTER 10

The Mediterranean Diet is a dietary pattern and lifestyle that is characterised by its multiple nutritional benefits, as well as by its effects on the environment, society and economy. This pattern has been eroding steadily over the last few decades leading to an increasing waste of food, knowledge and natural resources. In order to promote the Mediterranean Diet as a sustainable food consumption pattern, it is essential to identify and quantify its constituents and promote policies that will integrate these characteristics in the lifestyles of modern societies.

CHAPTER 11

In the Mediterranean region the food losses and waste are estimated to exceed USD 50 billion annually in terms of farm gate prices. These losses are often attributed to the lack of appropriate infrastructures throughout the food value chain; therefore there is a pressing need for establishing "green" food value chains to serve the specific goals of prevention, reduction and recapture centred on products, processes and systems. Within this context, critical issues in post-harvest management should be taken into consideration by implementing new technologies such as active and intelligent packaging, nanotechnologies, use of sensors, indicators and new ethylene removing approaches. Moreover, investment in research and development is a prerequisite for greening the food value chain in the Mediterranean while the major challenge is to attract funds for investments in green, innovative infrastructures in order to increase exports as well as food security. It is thus clear that policy-makers and policy-level decision makers must urgently consider these issues as they contribute to improved food security (and health and safety), the mitigation of climate change, increased employment opportunities and the struggle for gender equality.

CHAPTER 12

The potential of innovation when addressing the challenges faced by the agri-food system is widely recognised today. This chapter aims to explore the contribution of innovation to FLW prevention and reduction that weaken the sustainability of food security and the agri-food system in the Mediterranean. After presenting innovation models and types (product, process, organisational, social, political, institutional), it then describes the existent strategies in food waste management hierarchies and pyramids and provides concrete examples of innovations that have been used in different countries and contexts for the prevention and/or the reduction of food waste along the food chain. Some initiatives and good practices for FLW recycling and re-use are also mentioned. Innovative practices should be mapped and disseminated to reach the concerned actors of the food chain and to develop an enabling political and institutional environment.

CHAPTER 13

Food waste is directly related to consumer behaviour but it is also indirectly related to retailer behaviour. This chapter successively addresses the current trends in Mediterranean developing countries and those observed in developed ones. It also provides insights of some specific countries that are reviewing their national policies. This analysis reveals that food waste occurs with greater intensity in developed countries and developing countries should learn from past experiences of wealthy consumers. The economic crisis has resulted in a change in consumption habits and greater awareness on food waste. Food banks collecting important quantities of food, which are distributed to people in need, have strongly developed. Awareness-raising campaigns for short-term and long-term impact on consumer education seem to be the most effective tool to reduce food waste.

CHAPTER 14

This chapter and the section that it introduces address a little tackled and yet very important subject: the waste of knowledge and human resources. It provides an overview of the establishment and evolution of agricultural knowledge in its various forms (technical knowledge, knowhow and associated lifestyles). It highlights both the factors that threaten knowledge and their rediscovery under the form of new systems of knowledge and innovation. The chapter concludes by providing a number of recommendations for inclusive policies aimed at the protection and the remobilisation of this knowledge.

CHAPTER 15

The concept of agricultural knowhow here refers to the knowledge accumulated over centuries and that has been slowly carved by exchanges, confrontations, trade and the mixing of cultures even at very local levels throughout the Mediterranean. Although the differences between the North and South of the basin are strongly marked, each locality has traditionally enjoyed a unique identity and a strong individuality in its history. Closely related to the loss of traditional knowhow, the weakening of these identities is shaping a new Mediterranean. A Mediterranean that is northern and southern, local and global, technical and traditional, a constant rebalancing region that is a both complex and unstable. A Mediterranean where it is becoming urgent to save knowhow in danger of being marginalised (and depleted) and align it with the scientific advances of the past decade, in order to address in an integrated way, the various current and foreseeable crises that threaten the fragile balance supporting life in this basin. This chapter argues for the emergence of new production systems, breaking with the current trend of resource degradation and marginalisation of large rural areas, in order to meet these challenges. Agro ecology is presented here as one possible way to collectively live through this course in the cultural, scientific and economic evolution of the Mediterranean.

CHAPTER 16

This chapter addresses family agriculture and its assets to promote the development and the fight against all forms of waste starting with the waste of knowledge and human resources. It stresses the need to act in favour of this agriculture that is faced with several challenges. The well-known guidelines for such an action are recalled and new fields of intervention are identified in order to ensure that knowledge and innovation systems that are being implemented, or even the ongoing digital revolution in agriculture take account of family agriculture.

CHAPTER 17

This chapter aims at exploring ways to better link agri-food knowledge to food security needs and challenges in the Mediterranean area faced with different sustainability issues including food insecurity and malnutrition. It provides an overview of agricultural knowledge generation and dissemination and the role of agricultural extension and advisory services within the agricultural innovation system. It highlights the main knowledge and research needs related to the four dimensions of food security (availability, access, utilisation, stability). This chapter also presents some options and strategies for developing an effective knowledge system for sustainable food security by stressing the need for a new transdisciplinary science of sustainable food systems and the involvement of producers (men, women, and youth) and their organisations. Many of the challenges regarding food and nutrition security are common to all Mediterranean countries. This chapter concludes that it is vital to set up a joint research agenda and education programmes to address them in a collaborative way and calls for strengthened regional collaboration and agri-food diplomacy.

1 PART ONE

NATURAL RESOURCES in the Mediterranean

CHAPTER 1

GLOBAL PERSPECTIVE OF NATURAL RESOURCES

Matthieu **Brun**, *Sciences Po Bordeaux*
Pierre **Blanc**, *Bordeaux Sciences Agro and Sciences Po Bordeaux*
Halka **Otto**, *FAO*

The intense negotiations of 2015 led humankind to question development models, given the consequences of climate change and the deepening of inequalities. Two major concerns continue to dominate the agenda: how to feed a growing population, and how to do so while protecting the environment and natural resources for future generations.

People living on the planet are hungry for land and thirsty for water, and tensions abound over the resources needed to meet their needs in terms of food, housing, heating and entertainment. All these activities which, at local level, are in growing competition with one another, have an impact on the state of natural resources, at times erupting into crises and violent conflicts, which threaten the peace and security of countries or entire regions, as can be seen today in the Middle East (Werrell and Femia, 2013, p. 15; IRIN, 2009). If the current trend for waste and applying pressure on ecosystems, primary forests, water and land escalates, people's living conditions cound undergo a profound transformation in the future, with far-reaching consequences. A paradigm shift is therefore not only desirable, but essential, and massive but crucial efforts will be needed for the collective management of natural resources at both global and local level.

The Mediterranean is by no means exempt from this alarming state of affairs. On the contrary, it reflects all the tensions that revolve around the management of natural resources and agriculture. Although its demographic weight in the world is declining, the region's growing population continues to exert strong pressure on already scarce natural resources. Indeed, population growth coupled with strong coastal urbanization is leading to overexploitation of resources and is compromising the potential for development in the region. Before embarking in the following chapters on a detailed analysis of the state of natural resources in the Mediterranean region, this first chapter offers a global perspective of the environment, as well as the threats and challenges that menace natural resources on the planet as a whole.

Between scarcity and unequal distribution: Some global perspectives on the state of natural resources

The planet is being subjected to a range of transitions, all at the same time. Two of these have a direct impact on natural resources: demographic transition, taking the world population to new levels, and the food transition, with a rise in daily intake, generating unprecedented production requirements as a result. People living on all the continents have therefore intensified their use of land and water, and extended the area of land under cultivation. At times, this has been at the expense of forests and terrestrial biodiversity, which is receding in an alarming manner in certain parts of the world. In an effort to meet increasingly demanding requirements, people are turning to the planet's seabeds, which offer huge reserves of food and a biodiversity that is starting to be affected in some areas. The demographic transition, coupled with the global rise in average income, also tends to place a burden on energy resources.

Marine and fisheries resources

For a significant share of the world's population, marine and fisheries resources are key to subsistence and prosperity. Their exploitation, from the shores of the Mediterranean to the inland seas of Europe and Asia and the continental waters of Canada, Brazil and China, has enabled great civilizations and major powers to flourish. The contribution of fisheries and aquaculture products to human diets has been recognized by member states of the Committee on World Food Security, proof of the key importance of this sector in combating hunger and malnutrition (HLPE, 2004). However, as a result of human activity, fisheries resources have become fragile and are often overexploited to satisfy the needs of a soaring population, whose members have never before consumed so many food products drawn from seas and rivers (FAO, 2014a). Technological progress, rising population density along the coasts and increasing urbanization all add to pressure on resources and the biological diversity of marine environments. Already dramatically affected by pollution and overexploitation, these areas are also being transformed by a wide range of economic activities, such as fishing, extraction of minerals, sand, gas and oil, transport and leisure activities, as well as being threatened by climate change, whose negative impact is now making itself felt on aquatic resources and ecosystems.

The state of fisheries stocks and resources gives considerable cause for concern. While global production of marine fisheries reached its peak in 1996 at 86.4 million tonnes, overall fisheries production, which rose to 93.7 million tonnes in 2011 (FAO, 2014a, p. 23), is still growing. According to the FAO State of World Fisheries and Aquaculture report published in 2014, the Northwest Pacific showed the highest level of production in 2011, followed by the Southeast Pacific. In the Indian Ocean, captures continue to rise, with a growth of 17% between 2007 and 2011. The fishery resources in the Atlantic have suffered greatly from high levels of exploitation. While some stocks in the north Atlantic have shown signs of recovery due to improved management systems, in the southeast, 55% of stocks monitored were being fished at a level that is not biologically sustainable in the long term. At global level, overexploited stocks have increased since the 1970s, accounting for 28.8% of harvested fish stocks in 2011. In the Mediterranean and Black Sea, 52% of stocks surveyed were fished at unsustainable levels. For example, those of cod and mullet are overexploited, while those of sole, sardines and anchovies (pelagic species) are considered to be fully exploited. According to the Red List of threatened species drawn up by the International Union for the Conservation of Nature (IUCN), 43 species of native marine fish are threatened at regional level (Abdul Malak *et al.*, 2011, p. 17). The position of bluefin tuna in the Mediterranean, whose reproductive potential has declined by 50% over the past forty years, remains extremely worrying, despite the 2006 launch of a recovery plan, with revised fishing quotas, which has led to a slight improvement.

Water resources: towards a global deficit?

While the International Decade for Action *Water for Life* came to an end in 2015, water resource management faces greater challenges than ever. Unequal access to an increasingly scarce resource, whose quality is far from optimal for assuring a balanced, healthy lifestyle, exacerbates social tensions and conflicts throughout the world, while triggering ambitions for power on the part of governments (Blanc, 2012; Galland *et al.*, 2008). The planet's water resources are increasingly sought to meet human needs. Volumes than can be mobilized through human intervention are extremely small: more than 97% of the Earth's water is salty, and once the water contained in glaciers and permanent snow is taken into account, human beings only have 0.7% of the Earth's water for their various uses, such as agriculture, sanitation and industry, etc.

The geographical distribution of water on the planet is extremely unequal. Today, one-third of humanity suffers hydric stress – less than 1,700m^3 of freshwater available per inhabitant per year – when the global average is between 5,000 and 6,000m^3. The UN forecasts that by 2025, nearly 1.8 billion people will be living in areas affected by water shortage, while currently, 9 countries share 60% of all renewable natural freshwater resources[1]. According to AQUASTAT[2], the level of dependence on external water resources is more than 95% in Egypt, compared with 8% in the United States of America, and these figures are set to become even more acute in the future for countries such as Egypt, Malta, Libya, Jordan, Cyprus, Yemen and the Gulf Emirates, which have extremely low or almost non-existent levels of water availability. While global reserves of water resources have remained sufficiently stable throughout the history of humankind, its needs have risen constantly (FAO, 2011). First of all water-consuming sectors is agriculture, which has to feed a population that grew by a factor of 4.5 between 1914 and 2014. Water withdrawals for irrigation have risen by more than 60% since the 1960s and now account for some 70% of total water extraction. The global surface area of irrigated land increased fivefold during the 20th century, mainly in Asia and the arid or semi-arid regions, where populations growth is strongest. With the spread and promotion of technological and

1 - These are Brazil, Russia, Indonesia, China, Canada, the United States of America, Colombia, Peru and India.
2 - AQUASTAT is FAO's global water database and information system.

organizational innovations, irrigated surface areas are expected to increase by 14% by 2035, in an effort to raise still low levels of productivity in some African regions (FAO, 2011). Urbanization and industrialization are also factors that influence levels of water consumption. The growth of cities and the process of urbanization taking place in Africa and Asia are combining to exert even greater pressure on resources, as well as increasing pollution of the water already available. The number of megacities with more than 10 million inhabitants could reach 50 by 2025, while in 1950 there were just 3. As a result, the prospect of a global water deficit (if it is possible to measure water resources on such a scale) looms large, unless there is a change in the way this resource is used and distributed (UNESCO, 2015). The United Nations World Water Assessment Programme (WWAP) predicts that 40% of the world's population will be living in areas of high water stress by 2030 and highlights the risks to groundwater (WWAP, 2015): currently, aquifers supply drinking water to half the world's population; already, one in five is overexploited.

Soils: a threatened resource neglected by policy

Although 2015 was declared the International Year of Soils, political mobilization is still relatively weak on this issue. Yet, as highlighted by FAO, 33% of land is moderately or severely degraded due to erosion, salinization, compaction, acidification and chemical pollution of soils (FAO, 2011, p. 138). The extent of soil degradation threatens the capacity of future generations to satisfy their dietary and energy needs. By 2050,supply for foodstuffs, animal feed and fibres will have to increase by 60% to feed a global population of between 8 and 11 billion people (Dorin *et al.*, 2010, p. 31). The scope for expanding areas of arable land is limited, since most of the land still available is not suited to agricultural production. Land suited to crop cultivation is almost non-existent in Southeast Asia, the Near East or North Africa. In many other countries, the issue arises of which agricultural models to adopt in order to increase the productivity of land that is already cultivated. The agricultural intensification practised by some European countries during the second half of the 20th century has revealed its limitations through environmental degradation, especially soil and water pollution, as well as through the impoverishment of biological diversity of species that it has caused. In common with other natural resources, land is threatened by human activity and climate change. Artificialization via land use, pollution of soils and sub-soils, and erosion – these are the three major constraints affecting soils at global level, reinforcing the need for coordination around Sustainable Development Goal (SDG) No. 15 to conserve and restore land ecosystems. The issue of land is not just one of surface area, but also of distribution. Growing agrarian capitalism is targeting countries that find themselves in difficulty, with a trend towards investment in land throughout the world. The result is that many producers are prevented from having access to farmland. Nearly sixty years after the period of major agrarian reforms, a form of re-concentration of land ownership is being seen, which is profoundly changing rights and regimes for farmland management. Such competition is forcing family farmers to work land that is inadequate to ensure either their food security, or that of local and regional supply channels.

Forests: reversing a negative trend?

Mobilization to protect and conserve forest resources – particularly evident in 2011, which the UN declared the International Year of Forests – has found a special resonance in civil society, leading to a decline in the global pace of deforestation. Forests serve functions that are crucial to the survival of life on Earth, acting as lungs for humankind, barriers against soil erosion, carbon sinks and reservoirs of biodiversity, food and energy resources. Yet during the past three centuries, forests worldwide have diminished by about 40%, and 29 countries have lost almost 90% of their forest cover (FAO, 2010). Some 6.6 million hectares of forests disappeared each year between 2010 and 2015, when FAO mapped 3.7 billion hectares of forests (FAO, 2015). It should be noted that the annual rate of forest loss declined between 1990 and 2015. Between them, Russia, Brazil, Canada, China and the United States of America account for half the world's forested areas.

Forests formed of indigenous species, in which there is no trace of visible human activity – so-called primary forests – represent 36% of forested surface area (FAO, 2010, p. 87). However, these expanses have declined by nearly 40 million hectares since 2000, according to FAO. Planted forests accounted for 7% of total surface area in 2010 and increased by 5 million hectares between 2000 and 2010. This rise is closely linked to the increase in demand for raw materials for timber related industries (energy, construction, etc.). Some 12% of forests are targeted for biodiversity conservation. At global level, there is wide diversity among forests, with local characteristics and particular phenotypic features. Tropical and subtropical forests (61% of global forested area), which are evergreen, are extremely rich in biodiversity: in these complex ecosystems, there are more than 50,000 species of trees. Boreal forests, made up of conifers and found around the polar circle in the northern hemisphere, account for 25% of global forested area, and temperate forests with deciduous leaves (birch, oak, etc.) and conifers account for 13%. There are other types of forest, such as tundra and Mediterranean forests. In 2010, these latter covered 25 million hectares in countries of the Mediterranean region, which has a total forest area of 85 million hectares (CIHEAM, 2013). Particularly fragile, their surface area has declined dramatically, despite the important ecological role that they play in Mediterranean ecosystems. Their disappearance is a major cause for concern in the region. Certain species are especially emblematic of these lands and their history, such as the cedar, the Aleppo pine and the argan tree. In fact, more than 3,500 rare endemic species out of the 6,000 mapped in the Mediterranean are vulnerable or threatened. Demographic pressure coupled with forest fires[3], overgrazing and reduced forest cover to make way for agriculture all pose a direct threat to the Mediterranean forest ecosystem, and on a more global scale, to forests worldwide.

Between 2000 and 2010, 13 million hectares of forests were converted each year to other uses, compared with a figure of 16 million in the 1990s. While this conversion and deforestation has subsided in the past twenty years, the pace at which these phenomena occur remains highly alarming. South America, compromised by large

3 - According to the FAO Department of Forestry, between 2010 and 2016, 269,000 forest fires were recorded in Mediterranean countries, burning more than 2 million hectares.

tracts of land given over to soya monoculture, and the African continent are both experiencing net forest losses that are among the highest in the world. Australia, renowned for its endemic species, has also seen massive forest losses caused by drought and fires (FAO, 2010, p. 18). The total area of forests remains relatively stable in North America and has increased in Europe and Asia. But while there have been net gains of forest land in some parts of the world, there is a growing risk of primary forests being converted to monocultures of rubber or palm oil, which endangers local biodiversity in tropical areas. Threatened by humans, destructive insects, diseases and climate change, sustainable forest conservation must occupy a central position in the 2030 sustainable development agenda, as highlighted by UN Secretary General Ban Ki-Moon, in March 2011.

Biodiversity: towards a "sixth mass extinction"?

The Millenium Ecosystem Assessment revealed the extent of the consequences of modifications to ecosystems to meet the needs of the world's population. According to the final report, ecosystem transformations during the past fifty years have taken place at the fastest pace ever in the history of humanity (Millenium Ecosystem Assessment, 2005). These changes have made it possible to meet needs for food, freshwater, rubber, fibre and energy, but have led to substantial and irreversible losses of land-based and aquatic life. The protection of biodiversity, which is defined in the 1992 Convention on Biological Diversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems", has been placed on the agenda of the international community. Each day, science makes progress in categorizing, discovering and assessing threatened species. There is considerable scientific controversy about the pace of disappearance and extinction of living species. But whether the rate is 50, 100 or 1,000 times greater than that at the beginning of life on earth, the consequences for the human race and its environment are catastrophic. Some scientists are talking openly about a sixth mass extinction, the last one being during the Cretaceous age, which saw the disappearance of the dinosaurs, 65 million years ago (Billé *et al.*, 2014; Dirzo *et al.*, 2014; Ceballos *et al.*, 2015).

Among the many ecosystems that are threatened are coral reefs, which have higher levels of biodiversity than tropical forests. According to one Australian researcher, 30% of these reefs have been damaged by fishing, disease and pollution (Wilkinson, 2004). Some 35% of mangroves have also disappeared during the past two decades due to conversion to aquaculture, overexploitation and storms (Millenium Ecosystem Assessment, 2005). The latest version of the IUCN Red List, drawn up in 2015, classifies 22,784 species out of 77,340 studied as "threatened with extinction": 41% are amphibians, 13% birds, 31% sharks and 25% mammals. Megafauna (elephants, rhinoceroses, polar bears, etc.) and invertebrates (butterflies, spiders, ladybirds, etc.), which have declined by 45% since 1980, have seen the sharpest drop (Dirzo *et al.*, 2014).

There are five major sources of pressure weighing on biodiversity: degradation of natural environments (e.g. deforestation), overexploitation of natural resources (e.g.

fisheries resources), the introduction of invasive species (farmed fish, exotic pets, shellfish introduced into the Mediterranean through the Suez Canal and ballast water, etc.), pollution (for example, that caused by heavy metals) and climate change. Due to the opening up of commerce, increased trade and greater movement of goods and people in the Mediterranean, the risks of introducing and disseminating harmful organisms is increasing in an alarming manner[4]. The fight to halt losses linked to harmful organisms is particularly important to conserve food security in the Mediterranean, which is a net importer of cereals.

In terms of production, the agricultural intensification seen in some countries in recent decades has major impacts on the diversity of genetic resources for food and agriculture. Noteworthy among the many examples is the selection of certain breeds of dairy cow, which is causing other supposedly less productive breeds to be abandoned and disappear, and a trend for some regions to focus on producing a limited number of crops.

Energy at the heart of an interconnected system for food security

In the 20th century, the development of industry and transport has mobilized a growing quantity of resources, increasing total energy use more than twentyfold. More than 30% of this consumption is currently absorbed by the agrifood sector, mainly for agricultural production. But this is not the only energy intensive sector: transport, heating and construction require more and more energy to satisfy human requirements. According to a scenario drawn up by the International Energy Agency, by 2040, global energy demand will increase by 37% (IEA, 2014), and the global energy mix will be almost equally divideed into four parts: oil, gas, charcoal and "low carbon emission" energy sources. In a situation in which climate constraints contribute to the reshuffling of cards in the global energy game, acute problems are forecast regarding limited natural fossil resources, the need for public policies to support renewable energy and interdependence between energy production and consumption sectors. Climate change and the increase in greenhouse gas emissions are the main factors exerting pressure on levels of consumption and national policies. Given that the agrifood sector alone accounts for as much as 20% of greenhouse gas emissions[5], there is an urgent need to plan decarbonized development pathways[6]. Today's food systems are strongly dependent on fossil fuels at all stages of production. Continuing down this path is not a viable option for the agriculture sector, nor for the heating and transport ones. The balance between food security and energy requirements has become a burning issue and a source of political instability, as demonstrated by the rise in food prices after 2007, which was partly linked to the growing demand for biofuels. It is crucial to adopt an approach that takes into

4 - CIHEAM's *Watch Letter* No. 33 (CIHEAM, 2015) examines various phytosanitary threats, such as the tomato leaf-miner pest and *Xylella fastidiosa*, which has already contaminated olive groves in Puglia, southern Italy and is threatening Mediterranean arboriculture. Publications underscore the need for cooperation to explore the threats and develop measures for prevention and sanitary protection.

5 - More than 3% if changes in land use are taken into account.

6 - On this subject, see the *Deep Decarbonization Pathway* project carried out by the Institute for Sustainable Development and International Relations and the Sustainable Development Solution Network.

account the interconnection between different resources, shaping a system in which any intervention on one part of the system (for example a policy to encourage ethanol production) has a knock-on effect on others (levels of water or an aspect of food security). So it is important to taken into account the positive and negative spin-offs, as well as the interdependencies between policies and useage of water and energy for food production at various levels, from local to global (FAO, 2014b). For example, we know that cultivating cereals to produce agrofuels, thereby securing energy supplies, consumes both land and water and enters into competition with food production. The question should also be asked as to the levels of fossil fuels required in different contexts for the production of ethanol, analysing if this approach does not actually make very little economic or environmental sense. Water, energy, food and land are all crucial resources for meeting human needs. It is worth remembering that nearly 800 million people have no access to good quality water and that 1.5 billion inabitants do not have electricity. Access to these natural resources and their sustainable management is a priority to enable economic and social development to take place and to fight poverty. Water supply, and even autonomy, should be assured for farmers suffering from food insecurity and poverty. They have a very important role to play, both in increasing output and mitigating global warming, provided that they adopt solutions that are compatible with food crops. Farmers vulnerable to the scourge of food insecurity and economic uncertainty are the first actors with the scope to intervene in this water, energy and food nexus, by reducing losses and wastage, adopting energy saving practices and developing local energy sources and decentralized management systems for all resources. However, in the South as in the North, such change will only be possible with public policy support and the engagement of the private sector, as well as that of technical and financial partners, such as development banks, coupled with implementation of cooperation policies between countries. Nor should we neglect the effects of decentralized management of natural resources such as energy on the democratization of societies and the participation of everyone in collective choices.

Humans and their environment: Advocacy for natural resource management

"Where there is danger there is also salvation". As Hölderlin suggested as long ago as the 18th century, humanity is bound to find responses to the threats that emerge and which, in this case, are self-inflicted. Humankind is being invited to bring about a real revolution if it wants to manage the resources available to it. Already, a number of technical and institutional initiatives are under way.

Sound management for future generations

We have seen that protecting the environment and natural resources is more crucial than ever in order to address the many challenges posed by climate change and population growth. Given the urgent nature of ecosystem degradation, there have been many calls during the course of modern history for women and men to plan and manage the way in which they interact with their environment. For example, the report published by the Club of Rome in 1972, titled *The Limits to Growth*, better known as the *Meadows Report*, used a series of scenarios to show that excessive consumption of natural resources to satisfy the appetite for growth could result in a major and sustained economic crisis. Although, in spite of technical progress, human beings cannot bring an extinct species back to life or make desert land once covered with forests bloom again, in the course of their history, societies have developed models for the collective management of natural resources, and these have formed a common heritage. Agriculture, and the exploitation of these resources to meet the needs of humankind, have made it possible to build society and today still offer a means for forging a social link on many levels. Farmers should be at the heart of this revitalized social fabric.

Natural resource management as practised today revolves around three primary moral and ethical principles, as presented in the Brundtland report, *Our Common Future*, which institutionalized the concept of sustainable development[7]:
– The principle of stewardship states that natural resources are an asset that goes beyond human existence. Since natural resources are inherited, they should be passed on to future generations, with as few changes as possible.
– Natural resource management should be supervised by representatives of users, first and foremost farmers and their organizations, but also entrepreneurs, consumers and civil society. In a world in which urban and rural boundaries are shaping new networks of territories, users and managers of natural resources should be represented at each scale of decison-making, be it at the level of a village, watershed, region, country or government or multilateral organization.
– Access to natural resources, like their redistribution, must be fair and transparent.

These three dimensions argue strongly for collective action and implementation of new dynamics for local and international development. Without greater global awareness and full realization of international agendas that have already been launched, such as the Aichi targets adopted in 2010 by the Convention on Biological Diversity or commitments undertaken at COP21 in Paris, the trend towards degradation of the environment and productive resources can only accelerate, with scant prospects of reversal. According to a report from the OECD, the costs of inaction on soil conservation, climate change and biodiversity degradation will be massive, if no new policy is put in place (OECD, 2012). According to these forecasts, by 2050, land-based biodiversity will decline by a further 10% and more than 40% of the global population will live in water catchment areas subject to high levels of hydric stress, as in North Africa. Challenges regarding food, shelter and heating will continue to increase and irreversible changes will jeopardize gains in improved living conditions made over several centuries. It is therefore crucial to reverse this trend and work towards mobilization on the widest scale possible for a major shift in the energy, agriculture and food sectors.

7 - The report, written in 1987, defines sustainable development as development "that meets the needs of the present without compromising the ability of future generations to meet their own" (Brundtland, 2011).

Better management means less waste!

To address future challenges of food security, prosperity and environmental degradation, it is unthinkable to continue following the pathway taken by consumer societies in Europe, the United States of America and some emerging countries. The growth model passed on by the so-called Thirty Glorious Years, pushed to extremes, is leading to serious overexploitation of natural resources. The time has come to ask ourselves about the share of resources that are wasted in meeting our needs. Such waste involves a large part of the world, so it is not a question of heaping opprobrium on one country in particular. Future generations will grow up in a world in which income disparities between countries will decline, while they continue to rise within the same country. In this regard, the question of using natural resources at national scale must be connected to the issue of social and economic inequalities. These latter are not just the result of scarcity and poor management of natural resources, but are themselves a source of growing problems related to the environment and ecosystem degradation. Moreover, the most inegalitarian growth models, which are rapidly developing in emerging countries, weaken citizens' consensus on the management of common assets, promoting in its place a movement for private appropriation of resources (Genevey, Pachauri and Tubiana, 2013). Redistribution policies drawn up in a collective and participatory manner, in the spirit of the declaration adopted at the Rio Summit in 1992, would help to combat inequalities and accelerate the transition towards sustainable economic and social models. As such, food and energy consumption are strongly affected by these socio-economic inequalities. Levels of consumption and waste of natural resources are testimony to the disparities of wealth between countries and to choices of development models. While a Californian consumes 4,500 litres of drinking water per day, a Parisian uses 240, and the global average is 40 litres. Food, shelter and transport are sectors where there are not just glaring inequalities, but they are also the greediest in terms of natural resources. The massive waste caused by lifestyles in which a large part of the world's population is now trapped – at times against their will – represents losses of resources that can never be retrieved. Some 40% of primary energy used in the world by 2050 could be saved by systematically tracking and reducing waste (Perthuis, 2009, p. 182). According to FAO, one-third of global food production, from farm to fork, is lost or wasted each year, the equivalent of 1.3 billion tonnes of food (Gustavsson, 2011). And let us not forget another form of waste, that of knowledge and knowhow. Combating losses and waste in all geographical settings and at all stages of production and consumption is therefore a powerful lever for conserving natural resources and hence an opportunity to rethink the sustainability of food systems. Addressing food losses also has an impact on the three dimensions of sustainable development: economic, social and environmental (Brun and Agamile, 2015, p. 96).

A great many initiatives are now in hand to help reduce the carbon footprint of our food systems and consumption patterns, with consideration being given, for example, to developing shorter supply circuits, agroecology, high environmental quality buildings and the sharing or collaborative economy, which is revolutionizing ways of consuming and using individual services. Public policies should be mobilized to enable these innovative and alternative models to emerge and find outlets. The

Mediterranean region has already tackled this problem of losses and waste, as shown by the Mediterranean Action Plan (MAP) and initiatives launched by international organizations such as CIHEAM, OECD and FAO, as well as, recently, the G20 under Turkey's presidency. G20 Ministers Agriculture meeting in May 2015 in Istanbul committed to setting up an exchange platform for food and agricultural losses and waste.

While changes are essential in food consumption and production patterns, the question also arises about the extent of changes needed and the efforts of each person. Better management and protection of natural resources is a common responsibility for all. Yet the efforts required to achieve this are different in each case, for the legislator, the consumer and the private operator. The International Year of Family Farming declared in 2014 underscored the importance of this type of agriculture for food security, global agricultural biodiversity and sustainable use of natural resources. In a world marked by climate uncertainty, competition for land and growing urbanization of lifestyles, coupled with agricultural modernization in countries of Europe and North America, transformation of this kind of smallholder and household farming is a major issue. Aside from the economic and social consequences that it will have on millions of small-scale farmers, it is the coexistence between industrial agriculture and family farming that today warrants careful scrutiny by decision-makers and civil society. These two types of agricultures do not have the same level of access to financial, political, technical and organizational resources. National and local public policies must therefore be defined to help family farmers to meet their food needs, market their output in local supply chains, produce their own energy, etc., as well as to support innovative initiatives such as agroecology, which enables production and processing methods to be adapted to natural environments and economic and social systems. While an essential prerequisite, regulating and setting in place standards is not the only way to achieve better management and use of natural resources. For example, environmental information and labelling can help to unlock technological and social barriers in production chains through a business to business perspective. It is therefore important to adopt a systemic approach to promote change, while attempting to make the various actors accountable for their commitments. Such accountability will be a decisive factor in achieving the Sustainable Development Goals, along with governance of the changes that ensue from them.

Innovative processes for natural resource management

Difficulties in conserving natural resources despite the fast pace of population growth are affecting production methods and require differentiated policy responses. What is needed is to take action against the destructive processes already under way, while supporting innovative approaches that offer a promising alternative, constantly exploring new solutions. Science and technical progress have certainly led to an improvement in our knowledge of ecosystems, but this remains inadequate. Although controversies serve to drive science, there are too many when it comes to assessing biodiversity or the impact of human activity on other natural resources. Research-development needs are therefore massive. Research needs to leave the laboratories and go out and question practices, helping to set up supportive policies for innovators, especially producers, who can then create local solutions to protect the environment. Nor should we overlook the contribution of human sciences to improving natural resource management. For example, science should question the way in which a market value is attached to ecosystem services, as well as the limits of such attribution. Likewise, a considerable volume of research developed in the early 1990s has shown the contribution of participatory management to the conservation of natural resources, and *a contrario* the inadequacy in this respect of administrative decisions that follow a top-down approach. The success of early initiatives conducted in Tunisia, through the Douar development programme, or in Morocco, through watershed management projects, demonstrates the importance of involving local communities (including agricultural producers and fishers) in the design, implementation and evaluation of environmental policies (Pintus, 2009, p. 29). Paying closer attention to participatory natural resource management is also proving crucial, given the recent interest in going back to the land shown by urban communities in Mediterranean countries. This innovative process, which involves profound changes in terms of governance and public action, call for public policies that intervene at various levels, from local to international – if it is possible to talk of international public policies – that are designed to be consistent with agendas for sustainable development and poverty reduction. Their implementation will be a powerful lever for the ecological and energy transformation desired by civil society.

Natural resource management and sustainable development – a question of scale

While a number of threats menace ecosystems at global level and in the Mediterranean, there is a wide range of solutions on offer and the international community is negotiating common agendas for action. The year 2015 marked a new turning point, with events that will be remembered for decades to come, such as the Paris conference on climate change, the financing for development conference in Addis Ababa and the definition of the post-2015 development agenda for the United Nations. Three objectives specifically target natural resources, but their protection is also critical to the achievement of the other fourteen goals. Indeed, access to natural resources and their conservation for future generations will have direct consequences for poverty reduction, the eradication of hunger and malnutrition and the promotion of women's rights and education for all. Competition for water, land and energy and the destruction of ecosystems can also result in violent conflicts, as happened in Liberia or Angola, and lead to violations of human rights[8]. Acknowledging the role of environmental issues in violent conflicts or the fight against poverty underscores the importance of natural resource management in peace-building and, more generally, in developing or promoting democracy.

8 - According to the United Nations Environment Programme, since the 1990s, at least 18 violent conflicts have been fuelled by exploitation of natural resources. Timber, diamonds, gold, precious minerals or hydrocarbons, and competition for high value natural resources, are acknowledged as having played a dramatic role in several recent civil wars (UNEP, 2009).

The diagnosis set out at the start of this chapter, of a dangerously rapid degradation of natural resources, tends to be true of all areas that are now witnessing the impacts. It is therefore urgent to pay particularly close attention to coordinating various levels to reach a common objective: if natural resources are a common public good, policies for their management span a two-way horizon, from local to global and from global to local. When it comes to implementing international agendas, it remains critical to bear in mind how different countries will seek to achieve these objectives in a global and sectoral framework. The choice of local communities, including producers and the organizations that they represent, sometimes framed by proactive public policies, can have consequences for the authorities, or even the governments of neighbouring countries. The same can be true of water resource management for a river that crosses several countries, or a regulation on air quality. Political judgement must be exercized at several levels and, if action is to be consistent, dialogue must more than ever be promoted in democratic fora, at regional and global level. Implementation of the SDGs, and the imperative of sustainable natural resource management, can also be powerful drivers for revitalizing regional development. Indeed, managing natural resources sustainably or combating climate change as part of the post-2015 development agenda requires that private transnational actors and subnational authorities have space for expression, as a guarantee of their engagement, and above all, their accountability.

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CHAPTER 2

MANAGEMENT OF LIVING MARINE RESOURCES

Anna **Carlson**, *FAO*
Francesc **Maynou**, *CSIC Barcelona*
Bernardo **Basurco**, *CIHEAM*
Miguel **Bernal**, *FAO*

The Mediterranean region is one of the most populous regions in the world. It is made up of more than twenty countries representing varying stages of economic development and diverse political systems. Despite the diversity of the region, these countries are united by their reliance on the Mediterranean Sea and their shared interest in the exploitation of its living marine resources.

The Mediterranean Sea is home to more than 694 described species of marine vertebrates, of which over 500 are recorded species of fish; 363 of these fish species are living marine resources that are targeted by fisheries. It is this incredible diversity that has drawn fishermen to this region for millennia. Indeed, fishing activities in the Mediterranean have been evolving and expanding continuously since the Upper Palaeolithic period, over 40,000 years ago (Van Neer *et al.*, 2005), leaving an indelible imprint on the socio-economic and cultural fabric of this region.

However, anthropogenic activity has had an important impact on the biodiversity of the Mediterranean region's coastal and wetland ecosystems. Pollution from atmospheric and land-based sources has taken a toll on the marine environment. Furthermore, overfishing and fishing methods result in an abundance of bycatch and discards. Moreover, illegal, unreported and unregulated (IUU) fishing has led to inefficient and wasteful exploitation of marine resources and pernicious effects on the status of fish stocks.

To address such threats, sustainable governance of the Mediterranean Sea requires the coordination of a large number of countries and the alignment of diverse environmental and economic development interests. This chapter discusses such governance efforts, focusing in particular on management measures to improve the health of Mediterranean fisheries and to reduce wasteful activities. Firstly, this chapter describes the characteristics of Mediterranean fisheries, outlining the principal management challenges contributing to inefficient and wasteful exploitation of living marine resources. The review of tangible actions conducted to address these challenges at both regional international levels and that of management measures and legal frameworks that are currently in force will enable discussions on current challenges and suggestions for future action.

Characteristics and principal challenges of fishing activity

This chapter will specifically focus on the impact of fishing activity on the Mediterranean marine environment, the steps that have been taken to improve the management of these resources and the challenges that remain. A summary of the main characteristics of Mediterranean fisheries and their management is provided here below. Further discussion and analysis of Mediterranean fisheries can be found in the GFCM's report *The State of Mediterranean and Black Sea Fisheries* (SOMFI) (FAO, 2016), as well as in key publications of the CIHEAM (CIHEAM, 2014; Oliver, 2002; Basurco, 2008).

The marine environment

The Mediterranean Sea is a rich and diverse environment, characterised by its temperate climate, its deep blue colour, and its numerous important ecosystems. Despite representing only 0.8% of the surface area and less than 0.25% of the volume of the world's oceans, approximately 7% of the world's known marine fauna and 18% of the world's known marine flora can be found in the Mediterranean, 28% of which are endemic to the region (Oliver, 2002; FAO, 2011). In order to recognise and protect this diversity, the International Union for Conservation of Nature (IUCN) has designated the Mediterranean as a global biodiversity hotspot (Cuttelod *et al.*, 2008; Bazairi *et al.*, 2010).

Unfortunately, this biodiversity hotspot faces numerous threats. In particular, uncontrolled development, urbanisation, land-based pollutants, and atmospheric pollutants threaten the health of Mediterranean ecosystems. Eutrophication, resulting from land-based and atmospheric pollution, has had a particularly negative impact on Mediterranean fisheries (Caddy, 1993), and in particular, increased incidents of toxic blooms have been reported, with blooms of phytoplankton and benthic diatoms resulting in local fish mortality due to anoxia (UNEP and FAO, 1990). The negative impacts of pollution on fisheries are further compounded by overfishing and other detrimental fishing activity that exacerbate the adverse impacts on fish stocks.

Attempts have been made to curb these negative impacts. The Global Environment Facility (GEF) has been adopted by all twenty Mediterranean nations under the Barcelona Convention[1] and has resulted in a Strategic Action Programme (SAP) for land-based sources of marine pollution, living resources and critical habitats.

1 - Mediterranean Action Plan (1999).

Furthermore, the General Fisheries Commission for the Mediterranean (GFCM or "The Commission" – see Box 1) of the FAO has made important strides with regards to the development of management plans, legal frameworks, and conservation efforts to promote the sustainability of living marine resources in the Mediterranean.

Socio-economic characteristics of fishing activity

Unlike in other regions of the world, Mediterranean fishing activity is not characterised by an over-reliance on large mono-stocks (Farrugio *et al.*, 1993). Due to the high species diversity of the region, modern fishing activity in the Mediterranean employs a variety of fishing techniques and gears, which have allowed fishing activity to adapt to the region's diverse environments, socio-economic contexts, available materials, and target species. The vast majority of capture fishing activity is carried out on board fishing vessels, although some traditional passive and active fishing techniques are still operated from the coast without the use of vessels.

The urgent and important need for measures to manage Mediterranean fishing activity must be reconciled with the important socio-economic impact of this sector. To this end, fishery management strategies are that consider topics such as livelihood strategies and poverty reduction alongside scientific advice needed. Reducing waste in fishing is one potential policy strategy that addresses the joint issues of environmental, social and economic sustainability in fisheries. Not only do policies addressing this important issue reduce pressure on the resource, but they also potentially make fishing activity more economically efficient. The exploitation of living marine resources plays a significant role in the livelihoods of people residing along the Mediterranean coast and the status of stocks is highly dependent on their socio-economic significance. The total value of fish landings in the Mediterranean is approximately USD 2.7 billion, representing approximately 0.04% of the combined GDP of those Mediterranean riparian states that have reported landing data. Furthermore, this value is underestimated as not all data for all riparian countries were reported. Of this total landing value, five countries account for over 85%, namely, Italy, Turkey, Spain, Greece and Tunisia. Of these countries, Italy garners the highest landing value in the region (approximately USD 1 billion) (FAO, 2016).

In terms of employment, the primary fishing sector (employment on board fishing vessels) provides just under a quarter of a million jobs in the Mediterranean. Data on youth or women's employment is not collected for all Mediterranean countries, although some evidence, especially in the field of small-scale activities suggests that women contribute significantly to the sector. Furthermore, total employment in Mediterranean fisheries becomes much higher if employment in related secondary sectors, such as fish processing, vessel maintenance, or port services is also considered. Data for EU member countries indicates that the fish-processing sector accounts for, on average, one-third of total employment in fisheries (STECF, 2015). Furthermore, the role of women in fish processing is significant, with female employment accounting for, on average, 45% of fish processing employment in EU-member Mediterranean riparian states (STECF, 2014).

Overall, small-scale or artisanal fisheries (SSF) represent the dominant fleet sector in the Mediterranean. Small-scale fleets, also frequently called artisanal or coastal fisheries, can be described as "low-capital ventures where the fisherman is often the owner of the vessel, in contrast to industrial fisheries involving major investments by companies or financial groups" (Oliver, 2002). These fisheries are often associated with the notion of "coastal fishing", that is to say, fisheries located on the continental shelf and very close to the coastal zone. Exploitation areas can be reached in a few hours from the ports, or even from the beaches (Oliver, 2002). In this region, the role of these fisheries has always been vital, representing a crucial link between local knowledge, cultural heritage, and the local environment.

In this regard, this sector is highly diverse and dynamic, varying enormously from one location to another, targeting a wide variety of species and highly adaptable. Small-scale fleets are able to adjust techniques relatively easily and can adapt to fishing seasons based on a rotational system. Over fifty types of fishing gear are used to target hundreds of species including demersal fishes, crustaceans and some small and large pelagic species. They also provide a significant contribution to food security and rural economic development and tend to produce little waste (FAO, 2016).

Approximately 67,000 vessels are officially declared as small-scale fleets, which is roughly 80% of the entire Mediterranean fleet. Furthermore, this sector employs at least 60% of the total number of people working directly in the fishing sector, amounting to nearly 132,000 people. However, these figures are likely to be much higher, considering that landing sites for artisanal fisheries are highly dispersed along the coastline and therefore the monitoring, control and surveillance (MCS) of artisanal fisheries is typically weak. Likewise, the contribution of fish workers engaged in the post-harvesting activities of SSF is similarly difficult to quantify. Moreover, these estimates do not take into account the un-registered small vessels, especially those without engines, and those fishermen, recreational or not, that operate without boats, fishing from the shoreline.

Despite their social importance, the total capture by weight from SSF is relatively small, currently representing about 12% of the total catches in the Mediterranean and Black Sea region. It is estimated, however, that this small volume represents a significant percentage of the value of the region's catch; production from the small-scale fleet segment represents approximately 23% of the total value of capture fisheries in the region. Considering these figures, fish produced by SSF are of high economic value. Generally, the catch is sold fresh in local markets, marketed directly to private consumers or restaurants, or directly exported (FAO, 2016).

The role of fishermen organisations or cooperatives is particularly important for the small-scale sector, often representing a useful way to manage fishing activity, both from a biological and economic point of view. Thus, on the French Mediterranean coast, producer fishermen organisations called "prud'homies" help to regulate small-scale fishing activity, resolve conflicts, and ensure the economic sustainability of its members. In Spain fisher guilds called "cofradias" cover 83% of Spanish fishing employment and they are present across the entire Spanish coastline and its islands. In addition to developing strong, common management measures, these guilds also provide important economic guidelines for the sale and marketing of catches, allowing them to use market mechanisms to enforce compliance with regulations and punish transgressors (FAO, 2016).

The role of fishermen organisations is also highlighted through the recently adopted FAO *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication* (June 2014), which underlines the importance of small-scale fleets and the need to ensure that they continue to provide for decent livelihoods within coastal communities. Their role in promoting sustainable development is paramount and efforts are needed to preserve this sector, irrespective of increasing competition coming from other uses of the sea. Such is the case in the Mediterranean Sea, where small-scale fleets are in need of support in order to maintain the vitality of Mediterranean fishing communities.

In addition to small-scale fleets operating in the Mediterranean, a sizable industrial fishing sector is also present. While making up only 20% of the fleet operating in the region, these vessels are responsible for the largest share of landings, both in terms of volume and value. These fleet segments include purse seiners of over 12 metres, 38% of total volume of landings, trawlers of between 12 and 24 metres, 13% of total volume of landings and polyvalent vessels of over 12 metres, 10% of total volume of landings. The fleet segments that account for the highest value of landings are trawlers of between 12 and 24 metres (27% of total landed value) and purse seiners (21% of total landed value). These trawlers and purse seiners tend to be more highly concentrated in the Western and Adriatic sub-regions of the Mediterranean. The economic impact of this industrial sector is significant, with the annual landed value (value of first sale prior to processing) amounting to just below USD 2 billion. Approximately 80,000 people are employed on board fishing vessels in the industrial fishing sector in the Mediterranean, amounting to approximately 40% of total employment (FAO, 2016).

Altogether, the total value of trade in fishery products by Mediterranean countries (the sum of both inter-Mediterranean and extra-Mediterranean trade) is over USD 26 billion. This value includes both the value added from fish processing, marketing and transport costs, and trade tariffs for both fishery and aquaculture products from Mediterranean countries. Overall, the majority of Mediterranean riparian states are net importers of fish products, the exceptions being Morocco, Malta, Tunisia, Turkey, Croatia, Albania, and Greece, that are net exporters (FAO, 2016). Although imports of fish products in the region show a positive trend, on average increasing by 24% over the period 1999-2009, this average is significantly less than the global average increase of 39% (Basurco *et al.*, 2014).

Such trends may reflect the diverse fish consumption habits throughout the region. On the one hand, in many Mediterranean countries, fish consumption is quite high; particular in Spain (12.4% of daily protein consumption from seafood), France (8.1%), Malta (7.8%), Cyprus (7.7%), and Croatia (6.7%) all consume more than the global average (6.6%). On the other hand, many Mediterranean countries have very low seafood consumption, despite their proximity to the sea. Consumption is particularly low in many of the Balkan and North African countries (e.g. 1.6% in both Algeria and Albania).[2] Although cultural and culinary traditions may account for low fish consumption in certain countries, in general, intense regional population growth and rising incomes across the region have resulted in growing demand for fish products. On average in the Mediterranean region, fish consumption has grown by approximately 10% over the past decade.

Stock assessment and data collection

As mentioned previously, living marine resources in the Mediterranean face numerous threats including overfishing, environmental pollution and adverse impacts from commercial activity in the region (CIHEAM, 2014). Combined with the growing regional demand for fish products, these factors intensify the pressure on the living marine resources of the Mediterranean and are the principal causes of unsustainable fish mortality. To reduce such pressure, management measures, including efforts to reduce waste and protect vulnerable habitats, are vital.

A crucial step in developing strong management measures is the accrual of accurate knowledge on the status of living marine resources. Scientific assessments of the status of fish stocks are carried out regularly in the Mediterranean. Recent assessments have concluded that approximately 85% of the main commercial stocks are currently subject to unsustainable levels of fish mortality throughout the Mediterranean and Black Sea. (on average, fish mortality is approximately 2.5 times higher than is considered sustainable). In the Mediterranean, the species subject to the highest mortality is hake, averaging a fish mortality that is nearly five times the desired level. In some hake stocks, fish mortality can reach up to twelve times the target sustainable level. Species mortality rates are subject to great regional variation throughout the Mediterranean and, for this reason, a sub-regional approach to management has been advocated. In general, demersal species suffer higher exploitation rates than small pelagics (sardines, anchovies or sprats) whose average fish mortality rates are closer to a sustainable level. Only a few demersal species, such as whiting, some shrimp species, picarel, and red mullet, are considered sustainably fished in certain areas.[3]

Despite the best efforts of the scientific community, a number of issues pose challenges to the accuracy of the overall information on the status of stocks. First, due to the high diversity of species in the area and the lack of information on catches, biology, ecology or distribution of some of the species caught, not all stocks are assessed. Furthermore, IUU fishing and discarding of unwanted catches lead to inaccurate data on landings. Although techniques are employed to account for this activity in stock assessments, such activity impairs the accuracy of scientific knowledge and thus the effectiveness of the management advice that is produced.

2 - FAOSTAT, protein supply quantity (g/capita/day).

3 - More precise details regarding the status of stocks, along with the results of the Stock Assessment Forms and landing statistics, can be found in chapter 3 of the SOMFI Report (FAO, 2016).

IUU fishing

Indeed, IUU fishing is inordinately detrimental to the rational management of living marine resources. Despite the efforts made to enact regulations regarding legal fishing activity and to improve country-level compliance with these regulations, a significant portion of fishing activity in the Mediterranean still takes place within an illegal context and therefore escapes regulation. As such, IUU activity can derail management plans and undo progress made. Globally, it is estimated that IUU fishing results in a loss of approximately 10 billion euros annually, equal to approximately 19% of the global value of reported catches. In the Mediterranean, IUU activity (typically in the form of unreported fishing) is particularly prevalent in small pelagic, tuna, swordfish, turbot, whiting, shrimp, and Norway lobster fisheries (Ozturk, 2015). The fight against IUU fishing in the Mediterranean is a major challenge and a priority of fishery management in this region.[4]

Bycatch and discards

During the harvesting process, the production of unwanted species or unwanted fractions of commercial species ("unwanted catches" [Kelleher, 2005]) is a recurrent problem of world fisheries and this is mainly due to imperfect selectivity of the fishing gear. Unwanted catches are in many cases returned to the sea ("discards"), dead generally, representing a waste of natural resources (Condie *et al.*, 2014). Unwanted catches and discards are usually poorly documented and result in fish mortality that is usually not taken into account in fisheries assessment models, potentially leading to the underestimation of the true fish mortality. Unwanted catches are detrimental to the productivity of stocks, for example, by killing juvenile individuals before their optimum production potential is achieved (i.e. production forgone). Under the current trawl selection pattern, for instance, undersized individuals predominate in the catches of hake and red mullet in the Mediterranean, especially during the periods of recruitment (Sala and Lucchetti, 2011).

Discarding practices and amounts vary considerably in different areas and across fishing gears in the Mediterranean Sea, although bottom trawls typically have among the highest discard rates. Mediterranean trawlers may discard approximately 40% of hake or red mullet, particularly during the recruitment periods (European Commission, 2011). Discards are not restricted to trawl fisheries, although the discard ratios of other gears are generally lower due to the higher species or size selectivity of most static gears (Kelleher, 2005). Purse seines also produce significant discards, despite having a lower proportion of unwanted catches (15% or lower) (Tsagarakis *et al.*, 2013), simply because they are responsible for the majority of fish catches. Small-scale fleets predominantly have low discard rates in the Mediterranean, although some exceptions exist, such as trammel nets for the prized spiny lobster (42% discard rate) (Quetglas *et al.*, 2014) or hydraulic dredges for clams (50% discard rate) (Morello *et al.*, 2005).

4 - OTH GFCM 38/2014/1, Roadmap on fighting IUU fishing in the Mediterranean Sea; OTH GFCM 37/2013/2, Roadmap on fighting IUU fishing in the Black Sea.

A recent review (Tsagarakis *et al.*, 2013) shows that discards can vary from 10% to as high as 90% of the total weight caught in Mediterranean fisheries, with lower discard rates in coastal fisheries of the eastern basin (e.g. mixed fisheries in Turkey or Egypt) and high discard rates in trawl fisheries and high discard rates in most bottom trawl Mediterranean fisheries (approximately 30% in weight). Nevertheless, these average figures do not fully capture the great heterogeneity in discard practices across different fleets, at different times of the year and among the different markets for which they are producing. Further examination of the breakdown of discard activity by gear type and Mediterranean sub-region can be found in SOMFI, the GFCM's flagship report (FAO, 2016).

During fishing operations, unwanted catches may be partially or entirely discarded. Some species that are routinely caught and marketed may be discarded at specific times of the year for economic reasons (market glut for instance). In general, discarding is associated with inadequate fish handling technology or market constraints (Catchpole *et al.*, 2005). For instance, there are cases when unwanted catches cannot be avoided because the fishing gear has selectivity limitations and the on-board storage capacity is limited. A market rationale for discarding is mainly present in the case of species with low commercial value or when specimens are damaged or of poor quality.

In addition to producing unwanted catches of species subject to regulation, imperfect fishing methods and practices have a direct impact on components of exploited marine systems, such as sensitive habitats or protected species, resulting in a diminished social value of marine ecosystems (Suuronen *et al.*, 2012). Low selective fishing gears are detrimental to marine mammals, sea turtles or seabirds, which are unintentionally caught and subsequently released with low chances of survival (Tudela *et al.*, 2005; Snape *et al.*, 2013). Seabirds offer a further example of the negative ecological impact of discarding: bird populations have suffered artificial increases as they become accustomed to exploiting discards as a predictable foraging resource, rather than pursuing traditional natural food sources. Ultimately this increase in seabird populations affects the structure of marine communities by interference competition (Arcos *et al.*, 2008; Oro *et al.*, 2013). Some fishing operations also generate significant discards of habitat-forming invertebrates by fishing in sensitive habitats (maërl beds, sea-grass beds, cold corals) (Barberà *et al.*, 2003).

Given the impossibility of completely avoiding unwanted catches, it is necessary to devise technical solutions along with economic and social incentives to eliminate these catches. Through the Common Fisheries Policy and the so-called "discard ban", European countries have agreed to phase out discards of commercial species subject to quotas or Minimum Conservation Reference Size[5]. A number of research projects, currently funded by the European Commission, are seeking to achieve this goal (especiallythe MINOUW,[6] DiscardLess,[7] DISCATCH[8] projects). Furthermore, all

5 - EU Reg. 1380/2013.
6 - http://minouw.icm.csic.es
7 - www.nsrac.org/category/project/discardless
8 - http://fr.med-ac.eu/index.php

Mediterranean countries have prioritised the reduction of incidental taking of vulnerable species by approving dedicated GFCM Decisions.[9] A general programme to address discards at the Mediterranean-level is currently being launched within the GFCM.

Management achievements: institutional responses

Considering these challenges for the management of living marine resources in the Mediterranean, a number of concrete actions have been taken at regional level to ensure their future sustainability. The following legal framework and management measures are the result of productive international and regional cooperation to address these management challenges.

International legal framework

First and foremost, a strong international legal framework must be in place in order to enact effective management measures. There are certain goals that States cannot achieve alone. Sustainable fisheries, for instance, can only be achieved through cooperation among States, as the stocks and ecosystems, and in some cases the resource exploitation, are shared. Various legal frameworks have emerged over time to support and facilitate such regional cooperation. Such legal frameworks lay the groundwork for the successful achievement of a number of the Post-2015 Sustainable Development Goals, in particular, those goals pertaining to the conservation and sustainable use of oceans, seas and marine resources, as well as those goals that seek to end hunger and poverty and to promote economic development and decent work. Of utmost importance to the global management of marine resources is the 1982 United Nations Convention on the Law of the Sea (UNCLOS), or the so-called “Constitution for the Seas”[10], which defines the responsibilities of States to manage and use fishery resources within their Exclusive Economic Zones (EEZ) and also obliges States to cooperate with the competent Regional Fisheries Management Organisations (RFMO) in their area.

Additional international legal frameworks that support management efforts in the Mediterranean include the FAO’s own Code of Conduct for Responsible Fisheries (1995), the International Plan of Action to prevent, deter, and eliminate IUU fishing (IPOA – 2001), the Port State Measures Agreement (2009) and, most recently, the above-mentioned FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (FAO, 2015). These “SSF Guidelines” are particularly important in that they were developed through a unique consultative process which brought together stakeholders in order to address the complimentary issues of responsible fisheries and social development in coastal and inland fishing communities.

9 - REC.CM-GFCM/35/2011/3 On reducing incidental bycatch of seabirds in the GFCM area of application; REC.CM-GFCM/35/2011/4 On the incidental bycatch of sea turtles in fisheries in the GFCM area of application.

10 - UN Division for Ocean Affairs and the Law of the Sea, 1998 (www.un.org/depts/los/convention_agreements/convention_historical_perspective.htm).

The role of the GFCM

As the competent RFMO in the Mediterranean, the GFCM is strongly supported by the aforementioned international legal frameworks. It is the logical body to coordinate Mediterranean, as well as Black Sea, riparian countries in the targeted governance of the region's living marine resources in a way that is adaptable to the evolving nature of the Mediterranean marine environment. Although the responsibility of overseeing and coordinating region-wide management measures falls under the auspices of the GFCM, its work complements and supports the work of riparian state governments, the European Union, numerous partner organisations and countless academic institutions and scientific experts.

The functioning of the GFCM

The evolution of the GFCM

The General Fisheries Commission for the Mediterranean (GFCM) came into force in 1952. Unlike other regional fisheries bodies, safeguarding the living marine resources in the Mediterranean and Black Sea, the GFCM was created within the institutional framework of the FAO, thus becoming the medium through which FAO fishery policies were tailored to the specific regional and sub-regional needs of the Mediterranean (Major Fishing Area 37 according to the FAO). Over the years, the role of the GFCM has evolved considerably, resulting in a more modern legal and institutional framework, strengthened compliance mechanisms and enhanced cooperation with States and organisations. An important evolution in the history of the GFCM came in 1997 when it was empowered to adopt conservation and management measures in the form of binding recommendations for its Contracting Parties. Since then, binding measures have been enacted, improving the Commission's ability to safeguard the living marine resources in its area of application.

The GFCM and its subsidiary bodies

Today, the GFCM benefits from the membership of 24 Contracting Parties, including 22 Mediterranean and Black Sea riparian states, Japan and the European Union.[11] From an institutional point of view, the GFCM serves as the primary mechanism for coordinating fishery policy among the riparian states of the two Seas. During the sessions of the Commission – the GFCM governing body being made up of national delegates from Contracting Parties – decisions are made regarding fisheries management, compliance and enforcement efforts in the GFCM area of application. Binding recommendations made by the Commission must be transposed by Contracting Parties into their national legislations.

Through the Commission's subsidiary bodies, meetings that provide fora for national scientists to address technical issues of interest to the Commission are organised. In particular, during the working groups and thematic workshops available data is gathered and analysed. Scientific advice which is subsequently revised and validated by the technical subsidiary committees, such as the Scientific Advisory Committee on Fisheries (SAC) is then formulated. Contracting Parties and Cooperating non-Contracting Parties are required to report data on national catches, bycatch, fleet, effort, socio-economic components, and biological aspects, which are then used as the basis for the formulation of scientific advice. All activities of the GFCM, including the technical and statutory meetings, are open to partner organisations and observers in order to promote transparency and consultation.

11 - The EU is a contracting party to the GFCM and its participation to the GFCM is subject to EU applicable rules. Further explanation of this relationship and EU fisheries policies can be found in Churchill and Owen (2010).

Improved scientific knowledge and increased stock assessments

In addition to building a strong legal framework to support management efforts, scientific knowledge on the status of stocks has also improved. The increasing trend in the number of validated stock assessments throughout the region is an important achievement for Mediterranean living marine resource management. The number of assessments performed annually by the GFCM's Sub Committee on Stock Assessment (SCSA) and subsequently validated by the GFCM SAC has typically fluctuated between 20 and 40 stocks. However, this number has increased in recent years. Considering that assessments for small pelagic species remain valid for a maximum of two years and assessments for demersal species are valid for a maximum of four years, approximately 200 validated stock assessments are currently valid. In 2014, the percentage of landings assessed has nearly doubled from the previous year, with around 45% of total landings assessed in 2014, that is, an increase of 20% with regards to 2013.[12] Such improvements in the quantity of stock assessments in the Mediterranean allow for more accurate and effective management solutions.

Regional management plans

Other major achievements include the implementation of management measures that build upon the scientific knowledge gathered from stock assessments and other research activities. Such management measures have included regional management plans, Fisheries Restricted Areas (FRAs), gear selectivity measures and species prohibitions and restrictions. These measures serve not only to limit fishing activity, but also to curtail bycatch, discards, and other wasteful fishing activity.

Multiannual management plans are a principal tool employed by the Commission for achieving long-term sustainability of stocks.[13] Moreover, per applicable GFCM rules, the Commission has the mandate to ensure compliance with these plans. This tool has been increasingly used in recent years, with several regional management plans having been adopted as of late. Of particular note is the multiannual management plan for fisheries of small pelagic stocks in the Adriatic Sea, which was revised in 2014 and 2015 following the advice of the SAC. Management guidelines also exist in the Mediterranean for red coral, whose populations are nearly depleted in certain areas. Two recommendations have been issued in 2011 and 2012 as a temporary measure for the conservation of this highly valuable species from an ecological and economic point of view. More recently, at its 39th session, the Commission adopted a recommendation on the sensitive zone of the Strait of Sicily, as a first step towards the establishment of a management plan for demersal fisheries in the area.[14] This recommendation restricts Contracting Parties and Cooperating non-Contracting Parties to exclusively fish deep-water rose shrimp

12 - Information regarding further efforts to improve stock assessments in the Mediterranean can be found in chapter seven of the GFCM's Biennial Report (CFCM, 2016).

13 - *Guidelines for Multiannual Management Plans towards Sustainable Fisheries in the GFCM Area* (GFCM, 36th Session, 2012).

14 - Recommendation GFCM/39/2015/2 on the establishment of a set of minimum standards for bottom trawling fisheries of demersal stocks in the Strait of Sicily, pending the development and adoption of a multiannual management plan.

and hake whose size exceeds the minimum reference conservation size. Those elements of the recommendation are currently being transposed into national management plans.

In general, GFCM Members are in favour of adopting common or harmonised measures for the management of selected fisheries. However, technical and operational issues persist regarding how best to evaluate alternative management measures, how to take decisions regarding management plans and how to ensure adequate stakeholder participation. Above all, a strong political will is required to enact effective management plans.

Fisheries Restricted Areas (FRAs)

To preserve fishery resources and to minimise the impact of fishing on certain habitats of high ecological value, the use of area-based management tools such as fisheries restricted areas (FRAs) have also been utilised (GFCM and RAC/SPA, 2007; GFCM, 2012; GFCM, 2013). In this regard, the GFCM is one of the few RFMO's in the world that is able to restrict fishing activity by closing fishing areas or prohibiting the use of certain gears in certain areas.

To date, eight FRAs have been established in the Mediterranean in order to protect deep-sea sensitive habitats.[15] As a result of decisions taken in 2006 and 2009, fishing with towed dredges and bottom trawl nets has been forbidden in the Lophelia reef off Capo Santa Maria di Leuca, Italy; the Nile delta area cold hydrocarbon seeps in Egypt; the Eratosthenes Seamount in Cyprus; and the Gulf of Lion in France. Together, these four FRAs represent a total area of 17,678 km^2 or roughly 0.7% of the Mediterranean Sea's surface area.

In 2016, the GFCM established an additional three new FRAs, prohibiting fishing with bottom trawlers in three areas of the Straight of Sicily: East of Adventure Bank, West of Gela Basin and East of Malta Bank. In 2016, the GFCM also formally declared all waters below 1,000 meters as a FRA, based on the 2005 decision to bar bottom-trawling activities in those the deep-sea benthic environment.[16] This decision resulted in the protection of over 58% of the total surface of the Mediterranean and Black Sea.

Gear selectivity measures

The establishment of gear selectivity measures is an example of management achievement that directly results in a reduction of waste from fishing activity (particularly a reduction of unwanted catches and discards). In particular, the use of driftnets larger than 2.5 km is prohibited in the Mediterranean.[17] A minimum mesh size has also been adopted throughout the region, requiring a minimum of 40 mm for square codend or 50 mm for diamond mesh for demersal trawling.[18] A prohibition on the use of towed gears and ROVs for red coral harvesting and the total prohibition of

15 - Recommendation GFCM/30/2006/3, Recommendation GFCM/33/2009/1 and Recommendation GFCM/40/2016/4.

16 - REC.CM-GFCM/29/2005/1 on the management of certain fisheries exploiting demersal and deepwater species.

17 - REC.CM-GFCM/22/1997/1 on limitation of the use of driftnets in the Mediterranean.

18 - REC.CM-GFCM/33/2009/2 on the minimum mesh size in the codend of demersal trawl nets.

any red coral harvesting below a depth of 50 m are also in effect.[19] These measures are set up to ensure the protection of large marine vertebrates such as pelagic sharks, cetaceans, sea turtles, and sea birds; the protection of demersal stocks; and the protection of red corals, respectively.

Species prohibitions and restrictions

Measures have also been implemented to promote the protection and conservation of selected threatened species. To this end, a number of species restrictions are in effect in the Mediterranean. For example, throughout the Mediterranean, it is prohibited to retain on board, transship, land, store, sell, or offer for sale any part or whole carcass of bigeye thresher sharks (*Alopias superciliosus*) or hammerhead sharks (with the exception of *S. tiburo*).[20] To offer further protection to sharks and rays throughout the region, the GFCM has also prohibited shark "finning", has reduced trawl fishing in coastal areas, and has prohibited the capture of species listed in Annex II of SPA/BD Protocol (Special Protection Area/Biological Diversity).[21] The GFCM has established a closed season for fisheries using Fish Aggregation Devices (FADs) in order to protect dolphin fish.[22] The GFCM has prohibited harvesting of red coral colonies whose basal diameter is smaller than 7 mm in order to protect red corals.[23] Finally, the GFCM has established a minimum landing size to protect small pelagic species (sardines and anchovies) in the Adriatic.[24]

Improved compliance mechanisms

In parallel with the establishment of sound management measures based on the best available scientific advice, developments have also taken place to buttress compliance mechanisms to ensure that such management measures are enforced. For the past several years, the GFCM has been carrying out work to clarify and identify the compliance status of each of its members. Each year, the GFCM Compliance Committee (COC) has the mandate from the Commission to verify the correct implementation of the GFCM decisions by Contracting Parties, ensuring that that the Cooperating non-Contracting Parties and non-Contracting Parties are compliant with the GFCM recommendations and the international legal framework. In the case of non-compliance, the GFCM, through the COC, has the authority to take measures to resolve the situation of non-compliance. Since 2013, this clarification process has

19 - REC.CM-GFCM/35/2011/2 on the exploitation of red coral in the GFCM area of application.

20 - REC.ICCAT-GFCM/34/2010/4 (C) Recommendation [09-07] by ICCAT on the Conservation of thresher sharks caught in association with fisheries in the ICCAT convention area and REC.ICCAT-GFCM/35/2011/7 (C) Recommendation [10-08] on hammerhead sharks (family Sphyrnidae) caught in association with fisheries managed by ICCAT.

21 - REC.CM-GFCM/36/2012/3 on fisheries management measures for conservation of sharks and rays in the GFCM area of application.

22 - REC.CM-GFCM/30/2006/2 on establishment of a closed season for the dolphin fish fisheries using fish aggregating devices.

23 - REC.CM-GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area of application.

24 - REC.CM-GFCM/37/2013/1 on a multiannual management plan for fisheries on small pelagic stocks in the GFCM-GSA 17 (Northern Adriatic Sea) and on transitional conservation measures for fisheries on small pelagic stocks in GSA 18 (Southern Adriatic Sea) and REC.CM-GFCM/38/2014/1 amending Recommendation GFCM/37/2013/1 and on precautionary and emergency measures for 2015 on small pelagic stocks in the GFCM GSA 17.

already yielded fruit and, in fact, has helped fortify cooperation, allowing Members and non-Members the opportunity to ask for technical assistance and to better comply with GFCM decisions.

Efforts to reduce IUU fishing in the Mediterranean

Strides have also been made to reduce IUU activity in the region, an important element in ensuring that all fishing activity can be accounted for and thus that appropriate and effective management measures are applied. Since 2001, when the FAO first highlighted and defined the issue of IUU fishing through the IPOA[25] (International Plan of Action) the GFCM has adopted several recommendations to combat this scourge in the Mediterranean, including a recommendation on Port State Measures (PSM), a recommendation providing for a list of IUU vessels, and a recommendation on the use of VMS (Vessel Monitoring Systems). In fact, the GFCM PSM recommendation,[26] coupled with the FAO PSM Agreement, constitutes one of the most important weapons in the fight against IUU fishing. These texts give States the mandate to take action, for example by requiring Port States to refuse entrance to a vessel involved in illegal fishing or by compelling Port States to inspect suspected IUU vessels.

In consideration of this important issue, the GFCM has also developed a roadmap for the fight against IUU fishing in the region and is actively seeking ways to provide technical assistance to countries that have experienced difficulties in implementing this roadmap.

Ongoing challenges and future action

Although tremendous progress has been made, the living marine resources of the Mediterranean remain under critical human pressure and additional work is needed to meet sustainable development goals in the context of the Post-2015 Agenda. At a regional level, improving the management of living marine resources in the Mediterranean requires constant improvement on a number of fronts.

Improved resource management based on the best available scientific advice is crucial. To this end, the GFCM's future work plan calls for activities to re-evaluate its approach to the management of stocks in order to better address sub-regional variations. Furthermore, activities to improve fisheries data collection, to improve estimations and monitoring of bycatch and to reduce waste are foreseen. An important challenge, however, is to couple this activity with constant improvements in compliance mechanisms. To this end, among other activities, the GFCM has taken an aggressive stance in the fight against IUU fishing and its future work plan calls for better monitoring and surveillance in order to combat IUU activity.

The integration of socio-economic considerations into living marine resource management is another enormous challenge. Social and economic incentives need to be considered in order to change behaviour and support vulnerable groups such as SSF,

25 - Article 3 of the "FAO International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing" of 2001.

26 - REC.MCS-GFCM/32/2008/1 Regional scheme on port state measures to combat illegal, unreported and unregulated fishing activities in the GFCM area.

within the fishing sector. Based on the premise that healthy marine ecosystems are more productive and crucial for sustainable marine-based economies, the concept of Blue Growth has been presented as a vision for joining environmental, social, and economic management concerns.

Improvement of fisheries data collection

The continuous improvement of scientific knowledge on the status of stocks in order to support effective management plans work is underway to enhance the collection of fisheries data in the Mediterranean. Addressing data from both Mediterranean and Black Sea fisheries, the GFCM Data Collection Reference Framework (DCRF) will soon come into effect and will become the primary tool for the collection of the data upon which the SAC's scientific advice is based. This tool aims to be an efficient and streamlined instrument that will integrate data collection and sub-regional multiannual management plans. It will offer a standardised and yet flexible way of reporting all required information for the fisheries management decision-making processes. The data requested by the DCRF is designed to be wide-ranging and useful to multiple users and sectors. The DCRF includes seven tasks. Task I addresses global figures of national fisheries and requires annual data on total landing, number of vessels, total capacity and total engine power by country. Task II requires data on fish catches including total annual biomass landed by fleet segment, by country and by Geographical Sub-Area (GSA), as well as data on individual species. Task III requires the quantification of the bycatch of vulnerable species such as seabirds, turtles, marine mammals and sharks. Task IV requires data that allows for the monitoring of fleet capacity. Task V requires the data necessary to monitor the amount of effort deployed and evaluate fishing pressure and fishing trends in CPUE. Task VI requires data on socio-economics, particularly the economic value and social implications of fisheries and will require data collection not only at country level, but also at the GSA and fleet segment level. Finally, Task VII requires the collection of the biological data necessary for the assessment of the status of the main exploited stocks, the status of marine ecosystems and the status of special interest stocks such as red coral, eel and dolphinfish[27].

Improvement of estimations and monitoring of bycatch

The action of DCRF includes specific compulsory tasks aimed at estimating the extent of the bycatch of endangered species in the Mediterranean. The increased data collection on this important issue seeks to complement the binding GFCM decisions taken in recent years that are aimed at mitigating bycatch. Although the DCRF streamlines the process for reporting bycatch data, it requires highly detailed information regarding the incidental taking of seabirds, sea turtles, seals, cetaceans, and sharks and ray species as identified in Annex II (list of endangered and threatened species) and Annex III (list of species whose exploitation is regulated) of the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean). Moreover, according to Recommendation GFCM 36/2012/2, any incidental taking of rare sharks and rays, even if not

27 - You will find more detail in the GFCM's SOMFI report (FAO, 2016).

present in the Barcelona Convention, should also be reported. The information available to identify fisheries with incidental catches of vulnerable species is still currently limited. It will therefore be important to collect existing data and identify additional/alternative sources of information to guide any possible revision of monitoring schemes. Data on the number of specimens taken as well as the fleet segment and gear type (if available), is requested to be reported through the DCRF. Proposed suitable methods of recording incidental bycatch are the use of on-board observers and the self-sampling system. Such data collection will significantly aid in developing management measures to reduce waste from fisheries.

Better monitoring and increased struggle against IUU activity

The GFCM is committed to amplifying its fight against IUU, for example, by improving control measures and offering inspector trainings in cooperation with relevant partners. Ways to estimate IUU fishing activity and further enhance current measures already in effect are also being experimented. Another important challenge that the GFCM is taking on, in cooperation with other relevant actors, is the development of a fully-fledged prototype of a centralised GFCM control system. A pilot study to be overseen by the GFCM Secretariat will soon be launched. At the same time, while recognising the role of small-scale fisheries in IUU fishing in the Mediterranean, the GFCM is studying ways to address control issues not just in the industrial sector but also in the small-scale fishing sector.

The benefits of this fight against IUU are multiple and essential. The objectives of these actions are to improve the sustainable management of fisheries, to improve the monitoring of fishing activities carried out by a flag State's vessels and to ensure the fair trade of fishery products in the Mediterranean region. Finally, and perhaps most importantly, such action seeks to improve the welfare and safeguard the livelihoods of communities and individuals that rely on the long-term sustainability and good environmental status of living marine resources in the Mediterranean.

Better support provided to Small Scale Fisheries

Considering that the small-scale fishing sector in the Mediterranean offers significant employment opportunities for coastal communities and has a relatively low impact on Mediterranean living marine resources, efforts to support and promote SSF should be considered. The FAO is actively promoting a Blue Growth strategy that seeks to enable fisheries-dependent people to act as environmental stewards in order to actively support food security, poverty reduction and the sustainable management of aquatic resources. This strategy seeks to make fishing activity more economically efficient for fishers while also improving the long-term economic viability and environmental sustainability of the activity.

Likewise, while recognising the importance of SSF in the Mediterranean, the GFCM has taken steps to promote the sustainable development and Blue Growth strategies for this sector. To this end, the GFCM organised, in collaboration with the FAO Fisheries Department, the FAO regional projects, WWF, MedPAN and the CIHEAM, a "First Regional Symposium on Sustainable Small-Scale Fisheries in the Mediterranean and Black Sea" held in Malta from the 27-30 November 2013 gathering over 170 participants, including members from international organisations, NGOs, fishermen associations, stakeholders and civil society. This symposium was an opportunity to gather valuable information about a sector for which the data available is quite poor. Following the success of this Symposium, a follow-up Regional Conference entitled "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea" was held in Algiers, Algeria from the 7-10 March 2016. An important part of this conference was dedicated to adapting the aforementioned FAO Voluntary Guidelines on Securing Sustainable Small-Scale Fisheries to the specific circumstances of the Mediterranean region. The current challenge is to translate the lessons learned from these important events into future action to support SSF and SSF fishermen.

Better address regional variations through a Sub-regional approach

While recognising the sub-regional differences in ecology, socio-economics, development and fisheries management, the GFCM has sought to re-evaluate its approach to the management of stocks in the region. In line with the GFCM Agreement adopted in 2014, which stresses a sub-regional approach to fisheries management and aquaculture development in order to better address the specificities of the region,[28] a reorganisation of the subsidiary bodies of the GFCM Scientific Advisory Committee on Fisheries has been proposed at the 39th Session of the Commission.

This reorganisation would shift the SAC's subsidiary bodies from a thematic approach to a sub-regional approach in order to better address the specific realities of stock management within the sub-regions of the GFCM competence area. Under this proposal, the SAC subsidiary bodies would consist of sub-regional working groups from the Western, Central, Adriatic, and Eastern Mediterranean. It is hoped that such a reorganisation will allow the subsidiary bodies to better address the particular fishery management needs of each sub-region, applying an ecosystems approach by integrating, rather than isolating, thematic areas such as socio-economics and stock assessments.

It is with dedication to these crucial challenges that strides can be made to improve scientific and socio-economic knowledge, better monitor and enforce management measures, reduce waste and ensure the future sustainable use of Mediterranean fisheries for those whose livelihoods depend on them.

28 - GFCM:ES/2014/2(Rev.1) amended GFCM Agreement.

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CHAPTER 3

MANAGEMENT OF WATER RESOURCES

Andre **Daccache**, *CIHEAM*
Maha Abdelhameed **Elbana**, *Beni-Suef University, Egypt*
Abdelouahid **Fouial**, *CIHEAM*
Fawzi **Karajeh**, *FAO*
Roula **Khadra**, *CIHEAM*
Nicola **Lamaddalena**, *CIHEAM*
Ramy **Saliba**, *CIHEAM*
Alessandra **Scardigno**, *CIHEAM*
Pasquale **Steduto**, *FAO*
Mladen **Todorovic**, *CIHEAM*

Today, water scarcity is an urgent issue expected to impose severe constraints on the Mediterranean region for its development and food security. According to the World Water Assessment Program of the UNESCO (WWAP, 2015), without significant global policy change, the world will only have 60% of the water it needs by 2030. The Mediterranean region is one of the most water-scarce areas in the world. The region holds only 3% of the world's freshwater resources but hosts more than 50% of the world's "water poor" populations, or around 180 million of the region's 460 million inhabitants (Châtel *et al.*, 2014). The entire region has a supply of renewable water resources of about 1,452 km^3, which is distributed in an extremely inhomogeneous way between the North (74%), the East (21%) and the South (5%) (Ferragina, 2010). However, water scarcity is expected to intensify further in this region that has already been made fragile due to population and economic growths, desertification and the needs for environmental protection. In addition, the rise in temperatures will impose further stress on the Mediterranean's finite water resources as this region is identified as one of the most prominent climate response hot-spots. Water scarcity can involve not only a lack of water but also poor water delivery infrastructure and poor water management. Some consider water scarcity as an absolute shortage of physical supply while others argue that it is generated by poverty, inequality and bad water management policies. Water resource availability in the Mediterranean has already been negatively affected and this is seriously jeopardising food security and the environment.

This chapter exposes the different components affecting the variability of water availability and therefore assesses the reasons behind wastages and losses of water and the possible solutions with the aim of ensuring a more sustainable food production and environment. It presents a holistic approach to water issues, analysing the current situation, based on the actual irrigated vs. rainfed areas, and then setting the general framework for required actions, the so-called "Water-Energy-Food Nexus". Within this triangle, this chapter explains the components that would greatly influence the overall improvement of the other components, the tools to be adapted for the achievement of higher efficiency at farm level vs. the whole ecosystem, the effects of climate change, emphasising the importance of the involvement of stakeholders and finally, the indispensable comprehensive management that can be achieved under a reliable water governance.

Water use in Agriculture: current situation, future scenarios and challenges

Agriculture is the largest water consumer in the Mediterranean (including northern and southern countries): it uses an average of 64% of water (varying from 50% up to 90% in some countries), followed by industry (including the energy sector and the tourism industry) (22%) and the domestic sector (14%) (GWP, 2010). By 2050, agriculture will need to produce 60% more food globally and 100% more in developing countries (Alexandratos and Bruinsma, 2012). In many of the low rainfall regions of the Middle East and Northern Africa, most of the exploitable water is already withdrawn, with 80% to 90% of it used in agriculture. So, rivers and aquifers are depleted beyond sustainable levels (FAO, 2011a). The agricultural sector will therefore need to increase crop productivity with respect to water in order to achieve food security. Producing more "crop per drop" will be one of the major challenges in the years to come.

Agriculture can be considered both a cause and victim of water scarcity. Of all sectors of the economy, agriculture is the most sensitive to water scarcity. Mediterranean countries increasingly rely on groundwater, which is a significant source of water across the region, to meet the rapid growth of the agricultural sector. The use of new technologies has led to groundwater extraction rates far in excess of recharge. The result has been a rapid depletion of aquifer reserves resulting in salt intrusion along coastal areas with consequent desertification. In addition, the dangerous pollution of aquifers by the leaching of agricultural chemicals has diminished the quality of groundwater and of rivers and streams fed by groundwater.

The water demand of the growing population, agriculture and industry put heavy pressure on the limited water supply of the Mediterranean region. Sustainable solutions are therefore required to meet the current and projected demand as well as to protect ecosystems. Integrated management of water resources with a holistic and inclusive approach requiring coordinated responses across the different sectors, is needed to ensure water and food security. Potential solutions to enhance water supplies include water harvesting with artificial groundwater recharge to increase water storage capacity and freshwater availability, wastewater reuse and solar energy desalination. In terms of trade, importing products requiring large amounts of water in their production ("virtual water"), constitutes a key element in helping to eliminate or at least soften water shortage and it is called to play a more important role to overcome water scarcity (Playán and Mateos, 2006).

Future water challenges in the Mediterranean call for innovative solutions with regards to the development of more sustainable water management strategies focusing on the conservation of this precious resource. Therefore, there is a need to balance water supply and demand with a focus on better management and conservation rather than only through the construction of infrastructures such as dams and water transfer systems. Since irrigated agriculture is the largest water consumer in the Mediterranean, significant water savings benefits could result from irrigating with reused or recycled wastewater. Water that is "wasted" is costly in terms of mobilisation and distribution; thus, these water savings would be a source of financial savings. With an average supply cost of 0.40 euro per m^3, almost 220 billion euros could be saved in 20 years (Hervieu et Thibault, 2009). To achieve food security while facing water shortages, it is necessary to implement a sustainable resource management. Indeed, food security is strongly dependent on effective trade policy, sustainable farming practices, water security, sustainable irrigation techniques and proper waste management (CIHEAM, 2015).

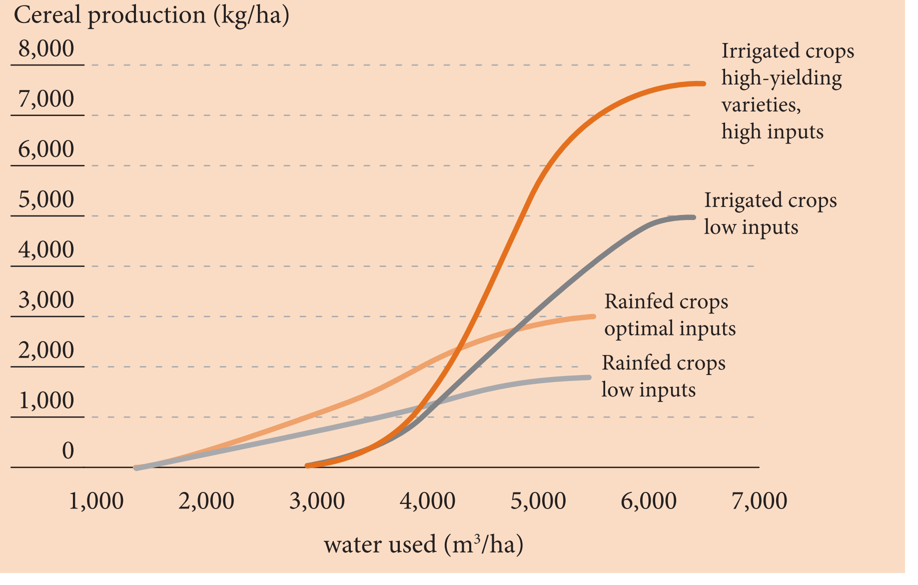
Agro-climatic suitability and yield gap (rainfed versus irrigated productions)

In 2000, about 25% of the global harvested areas were irrigated, with a cropping intensity (including fallow land) of 1.12 and over 50% of the world was suitable for rainfed agriculture, as reported by the MIRCA2000 (Portmann *et al.*, 2010). The major harvested crop in irrigated areas is rice with 1 million km^2 while wheat and maize crops are the largest harvested areas in rainfed lands with 1.5 and 1.2 million km^2, respectively (Portmann *et al.*, 2010).

The total area of rainfed agriculture differs spatially from 95% in Sub-Saharan Africa to 90% in Latin America, 75% in North Africa and the Near East, 65% and 60% for the East and South Asia, respectively (Wani *et al.*, 2009). Despite the irrigated agriculture area being much smaller than the rainfed area, it contributes to 40% of the total agriculture food production (FAO, 2002). According to the FAO (2002), the highest cereal yield that could be obtained from irrigation is more than the double the highest yield that can be obtained from rainfed agriculture. Even low-input irrigation is more productive than high input rainfed agriculture as shown in Figure 1.

Rainfall is one of the major constraints that could limit rainfed agriculture in semi-arid and dry sub-humid areas. Nevertheless, this constraint is not a result of the low precipitation but rather of its extreme variability with high intensities, few rain events, and poor spatial and temporal distribution of rainfall (Rockstrom *et al.*, 2010). Drought and land degradation are constraining the expansion or production increment of the agriculture system. This is also associated with the low efficiency in water use and lack of efficient policies to improve the situation in the short- and long-term. Inappropriate management of natural resources accompanied with farmers' lack of knowledge and lack of policy support and infrastructure including markets and credits, low investments in rainfed agriculture, planting traditional cultivars, low use of fertilisers and low rainwater use efficiency, pests and diseases and absence of integrated and compartmental approach for management are the main reasons for low on-farm yields and a large yield gap in rainfed agriculture (Wani *et al.*, 2009). The major constraints facing agriculture, especially the rainfed agriculture are summarised in Figure 2.

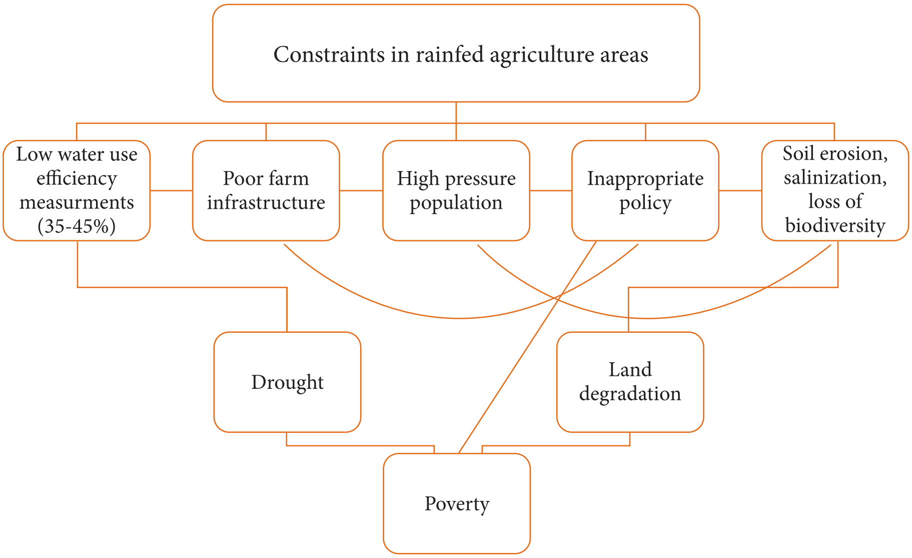
Figure 1 - Yields and water requirements of irrigated and rainfed agriculture



Source: FAO (2002).

The direct impact of the agro-climatic suitability on the yield produced from rainfed agriculture as well as the key role of water resources management for both rainfed and irrigated areas is apparent. Different ways and methods for the classification of systems are based on one or more criteria such as rainfall, temperature, major agriculture systems, differences in ecological characteristics, etc. The FAO Water Report No. 41 emphasises the need for "smart" realistic options in order to reduce and close the yield gaps in both small- and large-scale cropping systems worldwide. To make progress in this direction the following steps should be taken into account: definitions and techniques to measure and model yield at different levels (actual, attainable, potential) and different scales in space (field, farm, region, global) and time (short and long term); identification of the causes of gaps between yield levels; management options to reduce the gaps where feasible; policies to favour the adoption of gap-closing technologies.

Figure 2 - Constraints in rainfed agriculture areas



Source: Rockstrom *et al.* (2007); Wani *et al.* (2009).

Certain strategies and plans should be conducted to reduce the total number of the world's poor especially with the increasing population pressure. A study (Rockstrom *et al.*, 2010) analysed the yield gaps in rainfed agriculture, that is, the gap between the actual yields compared to the potential ones under better farm management for major grains for some selected African, Asian, and Middle East countries. Experience in Mediterranean countries showed that government's organisation alone cannot scale out improved production system technologies to reduce the yield gap and reduce food loss and waste, but it is indispensable in facilitating actions among stakeholders including the public sector, civil societies, and the private sector through: the creation of a policy and institutional enabling environment; the creation of a favourable investment climate; the strengthening of technology transfer and dissemination through public-private partnership; awareness raising and advocacy; the development of partnerships and alliances; support to innovative products and processes; capacity development at the supply chain and institutional levels; and the enhancing of research funding for high-yielding, water-efficient, and multi-diseases tolerant crops development programmes.

Irrigation efficiency along the distribution chain and water productivity

The use of "efficiency" in the analysis and evaluation of any system is a key indicator in understanding how each system helps reduce wastage on its own scale; but this might not apply to the overall system. In the agricultural sector, water use efficiency is far from being satisfactory. The term "efficiency" is often used in the case of irrigation systems and is commonly applied to each irrigation sub-system: storage, conveyance, off- and on-farm distribution, and on-farm application sub-systems (Pereira *et al.*, 2012). The concept of "water supply efficiency" or "irrigation efficiency" defines the difference between water withdrawn and the physical losses resulting from leakage from pipes and open channels as well as on-farm wastage through inappropriate water applications for the crops. For example, among the 23 countries of the Mediterranean, an estimated 25% of water is lost in urban networks and 20% from irrigation canals (FAO, 2012). Some authors prefer the use of the term "water productivity", the output of goods and services in physical or monetary terms per unit of water consumed, rather than the often confusing irrigation efficiency or water use efficiency (Rijsberman, 2006). Molden (2010) states that under optimistic assumptions, three-quarters of the additional food demand could be met by improving water productivity on existing irrigated lands. Experts estimate that developing countries use twice the amount of water per irrigated hectare than industrialised countries do, despite the fact that their crop yield is three times lower due to ineffective irrigation methods, inefficiencies, evaporation rates, etc. (GWP, 2010).

Water productivity can be improved mainly by an adequate agronomy and better cultivars. Since the main factors affecting efficiency from this perspective are actually the climate-soil-crop combination, this improvement should therefore be based on the suitable selection of each component. As for the engineering aspect, the modernisation and rehabilitation of water delivery and farm irrigation infrastructure can include the adoption of adequate technology and on-farm management practices. In most of the modernisation projects aiming at increasing irrigation efficiency, the consequences averred to be controversial: farmers switched to more profitable crops with higher water demands (Fernández García *et al.*, 2014). The use of technology alone, without the improvement of water management at basin and farm levels cannot solve water shortage issues. Improving water productivity will therefore require an understanding of the biophysical as well as the socioeconomic local environments crossing scales between field, farm and basin (Molden *et al.*, 2010).

The "chain of efficiency" approach proposed by some authors provides another way of examining this issue. This chain includes the following steps: conveyance efficiency and farm efficiency, application efficiency, consumptive efficiency and transpiration efficiency, assimilation efficiency, biomass efficiency and yield efficiency. This approach helps to analyse and assess the extent of the overall improvement in water use efficiency in terms of improvements in each step. In addition, the enhancement of water efficiency requires smart policies that include managers and farmers. The progress in technology has undoubtedly led to gains in water productivity. However, a knowledge-exchange system is needed to help farmers, water users associations and resource managers to identify the scope for further improvements, so that they can share greater responsibility across the entire water supply chain (Levidow *et al.*, 2014). Smart water management is necessary to combat scarcity and to help the agricultural sector adapt to the uncertain future.

Efficiency of on-farm irrigation systems

The efficiency of an irrigation system can be calculated at reservoir (storage efficiency), distribution system (conveyance efficiency), farm (on-farm water application efficiency) and plant (water use efficiency) levels. However, the overall irrigation efficiency can be expressed as the ratio of water volume used by the plant to the volume extracted from the source.

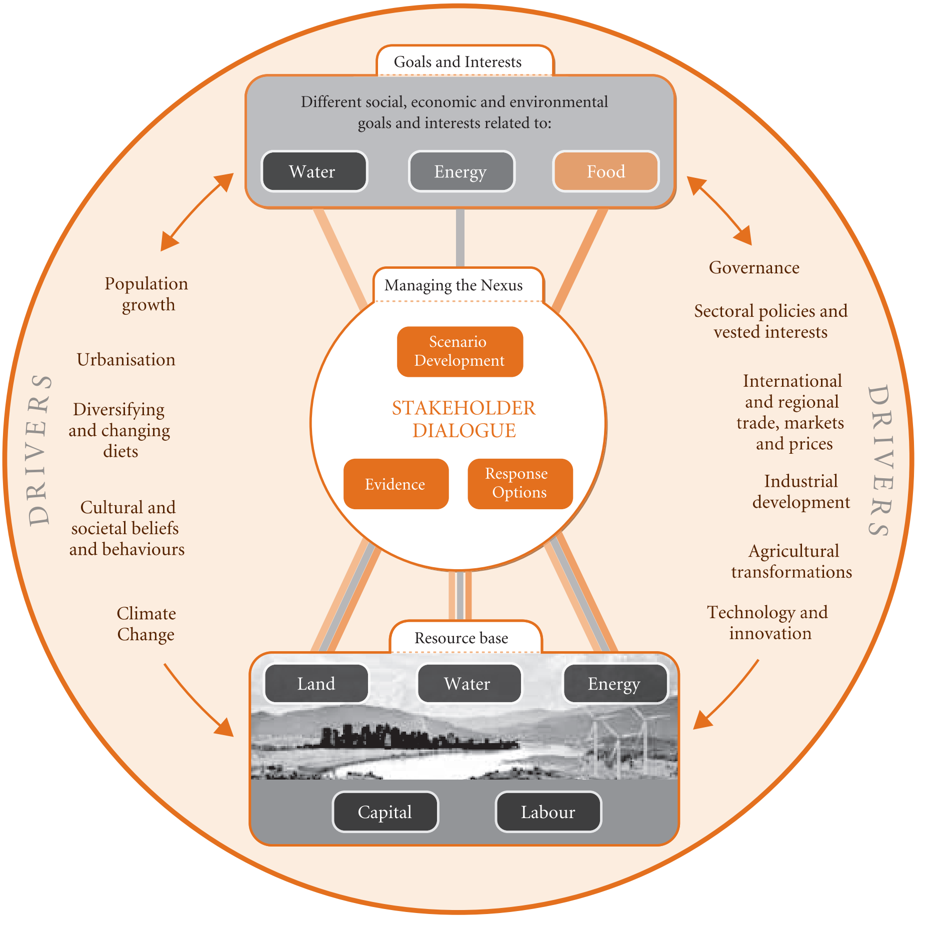
On-farm irrigation systems can be classified depending on their application method: trickle, sprinkler and surface. Pressurised water distribution systems have considerable advantages with respect to the traditional open channels as they can: 1) reduce greatly the water losses during transportation; 2) overcome the topographic constraints; 3) avoid the uncontrolled water withdrawals with the possibility to establish water fees based on water consumed; and 4) ensure great flexibility to farmers in managing their irrigation practices according to their needs (Lamaddalena and Sagardoy, 2000). Regardless of the irrigation method used, in order to be efficient, the system has to apply the desired volume of water in the right place with minimal wastage possible.

Water-Energy-Food Nexus

Water, energy and food systems are inextricably interconnected. Water is needed to produce agricultural goods in the fields and along the entire agro-food supply chain. It is also needed for almost all forms of energy generation, which, in turn, requires the production and transport of water and food, e.g. groundwater and surface water pumping, as well as wastewater treatment. The relationships and trade-offs within this triangle of resources are known as the "water-energy-food nexus" and any significant waste or inefficient strategy, would affect the whole system. These three systems intertwine and therefore any decision-making and actions related to one system impacts one or both of the other systems. Nexus policymaking is about designing resilient strategies in ways that take account of the connections between food, water and energy systems (WWF and SABMiller, 2014). It offers a holistic vision of sustainability that recognises and tries to strike balance between the different goals, interests and needs of the population and the environment. The framework of this approach is summarised in Figure 3.

While agriculture accounts for 70% of total global freshwater withdrawals, the food sector currently accounts for only 30% of the world's total energy consumption but produces over 20% of global greenhouse gas emissions. In addition, around one-third of the produced food, and the energy embedded in it, is lost or wasted (FAO, 2011b). This situation is expected to worsen in the near future as 60% more food will need to be produced in order to feed the world population in 2050 (FAO, 2014b). Climate change is also likely to exacerbate pressure on resources and therefore contribute to the vulnerability of the correlated systems and widening the waste gap within the triangle. To face these challenges, it is vital to plan future development by integrating all aspects to ensure that the three sectors (water, energy and food) are not considered in isolation, but in a way that each can contribute to the resilience of the others (WWF and SABMiller, 2014). Ensuring the reliability and efficiency of the system as a whole (that is, saving resources and reducing losses) by improving each of its essential components requires significant and sustained efforts at all levels. Another issue identified by the scientific community is the contradictory demands of the different components of the Nexus (CIHEAM, 2015).

Figure 3 - The FAO approach to the Water-Energy-Food Nexus



Source: FAO (2014b).

With the introduction of technology and mechanisation, the modernisation of agricultural practices has helped to increase yields and food security. In return, however, energy use for irrigation, which depends on the type of water distribution systems, on-farm irrigation systems and the source of water, has increased significantly. The Spanish experience is a good example. Since 2002, the Spanish government has developed a National Irrigation Plan and an Emergency Plan for the Modernisation of Irrigation systems with the aim of saving 3,000 m^3 of water per year in an effort to improve the conveyance efficiency. As a result, water use for irrigation per unit of irrigated area has been reduced by 21% from 1950 to 2007. However, the energy consumption has increased by 657% over the same period involving higher energy costs for farmers (Fernández García *et al.*, 2014). That is, the irrigation communities are now paying four times the cost of water in energy costs. Another example is the over exploitation of groundwater, which provides close to half of total consumptive irrigation water use for food production. Groundwater is generally more energy intensive than surface water, so that up to 40% of total energy use in some countries is used for pumping groundwater (Hoff, 2011).

Consequently, water, food and energy resources are linked through shared risks and opportunities and the collaboration between the three systems is crucial. The alternative competition to control resources serves the resilience capacity of the water-energy-food nexus (WWF and SABMiller, 2014). A coherent approach, on the contrary, highlights the interdependence of water, energy and food security and the natural resources that support that security. This approach identifies mutually beneficial responses and provides an informed and transparent framework for determining trade-offs and synergies that meet demand without compromising sustainability (Hoff, 2011). For the Water, Energy and Food Security Nexus, the resource limitations in all sectors require a shift towards resource use efficiency, demand management and more sustainable consumption patterns, thus saving by reducing wastage on all fronts. Policymakers need to adopt smart strategies to enhance the nexus considering the opportunities and synergies of all systems (Zahner, 2014; CIHEAM, 2015):

– Solar pumping solutions can reduce carbon footprints of irrigation systems;
– Precision irrigation generally improves energy productivity (but may not save much water);
– Intensification in rainfed agriculture that can reduce the demand for irrigation and associated blue water and energy inputs;
– Reduction of food wastage;
– Increased deployment of renewable energy technologies and increased efficiency through improvements in food production, processing and distribution;
– Changes in lifestyles and consumption patterns can also reduce pressure on water, energy and food;
– Increased investments in research and innovation for water and food security and nutrition, with due attention to neglected areas;
– Considering that the interactions between water, energy and food systems should incorporate full life-cycle assessments in terms of the mutual interaction between the three components of the full nexus;
– Resources policies and regulations should be more based on the scientific knowledge related to the use of resources and the natural or man-induced impacts.

New approaches and tools to improve water management

Agriculture's impact on water resources involves complex trade-offs between economic, social and environmental demands under a wide range of institutional structures. As a major consumer of water, agriculture has a significant impact on the resource quality and the water it uses is considerably wasted. The major challenge is to ensure that water resources used by agriculture are best allocated among competing demands to efficiently produce food and fibre, minimise the pollution it causes and support ecosystems, while meeting social aspirations under different property right arrangements and institutional systems and structures (OECD, 2006). Actually, irrigation systems perform way below their potential because of poor network maintenance and operation, inadequate irrigation and agronomic techniques and poor governance structure.

Many Mediterranean countries have embarked on reforming their water sector to face the increasing stress (Thivet and Fernandez, 2012). For decades, most of the national strategies favoured the supply-side, determined by the scientific and technological progress and dominated by investments and efforts to develop infrastructures and increase water storage and conveyance. They disregarded the large potential of saving water at the different scales of the chain. The focus has gradually been shifting towards sustainability, that is, the wise and responsible use of natural resources and safeguarding the rights of future generations (Ferragina, 2010). Supply-side strategies paved the way to demand management strategies with the primary objectives to rationalise and control water use, reduce waste and increase use efficiency and equity in view of limited supplies. How can we improve water management? Answering this question would require a supply management strategy, involving highly selective development and exploitation of new conventional and non-conventional water supplies, coupled with a vigorous demand management involving comprehensive reforms and actions to optimise the use of the existing supplies (Thivet and Fernandez, 2012). This alternative path adopts a mixture of tools to address technical, economic, institutional and behavioural dimensions of water management and thus achieving a greater efficiency in agriculture.

On the technical side, irrigation efficiency is determined by management, and good management requires comprehensive data collection and integration, sophisticated analytical tools and other “soft” sophisticated technologies. Thus, it is necessary to improve and use the existing technologies more effectively (precision agriculture, weather stations infrastructures, pumping efficiency, reliable system for evapotranspiration measurements, conservation tillage etc.) and/or adopt new irrigation practices (remote sensing data sources, weather forecasting, Decision Support Systems [DSS], plant-based data sensor systems, combinations of long-term management practices, statistically explicit analytical tools, etc.) (Neea, 2015). Since these technologies can only be used successfully if appropriate skills for their use have been integrated, their development must include capacity building through training of the people concerned.

From an economic point of view, improving water resource management requires recognising how the overall water sector is linked to the national economy (FAO, 2015), i.e. understanding how alternative economic policy instruments influence water use across different sectors at various scales. To this aim, fundamental changes in the institutional arrangements and regulations, improvements in the performance of water users and their organisation are all equally important. Irrigation institutions need to adopt a service-oriented approach and improve their performance in economic and environmental terms. Irrigation-sector institutions need to link their central task of providing irrigation services to agricultural production and to integrate their water demands and uses with other users at basin level. An enhanced appreciation of the water cascades and flows across landscapes and the circulation of groundwater within aquifers will lead to informed decisions on the use and reuse of agricultural water. This entails applying improved administrative principles and techniques and promoting the participation of water users (Kijne, 2003).

Participatory Irrigation Management (PIM) is a key term in the toolbox of current approaches to improve the performance of water resources management in the countries that are to cope with the issue of water scarcity, or problems associated with global and climate change in the foreseeable future (Regner *et al.*, 2006). PIM is an approach for irrigation sector reform with the potential to improve the sustainability of irrigation systems. It needs systematic public awareness campaigns, capacity building programmes, consultations and involvement of all stakeholders.

Participatory Irrigation Management

The growing concern on the need for PIM approaches is due to their advantages:

– Reducing financial and budgetary difficulties of government;

– Improving irrigation management efficiency;

– Better and timely Operations and Maintenance (O&M of irrigation infrastructure);

– Changing farmer's attitude of over dependence on external assistance;

– Positive experience on new institutional arrangements that can be extended to other areas;

– Promoting community activities;

– Facilitating collection of water fees.

The devolution of management responsibility over irrigation systems or parts thereof requires:

– A firm policy decision to transfer a meaningful level of responsibility over the management of irrigation systems to water users;

– A legal framework for the establishment and the empowerment of independent Water Users Associations (WUAs);

– The ability of WUAs to manage the irrigation system or sub-system serving them;

– The ability of public irrigation agencies to 1) provide technical and institutional support to WUAs and 2) oversee the performance of WUAs;

– Economically viable irrigated agriculture (to be independent and self-managed, WUAs must be financially autonomous and viable).

Source: Lamaddalena and Khadra (2012); APO (2002).

The implementation and sustainability of all the above require the recognition of the economic value of water along with the acceptance of the notion of opportunity cost and attention to cost recovery, though with concern for affordability and access right. Water tariffs are a fundamental tool for creating incentives to save and allocate water in an efficient way. Above all, in the agricultural sector, appropriate water tariffs could serve to promote more efficient use of water, reduce the burden on the taxpayer and give incentive to farmers to introduce water-saving irrigation systems and to recover the service cost. Pricing policy is often influenced by two conflicting goals: efficiency and equity. However, the apparent trade-off between the two can be overcome by a differentiation of water price according to place, consumption and type of allotments (Ferragina, 2010).

Since prevailing attitudes can either impede or drive innovation and its adoption, interventions to influence expectations and support are also important. To this aim, intensive and persistent public information programmes to raise awareness on the merits of the proposed strategies and the enforcement of implementation tools are of utmost importance.

Climate Change Impacts and adaptation measures (best practices)

Most Mediterranean countries, particularly the arid and semi-arid ones, are chronically water-stressed. Population growth, urbanisation, development progress and climate change will all exacerbate this stress and result in enormous pressure on limited water and land resources. To this end, the horizons of research should be widened to cover the major issues of Mediterranean agriculture, among which those related to the impacts of climate change on water resources and agricultural production. Recent analyses based on the A1B scenario of the Special Report on Emission Scenarios (SRES) indicated that the raise of air temperature would be the highest in some areas of Northern Africa and the Middle East, and in Southern Turkey (see Figure 4). In winter, the continental interior of South Eastern Europe and the Eastern Mediterranean would warm more rapidly than elsewhere. Differently, in summer, the Western Mediterranean would warm more than the other parts (Saadi *et al.*, 2015).

For the same time span (2000-2050), the average annual precipitation could have a decreasing trend of around 6% for the whole region. Most of Europe could get wetter in the winter season with the exception of Greece, Southern Italy and Turkey. In summer, an overall decrease of precipitation could be expected in the Euro-Mediterranean area, while an increase is foreseen in some areas of Northern Africa and the Middle East (Saadi *et al.*, 2015). Hence, a climatic water deficit, estimated as a difference between precipitation and reference evapotranspiration, could increase and be less favourable in the future than nowadays.

The shifting of agro-ecological zones will be one of the primary impacts of climate change that will interact with the land and water availability and agricultural productivity under new conditions. On the one hand, higher air temperature will decrease the growing cycle of plant species, anticipate sowing/planting dates, increase respiration rates, reduce period of yield formation, lessen biomass production and yield and, very likely, decrease yield quality (i.e. lower protein level of grains). On the other hand, the increase of air temperature will extend the overall period suitable for cultivation and permit, in some areas, for more than one cropping in the same year. The impact of climate change on agricultural production could be negative for most areas of the Mediterranean with a large variability and reduction of yield (Olesen *et al.*, 2011). No changes or slight increase in yield are expected for autumn and winter crops, while, for spring-summer crops, a remarkable decrease of yield is predicted due to temperature increase and shortening of the growing season (Saadi *et al.*, 2015). The possible increase in water shortage and in frequency and intensity of extreme weather events may cause higher yield variability and a reduction of suitable areas for traditional crops (Ferrara *et al.*, 2010). As a consequence of air temperature increase and the shortening of the growing season, the average crop water requirements (CWR) over the whole Mediterranean region are expected to decrease for winter-spring and spring-summer crops by 4 to 8% (Saadi *et al.*, 2015). Hence, a slight increase of CWR and irrigation inputs could be expected for perennial crops like olive trees.

Figure 4 - Spatial pattern of the mean annual and seasonal temperature difference (°C) between 2050 and 2000

Source: Saadi *et al.* (2015)

Most rainfed cropping systems could be negatively affected by climate change due to expected lowering of climatic water balance and overall reduction of water availability for agriculture. The latter is due to projected increase of water demand by other sectors. Overall, climate change could likely intensify the problems of water scarcity and sustainable agricultural production in the region.

The mitigation and adaptation measures to climate change should focus on conservation and more efficient use of natural resources in agriculture and other sectors. Particular attention should be reserved for the combined effects of temperature rise, rainfall variability, CO_2 increase and genetic and technological improvements (CGIAR, 2012). Hence, water and carbon balance of modern agro-ecological systems should be among the priorities for research. Equally so, the adaptation to extreme weather events and various abiotic stresses are of primary importance for agricultural production and food security. For arid and semi-arid Mediterranean lands, it is essential to select management practices and exploit varieties able to respond to adverse environmental conditions and to increase/stabilise yields and water productivity in the future. ACLIMAS (Adaptation to Climate Change of Mediterranean Agricultural Systems) is one of the projects pursuing this approach.

The ACLIMAS project

ACLIMAS is a demonstration project funded by the EC Sustainable Water Integrated Management (SWIM) programme. The consortium is composed of 15 partners from 10 countries and coordinated by the CIHEAM-Bari. The project started in January 2012 and was completed in December 2015.

The activities were conducted in six Mediterranean countries (Morocco, Algeria, Tunisia, Egypt, Jordan and Lebanon) with the objective of bringing a sustainable improvement of agricultural water management, stabilisation of yield and broader socio-economic development of target areas in the context of adaptation to climate change, increasing water scarcity and desertification risks. ACLIMAS focuses on cereals and legumes since they are strategic and complementary crops in the Mediterranean. The adoption of varieties resistant to abiotic stresses and adequate management practices (timing and density of sowing, minimum tillage, residue cover, crop rotation, water harvesting, irrigation/nutrient inputs, etc.) demonstrated the potential for yield increase between 10% and 30% and water productivity rise up to 50%.

The main target groups and beneficiaries of ACLIMAS are rural societies (farmers, growers and local breeders), farmer associations and local governmental extension services (policy makers and agricultural advisors) and governmental research institutions. ACLIMAS has involved directly more than 3,500 local stakeholders with a realistic possibility to produce a multiplier effect not only due to replication but also due to extension of the initiative to other communities and stakeholders.

Source: ACLIMAS (www.aclimas.eu/index-fr.html).

The translation of research findings into policy making and on-ground implementation is of paramount importance to promote appropriate and efficient farming systems able to adapt to climate change while reducing pollution and impacts on the environment and getting the benefits of this change (Ewert, 2012). This could be achieved through an appropriate institutional setting and further funding of the initiatives that focus on the demonstration units (see Figure 5) and on-farm implementation activities based on the locally tailored best management practices, modern monitoring-early warning systems and decision-making tools.

The relationship between climate change, natural resources, agricultural production and food security is very complex and requires the consideration of both bio-physical, social, economic, technical, political and anthropogenic (management) factors and their interactions at different scales and directions (from local to global level and vice versa). Particular attention should be given to the integrated coastal zone management and resilience of Mediterranean marginal lands. The efforts should focus on the effective implementation of innovative technological/management solutions and their economic and environmental impacts. Research should address the selection of appropriate indicators for the assessment of system-wide eco-efficiency improvements, the integration of existing tools and assessment methods in a coherent modelling environment, and the analysis and characterisation of existing water structures and management policies. Hence, the eco-efficiency approach should be extended to the whole chain of food production, conservation, transport and consumption.

Figure 5 - Conservation agriculture practices applied at ACLIMAS demonstration field in Bekaa Valley (Lebanon) (left) and demonstration field in CIHEAM-Bari (Italy) (right)

Source: M.T. Abi Saab, LARI (Lebanon) and R. Albrizio, CNR-ISAFOM (Italy).

Water Governance

Water governance represents a relatively recent topic of focus within the water community worldwide (UNESCO, 2015). It comprises all social, political, economic and administrative organisations and institutions, as well as their relationships to the development and management of water resource at different levels of society (GWP, 2003). It is more about the way in which decisions are made than about the decisions themselves.

While the social dimension points to the equitable use of water resources and the economic one draws attention to the efficient use of water and the role of water in overall economic growth, the political dimension is mainly directed at granting water stakeholders and citizens at large equal democratic opportunities to influence and monitor political processes and outcomes, thus emphasising a certain water equity for socially, economically and politically disadvantaged groups (Hamdy, 2012).

Water governance is needed for 1) managing an increasing demand; 2) ensuring an equitable, reliable and sustainable access to water; 3) overcoming shortcomings in accountability and transparency; 4) accomplishing the water sector reform process towards decentralisation and other aspects of integrated water resource management; 5) redefining water rights; and 6) mainstreaming gender issues (Hamdy, 2012; Scarlett, 2012).

Over the last 25 years, some common trends can now be identified in water governance:
– Significant decentralisation of some functions and establishment of effective participatory structures and processes;
– Efforts towards the effective application of the concept of "Integrated Water Resources Management";
– Enhanced recognition of the fact that bottom-up and inclusive decision-making is key to effective water policies;
– Strengthening of information tools and flows about deficiencies, failures and poor practices of water sectors.

Table 1 - Key co-ordination gaps in water policy and possible responses

Administrative gap	Geographical mismatch between hydrological and administrative boundaries. This can be at the origin of resource and supply gaps. => Need for instruments to reach effective size and appropriate scale.
Information gap	Asymmetries of information (quantity, quality, type) between different stakeholders involved in water policy, either voluntary or involuntary. => Need for instruments for communicating and sharing information.
Policy gap	Sectoral fragmentation of water-related tasks across ministries and agencies. =>Need for mechanisms to create multidimensional/systemic approaches and to exercise political leadership and commitment.
Capacity gap	Insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.), as well as relevant strategies. => Need for instruments to build local capacity.
Funding gap	Unstable or insufficient revenues undermining effective implementation of water responsibilities at sub-national level, cross-sectoral policies and investments requested. =>Need for shared financing mechanisms.
Objective gap	Different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organising the water sector). => Need for instruments to align objectives.
Accountability gap	Difficulty ensuring transparency of practices across different constituencies, mainly due to insufficient user commitment, lack of concern, awareness and participation. => Need for institutional quality instruments. => Need for instruments to strengthen the integrity framework at the local level. => Need for instruments to enhance citizen involvement.

Source: Adapted from C. Charbit and M. Michalun, "Mind the Gaps: Managing Mutual Dependence in Relations Among Levels of Government", *OECD Working Papers on Public Governance*, 14, 2009.

However, regardless of the institutional setting, water availability or degree of decentralisation of the different countries (OECD, 2015), several gaps (see Table 1) which hinder the governance process and further delay the implementation as well as the design of water policy still exist. The needs for improvement can be identified.

In the Mediterranean countries, the issue of water governance is given a low political priority, creating bottlenecks such as: 1) the lack of appropriate institutional and legislative provisions with weak planning and operational management, fragmentation and imbalance between and across centralised and decentralised levels, democratic deficits and an overall lack of awareness and participatory culture and 2) the deficiencies in implementation and/or operational tools, poor infrastructure, lack of data, reliable information, capacitated personnel and financial resources (7th World Water Forum, 2015). Nevertheless, Mediterranean countries offered, throughout the years, a large experience of progress in water governance. In fact, the national and regional schemes reinforced the capabilities of water managers at all levels, while the recent transboundary negotiations and continuous cooperation efforts keep moving the Mediterranean from water sharing to benefit sharing. Additionally, great willingness and ability to find and implement solutions to the water challenges has been shown by the Mediterranean societies, through a variety of stakeholders (CIHEAM, 2015).

Conclusion

Ensuring water security is the basis to guarantee food security around the globe and, in particular, in the Mediterranean basin as water and food security are intrinsically linked. The Mediterranean region faces context-specific challenges associated with water scarcity, producing enough food for a growing population, increasing competition for water between people and sectors, increasing degradation of water resources and ecosystems, and the lack of fair and transparent allocation mechanisms that recognise and protect the interests and rights of all users, especially the most vulnerable and marginalised. In addition, climate change is expected to exacerbate the unbalance between water demand and water availability.

As a consequence, water saving in the Mediterranean became a necessity. It has been perceived that the reduction of water losses along the distribution chain (from crops to conveyance infrastructures) along with the reuse of alternative water resources may greatly help to balance demand and supply. However, solving the water issue cannot be restricted only to physical saving in terms of volumes. Energy consumption should be taken into account together with management activities and appropriate governance models. Policy-makers need to adopt smart strategies to plan and implement successful water security and food security policy. This policy should be differentiated between the scales at which water saving should be achieved, thus allowing the achievement of adequate environmental protection measures.

Major challenges were highlighted along this chapter in order to draw some water policy recommendations. The starting point of such a policy would necessarily rely on the identification of the administrative, political, informative, social and technical gaps based on which actions can be designed. Identifying these gaps requires the involvement of all the water stakeholders to ensure the success of the process.

Therefore, a people-centred approach should be adopted at all levels with the aim of transforming the management of water resources into a participatory discipline, which can be reflected in a wider decision making process. In addition, before implementing any policy, it is crucial to ensure the coherence between water and food security-related strategies and plans. Sustainability must be considered as a permanent goal at all levels. Technically, aiming at a sustainable modernisation of irrigation systems does not mean the installation of the latest technologies, but increasing the resilience of irrigation systems and adopting optimal solutions for the territory and the operators, which basically starts by achieving equal access to water and by prioritising the most vulnerable and isolated users. At this point, building capacities to create the acceptability and operation of water management systems through investment in water education is essential. The awareness generated through this process will allow a better and faster adaptation of the stakeholders and a wiser, better-informed opinion that takes into account the environmental benefit as a sustainability and success indicator of any decision taken.

Finally, it is important to highlight that targeting zero hunger cannot be achieved only by improving productivity without a substantial reduction of food wastage. Hence, addressing the issue of food production becomes a matter of geographical allocation as a main pillar of food security.

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CHAPTER 4

SUSTAINABLE DEVELOPMENT OF LAND RESOURCES

Pandi **Zdruli**, *CIHEAM*
Feras **Ziadat**, *FAO*
Enrico **Nerilli**, *CIHEAM*
Daniela **D'Agostino**, *senior research scientist*
Fadila **Lahmer**, *CIHEAM*
Sally **Bunning**, *FAO*

The Mediterranean region and in particular the Middle East and North Africa (MENA) are characterised by the scarcity of their land resources suitable for biomass production due to aridity, inherently poor and human-degraded soils – especially in the mountainous areas – as well as limited rainfall and water supplies (Vianey *et al.*, 2015). The cultivated area could increase by improving the availability of water, as for instance in Egypt (between Cairo and Alexandria and in the Matrouh region). However, in a water-stressed region like the Mediterranean that is significantly affected by climate change (CC) impacts, these examples are exceptions and not the norm. Reports of the Intergovernmental Panel on Climate Change (IPCC) and other organisations involved in climate change scenarios in the Mediterranean region make no mention of the opportunity that the possible increase in water availability and arable land will present in the coming decades. In very limited cases, such as in Syria, before the political and social unrest rehabilitation actions were undertaken to bring new land into production through the building of terraces in rocky areas in order to grow olives and fruit trees. However, these interventions are costly, and require further investments for the soil to remain productive.

The scarcity of arable land and available water are among the main reasons why the MENA region strongly relies on food imports to feed its people. Furthermore, competition for land driven by strong economic interests and the increase in population, leads to an increasing pressure on natural resources. For these reasons, the Mediterranean, in particular the MENA region, no longer affords to waste its land.

Soil scientists and land experts do not like the term wasteland, as the land could never be waste or useless for any purpose. On the contrary, they believe that the multiuse nature of land involves various trade-offs that favour one use at the expense of others. Decisions that lead to changes in land use are often made on economic or political grounds rather than on ecological or social ones. This often leads to an inappropriate use or management of land resources and this may have many negative impacts: the degradation of soil and of water and biological resources, the loss of ecosystem functions and associated services, hence the wasting of land resources, urbanisation on productive soils, use of poor quality water or inadequate water for irrigation leading to salinisation, disturbance of fragile coastal ecosystems accompanied by biodiversity losses and ecological disruption.

Maintaining productive land and healthy soils to ensure food security, sustainable development and restoration of degraded land is crucial for the future of humankind. The 68th session of the United Nations General Assembly proclaimed 2015 as the International Year of Soils to raise awareness on the importance of soils. In response to these challenges, the Food and Agriculture Organization of the United Nations (FAO) and its Member Countries established in 2012, the Global Soil Partnership (GSP) whose mandate is to improve governance of the planet's soil resources in order to guarantee healthy and productive soils for a food secure world.

The Sustainable Development Goals (SDG) are explicitly aimed at improving soil quality, combating desertification and restoring degraded soil as well as improving access to ownership and control over land (SDGs 1.4, 2.3, 2.4, 15.3) (Osborn *et al.*, 2015). A promising way to conserve land resources and sustain productivity and ecosystem services for the present and the future, is by promoting the wide adoption of sustainable land management (SLM) practices and approaches that integrate biophysical, socio-economic and institutional considerations.

In regions such as the MENA region, where climatic conditions are particularly unfavourable, land degradation and desertification are threatening people's livelihoods and food security. Promising SLM options are available to reverse land degradation, sustain land productivity and reduce land waste. A comprehensive land-based approach is proposed to start with identifying and prioritising target areas where some of these options have high potential of success, then selecting the most appropriate SLM and, lastly, disseminate its practice supported by proper policies, financial mechanisms and continuous monitoring to be able to adapt to future climatic and socio-economic variations. Farmers' needs and wishes should be at the centre of sustainable land development processes.

This chapter provides an overview of the status of land resources in the Mediterranean region, highlighting the needs for their sustainable utilisation and emphasising why wasting them is not an option for the region, especially for food security reasons. The aim is also to highlight the regional and global efforts striving to support decision makers to achieve better land management and avoid wasting precious land resources through the establishment of partnerships and the implementation of national and regional projects.

Matrouh Rural Development Project (MARSADEV) project in Egypt: greening the desert

This multifaceted project aims to improve the living conditions of the Bedouin rural communities by recovering degraded lands, preventing erosion, enhancing water saving and harvesting, enriching soil fertility, and improving crop yields. One of the most significant achievements of the project is the land reclamation of the Wadi Kharrouba, a barren, eroded and abandoned watershed that has become a 13 hectare cultivated area of figs and olives. The region is very arid, with an average annual rainfall rate of about 100 mm a year. A number of dry tolerant plants such as *Opuntia ficus-indica*, *Atriplex litoralis spp*, *Moringa oleifera* and *Medicago arborea* will be planted in the semi circle terraces located in the surrounding slopes of the *wadi*. They will be used both for income generation and erosion control. Supplementary irrigation will be provided through water harvested in one upland reservoir. Wadi Kharrouba shows that "greening the desert" is possible when technological innovation and tradition are complementary to each other and local communities are both actors and players of the rural development process.

Source: www.facebook.com/Marsadev-project-Egypt-784471981631262/timeline/

Limited productive lands and fragile environments are under pressure

The Mediterranean region covers about 854 million hectares of land but only 118 million hectares (or 14%) are suitable for agricultural production. Northern Mediterranean countries cultivate on average about 35% of their territories but in the MENA region this figure drops to 5%. Libya is an extreme case with only 2% cultivated lands, Algeria with less than 4% and the vast majority of Egypt's 5% of agriculture land occurs in the Nile Delta. In addition, land cover in the region is composed of 15% natural pastures and rangelands, 8% forests and woodlands and 63% desert sands, shallow, saline and sodic soils, rocky and/or rock outcrops, waterlogged areas and, above all, areas sealed by urbanisation (Zdruli, 2014).

Drylands cover 33.8% of the territory of the Mediterranean Member States of the European Union – with the exception of France, these countries are all included in Annex IV of the United Nations Convention to Combat Desertification UNCCD. In Spain, drylands cover about 69% of the country. In Greece, Portugal, Italy and France, this number varies from 62 to 16%. Drylands are mainly concentrated in the southern and eastern Mediterranean countries where they cover 61% of the overall territory. Using the UNCCD aridity index, Uriel Safriel (2006 and 2009) points out that all Mediterranean countries have a great variety of drylands and their management should therefore take account of the local specificities. In southern countries bordering the Sahara-Arabian deserts there are hyper-arid lands (true deserts), semi-arid lands and dry-sub humid lands. In northern Mediterranean countries there are semi-arid lands, dry sub-humid lands, as well as humid areas (non drylands).

The *Mediterranean coastline* is roughly 46,000 km long and is almost equally divided into rocky and sedimentary coasts. The northern coast of the basin is especially toothed and includes big islands like Sardinia, Corsica, Crete, Cyprus, Malta and numerous small islands mostly belonging to Greece. These coasts and islands are subject to erosion, salt intrusion and flood risks due to sea-level rise. Coastal areas including wetlands are under continuous pressure from urban sprawl and infrastructure development fuelled mostly by the tourism industry that brings into the region about 300 million people each year. Impacts include associated waste and sanitation problems and loss of wildlife leading to a decline in the pristine land and seascapes that initially attracted tourists and residents.

Wetlands cover nearly 1 million hectares and paralic ecosystems (deltas, mud flats, lagoons, ponds, and coastal marshes) occupy about 500,000 hectares. Coastal wetlands play a crucial role in maintaining and enhancing environmental quality and providing invaluable economic benefits (Quentin Grafton *et al.*, 2009): they purify water, sequester carbon, help maintain the equilibrium of the water cycle, host millions of migratory birds and provide excellent environments for relaxation. Some European studies value the ecological services of wetlands as some 2.4 million euros per km^2 per year (Benoît and Comeau, 2005). The Mediterranean Sea could store an estimated 17.8 million tonnes of CO_2 every year worth up to 1.7 million a year, providing important climate change mitigation benefits (Melaku Canu *et al.*, 2015).

Irrigated lands cover 20% of the total agricultural lands (field and permanent crops) in the northern European Mediterranean countries. Spain ranks first in absolute terms for the total irrigated area that accounts for about 3,780,000 hectares while Greece ranks first for the irrigated area nationwide in percentage terms (38%). Due to its humid climate Slovenia irrigates only 1.5% of its agricultural lands (Zdruli, 2014). The situation is somewhat similar in southern and eastern Mediterranean countries that overall irrigate 22% of their agricultural lands or a total of about 13,585,000 hectares. Egypt tops the list since it literally irrigates (99%) or the whole land available for crop production. Expansion of irrigation has created salinity build-up problems in many countries in the Mediterranean: over the last two decades, in Egypt for instance about 1 million hectares have been affected by soil salinity due to inadequate irrigation water (Goma, 2005). Special attention should therefore be given to the quality and amount of water used for irrigation and the establishment of irrigation systems that are both efficient in water use and crop productivity and that provide adequate water for the leaching of accumulated salts and drainage to avoid water logging.

The *extension of urban areas* especially along the Mediterranean coasts and around big cities has often been made at the expense of agricultural lands. Built-up areas now cover nearly 40% of the Mediterranean coastline and if these trends continue, the figure could reach 50% by 2050. The most impressive examples are cities like Alexandria and Cairo (Egypt), Tripoli (Libya), Beirut (Lebanon), Casablanca (Morocco), Istanbul (Turkey) and many others cities in the South and East of the region. Extensive urbanisation changes have occurred mostly after the 1960s in big European cities like Barcelona (Spain), Athens (Greece), Marseille (France) and some islands like Sardinia and Sicily (Italy). With a total population of about 400,000 people, Malta accommodates around 1.2 million tourists every year. Montenegro is also worth mentioning. In 2013, it hosted almost 1.5 million tourists, which is more than twice its population. The tourism industry has played a major role in the overdevelopment of the coasts creating thousands of jobs and bringing economic revenues but associated with accelerated "littoralisation", which in itself is a specific process of land degradation (Zdruli, 2008).

Land degradation in the form of salinisation, water and wind erosion, sand encroachment, overgrazing, deforestation, compaction, organic matter decline and sealing is a serious problem in many countries. Saline and sodic soils alone cover more than 10 million hectares in the Mediterranean region. Estimates show that if the existing rates of land degradation and desertification, including land take and soil sealing (due to urbanisation and infrastructure development) will continue, by 2020 another 8.3 million hectares of agriculture land will be lost compared with 1960. Could this area be considered wasted? Consequences of land degradation are extremely serious as the agricultural land would drop from 0.48 hectares per capita in 1961 to 0.21 hectares per capita, or less than half in 2020 (Zdruli, 2014). These frightening scenarios indicate possible social unrest, accelerated waves of immigration towards the North Mediterranean (already occurring) and perhaps in the longer term, increased unemployment, famine and civil strife including ethnic/religious reprisals.

The above analyses provide insights on the status of land resources in the region and the ongoing dynamics of change, often accelerated by specific social and political contexts. This supports the need for comprehensive planning of resources across sectors and actors to optimise the use of limited land and water to avoid wasting them. This becomes even more critical when addressing emerging challenges such as population movements, land degradation and climate change. Therefore, understanding the current status of land use planning opportunities and promoting participatory approaches, up-to-date geospatial, economic analysis and scenario development tools are necessary to plan the optimal use of the land, satisfy competing interests and minimise conflicts at regional and country level.

Technically, assessing land suitability for different land uses taking into account, social, economic, environmental and governance issues, should guide the selection of the optimum utilisation that improves productivity, reduces land degradation and provides livelihoods for local populations. Soil-landscape modelling is among the available modern tools to support land suitability analysis (Al-Shamiri and Ziadat, 2012; Ziadat *et al.*, 2015). However, the land use planning process needs to be revised to ensure efficient integration of all related issues that govern the allocation of different land uses. "Action to promote balanced development on both shores of the Mediterranean is more necessary than ever; once the cobwebs of its former attributes have been removed, the new *mare nostrum* will be feasible if, and only if, *terra nostrum* also becomes a common horizon!" (Hervieu and Thibault, 2009). Seven years later this statement remains valid more than ever.

Mediterranean soils and climate change

There is ample evidence that climate change will impact the Mediterranean region in various ways but all climate models predict that the region would become *drier* and *hotter* and the intensity of extreme events and drought would increase

(Giannakopoulos *et al.*, 2005; Seguin, 2010; CIRCE project, 2011). Sea level rise is also a critical issue for countries such as Egypt that could have dire consequences as a one metre increase could cover an area of 970 km^2 in the Nile Delta affecting 9% of the whole population and about 13% of its agricultural land without considering extensive damage to infrastructure and to the fragile coastal ecosystems such as the wetlands. Italy may also lose 6% of its territory and many of the Mediterranean lagoons may disappear (ISMEA and IAMB, 2009).

Among the commonly mentioned major impacts of climate change in the Mediterranean are coastal flooding, soil erosion, sea water intrusion in aquifers affecting irrigation groundwater reserves and consequently causing soil salinity build up, increased aridification and desertification[1] (Giupponi and Schecter 2003; Saadi *et al.*, 2015). Economic activities, particularly in coastal zones and for the vulnerable population of small islands, and food security are also being threatened. Climate migrants atop of political and economic refugees from the South towards the North are also a point of increasing concern.

Besides the potential decrease of land resources suitable for crop production, climate change could also be associated with the increase of arid areas at the expense of more humid ones. If this happens, reduced capacity of agricultural production and increased irrigation water demands will be the direct consequence. Over time, agriculture could also suffer due to shorter growing seasons for crops, heat stress during flowering and rainy days during sowing with negative impacts on livestock due to declining fodder and water resources. Other consequences of climate change in particular could include heavy rainfall and storms that can increase soil erosion by wind and water, flash flooding, slope instability, reduced soil water retention and ground water recharge. These effects could have further impact on the economic development of the region, as tourists or incoming residents may look for alternate destinations putting at risk all the heavy investments made by the tourist and housing industry.

Potential climate change may affect the yields of some crops (such as legumes, cereals and tubers) and contribute to the disappearance of some olive groves due to reduction of rainfall water and poor annual distribution. This is quite worrying. Again, the southern Mediterranean is most likely to experience crop failures, livestock stresses and reduced productivity aggravating the already vulnerable food security and poverty situation. Global estimates indicate that maize production would be roughly 6% higher and wheat production 4% higher had agriculture not been exposed to climate trends observed since 1980 (Lobell and Costa-Roberts, 2011). One way of addressing climate change impacts on agricultural production would be the adoption of adapted crop and livestock management techniques such as changes in sowing dates, development of new cultivars that are drought and salinity resistant, agroforestry and crop-livestock integration (Benauda *et al.*, 2015). The role of healthy soils in building a resilient system against climate change/variability and providing ecosystem services is very crucial. The best documented example is conservation

1 - The UNCCD defines desertification as “land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities”.

agriculture that integrates permanent soil cover, minimum soil disturbance and crop rotations as complementary remedies to climate change by protecting the soil, increasing organic matter content and biological activity in the soil and enhancing carbon sequestration. Countries are encouraged to identify and develop for each agro-ecological context a set of adapted climate smart agriculture technologies (including conservation agriculture), that simultaneously contribute to productivity, adaptation to climate change and mitigation.

Soil ecosystem functions and services

As noted under the Global Soil Partnership (GSP) vision, soil is a *non-renewable* resource in the human life span. It can be considered renewable only on a geological time scale. It is far more than a substrate to provide nutrients and water to plants, it is fundamental for filtering water, buffering pollutants, recharging aquifers, regulating gas and nutrient exchanges and mediate bio-geo-physical and chemical interactions with the surrounding environment. Healthy land (and therefore people) requires sustained soil fertility and the well functioning of the soils as a basis for biomass production and environmental services. Soil is the "foundation" for the functioning of the ecosystem and ensures renewable water reserves. Therefore, sustainable use and management of soil ensures the wellbeing of human beings and the society as a whole.

The International Year of Soils

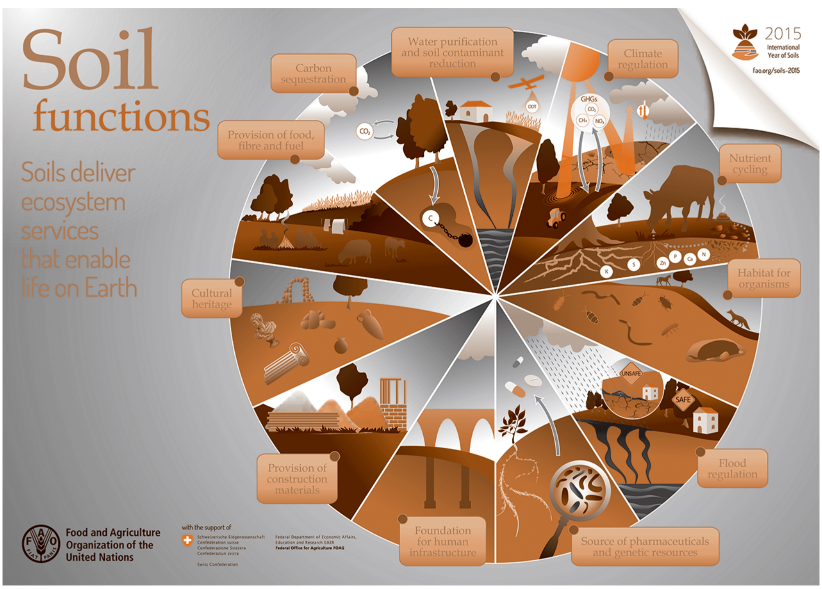
A major platform for raising awareness of the importance of soils for food security and nutrition and essential eco-system functions

On 5 December 2014, the 68th UN General Assembly declared 2015 the International Year of Soils (IYS) and endorsed the celebration of World Soil Day on 5 December. The Food and Agriculture Organization of the United Nations has been nominated to implement the IYS 2015 within the framework of the Global Soil Partnership and in collaboration with Governments and the secretariat of the UN Convention to Combat Desertification. The FAO is also supporting and encouraging World Soil Day advocacy and events worldwide. The "Healthy Soils for a Healthy Life" initiative will continue to promote the importance of healthy soils and encourage the adoption of regenerative landscape management practices to ensure continued momentum post IYS.

2015 International Year of Soils

Soil is an important component of the natural ecosystem (see Figure 1) but the reduction of *supporting ecosystem services* is already occurring and will ultimately lead to the persistent decrease in the ability to provide *provisioning* and *regulatory* services (Haygarth and Ritz, 2009; Dominati *et al.*, 2010). *Supporting services* include soil functions of crucial importance such as primary production for terrestrial vegetation, soil formation, rock weathering, nutrient cycling and release of nutrients. It is widely recognised that nutrient cycling is the largest contributor of goods and services providing annually about 51% of the total value (USD 33 trillion) of all ecosystem services (FAO, 2011). The importance of soil functions in maintaining sustainable production of food and ecosystem services is especially emphasised in the southern Mediterranean region that faces relatively complex climatic and socio-economic conditions. Therefore, building a soil management decision support system is needed to formulate and put in practice related policies. Systems like this provide the tools needed by decision makers to design sustainable land use planning based on baseline data and on strategic development priorities at different scales.

Figure 1 - Soil functions and services



Source: FAO, 2015 (www.fao.org/resources/infographics/infographics-details/en/c/284478/).

The Global Soil Partnership serves as the global institutional framework in support of an overwhelming process leading to the adoption of sustainable development goals for soils and their subsequent implementation:

– The GSP will contribute to environmental wellbeing by, for example, preventing soil erosion and degradation, reducing greenhouse gas emissions, promoting carbon sequestration and sustainable use of agricultural inputs for soil health and ecosystems management.

– It will equally contribute to human wellbeing and social equity through improved use and governance of soil resources, by finding alternatives to soil degrading practices through participatory experiential processes, and being sensitive to issues of gender and rights of indigenous peoples.

The GSP is an interactive and responsive partnership. The GSP will also increase awareness and contribute to the development of capacities, build on best available science, and facilitate/contribute to the exchange of knowledge and technologies among stakeholders for the sustainable management and use of soil resources. The GSP addresses five main pillars of action:

– Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity;

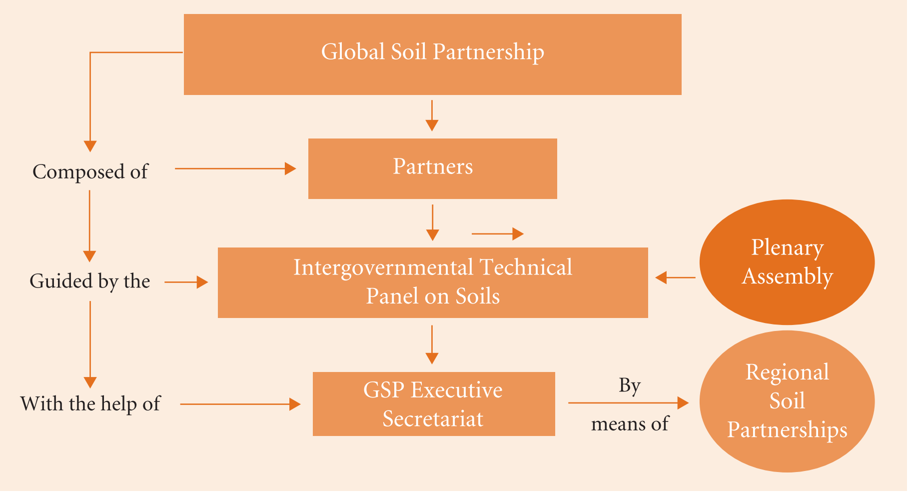
– Encourage investment, technical cooperation, policy, education awareness and extension in soil;

– Promote targeted soil research and development focusing on identified gaps and priorities and synergies with related productive, environmental and social development actions;

– Enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines;

– Harmonisation of methods, measurements and indicators for the sustainable management and protection of soil resources.

Figure 2 - GSP composition and governance



Source: www.landmatrix.org/en/

Land dynamics and socio economic implications

Mediterranean complexity in land issues is expressed both in physical, socio-economic and governance terms. As most of the northern countries are EU member states, the legislation dealing with land and soil follows EU regulations and directives. There are differences across southern and eastern Mediterranean countries due to lack of mechanisms for harmonisation. A good example could be the diverse stand taken by countries on issues related to land acquisitions. Egypt for instance is making land acquisitions elsewhere in the world but at the same time is also subject to such investments. On the contrary, Morocco is a recipient country in relation to large land acquisitions and it appears that there is internal support for these foreign investments (Mahdi, 2014) as they are associated with increased employment and domestic productivity. Rural specialist economists have different views about land acquisitions that are also referred to as "land grabbing" or "large land acquisitions". The largest land acquisitions are obviously made by powerful European countries, USA and fast growing economies (China, India, UAE) whose priority is to meet their own food needs.

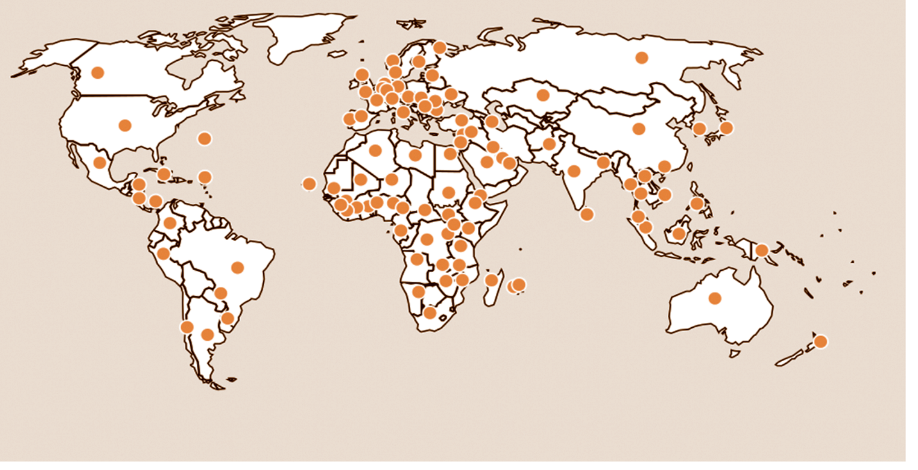
While recognising the need for foreign investments in many developing countries including those in the MENA region, the governments of these countries should give first priority to their national food security interests and not to the economic goals of land buyers or leasers. Moreover, prior legal contracts should be agreed upon on many issues and in particular in food distribution and access allowing hosting countries to first improve their food security standards.

The globalisation of the world economy led to important changes in the land dynamics. Europe for instance has become a net food importer with about 40% of its needs for direct food products or animal feedstuff coming from lands cultivated outside the continent. Such trend may even become more evident due to climate change impacts predicting yield anomalies (IPCC, 2014). On the other hand, if soil-sealing rates in the EU continue to increase, they could have severe consequences both in the region and abroad. Studies show that for each hectare of agricultural land sealed or lost from agricultural production in the EU, about ten more hectares of land have to be put into production elsewhere to compensate for these land losses (Gardi *et al.*, 2015) hence putting at risk the food supplies of other much vulnerable countries.

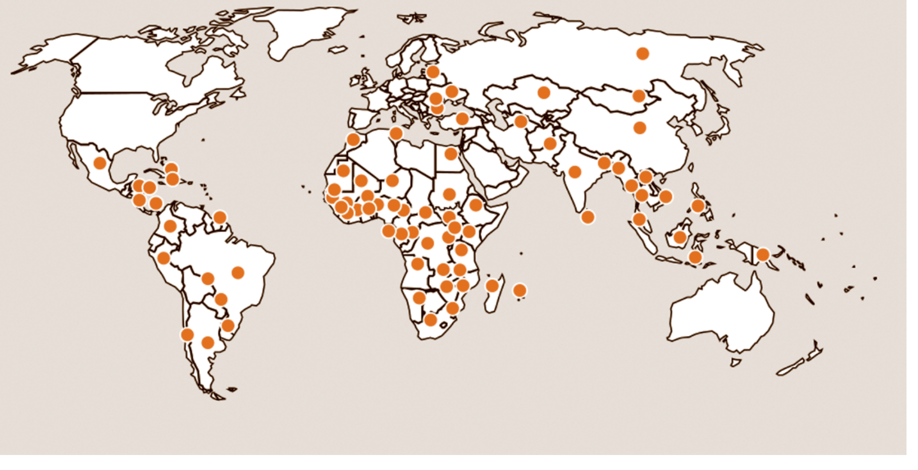
Various researchers, reported by the media, have put forward the fact that the Arab Uprisings were fuelled by the increasing food prices especially in Tunisia and Egypt. However, at least in the case of Tunisia, processes of agricultural restructuring during the past twenty years contributed to a large extent to the revolutionary dynamics, giving thus a political dimension to food issues (Gana, 2012).

Land dynamics and governmental policies play a fundamental role in the socio-economic situation in the Maghreb. For example in Tunisia and in Morocco since the late 1980s much attention has been concentrated on the development of the coastal areas bringing fresh revenues from the tourism industry, but such process has been largely detrimental for inland areas (Gana, 2012). This is also the case in Egypt where there are great disparities between the delta region, which is highly urbanised and the Nile valley where rural development has, in recent years, received only secondary attention from public policy. Indeed, priority has been given to urban issues that are considered as potentially explosive.

Figure 3 - Land acquisitions globally



Global investor countries. Note the complex figures in Sub Saharan Africa and the intensity of these deals from European countries.



Target countries offering land deals. Sub Saharan African countries are both targets and investors. Note that Europe is the largest investor in land deals.

Source: www.landmatrix.org/en/get-the-idea/global-map-investments/

At political level, the process of land reform in Tunisia is neither easy nor straightforward. The policies of the late 1980s were directed towards the transfer of farm cooperatives to private investors creating large farms of olive groves, fruit trees and horticulture crops. This is much different from the traditional cereal-based agriculture. However, such process brought about tensions and many peasants lost their right to land and got involved in land protest movements. The same was true with the transfer of state-owned farms to private investors. There is growing consensus among the political parties in Tunisia regarding the fact that a land agrarian reform may be needed to also solve potential social issues (Gana, 2012). The Tunisian case demonstrates the importance of land tenure and land rights as determining factors of social stability in the mostly rural societies of the MENA region.

The FAO has recently adopted the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the context of national food security (see box) as a way forward to improve governance and thereby encourage sustainable land management and enhance food security. These principles should be thoroughly implemented in the MENA region.

Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

These Voluntary Guidelines seek to improve governance of tenure of land, fisheries and forests. They seek to do so for the benefit of all, with an emphasis on vulnerable and marginalised people. Their goal is to ensure food security, progressive realisation of the right to adequate food, poverty eradication, sustainable livelihoods, social stability, housing security, rural development, environmental protection, sustainable social and economic development and to:

1) Improve tenure governance by providing guidance and information on internationally accepted practices for systems that deal with the rights to use, manage and control land, fisheries and forests.

2) Contribute to the improvement and development of the policy, legal and organisational frameworks regulating the range of tenure rights that exist over these resources.

3) Enhance the transparency and improve the functioning of tenure systems.

4) Strengthen the capacities and operations of implementing agencies; judicial authorities; local governments; organisations of farmers and small-scale producers, of fishers, and of forest users; pastoralists; indigenous peoples and other communities; civil society; private sector; academia and all persons concerned with tenure governance as well as to promote the cooperation between the actors mentioned.

The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests or VGGT were officially endorsed by the Committee on World Food Security on 11 May 2012. Since then, their implementation has been encouraged by the G20, Rio+ 20, the United Nations General Assembly and the Francophone Assembly of Parliamentarians. The Guidelines are meant to benefit all people in all countries, although there is an emphasis on vulnerable and marginalised people. The Guidelines serve as a reference and set out principles and internationally accepted standards for practices for the responsible governance of tenure. Whilst providing a framework that States can use when developing their own strategies, policies, legislation, programmes and activities, they also allow governments, civil society, the private sector and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices.

Sustainable land management is the answer

Feeding an increased population will be a significant challenge for the whole region but for the MENA region this could be an enormous endeavour. While recognising the need for mitigation actions to alleviate climate change effects, adaptation (Brown *et al.*, 2015) would be the ultimate and unavoidable choice. Nevertheless, the agriculture sector should be supported by appropriate funding to reach this goal. Hence, the most pressing and urgent need for the region would be to support the wide adoption of sustainable land and water management practices, including the conservation and sustainable use of biodiversity to value the substantial economic, environmental and social benefits that would be generated. This would enable investments to be prioritised, scaled up and mainstreamed across the diverse production systems, landscapes and eco-regions. Adapted Sustainable Land Management (SLM) practices should be identified for each biophysical and socio-economic context as they can increase productivity, particularly by improving water use efficiency, restoring degraded soils, optimising nutrient cycles for sustained crop production, enhancing vegetation cover and biodiversity, sequestering carbon and reducing greenhouse gas emissions, increasing food security and the resilience to climate change. Healthy soils and diversified production systems produce healthy food, support healthy lives, and promote a healthy environment as well as contribute to climate change adaptation and mitigation.

Furthermore, given the fact that 70% of the food produced globally comes from small scale farmers (Maass Wolfenson, 2013) and the average farm size in the MENA region is much less than 5 hectares, small farmers play a crucial role in food production in the region. Enhancing their capacities to get better organised would help them to strengthen their position along agricultural food chains. Smallholders, the majority of whom are family farmers, make significant contributions to the sector thanks to the economic, cultural and environmental functions they accomplish in rural societies and the overall agricultural sector. Hence, success can only be reached when farmers either individually or grouped in associations and cooperatives are willing to apply innovative technologies that boost production and protect the environment. Despite initial mistrust when new technologies such as no till or minimum tillage are first implemented, there are endless examples showing that, even under Mediterranean conditions, the successful uptake of such technologies is possible when they first are implemented through a participatory processes, in consultation and in agreement with local people (ICARDA-CCAFS, 2012). The scaling out and mainstreaming of SLM options to reach farmers and decision-makers is therefore very crucial now more than ever.

The World Overview of Conservation Approaches and Technologies (WOCAT)[2] initiative has shown that SLM has the potential to increase yields by 30% to 170%, increase water use efficiency by up to 100% and increase SOC by 1% in degraded soils and up to 2% to 3% in non-degraded ones (WOCAT, 2007; CDE, 2010). Most common SLM techniques include soil and water conservation measures (terracing,

2 - www.wocat.net

contour planting, living barriers, reduced tillage, mulches, cover crops, grazing corridors, water harvesting) and soil fertility management (manure, compost, biochar[3], biomass transfer, agro-forestry with nitrogen-fixing trees like Faidherbia albida and shrubs like Tithonia). These can be integrated in suitable combinations through integrated soil and ecosystem management including intercropping and rotations with biological nitrogen fixing (BNF) legumes that can add (allow nitrogen fertilisation) to the soil up to 300kg N/ha^{-1} in a season, for the effective use of the soil profile, for pest and disease control and integrated crop-tree-livestock management in the wider landscape.

Innovation technologies like "EverGreen" agriculture as a form of more intensive farming that integrates trees with annual crops to sustain a green cover on the land throughout the year or "Climate-Smart Agriculture", which includes techniques such as mulching, inter-cropping, no-till farming, improved grazing and better water management are proving to be efficient by increasing farmers' income also through carbon credits and providing environmental benefits that reduce greenhouse gas emissions and enhance food security (World Bank Institute, 2012). Additionally, Conservation Agriculture (Benauda *et al.*, 2015) especially in the drylands is also promising as it provides a low-cost entry point for long-term sustainability. It is based on a "no-tillage" approach, which aims to reduce the impact of farming on the environment and on the farmland itself and it is characterised by three principles namely: 1) minimum mechanical soil disturbance, 2) permanent organic soil cover, and 3) diversification of crop species grown in sequences, rotations and/or associations.

"4 pour 1000: soils for food security and climate": a French Government initiative

Key to the success of COP21 on Climate Change held in December 2015 in Paris, the "4 pour 1000" combines the restoration of degraded land, food production and the fight against climate disruption. Building on solid, scientific evidence and concrete actions on the ground, it aims to show that food security and combating climate change are complementary and ensures an agriculture that provides solutions to climate change. This initiative consists of a voluntary action plan under the Lima Paris Agenda for Action (LPAA), backed up by a strong and ambitious research programme. The "4‰" Initiative aims to improve the organic matter content (by 4 grammes for every 1,000 grammes of CO_2 a year) and promote carbon sequestration in soils through the application of agricultural practices adapted to local situations both economically, environmentally and socially applying the principles of agro-ecology, agroforestry, conservation agriculture and landscape management.

Source: www.4p1000.org

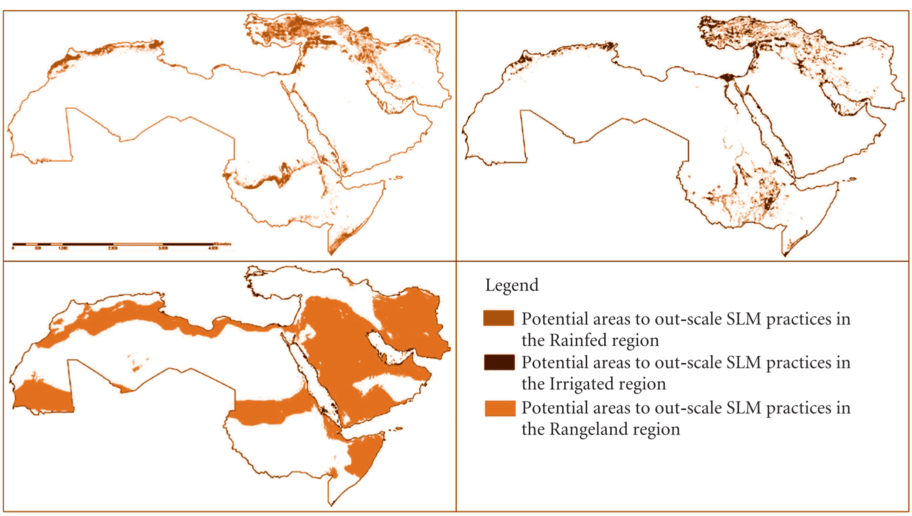
The issues of SLM, soil quality (Mandal *et al.*, 2011; Bone *et al.*, 2012) and holistic adaptive land management (Herrick *et al.*, 2012), however, require a profound recognition of local conditions as there are no universal "ready-to-use recipes" for each place on Earth. Over the last two decades, WOCAT, at the front line of this process,

3 - www.biochar-international.org

supported by a management team from the Centre for Development and Environment (CDE) of the University of Bern, the FAO and the International Soil Reference and Information Center (ISRIC), has established a well-accepted and unique framework for documentation, evaluation, monitoring, and dissemination of SLM knowledge, covering all steps from data collection to database creation, mapping of degradation and conservation to the use of this information for decision support (Schwilch *et al.*, 2014). In 2013-2014 the Partnership was expanded to an international consortium that supports the global knowledge management activities and the country and regional network of members. The WOCAT database has been selected by UNCCD as the reference database on SLM best practices.[4]

Over the past several years, technical practices were fine-tuned and tested and a number of solutions for the best management of water and land were developed for the MENA region. Among some of the proven interventions are water-harvesting practices in the driest areas, water-saving techniques (raised-beds and deficit irrigation) in irrigated areas, and supplemental irrigation in rainfed areas. To ensure their adoption by farmers and positive results from their implementation, suitable techniques/technologies need to be disseminated on a large scale. Identifying areas similar to those where these technologies were established and verified is needed to facilitate the out-scaling process. Similarity analyses, made available for decision makers, were used to find potential areas for out-scaling selected SLM practices (see Figure 4) (Ziadat *et al.*, 2015).

Figure 4 - Potential areas for out-scaling SLM practices in three dominant agro-ecosystems of the MENA region



Source: Ziadat *et al.* (2015).

4 - From a WOCAT management team (Centre for Development and Environment, University of Bern, FAO and ISRIC) and funding for the Secretariat mainly provided by the Swiss Development Cooperation, to a consortium of partners supporting the wider WOCAT network among countries, also including SDC, GIZ, FAO and the CGIAR centres – CIAT, ICIMOD and ICARDA.

SLM adoption needs a governance that ensures access rights over land resources by men and women including female headed households, secure tenure arrangements, as well as a supportive enabling environment for the testing, validation and wider uptake of proven practices for example through access to credit, extension services, markets, etc. Payments for environmental services that are generated through SLM practices notably, carbon, water and biodiversity credits, are being tested in the MENA region as means to enhance income for the land users.

However, they have been proven to be more suitable for landscape scale interventions rather than at individual farm level because of high transaction costs in monitoring, verifying, reporting and paying. The VGGT described above and the Guidelines for Responsible Agricultural Investments (RAI) that have been developed by the FAO through wide consultative processes provide a basis for enhancing governance and investments in SLM, and must therefore, as far as possible, be disseminated and implemented. In early December 2015, the FAO Council supported the initiative for developing the Voluntary Guidelines for Sustainable Soil Management whose main goal will be to support the implementation of the principles of the World Soil Charter.

Conclusion

Land misuse and mismanagement not only destroys soils and results in loss of ecosystem services but also impacts our human heritage. Anticipated climate change may worsen the situation as about 175 million more people may go hungry by the end of the century if no action is taken (Brown *et al.*, 2015). On the other hand, all over the world, generations of farmers and herders have shaped and maintained specific agricultural systems and landscapes that value local natural resources. Their management is based on experience, practices and local knowledge. These ingenious *agricultural* systems, that abound in the Mediterranean region, reflect the evolution of humankind, the diversity of its knowledge, and its profound relationship with nature.

Due to its natural conditions, demographic trends and environmental constraints, the challenge of sustained agricultural productivity in the Mediterranean relies mostly upon proper use and management of existing agricultural land resources. These are also the conditions that could provide a measure of success in the quest for achieving the recently endorsed Sustainable Development Goals to improve food security and living conditions, especially for the rural poor. The dramatic political and social events throughout the Arab World initiated since 2011 only reinforce the need for continued stewardship for land resources (Zdruli and Lamaddalena, 2015). This could only be achieved if sustainable land use planning is introduced in governmental agendas and maximum care is applied to implement legislation that optimise and protect land and avoid its wasting.

Traditional Mediterranean agro-ecosystems that have adapted and evolved over the years have resulted not only in outstanding landscapes, a globally significant agricultural biodiversity, but also, above all, in the sustained provision of multiple goods and services, food and livelihood security and quality of life. The innovations and ingenious practices of the land users themselves, the farmers, livestock keepers, forest managers and even fisher folk, contribute to improving food supply and providing environmental benefits for the community (Laureano, 2001) as well as sustaining livelihoods and wellbeing of rural societies.

Awareness on SLM is also important. Since 2012, the UNCCD honours outstanding farmer organisations and NGOs involved in soil conservation activities with the Land for Life Award. In 2015, the SEKEM Initiative[5] in Egypt was awarded with this prestigious price. The UNCCD is also promoting the "*Zero-net land degradation*" by 2030 concept (UNCCD, 2012), further developed by the COP12 in Ankara in October 2015; for each degraded hectare of land another one must be restored or rehabilitated elsewhere building hence a land-degradation neutral world (Stringer, 2012). The African Great Green Wall Initiative for the Sahara and the Sahel and the TerrAfrica Strategic Investment Programme for Sub-Saharan Africa represent concrete examples of awareness by African Governments, the African Union, the New Partnership for Africa's Development (NEPAD) and by the donor community of the necessity to reverse degradation across ecosystems, landscapes and the wider continent and their commitment to the achievement of land degradation neutrality.

The challenges of SLM as a tool to avoid land waste and improve food security must be addressed simultaneously with the development of policy guidelines and their implementation. Experience has shown that land protection priorities often take a back seat in governmental agendas. The Thematic Strategy for Soil Protection for instance never materialised as an EU Directive and in 2015, the European Commission noted that the proposal for a Soil Framework Directive had been pending for eight years with no effective action; as a result it decided to withdraw the proposal. This was a big setback. Nevertheless, in 2013, the 7th Environment Action Programme restated the EU's commitment to "*reduce soil erosion, increase soil organic matter, limit the effects of man-made pressures on soil, manage land in a sustainable fashion, and remedy sites with contaminated soils*". In 2015 the EC presented a Communication aiming "no net land take" by 2050, reducing erosion rates and increasing soil organic matter. These are a good starting point also for the MENA countries to set targets that respond to their specificities and needs.

The "Mediterranean syndrome" characterised by structural deficiencies common to most countries in the region such as corruption and lack of comprehensive plans to combat environmental problems and poor cooperation between the various administrative sectors that hold competencies for land management and territorial development should not last forever. It should not take the occurrence of calamities, such as the latest flooding in the Côte d'Azur area in France in October 2015 that killed 17 people, to make governments be concerned about the sealing or degradation of land and their impacts on the environment, returns from investments and human livelihoods and welfare. If we are to meet the increasing demands from the growing world population and changes in living standards that are estimated by the FAO to require a 70% increase in global food production by 2050, business as usual is no longer an option. Protecting land from degradation processes and restoring already

5 - www.sekem.com/aboutus.html

degraded lands is a long but essential process requiring a transformation towards sustainable food and agricultural systems and appropriate strategies and actions should be included in the long-term development plans of each Mediterranean country.

In September 2015, the United Nations General Assembly approved 17 SDGs. Among them, SDG 15 calls to "*Sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss*". SDG 15.3 specifically tackles land and soil: "*By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world*". This was a historic shift from the previous Millennium Development Goals because at this point in time there are no countries that tell others what to do, but all have an equal share of responsibility for the wellbeing of the planet. Given this context and due to its geographical and political position, the Mediterranean offers a great opportunity for implementing the SDGs to secure a better future for its people.

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CHAPTER 5

FORESTS: FACING THE CHALLENGES OF GLOBAL CHANGE

Inazio **Martínez de Arano**, *EFIMED*
Valentina **Garavaglia**, *FAO*
Christine **Farcy**, *Université catholique de Louvain*

Mediterranean countries have around 85 million hectares of forests, representing 2% of the world's forest area. There are more than 12 million hectares of new forests since 1990, most of them due to natural regeneration and colonisation of agricultural lands. This represents an increase of 0.68% every year and suggests the strong dynamic character of the region.

Home to ancient civilisations, birthplace of three great religions, cradle of the Renaissance, the Mediterranean Basin has for millennia been under human pressures that left a visible mark on the landscape. Mediterranean forests are highly humanised ecosystems and complex socio-ecological systems that require more attention from the international community. The Mediterranean region is totally immersed in global megatrends (i.e. globalisation, tertiarisation, urbanisation, climate change) that affect all aspects of life. The way people think about and relate with forests is also changing, as is the socio-ecological environment in which silviculture takes place.

New threats, like climate change or demographic increase, new challenges, like adapting forest management to forest multifunctionality, and new opportunities like the green economy, emerge. In this changing and challenging context, the need to promote sustainable forest management practices and policies became urgent, in order to obtain social and economic benefit and avoid waste of forestry resources.

This chapter gives an overview of the evolution of the Mediterranean forest in the past and presents current trends, explores the impacts of some of the main global megatrends in Mediterranean silviculture and highlights some emerging solutions.

The evolution of Mediterranean forests and current trends

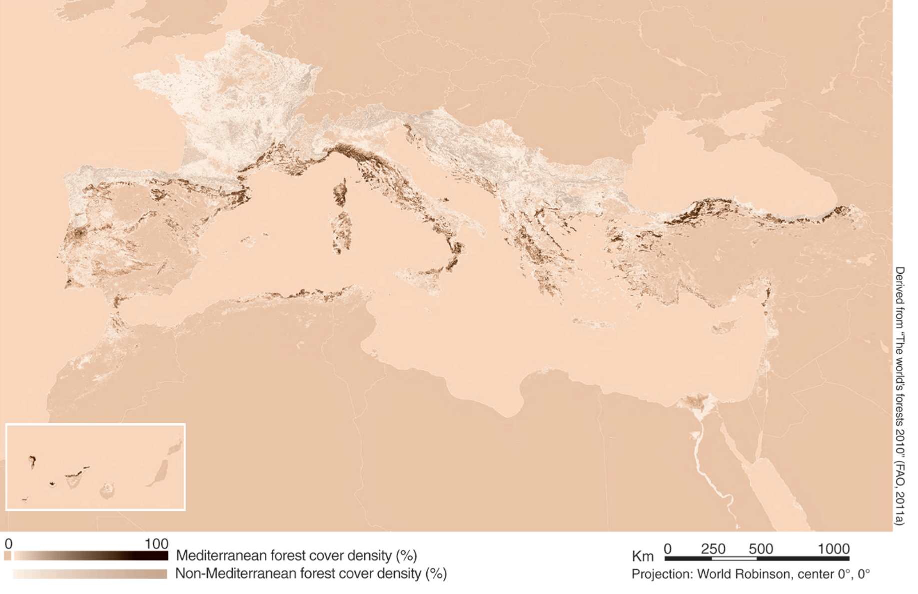
The current extent (see Figure 1) and conservation status of Mediterranean forests and their structure dynamics are determined as much by societal processes as by biological ones. These influences are quite old and date back to prehistory. Through successive waves of high pressure and remission, the forest changed, disappeared or withdrew away from human action.

Human activity, a key factor in Mediterranean forest ecology

The impact of humans on Mediterranean forests is much deeper and subtle than commonly expressed by the terms "deforestation" and "forest degradation". There is increased evidence that humans have contributed to configure the Mediterranean forests we see today since long before the last Glacial Maximum.

Despite the fact that the use of fire as a tool to modify the structure of the landscape expanded across Europe only around 120,000 BC, traces signal a possible use of fire by humans with the arrival of *Homo sapiens* populations (1.2 million years BP) and it was probably used to conquer new hunting grounds 400,000 years ago. It is legitimate to think that human action was already a relevant factor in shaping the structure and dynamics of forest ecosystems while they were retreating and expanding under the influence of changing climates.

Figure 1 - Distribution of Mediterranean forests



Sources: FAO and Plan Bleu (2013).

During the Last Glacial Maximum (120,000-10,000 BP) the climate was much colder and dryer across the Mediterranean basin and ice caps covered mountains in the Iberian Peninsula, Greece, the Balkans, Turkey and the Atlas Mountains (Morocco). A period of rapid warming and increased humidity followed. By 11,000 BP forests had greatly expanded across the Mediterranean region. Only after 8,000 BP a "typical" Mediterranean forest dominated by evergreen oaks and pines became dominant in areas like current Greece and Cyprus. By then, the capacity of humans to modify the landscape had greatly increased.

The Ohalo site in Galilee shows evidence of cultivation and seed processing by 19,000 BP. Pigs, goats and sheeps where domesticated in the Fertile Crescent between 13,000 and 9,000 BP during the Neolithic Revolution. The population growth resulting from this deep change in lifestyle is substantial (Le Houérou, 1981). All these developments rapidly expanded across the Mediterranean. The extensive use of fire, tree cutting and the selection of useful trees have certainly influenced vegetation, already favouring certain species or live traits such as those related with fire resilience.

In the subsequent millennia, the Mediterranean region gave birth to complex societies capable of using and shaping natural resources. During the Bronze and Iron ages, the expansion of agriculture, livestock farming and the use of fire to shape vegetation were accompanied by a sophisticated use of wood and the development of trade on a large scale. In many respects, it was during the classical times that what we consider the "typical Mediterranean landscape" was modelled. All along the emergence of human civilisations, Mediterranean forests made room for agriculture and human settlement, creating the mosaic landscapes that we still recognise today. Forests also sustained livelihoods and social developments by supplying, along with long-range trade, fundamental resources for the construction of fabulous fleets and buildings, fuel for domestic and proto-industrial needs, materials for food, health and handicraft, as well as fodder and feed for livestock. Locally, this has led to forest destruction and shortages of resources.

Mediterranean forests become scarce

In the subsequent centuries, as population and demand for multiple resources augmented, the pressures on forest ecosystems increased. Demand for agricultural and grazing lands pushed forests back to mountainous and remote areas. Forests still remained the main source of biological raw material for humans and their activities well into modernity. As an example, looking at their present situation, it is difficult to imagine how, although complemented by wood imports from remote areas, Mediterranean forests could maintain, through several centuries, multiple human needs and also supply the fine woods needed to create the fabulous fleets of the Ottoman Empire and its Spanish, French or Italian rivals.

The progressive reduction and increased utilisation of Mediterranean forests accelerated greatly during the 17th and 18th centuries in most regions, and was especially intense in the northern Mediterranean countries. Due to high demands for timber and other non-wood forest products (cork, pitch, etc.), conflicts for the use of forest resources became prominent and the need for regulation was more pressing. Across the northern Mediterranean and other European regions, a large collection of trials and regulations attempted at mediating the conflicts between shipbuilding and energy uses, between the navy and the forge industries and between the crown and local communities. Frequently, rulers have tried to reserve the best forests for shipbuilding against the will of local populations, while the obligation to replace harvested trees with new plantings became widespread (Williams, 2006). However, no regulation would stop the wave of severe deforestation and degradation that expanded across the globe during the late 17th and early 20th centuries accompanying the industrial revolution. The until then unknown demands for feedstock and timber to supply the energy and material needs of new industries, railroad ties and electricity posts grew exponentially. This happened simultaneously with the maximum agricultural expansion, which was necessary to feed a growing population on the eve of the green revolution.

The evolution in the eastern Mediterranean was not that dissimilar, although it is now recognised that forest resources, although heavily used by a large rural population, were largely preserved until the mid-19th century (Davis, 2007). Customary governance structures had been largely kept under Ottoman rule, as the empire had no forest regulation except for those large areas reserved to serve the imperial navy and armouries. The situation changed abruptly in the 19th century. The modernisation efforts of the Ottoman administration facilitated the adoption of modern forest ideas developed in France and Germany. The State sought greater control over forest resources and significant amounts of timber were harvested to help replenish the suffering State Treasury. The development and supply of the Ottoman railways during the first half of the 20th century brought in an intense wave of deforestation, with Lebanon, for example, losing over 60% of its remaining forests (Oedekoven, 1963).

In the southern Mediterranean, the new colonial powers that took over the Ottoman possessions, brought in new rules, ideas and values. Colonial forest regulations gave the State the right to manage all forests, frequently favouring the needs of the metropolis and upsetting customary arrangements, which led to the destabilisation of secular land tenure. The result was a period of intense deforestation. It is estimated that half of the remaining forests in Morocco, Algeria and Tunisia were deforested under colonial rule. Turkey also suffered significant destruction of forest resources during this period (Williams, 2006).

Although known since antiquity, it is in these times of great resource degradation that the strategic relevance of water-related forest services was recognised in the emerging regulations and institutional arrangements. In fact, intense erosion and catastrophic flood events have frequently given a final impulse to governmental action. Modern forest services and forest regulations were created across the globe and particularly in the Mediterranean region, frequently to “protect” forests from people. Forestry schools spread notions about “sustainable forest management”, but these were not always well adapted to the local context and in particular to the agrarian economy in place (Mermet and Farcy, 2011). Afforestation programmes become mainstream, frequently related to sand dune control (Portugal, Spain) or hydrological corrections.

Mediterranean forests under global change

The situation changed considerably in the last sixty or seventy years, at least in relation to forest area and deforestation. In fact, forests are expanding at unprecedented rates in northern Mediterranean countries while deforestation has stopped or even been reversed in southern and eastern Mediterranean countries (see Table 1) (FAO and Plan Bleu, 2013). The reasons for this drastic change needs to be found in the deep socio-economic changes that are taking place at accelerated rates since the mid-20th century.

The pace of global change has dramatically changed to reach a level where human activities have become an environmental force that rival natural processes (Steffen *et al.*, 2011). Between 1950 and 2010, the population more than doubled and there was a tenfold increase in economic activity. International trade, capital and information flows rapidly expanded leading to highly integrated national economies. The pressure on natural resources has greatly increased. Half of the world surface is domesticated. Water use and water resources regulation has increased six fold in the same period reaching planetary limits (about 70% of the world's freshwater resource is now used for agriculture). There has been a fivefold increase in the use of fertilisers: today, manufactured nitrogen for soil amendment exceeds the terrestrial natural production of reactive nitrogen. The atmospheric concentration of CO_2 rose from 58ppm in 1950 to 369ppm in 2000. Sociological and cultural changes are also deep and fast. One of the most dramatic changes of the past decades is urbanisation and rural abandonment or stagnation (Farcy *et al.*, 2016). For the first time in history, since 2010, over half of the human population now lives in urban areas. In the 19th century, a new change of gear took place. Before, the "great acceleration" was almost entirely driven by developed countries. Nowadays, several large developing countries are rapidly increasing their share in the global economy and in the consumption of natural resources (Steffen *et al.*, 2011) as is the case for some northern African and eastern Mediterranean countries. In addition, biotechnologies increasingly allow for modifying life organisms to better suit human needs creating conditions for a new "Green Revolution".

Global change is now affecting all the life support systems of the Earth and is challenging more than ever the capacity of society to provide decent livelihoods for all. There is increased awareness on the biological boundaries of our landscapes. The Rio Conventions are an attempt to build global governance by structuring the relationship between humankind and the Earth's systems. The need to decouple economic growth and resource consumption is well recognised. This has sparked a new interest in the knowledge-based production and transformation of bio-based resources for multiple uses and is opening new opportunities for the forest-based products.

Table 1 - Evolution of forest cover in the Mediterranean (1990-2010)

Country	Land area (1,000 ha)	Forest		Other wooded land				% of total forest area in Mediterranean countries
		1,000 ha	% of land area	1,000 ha	% of land area	1,000 ha	% of land area	
Spain	49,919	18,173	36	9,574	19	37,438	68	21
France	55,010	15,954	29	1,618	3	55,261	72	19
Turkey	76,963	11,334	15	10,368	13	18,495	63	13
Italy	29,411	9,149	31	1,767	6	38,868	87	11
Morocco	44,630	5,131	11	631	1	6,937	64	6
Bulgaria	10,864	3,927	36	0	0	6,351	49	4.6
Greece	12,890	3,903	30	2,636	20	5,457	60	406
Portugal	9,068	3,456	38	155	2	5,623	64	4
Serbia	8,746	2,713	31	410	5	2,099	41	3.2
Bosnia and H.	5,120	2,472	48	549	11	3,118	56	2.9
Croatia	5,592	1,920	34	554	10	233,997	98	2.2
Algeria	238,174	1,492	1	2,685	1	740	37	1.7
Slovenia	2,014	1,253	62	21	1	14,230	92	1.5

Table 1 - Evolution of forest cover in the Mediterranean (1990-2010) (continued)

Country	Land area (1,000 ha)	Forest		Other wooded land				% of total forest area in Mediterranean countries
		1,000 ha	% of land area	1,000 ha	% of land area	1,000 ha	% of land area	
Tunisia	15,536	1,006	6	300	2	1,402	55	1.2
FYROM*	2,543	998	39	143	6	1,709	62	1.2
Albania	2,740	776	28	255	9	17,852	97	0.9
Syria	18,378	491	3	35	0.002	638	46	0.6
Montenegro	1,382	467	34	277	20	175,407	100	0.5
Libya	175,954	217	0.001	330	0.002	537	58	0.3
Cyprus	924	173	19	214	23	1,977	91	0.2
Israel	2,164	154	7	33	2	780	76	0.2
Lebanon	1,023	137	13	106	10	8,675	98	0.2
Jordan	8,824	98	1	51	1	99,455	100	0.1
Egypt	99,545	70	0.0007	20	0.0002	29	64	0.1
Others	686	25	4	0	0	632	92	0.1

* FYROM: Former Yugoslav Republic of Macedonia.
Source: FAO and Plan Bleu (2013).

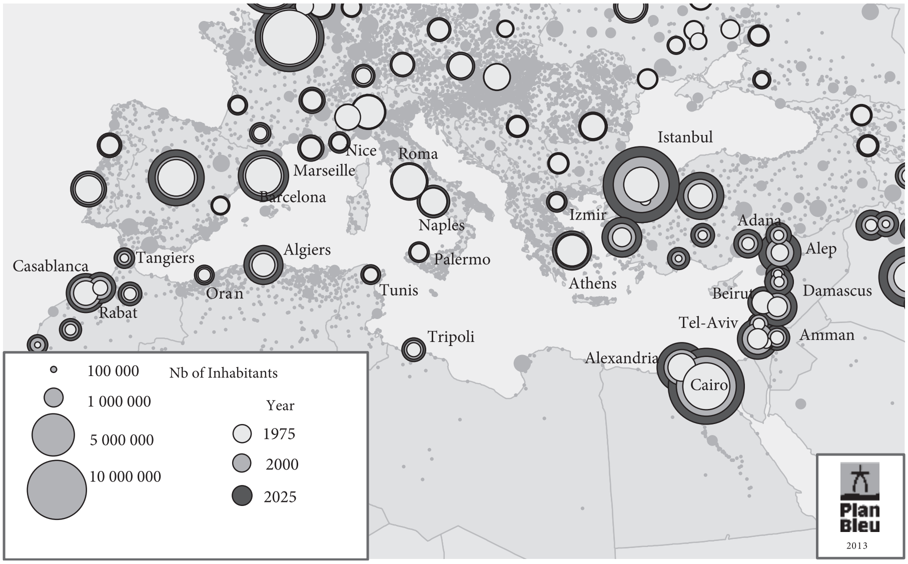
Population growth, urbanisation and social change: consequences for forests and forestry

The Mediterranean region has undergone significant socio-economic development. In the last 60 years its population has more than doubled, reaching 570 million inhabitants in 2010 and heading towards over 600 million by 2050 (Population Reference Bureau, 2013). Most of this growth is taking place in the Middle East and North Africa (MENA) region, which has one of the world's most rapidly expanding and young populations. Southern and eastern Mediterranean countries now contribute with over half the population, while they represented less than one third in the 1950s. Additionally, the region supports a very significant seasonal population, as it is the destination of almost one third of the world tourism or over 330 million international visitors in 2014 (World Travel and Tourism Council, 2014). All across the region, there is a strong surge in demand for food, water, housing and transport that has not been matched by a similar increment in the production of raw materials, feedstock and food. According to a recent study "the overall Mediterranean region is using approximately 2.5 times more renewable resources than its ecosystems can provide" (Global Footprint Network, 2015). The Mediterranean has become a net importer of raw materials and consumer goods. The region has the biggest share of the world's population living under water scarcity (FAO and Plan Bleu, 2013). Moreover, it faces enormous difficulties to provide jobs to its population as is reflected by high unemployment rates (Roudi, 2011). Stimulating green entrepreneurship to create local value chains on goods and services provided by forests and to progress towards sustainable consumption and a more circular economy would open new opportunities for forest and rangeland management.

Urban areas have been the primary locus of this growth (see Figure 2). In the MENA countries, the rate of urbanisation grew from 48% in 1980 to close to 60% in 2000, and it is expected to exceed 70% by 2015 (against an average of 54% for all developing countries). Indeed, the region's average annual urban growth rate of 4% in the past two decades is exceeded only by sub-Saharan Africa, which is far less urbanised (World Bank, 2015).

This rapid increase of urban populations and lifestyles constitutes one of the major changes of our era (Seto *et al.*, 2011). The resulting expansion of urban areas leads to the irreversible loss of land. It is a primary driver of habitat loss, and species extinction, destruction of prime agricultural soils, also having impacts on hydrological systems and local climates. It is occurring in a context of poor economic performance and high unemployment rates leading to the proliferation of slums and informal peri-urban settlements, increasing urban sprawl and informal economic activities (World Bank, 2015). In less developed countries, this is putting additional pressures on forest resources as urban dwellers still frequently rely on firewood as a source of domestic energy. In addition, available data clearly shows that Mediterranean citizens have very limited access to forests and green areas. This can be as low as $7m^2$ *per capita* in Italy or $2.5m^2$ *per capita* in Morocco (Salbitano *et al.*, 2013). This has deleterious effects in quality of life and human health. Urban expansion is a complex issue related not only to increasing urban and rural exodus, but also to international capital flows, land use policies, transport costs or the structure and size of the informal economy (Seto *et al.*, 2011). Consequently, preserving and managing urban and peri-urban forests must be a crosscutting objective across policy areas for the wellbeing of inhabitants.

Figure 2 - Urban population distribution and increase in Mediterranean countries (2011)

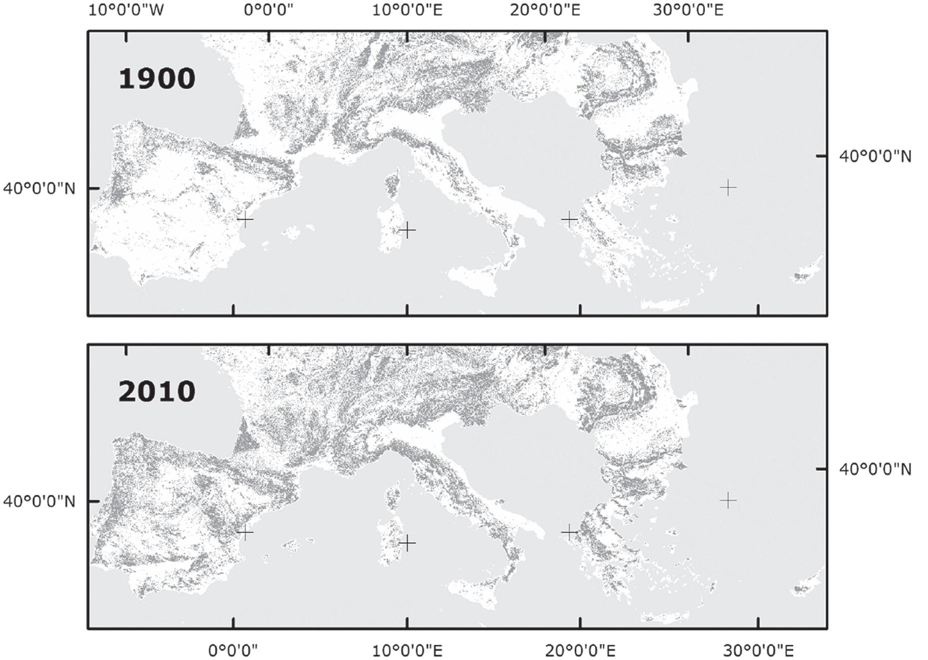


Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

In the northern Mediterranean, the "Green Revolution" has favoured the intensification of crops in the low lands, rendering traditional extensive agro-forestry economically and socially unviable. Urbanisation induces progressive social desertification and aging of the population in the rural areas, as extensive grazing and family subsistence farming are abandoned and agriculture is only maintained where intensification is profitable (Farcy *et al.*, 2016). The rapid adoption of fossil fuels as the main energy source also in rural areas, has led to a general lack of demand for firewood and charcoal and in turn to land abandonment and an increase of forests (see Figure 3). These new forests remain largely unmanaged. The incapacity of society to generate value from large proportions of the landscape entails a waste of resources.

Forests in Europe's southern countries have expanded rapidly in the past few decades, with forest cover at the highest level in centuries. Across the region, forest cover fell to a minimum of approximately or even less than 10% during the 19th and early 20th centuries. Today it is set to surpass the 50% mark. Generally, these expanding forests are also gaining biomass, as management intensities are generally very low. With few exceptions, fragmented, uncompetitive value chains are unable to supply other more sophisticated demands or to sustain decent jobs and to retain rural population. Except for areas dominated by plantations, wood extraction represents typically up to 50% of the increment. Paradoxically, some Mediterranean regions host important forest-based industries, but these are almost totally based on wood imports and are unconnected to local forest resources.

Figure 3 - Estimated expansion of European Mediterranean forests since 1900



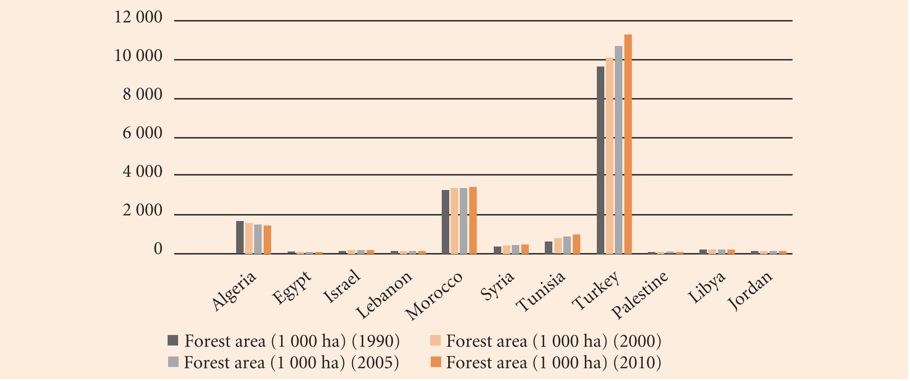
Source: Elaborated based on data from Fuchs *et al.* (2013).

The absence of viable value chains maintains these young new forests largely unmanaged, vanishing the economic income that could be generated for the region. The consequences of this phenomenon are multiple and complex. Some are clearly positive. The increased forest area and increased stocking levels can help restore soil fertility after centuries, sometimes millennia, of degradation. In addition, it is increasing the habitat availability for forest specialist species. On the other hand, those species depending on open landscapes are suffering from habitat loss. There are also negative consequences. The lack of management leads to rapid build-up of fuels and produces forest structures that are very favourable for fire spread. Increased continuity in the landscape and favourable climatic conditions increases the occurrence of *megafires* (San Miguel-Ayanz *et al.*, 2013) and associated ecological and societal risks.

Southern and eastern Mediterranean countries share many of those trends (see Figure 4). Strong urbanisation and reliance on fossil fuels have also reduced the pressures on forests. However, rural areas are still relatively densely populated.

Forests and rangelands help sustain stable or increasing populations then inevitably exert strong pressures on natural resources through subsistence agriculture. The presence of browsing animals is ubiquitous and firewood removals are intense. Low-density, low-stoked forests with sparse understory dominate. They are frequently threatened by the encroaching of agriculture and expansion of settlements. In this context, governmental actions in the last decades have been a decisive factor to slow (Algeria), halt (Lebanon, Jordan) or even to revert (Morocco, Tunisia) deforestation (FAO and Plan Bleu, 2013; FAO, 2015). As shown in Table 2, planted forests account for a significant share of forests in most northern African and eastern Mediterranean countries. This has also required significant investments in afforestation and in protecting forests from social pressures. Forests are generally state-owned and local populations typically have limited capacity to manage them and to realise material benefits within sustainable practices. At the same time, forest authorities, following a "command and control" scheme, try to reduce human pressures. This generates frequent conflicts of interest between the rural population and the forest administration. Careless action and conflicts with the forest authorities are among the major causes of forest fires in Algeria (Meddour-Sahar *et al.*, 2012).

Figure 4 - Changes in forest area in Southern and Eastern Mediterranean countries



Source: FAO and Plan Bleu (2013).

Big challenges remain in order to secure the conservation, sustainable management and restoration of forest resources. The complicity of local populations is probably the most relevant factor for success. Negative pressures will remain until rural and peri-urban populations are able to improve their livelihoods, or at least to perceive significant benefits, from the sustainable management of Mediterranean forests. Until then, the conservation of forest resources will remain a wicked problem for decision makers and the broader society.

The effects of increased urbanisation on forests do not stop there. The expansion of urban lifestyles and the reduced access to natural and rural areas are generating changes in the social perception on forests and forestry. Changes in the school

Table 2 - Extension of planted forests

Country/area	Planted Forest			Natural Forest	Planted Forest
	1,000 ha	% of forest area	% of which introduced species		
Albania	94	12	8	*683*	*94*
Algeria	404	27	–	*1,088*	*404*
Bosnia and H.	999	46	–	*1,186*	*999*
Bulgaria	815	21	5	*3,112*	*815*
Croatia	70	4	39	*1,850*	*70*
Cyprus	31	18	5	*142*	*31*
Egypt	70	100	83	*0*	*70*
France	1,633	10	36	*14,321*	*1,633*
Greece	140	4	–	*3,763*	*140*
Israel	88	57	30	*66*	*88*
Italy	621	7	15	*8,528*	*621*
Jordan	47	48	–	*51*	*47*
Lebanon	11	8	74	*126*	*11*
Libya	217	100	–	*0*	*217*
Morocco	621	12	33	*4,510*	*621*
Portugal	849	25	99	*2,607*	*849*
Serbia	180	7	–	*2,533*	*180*
Slovenia	32	3	–	*1,221*	*32*
Spain	2,680	15	37	*15,493*	*2,680*
Syria	294	60	17	*198*	*294*
FYROM*	105	11	–	*893*	*105*
Tunisia	690	69	30	*316*	*690*
Turkey	3,418	30	2	*7,916*	*3,418*

* FYROM: Former Yugoslav Republic of Macedonia.
Source: FAO and Plan Bleu (2013).

systems and lifestyle have been reinforcing this trend (Pergams and Zaradic, 2008). The role of peri-urban forests becomes increasingly important but this is often neglected (Scott *et al*., 2007). Studies also suggest that forest management and related forest issues are not well understood outside the small forestry community and that there is a significant gap between reality and people's understanding. Such gaps in social perception can have high impacts on forest management decisions, where urban citizens and authorities make decisions that affect forest resources and rural population, or where people from developed countries draft a global agenda on forestry issues that affects developing countries (Farcy *et al*., 2016). As an example, European citizens from Mediterranean countries still think that deforestation is major problem for their forests while, as we have seen, forest cover is reaching maximums unknown for centuries. Also, European highly urbanised societies generally disregard the actual or potential contribution of forest as a source of sustainable raw material and its economic dimension, favouring conservation and recreational uses (ECORSYS, 2009). Finally, social perception can shape forest-related policies and approaches, including financial frameworks for forest management.

Globalisation and the structural changes in markets for forest products

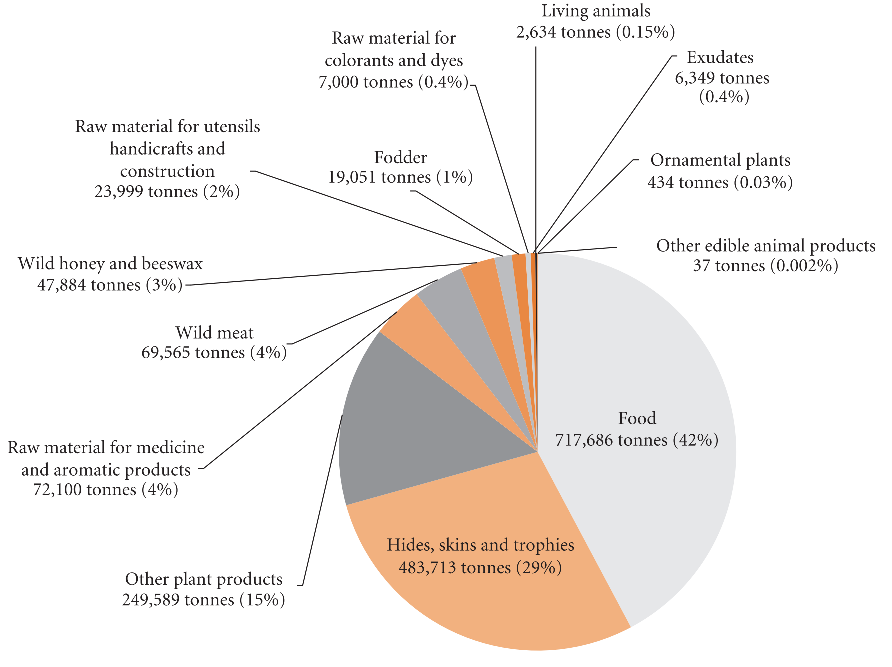
Globalisation can refer to the fast spread of ideas and governance structures but frequently, its main objective focuses on the consequences of strong economic integration through the development of trade and capital flows across borders. The liberalisation of trade coupled with the emergence of new global players in the forestry sector is having major impacts in the markets of forest products and the related value chains.

Mediterranean forests are known for the relatively higher and multifunctional value provided by non-wood forest products and ecosystem services (see Figure 5). Yet, wood is still one of the major contributors to the total economic value of Mediterranean forests and is still one of the main drivers and sources of income for forest management (Merlo and Croitoru, 2005). Wood markets have significantly changed in the last few decades and Mediterranean forests need to adapt.

Emerging economies in Asia and the Southern Hemisphere capture an increasing part of the production and the demand for forest-based products. The Mediterranean region is a significant net importer of wood products from other areas, and has no competitive advantages in commoditised low added value products. With few exceptions, Mediterranean silviculture is characterised by high harvest and logging costs, dispersion of the offer, high heterogeneity of qualities, and very different regulations and market arrangements. The biggest share of the paper and woodworking industries are based on imported timber. Local wood value chains are formed by small companies with low innovation capacity producing low added value products. The Mediterranean forest is not profitable and this is jeopardising forest management in itself.

Many countries of the Mediterranean region with significant wood resources are putting their efforts in developing biomass markets and the corresponding supply chains, even if currently stumpage prices are generally rather low. The question is, whether biomass and forest products alone will be enough for the forest-based sector to stay viable. The answer might turn to be negative. Being at the bottom of the value chain, energy requires extensive resources and produces limited employment and wealth. Moving up towards higher added value products and services seems to be necessary if forests are to contribute to solving current societal challenges.

Figure 5 - Non-wood forest products removals in the Mediterranean countries (2010)



Source: FAO and Plan Bleu (2013).

Globalisation does not only have an impact on wood and timber-based products but also on non-wood forest products. China is the world's largest producer of honey and dominates export markets of pine nuts and resins. Spanish resin production peaked in 1962 with 55,000 tonnes. It dropped to only 2,500 tonnes in 2010, as local industries moved to imported resins. In the same period, China's production expanded from 180,000 tonnes to over 800,000 tonnes. Overall, western countries (USA, France, Spain, Portugal) represented some 60% of the world production of resins until the early 1960s. In the last 20 years, China alone has supplied around 80% of the global demand, with Brazil in second place with an additional 8% (MAGRAMA, 2013). This market situation produces big pressures on prices and also high price volatility, factors that are seen as the main obstacle for reactivating resin production in the region. The increased relevance of Chinese internal markets and a favourable momentum for the "green chemistry" can offer new opportunities for producing resin in over 8 million hectares of Mediterranean forests (MAGRAMA, 2013).

Activating forest management in the Mediterranean region is a major challenge that requires the development of competitive value chains on wood, non-wood products, agroforestry and ecosystems services. There is an urgent need to find a new paradigm and to start seeing Mediterranean forests and rangelands as a source of richness. Finding adequate business models and advancing through the value chains to capture an increased share of the value is definitely necessary.

Maximise the production of goods and services of Mediterranean forest ecosystems in the context of global changes

Mediterranean forests in Europe, North Africa and the Middle East will be increasingly subject to human pressures (overgrazing, fuel wood collection, wildfire, agricultural conversions, etc.) and the effects of climate change (increasing temperatures, declining rainfall, pest attacks, etc.). These consequences are all the more evident where populations are strongly dependent on forest ecosystems. In this region, forest administrations and managers also have to face significant technical and financial difficulties in sustainably managing Mediterranean forest ecosystems. In this context, the regional project that focused on maximising "the production of goods and services of Mediterranean forest ecosystems in the context of global changes" was funded by the French Global Environment Facility and managed by the FAO Committee on Mediterranean Forestry Questions - *Silva Mediterranea* - and Plan Bleu.

The aims of the project are 1) to integrate the impacts of climate change into forestry management policies and produce data and tools regarding both the vulnerability of forests and their ability to adapt; 2) to assess the socio-economic values of goods and services provided by Mediterranean forest ecosystems; 3) to improve modes of governance for Mediterranean forest ecosystems at territorial scale; 4) to optimise and value the role of Mediterranean forests in climate change mitigation (carbon sinks), via the production of methodological tools.

The support provided to the targeted countries (Algeria, Morocco, Lebanon, Tunisia and Turkey) will promote the sustainable management and rehabilitation of Mediterranean forests in order to ensure and value the sustainable provision of forest goods and services.

Climate change

The Mediterranean is one of the world regions with a greater impact of climate change, which is already having a concrete impact on forest-related policies. Increased temperatures, reduced precipitation and longer and more frequent droughts are predicted under scenarios of the Intergovernmental Panel on Climate Change (IPCC). Such changes have major implications for the functioning and sustainability of Mediterranean forest ecosystems. Increased water stress, more favourable conditions for catastrophic wildfires, tree species migrations, forest dieback, proliferation of existing and new pests and diseases are among the expected impacts of climate change on forests (Lindner *et al.*, 2010).

In a context of increased uncertainty, adaptive management approaches are needed. These are not only urgent for the Mediterranean forests themselves but also for regions that might experience a shift in climate towards a typically Mediterranean one in the future.

There is quite a significant amount of knowledge available that can guide sound forestry practices. The most critical challenge is integrating that knowledge into the rapidly-evolving environmental, social and economic context. Adaptation to climate change needs to be not only scientifically sound; it must also be economically sustainable and socially acceptable. Forest management objectives, decision-making tools, policies and strategies need to be adapted to future conditions and new demands for forest goods and ecosystem services.

Climate change is at the core of significant policy developments and the role of forests in the adaptation and mitigation of climate change is increasingly recognised. Until now, the main focus has been placed on mitigation efforts targeting high-productivity tropical forests, but this might change in the short term (see for example the 2009 initiative of the Global Environment Fund [GEF]). The decision taken at the COP21 puts adaptation of forest to climate change at the same level as mitigation. Developing carbon stocks and reducing emission from deforestation and forest degradation is recognised along with the non-carbon benefits of the integral and sustainable management of forests. The need to move towards a more sustainable development model is creating a suitable and positive momentum to forests. The role of forests in a green economy and the potential to supply the bioeconomy is increasingly recognised at global, regional, national and local levels.

Innovative forest management policies and approaches

Mediterranean forests are immersed in a striking paradox. They are very valuable and represent a critical green infrastructure that can help addressing the most critical challenges that emerge from global change. However, it seems that our society has lost the capacity to understand those values, to insert them into the economic flows and to develop a balanced approach to their sustainable management. Therefore, Mediterranean forests have become a *sink of* public resources needed to protect forests from climate change and people.

Developing sustainable and completive value chains on wood, non-wood products, agroforestry and ecosystems services has become the cornerstone for the protection and management of Mediterranean forests, as stated also in the Tlemcen Declaration[1] and the Strategic Framework for Mediterranean Forests (SFMF)[2].

The Tlemcen Declaration calls on regional, national and local political, administrative authorities and stakeholders in the Mediterranean region to develop and adapt their strategies and policies (including governance) for the sustainable development of forests. A broad consultation is exhorted, which includes forest managers, experts, the scientific community and stakeholders to implement innovative strategies. The Tlemcen Declaration promoted the adoption of the SFMF that aims to provide a common policy direction for integrated management. With the support of this regional policy agenda, the several initiatives already happening in the region are

1 - Tlemcen Declaration (www.fao.org/forestry/36632-03883494ea162d6695e84f2182b57129f.pdf).
2 - SFMF (www.fao.org/forestry/36306-08872a0d33e559c4f5c42304068d43763.pdf).

moving towards a renewed regional collaboration. The objective is to make the inhabitants aware of the values of Mediterranean forests by promoting regional initiatives and collaborations.

The Great Green Wall for the Sahara and the Sahel initiative: promoting sustainable management and restoration of forests, rangelands and other natural resources in Africa's drylands

Contrary to popular perception, desertification is not the loss of land to the desert or through sand-dune movement. Desertification refers to land degradation in arid, semi-arid and sub-humid areas resulting from factors such as human pressure on fragile ecosystems, deforestation and climate change. Desertification and land degradation have a strong negative impact on the food security and livelihoods of the local communities in Africa, where two-thirds of the land cover consists of drylands and deserts.

The Great Green Wall for the Sahara and the Sahel is Africa's flagship initiative, established in 2007 to combat the effects of climate change and desertification and brings together more than 20 African countries including North Africa, the Sahel and the Horn, together with international organisations, research institutions, civil society and grassroots organisations. More than a wall, it is conceived as a mosaic of sustainable management and restoration interventions in production landscapes including forests and agrosilvopastoral systems, rangelands and associated natural resources.

The FAO has provided technical support to the African Union Commission and thirteen partner countries with the financial support of the European Union (EU) benefiting Algeria, Burkina Faso, Egypt, The Gambia, Mauritania, Nigeria, Senegal, Sudan, Chad, Djibouti, Ethiopia, Mali and Niger. The aim is to initiate the Great Green Wall harmonised strategy which was adopted by the African Ministerial Conference on the Environment in 2012 and the African Union Assembly in 2013, to help in the start of projects in thirteen countries and to implement a capacity development strategy, an action plan as well as a communication strategy. As a follow-up to this successful EU-FAO collaboration, a 41-million euros wider programme "Action Against Desertification" (AAD) was launched in July 2014 in collaboration with the ACP Secretariat, the African Union Commission and funding support from the EU and other partners. This provides a great opportunity for implementation of some components of the Great Green Wall action plans developed in six Great Green Wall countries (Burkina Faso, Ethiopia, The Gambia, Niger, Nigeria and Senegal) and expansion of activities to the Caribbean (Haiti) and the Pacific (Fiji) building on the successful results of activities carried out in Africa and on south-south cooperation among African, Caribbean and the Pacific countries (ACP). The AAD specific objective is to improve the condition and productivity of the agrosilvopastoral landscapes of these eight countries affected by desertification, land degradation and drought.

Source: FAO (www.fao.org/in-action/action-against-desertification) and www.fao.org/forestry/aridzone).

Forests are dynamic social-ecological systems and they are subjected to innovation promoted by different forest-related stakeholders. The Mediterranean Model Forest Network (MMFN)[3] is exploring participatory approaches and territorial innovation to advance towards sustainable forest management. Created in 2008, it now gathers

3 - Mediterranean Model Forest Network (www.imfn.net/index.php?q=node/158).

thirteen regions from nine different countries. Andalusia's regional government has engaged shepherds in firebreak maintenance and fuel reduction through innovative contractual arrangements[4]. Today there are some 200 shepherds and over 100,000 animals involved in fire prevention. This successful approach is now expanding to other regions. In the Alentejo region, Portugal, a broad partnership of municipalities, cooperatives, business companies, research facilities and individual entrepreneurs have created a platform[5] to stimulate the creation of innovative business models for non-wood forest products and other wild resources such as aromatic plants, honey, mushrooms and wild fruits (*Arbutus unedo* or *Ceratonia siliqua*). Connecting actors fostered the sharing of knowledge conducive to the formation of greater added value and sustainable value chains. In Castilla y León, the regional government offers local communities the opportunity to auction their allowable hunting rights on the Internet in a way that resembles eBay[6]. This initiative not only increased transparency, it has also generated more income, and more importantly, it offers an unparalleled opportunity for territorial marketing and promotion of associated services. In Morocco, the booming demand for argan oil (the most expensive edible oil in the world) is providing economic and social benefits for rural communities especially when, organised in cooperatives, local actors have been able to capture a relatively greater part of the value (Lybbert *et al.*, 2010). Turkey has promoted the development of forest cooperatives since the 1970s with nowadays over 2,000 cooperatives involving some 300,000 villagers. Cooperatives are given priority to use forest products and to work in the forest. They produce planting stocks and provide technical assistance. Some cooperatives also engage in the collection and commercialisation of non-wood forest products and provide tourism and recreational services. Innovative approaches to the commercialisation of non-wood forest products, often associated with territorial marketing strategies, and the promotion of the bioenergy value chains are emerging throughout the region.

In the context of an increasing need for job creation, in particular for youth, bioeconomy presents promising opportunities that can be exploited through market-pull and innovation in bioenergy, but also through the increasing demand for engineered wood products for sustainable construction, and biomaterials based, for example, on cork and resin. Edible products also have economic potential, leveraged through territorial marketing and other accompanying actions. Financing multipurpose forestry might also require the development of instruments such as payments for ecosystem services (PES) to link forestry with other sectors (e.g. water and tourism sectors) that could, in turn, benefit from increased management levels and reduced risk (e.g. prevention of wildfires, landslides and flooding). Many of these developments are already happening across the Mediterranean.

4 - Ganadería extensiva (www.ganaderiaextensiva.org/pastoralismo-y-prevencion-de-incendios/)

5 - www.alentejosilvestre.com/

6 - www.subastasdecaza.com/

Conclusion

It seems that modern societies have lost the capacity to generate value from large portions of the Mediterranean landscape. In some areas, forest cover, biomass and *megafires* proliferate, and in others strong land-use change, overgrazing and over-exploitation put increasing pressure on the ecosystem. The region cannot possibly afford this waste of resources. Reversing this situation will be the most critical challenge for Mediterranean forestry in the years to come. In this region, turning brakes into opportunities is possible, by creating better opportunities for youth in the field of tertiary economy, or by building more partnerships between private and public, cities and countryside, forest and water, culture and slow tourism. This requires innovative approaches to governance, land tenure, and the involvement of rural and urban populations. Finding adequate business models and moving to higher added value products and services is necessary. The Mediterranean region must be able to manage forests better for the benefit of urban, rural and local populations and create job opportunities and richness while preserving the multifunctionality of forests through sound practices and governance structures.

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CHAPTER 6

PLANT AND ANIMAL RESOURCES DIVERSITY

Badi **Besbes**, *FAO*
Christini **Fournaraki**, *CIHEAM*
Francesca Marina **Tavolaro**, *FAO*
Katerina **Koutsovoulou**, *CIHEAM and University of Athens*
Grégoire **Leroy**, *FAO*
Irene **Hoffmann**, *FAO*

According to the Convention of Biological Diversity (CBD), biological diversity – or biodiversity – means "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems".

Biodiversity plays a key role in human nutrition by safeguarding the sustainable productivity of soils and providing the genetic resources for all crops and livestock species harvested for food. The diversity of plant and animal resources underpins the wellbeing of society and serves as an important source of food and income, particularly for poor communities living in rural areas. Moreover, plants and animals provide medicine, timber, biomass, energy, fertiliser and transport, as well as other services that people need for their livelihoods and welfare. The loss of biodiversity threatens the sustainable productivity of existing ecosystems and ultimately leads to the waste of natural resources, primarily affecting the livelihood of poor rural communities. According to the FAO (FAO, 2010 and 2015), the serious degradation of agricultural resources has already led to severe losses of crop varieties and 7% of livestock breeds.

The term "genetic diversity" refers to the genetic variability between and within species. It plays an important role in the adaptation of both wild and domestic species to their changing environments, and hence in their survival. Domestic plant and animal species are used for food and agriculture. Following the FAO terminology, these are referred to as plant genetic resources (PGR) and animal genetic resources (AnGR). This chapter assesses the state of plant and animal resources diversity (wild and domestic species) in the Mediterranean region and gives a brief inventory of these genetic resources whilst focusing on crosscutting issues. It highlights their importance, describes the needs for their wise management and identifies ways to address them. To this end, the authors endeavoured to address the following questions: what are the roles, uses and values of plant and animal genetic resources in the region? What is the current status of these resources? What threatens them? What capacities do the different countries have to manage them? What are the needs for their sustainable management?

These questions constitute the different sections of this chapter and will be addressed at regional level and, where possible, by sub-region rather than by country. For the analyses of AnGR, the data of all Mediterranean countries recorded in the FAO Domestic Animal Diversity Information System (DAD-IS) was used. In addition, country reports submitted by 14 Mediterranean countries[1] in preparation of *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture* (Scherf and Pilling, 2015) (referred to as 2nd SoW-AnGR) were also used. For these analyses, the Mediterranean countries were divided into three sub-regions, based on their common history and economic and cultural similarities:
– Near East and North Africa (NENA): Algeria, Egypt, Lebanon, Morocco, Libya, Syria, Tunisia;
– The Balkan countries (BC): Albania, Bosnia and Herzegovina, Croatia, Cyprus, Montenegro, Slovenia;
– South West Europe (SWE): France, Greece, Italy, Malta, Portugal, Spain.
Turkey and Israel were grouped with BC and SWE, respectively. Gibraltar, Monaco and the Palestine Territories were not included as there is no available data on them in the DAD-IS database.

Efforts to use uniform terminology between plant and animal genetic resources were made but differences may subsist due to different nomenclature and classification systems.

Roles, uses and values of plant and animal diversity

Contribution to national economies

The contribution of agriculture, including livestock and fishery, to national economies varies greatly across the Mediterranean region. This contribution is highest in NENA and BC countries, with average additions of value to national Gross Domestic Product (GDP) of 10.2% and 9.2%, respectively, and lowest (2.3%) in SWE (FAO, 2015). The agri-food trade balance is favourable to SWE countries. Among the NENA countries, Morocco is the major exporter of all food and live animals to the European Union (EU), followed by Egypt. In the BC region, Croatia is the main exporter of agriculture and food products, while Croatia and Bosnia Herzegovina are the main importers (ARCOTRASS, 2006). According to Spanish data (INE, 2015), there is a clear relationship between exports and employment in the agriculture, forestry and fishery sectors.

1 - Albania, Algeria, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Montenegro, Portugal, Slovenia, Spain and Turkey. In addition, Tunisia submitted a report specifically for the purpose of this chapter.

Wild foods of both plant and animal origin are of considerable economic value, but are excluded from official statistics. Apart from the provision of food, wild plant and animal resources provide important ecosystem services that contribute significantly to national and global economies. For example, the economic values of the global herbal medicine market were roughly estimated at USD 43 billion in 2001. Across Europe, crop pollination by insects (including bees) accounted for 14.6 billion euros annually, which equalled 12% of the total economic value of annual crop production. The economic gains attributed to pollination services strongly varied among countries and were highest for Mediterranean EU countries (Leonhardt *et al.*, 2013).

Contribution to human nutrition

PGR and AnGR diversity, key to balanced human nutrition, is only possible through the production of nutritionally diverse food products in diverse food chains. This diversity is mainly observed at species level. However, variety/cultivar/breed-level differences do exist and have begun to attract some attention in recent years. For instance, the FAO/INFOODS Food Composition Database for Biodiversity includes data on the nutritional composition of products from different cattle and pig breeds. In the case of nutritional differences between cultivars, studies show that Mediterranean citrus cultivars vary in organic acids, vitamin C and sugar contents (Bermejo and Cano, 2012). The nutritional properties of extra-virgin olive oil also vary among olive cultivars in terms of oleolic acid and tocopherols content (Tripoli *et al.*, 2009).

The Mediterranean diet is seen as a cultural model for healthy eating (Altomare *et al.*, 2013; Willett *et al.*, 1995). The habit of consuming wild food, of both plant and animal origin (especially plants) is still prevalent in the Mediterranean region, particularly among rural people. Wild plant varieties are richer than the corresponding cultivated ones in micronutrients and secondary metabolites as an adaptation to local environmental conditions. Plant varieties consumed for food or used as food additives (e.g. aromatic herbs such as oregano) constitute 39% of the total taxa identified in the MEDUSA network[2]; 39% are bee-forage plants or plants consumed by animals or invertebrates and contribute indirectly to human nutrition. A total of 2,300 plant and fungal taxa are consumed in the Mediterranean region (Rivera *et al.*, 2006). Animal source foods (mainly meat, milk and eggs) provide essential nutrients for optimal protein, energy and micronutrient nutrition (especially iron, zinc and vitamin B12).

Contributions to poverty alleviation and livelihoods of rural populations

Rural households' income and livelihoods, especially for poor people, are highly dependent on biodiversity. According to the World Resources Institute global report (WRI, 2005), income generated from wild or uncultivated natural ecosystems contributes 15% to 40% of total family income, either cash or in-kind. Thus,

2 - A total number of 1,163 traditionally used native and naturalized taxa were identified in the framework of the MEDUSA network (1996-1998), which is established by CIHEAM and coordinated by its Institute of Chania. The Medusa Database is available at: http://medusa.maich.gr.

the poor are more vulnerable to biodiversity degradation or loss than rich people who can purchase substitutes or shift production and harvesting to other regions (Billé *et al.*, 2012).

Understanding the link between plant and animal diversity, food security and poverty alleviation requires an understanding of their role in the livelihoods of the poor. For instance, livestock do not only provide diverse and critical supplements to staple plant-based diets (Murphy and Allen, 2003), they also provide manure for soil fertilisation and fibre for clothes, produce power and serve as financial instruments and enhance social status. In some communities, livestock-related cultural uses (including gifts and loans of livestock) help to build and maintain social ties. In the NENA region, small ruminants are extremely adaptable and suited to foraging in both semi-arid and arid conditions, providing an important source of meat, milk, wool fibres and skins (Montgomery, 2014).

Ecosystem services and functions

Ecosystem services are essential for human life as they provide food and clean water (provisioning services), regulate floods, drought, land degradation and diseases (regulating services), support soil formation, nutrient cycling and pollination of crops (supporting services), and provide recreational, spiritual and cultural benefits (cultural services). Both crop and livestock productions are interdependent with ecosystem services and thus biodiversity, resulting in both positive and negative impacts. On the one hand, agricultural landscapes that contain significant areas of semi-natural lands are important for wildlife, such as breeding sites for birds. On the other hand, pesticides and habitat loss, degradation and fragmentation threaten natural pollinators. The first assessment from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[3] warns about the decline in the number of pollinating insects and animals, affected by climate change, disease and the use of pesticide.

The Mediterranean region landscape has been shaped over thousands of years by low intensity and localised subsistence farming activities. In this environment, several forms of sustainable agrosilvopastoral farming systems have evolved, making best use of natural resources while creating a complex mosaic of semi-natural habitats rich in wildlife. For instance, Kerstin Sundseth (2009) describes the *dehesas* and *montados* of the Iberian Peninsula as a prime example of a sustainable multifunctional agricultural system. These areas are capable of producing a whole range of different goods and services (e.g. shade and food for livestock, cereal production, timber charcoal and cork) while striking a delicate balance between productivity and wildlife conservation.

The main mechanisms involved in livestock creating or maintaining specific habitats are selective grazing, nutrient redistribution, treading and seed distribution (Wrage *et al.*, 2011). In several cases, their significance has been illustrated by the unexpected and undesirable consequences of the removal of livestock from particular ecosystems,

3 - Nature.com (www.nature.com/news/global-biodiversity-report-warns-pollinators-are-under-threat-1.19456).

such as wildfires that regularly sweep across the Mediterranean region in late summer, causing damage to property and wildlife. Around 600,000 hectares have been estimated to burn every year in the Mediterranean area (Alexandrian, 1999; Morandi, 2002). Grazing by domestic livestock reduces the wildfire risk by limiting the shrub and herbage biomass and maintaining landscape heterogeneity (Ruiz-Mirazo and Robles, 2012). For instance, in agro-pastoral ecosystems in the rural community of Sistelo, in northern Portugal, the association between cattle and the maintenance of pasturelands hinders encroachment caused by natural succession and prevents wildfires (Rodríguez-Ortega *et al.*, 2014). In Croatia, the Slavonian Syrmian Podolian native cattle breed plays an important role in maintaining the grasslands in the Lonjsko Polje Nature Park. In Greece, a project implemented by the Society for the Protection of Prespa in Lake Mikri Prespa has shown that grazing by water buffalos effectively controls the re-growing of reeds and thus plays an important role in the creation of wet meadows. This is beneficial not only for biodiversity since wet meadows are important for the lake ecosystem (spawning grounds for fish, feeding grounds for birds, etc.), but also for the economic activities of local people (fishing, use of reed beds for buffalo food and thatch for barns, etc.).

Status of plant and animal diversity

Species, varieties and breeds diversity

The Mediterranean region is particularly known for its plant diversity, with c. 25,000-35,000 native species (around 10% of the world's vascular plants) of which 13,000 are endemic to the region (Myers *et al.*, 2000). This exceptional concentration of endemic species (see Table 1) is the reason why the Mediterranean region is the third richest hotspot[4] in the world (Mittermeier *et al.*, 2004). The vascular flora of the Mediterranean area is recorded in the online Euro+MedPlantBase. The region also has a high proportion of endemic terrestrial animal species, with 48% of the reptiles, 25% of the mammals and 3% of the birds populations in the world (Cuttelod *et al.*, 2008).

The Mediterranean region is one of the eight centres of cultivated plant origin and diversity, with over 80 plants, the most important of which are cereal crops, pulses, fruit trees, and vegetables. It is also a hotspot for traditional varieties (also known as landraces, local varieties or farmers' varieties) and hosts a large number of Crop Wild Relatives (CWR, i.e. wild plant taxa that have an indirect use derived from their relatively close genetic relationship to crops). According to the European Crop Wild Relative Diversity Assessment and Conservation Forum, approximately 25,000 CWR species are known to exist in Europe and the Mediterranean. They account for almost 80% of the area's flora.

4 - A region is qualified as a "hotspot" if it has at least 1,500 endemic vascular plants and has lost 70% or more of its original vegetation compared to its historical habitat cover.

Table 1 - Wild plant and animal species in the Mediterranean basin

Taxonomic group	Number of species	Number of endemic species	Percentage endemism
Plants	30,000	13,000	43
Mammals	330	87	26
Birds	600	16	3
Reptiles	357	170	48
Amphibians	115	71	62
Freshwater fish	400	253	63

Source: CEPF (2010).

In the livestock sector, more than 36 species of domesticated birds and mammals are used in food production. As of June 2014, the FAO DAD-IS describes 8,127 breeds across the world (both local and transboundary)[5] belonging to 19 mammalian and 17 avian species (Scherf and Pilling, 2015). Cattle, sheep, chickens, goats and pigs are the main livestock species in terms of numbers (the so-called "big five"). For the Mediterranean countries, 1,529 (1,250 local and 292 transboundary) breeds from 24 species have been reported (see Table 2). Among the Mediterranean sub-regions, the largest proportion of local breeds is reported in SWE, followed by BC and NENA. The "big five" species account for 77% (966) of local breeds and 71% (206) of transboundary breeds. The livestock species with the largest number of local breeds are sheep (311 breeds), followed by chicken (260 breeds) and cattle (164 breeds).

Table 2 - Number of local and transboundary livestock breeds in the Mediterranean area

	SWE	BC	NENA	Total Mediterranean area
Local breeds	804	305	141	1,250
Transboundary breeds*	151	143	71	292

* Transboundary breeds are counted once in each sub-region, where they occur. Thus, they are counted more than once.
Source: DAD-IS database.

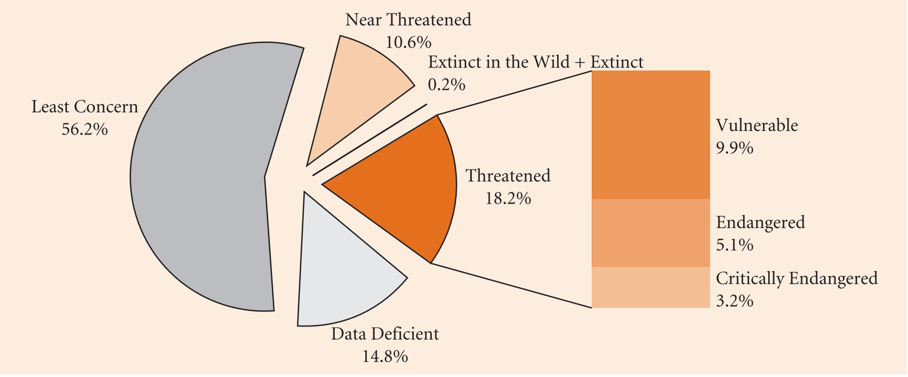
5 - Based on their geographic distribution, livestock breeds are classified into two categories: local and transboundary breeds. Local breeds are breeds that occur only in one country, while transboundary breeds occur in more than one country.

Conservation and risk status of plant and animal resources

Data on the conservation status of wild species in the Mediterranean region is increasing but it is not easily accessible at regional, national or thematic level. Selected key sources of information on biodiversity that include Mediterranean countries are the Biodiversity Data Centre (BDC) and the Red List of Threatened Species elaborated by the International Union for the Conservation of Nature (IUCN). The IUCN Red List classifies the threatened species into three categories (vulnerable, endangered and critically endangered) based on several biological factors such as the rate of decline, population size, area of geographic distribution, and distribution fragmentation. In the Mediterranean region, of the 405 terrestrial and freshwater wild plant species, accounting for 1.6% of the region's flora, that have been assessed using the IUCN Red List criteria, 52 are threatened at the global level (13% of the assessed taxa). However, the number of assessed plants is too low for this percentage to represent the actual pressures on the Mediterranean plant diversity. In fact, the estimated number of Mediterranean plant species to be assessed varies between 3,000 and 4,000. On the other hand, an adequate number of wild animal species (about 3,500 terrestrial animal species, mostly vertebrates) has been assessed for the IUCN Red List (IUCN, 2015). The proportion of threatened terrestrial animal species in the Mediterranean is about one fifth (18.2%) (see Figure 1). Moreover, globally, 20.4% of terrestrial animal populations are decreasing, 3.7% are increasing and 31.2% are stable. These trends should be considered with caution as population data is limited (the trend is unknown for 41% of the assessed taxa).

The high biodiversity in the Mediterranean is also reflected in the c. 18,000 protected areas (terrestrial, freshwater or marine) that are recognised, dedicated and managed through legal or other effective means, covering up to 18% of each country's surface (United Nations Environment Programme – World Conservation Monitoring Centre).

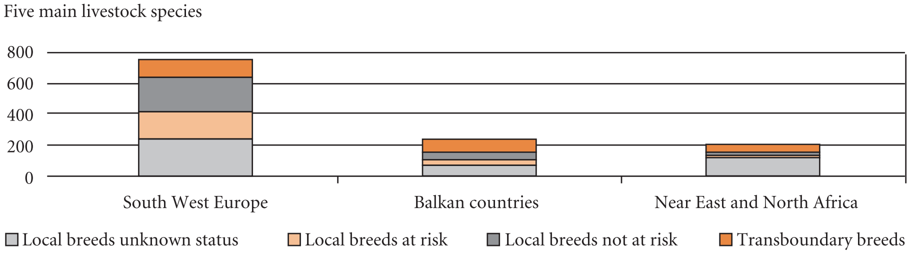
Figure 1 - Conservation status of Mediterranean wild animals assessed for the IUCN Red List of Threatened species



Source: data exported and analysed in July 2015.

Regarding PGR, data on selected crops shows a large rate of extinction in the Mediterranean area. For instance, only 5 to 10 out of 382 almond cultivars remain on the island of Mallorca (Socias, 1990). Information on the status of AnGR also remains far from complete as a large part of Mediterranean local breeds (45%) is classified as being of unknown risk status due to lack of recent population data (see Figure 2). This proportion ranges from 37% in SWE to 45% in BC, and is particularly high in NENA (82%). However, it should be noted that the level of information varies substantially across species. For instance, 83% of local chicken breeds have an unknown status in SWE, a large part of which corresponds to French breeds.

Figure 2 - Breed status of the main livestock species (cattle, sheep, chickens, goats and pigs) according to regions



Countries included: Albania, Algeria, Bosnia Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Montenegro, Morocco, Portugal, Slovenia, Spain, Tunisia, Turkey.
Source: DAD-IS database.

Threats to plant and animal diversity

Threats to wild plant and animal diversity

The major threats to wild biodiversity include unsustainable agriculture, habitat loss and degradation, invasive alien species, unsustainable hunting and harvesting, wildfires and climate change. Agriculture, including conversion of wild lands and intensification, is a threat for biodiversity worldwide. For the period 2007-2013, the major threats caused to European habitats in the Natura 2000 Network are associated with agriculture (EEA, 2015). Animal production impacts on biodiversity are mostly due to the conversion of natural areas into pastures and forage production areas, as well as overgrazing. In eastern Mediterranean countries (including BC countries), overgrazing of pastoral lands is the most significant threat to Important Plant Areas (IPAs)[6] in more than 50% of the sites, whereas deforestation, tourism, intensification of arable farming and unsustainable collection of plants affect over one third of the IPAs (Radford *et al.* 2011).

A worldwide study on the negative impacts of food wastage on biodiversity (taking into account only mammals, birds and amphibians) has shown that agriculture is responsible for 66% of threats to species, with production of crops to be twice as damaging as livestock production (FAO, 2013). Another study focusing on the Mediterranean region, which took into account vertebrates, has identified the most

6 - Important Plant Areas (IPAs): areas of landscape that have been identified as being of the highest botanical importance.

important threats to Mediterranean species as, by order of importance, habitat loss and degradation, agriculture intensification, overexploitation (unsustainable harvesting, hunting and fishing), natural disasters, invasive alien species[7] (IAS) and human disturbance (Cuttelod *et al.*, 2008).

IAS have significant negative impacts on biodiversity as well as on economic activities (e.g. spreading diseases to domestic plants and animals). In the Mediterranean region, invasive plant species as well as several terrestrial invasive animal species impose an important threat (Vlachogianni *et al.*, 2013). For instance, *Oxalis pes-caprae*, a plant native to southern Africa, and one of Europe's 100 worst invasive species, is now established in Spain, France, Malta, Italy, Greece and Turkey and North Africa.

The region is considered as vulnerable to climate change. The prospects for the climate point towards a general rise in temperature with more and longer periods of higher temperatures and with changes in precipitation and distribution of water (EEA, 2002). The predicted warming and drying of the Mediterranean region, as well as the increase in extreme climatic and fire events, are likely to have a significant effect on the biodiversity. Climate change is expected to result in a shift of a large proportion of Mediterranean basin species (Thuiller *et al.*, 2005) and to facilitate IAS in various ways: 1) new species will enter specific regions and may become invasive; 2) species hierarchies in ecosystems will change, leading to new dominants that may have invasive tendencies; and 3) climate induced stress in an ecosystem will facilitate invasive pathways (Masters and Norgrove, 2010).

Unsustainable harvesting of wild plants and hunting of animals are also important factors threatening biodiversity. Increased demand for North African wild plants coupled with unsustainable collection from the wild (including for firewood) has led a number of important plant species to become scarce in areas where they were previously abundant (Cuttelod *et al.*, 2008). An estimate of 500 million birds are hunted as they migrate through the Mediterranean each year, most of them in North Africa and the Middle East (Project LIFE04 SUSTAINABLE HUNTING).

Global warming and seed germination: the case of *Nepeta sphaciotica*, an alpine Cretan endemic plant

Climate change will particularly affect the geographical distribution and conservation status of narrow endemic species of Mediterranean mountains. *Nepeta sphaciotica* is a critically endangered species of European Community priority with a single population occurring in the Lefká Óri Mountains (Crete), at c. 2,300 m a.s.l. Seed germination of the species occurs in late spring after snowmelt, triggered by a temperature rise above 15 °C, an adaptation to avoid seedling emergence after seed dispersal, during the fall. The anticipated, warmer autumn temperatures (c. +5 °C as projected by the rather moderate climatic scenario B2a) will induce untimely seed germination that will undoubtedly result in seedling demise during the prolonged period of snow cover (or by freezing temperatures in case of no snow) thus jeopardising the population regeneration and, in the long run, the species survival itself.

Source: Thanos and Fournaraki (2010).

7 - Alien species (often referred to as non-native, non-indigenous or exotic species) are plants, animals, fungi and microorganisms that have been transported inadvertently or intentionally across ecological barriers and have established themselves in areas outside their natural range.

Threats to domestic plant and animal diversity

The driving forces behind the erosion of PGR and AnGR diversity are diverse and often act in conjunction. At global level, the major ones include the agricultural sector trends, which have been expanding, intensifying and scaling-up. These trends were favoured by enabling policies and legislations. While disasters and emergencies are additional risk factors, climate change will become more relevant in future.

Sector trends. The "Industrialisation" of production systems, resulting in intensification, scaling-up and geographical concentration, has been a response to the increasing demand for food products. This industrialisation was favoured by technological developments that enable production environments to be controlled and genetic material to be transported around the world. The first *Report on the State of the World's Animal Genetic Resources* (SoW-AnGR) noted that the intensification of the livestock sector led to the more widespread use of a narrow range of international transboundary breeds, often exotic to the countries where they were being used (Rischkowsky and Pilling, 2007). Increased use of these exotic breeds and particularly indiscriminate crossbreeding are viewed by the second SoW-AnGR as the main factors driving to the erosion of AnGR along with weak AnGR management policies and programmes, and low competitiveness of local breeds in terms of output levels (Scherf and Pilling, 2015). Obviously, several of these factors are closely related. The Mediterranean region did not derogate from this trend, particularly in the dairy and poultry subsectors. Changes in the farming structure are important, potentially putting at risk locally adapted multipurpose breeds and their small upland and mountain farmers (Montgomery, 2014).

Agricultural intensification also contributes to decreased crop diversity, mainly *via* the introduction of modern cultivars. In Greece, local varieties of cereals were displaced by superior modern varieties, and nowadays account for hardly 1% of the total allocated acreage. An analogous trend is becoming apparent in vegetable crops (FAO, 2010). The use of a small number of highly selected commercial breeds and cultivars to produce food causes a reduction of genetic diversity between and within species and thus the resilience capacities.

Policies and legislations. Sector trends that threaten plant and animal diversity can be favoured by public policy and legislation. This is the case when production systems that harbour diverse plant and animal populations are adversely affected, whether directly or because of competition from other production systems or imported products that benefit disproportionally from such policy and legislation. Therefore, policies that promote the introduction of high external input production systems or the use of exotic animals can pose a threat to locally adapted breeds (Rischkowsky and Pilling, 2007).

Disasters, emergencies and climate change. Catastrophic events such as earthquakes, floods and disease epidemics have the potential to kill large numbers of animals in a short period of time. They are a particular threat to breed populations that are concentrated within a limited geographical area. In addition, the actions taken to deal with such emergencies, such as the restocking of livestock populations using exotic animals, can also be a threat to AnGR.

Climate change will affect the geographic distribution of crops, traditional varieties and CWR. This impact will depend on the sensitivity of traditional varieties to climate variability, the environmental conditions present in their centre of diversity, and the management, preferences and incentives for the farmers who grow them (Bellon and Van Etten, 2014). Some varieties will evolve and adapt to these changes by adjusting their phenological stages to changing growing season and possibly altered yields.

Climate change will ìmpact livestock production systems in many ways. For example, if temperatures increase, heat stress in the animals themselves may become an increasing problem. According to a survey, dairy cows in the hotter southern European countries spent more than half of the day under heat stress, resulting in an estimated milk loss of up to 5.5kg/cow/day (FeedInfo News, 2015). In Italy, M.I. Crescio *et al.* (2010) reported that high temperatures and air humidity during breeding season increased cattle mortality risk by 60%. The availability of feed and feed quality, and the prevalence of diseases and parasites can also be affected by changes in the local ecosystem. These effects have the potential both to kill large numbers of animals in a short period of time and to gradually disrupt livelihoods, which are based on livestock keeping. If changes are rapid, the adaptive link between a breed and the production environment in which it has traditionally been kept may be broken.

Capacities in the management of plant and animal diversity

Legal agreements and institutional capacities

The international legal framework for biodiversity includes several international conventions and agreements. The majority of the Mediterranean countries are signatories to these agreements (see Table 3), which provide the foundation for the establishment of common strategies for biodiversity management in the region. In fact, some regional legally binding agreements exist for the conservation of biodiversity such as the "Habitat" and "Birds" Directives for the countries of the European Union, the African Convention on the Conservation of Nature and Natural Resources (or Algiers Convention) and the Bern Convention for Europe and some African countries.

Biodiversity-related Conventions

– *The Convention on Biological Diversity* (CBD) (UNEP, 1993) is the leading global agreement to address the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising from the use of genetic resources.

– *The Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) (UNEP, 1975) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

– *The Convention on the Conservation of Migratory Species of Wild Animals* (CMS or Bonn Convention) (UNEP, 1982) aims to conserve terrestrial, marine and avian migratory species and their habitats.

– *The International Treaty* (ITPGRFA) (FAO, 2004) and the Global Plans of Action for Plant (GPA-PGR) (FAO, 2010) and Animal (GPA-AnGR) (Rischkowsky and Pilling, 2007) Genetic Resources for Food and Agriculture promote the conservation and use of PGR and AnGR for sustainable agriculture and food security.

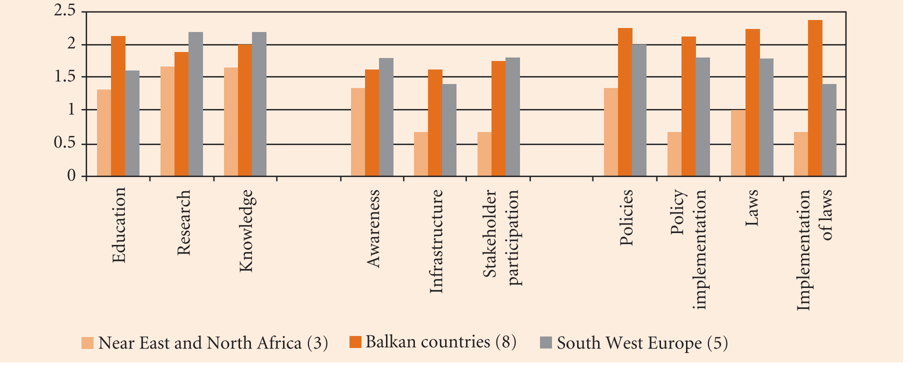
– *The Convention of Wetlands of International Importance* (or Ramsar Convention) (IUCN, 1975) ensures the conservation and wise use of wetlands and their resources.

– *The International Plant Protection Convention* (IPPC) (FAO, 1952) aims to protect domestic and wild plants by preventing the introduction and spread of plant pests.

All Mediterranean countries have signed the CBD, the latest member being the Palestinian Territories in January 2015. To implement the Convention, most countries have developed National Biodiversity Strategies and Action Plans, and/or integrated them into broader national and regional plans for environment and development. For the other agreements, the level of implementation and enforcement varies between sub-regions and among countries within a sub-region, depending on many factors such as institutional and human capacities as well as the level of awareness.

An assessment of the adequacy of legal and policy measures, and institutional and human capacities for the management of AnGR in the Mediterranean countries was conducted using the country reports prepared as part of the 2nd SoW-AnGR process. Six countries indicated having strategies and action plans endorsed by their respective government and five indicated that they are developing such instruments. Overall, countries reported greater capacities for education, research, and policies and legislation and their implementations, compared to their capacities in infrastructure, awareness and stakeholder participation (see Figure 3). NENA countries reported lowest levels of capacities, whereas those reported by BC and SWE countries are almost equivalent.

Figure 3 - State of capacities reported in different area of animal genetic resources management



The countries (Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Montenegro, Morocco, Portugal, Slovenia, Spain, Tunisia and Turkey) provided a score for the state of capacities in each area, which were converted into numerical values (none = 0; low = 1; medium = 2; high = 3).
Source: Country reports.

Table 3 - Major international and regional conventions, treaties and protocols related to biodiversity governance, and their ratification by the Mediterranean countries

Country	International Conventions										Regional Conventions			
	Convention on Biological Diversity (CBD)			CITES	CMS	Ramsar Convention	WHC	FAO		Algiers Convention	Barcelona Convention	Bern Convention	Habitats & Birds Directive	AEWA
	The Convention	Nagoya Protocol	Cartagena Protocol					ITPGRFA	IPPC					
Albania	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
Algeria	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Andorra	✓					✓	✓					✓		
Bosnia and H.	✓		✓	✓		✓	✓		✓		✓	✓		
Croatia	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
Cyprus	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Egypt	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
France	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
FYROM*	✓		✓	✓	✓	✓	✓	✓	✓			✓		✓
Greece	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Israel	✓			✓	✓	✓	✓		✓		✓			✓
Italy	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Lebanon	✓	✓	✓			✓	✓	✓	✓		✓			✓
Libya	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Malta	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
Monaco	✓			✓	✓	✓	✓				✓	✓		✓
Montenegro	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
Morocco	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
Portugal	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
San Marino	✓			✓			✓							
Slovenia	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Spain	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Palestinian Territories	✓		✓				✓							
Syria	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓
Tunisia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Turkey	✓		✓	✓	✓	✓	✓	✓	✓		✓			

* FYROM: Former Yugoslav Republic of Macedonia.
Source: authors.

National activities for the management of genetic resources

According to country reports prepared as part of the 2nd SoW-AnGR process, AnGR inventory and monitoring activities are low in NENA, intermediate in BC and high in SWE. A similar trend is observed for *in situ* conservation, whereas *ex situ* in vitro conservation activities exist mainly in SWE – 80% of countries in SWE reported having in place in vitro gene banks, compared to 43% in BC and 33% in NENA. The level of implementation of activities contributing to structured livestock breeding programmes (animal identification, pedigree and performance recording, etc.) are reported as high for SWE, intermediate for BC and low for NENA countries. On the other hand, the extent to which the management of AnGR is integrated with the management of plant, forestry and aquatic genetic resources was reported as being none to limited in most of the sub-regions (see Figure 4). However, a few exceptions do exist. For instance, Portugal focuses on the conservation and maintenance of some of its local breeds by supporting agrosilvopastoral ecosystem services, prime examples being the Alentejo and Bísaro pigs, which maintain oak forest as they roam freely feeding on acorns.

Figure 4 - Extent to which the management of animal genetic resources, in the Mediterranean sub-regions, is reported to be integrated with the management of plant, forestry and aquatic genetic resources

	Near East and North Africa (3)	Balkan countries (8)	South West Europe (5)
Development of joint national strategies or action plans	0.3	0.7	0.8
Collaboration in the characterization, surveying or monitring of genetic resources, production environments or ecosystems	1.0	0.5	0.7
Collaboration related to gentic improvement	0.3	0.2	0.5
Collaboration related to product development and/or marketing	0.0	0.5	0.5
Collaboration in conservation strategies, programmes or projects	0.3	0.7	0.5
Collaboration in awareness-raising on the roles and values of genetic resources	1.0	1.0	0.7
Training activities and/or educational curricula that address genetic resources in an integrated manner	0.3	0.7	0.7
Collaboration in the mobilization of resources for the management of genteic resources	0.0	0.5	0.7

None=0, limited=1, extensive=2; number of countries (Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Montenegro, Morocco, Portugal, Slovenia, Spain, Tunisia and Turkey) in parenthesis.
Source: country reports.

Value addition is important for the sustainable use of local genetic resources which are often less productive than commercially bred and intensively raised breeds or varieties. Higher per unit prices of products help compensate for lower quantities. Differences between the sub-regions exist with regards to their efforts to register products and market them with specific quality labels. The EU Database of Origin and Registration (DOOR)[8] shows that five SWE countries (France, Greece, Italy,

8 - European Commission (http://ec.europa.eu/agriculture/quality/index_en.htm).

Portugal and Spain) together have 922 registered labels and 62 submitted ones; they also have 877 entries in the Slowfood Ark of Taste[9]. Among the NENA countries, only Morocco has one DOOR submission. However, Algeria, Egypt, Jordan, Libya, Lebanon, Morocco, the Palestine Territories and Tunisia have 64 entries in the Ark of Taste. These differences indicate cultural differences in the attachment to regional or special foods and a history of labelling local products (which is highest in SWE), but also the technical and financial capacity to engage in registration and compliance procedures related to product differentiation (which may explain the low DOOR registrations from BC and NENA).

Examples of collaborative activities in the Mediterranean region

–*The IUCN Mediterranean Species Programme* encourages the development and availability of scientific data on Mediterranean species and focuses on species' assessments at global and regional level and key biodiversity areas in the Mediterranean.

– *The World Wildlife Fund (WWF) Mediterranean Programme* aims to conserve forest and freshwater ecosystems and to promote sustainable environmentally friendly practices.

– *The European and Mediterranean Plant Protection Organization (EPPO)* develops strategies against the introduction and spread of dangerous pests and to promote safe and effective control methods.

– *The European Cooperative Programme for Plant Genetic Resources (ECPGR)* aims at ensuring the long-term conservation and facilitating the increased utilisation of plant genetic resources in Europe.

– *The European Gene Bank Network for Animal Genetic Resources (EUGENA)*, coordinated by the European Regional Focal Point for Animal Genetic Resources, collaborates with national gene banks for AnGR to develop an integrated regional conservation approach in Europe.

– *The GALIMED project* (*Genetic Adaptation of bovine Livestock and production systems in Mediterranean region)* characterised nineteen cattle breeds from eight Mediterranean countries in order to study the genetic basis of local cattle breed adaptation to local environments.

– *The DoMEsTIc project (MEditerranean bioDiversity as a tool for the sustainable development of the small ruminant sector)* investigates the factors that influence the sustainability of pastoral and rangeland production systems in four Mediterranean countries. It aims also to provide tools for the valorisation of local genetic resources and their access to markets.

– *The International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)* is an international organisation based in the Mediterranean, actively involved in the fields of agriculture, food, fishery and rural territories, aiming to respond to the needs of the States and of the agro-food actors.

– *The International Centre for Agricultural Research in the Dry Areas (ICARDA)* research and training programme covers most southern countries of the Mediterranean. It focuses on strengthening the sustainable use of sheep and goat genetic resources.

9 - Slow Food Foundation (www.fondazioneslowfood.com/en/what-we-do/the-ark-of-taste/).

Conclusion

The Mediterranean area is undoubtedly a major centre for both wild and domestic biodiversity. This richness plays a key role in food security and nutrition and serves as a source of income and other services that people need for their livelihoods and welfare. The loss of biodiversity, caused by agricultural intensification, tourism, demographic increase and climate change, threatens the sustainability of existing ecosystems and ultimately leads to waste of natural resources, primarily affecting the livelihood of poor rural communities.

The majority of the Mediterranean countries have signed biodiversity related conventions and agreements. These should be translated into national policies and strategic plans for the sustainable management of plant and animal genetic resources promoting the integration of agro-ecosystem approaches. All Mediterranean countries should take more active steps to implement the FAO Global Plans of Action for animal, plant and forest genetic resources for food and agriculture, the Strategic Plan for Biodiversity 2010-2020 and achieve the Aichi Biodiversity Targets adopted by the CBD, many of which promote sustainable food production and decrease of food waste.

The characterisation, inventory and monitoring of status of plant and animal genetic resources should become a priority, particularly for southern Mediterranean countries. They are required for the establishment of early-warning and response systems that can rapidly identify those varieties and breeds at risk, allowing quick and well-defined actions to be taken. The conservation of plant and animal genetic resources in both *ex situ* collections and *in situ*/on-farm should also become a priority. Cross-border cooperation projects and networks are effective tools for knowledge transfer among stakeholders working on biodiversity conservation. Likewise, the establishment of networks for the preservation of traditional knowledge linked to crop and livestock production should be promoted. For plants, the storage of seeds in local farmer driven seed banks is the most effective and low-cost method for their long term-conservation.

Moreover, the promotion of initiatives for adding value to the products of local crops and breeds through commercial differentiation and niche marketing is needed. Different quality schemes can be used (protected designation of origin, protected geographical indication or traditional specialty guarantee). Niche markets, which require a relatively high level of organisation among producers, a reliable marketing chain, well-organised marketing campaigns and an effective policy or legal framework, normally emerge in more affluent economies. However, several success stories in the countries of eastern and southern Mediterranean are also recognized and deserve to be supported.

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CHAPTER 7

ENERGY AND AGRI-FOOD SYSTEMS: PRODUCTION AND CONSUMPTION

John **Vourdoubas**, *CIHEAM*
Olivier **Dubois**, *FAO*

The objective of this chapter is to present the role of energy in the Mediterranean agri-food sector and to discuss the possibilities. Agri-food chains require large amounts of energy and produce various wastes that can be utilised for energy generation. Therefore, these chains are both consumers and producers of energy. Additionally, rural areas can explore their renewable energy potential in order to increase energy supply and create additional incomes to the farmers. Improvements in energy efficiency and higher use of renewable energies in this sector can increase its sustainability. Considerations regarding how developed and developing countries differ in terms of energy efficiency and bioenergy are very relevant to discuss links between energy and agri-food systems in the Mediterranean Basin because the region includes both types of countries.

After a presentation of global issues, this chapter provides an overview of energy mix and discusses challenges and opportunities regarding energy efficiency and increased renewable energy in the Mediterranean agri-food sector. We briefly address the relevance of the water-energy-food nexus approach to tackle energy issues in the agri-food sector in the region before stressing the importance of gender equality in the production and consumption energy in the sector in order to enhance its sustainability.

Global considerations on energy in agri-food systems

Current energy consumption in agri-food systems is unsustainable on the long term (FAO, 2011). Food systems currently consume 30% of the world's available energy, with more than 70% occurring beyond the farm gate, and produce over 20% of the world's greenhouse gas emissions (around 31% if land-use change is included). At the same time, about one-third of the food we produce is lost or wasted, and with it about 38% of energy consumed in food systems. Moreover, modern food systems are heavily dependent on fossil fuels. According to estimations, in the next decades there will be significant and simultaneous increases in water, energy and food needs. These will lead to a degraded and depleted natural resource base, and increasing climate change challenges (FAO, 2014a).

Modernising agri-food systems by increasing the use of fossil fuels, as in the past, will be neither an affordable nor a sustainable option because of climate change and the impact of high and volatile fossil fuel prices on production costs and food prices. As a result, due consideration to energy and its links with water and food production and its use in agri-food systems development is crucial. In particular, the agri-food value chain will have to become gradually decoupled from fossil fuel dependence so that it can deliver more food with less and cleaner energy. To address these challenges, "Energy-Smart" agri-food systems are required including improved access to modern energy services through integrated food and energy production, improved energy efficiency, an increased use of renewable energy and the promotion of a water-energy-food nexus approach throughout agri-food chains.

Improvement in energy efficiency is generally considered as the best strategy to reduce CO_2 emissions, to limit energy dependence and to alleviate the effect of oil prices increase (MEDENER, 2013). Energy intensity is a useful indicator of energy efficiency. The evolution of this factor in recent decades provides some interesting findings (Schneider and Smith, 2009). Globally, energy intensity in agriculture significantly increased until the mid-1980s; after which it decreased. This is a crucial change as it shows that in recent years agriculture has managed to produce more food per energy input. However, this global trend masks important differences between industrialised/OECD and newly-industrialised or developing countries: while both types of countries have experienced a reduced intensity in land and workers' use, the energy intensity of fertilisers and agricultural machinery has decreased in industrialised countries since the beginning of the 1980s, whereas it has steadily increased in developing countries since 1965. These differences can be explained by two factors. Regarding OECD countries, a combination of the collapse of high input agriculture for example in the USSR countries in the mid-1980s, more efficient use of inputs through increased adoption of "precision agriculture"[1] starting at the same period, and the increase in the implementation of *low* or *zero tillage* techniques. "Precision agriculture" technologies are often rather "high tech" and involve significant capital investment. Therefore, even if farmers in developing countries had access to them, these technologies are generally too expensive for smallholders and only viable for middle-to large-scale farmers.

Regarding newly industrialised and developing countries, the steady increase in energy intensity has been dominated by high external inputs farming systems, especially in China and India. However, it is also important to mention low external input systems that may have a relatively high energy intensity in case of low production associated with limited external energy uses, or obtain good results in terms

1 - "Precision agriculture" (also called "precision farming" or "site specific management") is defined as the application of a holistic management strategy that uses information technology to bring data from multiple sources to bear on decisions associated with agricultural production, marketing, finance and personnel.

of energy intensity where low levels of external inputs are associated with energy inputs coming mainly from human or animal labour. In this case good performance is explained by a more integrated use of resources (crops and livestock for example), and the more systemic use of agricultural residues as inputs to the farming system – hence reducing the need for external and fossil fuel-dependent inputs. Such farming systems all over the world (Pretty *et al.*, 2006), are therefore a valid option for farmers who cannot afford "precision agriculture".

Changes in energy efficiency are often difficult to explain because. 1) They depend on the technical performance of the energy used, the importance of energy transformations, climate conditions (heating and cooling needs), the structure of each economic sector that uses energy (MEDENER, 2013). 2) The data available on energy efficiency in agriculture does not consider post-harvest stages; although in many cases, especially in industrialised agriculture, most of the energy consumed in agri-food chains occurs at those stages. This is also partly because a significant proportion of food losses and waste – and related energy losses – occur at post-harvest stages. In developing countries, these losses often occur at storage, transport and processing stages. Adequate access to energy at these stages, including from the use of agricultural residues, can significantly contribute to reducing such losses. 3) Different causes can lead to similar trends. Indeed, the increase in precision agriculture, the collapse or underdevelopment of the agricultural sector, but also low input agriculture can result in low energy intensity. Table 1 presents possible ways to improve energy efficiency in agri-food systems.

Agriculture has a unique link with energy as it can both consume and produce energy, the latter through bioenergy whose use is very old (wood for heating and cooking for example). It currently accounts for about 10% of the world energy mix. Bioenergy being the only renewable source of energy that can replace fossil fuels in all energy markets (heat, electricity and transport) its share in the future energy mix is bound to substantially increase up to 25-30% according to the latest estimates (IEA, 2010).

Again, here, a distinction should be made between developed and developing countries. In many developing countries, bioenergy is the most accessible source of energy in rural areas. It is therefore often used for domestic purposes (cooking and heating) and when it is done in an unsustainable way it can lead to forest degradation and deforestation. So far, production and use of modern bioenergy is not very common. On the other hand, in developed countries and some emerging economies (e.g. Brazil, India, China), modern bioenergy is much more common, be it in the shape of biofuels or the industrial use of woody biomass.

Among the different types of bioenergy, liquid biofuels (often simply called biofuels) have been the most controversial ones. The most controversial aspects – at least for first generation ones based on sugar, starch and oils – concern their environmental and food security risks, more particularly when produced on a large scale. These risks are mainly related to possible biodiversity loss and increase in GHG emissions caused by land conversion; the latter with possible competition for land between energy and food crops, and the impact on food prices caused by the diversion of crops to biofuel production. However, as with many products based on land and natural resources, liquid biofuels are not bad or good *per se*. It all depends on how they are managed, including feedstock and land choice, farming practices, and other stages of the biofuel supply chain. Based on some recent work conducted by the FAO[2] and others, knowledge on good practices to minimise risks and harness the opportunities associated with liquid biofuels has been shared: agro-ecological zoning, sustainable yield increase, integrated food energy systems and outgrower schemes.

Table 1 - Examples of energy efficiency improvements in the agri-food sector through direct or indirect interventions

	Directly	Indirectly
Pre-harvest	Fuel efficient engines/maintenance Precise water applications Precision farming for fertilisers Adopting no-till practices Controlled building environments Heat management of greenhouses Propeller designs of fishing vessels	Less input-demanding crop varieties and animal breeds Agro-ecological farming practices Reduction of water demand and losses Energy efficient fertiliser and machinery manufacture IT identification of fish stock locations
Post-harvest	Truck design and operation Variable speed electric motors Better lighting and heat processes Insulation of cool stores Minimised food packaging Technology transfer and education Improved efficiency of cooking devices	Improved road infrastructure Reduction of food losses at all stages Matching of food supply with demand Promotion of diets with a lower consumption of meat Decrease in obesity levels Labelling of food products

Source: FAO (2011a).

Residues from agriculture and forestry are often considered as a win-win solution regarding the production of bioenergy. However, great caution is needed concerning possible competing uses of these residues. In particular, for small-scale producers, such residues are often the most accessible source of fertiliser and soil protection,

2 - FAO's work includes a project on Bioenergy and Food security (BEFS), Bioenergy and Food security Criteria and Indicators (BEFSCI), a decision Support Tool on Sustainable Bioenergy (with UNEP), and Integrated Food Energy Systems. More details can be found on the FAO bioenergy website (www.fao.org/bioenergy).

as well as animal feed. The FAO has developed tools that allow the assessment of how much residue would be available for bioenergy purposes, both at territorial and farm levels.

Energy availability and energy trends

The Mediterranean region is far from being homogeneous when it comes to energy. Firstly, there are differences between NMCs that are all developed countries and SEMCs, which are at different stages of development (from very wealthy to relatively poor). This matters a lot from an energy point of view as emerging economies and developing countries will experience significant increase in energy needs in the future. According to the estimations, energy needs in SEMCs will double from 2000 to 2020 (GEF, 2008). Secondly, while some countries are oil producers and exporters, several Mediterranean countries are energy dependent and energy importers. Moreover, this situation has been changing in several countries of the eastern Mediterranean region including Cyprus, Israel, Jordan, Lebanon, Syria and the Palestinian territories. Recent discoveries of large hydrocarbon resources, particularly natural gas, are going to alter their energy landscape: they might be able to cover their energy demands and probably export hydrocarbons to European countries, as in the case of Algeria and Libya. Moreover, it seems quite probable that large offshore hydrocarbon reserves will be discovered soon in the territories of Greece and Turkey thus reducing their energy dependence. However, all Mediterranean countries will have to decarbonise their agri-food systems by reducing their use of fossil fuels – be it domestic or imported – in order to address climate change challenges. Finally, an additional differentiation can be made between countries that enjoy political stability and those, mainly SEMCs, which have faced political instability and social uprisings.

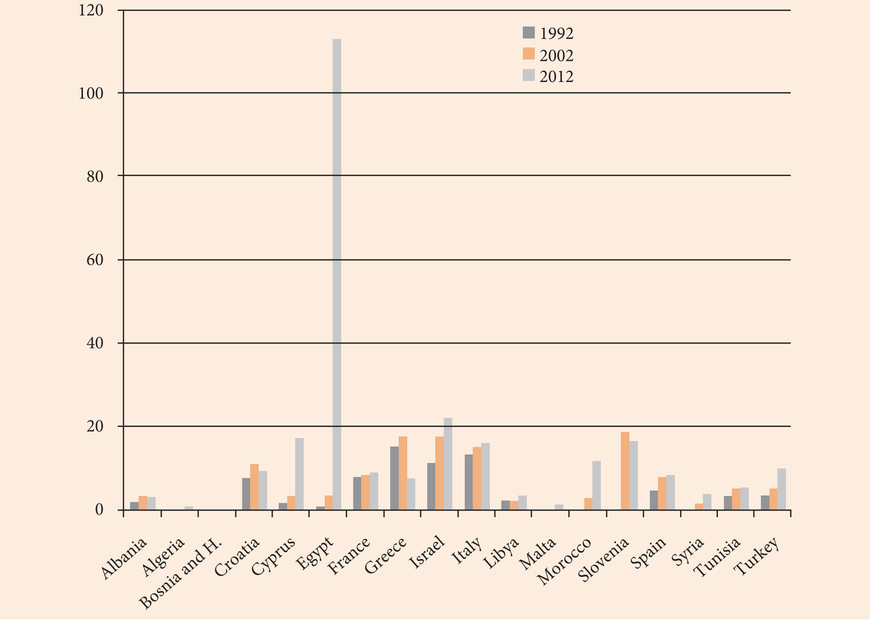
The above-mentioned differences do not allow for generalisations regarding the energy situation in agricultural sector in the region as a whole. However, one can reasonably say that Mediterranean countries: 1) Heavily depend on fossil fuels regarding their energy supply – this dependency is estimated at 75-90% (Fader *et al.*, 2014); 2) In the SEMCs, energy demand in the Mediterranean Region as a whole may increase by 65% during the period 2010-2025 (ENPI, 2014) due to population growth and economic development; 3) All countries have a high potential for improving energy efficiency and using renewable resources.

Energy efficiency

As regards energy efficiency, over the period 2000-2010, the primary intensity of most countries has decreased, except in Morocco and Algeria (that is also an oil exporter) where fossil fuel use in agriculture is subsidised. In southern countries, this decline was 2.5 times slower than in EU countries, except in Tunisia and Lebanon (MEDENER, 2013). This situation is less clear regarding the agricultural sector, as illustrated in Figures 1, 2 and 3 which present energy intensity of agriculture (up to the farm gate) in a sample of countries for the years 1992, 2002 and 2012 per unit of land, monetary value and food supply, respectively (FAOSTAT, 2012)[3].

A few interesting observations emerge from these Figures. Broadly speaking, energy intensities in agriculture (i.e. pre-harvest) are higher in SEMCs than in NMCs. In some cases there are different trends when one compares energy intensity per hectare and energy per value added and food supply (Israel, Italy and Tunisia). With the exception of France, all NMCs show a reduction of energy intensity in agriculture between 1992 and 2012. The picture is more varied regarding SEMCs. Water pumping for irrigation is a key factor in energy intensities. For instance, in 2010, energy consumption for pumping was close to 1 toe per irrigated (toe/ha) hectare in Morocco against 0.6 toe in Tunisia (MEDENER, 2013). In the fisheries sector, energy intensity depends a lot on the fishing technique: for example in Tunisia, in 2010, fire fishing was less energy consuming (0.3 toe/tonne of fish) than trawler fishing (2.2. toe/tonne) (MEDENER, 2013).

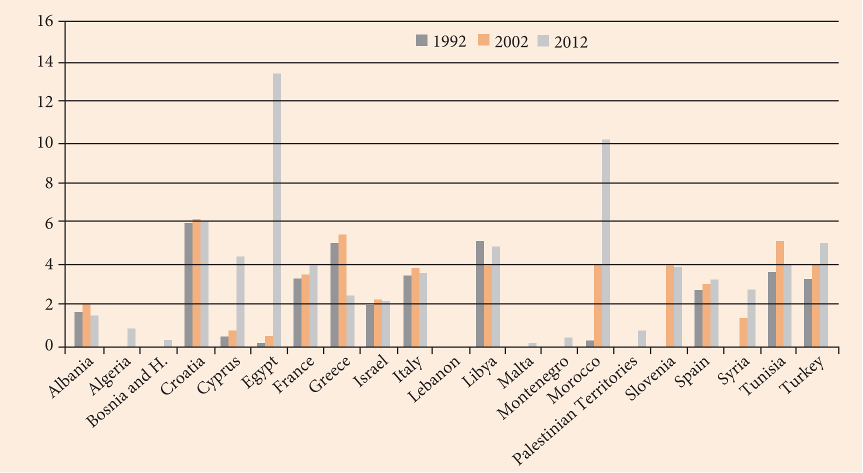
Figure 1 - Energy intensity according to arable land (GJ/ha)



Source: FAOSTAT (2012).

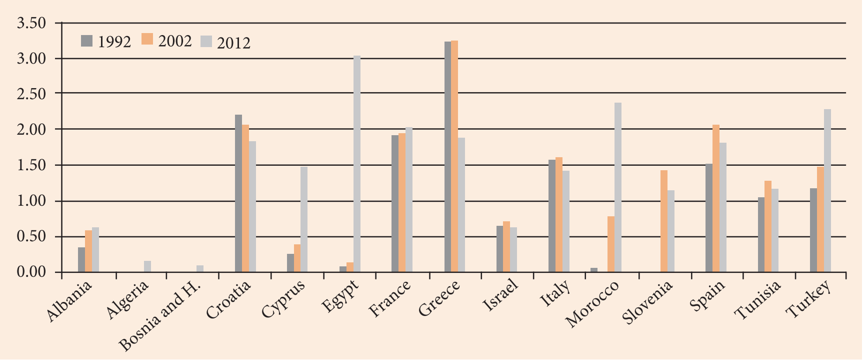
3 - The value for Egypt in 2012 seems abnormally high and might therefore result from a reporting error.

Figure 2 - Energy intensity according to the monetary value of agricultural production (MJ/$)



Source: FAOSTAT (2012).

Figure 3 - Energy intensity according to food supply (MJ/kcal)



Source: FAOSTAT (2012).

Many of the barriers that prevent investments in energy efficiency are common across all sectors: limited knowhow of policy makers, little awareness of energy efficiency of consumers and the financial sector, lack of technical capacity to develop and implement energy efficiency projects, limited access to affordable financing, subsidised energy prices and organisational and institutional gaps and overlaps (IEA, 2014). Governments can improve energy efficiency results by adopting a cross-sectoral approach to addressing implementation barriers, such as the lack of private-sector capacity and/or insufficient institutional coordination. IEA (2014) makes the following recommendations to improve energy efficiency in SEMCs:
– Establishment of energy data collection capacity;
– Development of national energy efficiency plans;

– Facilitation of private investment;
– Designation of lead energy efficiency institutions; and
– Progressive removal of energy price subsidies.

A recent study showed that most Mediterranean countries have implemented energy efficiencies programmes at different stages (Blanc, 2012). It foreseed that energy intensity in the Mediterranean should fall perceptibly by approximately 13% over the next twenty years. However, given the programmed energy mix (mostly fossil fuels), this will not limit emissions of CO_2, which are likely to increase by more than 90%. This is where the promotion of renewable energy in the region comes as a useful complement to energy efficiency.

Renewable energy

Exploitation of renewable energy is one pathway for Mediterranean countries to minimise their dependence on imported fossil fuels and reduce GHG emissions. Their potential for deployment in the Mediterranean Basin is very high but it is still largely underexploited, especially in non-EU countries. Renewable energies, particularly biomass, solar and wind energy are more used in NMCs compared to SEMCs.

Wind energy. With a long coastline, the Mediterranean region has an abundant potential for wind energy. As shown in Table 2, northern countries have many more wind farms compared with southern countries. Among the countries that have not yet developed wind farms, some are situated in areas with high wind potential and can easily increase their power generation thanks to this energy.

Table 2 - Wind power capacity and number of wind farms by country (2010)

Country	Number of farms	Capacity (MW)
Morocco	15	286
Algeria	1	14
Tunisia	3	20
Libya	1	20
Egypt	8	550
Jordan	3	2
Israel	1	6
Turkey	54	1,329
Greece	102	1,208
Italy	266	5,797
Spain	881	20,676
Portugal	245	3,702

Source: Bloomfield *et al.* (2011).

The integration of wind energy projects in the agri-food sector is an interesting economic opportunity for agricultural enterprises in the region. However the development of wind energy projects require heavy capital investments and attractive financing mechanisms for farmers need to be established. Capacity-building in terms of wind project development and management is also necessary. The next Box briefly describes a project in the Canary Islands where wind energy is used to desalinate water for agriculture.

On-grid wind energy for water desalination in the Canary Islands

The Canary Islands have neither local fossil fuel resources, nor abundant fresh water natural sources. However, there is plenty of wind, sun and seawater. The main water demand comes from the agricultural sector, which has a long tradition in the archipelago (fruits and vegetables are the main crops). The guarantee of a reliable and good quality water supply at competitive costs for this sector in the eastern islands is only possible with the production of desalinated water (in some islands, there is almost a 100% dependence on desalination for the water supply).

The location of crops in windy areas close to the shore is a clear advantage when considering the combination of electricity generation from wind power and water production from desalination plants. The local government has been a pioneer in creating a specific regulation to promote the simultaneous implementation of a wind farm associated with the energy consumption of a local industry. Firstly, it was the public water companies on the eastern islands (Lanzarote and Fuerteventura) that owned SWRO (seawater reverse osmosis) desalination plants. According to regional legislation, the nominal power of the desalination plant must be at least 50% of the installed wind power and the annual balance of electricity consumed by the SWRO unit must be 50% or more of the electric energy generated by the wind farm.

An illustrative example is the initiative of a local agriculture cooperative (Soslaires Canarias S.L.) which installed a 5,000m^3/d SWRO plant associated to a grid-connected 2.64MW wind farm (4 x 660kW wind turbines) in Playa de Vargas (East of Gran Canaria Island), with a total investment of 5.2 million euros (wind farm 46%, SWRO plant 21%); both installations were commissioned in 2002. The desalination plant occupies an area of around 450m^2 and is able to produce up to 1.5 million cubic meters per year for the irrigation of more than 150 hectares. The water produced is of high quality (slightly over 400ppm) and the plant has an excellent specific energy consumption (approx. 7.9MJ/m3, equivalent to 2.85kWh/ha of irrigated land). The annual electric energy balance (wind energy production minus energy consumption due to water production) is positive, avoiding the emission of more than 6,000 tonnes CO_2/year.

The management and technical staff for the tasks related to the wind farm and desalination plant is composed of seven technicians with a total personnel cost of around 150,000 euros/year. Thanks to the water quality and the constant water supply, the diversification of crops and ratio of productions has changed drastically. Prior to this investment, tomatoes were the only crop. Now more than fifteen types of vegetables (gourds, beans, kidney-beans, cucumbers, etc.) are being cultivated. Although the cost of the desalinated water is higher than the existing (low quality) groundwater, the income increment has been significant for local farmers.

Source: FAO (2014b).

Solar energy. The Mediterranean region receives one of the highest solar radiation in the world. Large availability of unexploited lands in the region, especially in SEMCs, makes solar energy systems, especially photovoltaics an attractive proposition for regional countries. Agricultural farms in the Mediterranean region can use PV systems for domestic as well as commercial power generation. Solar energy is often used in greenhouses and irrigation.

Controlled environment agriculture such as greenhouse horticulture is an interesting farming system as it can increase sustainable food production and food safety by, *inter alia* simultaneously reducing the use of natural resources such as land and water to produce food, allowing cultivation in unsuitable land and environments, stabilising seasonal productivity and reducing risks resulting from extreme events and climate change and increasing the income per unit of land, hence raising the revenue of small family farms (Adami and Battistelli, 2015). However, control of the agricultural environment requires energy and average energy use accounts for 10% to 30% of total production costs, depending on the region (FAO, 2013). If the required energy can be produced onsite from renewable sources in a cost effective way, then the overall system can be self-sustaining.

Vegetable growers can adopt a range of greenhouse system technologies including solar energy to improve climate control and energy use. However, there are numerous obstacles and constraints to overcome. The existing technology and knowhow developed in northern European countries are generally not directly transferable to the Mediterranean: high-level technology is beyond the means of many growers in SEMCs due to the high cost compared with the modest investment capacity; and knowhow from northern European growers is often inappropriate with regards to the problems encountered in the Mediterranean region (FAO, 2013). The next box briefly presents the case of photovoltaic energy in Greece.

Photovoltaic energy in Greece

The rapid development of solar-PV in Greece during the last six years led to the achievement of the national targets for photovoltaic energy set for 2020, seven years in advance. Currently Greece covers 5% of its electricity needs with PV power and is ranked 5th in the world in terms of installed PV power per capita. The Greek government provided various incentives to promote these investments, thus supporting the rapid growth of this energy in the country: capital subsidies to the investments but mainly attractive feed-in tariffs for the generated power (initially the feed-in tariffs were in the range of 0.40 to 0.55 euro per kWh but later the tariffs decreased substantially) coupled with contracts to sell the generated power according to a grid of predefined prices for twenty to twenty-five years. This has pushed thousands of people to invest in this technology. Most of the photovoltaic parks have been installed in agricultural areas; which can be categorised as follows: PV installations with nominal power of over 200kWp; PV installations with nominal power of 20-200kWp and PV installations of 3-10kWp placed on the roofs of various buildings. It is estimated that over 50,000 companies and individuals have invested in PV cells in Greece creating around 50,000 direct and indirect new jobs. The total invested capital in solar-PVs in Greece currently exceeds a few billion Euros.

Residents in agricultural areas have benefited from the growth of solar-PVs in Greece. They have increased their income by investing in this sector. Nevertheless, in recent years, changes in the common agricultural policy of EU have led to the reduction of solar-PVs. Due to relatively high irradiance, electricity generation from PV in Crete is approximately 1,500kWh per kWp installed. In addition to the feed-in tariff initiative, in the end of 2014, the government offered a new initiative related to net-metering: this measure promoted the installation of PVs in residential buildings or in enterprises in order to balance the generation of electricity produced and consumed by the network; the household or enterprises had therefore the possibility to zero their electricity bills and thus make energy savings. The growth of PVs and other renewable energies for the generation of electricity such as small hydro, wind parks and biomass power plants will allow the transformation of the existing power system in a decentralised mode where electricity will not only be generated in few large plants using mainly fossil fuels but it will be generated in many decentralised plants using various renewable energy sources. In Crete, electricity is currently generated by over a thousand decentralised power plants compared with two central plants, which operated in the island two decades ago. Decentralised power plants using local renewable resources will obviously be mainly located in agricultural areas where the inhabitants will significantly benefit from this transformation.

Source: Vourdoubas (2015).

Irrigation is widely used in the Mediterranean region, and it is a major consumer of energy in agriculture. A lot of attention has therefore been focused on how to achieve better energy efficiency and promote the use of renewable energy (solar in particular) in irrigation activities. A recent study on solar irrigation in the Mediterranean concluded that (Fader *et al.*, 2014):

– Climate change will very likely increase irrigation requirements.

– Improved irrigation technology and distribution systems have a large potential for saving water.

– More energy will be needed for irrigation in future, whether because of higher irrigation water requirements or due to more extensive pressurised systems.

– Photovoltaic panels could produce the energy needed for irrigation.

– The areas needed for photovoltaic panels are small enough to be placed on roofs of agricultural buildings without hindering agricultural production.

Summary of the key messages of the FAO-GIZ workshop on "Prospects for Solar-Powered Irrigation Systems (SPIS) in developing countries"

1) *Solar energy for irrigation is a technically mature option and can constitute an alternative to the conventional sources of energy.* There are however, preconditions for investing in SPIS, such as tenure security, right investment and technological knowhow requirements that depend on site-specific conditions and specific needs and skills of farmers.

2) *Currently a knowledge and information gap surrounding SPIS still persists.* More communication and exchange regarding SPIS experiences at different levels is needed to scale-up efforts and to promote their use.

3) *Under the right circumstances, SPIS technology can benefit small-scale farmers.* SPIS has been successfully piloted at small-farm levels and can substitute non-solar irrigation solutions, depending on the socio-economic and political conditions of the local context.

4) *Capacity building is needed for all actors involved in the design and implementation of SPIS*, including users, service providers and where appropriate, local manufacturers.

5) *Finding the right financial mechanisms and business models to support SPIS is a major challenge*. Many types of mechanisms exist and there is no agreement on which systems work better. *There is however consensus around the fact that while necessary, subsidies should be "smart" i.e.* it should be clear from the beginning that they are a temporary solution and should lead to market-based financial mechanisms.

6) *There is currently a lack of policies that account for the above considerations and also a lack of regulations regarding quality insurance and control.*

7) *Different institutional arrangements exist regarding the implementation of SPIS.* No conclusion was reached on the pros and cons of these different arrangements.

8) *Pilot SPIS might be needed to convince decision-makers to develop the right policies and institutions to scale up SPIS*. Such pilots should involve relevant stakeholders at both local and national levels from their onset.

9) *The above considerations clearly show that action to promote sustainable SPIS*: should occur at both farm and national levels and adopt an integrated and inclusive approach (e.g. nexus and sustainable livelihoods); and takes time – often up to 3-4 years – between concept and implementation.

Source: FAO/GIZ (2015).

In May 2015, FAO and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the German international cooperation agency for development organised a workshop on "The prospects of solar-powered irrigation systems in developing countries". The previous Box presents a summary of the key findings as they are relevant to SEMCs.

Bioenergy. The Mediterranean region has abundant biomass energy resources, which have remained largely unexplored. According to conservative estimates, the potential of biomass energy in the Euro-Mediterranean region is about 400TWh per year (Zafar, 2015a). Traditionally, biomass energy has been widely used in rural areas for domestic purposes in the MENA region, especially in Egypt, Yemen and Jordan. The escalating prices of oil and natural gas, the resulting concern over energy-security, have led the MENA countries to explore alternative sources of energy.

Large quantities of crop residues are generated in the region every year and they are vastly underutilised. Currently, these residues are usually ploughed back into the soil, or they are burnt, left to decompose, or grazed by cattle. These residues can be processed into liquid fuels or thermos-chemically processed to produce electricity and heat in rural areas. Use of residues of vineyards and wine have been used successfully in an existing winery in Sicily for power generation (Corona *et al.*, 2010): the nominal power of the plant is 950kW. The generated power in injected to the grid and sold at an attractive feed-in tariff that is higher than the buying price. The electric efficiency of the plant is 22% and the annually generated power is higher than the annual plant consumption. As demonstrated the above-mentioned example, biomass use for energy generation results in many environmental, economic and social benefits. The first Box presents a biogas project in Jordan while the second explains the case of use of olive tree by-products for heat generation in Crete.

Biogas Plant at Rusaifeh Landfill

In collaboration with the United Nations Development Programme (UNDP), the Global Environment Facility (GEF) and the Danish government, the Jordanian government established a 1MW biogas plant at the Rusaifeh landfill near Amman in 1999. The plant has been successfully operating and its capacity has recently been increased to 4MW. The project consists of a system of twelve landfill gas wells and an anaerobic digestion plant based on 60 tonnes of organic wastes per day from hotels, restaurants and slaughterhouses in Amman. The successful installation of the biogas project has made it a role model in the entire region and several big cities are striving to replicate it.

Source: Zafar (2015b).

Utilisation of olive tree by-products for heat generation in Crete

Olive trees grow across the Mediterranean enabling the production of excellent edible olive oil. Olive tree byproducts produced during the processing of olives like olive kernel wood are very good solid fuels used extensively today for heat generation. Olive paste from olive mills after the extraction of olive oil is further processed in olive kernel oil producing plants where olive kernel oil and olive kernel wood are produced. Olive kernel wood has very good burning qualities and heat content 3,700-4,100 kcal/kg at moisture content of 12%. It is used as heating fuel in olive mills, various small and medium enterprises, greenhouses and various residential and other buildings. The current total olive kernel wood production in Crete is approximately 110,000 tonnes/year and its price about 0.08 euro per kg, which is significantly lower (compared with its heating value) than the price of heating oil. Burnt according to locally manufactured simple systems with an efficiency of about 70-80%, it is a preferable fuel for heat generation in Crete and in Greece particularly in the present context of severe economic crisis. Olive kernel wood is not currently used for power generation in Crete although there are projects for the cogeneration of heat and power. Olive tree wood is also an excellent solid fuel used for heat production in open fires and wood stoves mainly in residential buildings. Various efforts have been recently made in Crete for the production of wood pellets from olive kernel wood and "olive biomass" produced from the processing and refining of olive kernel wood is available on the market.

Table 3 - Prices of various energy sources in Crete (2015)

Energy source	Price (€/1,000kcal)	Efficiency (per cent)	Price (€/1,000kcal delivered)
Olive kernel wood	0.022	70	0.036
Fuel oil	0.045	0.095	90
Heating oil	90	0.050	0.106
Electricity	0.116	100	0.116
Electricity/heat pump	0.116	200-250	0.046- 0.058

Source: Vourdoubas (2015).

The high potential of biomass, solar and wind energy in the Mediterranean basin and the current developments in solar-PV and wind energy technologies allow the generation of additional incomes for farmers due to the production of electricity with governmental support and various policies. In areas facing economic problems due to low food production or low food prices, the possibility of generating biomass, sun and wind energy offers the local population new ways to increase its income and standard of living. Attractive feed-in tariffs for electricity generated from these renewable energies with a low nominal capacity of 5 and 100kWp combined with the decrease in installation costs (for solar devices) have the potential to boost their investments. Additional incomes resulting from energy savings can also be obtained from households or small and medium enterprises with a net-metering policy allowing them to install renewable energy systems with capacities of 3 and 50kWp in their premises. The high potential of solar, wind and biomass in the region allows the establishment of energy cooperatives at local and national level. This practice that is already common in many European countries ensures the exploitation of renewable energy locally, generating electricity and selling it to the grid. Therefore, together with agricultural cooperatives, energy cooperatives can bring additional economic benefits to local populations.

More broadly, the establishment of or the support provided to producer associations and consumer associations promoting access to modern energy in rural areas creates opportunities to gain experience in the running of civil society organisations representing and involving rural people and communities. The latter will therefore participate more actively in decision-making processes. Moreover, providing a feeling of modernity, access to energy has a transformational effect: their involvement in a successful small business activity, the co-operative management and sustained income generation develop their self-confidence. Producer organisations and cooperatives can also reduce investment and operations costs regarding renewable energy systems and improve access to knowledge. All these factors are likely to have knock-on effects on entrepreneurship, community organisation and give way to new future ventures. This is especially the case for decentralised bioenergy production and use, as this type of energy lends itself more easily to the development of local value chains (Practical Action Consulting, 2009).

The water-energy-food nexus

The production of food and energy as well as the use of water, energy and land that it involves, are closely interwoven. Referring to the Mediterranean region, more specifically to SEMCs, many of the development issues are related to water, energy and agriculture and food issues because many people in the region do not have access to satisfactory services in these areas. In this context, the water-energy-food Nexus has emerged as a useful concept to describe and to address the complex and interrelated nature of our global resource systems, on which we depend to achieve different social, economic and environmental goals.

In practical terms, the Nexus Approach helps to better understand and systematically analyse the interactions between the natural environment and human activities, and to work towards a more coordinated management and use of natural resources across sectors and scales. This can help to identify and manage trade-offs and to build synergies through our responses, allowing for more integrated and cost-effective planning, decision-making, implementation, monitoring and evaluation (FAO, 2014a).

In order to make the Nexus concept operational, three non-sequential sets of activities should be undertaken through adequate stakeholder involvement (FAO, 2014a):
– Evidence refers to the collection and analysis of data to discuss and identify the interlinkages of water, energy and food systems and the impacts that any change can have on the system;
– Scenario development refers to the possible impacts of interventions or policies on the natural environment and society. Specific interventions are identified, assessed and discussed;
– Response Options where different stakeholders engage in an open and participatory dialogue to build consensus among themselves on specific policy issues and to decide on how to intervene.

The symposium "Agrosym 2014" has raised the issue of the crucial importance of understanding the complex relationship between water, energy and food systems and the necessity to develop a sustainable and secure future for the Mediterranean region (Hamdy *et al.*, 2014). This study suggests that, in order to achieve water, energy and food goals, there is need for a coordinated harmonised Nexus knowledge base and data base indicators and metrics that cover all relevant spatial and temporal scales and planning horizons. A full life cycle analysis across the nexus is also required. Such an improved nexus understanding could underpin new decision and policy making in a green economy framework. The next Box presents two typical cases where a water-energy-food Nexus Approach helps address trade-offs and foster opportunities in energy for agriculture.

Nexus examples that are relevant to the Mediterranean Region

Solar energy for irrigation

The irrigated area in the Mediterranean region has doubled over the last forty years and now represents a fifth (21%) of the total cultivated agricultural land in the region (Plan Bleu, 2008). Shifting from rain-fed to irrigated production would increase irrigation demand by 137% (166 km^3/yr) whilst CO_2 emissions would rise by 270%. At the same time, clean energy solutions like solar irrigation that provide energy at limited or no operational costs bear the risk of depletion of water tables due to over-pumping. They also face other challenges and bear opportunities. In order to support the sustainable intensification of agriculture, particularly in the Mediterranean region, there will be a need for low cost, reliable, efficient irrigation systems that avoid excessive groundwater pumping supported by policies that recognise trade-offs but also promote synergies between saving water, reducing CO_2 emissions and intensifying food production.

Wind energy for water desalination

Many arid zones of the southern and eastern Mediterranean face simultaneously population growth leading to the depletion of underground water reservoirs due to irrigation and drinking water increasing needs and pollution of surface waters. Water desalination has been tested as a possible solution to address these challenges. However, water desalination is quite energy intensive. Therefore, conventional desalination systems consume a lot of fossil fuel to produce electricity to run the operation. Solutions involving the use of renewable energy exist. However, these schemes are often knowledge and capital intensive. There is a trade-off between the use of capital and knowledge for sophisticated technologies versus using more conventional ones.

The Nexus Approach is most useful in situations where at least one of the elements (water, energy or food) is scarce. It is therefore of particular relevance to the southern and eastern countries of the region, as most of them face water scarcities and several challenges in terms of energy and food security. The GIZ has started to support the Arab League regarding nexus regional dialogues and the EU will also provide its support as from 2016.

Gender considerations in the agricultural production and consumption of energy

According to the FAO (2011c), closing the gender gap in agriculture would generate significant gains for the agricultural sector and for society. If women had the same access to productive resources as men, they could increase yields on their farms by 20 to 30%. This could raise total agricultural output in developing countries by 2.5 to 4%. Production gains of this magnitude could reduce the number of hungry people in the world by 12 to 17% (FAO, 2011c).

In developing countries, men and women experience the lack of access to modern energy in a very different way. In particular, in rural areas, traditional socio-cultural roles make things more difficult for poor women when compared to men. Many women are compelled to spend a lot of their time in drudgery (fetching water, carrying wood, and processing food by hand) due to the lack of water pumps, modern fuel sources and grain mills. Access to energy can therefore free women for more rewarding and productive activities. As a result, they could become more interested in creating energy cooperatives using local renewable energies (such as solar and bioenergy from the waste generated during farming and cattle breeding) and increasing energy supply (such as the use of solar-PV energy for collective water pumping) since they experience the difficulties when carrying wood fuel from long distances. Women might also be keener to use energy-saving techniques in their homes and their working facilities particularly if they gain access to micro credit to support their investments in renewable sustainable energy, which is necessary to promote sustainable energies among them. According to a recent study by the International Centre for Research on Women (ICRW) (2012), engaging women in the development and distribution of a (renewable energy based) agricultural technology, which in turn enables their access and use of technology, generates a positive chain reaction with extensive outcomes. This process unlocks two key pathways to economic progress for women by enhancing women's productivity in existing economic activities and by creating new economic opportunities for women. The same report makes the following recommendations regarding gender aspects related to energy and agriculture:

– Gender responsiveness must become a core practice;

– Complementary services that facilitate consumers access to technologies should be tailored to ensure that women can benefit from them and that facilitate the pathways to women's economic advancement;

– Technology development efforts that seek to economically promote women must recognise the buyer/end user distinction when marketing technologies. Men often make decisions about technology purchases and control family finances, even if women are end users. Thus, expressed demand for technologies among women may not translate into realised demand if female users have little control over household spending;

– Demand generation efforts should appeal to larger numbers of female users by targeting marketing and awareness-raising efforts at women, as well as men, and making clear the potential economic benefits of using technologies;

– Technology development and distribution initiatives must measure their efforts to reach women and address their constraints in accessing and using technologies for their economic advancement;

– Investors and donors should attempt to create networks that enable technology investees and enterprises to exchange knowledge and best practices on achieving scale and economically advancing women; and

– In order to ensure that self-employed women are able to access and effectively use the powerful tools of technology, there needs to be an emphasis on economic empowerment, in addition to economic advancement.

Conclusion

The agri-food sector is both a consumer and a potential producer of energy. While the highest priority should be to ensure adequate access to modern energy services along agri-food chains, this should be as much as possible achieved concomitantly with improvements in energy efficiency and gradually, increased use of renewable energy, in order to decouple their development from their current high dependence on fossil fuels. The FAO Energy-Smart Food for People and Climate Programme addresses these challenges.

While Mediterranean countries display diverse energy situations, they all depend heavily on fossil fuels; many eastern and southern countries will experience a significant increase in energy needs due to important and simultaneous population and economic growth. All countries in the region have significant potential for improvement in terms of energy efficiency and use of renewable agriculture. These considerations also apply to the agri-food systems in the region.

Combining energy efficiency with more use of renewable energy would reduce the dependency of agriculture on fossil fuels and contribute to the reduction of GHG emissions from the sector. However, this will require improvement in policy and institutional measures, in particular regarding financial support, better considerations of gender aspects and support to producer organisations, standards and guaranteed markets. Promotion of gender equality in energy issues particularly in poor areas is very important in order to support and mobilise women in sustainable energy production and consumption. Women are likely to be keen in promoting energy and water sustainability and if they have access to micro-credit, they could increase energy sustainability using energy-saving techniques and local renewable energies. Combined with political stability in some countries in the region, all these measures are required to promote investments and sustainability in "Energy-Smart Food" in the Mediterranean. Currently, there is international support to promote both improved energy efficiency and increased use of renewable energy in the region. Such support should also be adequately provided for the agri-food sector.

Since many people in SEMCs do not have access to adequate energy, food and water resources, securing adequate levels of these resources is very important in order to ensure sustainable development. This requires a water-energy-food Nexus Approach, especially because scarcity means that trade-offs have to be addressed, and that possible synergies should be explored. The FAO Nexus Approach reflects this willingness to promote dialogue between water, energy and food in southern and eastern Mediterranean countries.

Due to the increasing overlap of the water-climate-energy Nexus and the strong link between agriculture and energy consumption, the CIHEAM has decided to confer a significant place to energy issues in its Post-2015 Agenda, particularly through the implementation of the MED-SPRING. Moreover, the highly complementary mandates and actions of the FAO and the CIHEAM paves the way for the establishment of a partnership between the two organisations involving both the expertise of the CIHEAM and its Institutes and the knowledge of the FAO on this matter.

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CHAPTER 8

THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT IN THE MEDITERRANEAN

Mélanie **Requier-Desjardins**, *CIHEAM*
Dorian **Kalamvrezos Navarro**, *FAO*

The eight Millennium Development Goals (MDGs) came to their conclusion at the end of the year 2015. The MDGs have been a milestone in global and national development efforts, catalysing important actions by governments and the wider international community in support of poverty eradication and human development. However, progress in achieving these eight MDGs has been uneven across regions and countries. In addition, the siloed approach of MDGs with regards to development objectives and their insufficient emphasis on sustainability have represented critical shortcomings that the new development agenda has aimed to address. Their disproportional focus on achieving economic growth and improving education and health left little space for trifling over the ecological aspirations of MDG 7 ("Ensure environmental sustainability"). After the first Rio Conference on Sustainable Development held in 1992, much of the MDG era was still characterised by the illusion of competing demands between economic, social and environmental progress.

In September 2015, the international community approved the 2030 Agenda for Sustainable Development as a successor framework to the MDGs, including seventeen new Sustainable Development Goals (SDGs). The new Agenda makes a resounding statement for addressing sustainability in all its dimensions, economic, social and environmental, while achieving the overall objectives of eradicating poverty and hunger. While the 2030 Agenda is intended as a global framework, not much discussion has taken place yet to consider what the new Agenda could mean for a region such as the Mediterranean, given its unique features, particular challenges and fragmented political integration. Although much progress has been made to achieve the MDGs in the region, several challenges remain to both ensure food security and reverse the degradation of natural resources. From 1961 to 2010, the region's ecological footprint increased by 54% whereas its biocapacity dropped by

21% indicating that socioeconomic progress heavily depends on natural resources and imports. Regarding sustainability priorities, the social pillar was very much promoted during the Rio Summit of 2002 (Johannesburg) which resulted in improved global socioeconomic conditions in the region; however, in the Mediterranean, this progress could be difficult to maintain and extend, due to a strong and costly dependency on resources as the Mediterranean environmental assets do not meet the region's demand (GFN, 2014).

Through the lens of agriculture and the sustainable use of natural resources, this chapter will outline the main challenges in the Mediterranean in the framework of the shift from the 2030 Agenda to the MDGs, highlighting critical improvements and gaps with respect to the new SDGs. It will then specifically focus on the main regional initiatives in the Mediterranean aimed at rural and agricultural sustainability, before an in-depth discussion on what it could mean and what it would take to implement the 2030 Agenda for Sustainable Development in the Mediterranean at regional, national and local levels.

The Role of Agriculture from MDGs to the 2030 Agenda for Sustainable Development

The 2030 Agenda for Sustainable Development and the seventeen SDGs and their 169 targets represent a radical shift from the MDG approach. They have adopted a fully integrated approach to sustainability, focusing on its three dimensions – economic, social and environmental; they are universal goals, which means they will apply to all countries and not only to the developing or least-developed countries. They are characterised by a strong country ownership and an inclusive process; they have adopted a more holistic approach, leading to a more integrated agenda, with critical sustainability dimensions covered under various Goals. They call for countries to mobilise domestic resources as well as enabling conditions to catalyse investments and resources, including, but not limited to, Official Development Assistance (ODA).

The new Agenda comes at a critical time and was welcomed by many, including the Mediterranean countries, which have contributed to its shaping through a patchwork of regional arrangements, including the Union for the Mediterranean, the United Nations Economic and Social Commission for Western Asia (UN-ESCWA), the Economic Commission for Europe (UNECE) and the Arab League. The world today is certainly very different to what it was in the year 2000, and while the narrow and segmented approaches of the past yielded some results, they can no longer carry us forward in the face of increasing environmental, social and economic challenges. Among the most pressing challenges facing the world today is feeding a growing global population projected to increase from over 7 billion currently to over 9 billion by 2050. This will require food production to increase by 60% globally and to nearly double in many developing countries (Alexandratos and Bruinsma, 2012). This challenge is compounded by the additional threats of climate change, increasing water and land scarcity, soil and land degradation, and a deteriorating natural resource base.

These threats will likely be felt more acutely in the Mediterranean, which has for some time been identified as a “climate change hotspot”. Climate change impacts in the region are becoming increasingly evident. Observations over the last decades show that temperatures have risen faster than the global average and that dry spells are becoming frequent. All model projections agree on the region’s future warming and drying with potential huge risks and costs to the region’s economy, population centres and biodiversity.

To a large extent, tackling these issues require investments in the capacities and the security of tenure rights of small-scale producers who still dominate the landscape around the Mediterranean, in order to help them remain stewards of natural resources and environmental wellbeing. The multidimensional causes of natural resource degradation require integrated actions across sectors to address the challenges. Better political and policy coherence, alignment, coordination and cooperation among agriculture, health, water, energy and other sectors are needed to improve global sustainability in consumption and production (CIHEAM, 2015). Reducing natural resource degradation and its associated social and economic costs, must begin with good governance of natural resource systems. The key lies in ensuring healthy and dynamic ecosystems that are more resilient to stresses and better able to cope with – and respond to – climate change, extreme weather events, emerging diseases, shifts in population patterns and economic disruptions and shocks.

Agriculture, a vector for sustainable development

Recent scientific research highlights the imminent reach of thresholds that will lead to irreversible changes in climate and ecosystems, and therefore in human societies. Agriculture is the main threat in five key areas: biodiversity loss, the disruption of nitrogen and phosphorus cycles, changes in land uses and water use challenges. Regarding the first two, these limits have already been surpassed (Costanza *et al.*, 2012). This means that the current level of food production already has excessively high marginal environmental costs. If global food production is to increase by 60% by 2050 without a drastic improvement in the sustainability of food systems, the costs for the environment and hence for human society will likely be overwhelming.

Compounding the challenge is the problem of food losses and waste, an estimated one-third of global food production is lost or wasted at different stages of the food chain (FAO, 2011a). While it is clear that food losses and waste exact an enormous toll on natural resources, the phenomenon has a variety of causes. Along the value chains and particularly with regards to processing and distribution methods, there are risks associated with the high concentration in the food industry on the one hand and a high concentration of produced varieties (with associated diversity loss) on the other hand.

Several proposals have been made in order to tackle the conundrum of increasing food production whilst ensuring the sustainable use and management of natural resources (FAO, 2011b, 2012a, 2013 and 2014). What is clear is that agriculture broadly understood (including crops, livestock, fisheries, forestry and aquaculture) is a critical priority sector in ensuring sustainable development, balanced in its three dimensions. Studies have demonstrated that agricultural growth is, on average, at least twice as effective in reducing poverty as growth originating in other sectors and up to five times more effective in resource-poor low-income countries. Productivity growth in agriculture generates demand for other rural goods and services and creates employment and incomes for the people who provide them, with benefits rippling from the village to the broader economy (FAO, 2012b). Simulations show that agriculture in green economy could produce 40 million additional jobs in the next forty years compared to a "business as usual" scenario (UNEP, 2011).

Also critical for the region will be the adoption of a more nutrition-sensitive approach to agriculture, wherein national policies and investments integrate nutrition objectives into food and agriculture policy and programmes, with the aim of ensuring food security and enabling healthy diets (ICN2, 2014). Whereas all the developing countries in the Mediterranean region have achieved the MDG 1.c target of reducing by half the proportion of undernourishment, progress on other fronts has been less encouraging. Out of the countries that have achieved the MDG 1.c target, only Turkey has also achieved the more ambitious World Food Summit target of halving the number of undernourished people. Across the Arab littoral of the Mediterranean, progress on stunting has been marginal in the last decade, even though the micronutrient deficiencies that account for this phenomenon have lasting effects on societies and economies. Moreover, the entire Mediterranean Basin has been affected by a "nutrition transition", where, as income and urbanisation increase, people gradually adopt a lifestyle with reduced physical activity and a diet of more energy-dense, semi-processed foods leading to an increase in overweight and obesity. In Arab countries, 45.1% of adults are obese, whereas obesity is over 20% in Malta, Spain, Turkey, Cyprus, Albania, Italy, Greece (ESCWA, 2013).

For any such progress to happen, agriculture must be decoupled from the degradation of natural resources and instead help increase productivity, reduce negative externalities and rebuild natural capital. The presence of significant risks generated by competition over land must also be recognised, as well as the competition between crops for food and those for bioenergy production. The appropriate instruments required to address these issues include integrated policy frameworks such as the "Voluntary Guidelines on the Governance of Tenure" (CFS, 2012) and the "Principles on Responsible Agricultural Investment" (CFS, 2014), as well as a broader rethinking of the many existing economic tools that penalise investment in the environment, such as price subsidies and subsidies for the combustion of fossil fuels and for food production. Such perverse incentives lead governments to effectively sponsor those practices that go against preserving the quality of environmental goods. Renewed regulatory frameworks will thus be needed to establish standards that regulate and promote sustainable agricultural practices.

It is clear from the above that agriculture lies at the heart of sustainability concerns reflected in the 2030 Agenda for Sustainable Development, providing the thread that links society, the economy and the environment. At the same time, agriculture is being, and will be, more affected by the ongoing deterioration of natural resources. Despite undeniable progress regarding food security improvement in the region, the impact of climate change may jeopardise these achievements by accelerating natural resources degradation and precipitating a decline in agricultural yields. Recent studies suggest that agricultural land will be reduced by a progressive desiccation of cropland in southern countries and by the flood risk related to the rise of the Mediterranean Sea (World Bank, 2014).

Sustainable rural development and the waste of natural resources

Regarding agriculture and rural development, the situation is rather contrasted between the South and the North of the Mediterranean; agriculture has many functions in both sub-regions though in different contexts. In the South, agriculture still dominates the rural economy and contributes to rural communities' livelihoods by providing jobs and food products (Campagne and Pecqueur, 2014). Rural tourism and agro-tourism are also developing, enhancing rural diversification, though reluctantly in view of the socio-political instability in many southern Mediterranean countries since 2011 and the lack of appropriate infrastructures. In the North, since the 1990s, the Common Agricultural Policy (CAP) was set up with the aim to improve the environment, landscape and social quality of rural areas. For decades, the CAP together with the rural development strategy guidelines fostered intensive farming practices until awareness was raised on serious health and environmental consequences. Some public health crises like the "mad cow disease" generated sufficient pressure from civil society to allow the development of alternative models of agriculture at political level, relying on the integration of social and environmental values at territorial level and the recognition of the multi-functionality of agriculture, the provision of environmental services by farmers and their contribution to economic diversification. Meanwhile, tourism has become a strategic opportunity for remote rural areas development. Alternative forms such as natural tourism, agro-tourism and ecotourism are flourishing, thus contributing to rural diversification.

Much progress has been made to achieve the MDGs in the region. Still, the waste of natural resources has become a serious constraint to sustainable rural and agriculture development. Moreover, local knowledge associated to natural resources management in specific contexts is also vanishing. As a matter of fact, in the Mediterranean, this knowledge loss is due to the significant transformations of rural societies and their agriculture over these last decades and also to the environmental degradation. Regarding rural societies, agricultural and economic policies have generally led to rural exodus, an increasing abandonment of land and agriculture by the youth, the ignorance of former practices and of their benefits for environmental quality and food production. Simultaneously, the emergence of a new type of agriculture funded by external investors that acquire land can contribute heavily to both the waste of natural resources and local knowledge (Bessaoud and Requier-Desjardins, 2014). Most investors usually prefer securing short-term gains without considering social and environmental associated costs.

Although the northern and the southern Mediterranean shores present important differences in their agricultural and rural development trends, sustainability is a common challenge for the entire region, the growth of inequalities, either economic, social or environmental, could quickly evaporate gains by generating more pressure on the region's natural resources, political stability and migration trends.

Main regional initiatives to address the challenge of rural and agricultural sustainability

Several regional initiatives have been launched in order to ensure sustainable development in the region. These initiatives have been substantially harmonised with the 2030 Sustainable Development Agenda process and the SDGs. They reflect a strong concern for improving coordination and governance in national decision-making processes.

The Mediterranean Strategy for Sustainable Development: towards an ecological approach to rural development

In 2005, the first Mediterranean Strategy for Sustainable Development (MSSD) was developed with a ten-year horizon under the coordination of the *Plan Bleu* and Mediterranean Action Plan (MAP) and in partnership with the countries of the region and major regional and international actors in the field of agricultural and rural development such as the CIHEAM and the FAO. The process and its outputs were closely aligned with the MDGs' structure and orientations. In 2014-2015, Mediterranean countries worked on the elaboration of the second Mediterranean Strategy for Sustainable Development (2015-2025) (UNEP-MAP, 2015a). The following Box presents the structure and objectives of this text.

Rural development according to the MSSD (2015-2025)

The MSSD focuses on the environmental dimension of sustainable development, highlighting the natural wealth of the region, the human pressures and the need to ensure development in the long run. The strategy has six main goals at two levels:

– Three are specific and linked to territorial reflections because they can be addressed jointly at local level: coastal and marine areas (1); natural resource management, production and food security and rural development (2); the management and planning of sustainable Mediterranean cities (3).

– Three are global and transversal: climate change as a priority for the Mediterranean future (4); the transition towards a blue and green economy (5); improving the governance to promote sustainability (6).

Agriculture is not a strategic objective *per se* but either a sub-objective of environmental targets or a target related to the access to markets. Main actions relate then to the development of sustainable rural tourism, the valorisation of local knowledge and to the capacity building of rural actors to enhance agricultural and rural sustainability.

Source: UNEP-MAP (2015).

Regarding agriculture and rural development issues, the second MSSD recommends an ecosystem approach integrating the different dimensions of sustainability. Indeed, the second target reaffirms that natural resources, rural development, and food security are interdependent components all contributing to collective wellbeing. Throughout the text of the second MSSD, appropriate legislation and regulations are referred to as relevant tools contributing to mainstream rural development. Environmental impact assessments are promoted to improve the management of natural resources within the economic objective of production.

Suggestions of better regulations include:
– The implementation of incentives for farmers to engage in agricultural practices that protect the environment and for industries to restore land and water resources that have been degraded due to extracting activities.
– The regulation of the competition over land between food security and energy objectives within agriculture.
– The evaluation of the processes of land attribution and of their conditionality. This is a critical issue because there are seldom constraints regarding the integration of environmental and social concerns in these arrangements (Vianey *et al.*, 2015).

Similarly to the SDG process, the second MSSD seeks to overcome intra-regional disparities to offer a single and coherent vision for the region's future. This may entail the harmonisation of some regulations regarding the environment at regional level. Governance has also been identified as a priority objective throughout the participative process of elaboration: sustainability cannot be reached without development practitioners and ordinary citizens being equipped to respond appropriately to global challenges. As the degradation of natural resources in one place can have impacts at regional level, collaboration between Mediterranean countries is therefore necessary for sustainability.

Two relevant regional initiatives: Climate Change Adaptation Framework and the OZHM

One of the three transversal sustainability issues in the MSSD relates to the necessity of climate change adaptation, given that the impact is expected to be particularly acute in the region. This has led to the elaboration of a Regional Climate Change Adaptation Framework for the Mediterranean Marine and Coastal Zones, still under development (UNEP, 2015). Five elements in the draft document of this strategy are already in line with the MSSD and the 2030 Agenda for Sustainable Development:
– The lack of shared scientific knowledge on climate risks, vulnerability impacts and adaptation in the Mediterranean. This is about broadly addressing the issue of capacity building at all levels and for all groups, as a prerequisite to the implementation of sustainability.
– The lack of transfer of existing knowledge to all the segments of society.
– The need to develop regional collaborative research networks to better generate and share knowledge, which relates to the issues of science and knowledge that are central to sustainability.
– The promotion of an enabling institutional environment for the integration of adaptation into national and local planning, including the implementation of

necessary reforms, which is in line with target two of the MSSD emphasising regulation and legislation to organise natural resources management in the ecosystems and rural development sustainability approach.

– The necessity to find suitable funding systems to increase investments to combat climate change and favour adaptation, which is related to innovative funding in the quest for sustainability.

Regarding agriculture and rural development, the strategy plans to identify the main geographical areas of vulnerability as a prerequisite for the development of contextualised adaptation actions, and to invest in research activities (for instance on agricultural seeds) and the monitoring of these adaptations. Knowledge is a core issue as all the above-mentioned orientations intend to limit the waste of knowledge.

Similarly, the Observatory of Mediterranean Humid Zones (OZHM) is a regional initiative referring to sustainability processes and focusing on the production of operational knowledge. The OZHM was created in 2009 as a unit coordination of thirty-four technical and institutional partners in the Mediterranean, including, conservation and development administrations, civil society organisations, higher education and research bodies and some representatives of both the Ramsar Convention on Wetlands and the Convention on Biological Diversity (UNCBD). It aims at: giving appropriate information on the state and tendencies of humid zones (1), identifying the threat and delivering appropriate orientations to promote their conservation, rational use and their restoration (2), and evaluating how these areas are considered in the Mediterranean sustainable development context (3). The OZHM approach is built on the DPSIR model (Drivers, Pressures, State, Impacts and Responses Model) initially developed by the Economic Organisation for Economic Cooperation and Development (OECD, 1992) and the European Environmental Agency (AEE, 1999) to promote sustainability in public policies. The Observatory also works in line with the SDGs approach, developing indicators of state pressure and tools that are coherent with the sustainable development approach. This coherence is crucial because country partners need to understand clearly how thematic or global initiatives can be interlinked and implemented at national and local levels.

The Observatory delivered its first assessment in 2012 (OZHM, 2012a and 2012b), which confirmed the disappearance of half the humid zones during the last century and the further degradation of most remaining areas, even when they are protected. It is a critical issue for sustainability, as humid zones are one of the main bases allowing the economic development of the region. The Observatory also identified a lack of skills and knowledge about ecological and environmental issues within the administrations in charge of development, both at local and national levels.

Local planning and the low consideration of environmental issues

The implementation of sustainable development norms encourages countries to develop planning processes at local scale and in a participatory manner. The OZHM has launched several studies to see how environment is taken into account in local planning processes and documents in the southern and eastern Mediterranean.

The analysis carried out on nineteen local planning documents shows that environment is marginal in the strategic axes that are declined into projects and actions. At local level, the environment is better represented, but mainly with a utilitarian vision considering the environment only for human needs. These results relate to both the institutional segmentation between development and environment administrations and a lack of skills and knowledge in the field of ecology and environment.

Capacity building on global challenges and the environment therefore appears as a main strategic and urgent target to promote sustainability, sound reflections and implementation at local level where the sustainability can be tangible, perceived and lived by all actors.

Source: Chazée et al. *(2013).*

The MSSD invites countries to focus more on environmental goals while elaborating development actions and encourages them to make flexible use of the regional framework and to develop and strengthen their national priorities. Countries can also refer to and benefit from other regional or global initiatives as they are in line with the SGD and the MSSD process. Regional cooperation is necessary in terms of collaborative production and sharing of knowledge.

Mediterranean regional cooperation: the Euromed and the European Neighbourhood Policy (ENP)

The Mediterranean region is influenced by European policies and cooperation projects in the context of the European Neighbourhood Policy (ENP). One main objective of the ENP is to reduce socio-economic disparities in the region and to integrate the environmental dimension in development projects. It is implemented through various channels and tools such as the cross border cooperation programme in the Mediterranean, ENPI CBC MED (European Neighbourhood and Partnership Instrument – Cross-Border Cooperation in the Mediterranean).

Since 2008, the cross border cooperation programme "Mediterranean Maritime Basin" aims at promoting socio-economic development (1), environmental sustainability (2), better mobility for people, goods and capitals (3), cultural dialogue and local governance (4). It is dedicated to private and public actors from the coastal regions bordering the Mediterranean and organised in cross-border partnership. Ongoing and ex-post capitalisation (2007-2013) shows that among the 95 funded projects, 38 concerned environmental issues such as water, waste, energy, natural resources and coastal areas. In order to better understand the place given to agriculture in the funded projects, one still needs to get back to the projects classification according to the three calls for tender. In 2008-2014, 32 projects have been funded according to environmental priorities. Among them, four deal with agriculture, more specifically with agricultural water (3) and agricultural pollution (1).

ENPICBC MED projects (2007-2013) and the marginal place of agriculture

With regards to the projects funded that address priorities other than strictly environmental, three of them focus on the "promotion of socio-economic development and the enhancement of territories" and the "promotion of agriculture and agrifood systems" and five others related to the "promotion of cultural dialogue and local governance" deal with agriculture. In total, when adding the four projects addressing interactions between environment and agriculture, there are twelve projects out of ninty-five that address agricultural issues: four are connected to environmental objectives, five to participatory governance processes and three to socio-economic development.

More broadly, regarding agriculture and rural development, only one EU ENP programme specifically targets this sector: the European Neighbourhood Programme for Agriculture and Rural Development (ENPARD) implemented by the CIHEAM in the Neighbouring countries since 2012. This programme provides reflections and orientations for the development of agricultural policies that support farmers and rural development in the Euro-Mediterranean countries.

Source: ENPI CBC (www.enpicbcmed.eu).

Implementing the 2030 Agenda for Sustainable Development in the Mediterranean

While the 2030 Agenda for Sustainable Development has been designed by member States in the context of an intergovernmental UN process, implementation will invariably take place at national and particularly local level. It is evident that the local dimension of development is increasingly intertwined with global and national issues. Issues such as peace, human security, health, employment, climate change and migration are mainly addressed at regional and international level, but long-term solutions often require attention to national and local dimensions, implications and nuances. Local planning, participation and governance will therefore be crucial for most solutions. To a large extent, the achievement of many MDGs indeed depended on local governments and local stakeholders. The 2030 Agenda for Sustainable Development will thus require national commitment to provide an appropriate legal framework, as well as institutional and financial capacity to local governments. National and local contexts are often shaped by the economic and social situation, colonial history, political realities and social norms and behaviours. Since the Mediterranean region is one of the more diverse regions in the world, the implementation of the 2030 Agenda will be more successful if solutions to problems fit the local context taking account of cultural characteristics and if the full diversity of stakeholders is captured.(e.g. governments, civil society, business etc.) (UNDG, 2014a).

As the emerging development agenda is expected to encapsulate a set of development goals that are more interdependent, transformative and universally applicable than the MDGs, the 2030 Agenda will require greater capacities, more responsive institutions and stronger political will for successful implementation. In this regard, strong public institutions can be enablers, but unfortunately, what has often been the case in the region are weak public institutions that have sometimes encumbered implementation. A transformative development agenda will thus require upgraded, coordinated and integrated institutions and capacities, especially in the southern Mediterranean countries that are going through political transitions.

Effective coordination mechanisms to strengthen vertical (multi-level) and horizontal (multi-stakeholder) relationships in the Mediterranean region are necessary for the implementation of the 2030 agenda. National governments and multilateral organisations must promote enabling environments to maximise the full role of local and regional governments and local stakeholders in development. At national level, implementation responsibilities should be clearly divided among different levels of government, taking into account the distinct comparative advantage of each level, and accompanied by effective coordination mechanisms that harmonise efforts across them. In concert with national governments and key local stakeholders, local governments can plan and manage appropriate local responses to the challenges of urbanisation, resilience and sustainable use and management of natural resources. Decentralisation, subsidiarity and good governance at all levels are essential for the implementation of the 2030 Agenda (UNDG, 2014b).

At the policy level, it is clear that the piecemeal approaches of the past require a drastic overhaul. The MDG approach in several countries of the region suffered from a focus on quick fixes and narrow-scale interventions, and was mainly assessed in the quantitative dimension of development rather than the qualitative one. For example, access to water, as measured by the MDG indicators improved in a number of countries in the region. However, those indicators did not take into account the quality of water resources or the intermittency of the service (ESCWA, 2014). With the SDGs reflecting a comprehensive approach to development that focuses on both quantitative and qualitative measures, an analogous coherent and coordinated approach to national development will be needed, including the adoption of progressive economic, environmental and social policies and protection systems.

In this regard, there will be a particular need to promote inclusive development and reinforce the positive nexus between natural resource management, poverty and hunger. Sustainable production and consumption patterns are key factors in a region facing an unprecedented confluence of economic, social and environmental pressures. Economic growth, agricultural production, industrial development and manufacturing, and access to food and social services all need to be approached from that perspective. For example, enhancing water use efficiency and preventing land degradation to improve agricultural production is expected to help address food security challenges in the region (ESCWA, 2013). Conversely, growth is not sustainable in a context of high and rising inequality. Increased agricultural production that relies on a rapidly reducing forest cover or the depletion of aquifers is not sustainable. Similarly, intensive fishing and marine pollution exert a mounting pressure on littoral countries of the Mediterranean due to the closed nature of the sea.

While a drastic overhaul of current practices is necessary, instead of starting from scratch, the implementation of this new vision for sustainable development in the Mediterranean should not be built on existing national and regional strategies and action plans (such as those on sustainable consumption and production, water, energy and education) and in line with commitments to global agreements, so as to avoid duplication of efforts. There is no paucity of multilateral environmental agreements in the region for instance. All Mediterranean countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), the Ramsar Convention on Wetlands, and most countries are also parties to the United Nations Convention on the Law of the Sea (UNCLOS) (with the exceptions of Turkey, Syria and Israel).

Nevertheless, there is a gaping weakness in regional governance. The Mediterranean is characterised by a fragmented political organisation of littoral countries that may challenge the implementation of policies, plans and programmes that require joint action. The most acute divide is between the countries of the northern Mediterranean shore, most of which are developed countries, members of the European Union, and the countries of the southern and eastern shores, most of which are middle-income, developing countries, members of the League of Arab States and the Organisation of Islamic Cooperation. As such, there are only a few initiatives and programmes that address questions of sustainability in the Mediterranean region as a whole, and even these have seen their effectiveness hampered by the aforementioned political fragmentation of littoral countries.

Conclusion

The mixed track record of the Mediterranean countries in achieving the MDGs, the fragmented political integration of the region, its specificities and fragility in terms of natural resources, as well as the poor integration of environmental concerns in local planning, present a significant challenge for the implementation of the 2030 Agenda for Sustainable Development, in particular, SDGs, at regional level. Only drastic improvements in the governance of natural resources and targeted measures to achieve more resilient, climate-smart, low-waste and sustainable production and consumption can ensure that the needs of present generations are met without compromising the ability of future generations to meet their own needs.

Although much progress has already resulted in hunger alleviation and improved health in the region, other acute challenges remain in order to ensure food security and to reverse natural resources degradation in the future. Natural capital degradation is thus a serious constraint for the achievement of sustainable rural development. In a context of major transformations in rural societies both in the North and the South, the loss of natural resources implies an associated loss of local knowledge regarding these resources. Therefore, the waste of natural resources is linked to knowledge loss and this interaction requires a more comprehensive analysis in order to ensure the sustainability of rural and agricultural development in the region.

The 2030 Agenda and the SDGs offer a comprehensive vision to address these challenges in an integrated way, with a radical improvement over the siloed approach prevalent in the MDG era. Ensuring sustainable use and management of natural resources whilst eradicating poverty and hunger will be a monumental task.

Nonetheless, it is feasible if we accept that we must transform consumption and production systems, embrace sustainable living and working practices, improve governance for development and, crucially, secure the political will to act.

However, the implementation of the 2030 Agenda in the Mediterranean will be more successful if solutions to problems fit the local context, if global targets are translated into national targets, and if political commitments are made to provide appropriate legal frameworks and the required institutional and financial capacities. At the same time, building on already existing regional instruments for rural and agricultural development should ensure greater effectiveness and a harmonised approach between littoral countries that otherwise appear to belong to distinct political and socio-economic spheres. To paraphrase Plato, all Mediterranean countries are like frogs sitting around the same pond, and in this regard they all share a common responsibility for its sustainable development.

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2 **PART** TWO

FOOD LOSSES AND WASTE

in the Mediterranean

CHAPTER 9

FOOD LOSSES AND WASTE: GLOBAL OVERVIEW FROM A MEDITERRANEAN PERSPECTIVE

Roberto **Capone**, *CIHEAM*
Anthony **Bennett**, *FAO*
Philipp **Debs**, *CIHEAM*
Camelia Adriana **Bucatariu**, *FAO*
Hamid **El Bilali**, *CIHEAM*
Jennifer **Smolak**, *FAO*
Warren T.K. **Lee**, *FAO*
Francesco **Bottalico**, *CIHEAM*
Yvette **Diei-Ouadi**, *FAO*
Jogeir **Toppe**, *FAO*

Every year, one third of all the food produced for human consumption is either lost or wasted along local, national, regional and global food supply chains thus affecting the sustainability of the food system and its capacity to ensure food and nutrition security for all. *Food loss* is the decrease in quantity or quality of food reflected in nutritional value, economic value or food safety of all food produced for human consumption but not eaten by humans, while *food waste* is part of the food loss and refers to discarding or alternative (non-food) use of safe and nutritious food for human consumption all along the food supply chains (FAO, 2014a).

The huge challenge of food loss and waste (FLW) has been addressed at global level by the 41st session of the Committee of World Food Security (CFS, 2014) that called upon all public, private and civil society actors to promote a common understanding of FLW and create an enabling environment based on the "food use-not-loss-or-waste" hierarchy in order to support sustainable food systems. The approach is particularly recommended for monitoring and measurement targets.

The economic, social, and environmental impacts of FLW must be addressed concurrently. Producing food that is lost or wasted and is not adequately utilised for human consumption means unnecessary aggravating pressures on the planet while bringing us further from the paramount objective of the sustainable food system that is to ensure food security and nutrition to all. Various studies have underlined the fact that FLW impacts food security and nutrition and that prevention and reduction are indispensable in order to minimise environmental impacts thus, preserving the food systems' ability to sustain future increases in global demand for food and ecosystem services (HLPE, 2014).

Currently, about 795 million people still suffer from hunger and over 2 billion people suffer from micronutrient deficiencies. It is unacceptable that over a third of the world's food is lost or wasted along the food supply chain or ends up in landfills (FAO, IFAD and WFP, 2015; FAO-RNE, 2011; FAO, 2014b; FAO, 2015a and 2015b; Barilla, 2013). A better management and distribution of food resources globally, regionally, nationally, and locally could be beneficial to the society's least privileged (FAO-RNE, 2011; FAO, 2014b; Rutten *et al.*, 2015).

The Second International Conference on Nutrition (ICN2) had two outcome documents, i.e. Framework for Action and the Rome Declaration on Nutrition acknowledging that "current food systems are being increasingly challenged to provide adequate, safe, diversified and nutrient rich food for all that contribute to healthy diets due to, inter alia, constraints posed by resource scarcity and environmental degradation, as well as by unsustainable production and consumption patterns, food losses and waste, and unbalanced distribution." Moreover, "food losses and waste throughout the food chain should be reduced in order to contribute to food security, nutrition, and sustainable development." While Recommendation 11 of the Framework for Action of ICN2 states that it is important to "improve storage, preservation, transport and distribution technologies and infrastructure to reduce seasonal food insecurity, food and nutrient loss and waste."

Food systems are confronted with major sustainability challenges (CIHEAM and FAO, 2015). Food insecurity and malnutrition are still prevalent in some countries of the region. Population is steadily increasing in the Southern and Eastern Mediterranean countries (SEMCs) in parallel with the increase in food demand across the region. At the same time, agricultural production has to cope with the ever-increasing demand with limited natural resources, principally in the south. Moreover, agriculture is the main water consumer in this region where its scarcity is the most critical development problem and one of the main factors limiting agricultural growth (CIHEAM, 2008).

FLW data are scarce and fragmented along supply chains at local, national, regional and global levels. The FAO estimates that FLW in the Near East and North Africa (NENA) amounts to 250kg/capita per year, valued at over USD 60 billion per year, or USD 120 per capita (conservative estimate). NENA natural resources lost due to FLW amount to 42km^3/year of water (food production and supply chains), and 360 million ha/year of land. The Turkish bread waste data established as from 2013 is an interesting example of data produced at country level. It indicates a total of 4.9 million wasted loaves per day: 62.1% at bakeries, 10.2% at restaurants, hotels and dining halls, and 27.7% at households (OECD and FAO, 2014).

The FLW data collected use different methodologies, indicators and even definitions of FLW. There are significant gaps in their harmonisation that hinder comparability between studies, data sets, and capacity of decision makers to prioritise interventions over short, medium, and long terms. To address this issue a Food Loss and Waste Protocol[1], which is a multi-stakeholder effort to develop the global accounting and reporting standard, has been developed to enable countries, companies and other entities to quantify food waste in a credible, practical and internationally consistent manner and to identify where it occurs, thus enabling the targeting of efforts to reduce it.

The lack of accurate data exacerbates the inefficiency in the food chain. Precise and harmonised FLW data should be enhanced especially in a context where the food security and nutrition situation is fragile and the sustainability of consumption and production is threatened. To address this need, in May 2015, the G20 Agriculture Ministers invited the FAO together with the IFPRI to establish a platform, building on existing systems, for the sharing information and experiences on measuring and reducing FLW. The Ministers strongly supported the setting up of the Platform as a major outcome of the meeting, which was also endorsed by the G20 Leaders Antalya Communiqué in November 2015. The Technical Platform[2] on the Measurement and Reduction of Food Loss and Waste welcomes global membership. It will also work on solutions for low-income countries.

This chapter aims at providing an overview of the FLW issue and its implications for sustainability and food security, analysing drivers and causes of FLW along the entire food chain and highlighting different strategies and policies for its reduction and/or prevention. Divided into four parts, it provides a global perspective on FLW with a particular focus on the Mediterranean region.

Food loss and waste, food security, nutrition and sustainability

Food loss and waste and sustainable food systems development

A food system includes all elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to production, processing, distribution, preparation and consumption of food; outputs of these activities include socio-economic and environmental outcomes (HLPE, 2014). A sustainable food system is a food system that provides food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised.

In September 2015, the United Nations Agenda 2030 was adopted at global level engaging, for the first time, developing, transition, and industrialised countries alike. The Agenda 2030 Sustainable Development Goal (SDG) No. 12 “ensure sustainable

1 - www.wri.org/our-work/project/food-loss-waste-protocol
2 - www.fao.org/platform-food-loss-waste/fr/

consumption and production patterns" has set the target 12.3 "by 2030, halve the per capita global food waste at the retail and consumer level, and reduce food losses along production and supply chains including post-harvest losses"[3]. Twenty years after the Rio Earth Summit in 1992, the signatories of *The future we want* declaration committed themselves to the Agenda 2030 in response to today's and tomorrow's global challenges. Some countries have already taken up the challenge to ensure that enough food for the expected population growth would be available with measures including prevention and reduction of FLW, which drains natural resources, such as water, soil nutrient contents and energy when food is produced and not consumed by humans.

Four examples of national efforts to reduce FLW: China, South Africa, Turkey and the United States

China. In 2014, the Chinese government has taken several steps towards the reduction of FLW. The Central Committee and State Council issued a joint circular on "Practicing strict economy and fighting against waste". The State Administration of Grain, the Ministry of Industry and Information Technology, and the General Administration of Quality Supervision, Inspection and Quarantine issued a notice on "Saving food and reducing food losses among foodstuffs and oil-processing industries". The "Clean your plate" campaign focused on consumer awareness and behaviour change of actors along the supply chain.

Source: www.fao.org/platform-food-loss-waste/food-waste/food-waste-reduction/en/

South Africa. From 2 to 5 June 2015 South Africa hosted a national multi-stakeholder consultation workshop to gather information for a *National Food Waste Prevention and Reduction Programme* that will include pilot actions in Johannesburg and in Tshwane. *Think.Eat.Save (Guidance for governments, local authorities businesses and other organisations Version 1.0)* that is part of the FAO led Global Initiative on Food Loss and Waste Reduction and of the FAO and the United Nations Environment Programme (UNEP) Sustainable Food Systems Programme foresees pilots for country implementation support and South Africa is the first pilot.

Source: www.fao.org/save-food/news-and-multimedia/news/news-details/en/c/293895/

Turkey. In January 2013, the Turkish Grain Board (TMO) and the Ministry of Food, Agriculture and Livestock together with relevant stakeholders along the supply chains launched the Campaign for Preventing Bread Waste. By 2014 the programme had achieved the following outcome: (1) a reduction of 18% on average in waste from 2011 to 2012; (2) bread waste which was 5.9 million loaves per day (2.17 billion loaves per year) in 2012 decreased to 4.9 million loaves per day (1.8 billion loaves per year) in 2013. The value of bread waste, which was 1.6 billion Turkish lira (around USD 697 million) in 2012, has been reduced to 1.3 billion Turkish lira (around USD 565 million); 40% of this reduction was registered in households, staff dining halls and student dining halls.

Source: www.tmo.gov.tr/Main.aspx?ID=1045

3 - SDG Target 12.3 contributes directly to SDG Goal 2 and SDG Target 12.5.

	Before the Campaign (end of 2012)	After the Campaign (end of 2013)
Annual expenditure on bread consumption (billion Turkish lira)	26	23.5
Annual expenditure on bread consumption (billion USD)	13.8	12.4
Daily bread production (million loaves)	101	91
Daily bread consumption (million loaves)	95	86
Daily bread waste (million loaves)	5.95	4.9
Daily per capita bread consumption (g)	319	284
Daily per capita bread waste (g)	19.9	16.2

Source: OECD and FAO (2014).

United States. In September 2015, the US Environmental Protection Agency (EPA) and the US Department of Agriculture (USDA) announced a national goal to reduce food waste by 50% by the year 2030. The United States estimate that approximately 31% of the overall food supply available to retailers and consumers is lost or wasted with impact on food security, natural resources, and climate change.

The Agenda 2030 requires measurable and verifiable indicators that must reflect development pathways and be economically, socially and environmentally sound without infringing the principle of sovereignty (Voituriez, 2013). The FAO is working on the Global Food Loss Index (GFLI) indicator for SDG 12.3 to monitor the success of countries in reducing food loss. The compilation of the GFLI shall be based on the food loss estimates recorded in the Food Balance Sheets, while the quality of these figures is currently being improved by broadening and enhancing the primary database and developing further the methodology. Currently, GFLI uses dietary energy supply, expressed in kilocalories (kcal), as the reference unit of measure. The GFLI will be aligned with data on agricultural production, foreign trade and the various types of utilisation of agricultural products.

The *Zero Hunger Challenge* – the UN's Secretary-General's vision for a future free from hunger issued during Rio+20 – identifies five interconnected elements for key areas of intervention and strongly links food security and nutrition to food systems sustainability and food loss or food waste prevention and reduction: 1) 100% access to adequate food all year round; 2) zero stunted children under 2 years of age; 3) all food systems are sustainable; 4) 100% growth in smallholder productivity and income; 5) and zero food is lost or wasted (UN, 2012). FLW was addressed by the 41st Session of the Committee on World Food Security (CFS) in 2014. During its 39th Session (October 2012), the CFS requested the High Level Panel of Experts on

Food Security and Nutrition (HLPE) to undertake a study on "Food losses and waste in the context of sustainable food systems" to be presented during the CFS Plenary in 2014. According to the HLPE report, FLW is a consequence of the way food systems function, technically, culturally and economically at micro, meso and macro levels (HLPE, 2014). Lastly, the G20 Agriculture ministers highlighted the extent of FLW as "a global problem of enormous economic, environmental and societal significance" and encouraged all G20 members to strengthen their collective efforts to reduce FLW. In the context of policy coherence fostered by the G20, the Development Working Group was encouraged to continue its efforts to develop actions to reduce FLW as part of its Implementation Plan for the G20 Food Security and Nutrition (FSN) framework. During its Presidency of the G20, Turkey took the initiative at the G20 Ministerial meeting on Agriculture, to place the challenges of food security and nutrition among one of the priorities[4].

FLW indicators on global food security and nutrition

One third of the food produced is lost or wasted, this is unacceptable in a world where approximately 795 million people do not have appropriate food availability and access for sufficient energy, macro and micronutrient intake (Gustavsson *et al.*, 2011; FAO, IFAD & WFP, 2015; WHO, 2016). This mega scale of energy deficit and macro and micro-nutrient deficiencies worldwide requires increased diversified food sources.

Food energy loss in FLW. When converted to calories, global FLW amount to approximately 24% of all food produced (Kummu *et al.*, 2012). Every one out of four food kilocalories intended for human consumption is not ultimately consumed by humans (Kummu *et al.*, 2012; Lipinski *et al.*, 2013; Searchinger *et al.*, 2013). This figure is lower than the commonly cited figure (one-third), which measures food loss by weight. This points to the basket of different types of food that are lost and wasted ranging, for example, from calorie rich cereals to nutrient-dense but low-calorie fruits and vegetables (Searchinger *et al.*, 2013).

According to the FAO (2013a), if 25% of the global FLW could be saved, it would be sufficient to feed 870 million hungry people in the world under the condition of ensuring adequate social, economic, and physical access. A global overview of FLW along food chains has found that, on average, only 43% of foods cultivated for human consumption were actually consumed. Globally, farmers were able to produce food that was equivalent to 4,600kcal per capita per day. However, 600kcal per capita per day was lost because of inefficiencies in harvest, transport, storage, and processing. Moreover, the conversion of food supply (mainly grains) to feeds for livestock caused a further net decrease in 1,200kcal/capita/day. Furthermore, caloric estimates of FLW did not capture the nutritional quality or micronutrient losses (e.g. vitamin A, iron, zinc, iodine) (Smil, 2004).

4 - One of the main outcomes of the Turkish Presidency of the G20 consists of the establishment of the *Technical Platform on the Measurement and Reduction of Food Loss and Waste* (available at www.fao.org/platform-food-loss-waste).

Nutrient losses in FLW. Until recently, there has been a lack of data on nutrient loss in FLW to understand the scales and causes of the issue at global, national and local levels. The availability of these analytical data is crucial to inform data-driven food systems policies and programmes aimed at reducing FLW and its associated nutrient loss, and to advocate for sustainable food consumption and production patterns.

Two recent FAO studies indicated that micro-nutrient losses due to FLW along the food chain are alarmingly high (Serafini *et al.*, 2015; Lee *et al.*, 2015). Based on the Global Food Losses and Food Waste Report (Gustavsson *et al.*, 2011), the first FAO study estimated loss and waste of vitamins A and C from fruit and vegetables loss along the food chain in seven regions of the world. Massive micro-nutrient losses from FLW occur in the industrial Asia, with Europe in the middle, and Latin America and Sub-Saharan Africa at the lower end (Serafini *et al.*, 2015). Higher nutrient loss occurs during agricultural production, post-harvest and consumption. Reduction in FLW could potentially avail more nutrients and phytochemicals for human consumption, contributing to the alleviation of micronutrient deficiencies, health promotion and prevention of non-communicable diseases, in both low and high income countries, in particular among vulnerable populations. Unfortunately, current methodologies in collecting FLW data and estimating nutrient losses have limitations that need to be addressed to improve precision (Serafini *et al.*, 2015). Findings from the FAO country-based study on micro-nutrient losses in FLW are shown the following Box.

Micro-nutrient loss for human consumption due to FLW: FAO methodology

Based on the current available data and methodology developed by the FAO, the annual vitamin A loss along food chains in Norway in 2011-2012 was approximately 354,824 tonnes per year (227,667 tonnes per year of fruit; 127,157 tonnes per year of vegetables) which has led to about 280.3kg Retinol Equivalent (RE) per year loss of vitamin A. If this level of vitamin A loss were reduced and made available to feed vitamin A deficiency (VAD) children under 5 years old, approximately 1,807 million of VAD children in the world would have met their vitamin A needs.

Using an FAO case study in Kenya (2013), the annual volume of food loss in four selected food supply chains were estimated at 1,835,468 tonnes per year (451,842 tonnes of bananas per year, 879,789 tonnes of maize per year, 462,453 tonnes of milk per year and41,284 tonnes of fish per year). This food loss corresponds to approximately 338.8kg RE per year loss of vitamin A. If such a quantity of vitamin A were made available to feed VAD children under 5 years old about 2.18 million children would have met their vitamin A needs. In Kenya, the number of VAD children under 5 years old was about 5.84 million during that period; therefore, nearly 37.4% VAD children under 5 years old in the country would have benefited from an access to these vitamin A rich foods if food loss was prevented and reduced and if adequate (social, economic and physical) access was ensured.

Source: Lee et al. *(2015).*

Hidden nutrient losses in the food chain. FLW is generally measured in weight. Some studies have also used caloric metrics while others use economic units. Food quality loss or waste (FQLW) is more difficult to access and measure, as there are different quality and nutritional attributes, which may or may not be correlated to each other. According to HLPE (2014), *food quality loss or waste* (FQLW) refers to the decrease of food quality attributes (e.g. nutrition, aspect, etc.) due to the degradation of the product throughout the food supply chains, from primary production to end consumption level. FLW in mass does not fully take into account the nutritional dimensions as food quantity might be preserved (with low levels of FLW measured in mass) while this does not necessarily mean that micro- and macro-nutrients are equally preserved (HLPE, 2014).

As food travels from the producer to the consumer, through handling, processing and storage along the food chain, qualitative losses of nutrients take place. Understanding how nutrient concentration in food varies with different handling processes and storage conditions as well as the hot spots in the food chain where hidden nutrient losses occur would help improve food handling, processing and storage procedures, thereby maximising the nutritional quality of food for human consumption. The HLPE (2014) recognised that this is a research gap that warrants new research to unveil the nutritional aspects of "food quality loss or waste". To address this issue of hidden nutrient losses in the food chain, the FAO plans to explore the methodologies to evaluate qualitative loss of nutrients in the food chain.

Promotion of food security and nutrition through recovery and redistribution of safe and nutritious food. Where FLW cannot be prevented at source, recovery and redistribution of safe and nutritious food for human consumption (RR) could contribute to food security and nutrition, option indicated also by the Committee on World Food Security (HLPE, 2014). In 2015, the FAO provided a voluntary framework definition of recovery and redistribution: "Recovery of safe and nutritious food for human consumption is to receive, with or without payment, food (processed, semi-processed or raw) which would otherwise be discarded or wasted from the agricultural, livestock, forestry and fisheries supply chains of the food system. Redistribution of safe and nutritious food for human consumption is to store or process and then distribute the received food pursuant to appropriate safety, quality and regulatory frameworks directly or through intermediaries, and with or without payment, to those having access to it for food intake."

Worldwide various community level initiatives are implemented along supply chains from primary production to end consumer level: gleaning networks, food banks and food pantries, as well as social supermarkets. The dual approach of reducing FLW at source while implementing, monitoring and evaluating RR presents challenges and opportunities for all food system actors, including the end consumer. It warrants empirical country data to assess the FLW scale in order to inform policy actions that sustainably minimise FLW while providing RR tools for operators and ensure monitoring, evaluation and appropriate accountability.

Food banks networks

The main mission of a food bank is to provide recovered safe and nutritious food available along supply chains to food insecure people. It also supports the community through potential auxiliary functions such as the implementation of job training and supplemental educational programmes. Food banks restrict distribution to vetted and qualified institutions that deliver services to the low and/or no-income community and that incorporate food assistance as a component of those services (e.g. homeless or domestic abuse shelters, orphanages, soup/community kitchens, drug and alcohol rehabilitation facilities, medical clinics, food pantries, social supermarkets).

Founded in 1986, the European Federation of Food Banks (FEBA) brings together 256 food banks situated in 21 countries. Supply management and food distribution are handled by 12,934 volunteers and 924 employees. FEBA food banks recover food from the food industry and retail stores, European and national food aid programmes or from individual donations of retail pre-packaged foodstuffs. Nearly half (44%) of the food collected in Europe comes from the European programme of food aid for the most deprived, 22% comes from the food industry, 17% comes from retail stores, 14% from individuals through national and local collections, and 3% from withdrawals from national markets. 401,000 tonnes of food were distributed in in 2011, 388,000 tonnes in 2012 and 402,000 tonnes in 2013 (FEBA, 2014). In 2014, FEBA member food banks distributed 411,000 tonnes of food to 5.9 million people in partnership with 33,800 partner charitable organisations.

The Global Food Banking Network (GFN) was founded in 2006 and currently supports a network of over 250 operational food banks in more than 30 countries (21 countries in 2013, 23 countries in 2014). Recovery and redistribution differs highly in quantity across food banks for cereals, roots and tubers, oil crops and pulses, fruits and vegetables, meat, fish and seafood, dairy and eggs and beverages. In 2012, the network distributed more than 450,000 tonnes of food to more than 19,000 institutions that support communities directly. In 2013, more than 550,000 tonnes of food were distributed to approximately 25,500 social service agencies. The total number of people that are annually accessing the food bank services ranges from 1,000 to 1,500,000 in their respective countries (GFN, 2014).

Food banks require access to multi-stakeholder dialogue platforms and resource mobilisation, infrastructure and public–private partnerships. Moreover, tools for monitoring and evaluation are essential as they provide guidance on food safety and quality (including human nutrition) and further data on the four dimensions (availability, access, utilisation and stability) of food and nutrition security for the people accessing the services provided. Finally, food banks cannot be used as a substitute of social protection measures that address the underlying poverty and inequality, and subsequently generated food and nutrition insecurity.

Source: Bucatariu (2016).

Food security and nutrition in the Mediterranean region. In the Mediterranean region, food availability is limited for several reasons. Water scarcity is a constraint for agriculture production as per capita renewable water availability in most countries falls below the threshold of water scarcity of 1,000m^3 per capita per year. Likewise, constantly threatened by desertification and urban encroachment, the availability of arable land per capita is the lowest in the world (FAO, 2015b). There is also a growing demand for food from fast-growing populations in urban areas with rising incomes. There is also a shift in food preferences towards higher-value products (often more perishable). Moreover, FLW in the SEMCs are high and contribute to reduced food availability, aggravated water scarcity, adverse environmental impacts and increased food imports in an already highly import-dependent region. There is an increasing concern for the food security and nutrition situation in the South of the Mediterranean as they highly depend on food imports. The South Mediterranean is a net importer of agricultural commodities, animal products and feed (FAO, 2015a). SEMCs import half of their basic crops. In 2013, the region imported about 29 million tonnes of wheat, and between 2002 and 2013, imports of all agricultural food products have risen by 63% (USD 69 billion) (FAO, 2015a). Prevention and reduction of FLW is essential because FLW undermine all four components of food security and nutrition, i.e. availability, access, utilisation and stability (HLPE, 2011; FAO, 2012a, 2012b, 2012c). Reduction of FLW contributes to make more foods and nutrients available to feed the world and prevent and control energy deficits as well as micronutrient deficiencies, especially among the vulnerable.

The Second International Conference on Nutrition (ICN2)

The Second International Conference on Nutrition (ICN2) was an inclusive intergovernmental meeting on nutrition held at the FAO Headquarters in Rome on the 19-21 November 2014 and jointly organised by the FAO and the World Health Organisation (WHO), in cooperation with the High Level Task Force on the Global Food Security Crisis (HLTF), IFAD, IFPRI, UNESCO, UNICEF, World Bank, WFP and the WTO. The main outcomes of this high-level ministerial conference were the Rome Declaration on Nutrition and the Framework for Action.

The ICN2 Rome Declaration on Nutrition acknowledged "that current food systems are being increasingly challenged to provide adequate, safe, diversified and nutrient rich food for all that contribute to healthy diets due to, inter alia, constraints posed by resource scarcity and environmental degradation, as well as by unsustainable production and consumption patterns, food losses and waste, and unbalanced distribution". Moreover, it invites the States to "reduce food losses and waste throughout the food chain should be reduced in order to contribute to food security, nutrition, and sustainable development". Recommendation 11 of the Framework for Action incites them to "improve storage, preservation, transport and distribution technologies and infrastructure to reduce seasonal food insecurity, food and nutrient loss and waste".

Source: www.fao.org/3/a-ml542e.pdf and www.fao.org/3/a-mm215e.pdf

Understanding the qualitative nutrient losses in the food supply chain (hidden nutrient losses) would help improve post-harvest food handling, processing and storage so that maximum nutrient concentrations in food are retained for human consumption. A reduction in 50% of food waste at retail and consumer level as well as a reduction of food loss along the food supply chains, as targeted by the SDG 12.3, is a promising policy action to help achieve the SDG 2, i.e. to end hunger and eradicate all forms of malnutrition, including micro-nutrient deficiencies, by the year 2030.

FLW and sustainable food systems

The world's food system is not nutrition-sensitive, efficient and sustainable to ensure global food security and nutrition. "The world's food system – with its reliance on industrialised production and globalised markets – produces ample supplies, but creates some problems for public health. Part of the world has too little to eat, leaving millions vulnerable to death or disease caused by nutrient deficiencies, while another part overeats, with widespread obesity pushing life-expectancy figures backwards and pushing the costs of health care to astronomical heights." (Margaret Chan, Director General, WHO, ICN-2 Rome, 19 November 2014).

Launched in the context of the 10-Year Framework of Programmes (10YFP) on Sustainable Consumption and Production (SCP), the Sustainable Food Systems Programme (SFSP)[5] identified, through a public consultation, FLW as a key issue that the SFSP should focus on for accelerating towards sustainable food systems (FAO-UNEP, 2014). The Sustainable Consumption and Production Regional Action Plan for the Mediterranean, the first regional plan to promote SCP, was presented for endorsement at the meeting of the Contracting Parties to the Barcelona Convention (COP19) (UNEP-Mediterranean Action Plan) held on the 9-12 February 2016 in Athens (Greece). The 21 Mediterranean ministers and the European Union approved the Regional Action Plan on SCP for the Mediterranean. Its multi-stakeholder focus approach focuses on four areas: 1) food, agriculture and fisheries; 2) goods manufacturing; 3) tourism; 4) housing and construction. Its roadmap for implementation includes suggested actions, specific targets and relevant partners and initiatives. The food and agriculture priority area calls for the promotion of good environmental practices for production and processing, including the transfer of innovation and technology upstream and downstream and minimising resource waste. The SCP Action Plan applies the hierarchy of "prevention at source, recovery and recycling of resources".

Sustainable Consumption and Production Regional Action Plan for the Mediterranean

Operational objectives and actions for consumption and production priority area Food, Fisheries and Agriculture (FFA).

Operational Objective 1.1: Promoting Innovation and Knowledge in the implementation of Best Environmental Practices and Technologies in the growing, harvesting, processing and consumption phases, allowing efficient management of resources, minimising environmental impacts of the FFA sector throughout its life cycle.

Suggested actions (No. 4) to reach operational objective 1.1: Prevent and minimise resource waste and food wastage throughout the life cycle of the food; promote the production and use of energy and compost from food waste coming from the selectively-collected fraction of the municipal waste and agricultural organic waste.

5 - www.fao.org/fileadmin/templates/ags/docs/SFCP/Activities/Preliminary_proposal_for_the_10YFP_on_Sustainable_Food_Systems_Programme.pdf

Progress indicators including baseline (BL) and Target (T) by 2021:

– Number of agriculture ministries that benefit from capacity building on resource and food waste.

– Number of pilot projects implemented that adopt the prevention of resource and food waste.

– Number of dissemination events at regional level aimed at promoting the findings.

Key Partners: IFAD, FAO, WFP.

Operational Objective 1.3: Sensitise and educate food producers, retailers and consumers, and support the development of appropriate market tools and information, to promote sustainability throughout the value chains of agriculture and fisheries management, as well as food processing and food distribution.

Suggested actions (No.12) to reach operational objective 1.3: Implement information and education campaigns to promote the concept of the "Mediterranean Diet" and ensure public engagement in the production and consumption of sustainable food and local agriculture and fisheries products, along with reduction of food waste. Increase consumer awareness regarding best practices to prevent food wastage (quantity, storage, expiry dates, etc.).

Progress indicators including baseline (BL) and Target (T) by 2021:

– Number of countries participating in the regional competition related to the "Mediterranean Diet".

– Number of regional workshops and trainings organised to support producers and consumers in adopting the concept of the "Mediterranean Diet".

Key Partners: UNEP, FAO, UNESCO, CIHEAM, WWF, *Fundacion Dieta Mediterranea*

Source: UNEP-MAP (2015).

There are many regions and countries engaged in efforts tackling FLW. For instance, the 2013 Near East and North Africa (NENA) Regional Strategic Framework for reducing FLW[6] is based on the region's socio-economic and natural resources context. Moreover, the 2014 FAO report on FLW Reduction in Europe and Central Asia[7] for Improved Food Security and Agrofood Chain Efficiency complements the FLW reports for Turkey, Ukraine, Armenia, Kazakhstan, and Tajikistan. Finally, the European Commission launched the Communication on Closing the loop – An EU action plan for the Circular Economy[8] on the 2 of December 2015. The EU and Member States are committed to meeting the SDG 12.3 and to support this achievement they will: 1) elaborate a common EU methodology to measure consistently and in co-operation with Member States and stakeholders; 2) create a multi-stakeholder platform in order to help define measures needed, facilitate inter-sector co-operation, and share best practices and results achieved; 3) take measures to clarify EU legislation related to waste, food and feed and facilitate recovery and

6 - www.fao.org/documents/card/en/c/e9589c20-5507-4eee-a965-22fc5a08f42f/

7 - www.fao.org/save-food/regional/easterneurope/en/

8 - http://ec.europa.eu/priorities/jobs-growth-investment/circular-economy/docs/communication-action-plan-for-circular-economy_en.pdf redistribution of safe and nutritious food for human consumption and the use of former foodstuffs and by-products from the food chain for feed production, without compromising food and feed safety; 4) examine ways to improve the use of date marking by actors in the food chain and its understanding by consumers, in particular "best before" date labelling.

Concurrent environmental implications of FLW

FLW reduction is considered essential to reduce the environmental footprint of food systems (HLPE, 2014; FAO 2012a, 2012b, 2013a, 2014b, 2015a et 2015b; UNEP, 2012a and 2012b). FLW amount to major squandering of resources, including water, land, energy, labour and capital, and needlessly produce greenhouse gas emissions (Gustavsson *et al.*, 2011; FAO, 2013a). FLW leads to unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide (Lipinski *et al.*, 2013). According to the FAO (2014b) estimations, total FLW reaches up to USD 1 trillion of economic costs per year with additional environmental costs that reach around USD 700 billion and social costs around USD 900 billion.

FLW environmental and social costs include:
– 3.5Gt CO_2 of greenhouse gas emissions. Based on the social cost of carbon, these are estimated to cause USD 394 billion of damages per year;
– Increased water scarcity, particularly for dry regions and seasons. Globally, this is estimated to cost USD 164 million per year;
– Soil erosion due to water is estimated to cost USD 35 billion per year through nutrient loss, lower yields, biological losses and off-site damages. The cost of wind erosion may be of a similar magnitude;
– Risks to biodiversity including the impacts of pesticide use, nitrate and phosphorus eutrophication, pollinator losses and fisheries overexploitation are estimated to cost USD 32 billion per year;
– Increased risk of conflict due to soil erosion, estimated to cost USD 396 billion per year;
– Loss of livelihoods due to soil erosion, estimated to cost USD 333 billion per year;
– Adverse health effects due to pesticide exposure, estimated to cost USD 153 billion per year.

Losses or waste of the resources used for production are a major source of negative impacts, including emissions of greenhouse gas (GHG) at disposal. Indirect environmental externalities include unnecessary surface and ground water pollution caused by the intensive use of nitrogenous fertilisers in agriculture. Negative externalities include also those that mono-cropping and agriculture expansion into wild areas create in terms of biodiversity loss (FAO, 2013b). Food waste is also waste of land resources (Wirsenius *et al.*, 2010; FAO, 2013b). FLW account for more than one quarter of total consumptive use of finite and vulnerable freshwater resources and more than 300 million barrels of oil per year (Lundqvist *et al.*, 2008; Hall *et al.*, 2009).

National case study by WWF-Italy

A study conducted by WWF-Italy (2013) analysed the environmental footprints of food waste in Italy. It showed that in 2012, 706 million m^3 of water were associated with the waste of meat, cereals, fruits and vegetables, tubers and roots, and milk by Italian consumers. The contribution to water waste changes from a food product group to another: 43% of water waste is due to the waste of meat and meat products, 34% due to cereals and bakery products, 16% due to fruits and vegetables, 3% due to roots and tubers, and 4% is associated to milk and dairy products waste.

Food waste-related greenhouse gas emissions amount to 14.3 million tonnes of CO_2 equivalent associated with food wasted by Italian consumers in 2012 (10.2 million tonnes more are associated to food loss along the supply chain). Moreover, 143 thousand tonnes of reactive nitrogen are associated with food wasted by consumers, plus other 85.8 thousand tonnes of nitrogen wasted along the supply chain.

Source: WWF-Italy (2013).

In the SEMCs, the environmental impact of FLW is dire given the scarce and declining natural resources, especially water, and the pressure from the growing demand for agriculture production. The FAO (2013b) estimated the blue water footprint of FLW in SEMCs (NAWCA region) at 42 km^3 annually, or 17% of the global figure of 250 km^3. This exceeds by far the water loss of any other region in per capita terms (Kummu *et al.*, 2012), and a large share of the blue water footprint is attributed to cereal production (FAO, 2013b). Land loss due to FLW is also severe, exceeding 360 million hectares and greater than in any other region. This is largely explained by animal feeding for meat and milk production on non-arable grasslands, and low livestock productivity due to low yields of the grasslands themselves (FAO, 2013b). The carbon footprint attributed to FLW is estimated at 200 million tonnes per year, or 6% of the global total of 3.3 Gtonnes (FAO, 2013b).

Making the food supply chain more efficient through loss and waste reduction measures will reduce pressure on resources required for food production and lower greenhouse gas emissions (Foresight, 2011). Reducing the amount of food wasted throughout the food chain in the entire Mediterranean area would help to improve food and nutrition security and contribute to easing pressure on natural resources especially water; increase the amount of food available for human consumption for the given level of inputs, thereby improving input use efficiency (Ingram, 2011); and reduce water needs in agriculture (Lundqvist *et al.*, 2008) as well as environmental impacts (Lundqvist *et al.*, 2008; Nellemann *et al.*, 2009).

Economic implications and value of FLW

From an economic viewpoint, FLW generation, prevention and reduction, as well as management have impacts for all actors in the food supply chains and in the overall food system (Gustavsson *et al.*, 2011). Research shows that the prevention and reduction of the loss or waste of safe and nutritious food for human consumption is being supported in all regions of the world. The potential for intra- and inter-regional economic impacts would need to be further understood. Moreover, high-level considerations of the socio-economic impacts of FLW need to be balanced with value chain analyses that include data on costs related to the prevention and reduction measures to be implemented for short-, medium- and long-term returns on investments along food supply chains, including for the end consumption level (Rutten *et al.*, 2015).

Food loss during harvest and in storage represents a loss of income for farmers and higher food prices for consumers (FAO, 2013a; Lipinski *et al.*, 2013). FLW imply that consumers pay a higher price for food due to the inefficiencies of the food system as a whole. In principle, with a reduction in FLW, the overall food supply available for human consumption would increase. According to the FAO (2013), FLW roughly amount to USD 680 billion in industrialised countries and USD 310 billion in developing countries. In SEMCs (or NAWCA region), the FAO (2013b) reaches a conservative estimate of USD 60 billion per year.

FLW reduction may improve food security and nutrition due to potential lower food prices and increased food purchasing power. However, if food becomes more affordable, households may waste more or trade-up and spend the saved income from the reduction of food waste for other services or higher quality food (Mhlanga and Bucatariu, 2015)[9]. In the short-run, producers may have to incur also food loss reduction costs. Meanwhile, consumers may delay spending savings on previously wasted foods (Rutten, 2013a). Some studies point out that a greater supply of food due to the reduction of food loss at production stage, without changes in consumption patterns, could simply raise waste downstream. Some consumers would have access to more food so could produce more food waste while other consumers would continue on their path of waste if nothing is done to avoid it (Rutten, 2013b; Godfray *et al.*, 2010). All in all, the economic outcomes of FLW reduction actions and strategies depend on the extent to which food loss or waste are prevented and reduced, causes, and costs involved (Rutten, 2013a).

Drivers, causes (micro, meso and macro) and extent of FLW along the food supply chains

FLW in the world

Extent of FLW. An FAO study (Gustavsson *et al.*, 2011) was the first systematic effort to quantify FLW at global and regional levels. It estimates that around one third of all food produced in the world is lost or wasted. The study indicates that FLW vary from one country, commodity and season to another (Lundqvist, 2010). Losses in the first part of the food chain are more important in developing countries (Venkat, 2011; Lundqvist *et al.*, 2008), while in industrialised countries most losses occur at

9 - FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) is a project about working towards a more resource efficient European Union by significantly reducing food waste. and it is funded by the Framework Programme 7 of European Commission from August 2012 to July 2016. According to the FUSIONS definitional framework (2014), "food waste is defined by the final destination of all food, and inedible parts of food, removed from the food supply chain. Any food and inedible parts of food, removed from the food supply chain sent to recovery and disposal operations are termed "food waste". Any food, or inedible parts of food, sent to animal feed, bio-material processing or other industrial uses are termed "valorisation and conversion" and are distinct from "food waste".

later stages of the supply chain and at consumer level (Gustavsson *et al.*, 2011). In developing countries, 40% of losses occur at post-harvest and processing levels while in industrialised countries more than 40% of losses happen at retail and consumer levels. Every year, consumers in rich countries waste almost as much food (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes) (FAO, 2013c).

Fruits and vegetables, plus roots and tubers have the highest wastage rates of any food. Studies carried out by the FAO estimated yearly global FLW by quantity at roughly 30% of cereals, 40 –50% of root crops, fruits and vegetables, 20% of oilseeds, meat and dairy products, and 35% of fish (FAO, 2013c). As for post-harvest losses, estimates range from 8-22% of cereals lost at farm-level and post-harvest due to poor storage (Bala *et al.*, 2010) to nearly 100% in some situations for horticultural produce (Parfitt *et al.*, 2010). Moreover, over 40% of marine fisheries are wasted as by-catch (Davies *et al.*, 2009). According to Davy Vanham *et al.* (2013), the foods that households waste the most in the 28 EU countries (EU27 and Croatia) are fresh vegetables and fruit as well as bakery items (cereals product group) such as bread and cakes.

FUSIONS Food waste data set for the 28 EU countries: new estimates and environmental impact

The total estimate equates to 173kg of food waste per person in the 28 EU countries. As the total amounts of food produced in the EU for 2011 were around 865kg per person (FAOSTAT, Food Balance Sheets), this would mean that 20% of the total food produced ends up as food waste. It should be noted that this 20% in part comprises inedible food, which is unavoidable by nature. There is a moderately high uncertainty on this estimate of food waste amounts; the approximate 95% confidence interval is of about 14 million tonnes (or about 16%). Given that the approach is new, in particular the results for the production and processing sectors are likely to change when more studies become available. Moreover, according to FUSIONS calculations, the generated food waste costs the 28 EU countries around 143 billion euros.

Source: FUSIONS (www.eu-fusions.org/index.php/publications).

Drivers and causes of FLW. The identification of causes of FLW is important in order to identify solutions for prevention, reduction and priorities for action. Several studies on FLW have identified different causes of FLW. Loss and waste along the food supply chain often result from interrelated causes and an action at one stage in the chain can affect the whole chain. According to High Level Panel of Experts (HLPE, 2014) and other literature sources, the main FLW causes include:

– Pre-harvest factors and produce left un-harvested: differences in production and agronomic practices may result in different quality at harvest, different suitability for transport and shipping, different storage stability and different shelf-life after harvest (Florkowski *et al.*, 2009).

– Harvesting and initial handling: poor harvest scheduling and timing, inefficient harvesting equipment, inappropriate handling of the produce, and temperature management are key contributors to FLW.
– Storage: the major cause of post-harvest loss is the lack of proper storage facilities (Gustavsson *et al.*, 2011). If infrastructure for initial storage is lacking, perishable produce can spoil within hours (Rolle, 2006; Stuart, 2009).
– Transport and logistics: can be a major cause of FLW, by introducing a time span between production and consumption, of particular importance for fresh products, as well as additional risks of mechanical and heat injury. Losses occur when, for instance, the cooling system malfunctions during transport or other logistics systems parts break down.
– Processing and packaging: lack of raw packaging materials and technologies for manufacturing of appropriate packaging along with technical malfunctions and inefficiencies cause food loss. Errors during processing lead to defects in the end product, such as wrong size, weight, shape, appearance or damaged packaging that may lead to food loss if the safe and nutritious food is not recovered and redistributed for human consumption.
– Retail and other distribution systems: influences the activities of supply chains as they dictate the quality of the produce to be supplied and displayed in outlets. Conditions within the retail outlet (temperature, relative humidity, etc.) and handling practices have an effect on quality, shelf-life and acceptability of the product.
– Consumption: socio-economic, demographic, or income-related behaviour are among FLW causes at consumer level (WRAP, 2009; HISPACOOP, 2012; Baptista *et al.*, 2012). These include poor planning of purchases often leading to buying more than is needed; discarding food due to confusion over "*best-before*" and "*use-by*" dates and misinterpretation of other information displayed on the food labels; lack of appropriate storage or stock management in the home; excess portions prepared and not eaten; inadequate food preparation techniques.

Recovery and redistribution of safe and nutritious food for human consumption

Where FLW cannot be prevented at source, recovery and redistribution of safe and nutritious food for human consumption could contribute to food security and nutrition. This option was indicated by the CFS. In 2015, the FAO provided a voluntary framework definition: "Recovery of safe and nutritious food for human consumption is to receive, with or without payment, food (processed, semi-processed or raw) which would otherwise be discarded or wasted from the agricultural, livestock, forestry and fisheries supply chains of the food system. Redistribution of safe and nutritious food for human consumption is to store or process and then distribute the received food pursuant to appropriate safety, quality and regulatory frameworks directly or through intermediaries, and with or without payment, to those having access to it for food intake." This pyramid of usage may be useful in examining and making decision on food uses (see Figure 1 in chapter 12, p. 285).

Source: Bucatariu (2016).

FLW in the Mediterranean

Accurate estimations of the magnitude of FLW are lacking. Nevertheless, there is no doubt that FLW remain unacceptably high. Per capita food waste by consumers is between 95 to 115kg a year in Europe and North America, while consumers in sub-Saharan Africa, south and south-eastern Asia, each throw away only 6 to 11kg a year (Gustavsson *et al.*, 2011). In North Mediterranean countries, there is the example of Spain where more than 7.6 million tonnes of food are wasted each year. These statistics echo across the European Mediterranean with France wasting 9 million tonnes and Italy 8.8 million tonnes each year (Charalampopoulou *et al.*, 2014). Additionally, the study carried out by Andrea Segrè and Luca Falasconi (2011) were the first ones to provide a quantification of waste along the whole food supply chain in Italy: 20 million tonnes from the field to the fork. FLW were estimated in five stages along the food supply chain: manufacturers; primary cooperatives; processing industries; wholesale and retail distributors; consumers (Segrè and Falasconi, 2011). In 2009, 17.7 million tonnes of agricultural produce was left in the Italian fields, representing 3.25% of total production (Segrè, 2013). Previous literature highlighted the need to have better FLW data (BCFN, 2012; WWF-Italy, 2013).

The 2013 Near East and North Africa (NENA) Regional Strategic Framework for reducing FLW is based on the region's socio-economic and natural resources context (FAO, 2014a). FLW in the NENA region are high (see Table 1) and contribute to reduced food availability, aggravated water scarcity, adverse environmental impacts and increased food imports, in an already highly import-dependent region. FLW severely affect the availability of food in the Near East region including many SEMCs and are unexpected in a region that is so dependent on the international markets to meet its food needs. Quantitative FLW in the NENA region are estimated at 14 to 19% of grains, 26% of roots and tubers, 16% of oilseeds and pulses, 45% of fruits and vegetables, 13% of meats, 28% of fish and sea foods, and 18% of dairy products. For fruits and vegetables, which have the highest proportion of loss and waste, country-specific data indicates that a substantial part (as high as 29% for fresh vegetables in Egypt) of this loss occurs at post-harvest stage (FAO, 2014a). Up to 68% of FLW occur during production, handling, processing and distribution phases of the food supply chain, due to many reasons such as extreme environmental conditions, inadequate storage, transport and packaging infrastructure (FAO-RNE, 2011). Waste at consumption stage is estimated at 32% and occurs mostly in urban centres. Significant waste takes place during various social events and festivities (FAO, 2014a).

The percentages of FLW of the edible parts of seven food commodity groups in the Mediterranean countries are shown in Table 2. Food waste at consumption stage is higher in Northern Mediterranean countries (Europe region) while post-harvest loss is higher in SEMCs (NAWCA region). In April 2014, the FAO Europe and Central Asia Regional Office published the Draft Synthesis Report on FLW in Europe and Central Asia including Turkey (whose aim was to quantify FLW) (Lacirignola *et al.*, 2014).

Table 1 - Magnitudes of FLW in selected crops in the Near East and North Africa (NENA) countries

	Amount of FLW	Phase(s) of FSC	Year	Source
Egypt				
Fresh fruits	19%	Production, transportation, marketing	1980	Blond (1984)
Fresh vegetables	29%	Production, transportation, marketing	1980	Blond (1984)
Wheat	13%-15%	Production to baking (processing)	2011	Kader *et al.* (2012)
Cereal and oil seeds	17.6 million tonnes	Farm, food processing	2009	Saleh (2012)
Legumes	1.9 million tonnes	Farm, food processing	2009	Saleh (2012)
Fruits and vegetables	8.8 million tonnes	Farm, food processing	2009	Saleh (2012)
Food processing by-product (e.g. stems, peel, husk)	570 thousand tonnes	Food processing	2009	Saleh (2012)
Pomegranate	23% (11 million Egyptian Pounds)	Post-harvest (Assiut Governorate)	2006	Kader *et al.* (2012)
Vegetables	7%	Marketing (Sharquia, Giza, Kaliobia governorates)	2006	Kader *et al.* (2012)
Fruits	6.5%	Marketing (Sharquia, Giza, Kaliobia governorates)	2006	Kader *et al.* (2012)
Iran				
Grapes	13%	Post-harvest	2002	Jowkar *et al.* (2005)
Cereals	12.9%	Post-harvest	2007	Kader *et al.* (2012)
Libya				
Potatoes	45%	Post-harvest	1985	Yahia (2005)
Onions	45.1%	Post-harvest	1985	Yahia (2005)
Tomatoes	40.8%	Post-harvest	1985	Yahia (2005)

Table 1 - Magnitudes of FLW in selected crops in the Near East and North Africa (NENA) countries (continued)

	Amount of FLW	Phase(s) of FSC	Year	Source
Lettuce	52.1%	Post-harvest	1985	Yahia (2005)
Cucumber	44.5%	Post-harvest	1985	Yahia (2005)
Oranges	33.5%	Post-harvest	1985	Yahia (2005)
Lemons	16.5%	Post-harvest	1985	Yahia (2005)
Grapes	29.9%	Post-harvest	1985	Yahia (2005)
Morocco				
Dates	40%-50%	Total		Ait-Oubahou and Bartali (2014)
Oman				
Total waste in supermarkets	3%-19%	Retail	2003	Opara (2003)
Summer potato	1.4%, 1.8%, 0.1%, 1% and 2%	Picking, sorting, packing, storing and transportation (respectively)	1997	
Fruits	24%	Household (Consumption)	2007	Opara *et al.* (2007)
Banana	28%	Household (Consumption)	2007	Opara *et al.* (2007)
Dates	7%	Household (Consumption)	2007	Opara *et al.* (2007)
Food	33% USD 175/month	Household (Consumption)	2012	Al-Beloushi (2012)
Saudi Arabia				
Tomato	17%	Production	2008	Al-Kahtani and Kaleefah (2008)
Fig	19.8%	Production	2008	Al-Kahtani and Kaleefah (2008)

Table 1 - Magnitudes of FLW in selected crops in the Near East and North Africa (NENA) countries (continued)

	Amount of FLW	Phase(s) of FSC	Year	Source
Grape	22.8%	Wholesale, import	2008	Al-Kahtani and Kaleefah (2008)
Cucumber	21.3%	Wholesale, import	2008	Al-Kahtani and Kaleefah (2008)
Grape	15.9%	Retail	2008	Al-Kahtani and Kaleefah (2008)
Dates	15%	Retail	2008	Al-Kahtani and Kaleefah (2008)
Cucumber	7%	Wholesale and Retail	2006	Alhamdan (2012)
Beans	4%	Wholesale and Retail	2006	Alhamdan (2012)
Green leaves	7.2%	Wholesale and Retail	2006	Alhamdan (2012)
Strawberry	13.05%	Wholesale and Retail	2006	Alhamdan (2012)
Tunisia				
Apples (government sector production)	10%-15%	Production, storage, transport, wholesale	1992	Kacem (1999)
Pears (government sector production)	10%-15%	Production, storage, transport, wholesale	1992	Kacem (1999)
Wheat	18.3%	Farm to fork, in terms of total wheat (production plus imports)	Before 2006-2012	Ksouri (2014)

Source: compilation of references.

Table 2 - Weight percentages of FLW (in % of what enters each step of the food supply chain) in Europe, in North Africa, in Western and Central Asia and in Turkey

Region	Commodity groups	Steps of the food supply chain				
		Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket retail	Consumption
Europe	Cereals	2	4	0.5-10	2	25
	Roots and tubers	20	9	15	7	17
	Oilseeds and pulses	10	1	5	1	4
	Fruit and vegetables	20	5	2	10	19
	Meat	3.1	0.7	5	4	11
	Fish and seafood	9.4	0.5	6	9	11
	Milk	3.5	0.5	1.2	0.5	7
North Africa, West and Central Asia	Cereals	6	8	2.7	4	12
	Roots and tubers	6	10	12	4	6
	Oilseeds and pulses	15	6	8	2	2
	Fruits and vegetables	17	10	20	15	12
	Meat	6.6	0.2	5	5	8
	Fish and seafood	6.6	5	9	10	4
	Milk	3.5	6	2	8	2

Table 2 - Weight percentages of FLW (in % of what enters each step of the food supply chain) in Europe, in North Africa, in Western and Central Asia and in Turkey (continued)

Region	Commodity groups	Steps of the food supply chain				
		Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket retail	Consumption
Turkey	Cereals	5.1	4	2	1	5
	Roots and tubers	7	6	2	3	2
	Oilseeds and pulses	15	5	7	1	4
	Fruits and vegetables	20	8	10	10	5
	Meat	10	0.2	5	0.5	1
	Fish and seafood	10	0.2	0.04	0.01	2
	Milk	10	1	1.5	6	1.5

Source: Adapted from Gustavsson *et al.* (2011) for data regarding Europe and NAWCA region and Tatlidil *et al.* (2013) for data regarding Turkey.

Regarding bread waste in Turkey, the results of the studies conducted show that of a total 4.9 million loaves of bread wasted daily in 2013, 62.1% are wasted at bakeries, 27.7% are wasted by households, 10.2% are wasted at restaurants, hotels and dining halls. The bread waste occurring particularly at bakeries is mostly due to the fact that sales points return unsold bread to bakeries. This bread is then either used as animal feed or thrown away (OECD and FAO, 2014).

Turkish policy and initiative on bread waste reduction

Launched in 2013, the Preventing Bread Waste campaign is coordinated by the Ministry of Food, Agriculture and Livestock and its subsidiary organisation, the Turkish Grain Board (TMO). The campaign aims to raise public awareness on waste, avoid waste throughout bread production and consumption stages, promote the consumption of whole wheat bread and contribute to the national economy. Thanks to the campaign carried out in 2013, the bread waste at household, staff and student dining halls decreased by 40% and by 1% in the private sector (restaurants, hotels and bakeries). The campaign has had remarkable outcomes although it has been carried out without imposing any legal sanctions and only with voluntary support. As a result of a study carried out to measure the impacts of the campaign in 2013, 384 million loaves of bread have been saved thus saving the Turkish economy 300 million Turkish liras (USD 136 million), a decrease in bread consumption occurred and 2.5 billion Turkish Liras (USD 1.1 billion) were saved. Consequently, the campaign resulted in a total of 2.8 billion Turkish Liras (USD 1.3 billion) savings for the national economy in 2013.

Source: Eker (2014).

In Egypt, the annual losses of wheat (both locally produced and imported) are valued at 6.6 billion Egyptian Pounds (over USD 1 billion), while the value of maize losses is estimated at 1.5 billion Egyptian Pounds. The reduction of half of the wheat and maize losses would lead to the savings of some 4 billion Egyptian Pounds annually. An estimate of average total waste ranged from 3 to 19% across supermarkets in Oman; while the amount of loss directly associated with handling damage was approximately 2% (FAO, 2013c). Egypt loses between 13 and 15% of the available cereals between harvesting and final consumption (FAO, 2013c). All fresh produce managers consistently identified tomato and banana as the two most important contributors to total wastage, with significant contributions also from grapes and lettuce.

According to the FAO (2013c), the major causes of food losses and waste in the NENA region include the lack of appropriate policy and regulatory framework, institutional weaknesses, inadequate and weak infrastructural base, and technological deficiencies or lack of innovation. The region suffers from very low cold chain capacity, especially important due to the hot climate of the region. Refrigerated storage capacity in Egypt is 0.0144 m^3 per capita, in comparison to 0.141 m^3 per capita in France, indicating that it is very low although the hot climate in the region requires a much higher capacity. The lack of and unreliability of power supply is a key challenge to establishing the cold chain in the region. Poor maintenance and management practices are another major factor concerning the infrastructure in the region. Other types of infrastructure face similar major constraints. Wholesale and retail markets in the region are often small, overcrowded, unsanitary and lacking cooling equipment, and adequate facilities for loading, unloading, ripening, consumer packaging and temporary storage.

According to the expert consultation meeting on FLW reduction in the Near East Region held in Egypt in 2012 (FAO, 2013c), lack of appropriate policy and regulatory frameworks and institutional weaknesses are the two main points to focus on in order to reduce FLW as they encourage negative attitudes and actions. Thus, intra-regional trade regulations which are inappropriately designed or implemented lead to perishable products (breaks in the cold chain and to the products being subjected to poor handling). There is also a lack of clarity in the institutional responsibility for food security, market management and monitoring and evaluation. In several countries, municipal governments and Ministries in charge of Agriculture, Supply, Industry and Health are all involved in managing food handling, processing, retailing and wholesaling with no or insufficient coordination, vertical and horizontal harmonisation, or demarcation of jurisdiction. The institutional framework at national and regional levels is usually short-lived and unsustainable as it depends on the government in place. Furthermore, there is usually no framework to foster strong partnership between ministries at various administrative levels as well as donors and international organisations.

Observation of household food waste

In Italy, waste reaches alarming levels at the consumer level. The data released by the Italian Association for the Defence and Orientation of Consumers show that the average household waste is of 35% for fresh produce, 19% for bread and 16% for fruits and vegetables (BCFN, 2012). According to Andrea Segrè (2013), household food waste is mainly caused by the fact that food is mouldy or expired, fruits and vegetables are not stored appropriately, and food has not been prepared according to the consumer's preferences or it is left to spoil. Yearly food waste in Italy reaches a value of approximately 8.7 billion euros that corresponds to a value of approximately 7.06 euro per family per week (Segrè *et al.*, 2014). In the same time, the food banks in Italy are contributing to recovery and redistribution of safe and nutritious food for human consumption: in 2015, the Fondazione Banco Alimentare Onlus estimated the recovery of 75,000 tonnes of food products and 1,100,000 ready meals.

Food Banks in Italy

Through its Food Bank Network composed of 21 Food Banks in Italy, the Fondazione Banco Alimentare Onlus (FBAO) is committed to fight against food waste and feed the most deprived. The FBAO was established in Italy in 1989 and is a member of the European Federation of Food Banks (FEBA) since 1990. Its mission consists of the daily recovery of food from all the sectors of the food supply chain (agriculture, production, distribution and collective catering) and its daily redistribution to 8,103 charitable organisations that assist 1,558,250 food-insecure persons in Italy. In addition, the network distributes food products received from the EU.

In 2015 the FBAO recovered about 40,448 tonnes of surplus food and collected 14,965 tonnes of donated food products, of which 9,201 tonnes during the National Food Collection Day. The Network also recovered 1,043,351 portions of ready meals and 319 tonnes of bread, fruit and fresh products from the collective catering, company and school canteens. The activity of this Network is made possible thanks to the daily commitment of 1,843 volunteers. A Manual for appropriate operational practices for charity organisations was published in early 2016 by Caritas Italiana and Fondazione Banco Alimentare.

Source: Fondazione Banco Alimentare Onlus, Italy (www.bancoalimentare.it).

A study estimated the annual food waste generation in the EU27 at approximately 89 million tonnes or 179kg per capita (Monier *et al.*, 2010). However, this study does not include primary agricultural and fisheries sectors in its estimations. Food waste is expected to rise to about 126 million tonnes by 2020 without additional prevention policy or activities. Households produce the largest fraction of EU food waste among the four sectors considered (manufacturing, households, wholesale/retail, and food service/catering sectors), at about 42% of the total (38 million tonnes), i.e. an average of about 76kg per capita (of which 60% may be avoided). In households, food waste comes from meal preparation, leftovers and purchased food that is not used in time. The proportion of food waste – in relation to the amount of food produced – is 5% of the total for the EU. However, it varies from country to country; from 1% in Germany to 21% in Estonia (Monier *et al.*, 2010). Data regarding the eight Mediterranean countries considered in the study show that the highest food waste, per capita and per year, is estimated in Cyprus while the lowest is recorded in Greece (Table 3). Considering national food waste in tonnes, three Mediterranean countries are ranked among the first six ones: France (3rd), Italy (5th) and Spain (6th).

According to the EUROSTAT data for 2006, France produces about 9 million tonnes of food waste every year of which, over 6 million tonnes can be attributed to the final consumer stage, 626,000 tonnes to the industry, while the remaining 2 million tonnes, more or less, can be attributed to the distribution and restaurant and food service sectors. According to ADEME (2010), every year, a French citizen wastes, on average, the equivalent of 20kg of food products: 7kg are still in their original packaging and 13kg of meal leftovers, damaged fruits and vegetables. In terms of catering, it is estimated that every meal, including the preparation and consumption stages, generates about 150g of organic waste.

A study by the Spanish Confederation of Consumers' and Users' Cooperatives (Hispacoop) showed that 31.6% of food waste comes from unconsumed leftovers. Each Spanish citizen wastes on average 250 euros per year in unused food; more than 45% of this is edible (Vay, 2014). A study carried out in 2005 to estimate household food waste – using a sample of 500 households in Ankara showed that waste accounted on average for 9.8% of the daily energy intake per person (i.e. 215.7kcal/person). The average daily food discard per person was 318.8g (Pekcan *et al.*, 2006). The Department of Sustainable Agriculture, Food and Rural Development of the

CIHEAM-Bari has undertaken an online survey in February-May 2015 to assess the knowledge and relative importance of FW in ten Mediterranean countries: Albania, Algeria, Bosnia-Herzegovina, Egypt (Elmenofi *et al.*, 2015), Lebanon, Macedonia, Morocco (Abouabdillah *et al.*, 2015), Montenegro, Tunisia and Turkey. The survey paid a particular attention to the issue of bread and bakery products wastage especially in Mediterranean Arab countries (Capone *et al.*, 2016).

Table 3 - Estimates of total food waste generation by Mediterranean EU member states

Mediterranean country	Manufacturing	Households	Other sectors*	Total food waste (in tonnes per year)	Food waste (in kg per capita)
Cyprus	186,917	47,819	21,000	256,000	344
France	626,000	6,322,944	2,129,000	9,078,000	144
Greece	73,081	412,758	2,000	488,000	44
Italy	5,662,838	2,706,793	408,000	8,778,000	149
Malta	271	22,115	3,000	25,000	61
Portugal	632,395	385,063	374,000	1,391,000	132
Slovenia	42,072	72,481	65,000	179,000	89
Spain	2,170 910	2,136,551	3,388,000	7,696,000	175
EU27	**34,755,711**	**37,701,761**	**16,820,000**	**89,277,472**	**179**

*The category other sectors includes wholesale/distribution and professional and collective catering services.
Source: according to Monier *et al.* (2011) based on EUROSTAT data.

Methodology and profile of respondents that took part in the CIHEAM-Bari survey on FW in selected Mediterranean countries

The tool used to conduct the food waste survey is a self-administered questionnaire. It was designed and developed in English, French and Arabic languages in December 2014 and made available from January till the end of May 2015 through the *Survio* website. The questionnaire consisted of 26 questions (one option and multiple-choice questions) and was divided into 6 sections: 1) food purchase behaviour and household food expenditure estimation; 2) knowledge of food labelling information; 3) attitudes towards food waste; 4) extent of household food waste; 5) economic value of household food waste; and 6) willingness and information needs to reduce food waste.

A total number of 2,657 completed questionnaires were received: 185 from Albania; 323 from Algeria; 583 from Bosnia and Herzegovina; 181 from Egypt; 216 from Lebanon; 245 from the former Yugoslav Republic of Macedonia; 122 from Morocco; 371 from Montenegro; 281 from Tunisia; and 150 from Turkey. The respondents from the ten countries were mostly females (64% female and 36% male) and rather young (84.7% are less than 44 years old) while most of them have high education level.

The results show that household's planning and shopping activities are important predictors of FLW. On the other hand, attitudes may change according to periods especially in Ramadan (84.8% declare that FW is higher during this month in Algeria, Egypt, Lebanon, Morocco, Tunisia and Turkey), due to the high quantity of food purchased and prepared but never eaten.

It seems that FLW is widespread in all these 10 Mediterranean countries, mainly in Albania (82.2%), Turkey (50%), Montenegro (47.2%), Tunisia (45.2%) and Morocco (45.1%). Few respondents declare that they do not waste any food (Table 4).

Table 4 - Level of household food waste (% of responses)

	Much more than it should	More than it should	A reasonable amount	Very little	Almost nothing
Albania	5.4	13.5	63.2	14.6	3.2
Algeria	4.6	6.5	29.4	47.4	12.1
Bosnia Herzegovina	4.3	11.1	25.0	39.3	20.2
Egypt	1.1	2.8	29.3	53.0	13.8
Lebanon	0.5	5.1	30.6	48.6	15.3
FYROM*	1.2	10.2	18.8	46.1	23.7
Morocco	6.6	13.1	25.4	51.6	3.3
Montenegro	3.8	14.0	29.4	38.3	14.6
Tunisia	3.9	9.6	31.7	48.8	6.0
Turkey	1.3	3.3	45.3	28.7	21.3

* FYROM: Former Yugoslav Republic of Macedonia.
Source: CIHEAM-Bari, *Household Food Waste Survey* (2015).

Regarding the category of food, the most wasted product groups are cereals and bakery products, fruits and vegetables (Table 5). In Tunisia, 81.5% of the respondents declare that they throw bread when they do not finish eating it.

Table 5 - Estimated quantity of purchased food thrown away

Food categories	Less than 2%	3% to 5%	6% to 10%	11% to 20%	Over 20%
Cereals and bakery products	45.5	20.3	12.5	8.7	13.1
Roots and tubers	63.3	20.4	8	5.5	2.7
Pulses and oil seeds	71.8	14	9.3	3.6	1.3
Fruits	64.8	18.3	8.1	5.6	3.2
Vegetables	56.7	22.5	9.3	6.8	4.7
Meat and meat products	72.8	11.7	7.7	4.6	3.2
Fish and seafood	82.5	10.7	4.1	1.8	0.9
Milk and dairy products	61.6	20.1	8.4	4.5	5.4

Note: The figures in the table refer to response percentages.
Source: CIHEAM-Bari, *Household Food Waste Survey* (2015).

The economic value of food waste generated each month is more than USD 6 for 52.7% of respondents' households, mainly in Lebanon (80.1%), Montenegro (63.3%) and Albania (61.6%) (Table 6).

Table 6 - Value of food waste generated per month (in USD)

	Less than 5	6-20	21-50	More than 51
Albania	38.4	25.9	29.2	6.5
Algeria	52	40.2	5.6	2.2
Bosnia Herzegovina	47.9	43.2	6.5	2.4
Egypt	78.5	14.9	5.5	1.1
Lebanon	19.9	54.2	19.0	6.9
FYROM*	55.5	38.8	3.7	2
Morocco	45.9	42.6	10.7	0.8
Montenegro	36.7	52.8	8.9	1.6
Tunisia	57.3	36.3	5.3	1.1
Turkey	42	42.7	10.7	4.7

* FYROM: Former Yugoslav Republic of Macedonia.
Note: The figures in the table refer to response percentages.
Source: CIHEAM-Bari, *Household Food Waste Survey* (2015).

In order to investigate knowledge about food labels, respondents were asked what is meant by “use by” and “best before” dates. Most of the respondents have a good understanding of food labels. However, few respondents answered wrong indicating that there is still some confusion surrounding the definitions.

Legal framework and institutional environment for FLW reduction in the Mediterranean countries

Strategies to improve food security in the region have traditionally focused on increasing food production while putting relatively much less emphasis on measures to reduce FLW. If implemented in an appropriate way, measures to reduce FLW offer the opportunity to increase food security while at the same time reducing further stress on scarce natural resources such as land and water (FAO, 2013c). As for the European Mediterranean countries, the European Union’s Waste Framework Directive[10], published in December 2015, requires Member States to adopt a common methodology for food waste measurement and to report food waste levels to the European Commission on a biennial basis.

Several countries have launched broad multi-stakeholder initiatives. In June 2013, France launched its National Pact against Food Waste. In April 2015, French policymakers released ambitious proposals for a national policy against food waste and for prevention, recovery and recycling. Some measures, including a ban on distribution level food waste, have already entered the legislative processes. The proposals are the result of a yearlong study led by the Ministries of Agriculture and the Environment. The national policy reflects a collaborative process, led by Parliament member Guillaume Garot. Inputs were sought and received from various experts and stakeholders. Their report calls for 36 regulatory and policy measures across the French food system (Mourad, 2015). The proposed policies against food waste also aim to create a new form of collaborative policy development in partnership with civil society, business, government, and grassroots movements.

36 measures for a policy proposal against food waste in France

Stakeholder responsibilities

1) Set into law a hierarchy of preferable actions to fight food waste;

2) Create innovative communication;

3) Clarify expiration dates on food products;

4) Organise local food recovery days;

5) Offer lifelong education about sustainable food;

6) Forbid supermarkets from throwing away edible excess food;

10 - http://eur-lex.europa.eu/resource.html?uri=cellar:c2b5929d-999e-11e5-b3b7-01aa75ed71a1.0018.02/DOC_1&format=PDF

7) Mandate donations to charitable organisations;

8) Ban destruction of edible food;

9) Include messages on food waste in retail advertisements;

10) Enable the donation of rejected "house" brand products;

11) Use QR codes to better inform consumers;

12) Adjust portion and packaging sizes;

13) Improve the use of expiration dates;

14) Encourage use of food by-products for animal feed;

15) Extend tax incentives to processed agricultural products;

16) Better regulate gleaning activities;

17) Strengthen professional training on food waste;

18) Promote the "doggie bag" habit.

The tools of a public policy on food waste

19) Create a dedicated public agency to implement food waste policies;

20) Measure food waste;

21) Mobilise households to conduct a large-scale food waste study;

22) Establish 1,000 community service positions focused on food waste;

23) Offer grants to encourage innovation;

24) Create a zero-waste certification programme;

25) Require product quality in exchange for tax benefits;

26) Assess the impact of food waste regulations;

27) Build innovative partnership to overcome logistic challenges.

Towards a new development model

28) Develop local working groups and local strategies against food waste;

29) Create dedicated devices in case of a production crisis;

30) Coordinate public policies related to food;

31) Form an inter-ministry committee on food waste;

32) Require leniency with regards to dumpster-diving and gleaning;

33) Establish a European committee against food waste;

34) Push for changes in European regulations to reduce food waste;

35) Integrate food waste in the COP 21 climate change negotiations;

36) Establish a decentralised cooperation programme: "1 percent" against food waste.

Source Guillaume Garot, Lutte contre le gaspillage alimentaire: propositions pour une politique publique, Paris, Ministry of Agriculture, Agro-food and Forests and the Ministry of Ecology, Sustainable Development and Energy, April 2015.

Six of the above-mentioned proposals were approved by both bodies of the French Parliament (Senate and National Assembly) in mid-2015. However, the French Constitutional Council subsequently raised procedural concerns, making it necessary for the Parliament to reconsider proposals 1, 5, 6, 7, 8, and 10 before their submission to the President of the Republic for final approval. On the 9th of December 2015, the proposal for a French law on the fight against food waste was voted unanimously by the National Assembly. The Senate voted unanimously in February 2016. Supermarkets with a footprint of 400m^2 or more will have to sign donation contracts with charities or face a penalty of 3,750 euros.

Source: National Assembly (www.assemblee-nationale.fr/14/propositions/pion2492.asp) and Senate (www.senat.fr/rap/l15-268/l15-268_mono.html).

The Spanish Ministry of Agriculture, Food and Environment is leading the multi-actor “More Food, Less Waste” Strategy. In this framework, a number of guides including the following ones were published, particularly the *Practical guide to reduce food waste in the retail sector* (2015), the *Practical guide to reduce food waste at education centres* (2014) and the *Practical guide for the consumer: How to reduce food waste* (2014) along with studies on the quantification of food waste. At sub-national level, local and regional authorities often play an important role, as in Catalonia for instance (Vay, 2014).

Governments from the NENA region have made concerted efforts to recognise the issue of FLW, and bring awareness to the need to reduction, and commit to strategic action. A major step was the collective request for support from the FAO to reduce FLW by 50% over 10 years (FAO, 2012c), particularly in the form of strategy development and analysis. A process to meet this request began with an Expert Consultation Meeting held in December 2012 (FAO, 2013c) to deepen the understanding of FLW and start charting a strategy for FLW reduction. Several workshops and meetings between diverse stakeholders were organised to hold discussions on regional and national perspectives of FLW. The major strategic thrusts to a reduction plan were established in a consultative manner. The resulting Regional Strategic Framework for Food Losses and Waste Reduction was presented by the FAO to its regional governing body (32nd Near East Regional Conference) in February 2014, and endorsed by member countries (FAO, 2014a). The document calls for evidence-based national action plans for FLW reduction, with clear objectives, baseline, indicators and targets. Some countries have engaged themselves through concrete actions: in 2013, the Kingdom of Saudi Arabia launched a commitment to reduce FLW and a proposed a “Strategy and Action Plan to Reduce FLW in the Kingdom of Saudi Arabia” that evolved into a component of the KSA Food and Nutrition Security Strategy. The focus is on both food loss and food waste reduction, and on generating quantitative and qualitative evidence as a first step.

On the 6 of February 2014, in the final declaration of the 10th meeting of the Ministers of Agriculture of the thirteen Mediterranean Member Countries of the CIHEAM in Algiers, the ministers and heads of delegations proposed the CIHEAM to strengthen instruments and networks and encourage regional initiatives aimed at addressing the issue of food waste (CIHEAM, 2014). While much work remains to be done by 2024, several activities are already underway also in Egypt, Jordan, Lebanon, Morocco, Tunisia, and elsewhere in the NENA region. Policy measures taken by Egypt regarding the subsidised "baladi bread" supply chain is contributing to the reduction of waste. Many initiatives and awareness activities focusing on waste are carried out at consumer level in Lebanon and in Italy.

Reforming subsidies in Egypt to improve targeting and reduce waste

In 2014, a reform of the Egyptian bread subsidy system sought to make subsidised bread more accessible to the most vulnerable, reduce inefficiencies and waste and reduce cost. In terms of waste, the subsidies on bread in Egypt are believed to be a driver of consumer wasteful behaviour and of the opportunistic behaviour among supply chain actors. Previously, flour was subsidised. It was therefore bought cheap and sold at higher prices as flour, bread, or "leaked" from the chain. Leakages occur at all stages of the chain, in ports, storage facilities, mills and bakeries. Consequently, up to 43% of purchased wheat is not turned into bread.

The reform introduced a smart card system that subsidised bread rather than flour and limited the amount to 5 loaves per person each day. Moreover, the quota is allocated through a credit balance, so that any leftover credit that is not spent on loaves can be converted into points and used to buy other subsidised food commodities (cooking oil, rice, or macaroni, for example). In this way, consumers have the incentive to acquire only the bread they need. Upstream actors are also encouraged to manage the supply chain more effectively since losses will result in less bread being sold.

In April 2015, the Egyptian government launched two others initiatives as part of its Cash Transfer Programme, entitled *Takaful* and *Karama* ("solidarity and dignity"). Under this programme, poor families receive the equivalent of USD 43 to USD 83 per month, while some elderly people and people with disabilities receive USD 47 per month. The programme aims to cover 1.5 million families by 2017. Takaful provides the income support provided that there are: 80% school attendance by children aged 6 to 18, attendance to medical check-ups for mothers and children under 6, and also to nutrition classes. In contrast, Karama provides unconditional income support to the elderly and people with disabilities. A national database is established to consolidate social safety net programmes. This Unified National Registry has made some progress in linking the smart card to other social assistance and social security databases.

Source: World Bank (2015) and FAO (2013c).

Initiatives to reduce FLW in Lebanon

The Lebanese Food Bank (LFB) was launched in 2013 with the main objective to eliminate hunger from Lebanon by 2020 by building on strong partnerships in the public and private sectors as well as on cooperation, and donations from individuals. Among the many LFB's actions, the Awareness Programme "Not To Waste Food" targets hotels, restaurants, catering companies, food factories, and individuals. Instead of throwing away the excess food, the LFB distributes it to orphanages, nursing homes and NGOs. The *MED-3R (Euro-Mediterranean Strategic Platform for a Suitable Waste Management*) is a waste management project. Regarding food waste, the aim of this project is to apply in Lebanon the same initiative carried out in France regarding the encouragement of restaurants and clients to use the take away leftover bags.

Source: Oneissi (2014).

Policies and initiatives to reduce FLW in Italy

The Italian Presidential Decree of 26 October 1972, No. 633 ("Establishment and implementation of value added tax", Article 10, Paragraph 12) states that donations made to public bodies, recognised associations or foundations with the sole purpose of assistance are exempt from tax (VAT). Italy is the first European Union country to have adopted the "Good Samaritan Law"(Law No. 155/2003) ensuring tax benefits similar to non-profit and of social utility institutions for organisations carrying out free distributions of food to the needy as charity. These fiscal benefits are within the bounds of the service provided i.e. food donation.

A national task force for the reduction of food waste has been set up by the Italian Ministry of Environment. On the 5 of February 2014, on the occasion of the national day against food waste, the task force met to start developing a national plan for waste prevention. Over 500 Italian municipalities have signed the "Charter for a network of local and regional authorities with zero waste" promoted by Last Minute Market, an academic organisation derived from the University of Bologna, thus pledging to reduce waste and loss along the food supply chain. In December 2013, the "National Network of Municipalities against Waste" (association Sprecozero.net) coordinated by the city of Sasso Marconi (province of Bologna) was established from the experience of the Charter.

Source: Last Minute Market (2014).

Challenges and opportunities for FLW reduction

Trends in production, consumption and local, national, regional and international trade of food suggest an increasing dependence of the NENA region on external sources for its basic food supplies. To close this widening import gap, there is a need to address several challenges such as: demographic pressures; sustainable management of water resources; enhancement of crops, livestock and fisheries productivity; reduction of food losses; and management of food imports (FAO, 2015b).

The challenge of addressing FLW must consider the whole supply chain from food production to food processing and retail, including the end consumer and waste management systems. Understanding and preventing FLW requires a deep understanding of international, regional, national and local food systems (HLPE, 2014; Ericksen, 2008; Ingram, 2011). For this purpose, further research and multi-stakeholder consultation and knowledge sharing is needed in the Mediterranean. Potential areas of interest could be:
– FLW quantification methods harmonised at different levels (in international food supply chains, and at national, local, and households level, etc.) for different food categories, groups, and identification of potential trends in time;
– Social, technological (storage, packaging), behavioural, attitudinal and cultural drivers and causes of FLW as well as the most effective solutions for different stakeholders;
– Environmental, financial and economic implications of FLW for different stakeholders;
– Effectiveness of main policy measures and coping strategies to reduce FLW;

– Potential contribution of food safety laws, regulations, and their interpretation and implementation for FLW prevention and reduction;
– Cost-benefit and cost-effectiveness analyses of technological, social, institutional solutions to FLW;
– Impacts of labelling, marketing, retailing and distribution approaches on FLW;
– Compositional analysis of FLW in the Mediterranean countries;
– Impacts on food and nutrition security of FLW;
– Knowledge of and perceived relevance of FLW among Mediterranean consumers;
– Consumer attitude towards waste and FLW;
– Impacts of gender and behaviour regarding food, food management, food waste along supply chains.

Improving the efficiency of the food supply chain, production techniques and infrastructures is of utmost importance for developing countries (Kader, 2005), while developed countries should conduct consumer education campaigns, and facilitate recovery and redistribution of safe and nutritious food for human consumption (Monier *et al.*, 2010; FAO, 2015a and 2015b). In addition to an enabling policy environment, the FAO (2014a) states that collaboration and coordination between all agents of the food supply chain and other stakeholders, and regional and international networking are also fundamental. Advocacy, education and legislation may also reduce loss and waste in the food service and retail sectors. In some countries, the existing legal and legislative framework regarding food quality and safety needs to be updated and revised. Legislation on date labelling of foodstuffs should be re-examined (Godfray *et al.*, 2010) and clarified for the industry as well as consumers. Public awareness campaigns are required for all food supply chain actors to promote relevant and practical procedures and technologies (FAO, 2014a). A comprehensive approach was adopted by Italy in August 2016 as it can be seen in the box provided below.

Law on food waste prevention (Italy)

On 2 August 2016 Italy adopted the law against food waste that has the following points:

1) It creates a regulatory framework to comprehend the existing rules concerning fiscal incentives (L. 460/97, L. 133/99), civil liability (L. 155/03) and hygiene and food safety procedures (L. 147/13).

2) It provides a set of definitions (e.g. food business operator, surplus food, food waste, donation, best before and use by dates, etc.).

3) It fosters the donation of confiscated food products.

4) It encourages companies to donate food rather than to destroy it by simplifying the administrative procedures to be given to public authorities.

5) It establishes a hierarchy for the use of products prioritizing the recovery for human consumption. Whether it is not possible to redirect food to feed people, it should be use for animal feeding or energy.

6) It recognizes the role of the "round table" managed by the Minister for Agricultural, Food and Forestry Policies as a tool for consulting all the stakeholders of the food supply chain. It adds 2 millions euros to the National Fund for the distribution of food products to the most deprived in order to purchase food.

7) It ensures an adequate number of hours of television and radio programs devoted to information and awareness about food donation and the fight against food waste.

8) It simplifies the donation of agricultural and farming surplus that fit for human and animal consumption.

9) It enables municipalities to reduce waste taxes for companies donating surplus food.

Source: www.bancoalimentare.it/en/Legge-Gadda-Spreco-Aliementare

Operational Manual for food donation in Italy by Caritas Italy and the Italian Food Banks Foundation

The Operational Manual aims to develop the correct hygienic practices that enable the recovery, collection, storage and redistribution of food by charitable organizations. The identification of good hygiene practices helps maximizing the collection and recovery of food, throughout the food supply chain, such as, primary production, products with defects in labelling, foodstuffs near their expiration date, public catering safe and nutritious cooked meals or ingredients. In reference to Regulation (EC) No. 178/2002 all food business operators must ensure food safety. According to Art. 21 of the Regulations (EC) No. 178/2002 R&R units are subject to the rules relating product liability (Law 155/2003 National Italian legislation) that equate them to the final link before the end consumer for the purposes of civil liability. The manual highlights and identifies the correct operating practices in terms of hygiene to guarantee food safety as governed by Regulation (EC) No. 852/2004. The manual is mainly referring to European Community law and national legislation (Italy) and welcomes the principle of flexibility granted by the Regulation 852/2004 that considers R&R units as food business operators.

Source: Recupero, raccolta e distribuzione ai fini di solidarietà sociale. Manuale per corrette prassi operative per le organizzazioni caritative, *Caritas Italy and the Italian Food Banks Foundation, 2015 (http://cdn3.bancoalimentare.it/sites/bancoalimentare.it/files/manualecaritasbanco016_web.pdf).*

The role of the private sector in FLW reduction is crucial. An enabling environment is needed for governments to stimulate private investment and engage the private sector. For the latter, the FAO (2014a) specifies that investment is required in improved food supply chains, appropriate farming technologies and household equipment, and in the use and reuse of lost food. During the last decades, efforts aimed at reducing FLW were significant. The first *Global Initiative on Food Loss and Waste Reduction* (also called SAVE FOOD) launched in 2011 and led by the FAO includes the following main partners: Messe Düsseldorf (Germany) and UN programmes such as IFAD, WFP and the UNEP and its *Think.Eat.Save Reduce Your Foodprint* awareness raising campaign. Moreover, SAVE FOOD collaborates with public sector representatives, private sector engaged companies and civil society organisation to ensure: 1) advocacy and awareness raising; 2) collaboration and coordination of world-wide initiatives; 3) policy, strategy and programme development; 4) support to investment programmes and projects.

To further stimulate commitment to the reduction of FLW, several cross-sectional strategies requiring action from multilateral and bilateral donors, intergovernmental agencies, national governments, and the private sector are needed (Lipinski *et al.*, 2013). It is clear that the feasibility, efficiency and sustainability of solutions and interventions for FLW reduction in the short, medium and long term have to rely on a multi-actor and cross-sectoral coordinated effort involving all relevant actors in the food supply chains including private and public actors as well as civil society. Policies can facilitate prevention and reduction of FLW and the sustainable use of limited natural resources such as water and land in view of their importance in the region. Additionally, policies should be time- and cost-bound and should set up appropriate results-based monitoring and evaluation systems that are transparent and provide appropriate accountability mechanisms. Steps should be taken to enhance the harmonisation of policies and strategies at international, sub-regional and regional levels. The development and endorsement of a regional strategic framework for FLW reduction in the SEMCs (NENA region) has been a major step forward in this regard (FAO, 2014a). The Milan Urban Food Policy Pact is another example of policy frameworks facilitating coordination.

The Milan Urban Food Policy Pact

On the 15 of October 2015, 117 cities across the world signed the Milan Urban Food Policy Pact. The Pact was presented to the United Nations Secretary General, Ban Ki Moon on the 16 of October, on the occasion of the World Food Day. This Pact aims to support policy coherence and was launched together with its Plan for Action and Selected Good Practices.

The Pact recommends actions for food waste reduction and measurement:

– Convene food system actors to assess and monitor food loss and waste reduction at all stages of the city region food supply chain (including production, processing, packaging, safe food preparation, presentation and handling, re-use and recycling) and ensure holistic planning and design, transparency, accountability and policy integration.

– Raise awareness on food loss and waste through targeted events and campaigns; identify focal points such as educational institutions, community markets, company shops and other solidarity or circular economy initiatives.

– Collaborate with the private sector along with research, educational and community-based organisations to develop and review, as appropriate, municipal policies and regulations (e.g. processes, cosmetic and grading standards, expiration dates, etc.) to prevent waste or safely recover food and packaging using a "food use-not-waste" hierarchy.

– Save food by facilitating recovery and redistribution for human consumption of safe and nutritious foods, if applicable, that are at risk of being lost, discarded or wasted from production, manufacturing, retail, catering, wholesale and hospitality.

Source: www.foodpolicymilano.org/en/urban-food-policy-pact-2

Strategies and best practices for reducing and/or preventing fish loss and waste

As described previously, the causes of FLW are specific to context and it is now unanimously acknowledged that multiple interventions focusing on the efficient use of resources and on the areas where FLW are most significant are required. Given the interwoven factors involved in their occurrence, the reduction of FLW will most likely rely on a combination of improvement in awareness, knowledge and skills, as well as technical, financial, infrastructural and policy support. While acknowledging the importance of common control measures (maintaining the cold chain, improving processing technology and packaging or assessing loss) buttresses the fundamental fact of "no one size fits all" in addressing FLW challenges. Therefore, a context-specific systematic analysis, inclusive of the sustainable value chain approach, and addressing the multifaceted dimensions of FLW, to set priority actions tailored to the given context, is necessary. It should be centred on the efficiency of the entire upstream and post-harvest system, and provide sound information to make cases for evidence-based policies, strategies and programmes. The analysis also includes a worthy ground for stocktaking of previous loss and waste reduction interventions and lessons, which can be adapted and up-scaled to the appraised context. The overview of a good practice in cold chain development in Moroccan fisheries casts some light on these patterns.

Cold chain and landing sites in Morocco, markets

This example is based on the work conducted by the Moroccan government in conjunction with the Millennium Challenge Corporation (MCC) and the US Trade and Development Agency (USTDA) to upgrade the cold chain infrastructure, services and knowledge and skills of artisanal fishery operators in better handling practices to reduce quality losses and improve the contribution of fish to national food security.

Morocco is a lead fishing country in the Mediterranean region irrespective of the effective area of origin of the fish produced. In 2013, it represented about 20% of the production share (excluding marine mammals, crocodiles, corals, sponges, shells and aquatic plants) of the region. It ranked third after Egypt (23%) and Spain (20.2%) for the production and second together with France after Spain (38.4%) for exports. However, this performance hides some challenges hindering the country's ability to satisfy the increasing domestic demand for quality fish, driven by an expanding tourist sector and expected growth in domestic fish consumption. So far, domestic consumption is well below the average for the region (12.5 against 20.1kg in 2011).

Indeed, due to inadequate coastal landing sites and port infrastructure, lack of unbroken cold chains from sea to consumer, weak integrity of the value chain, limited access to open markets, and insufficient training for fishermen and their cooperatives, small-scale fisheries remains the most undeveloped segment of Morocco's fishing sector. To address these issues, a modernisation programme was designed and implemented to improve the quality of the catch, maintain the value chain, and increase the fishermen's access to both local and export markets. Hence landing sites were built, support provided to help mobile fresh-fish traders invest in motorbikes with insulated boxes, transportation was improved along with the associated technical assistance and training was adapted to the targeted beneficiaries, designed to ensure that all beneficiaries become stewards of the new infrastructure and equipment after the end of the project. Efforts are also deployed to establish a network of Marine Protected Areas and increase monitoring efforts to ensure the sustainable catch of fish resources. More than 125,000 people are expected to benefit from the Small-Scale Fisheries Project, and household income is expected to rise by more than USD 273 million over the coming twenty years.

This approach was beneficial from two different perspectives. On the one hand, the project was built on approaches that had been field-tested by the government, incorporating some of the lessons that had been learned through trial and error. On the other hand, building the project on the past experiences of the Moroccan Government was an excellent way to build trust with the partners and to show the extent to which existing knowledge and "knowhow" were appreciated and valued. This project is a good reference for post-harvest loss reduction and design and implementation of interventions in similar contexts. The table below presents the process and key features identified by the consultant, who was involved in the implementation of one of the project's components.

Table 7 - Key features of cold chain development, Morocco

Building process	Key issues
Policy	Government is committed to economic improvement and development with the 2005 National Growth Strategy making fisheries a priority sector.
Legislation	Various standards developed to help implement better practices.
Skills and knowledge	Learning from previous projects during phases of planning and implementation. Capacity building is a strong aspect of project and associated with infrastructure and equipment modernisation including basic technical aspects. Capacity building for local construction companies to meet donor standards should have been provided earlier in project.
Services and infrastructure	Focus on the modernisation of infrastructure and services. Access to land is problematic in some locations and more communication with local authorities is required during planning. Feasibility studies completed were slower than expected due to differences in environmental and social standards.
Technology	Upgraded equipment is required to enable better handling of products and to improve the cold chain.

Some other good practices related to FLW reduction should be highlighted such as the one presented below and that are aimed at enhancing the utilisation of by-products to reduce food waste and support food and nutrition security.

Fish by-products, a valuable source of nutrients

Fish by-products constitute about 50% of processed fish and are the most valuable part from an economic point of view. Indeed, by-products are of higher nutritional value with a high concentration of the micronutrients lacking in many diets at global level, particularly affecting the most vulnerable groups especially women and children.

As more fish is being processed at industrial level before being sold, more of the remaining raw material (by-products) can potentially be processed into valuable products for direct human consumption. In most cases, these by-products are further processed into fishmeal and fish oil, primarily for feed purposes, and therefore indirectly contributing to food security. At present, more than 30% of the raw material used for the production of fishmeal and fish oil comes from by-products and waste rather than whole fish. This percentage is growing and increasingly replacing the small pelagic species historically used for this purpose. Fishmeal and fish oil are internationally traded products and represent an important source of revenue for some countries. These are also a very important feed ingredient for the aquaculture sector, the fastest growing food production system in the world.

The increasing demand for fish oil as a nutritional supplement has made it highly profitable to extract fish oil from by-products such as tuna heads. Oil extracted from cod livers has been a valuable source of vitamin D and vitamin A for centuries, and it is also increasingly recognised as a valuable source of long chain omega-3 fats. Mineral supplements can be made out of fish bones, although this is not yet widely done. However, low cost products with a high concentration of essential nutrients can easily be made from fish by-products. If traditions and demand for such products exist, fish by-products can play an important role in combating micronutrient deficiencies. The FAO is involved in several pilot activities, developing fish bone-based mineral products with high levels of essential minerals such as zinc, iron and calcium. A recent pilot production of a fish bone based mineral product showed high levels of most essential minerals, with for example 85mg/kg of zinc, 350mg/kg of iron and 84g/kg of calcium, in addition to significant amounts of iodine and essential omega-3 fats. The product was successfully mixed into traditional school feeding meals and highly appreciated by school children in Ghana. More than 2 billion people suffer from iron, iodine, zinc and vitamin A deficiencies, all found at high concentrations in fish by-products. Although most of the rest of the raw material, as a result of fish processing, is not currently utilised for human consumption, international trade has opened up new markets for fish products that are traditionally not consumed in their country of origin. For example, there is a growing demand for fish heads in some Asian and African markets, a product that is not considered as food in other regions. For years, the Nile perch caught in Lake Victoria has been locally processed, and high valued fresh fillets were exported out of the region. Raw materials such as back-bones and frames that have become a popular product on the local market, are now important products traded at local and regional level, and they are an important source of nutrients in local diet.

Source: Glover-Amengor et al. *(2012) and Olsen* et al. *(2014).*

Some other good practices related to reduction of FLW have been identified. They can serve as food for thought in planning and interventions, strategies and plans. In France, the "Small-scale fisheries and the zero discard target"[11] was set up but in other EU countries, regulations have been established to ban discarding of foodstuffs at the retailing level[12]. The FAO has a long history of collaboration with the CIHEAM-Zaragoza revolving around the organisation of advanced training workshops in different areas of fisheries. In the Mediterranean region the CIHEAM has the mandate to contribute to human resource development. Joint courses addressing "seafood Processing: Modern technologies and new product development", especially by-products and their benefits, economy and health challenges are provided.

Conclusions and recommendations

Globally, more than 1 billion tonnes of food produced for human consumption is lost or wasted each year while millions of people are still undernourished and over 2 billion people are micronutrient deficient. In order to move towards sustainable food consumption and production, demand and supply issues must be addressed by fostering socially innovative, efficient, and sustainable food production and consumption patterns. FLW have a direct and indirect effect on both food security and nutrition and food systems sustainability. Curbing the amount of FLW is therefore a tangible starting point.

Under the framework of the 2030 Sustainable Development Agenda, the Sustainable Development Goal 2 (SDG 2) aims to end hunger, achieve food security and improve nutrition while promoting sustainable agriculture by 2030, while the SDG 12.3 aims to ensure sustainable consumption and production patterns, 50% reduction in food waste at retail and consumer level and food losses along the supply chain by 2030. The relation and synergy between SDG 12.3 and SDG 2 to achieve global food security and nutrition should be strengthened because reduction in FLW (SDG 12.3) is indeed a promising solution to end hunger and all forms of malnutrition in the world, in addition to the resulting sustainable impacts on our economy, environment and society. Policy makers, food systems actors, namely farmers, food manufacturers, retailers, researchers, legislators, educators and consumers, etc. should collaborate to apply a food systems approach in an enabling environment to promote sustainable food production and consumption and to reduce FLW for better food security and nutrition for all.

In 2014, the ICN2acknowledged "that the current food systems are being increasingly challenged to provide adequate, safe, diversified and nutrient rich food for all that contribute to healthy diets due to, inter alia, constraints posed by resource scarcity and environmental degradation, as well as by unsustainable production and consumption patterns, food loss and waste, and unbalanced distribution[13]". The ICN2 Framework for Action recommends to "Improve storage, preservation, transport and distribution technologies and infrastructure to reduce seasonal food insecurity, food and nutrient loss and waste" (Recommendation 11).

11 - www.europarl.europa.eu/RegData/etudes/STUD/2015/540360/IPOL_STU(2015)540360_EN.pdf

12 - Loi du 21 mai 2015, www.legifrance.gouv.fr/

13 - www.fao.org/3/a-ml542e.pdf

Improved methodologies and standardised approaches to assess and evaluate energy and nutrient losses in FLW are important for countries to understand the extent and the root causes of the FLW issues so that appropriate strategies and measures can be implemented to monitor and curb FLW. This is to ensure that safer and more nutritious foods could be made available to feed the world populations. Furthermore, understanding the hotspots of qualitative losses of nutrients in the food chain would also help improve food handling, processing and storage after harvesting in order to preserve maximum nutrient contents in food intended for human consumption. As recommended by the CFS in 2014, where FLW cannot be prevented at source, the recovery and redistribution of safe and nutritious foods for human consumption could also contribute to food security and nutrition.

Losing or wasting food is economically, environmentally and socially unsustainable. FLW exacerbate food supply chain inefficiencies and contribute to food insecurity and malnutrition globally and in the Mediterranean region, especially in SEMCs. FLW lead to a major squandering of resources, including water, land, energy, labour and capital and needlessly produce greenhouse gas emissions, thus contributing to global climate change. Policy and strategy measures should be informed by reliable data that can lead to effective and efficient interventions for FLW reduction with short, medium, and long term return on investments that concerns all actors in the food systems, including food security and nutrition of end consumers and waste management challenges and opportunities. The recommended actions include the necessity of access to reliable data that includes harmonisation of definitions and terminology, methodologies, and reporting to establish baseline and benchmark statistics, and tracking systems to monitor FLW over time; coordination of public, private, and civil society policies and strategies; identification of specific contexts and needs for the organisation of appropriate awareness-raising and information campaigns; education programmes; improvement of food system management and governance.

Strategic plans must be developed for the food and agricultural sector. They should incorporate dimensions relevant to FLW reduction that are vertically and horizontally coordinated with the related sectors, for instance, health, social protection, education and training, trade and industry, energy and environmental sustainability. Policies aimed at achieving food and nutrition security in the Mediterranean region should address the issue of FLW. Strategies for FLW prevention and reduction can integrate:
– The application of current knowledge to improve food handling systems and ensure food quality and safety;
– The harmonisation of methodologies and terminology as well as definitions for FLW monitoring and reporting;
– The reduction of socio-economic constraints and facilitation of short, medium, and long term investments;
– The provision of more effective education to all stakeholders of the food supply chain, including farmers, processors, distributors, and consumers form all age groups;
– The availability of better and adequate infrastructure, including storage facilities and marketing systems;
– Improved research and capacity development;

– Enhancement of the capacity of small-scale producers;
– Human nutrition sensitive food systems.

Research outcomes should help design adequate policies, guidelines and recommendations for state and non-state actors in the Mediterranean food system. Given the seriousness of the problem, Mediterranean countries should urgently adopt FLW prevention and reduction strategies that are monitored and evaluated.

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The Global Initiative on Food Loss and Waste Reduction (SAVE FOOD)

The *Global Initiative on Food Loss and Waste Reduction (SAVE FOOD)* was launched in 2011 and works worldwide with the public and private sector as well as civil society for:

1) *Advocacy and awareness raising* on the impact of, and solutions to food loss and waste and for increased knowledge and changed behaviour of decision makers, food supply chain actors and consumers.

2) *Collaboration*and coordination of worldwide initiatives on food loss and waste reduction. SAVE FOOD is establishing a global *partnership* for information, solution sharing, and harmonisation of methodologies, strategies and approaches.

3) *Policy, strategy and programme development* for food loss and waste reduction. This includes field studies at local, national and regional levels and studies on the socio-economic impacts as well as the political and regulatory framework that affects food loss and waste.

4) Support to *investment programmes and projects*, implemented by private and public sectors. This includes technical and managerial support and capacity building (training) of food supply chain actors and organisations, either at the food sub-sector level or policy level.

To Join the Global Initiative on Food Loss and Waste Reduction and subscribe to the newsletter go to www.fao.org/save-food/partners/get-involved/en/

Technical Platform on the Measurement and Reduction of Food Loss and Waste

In December 2015, the FAO together with the International Food Policy Research Institute (IFPRI) launched the *Technical Platform on the Measurement and Reduction of Food Loss and Waste* for information-sharing and coordination of diverse stakeholders, such as international organisations, development banks, non-governmental organisations, the private sector and civil society. The Platform facilitates food loss and waste prevention, reduction and measurement at local, national and regional levels (www.fao.org/platform-food-loss-waste/en/).

Community of Practice on food loss reduction (CoP)

The *Community of Practice on food loss reduction* (CoP) serves as a global convener and an integrator of knowledge related to post-harvest loss (PHL) reduction. It offers a platform to facilitate linkages and information sharing amongst stakeholders and relevant networks, projects and programs such as the Global Initiative on Food Loss and Waste Reduction (SAVE FOOD) and the Swiss Development and Cooperation Agency (SDC) funded projects on post-harvest management (www.fao.org/food-loss-reduction/en/).

CHAPTER 10

THE MEDITERRANEAN DIET: A SUSTAINABLE CONSUMPTION PATTERN

Fatima **Hachem**, *FAO*
Roberto **Capone**, *CIHEAM*
Mary **Yannakoulia**, *University Harokopio of Athens*
Sandro **Dernini**, *FAO*
Nahla **Hwalla**, *American University of Beirut*
Chariton **Kalaitzidis**, *CIHEAM*

The term "Mediterranean Diet" was coined over 40 years ago, as the way of living and eating observed in the lands around the Mediterranean Basin and it was linked with the health benefits observed among the people adhering to it. The Mediterranean diet is closely related to social habits revolving around agriculture and food production, as well as the traditions linked to food preparation and consumption. This way of living has been known in the Mediterranean from the years BC, albeit with local adaptations to the various existing economic, social and religious contexts around the different regions.

Nowadays, due to the increasing urbanisation of the population, the globalisation of the agricultural market, the development of a mass food culture and the relative prosperity of the developed and developing Mediterranean countries, this diet has been progressively abandoned to a great extent. This is particularly true in urban areas, where people have lost a large part of the connection with the natural environment and have adopted a lifestyle that minimises the available time required to pay attention to avoiding food waste.

This chapter takes a closer look at the nutritional, socio-cultural and environmental benefits of the Mediterranean diet and their relations to reduced food loss and waste. It describes the drivers of its erosion and the impacts they have on the characteristic aspects of the diet and also suggests policies to be implemented in order to promote its adoption to improve food systems sustainability in Mediterranean countries. This will contribute to minimising food loss and waste along the whole food chain, from agricultural production, food collection, storage and distribution to consumption.

The Mediterranean diet, a sustainable diet that reduces food losses and waste

Nutritional adequacy and health benefits of the Mediterranean diet

The concept of the Mediterranean diet, whose main ingredients were known by the populations of the Mediterranean Basin of the pre-Christian era, was originally conceived by Ancel Keys in the Seven Countries Study (Keys, 1970). His observations indicate that all-cause and coronary heart disease death rates were lower in study cohorts with olive oil as the main dietary fat compared to northern Europe (Keys *et al.*, 1986). Since then, the scientific community recognised that the Mediterranean diet has profound health effects. Nowadays, the term is widely used in biomedical and non-biomedical studies to describe a dietary pattern characterised by high consumption of vegetables, fruits and legumes, moderate amounts of dairy products (principally cheese and yogurt), low to moderate amounts of seafood and poultry and low amounts of red meat. Olive oil is the main type of added fat and wine is consumed modestly, normally with meals (Willett *et al.*, 1995).

In numerous epidemiological and some interventional studies, greater adherence to the Mediterranean diet has been associated with longevity, as well as with lower prevalence and incidence of chronic diseases. Adherence to the MD has been specifically associated with a significant reduction in total mortality, mortality from cardiovascular disease and cancer, and it has been proven to lower cancer risk and to confer to primary and secondary prevention of coronary artery disease (including stroke) (Trichopoulou *et al.*, 2003; Sofi *et al.*, 2010). Last but not least, the Mediterranean Diet has been found to be protective against mild and advanced cognitive impairment (Yannakoulia *et al.*, 2015).

A lot of research has been conducted so far with regards to the abundant nutrients in this dietary pattern and their health benefits: monounsaturated fatty acids, fibre, antioxidants, such as vitamins E and C, resveratrol, polyphenols, selenium, glutathione. However, more recently, scientists tend to admit that the whole pattern is more important than any specific ingredient and that the health benefits go well beyond the individual effects of nutrients (Donini *et al.*, 2015). This is why, in this chapter we take into account nutrients and foods, their interactions, inter-correlations and cumulative outcomes. Furthermore, eating is a complex behaviour consisting of several factors apart from the choice of specific foods, such as the organisation of food into meals and the conditions of preparing and eating that may also influence health and wellbeing.

The Mediterranean diet, an intangible cultural heritage of humanity

The Mediterranean diet, derived from the Greek word *díaita* that means way of life, has been inscribed in UNESCO's Representative List of Intangible Cultural Heritage of Humanity on the 16 of November 2010. Its nomination was supported by four Mediterranean countries, Greece, Italy, Morocco and Spain. Cyprus, Croatia and Portugal joined in 2013. UNESCO recognised the Mediterranean Diet as a "set of skills, knowledge, rituals, symbols and traditions" ranging from the landscape to the table, and which in the Mediterranean basin concern "crops, harvesting, picking, fishing, animal husbandry, conservation, processing, cooking, and particularly the way of sharing and consuming the cuisine".

In modern times, the Mediterranean diet is threatened by the globalisation and internationalisation of lifestyles, two of the main reasons why farming populations are gradually being reduced and people are losing contact with the land as they become more urbanised.

Local economic development: women and small-holder farmers

Since the 1990s there has been a resurging interest in promoting local food systems as economically viable systems for farmers and consumers (Sonnino, 2013). Demand for local foods in many countries and regions around the globe has been increasing and, in parallel, there has been an increased interest in the implications of this growing demand for local development in the context of sustainability goals across environmental, economic and social arenas (Hinrichs and Charles, 2012).

Different definitions may be given to local foods, but in the present context this term refers mainly to geographical proximity, therefore the physical place where food is produced and/or consumed. While the Mediterranean diet fits well into the definition of local foods, it also fits into the definition of "locality" foods, which are foods that have "a specific geographical provenance..., but can be marketed anywhere" (Hinrichs and Charles, 2012).

The contribution that local food makes to local development has been well researched and documented, and some have gone all the way to consider it the vanguard of the "new" model of rural development (Goodman and Goodman, 2007). While economic growth and job creation are immediate objectives of local development, the concept goes beyond this to include the creation of new products, services and experiences and the associated development of new markets. In this sense the Mediterranean diet can be a lever for economic development. Local, international, gastronomic as well as medical tourism related to it is already being promoted in Greece, Italy, Spain and other countries in the Mediterranean. It is also leading to unique selling opportunities for Small and Medium-sized Enterprises (SMEs), cooperatives and producer organisations of the agro-food sector. In the first place, these new services and products benefit small-scale producers and empower women, in particular. Small-scale farmers produce the bulk of fresh food supply, a prominent characteristic of the Mediterranean diet in many countries around the Mediterranean Sea. They are also involved in post-production activities including small-scale processing of traditional and local food products that are finding entries into local and international markets. Women and their organisations actively contribute to local economic and social development through the agricultural work they do on family farms. They also play an essential role in transmitting knowledge on the Mediterranean diet as well as safeguarding the traditional knowhow and techniques by perpetuating the preparation of traditional food products. In addition, they preserve the knowledge of indigenous plants as edible foods and hence safeguard biodiversity. The role of women in the Mediterranean has been particularly crucial in expanding availability and accessibility of nutritional food on a sustainable basis. Through the preservation of abundant seasonal produce for later use during the year, they have made possible the availability of and access to diversified food using local produce: the Mouneh in the East Mediterranean, the Khazin in Egypt and the Aoula in Algeria are examples of traditional food-saving practices that women, collectively or individually, produced to make use of food surplus that could otherwise be wasted.

Environmental benefits of the Mediterranean diet: footprint and biodiversity

As described by its pyramid form (Bach-Faig *et al.*, 2011), the Mediterranean diet is mostly based on the consumption of fruits and vegetables, beans, nuts grains and seeds, while poultry, dairy products and especially red meat are consumed in smaller portions. However, the globalisation of the agricultural market and the increasing trend of urbanisation have modified the dietary patterns, with an increase of meat-based food products consumption.

The processes involved in food production consume resources and put pressure on the environment, in terms of greenhouse gas (GHG) emissions, water use, energy consumption, chemical inputs (fertilisers, pesticides, etc.) and land usage (UNEP, 2010). In particular, animal-based foods require more land and energy resources when compared to vegetable-related foods. Besides, conventional agricultural production methods have a greater environmental impact than organic methods (Baroni *et al.*, 2007).

Several studies have investigated the environmental footprint of the Mediterranean dietary pattern, in comparison with national and regional dietary patterns. Sara Sáez-Almendros *et al.* (2013) have compared the Spanish dietary pattern with the Mediterranean and western dietary patterns. The results reveal that the Mediterranean dietary pattern demands less soil, water and energy compared to the other two patterns. The western dietary patterns had the highest demands of these resources. Meat-based, high protein diets also have a higher carbon footprint, compared to fruit and vegetable based diets with lower protein content.

When consuming mainly plant, bio-diverse and local foods produced through eco-friendly systems, we contribute to the sustainable nature of the diet. Nowadays, in order to achieve high yields, only particular varieties of crops are used, usually in monocultures. This leads to the loss of wild varieties. As a result, the genetic diversity is reduced and the current crop genotypes lack the genetic richness of landraces. In contrast, the Mediterranean diet culture of growing crops and raising domestic animals consisted of using different varieties of wild ancestors, developed through natural breeding locally, hence increasing the genetic diversity and biodiversity. Furthermore, because of the dependence on local resources and food stocks, the fishing and hunting pressure on local fish and animal populations respectively was less severe. The global ever-increasing demand for food cannot be met by a simple return to traditional practices. However, through the implementation of proper policies and provision of incentives to farmers, it is possible to achieve sustainable agriculture and food that meets present and future food needs (FAO, 2014).

Socio-cultural benefits: social fabric and food cultural heritage

In the early Mediterranean diet pyramid (Willett *et al*., 1995), lifestyle behaviours have not been strongly emphasised as important components of the way of living. Apart from physical activity, factors like social support, sharing food, having lengthy meals and post-lunch siestas, were only mentioned as being of particular interest but not explored or further investigated. In 2011, the Mediterranean diet pyramid was revised in the light of contemporary lifestyle and sustainability (Bach-Faig *et al*., 2011), to refer to a lifestyle pattern rather than a diet *per se*. In the new revision, qualitative and quantitative elements were taken into account, as well as social and cultural features characteristic of Mediterranean life: eating in moderation, socialisation during eating, cooking skills, seasonality, biodiversity, eco-friendliness and consumption of local products, regular practice of moderate physical activity and adequate rest. The concept of frugality and moderation was emphasised because of the major public health challenge of overweight and obesity. Moderate consumption requires respective food production and use of resources, which leads to smaller food waste. This revised Mediterranean diet pyramid was conceived as a simplified main frame able to be adapted to different country-specific variations related to various geographical, socio-economic and cultural contexts. It was aimed at better popularising its applicability in the present daily lifestyle, without leaving out the different cultural and religious traditions and different national identities present in the Mediterranean area.

In essence, the traditional dietary patterns of people around the Mediterranean Basin encompass a lot of practices, skills, spaces and associated objects, in interaction with the surrounding environment. The perceptions we have about the Mediterranean diet and the scientific research that studies it still focus on foods and nutrients, but tend to forget about the cultural heritage associated with it that is equally important. There are some fragmentary reports noting that food consumption habits, including meal patterns, structure and hospitality rituals, are essential issues to consider when trying to adopt or adhere to the Mediterranean diet (CIHEAM and FAO, 2015). Furthermore, the preference for seasonal, fresh and minimally processed foods may, in most cases, maximise the content of protective nutrients and substances in the diet. The conviviality aspect of eating strengthens socialisation and communication. Perceived as opportunities for social interaction, mealtimes maintain and reaffirm individual and group identities, whereas devoting enough time and space to culinary activities is also important. Finally, regular practice of moderate physical activity (at least 30 minutes a day), adequate sleep and rest during daytime (naps) serve as basic complements to the dietary pattern (Willett *et al.*, 1995). The Mediterranean diet includes all these social aspects and expresses the intimate relationship between nature and people. However, it is a highly diversified heritage making it impossible to have a single model for all Mediterranean countries. There are variations reflecting different natural, economic, religious and cultural traditions. Although different countries in the Mediterranean region have their own dietary patterns, it is appropriate to consider these patterns as variants of a single entity: the Mediterranean diet.

The erosion of the Mediterranean dietary pattern

Drivers

Socio-cultural, economic and demographic factors. The drifting away from traditional diets to adopt less healthy lifestyles has become a common phenomenon in all Mediterranean countries, with the acceleration of modernisation and rapid changes in the lifestyle and economic activities related to it. Between 1950 and 2000, the population in the five Southern European EU-member countries doubled, while that of the remaining Mediterranean countries increased more than nine-fold (Salvati, 2014). The demographic divide between countries of the northern shore on the one hand and those of the eastern and southern shores on the other hand is caused by higher fertility and population growth rates in the latter.

Alongside the demographic change, a phenomenon of rapid urban growth has been taking place. Nowadays, it is estimated that two in every three inhabitants in the Mediterranean countries live in urban areas, and over a third of the population growth occurs in the coastal cities where most of the economic activities are concentrated. This urban growth is mostly brought by an internal redistribution of the populations and a rural exodus towards cities that offer employment opportunities and better lives. While the typology of the Mediterranean Basin with vast areas of hills, plateaux and mountains characterising the inland areas, has helped this movement towards the coasts, the growing international tourism along the shores has accelerated this phenomenon in the last two decades.

Rapid urbanisation has had impacts not only on the lifestyle and associated food consumption patterns but also on biodiversity, which is one of the defining characteristics of the Mediterranean diet. Nowadays, the Mediterranean coast is considered one of the world's biodiversity hotspots. On the other hand, urbanisation has largely contributed to farming and natural land degradation and loss along the coasts of the region, affecting the traditional agricultural livelihoods and local food production. Parallel to the demographic divide between the two shores, there have also been different urbanisation trends between the northern shore and the south-eastern shores of the Mediterranean: in northern countries, the urbanisation rate has been expected to increase moderately by 2050, it has been expected to grow more rapidly in North Africa (Salvati, 2014). In all cases, increased urbanisation favours the mass production of low cost food and the necessity for the transfer and storage of these products in urban centres is increasing the amount of spoiled and wasted food.

Another factor that has affected the erosion of the Mediterranean Diet is the change in family structure: from an extended one where culinary practices and knowledge were passed from one generation to another, to a nuclear family where the traditional wisdom on how to prepare and use food was lost. As with most patriarchal societies, Mediterranean women have had the main responsibility for food preparation, and often its production and distribution. The achievement of higher education levels and the entry into paid labour have contributed, at different paces in the countries of the Mediterranean region, to the fact that women are moving away from such a paradigm.

Impact of globalised markets on the Mediterranean Diet. The globalisation and liberalisation of trade have had a positive effect on improving food security around the globe. As a result of the opening up of markets, consumers have access to a wider and more diversified food offer all year round. However, this change has drastically affected the way food is produced, procured, distributed and consumed. One of the salient features of this change is the entry of international super- and hyper-markets in countries of the Mediterranean, changing the way people buy and consume food. The diffusion of supermarkets has happened at different paces in the countries of the northern shore and those of the eastern and southern shores, with the former embracing the phenomenon earlier. By the late nineties, most eastern and southern Mediterranean countries have experienced an increase in Foreign Direct Investment (FDI) in the retail sector pushed by the saturation and intense competition in domestic European and US markets and the much higher margins to be made by investing overseas.

At local level, the competition between large supermarket chains on the one hand, and traditional food shops on the other, has not been to the advantage of the latter. With increasing incomes, high rates of urbanisation and the changing of women's role within the family, a new way of life and demands have emerged. Supermarkets compete better than traditional shops as they bring with them significant improvements in standards of food quality and safety at competitive prices and convenience, factors which are highly attractive to an increasingly sophisticated consumer. Since the beginning of the nineties, there has also been a rise in the diffusion of fast food chains in the Mediterranean countries. Such changes have resulted in a gradual shift in the dietary consumption patterns towards a more universal one characterised by increased consumption of animal products, fats and sugar.

In parallel, the reputation of the Mediterranean Diet as a healthy diet has increased the demand for locally-produced foods and commodities. Thus, in recent years, a good part of the expansion of world consumption of olive oil was accounted for by increases in countries with no or little tradition in olive oil production or consumption like North America, non-Mediterranean Europe, Japan, Australia and Brazil. The liberalisation of trade has made olive oil a catalyst for economic growth in many Mediterranean countries propelled by the high economic returns from olive oil exports in particular. However, this has led to the increase of imports of cheaper vegetable oils and the replacement of olive oil in the diets of some Mediterranean countries especially in countries of the East and South Mediterranean.

Consequences of the erosion of the Mediterranean diet

Nutrition and health factors. Mediterranean countries have been witnessing a nutrition transition characterised by a shift towards a ẃesternised' diet that is energy-dense and high in refined cereals, animal protein, and fats, with typical foods consumed being red and processed meat, and refined grains. Unlike the Mediterranean dietary pattern, the Western dietary pattern has been associated with an increased risk of obesity (high body mass index and elevated waist circumference) as well as high risk of coronary heart disease, metabolic syndrome, and type-2 diabetes. A strong association has been reported between high consumption of unhealthy food components (processed meat, red meat, trans fatty acids, sugar-sweetened beverages, and sodium), low consumption of Mediterranean healthy foods (fruits, vegetables and beans, nuts and seeds, whole grains, and seafood omega-3 fatty acid), and increased risk of cardio-metabolic diseases (diabetes, systolic blood pressure, high body mass index, fasting plasma glucose, and total cholesterol) across all countries of the region, thus making such food consumption patterns strong predictors of these diseases. In addition, the dietary energy supply from the different food groups (healthy and unhealthy) shows that the traditional diet has been modified: most, if not all, of the Mediterranean countries have shown insufficient *per capita* consumption of protective foods, which fell well below recommended levels, and, inversely, a higher than recommended *per capita* consumption of harmful food components.

Evolution of the Lebanese diet

In Lebanon, studies have shown that the adoption of the Western dietary pattern (characterised by high intakes of fast food sandwiches, pizzas, pies, desserts, carbonated beverages, butter, juices, and mayonnaise) was positively associated with high body mass index and elevated waist circumference, and tripled the risk of hyperglycaemia and metabolic syndrome among adults. The Traditional Lebanese pattern, on the other hand, which is generally considered a Mediterranean pattern as it is highly loaded on fruits and vegetables, showed no association with any of the CVD risk factors.

Environmental impacts of the Mediterranean diet erosion. In the Mediterranean, environmental degradation has reached proportions that require immediate action (UNEP, 2010). The new production and consumption Mediterranean patterns based on animal products, require more water, land resources and energy. According to Cosimo Lacirignola *et al.* (2014) these imply high ecological, carbon and water footprints and unfavourable national virtual water balances. Therefore, it is crucial to increase adherence to the Mediterranean Diet to reduce pressure on the scarce resources.

The ecological deficit of Mediterranean countries during the period between 1961 and 2007 increased: the ecological footprint (EF) of consumption *per capita* increased while the biocapacity of the region decreased. The cropland EF is the most important component of the overall EF. Further evidence of the drifting away of the Mediterranean populations from the traditional dietary pattern and their increasing protein consumption is that the current food ecological footprint of the Mediterranean countries is not significantly lower than in other countries, even though typical products of the Mediterranean Diet (olive oil, vegetables and cereals) have a low EF per calorie provided.

The water footprint (WF) of consumption varies greatly among the different countries of the region. About 91% of the regional WF of consumption is due to agricultural products consumption. The increase in food demand will have effects on the volumes of water used for irrigation. Meat, dairy products and wheat represent more than a half of the WF of food supply in Mediterranean countries (Lacirignola *et al.*, 2014). Roberto Capone *et al.* (2013) analysed the environmental cost for Italy, in terms of water consumption, of non-adherence to the Mediterranean dietary pattern by comparing the estimated water footprint of the traditional diet and that of the current dietary pattern: the result was that the latter is about 70% higher than that of the ideal diet.

Many Mediterranean indigenous species are important ingredients in the preparation of century-old traditional food recipes. Unfortunately, the globalisation of agricultural markets and changes in lifestyles have had a negative impact on the conservation and use of these resources sometimes leading to their irreplaceable loss (FMFC, 2010). Indigenous knowledge is being lost and the genetic diversity of food crops and animal breeds is diminishing rapidly. An exacerbation of the genetic erosion of agro-biodiversity is reducing the sustainability of local production systems and hence their ability to safeguard the Mediterranean diet (FMFC, 2010). The standardisation of cultivation practices, mechanisation, monoculture and changes affecting traditional production systems have reduced the spectrum of diversity of the products used for preparing healthy and nutritious food recipes. Safeguarding and promoting the Mediterranean Diet is of paramount importance for the conservation of the extraordinary biological diversity in the region and *vice versa*.

Resource use intensity is still higher in the region. In European countries, the average fertilisers and mineral nitrogen consumption is higher than the worldwide average (Lacirignola *et al.*, 2014). This is further exacerbated by food losses and waste (FLW) implying the loss of precious resources (water, land, energy) and inputs (fertilisers). FLW reduction is now considered essential to reduce the environmental footprint of food systems. FLW are responsible for the loss of life-supporting nutrition and precious resources (air, water and energy) and they have two major direct environmental impacts: waste of the resources that are used to produce the lost and wasted food and negative impacts including emissions of greenhouse gas. According to Cosimo Lacirignola *et al.* (2014), FLW account for water loss ranging from 294 m^3 (Palestinian Territories) to 706 m^3 (Portugal) *per capita* per year.

Assessing the sustainability of the Mediterranean diet and food consumption patterns

Methodological approach

The notion of the Mediterranean Diet has undergone a progressive evolution over the past fifty years – from a healthy dietary pattern to a model of sustainable diet. In 2009, an international conference on "The Mediterranean diet as a sustainable diet model" was organised in Parma, Italy, by the Centro Interuniversitario di Ricerca sulle Culture Alimentari Mediterranee (CIISCAM), in collaboration with the FAO, the CIHEAM-Bari, the Italian National Institute of Food and Nutrition, the Forum on Mediterranean Food Cultures (FMFC) and Bioversity International. In 2010, the FAO organised a preparatory technical workshop to identify the four characterising dimensions required to assess the sustainability of a diet: nutrition and health, environment, economic and socio-cultural factors. This was followed by an international symposium on "Biodiversity and sustainable diets", organised by the FAO and Bioversity International in collaboration with the CIHEAM-Bari and the Italian National Institute for Research on Food and Nutrition (INRAN) during which the following consensus was reached on a definition of "sustainable diets": "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimising natural and human resources" (FAO and Biodiversity, 2012). Within this definition, the Mediterranean Diet was acknowledged as an example of a sustainable diet to be further studied along with other cultures and agro-ecological zones.

Thanks to its nutritional, health, socio-cultural and environmental characteristics and because it concerns a vast number of countries, the Mediterranean diet was chosen by the FAO for a pilot study intended for the assessment of the sustainability of diet models. In 2011, the FAO in collaboration with the CIHEAM-Bari developed methods and indicators for the assessment of the sustainability of diets and food consumption patterns, in the context of sustainable food systems in the Mediterranean area[1]. As an outcome of this collaborative effort, in the final declaration of the CIHEAM meeting of the Ministers of Agriculture held in Malta in 2012, the role of the Mediterranean diet as "a driver of sustainable food systems within the strategies of regional development and on that of traditional local products, since quantitative food security must also be complemented by qualitative approaches" (Lacirignola *et al.*, 2012) was highlighted.

From 2011 to 2013, through several international workshops, multidisciplinary seminars and discussions with many international experts, four dimensions within the three sustainability pillars (social, environment and economic) were identified for the assessment of the sustainability of the Mediterranean diet pattern: nutrition and

1 - www.fao.org/docrep/016/ap101e/ap101e.pdf

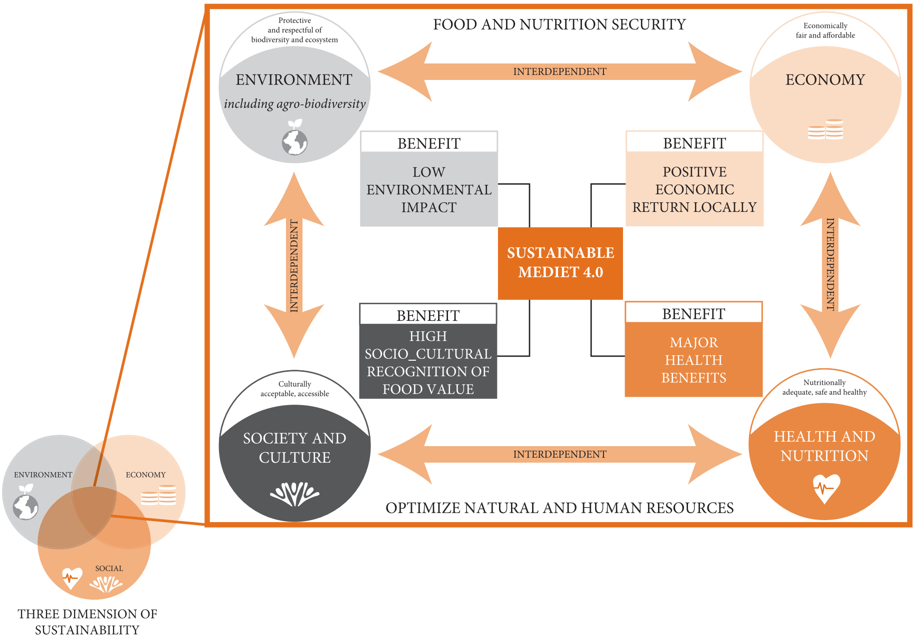
health, environment (including agro-biodiversity), economic and socio-cultural factors. This research enabled the preliminary drafting of a country-specific and person-centred methodological approach and a first, non-exhaustive, ensemble of indicators (Dernini *et al.*, 2013).

This methodological approach based on the use of indicators required a large quantity of data not yet available, intra- and inter-dimension evaluations, prioritisations and economic resources that were not available to accomplish such a complex task. It also required the evaluation of direct and indirect interactions and correlations between the four dimensions. Several challenging questions emerged: how could the relative importance of these indicators be measured? How could one calculate a value/score using the data gathered for each indicator in order to make up a composite index? What are the real available data? How could the different indicators to reach a score/index for assessing sustainability be combined? What is the importance of the four different sustainability dimensions? Are they all equal? Which are the priority criteria/themes within these dimensions? Which are the interdependences? At which scale (individual, household, country, and region) should this operational methodological approach be tested? How could the centrality of the individual, the consumer be measured to assess sustainable diets, in spite of lack of data on individuals and households?

In order to overcome these issues, in 2015, the FAO and the CIHEAM in collaboration with the Forum on Mediterranean Food Cultures (FMFC) and the International Foundation of the Mediterranean Diet, developed a new methodological approach, called the Med Diet 4.0 model (Figure 1), in which, three additional sustainability benefits of the Mediterranean diet are incorporated together with its well-documented health and nutrition values. This model highlights the health and sustainability characteristics of the Mediterranean diet and takes the definition of "sustainable diets" into consideration (FAO and Bioversity, 2012), as well as the four thematic sustainability dimensions and their four related benefits: major health and nutrition paybacks, high socio-cultural recognition of food value, low environmental impact and positive economic local return.

The main challenge for the further development of the Med Diet 4.0 model is to understand the interdependences between its four dimensions and the links between their related benefits. New interdisciplinary cross-cutting studies on the overlapping of these dimensions are therefore required. With four clearly identified benefits, the Med Diet 4.0 model can play a very important educational and communication role in the revitalisation of the Mediterranean diet. It can also provide a better understanding of its connections with Mediterranean food systems. By using the Mediterranean diet pattern as an ideal model, the Med Diet 4.0 model contributes to the development of realistic sustainable diet models and their characterisation in the context of Mediterranean sustainable food systems.

Figure 1 - The Med Diet 4.0 Model



Source: Dernini *et al.* (2013).

Promoting the Mediterranean diet: policies and research

In order to promote the Mediterranean diet as a sustainable lifestyle and dietary pattern, the collaboration of all main stakeholders of the Mediterranean agro-food sector (public institutions, civil society and private sector including producer organisations and cooperatives) is of paramount importance. In this field, international and intergovernmental organisations can act as catalysts of national and local initiatives. The CIHEAM and the FAO have recently signed a new partnership aimed at strengthening the livelihoods of rural communities in the region. This new partnership focuses on food security, nutrition and resilience. The Mediterranean diet is contemplated in the third thematic field of priority of the Memorandum of Understanding (MoU) addressing crises and threats related to food and nutrition security signed in October 2015. One of the fields of work regarding policy development deals with the implementation of a joint vision and strategies on sustainable food systems and the Mediterranean diet in the frame of the UN Post-2015 Agenda and Sustainable Development Goals (SDGs).

The Mediterranean iet as a pilot study

On the occasion of the 9th meeting of the Ministries of Agriculture, Food and Fisheries of the CIHEAM Member States that was held in in Malta in September 2012, the CIHEAM and the FAO organised an international seminar entitled “Improving the sustainability of diets and food consumption patterns: the Mediterranean diet as a pilot study”. The conclusions emphasised the need to develop guidelines to improve the sustainability of diets and food consumption patterns in the Mediterranean region. These were approved by the Ministers and were integrated into the final declaration of the meeting, which called upon Mediterranean and international institutions to support the implementation of the seminar recommendations.

Source: Lacirignola et al. *(2012).*

Promoting balanced nutrition especially among young people

Despite the widely promoted health benefits of the Mediterranean diet and the associated cultural heritage, during the past few decades, Mediterranean people, especially the younger generations, have gradually abandoned this traditional dietary pattern. Despite the fact that there is a lack of longitudinal data enabling a deeper analysis of dietary changes among young people and the exploration of mediating and confounding factors, urbanisation, population growth and the progressive globalisation of food supply have been identified as potential causative factors of this abandonment.

It is important to raise awareness among youth and encourage them to improve their eating habits, as eating behaviours are established early in life and have a great impact on the quality of life as an adult. These early interventions may significantly contribute to the prevention of chronic diseases and promote sustainable lifestyle patterns based on balanced nutrition and physical activity. In this perspective, new initiatives have been undertaken, especially in schools: changes in school food services, adoption of gardening programmes, media campaigns, classroom workshops with the teacher as a role model for a healthy lifestyle. However, these school initiatives promoting healthy lifestyles should develop further and help children and young people understand the relationship between food, wellbeing and the environment, food production and cultural differences. Eating habits can be influenced by recommendations for consumption frequencies, moderation in portions and sizes, development of culinary skills, seasonality, biodiversity, eco-friendliness and locality of food products (Bach-Faig *et al.*, 2011).

This holistic approach was recently adopted by the European Union through the Action Plan on Childhood Obesity 2014-2020[2]. For instance, in the framework of the extension of the national implementation of the “School Fruit Scheme”, education on combating food waste and the promotion of healthy environments are proposed. The increased intake of healthy foods and fresh fruit as well as their availability in schools are strongly encouraged. Health partnerships between national

2 - Action Plan on Childhood Obesity 2014-2020 (http://ec.europa.eu/health/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf).

governments, local governments and non-state actors (smallholders and family farmers, cooperatives, producer organisations supermarkets, retailers and other relevant stakeholders in the community) are of crucial importance for the achievement of these goals.

Local development, incentive schemes, and economic opportunities: the Mediterranean diet as a catalyst

In order to foster local development, local and national authorities must promote the Mediterranean diet. Olive oil is an interesting example of such a strategy. The healthy characteristics of olive oil have increased the demand and made consumers willing to pay a higher price for it in comparison to other edible oils. The growing of olive trees has a very positive impact on rural development as it reduces the high unemployment rate during harvest seasons. The activity is nowadays also combined with rural tourism: in some production areas there are organised tours along olive oil routes, making the olive tree a symbol of the Mediterranean life style. In addition, the growing segment of consumers preferring quality food with certification of origin, leads to the development of economic activities in these regions in addition to an undisputed market-share for the product itself.

The economic valorisation of local food experiences can be a strategy for development. The creation of synergies between producers and tourist operators (hotels, restaurants) enable the increase of purchases of Mediterranean products and at the same time increase the knowledge of traditional processes of production. This eventually leads to the development of agro-food enterprises and the creation of employment. However, Mediterranean touristic regions with agricultural activity are characterised by scattered small towns and villages and small-scale production, which makes the economic viability of such enterprises a challenge. Knowing that small-scale producers in the Mediterranean face a lot of constraints to survive in a globalised economy, collective action organisations (cooperatives and producer organisations) are being created to ensure the sustainability of this mode of production and consumption, to encourage newcomers, especially youth, to adopt sustainable agriculture practices as means of sustainable livelihoods. Access to productive inputs, technology, credit, information and markets are among the much needed services that cooperatives provide to small farmers, without which they might not be able to stay in business. In Egypt, memberships in agricultural cooperatives have made it possible for 4 million farmers to earn their income while in Lebanon, rural women cooperatives have made it possible for their members to increase their otherwise difficult access to local markets. Links to markets, whether domestic or international, are key factors for the success of this mode of production. A Mediterranean label could be a helpful tool in making entries to markets for products that meet the quality requirements. It is therefore necessary to assist small-scale farmers in meeting the requirements for quality and safety in order to increase their competitiveness. Information systems on market opportunities are also necessary to connect local production with niches of economic interest.

The MedDiet label for the promotion of the Mediterranean diet

With the Mediterranean being a primary tourist destination in the world with 150 million tourists visiting the coastal regions every year and with an influx that is expected to double by 2025, other strategies for the promotion of the Mediterranean diet need to be envisaged. In 2015, the Association of the Mediterranean Chambers of Commerce and Industry (ASCAME) initiated the project "Mediterranean diet and enhancement of traditional foodstuffs - MedDiet", financed by the European Union, and granted the "Med Quality Label" to three hundred restaurants located in six countries (Egypt, Greece, Italy, Lebanon, Spain, and Tunisia) in order to distinguish those who give priority to the Mediterranean diet. The MedDiet label certifies that restaurants offer authentic Mediterranean dishes that comply with the criteria that have been established by the project. A smartphone application is currently being developed to help people find restaurants, which have been granted the MedDiet label. Such incentives could also be extended to other retail outlets to increase adherence to the Mediterranean diet and create economic opportunities.

Domestic markets also provide ample opportunities for the trade of traditional foods in the Mediterranean. In southern Mediterranean countries in particular, dishes with high symbolic value need to be prepared from local foods and continue to have a central position in the identity of the community. In addition, the preferences of Mediterranean consumers to buy fresh produce from the traditional retail sector, especially open air markets, could be exploited and is a means of marketing for cooperatives.

While cooperatives and connections to markets are important for small-scale farmers, they are all the more so for women-led enterprises. In eastern and southern Mediterranean countries, women face more difficulties in accessing inputs, credit, land, and male-dominated markets as shown by a case study on Lebanon[3]. Nevertheless, the appreciation of traditional homemade products and the willingness of working women, who no longer have time or knowledge to prepare such foods, to buy traditional products made by other women provides the local market with the means to promote the Mediterranean diet. In Algeria, Egypt, Lebanon, Morocco and Syria, the number of women-led businesses that produce and sell traditional food has significantly increased in the last two decades. This growth has provided new sources of income that is sometimes the only income of certain households. Such initiatives have become among the most popular women empowerment programmes supported by national and international organisations in the eastern and southern Mediterranean shores. The National Observatory for Women in Agriculture and Rural Areas (NOWARA)[4] in Lebanon, for example, has been documenting and promoting such success stories since 2011.

Identifying opportunities for partnerships with local farms is of interest for both producers and consumers. Hence, as shown in the case of Brazil, purchasing from small scale farmers and women producers for school feeding programmes has proven

3 - Lina Abu Habib (ed.), "Case Studies in Women's Economic Empowerment. A Case from the Middle East", CRDTA (https://wideplusnetwork.files.wordpress.com/2012/10/seventhstoryofwomen.pdf).

4 - NOWARA (www.nowara.org).

to benefit the local economy and to improve nutritional outcomes among children. In the Mediterranean region, this type of programme could promote the Mediterranean diet and create a local economic cycle. However, high prices and fluctuations in product quality and inability to supply local food year-round could be the major obstacles for these enterprises. Assistance from the national authorities by means of the establishment of a national strategy for sustainable production and availability of local food, and in the form of subsidies or improved organisation of the producers, could help alleviate the pressure of the increased production cost, which is especially evident among small-scale producers.

Preserving natural capital

In order to foster and speed up transition towards more sustainable food consumption patterns profound changes in both food consumption and food production are necessary (Lacirignola *et al.*, 2014). Making food consumption models more similar to the traditional Mediterranean diet requires action at all levels (from the state to the individual firm and consumer) and this requires a focus on the maintenance of critical natural capital. It is also important to assess the environmental sustainability of the current Mediterranean food consumption patterns taking into account the different environmental footprints (Lacirignola *et al.*, 2014).

Public policies in all areas of the food system should consider the risks posed by the volatility of prices, sustainability, climate change and hunger. Policies in other sectors (energy, water supply, land use, the sea, ecosystem services and biodiversity) also need to be developed in closer conjunction with the strategies that are directly related to food, in order to protect the environment and reduce resource consumption. Achieving such a coordination of all these policies is a major challenge for local policy-makers. More effective policies, practices and governance (which must be supported by scientific research) are needed at different levels (spatial, temporal, jurisdictional levels etc.). Only sound policies will incite and help consumers and producers make sustainable choices (UN-HLTF, 2012).

The promotion of the Mediterranean diet needs to be accompanied by parallel research initiatives to support local agrobiodiversity and promote high quality local and typical products by focusing on the analysis of the nutrient content that is indispensable for the establishment of sustainable diets. Sustainable food and agriculture policies should also aim to improve the efficiency of agricultural production systems while at the same time preserve the diverse ecosystem services on which they depend[5]. Future agricultural intensification must seek to increase the efficiency of the use of inputs while minimising adverse effects on the environment. The use of energy and water needs to be optimised in all domains: transport, storage (e.g. cold chain), food processing, retail, consumption.

Food environmental sustainability cannot be achieved unless the issue of food losses and waste is recognised and treated. For these to decrease one must adopt multilevel strategies whose main axes would be: the application of current knowledge to

5 - www.who.int/trade/glossary/story028/en improve the food handling systems and ensure food quality and safety; more education to all stakeholders of the chain, including farmers and consumers; better and adequate infrastructure (storage facilities and marketing systems); improved research and development capacity and special attention to overcoming the limitations of small-scale producers. Interventions to reduce food waste will likely have an even greater impact on freshwater resource availability like other water use efficiency measures in agriculture and food production.

Conclusion

With the acknowledgment of the Mediterranean diet as a sustainable dietary model that has unequalled health, economic, socio-cultural as well as environmental benefits, comes also the recognition that this model diet is being eroded from its natural habitat. The traditional ways of producing and consuming food in the Mediterranean has changed to become a more "westernised" diet style, due to the changing economic and demographic trends, increasing urbanisation and population growth rates, improvements in incomes, change of ways of life and globalisation.

In order to protect and promote the Mediterranean diet, in the framework of their Memorandum of Understanding, the FAO and the CIHEAM have elaborated a vision and strategies to develop sustainable Mediterranean diets and food systems. From a methodological point of view, there should be data generation and collection in order to document the changing dietary habits in the region as well as their drivers in order to provide the information required to formulate adequate policies. Work on the indicators for diets sustainability assessment and research on local biodiversity to analyse the nutrient content of the local species including wild plants, should also be continued with the aim of disseminating them among the scientific community world-wide.

Evidence should be collected in order to advocate the increased adherence to the Mediterranean diet (in all dimensions, health, socio-culture, economics, and environment) as a sustainable diet model for the Mediterranean food systems, minimising food loss and waste (from production to consumption). The quantification of food loss and waste is important, as this will allow a better understanding of the changes happening in the region and help promote what was traditionally a "food-waste-saving culture". The meetings of the Governing bodies of both the FAO and the CIHEAM aim to draw the attention of the Ministers of Agriculture to the unsustainable situation of food systems around the Mediterranean and on methods and strategies to be adopted to cope with it.

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CHAPTER 11

INNOVATIVE POSTHARVEST TECHNOLOGIES FOR SUSTAINABLE VALUE CHAIN

Panagiotis **Kalaïtzis**, *CIHEAM*
Elena Craita **Bita**, *CIHEAM*
Martin **Hilmi**, *FAO and AGPM*

Nowadays, the distance that food travels from producer to consumer has increased as a result of food trade globalisation. Consequently, the up-keep of safety and quality along the food value chain is becoming a significant challenge. The twenty-two countries bordering the Mediterranean represent, in terms of value, almost 23% of the global trade in fresh vegetables and 25% of trade in fresh fruit. In the past fifteen years, exports have risen fivefold, including dramatic increases in fruit and vegetable shipments to the Middle East and North African (MENA) markets (FAO 2014a). For this reason, this chapter will focus on fruits and vegetables in order to question innovative postharvest technologies in green food value chain development in the Mediterranean.

Inefficiencies along the food production pipeline and the resulting waste have a strong negative impact on food availability, productivity and the environment. Greening food value chains plays a major role in improving food security (Godfray *et al.*, 2010). Food losses and waste (FLW) refer to the edible parts of plants and animals produced for human consumption that are not ultimately consumed by the population. They represent the decrease in the mass, nutritional value and/or quality attributes of edible food intended for human consumption (FAO, 2011). Food losses refer to the quantitative loss of food that occur during food value chain operations that does not reach intended consumers, while food waste refers to food that reaches intended consumers but is discarded and not consumed (FAO, 2011). Prevention and reduction of FLW is not only a goal in itself that is only tied to food security. It also relates to poverty alleviation, health and safety, employment generation, gender equality and preservation of the natural environment.

In the Mediterranean, particularly, in the MENA region quantitative FLW are estimated at over 250kg per year per capita (FAO, 2015) and at 594kcal per day in nutritional energy terms. Economic losses are estimated to exceed 50 billion dollars annually in terms of farm gate prices (FAO, 2014a) and the usage and consumption of natural environment assets (natural resources, ecosystem services, biodiversity, climate, etc.) that are lost and wasted are staggering. The horticulture secture is the most affected by FLW and is estimated at a staggering 45% (FAO, 2014a) and even 56% according to recent estimates (FAO, 2015). It is therefore clear that horticulture should be a priority area of intervention in the region. From a qualitative point of view, FLW are very high and exacerbated by a multitude of food distributional aspects ranging from lack of appropriate marketing infrastructures, to cold chains, logistics and pricing.

In the MENA region, food production is much lower than required. This is largely due to limited and depleting natural resources (arable land and water). Growing populations and growing rates of urbanisation have an increasing demand on already-stressed food systems in terms of quantity and of changing food preferences towards high-value, more perishable fruits, vegetables, meat and dairy. The region is a net importer of food and this leads to a wide range of economic, social, cultural and even political difficulties. Preventing and reducing FLW is the most efficient and feasible approach in economic as well as environmental terms in comparison to attempts at increasing food production. Inadequate data on FLW, lack of awareness on FLW, technical capacity to deal with FLW, lack of organised coordination by institutions in dealing with FLW, insufficient investment and lack of appropriate policies and regulations, all hinder the prevention and reduction of FLW in the MENA region (FAO, 2014a).

Thus, a holistic and comprehensive approach is required to address the evident inefficiencies found along the multitude of horticultural value chains that have a negative impact on food availability, poverty reduction, employment creation and the natural environment. Many of the FLW indicators found in the most diverse horticultural value chains are usually only symptoms of the root causes and do not provide information on the real root causes of such FLW. The green food value chain development approach for horticultural produce especially in postharvest management in terms of novel technologies and applied innovations is an efficient way of tackling FLW.

An overview of the green food value chain

Since the very high FLW in the Mediterranean countries can be attributed to the lack of appropriate infrastructure throughout the value chain, the development of a green food value chain should be considered. The latter focuses on the proactive prevention and reduction of the use of the natural environment (natural resources, ecosystem services and biodiversity) so as to diminish or mitigate adverse impacts or even have positive impacts on food value chain operations and activities. At the same time, the approach also considers disposal and recycling patterns of generated waste, to recapture value at every stage of the food value chain and thus further reduce environmental impact (Hilmi, 2015).

Thus, the main goals of greening food value chains are prevention, reduction and recapture primarily centred on products, processes and systems that influence environmental and economic performance. They can be classified into the following two categories: ensuring the efficient and sustainable use of the natural environment, while at the same time increasing the share of environmentally sound food products provided by renewable and recycled resources, maximising material and energy efficiency at each stage of the system; and preventing and reducing negative environmental impacts at all stages of the food value chain. The climatic conditions of the Mediterranean countries pose the major problems that need to be taken into consideration. The high temperatures especially during the summer period create a pressing need for environmentally friendly cooling technologies at each stage of the system. These technologies require energy, which has to be produced using environmentally friendly mechanisms.

Greening food value chains is a step-by-step process that begins with the identification of the occurrence of activities in food chains that have an environmental impact (which activities, where, why, how and when?) Such activities then need to be neutralised, or in other words, "*greened*". Once these environmental "*hotspots*" have been identified, the second step focuses on strategies that can *prevent* inappropriate use of the natural environment and the third step on strategies that *reduce* the inappropriate use of the natural environment. A fourth step looks at strategies that can *recapture* any value that can be found in waste from food chain operations and a fifth step considers all the efforts taking place in greening a food value chain (*stocktaking*). Step six provides a *checklist* to ascertain and evaluate if a food chain can be classified as *greener* and thus contribute to increasing food security and nutrition, and climate change mitigation. The process usually requires the public sector and economy sector to establish partnerships with all interested stakeholders in the private sector and among civil society. If the production and use of green energy is one of the main factors that will determine how green the food chain is, then every green technology approach, such as the installation of solar panels, wind energy devices placed in fruit and vegetable storage units, might be the answer for the greening of the system such as storage and transportation stages.

At the same time, the greening of value chains also considers disposal and recycling patterns of generated waste, to recapture value at every stage of the food value chain and thus further reduce environmental impact (Hilmi, 2015). In particular, a green pathway for developing food value chains requires innovative knowledge and technologies all along the agri-food chain. Wide access to state of the art knowledge and technology is therefore an important element in achieving greener food systems, thus enabling critical factors such as seasonality, globally-based growers, long transportation routes and storage delays to be converted into benefits (year-round availability of defined foods, waste reduction and reduced energy consumption).

Over the past few years, the emergence of greener food value chains and the renewed emphasis on efficiency and food safety has changed the way in which postharvest systems are conceived from a series of individual components to an integrated value chain linking producers and consumers through domestic and international trade.

A key and critical aspect of green food value chain development depends on improved postharvest management which, in turn, enables meeting consumer demand in a better and more efficient way, reducing costs and increasing benefits.

Eco-innovation in the agri-food chain: Barilla sustainable farming (BSF)

The BSF initiative of the Barilla group is an example of promoting more efficient cropping systems with the aim of obtaining safe and high quality agricultural products while protecting the environment and enhancing the social and economic condition of farmers. The first life cycle assessment of the environment was conducted on durum wheat pasta, including all chain phases (cultivation, milling, pasta production, packaging production or distribution and household cooking). The outcomes revealed that the phases with the highest negative impact on the environment were durum wheat cultivation and household cooking. The data have been used to update the "Barilla crop guidelines", and to publish a "Handbook for the sustainable cultivation of quality durum wheat in Italy", featuring a list of rules to help farmers make the production of durum wheat more efficient and sustainable, guide their long-term farm management strategy. A website (granoduro.net) also provides an online assistance system helping farmers to take operative decisions.

Between 2011-2013, an improvement in all performance indicators was observed by all farms that implemented the guidelines: a decrease in durum wheat direct production and inputs costs, yield increase resulting in an increase in gross income, a decrease in crop environmental impact (carbon, water, and ecological footprints) and an increase in nitrogen use efficiency. The adoption of appropriate cropping systems combined with suggestions from the group and the website led to an increase in yields of up to 20%, a decrease in farmers' direct costs of up to 31% and a reduction in CO_2 emissions of 36%, on average.

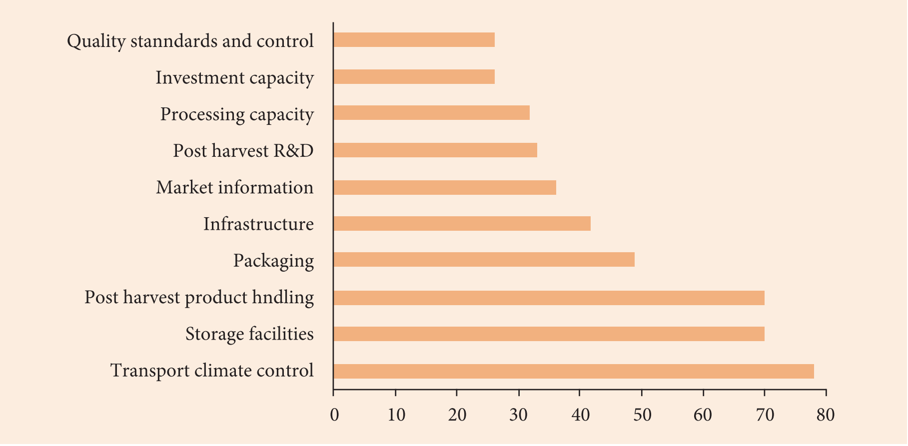
The BSF eco-innovation and its results are an interesting example showing that the sustainability goal provides opportunities for action that could lead to the application of environmentally advantageous and economically viable cropping systems in Italy in the near future. Although BSF is an innovation model only centred on durum wheat cultivation, it seems to have a value for several actors in the chain, including sourcing and supply chain operators, while at the same time, improving durum wheat environmental, social and economic sustainability. The involvement of sourcing and supply chain operators in the adoption of BSF might lead to a "win-win result'": research institutions (Horta) could use innovation outcomes for the implementation of web-based systems (like granoduro.net); universities (Cursa) could benefit in terms of research findings; farmers and elevators, from increased yields and revenues; processors, like Barilla, from the high quality of durum wheat received and obtained respecting sustainability parameters. By providing benefits to all actors involved, the BSF initiative has enabled discussions on the potential increase and distribution of value across the whole agri-food chain.

Source: Blasi et al. *(2015).*

Critical issues in postharvest management for the fruit and vegetable sectors

The causes of postharvest losses in the Mediterranean are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. Postharvest losses also vary greatly among commodities and production areas and seasons (Figure 1).

Figure 1 - Main categories for causes of postharvest losses (in %)



Source: Aramyan and Van Gogh (2014).

Postharvest loss in Mediterranean countries is mainly caused by biological spoilage due to inappropriate postharvest management practices (inadequate transportation facilities and improper handling systems of storage or packaging as well as unfavourable climatic conditions of high temperatures and low relative humidity). Significant economic and environmental losses result from the inability to retard ripening and associated excessive softening of fruits between harvest and marketing, while loss of water from vegetables negatively affects their quality (El-Ramady *et al.*, 2015).

Two core challenges of greening food value chains are enhancing food security (as well as safety) and at the same time providing for environmental conservation. This involves improving productivity and efficiency at all levels of food supply (including its management), of which an integral part is increasing the efficiency of postharvest systems. Developing advanced postharvest technologies will allow wholesalers, warehouses, retailers, transportation companies throughout the fresh-produce value chain to guarantee optimum quality and extended shelf life. Current research and development (R&D) as well as technology transfer in postharvest technologies aims to combine knowledge of plant physiology and technology for the optimal maintenance of quality following harvest. Optimal postharvest treatments for fresh produce seek to slow down the physiological processes of senescence and maturation, reduce/inhibit the development of physiological disorders and minimise the risk of microbial growth and contamination. In addition to basic postharvest technologies of temperature management, a wide range of other technologies has been developed including various physical (heat, irradiation and edible coatings), chemical (antimicrobials, antioxidants and anti-browning) and gaseous treatments (Mahajan *et al.*, 2014). Ultimately, FLW are reduced mainly through capacity development, in the form of education, training and extension services, for all actors across the food value chain (Table 1).

Table 1 - Approaches to the FLW reduction

Production	Handling and storage	Processing and packaging	Distribution and market	Consumption
Donation of unmarketable crops	Improved access to low cost handling and storage technologies (evaporate coolers, storage bags, metal silos, crates)	Re-engineering the manufacturing process	Donation of unsold goods	Donation of unsold food
Improved availability of agricultural extension services	Improved ethylene and microbial management of food in storage	Improved supply chain management	Change food date labelling practices	Conduct consumer education campaigns
Improved market access	Introduction of low-carbon refrigeration	Improved packaging to keep food fresher for longer	Change in-store promotions	Reduce portion size
Improved harvesting techniques	Improved infrastructure (roads)		Guidance on food preparation and storage and inventory systems	Teaching home economics in schools

Source: Lipinski *et al.* (2013).

New postharvest technologies to prevent food losses

New cooling systems and temperature control

The major effect of low temperature applications between harvest and produce end use is a reduction in metabolism and implicitly a delay in quality loss and senescence. Beneficial effects of pre-cooling on produce shelf life are more pronounced in highly perishable products. In order to help maintain a higher product quality and longer shelf life starting at the harvesting site, the most advantageous systems are the mobile forced air-cooling tunnels and crates. These systems provide a shorter delivery time to market and decrease on-site production costs. Instead, a wide range of pre-cooling systems (radiant cooling, evaporative cooling units, solar chillers, Cool-Bots) and other suitable solutions can be implemented in Mediterranean countries including the "zeer" that is one of the simplest and yet most efficient evaporative coolers. Costing less than 2 dollars to produce, the zeer can contain up to 12kg of food and be reused for several years. For example, tomatoes and guavas that normally expire within two days without any storage, last up to twenty days in a zeer.

With regards to the greening of the cold chain systems, sustaining their capabilities becomes increasingly challenging as populations grow and new technologies emerge. New warehousing and transportation technologies can reduce greenhouse gas emissions, improve air quality, and replace environmentally-destructive refrigerants with benign alternatives. A recent technology using liquid nitrogen engines is being considered as a "quick-fix" solution to air pollution caused by refrigerated transport by allowing produce suppliers to create a zero-emissions fleet. As a by-product of the industrial gas sector, the infrastructure allowing to provide liquid nitrogen is already in place and it is described as cheaper than traditional fuel. Meanwhile, vehicle emission technologies are emerging to address transport refrigeration units (TRUs). Battery-electric TRUs are already available, as are eutectic plates that store cold in a salt solution (similar in principle to a beer cooler cold pack), both of which are quiet and, with fewer moving parts require lower maintenance. The Mediterranean countries stand at a crossroad: whether to build their cold chains using conventional technologies or the cleaner technologies of the future.

Reducing fresh produce waste through sustainable packaging

Major supermarket chains are already leading the way by encouraging their suppliers to use bio-based packaging materials and this trend is likely to grow: future bio-based food packaging materials are likely to be blends of polymers and bio-nanocomposites, in order to achieve the desired barrier and mechanical properties demanded by the food industry. Important research has already been undertaken in this area. If commercialisation is still carried out on a small-scale, the next decade will see significant production of bio-nanocomposites for food industry use (Robertson, 2008).

Although environmental pollution seems to be one of the most important issues that the consumer is worried about, the latter seems neither to realise nor to be aware of the importance of recycling and/or biodegradable packaging. This lack of awareness is mainly due to inadequate information. A more intensive campaign towards consumers' education regarding recycling and biodegradable packaging must be undertaken by consumer organisations worldwide in conjunction with incentives from governments. As an alternative to the current petroleum-based polymers, today, increasing attention is given to biopolymers derived from renewable sources. Biopolymers obtained directly from biomass (starch, chitosan, gelatine, collagen, gluten, zein. etc.), by chemical synthesis from monomers obtained from biomass (polylactic acid – PLA – and other polyesters), or produced by microorganisms (polyhydroxyalcanoates, bacterial cellulose, etc.) (Weber *et al.*, 2002) are already being used as packaging materials or coatings for food. These materials can be biodegradable and many of them are edible. They enable the control of physical, chemical and microbial processes in foods as well as, or better than conventional plastics. Producing biodegradable plastics using renewable biomass that ends up in biodegradation infrastructures like composting facilities is ecologically sound and promotes sustainability (Narayan, 2005). The improvement in polymer technologies and the use of smart additives (sensors, time temperature indicators. etc.) will confer the same performance to bio-based packaging as conventional packaging, with the added value of compostability. Bio-based packaging is compatible with new, innovative technologies such as the e+Remover Technology for ethylene adsorption.

Strategies for efficiently achieving a sustainable development

– Minimise the number of packaging layers through the optimal combination of primary, secondary and transport packaging.

– Eliminate unnecessary packaging, for example replace the plastic on blister packs with a simple tie.

– Reduce unnecessary void space.

– Use cut-out windows on corrugated shippers to reduce the weight of the pack; an added benefit is product visibility which clearly shows the pack's contents.

– Reduce the thickness of packaging.

– Increase the amount of product per package to reduce the packaging/product ratio.

– Use bulk packaging for distribution of industrial products.

– Concentrate the products that can be concentrated.

– Eliminate the use of glues in folded carton board by using tab closures.

Source: Lewis (2008).

One of the main goals in developing postharvest technologies is to advance innovative packaging equipment such as active and intelligent packaging with enhanced functions in response to the difficulties in maintaining adequate postharvest storage and distribution, aimed at improving quality and safety of the produce. While in active packaging the product, the package and the environment interact in a positive way to extend shelf life, intelligent packaging is an extension of the communication function of traditional food packaging, providing the user with reliable and correct information on the conditions of the food, the environment and/or the packaging integrity. As such, innovative packaging solutions also contribute towards a more sustainable world in which the harmful impact of packaging waste and food loss on the environment is reduced. Active, intelligent packaging will provide more than passive protection, making readily and practically available valuable information about the quality and safety status of the food products and will contribute to the better management of the food chain, the reduction of food waste and increased protection of the consumer. The most important factor for the preservation of perishable products is temperature. Therefore, the monitoring and controlling of this parameter under packaging conditions is of utmost importance for the food value chain particularly in the Mediterranean climatic conditions.

Time temperature indicator (TTI) Technology

The time temperature indicator (TTI) is among the most widespread intelligent packaging techniques. A TTI can be placed on shipping containers or individual packages as a small self adhesive label that experiences an irreversible change (in colour) when the TTI experiences abusive conditions. TTIs are also used as freshness indicators for the estimation of the shelf life of perishable products. However, most active or intelligent systems add cost to the package. Thus, innovations in packaging must have a final beneficial outcome that compensates for the extra expenses required for this technology.

Ethylene Controlling Technologies

In the Mediterranean countries where the climate resembles that of subtropical areas (high temperatures and dry conditions), the delay in the ripening and senescence of fruits and vegetables is of paramount importance for the preservation of quality characteristics. Several active packaging technologies based on absorbing or releasing compounds that interact with the product have been developed:

– The demand for discovering alternative technologies capable of scavenging ethylene has led to the development of a new material called e+® active Ethylene Remover, which has a significant adsorption capacity of this gas. It's Fresh! Technology has also demonstrated profound effects on non-climacteric fruit types such as strawberry. The technology is being further tested on fruit, flowers and vegetables around the world.

– The SmartFresh Quality System is a brand of a synthetic produce quality enhancer based on 1-methylcyclopropene (1-MCP). It is applied in storage facilities and transit containers to slow down the ripening process and the production of ethylene in fruit. SmartFresh applications have consistently improved the retention of firmness and reduced weight loss in store, provided greener, more acid fruit that were less susceptible to superficial scald and bitter pit.

– Some vegetables that are considered as non-climacteric are both sensitive to ethylene and also the ethylene binding inhibitor 1-MCP. Thus, root crops are often "cured" to prolong their storage life and minimise losses, while crops such as onions and potatoes may also be treated with sprout suppressants such as ethylene prior to long-term storage. In citrus and bananas, ethylene supplementation is used to induce fruit degreening as a natural process.

Antimicrobial active systems

Moreover, the Mediterranean climatic conditions enhance microbial growth that severely compromises the healthy aspects of perishable products. Therefore, solutions to diminish microbial activity are of great significance for producers of fruits and vegetables. Also, a fair amount of work has been done to develop antimicrobial active systems using various polysaccharide and protein-based biopolymers, which in some cases (chitosan, for example) possess antimicrobial activity. They constitute a good basis for the development of antimicrobial active packaging and coatings that slowly release fungicides and bactericides that migrate onto the packaged foods and combat contamination. In one system, known as "BioSwitch" (De Jong *et al.*, 2005), an antimicrobial is released on command when bacterial growth occurs: when there is a change in the environment (pH or temperature) takes place or when the packaging is exposed to UV light, the antimicrobial responds accordingly. Antimicrobials incorporated in packaging materials could extend shelf live by preventing bacterial growth and spoilage. Further development should be expected in future to provide possibilities that conventional polymers do not offer and also help to limit the problems of using non-renewable raw materials and polluting the environment (Kerbellec *et al.*, 2008).

Emerging smart packaging technologies

To date, there are three major technologies for the production of intelligent packaging: sensors (and by extension nose systems), indicators and radio frequency identification (RFID) systems (Kerry *et al.*, 2006). Besides, traditional sensors to measure temperature, humidity, pH-level and light exposure, and chemical sensors have received increasing attention in recent years to monitor food quality and package integrity. Small and flexible chemical sensors are particularly interesting to develop intelligent food packaging that is able to monitor volatile organic compounds and gas molecules related to food spoilage especially in modified atmosphere packaging (MAP). Today, manufacturers gradually start producing some conventional electronic devices (amorphous silicium photovoltaic cells, temperature sensors) via flexible printing, to reduce costs. Very recently, Thin Film Electronics ASA announced that it has successfully demonstrated a stand-alone, integrated printed electronic temperature-tracking sensor system powered solely by batteries, designed for monitoring perishable goods.

Carbon nanomaterials offer a high specific surface area and therefore present excellent detection sensitivity. In addition, their excellent electrical properties (high current density, high electrical conductivity) and mechanical characteristics (light weight, highly flexible, even under low temperature) make them suitable to be used as chemical sensors. Recently, an innovative method was demonstrated for the fabrication of selective chemical sensors from carbon nanotubes and graphite on the surface of paper. These sensors are capable of detecting and differentiating gases and vapours at a ppm (parts per million) concentration level (Mirica *et al.*, 2013). Besides, some promising technological properties such as silicon photonic-based sensors have two important assets: low production costs and the potential to produce on a large scale. Indeed, the same infrastructure and methodologies can be applied as those applied in the production processes of conventional silicon semiconductors for electronic devices. CheckPack will develop a silicon photonic-based chemical micro-sensor to measure VOCs and CO_2 concentrations in the headspace of food packaging.

Biosensors for pathogen identification could be one of the active and intelligent systems of the future: antibodies could be attached to a plastic packaging surface to detect pathogens or toxins (LaCoste *et al.*, 2005). It is also believed that tomorrow's food packages will certainly include radio frequency identification (RFID) tags. At present, RFID is being researched at laboratory level only to promote the understanding of the storage air and fruit pulp temperatures as well as of relative humidity in typical fruit supply chains (Gander, 2007). The cost is the biggest obstacle of the wide-scale adoption of monitoring technologies in the food chain. RFID technologies, enables wireless monitoring systems at a much lower cost (for example through the integration of ultrawide-band communication) though not yet completely developed.

Nanotechnologies

Applications of packaging nanotechnologies have been shown to increase the safety of food by reducing material toxicity, controlling the flow of gases and moisture, and increasing shelf life (Watson *et al.*, 2011). Currently, most nanotechnology applications in the agricultural supply chain are concentrated in packaging. Ultimately, the idea is to design intelligent packaging based on nano-sensors in view of promoting information and management across all elements of an agricultural supply chain. When incorporated into polymer matrices, nanomaterials interact with the food and/or its surrounding environment, thus providing active properties to packaging systems and resulting in improvements in food safety and stability (Monteiro Cordeiro de Azeredo *et al.*, 2011). Biodegradable and fully compostable bioplastics packaging have already been produced from organic cornflour using nanotechnology (Neethirajan and Jayas, 2011). In addition, nanotechnology can be used in antimicrobial packaging systems including an antimicrobial nanoparticle sachet that disperses bioactive agents in the packaging or coating bioactive agents on the surface of the packaging material (Coma, 2008).

Scientists have developed a portable nanosensor to detect chemicals, pathogens and toxins in food on real time basis enabling safety and quality verification at control points in the supply chain (Tiju and Mark, 2006). Current sensors using electrocatalysis and nanotechnology represent a new and promising technology for the affordable detection of ethylene production in fruits which will enable research in areas where ethylene could not be measured before, due to lack of portable, sensitive, and near real-time measurement equipment (Mahajan *et al.*, 2014). Several pesticide manufacturers are already developing pesticides encapsulated in nanoparticles. These pesticides may be time-released or released upon the occurrence of an environmental trigger such as increased temperature and humidity, or excessive light (Mahajan *et al.*, 2014).

Information technologies in postharvest management

Information technology is increasingly impacting agriculture from fundamental inputs, such as genomics and computer modelling that can help drive the next generation agricultural technologies: seed and planting technology as well as food distribution with smarter logistics that can help deliver food more quickly using less fuel and fewer machine resources and with less spoilage all along until consumption. Smart IT systems can have a positive and global impact thanks to track-and-trace technologies that support food safety and ultimately optimise food value chains; by increasing farm multifactor productivity thanks to improved water logistics and application, optimised machine/fleet maintenance, and improved farm operations/processes (Denesuk and Wilkinson, 2011).

In the agri-food value chain, Ruiz-Garcia *et al.* (2010) proposed a model and prototype implementation for the tracking and tracing of agricultural batch products along the food value chain. The proposed model suggests the use of web-based systems for data processing, storage and transfer that makes information access, networking and usability to achieve full traceability more flexible. José A. Alfaro and Luis A. Rábade (2009) presented the case study of a firm in the Spanish vegetable industry and found that the firm had significant qualitative and quantitative improvements in supply, warehousing, inventory and production processes after the implementation of a computerised traceability system.

One of the widest spread technology used for traceability is the barcode. GS1 is a non-profit organisation dedicated to the design and implementation of global barcode standards for identifying goods and services to improve the efficiency and visibility of supply chains. These GS1 standards could be implemented throughout the food supply chain to enable traceability. There are GS1 member organisations in 108 countries. Their well-known global trade item numbers (GTINs) including the UPC (Universal Product Code), the SSCC (Serial Shipping Container Code) and the EAN (European/International Article Number) have been used by retailers and suppliers of packaged goods for decades. The adoption of GS1 standards varies by country and sector but has significantly increased every year, and efforts are under way to increase their adoption by companies in the upstream supply chain. GS1 standards for product identification (product type and lot numbers) are the basis of a major initiative undertaken by the produce industry to enable traceability back to the farm. The initiative is called the “Produce Traceability Initiative” (PTI) and aims at achieving the adoption of electronic traceability throughout the supply chain for every case of produce (Denesuk and Wilkinson, 2011).

Implementing greener supply chains in developing countries such as those of the Mediterranean region, both in terms of logistics and the use of environmentally-friendly technologies, can substantially support the development of a sustainable agriculture. Thus, the expansion of the applications of IT in developing green value food chains will contribute to the promotion of food security for a growing global population, while meeting the energy and ecosystem requirements.

Implementing strategies and policy recommendations

Research & Development

According to many studies, between 30% and 40% of fruits and vegetables are lost before reaching the final consumer. These losses are observed at harvesting, during packing, transportation, in wholesale and retail markets, and during delays at different stages of handling. Physical and quality losses are mainly due to poor temperature management, use of poor quality packages, etc. Less than 5% of funding for horticultural research and extension (R&E) has been allocated to postharvest issues over the past twenty years. Research ranges from the fundamentals of storage and preservation of quality throughout the marketing chain, to food-science aspects of agro-processing and responses of consumers to new food products. While thousands of development projects have been launched in Mediterranean and developing countries between 1990 and the present time, very few have focused on horticulture (approximately 1%), and only a third of these very few horticultural projects included a postharvest component (Kitinoja *et al.*, 2011).

Many of the above-mentioned technologies and techniques are already being implemented by individual organisations and companies. While researchers have identified many potentially useful postharvest technologies to be implemented in developing countries, there is a lack of information regarding the costs and financial benefits of these technologies since costs are rarely documented during research studies. In general, postharvest loss reduction science is less expensive than production research, in the framework of which multiple studies must be conducted over years or seasons. Capacity-building efforts undertaken in postharvest technology in developing countries must be more comprehensive, and include technical knowledge on handling practices and research skills (Kitinoja *et al.*, 2011) as well as consider the natural environment aspects of such activities. There are several initiatives from government and development partnerships in Mediterranean countries aimed at improving the livelihoods of women farmers through value addition and marketing of perishables food crops such as fruits and vegetables (Lipinski *et al.*, 2013). These initiatives have two-pronged benefits: they contribute to the economic empowerment of rural women and to the reduction of postharvest losses of perishable commodities. However such initiatives also need to include considerations related to natural environment elements.

Doubling the share of investment in addressing postharvest losses (from 5% to 10%) would be a significant improvement and a step towards increasing adoption rates of technologies and approaches to reduce postharvest losses. National governments, development banks, philanthropic foundations and international organisations dedicated to food security all have a role to play in increasing this investment. Food loss prevention training and education programmes must be implemented throughout the world. In many cases, insufficient funds have prevented the implementation of such programmes.

Policy and training

Postharvest loss interventions should be integrated and due consideration must be taken of the socioeconomic, business, natural environment and political context of a country. Strategies for the consideration these contexts suggested by Lisa Kitinoja *et al.* (2011) include: the integration of postharvest loss science and education into the general agricultural curricula and government extension services; the establishment of "Postharvest Training and Services Centres" to test reduction innovations under local conditions, identify the most promising and cost-effective techniques and practices, provide demonstrations of innovations determined to be technically and financially feasible, and provide hands-on training and capacity building to farmers; and the establishment of country-level Postharvest Working Groups that connect researchers, extension agents, farmers, and other food value chain actors concerned about the reduction of postharvest losses. Such groups could facilitate exchange of information, training, shared learning and national and regional collaboration revolving around postharvest loss reduction. Reducing food loss and waste requires collaborative initiatives that provide a number of benefits such as building capacity within the entities that need to take ground action to reduce food loss and waste or facilitate sharing and transferring of best practices and common pitfalls. Researchers, civil society and intergovernmental organisations can identify and share best practices, provide technical assistance and convene stakeholders.

In order to minimise undesirable changes in quality parameters during the postharvest period, a series of techniques can be employed to extend the shelf life of fresh produce. Postharvest technology comprises different methods of harvesting, packaging, rapid cooling and storage under refrigeration as well as under a modified or controlled atmosphere and transportation under controlled conditions, among other essential strategies to maintain the shelf life of fresh produce. At each stage of the food value chain, general solutions can be implemented to address specific causes of losses and waste, and they involve improved practices, adoption of technical innovations, investments, or a combination of these. Storage conditions must be improved all along food value chains. The support and cooperation of the food industry and retailing is also required to improve the clarity of food date labelling, to provide advice on food storage, or to ensure that an appropriate range of pack or portion sizes is available to meet the needs of different households. Investment in food processing infrastructure, including packaging, can be considered as a huge opportunity to contribute to improved situations of food security, especially in sustainable ways to fulfil the growing demands of metropolitan areas (FAO 2014).

Investments and gender issue

The major challenge for the Mediterranean countries is the mobilisation of funds to establish green infrastructures throughout the food value chain in order to enhance sustainability and increase profits for farmers, wholesalers and retailers. This would enable high quality fruits and vegetables to reach the European markets. Moreover, funds should be invested in research and development to deal with applied aspects of greening the food value chain in subtropical areas such as the Mediterranean basin. Generally, there is a lack of continuation between laboratory findings and field application of the results. Increased investments in postharvest technology R&D can have a major impact on reducing losses, preventing and mitigating environmental impacts, and increasing the food supply, thus leading to improved incomes without an increase in production and the wasting of expenditures on required inputs (increased demand for land, water, seeds, fertilisers, pesticides, labour, etc.).

The gender issue is another important challenge in Mediterranean countries. Despite the key role they play from production to food processing, women experience barriers in the postharvest handling practices. Most of them lack knowledge of and access to good processing practices and efficient processing tools. Additionally, they are often excluded from training opportunities because most producer organisations, through which such capacity-building efforts are conducted, are dominated by men. As a result, women farmers end up with inferior processed products that cannot meet market standards and are therefore discarded or sold to alternative markets for lower prices.

Conclusion

There is a clear need for a more holistic and integrated approach when dealing with postharvest losses in the overall context of greening food value chains. Postharvest innovations, as described above, coupled with the context of greening food value chains, can have a very large impact on the prevention, reduction as well as possible recapture of value in food losses. Thus, it is clear that policy makers and decision makers must consider such an approach, especially as it contributes to improved food security (and health and safety), the mitigation of climate change, increased employment opportunities and the furthering of women equality. The achievement of the Sustainable Development Goals (SDGs) will require a significant improvement in the efficiency with which resources are used. We need to "do more with less". This is sometimes called eco-efficiency, a term that was coined by the World Business Council for Sustainable Development (WBCSD) in its 1992 publication (Schmidheiny, 1992). The critical issue is that we have exceeded the sustainable carrying capacity of the Earth, and we need to reduce our demands on its resources. A range of possible eco-design strategies to increase efficiency are provided in Box 2. They include "source reduction" or light weighting of packaging, as well as improvements in the efficiency of distribution (Lewis *et al.*, 2001).

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CHAPTER 12

INNOVATION FOR THE REDUCTION OF FOOD LOSSES AND WASTE

Biagio **Di Terlizzi**, *CIHEAM*
Robert **Van Otterdijk**, *AGS, FAO*
Alberto **Dragotta**, *CIHEAM*
Patrina **Pink**, *AGS, FAO*
Hamid **El Bilali**, *CIHEAM*

Wasting food is an unsustainable, economically negative, environmentally wrong and morally unacceptable phenomenon. Food waste exacerbates the inefficiency of the food chain, thus contributing to food and nutrition insecurity in the Mediterranean region especially in southern and eastern Mediterranean countries (SEMCs). Food loss and waste (FLW) lead to a major squandering of resources including water, land, energy, labour and capital and needlessly produce GHG emissions. The potential that lies in the elimination of losses and waste along the food chain thus making more food available to consumers should be highly considered by Mediterranean policies and research agendas related to the agri-food sector.

FLW reduction constitutes a significant lever for broader improvements of the Mediterranean food systems that result in increased food security, food safety, quality and sustainability. It would help increase the available offer and the efficiency of the use of food. Therefore, innovation along the food chain is crucial for the reduction of both the amount and extent of FLW worldwide and particularly in the Mediterranean area. When developing FLW reduction solutions and strategies, especially technical and organisational ones, one should keep in mind that there has to be a compromise between obtaining an acceptable return on investment by an individual or the private sector, protecting the environment and fulfilling consumer demand for food safety, product quality, and a diverse variety of nutritious, flavourful, and acceptably-priced food (Buzby and Hyman, 2012).

Today, in the Mediterranean both the private and the public sectors are aware of the importance of innovation for the prevention of food losses and the reduction of food waste. Innovation represents a major issue within the European Union cooperation and development financial tools targeted towards the Mediterranean countries. Recently, the *Innovation Union*, a strategy aiming to create an innovation-friendly environment that makes it easier for great ideas to be turned into products and services, has been set up to enhance economic growth and contribute to the creation of jobs in the EU countries. In the framework of this strategy, the European Innovation Partnerships (EIP) play an important role as a new tool fostering innovation in the agrofood sector. In its roadmap for a resource-efficient Europe, the European Commission (EC) has set the target to halve the generation of food waste by 2020.

In order to highlight the potential of innovation in reducing the amount and extent of FLW along the Mediterranean food chains, this chapter revolves around several issues: innovation models and types; innovative integrated strategies for FLW management; product and process innovations for FLW prevention and reduction along the food chain; political, organisational and social innovations for FLW prevention and reduction; and innovative solutions and good practices for FLW recycling and re-use.

Innovation models and types

It is thanks to the human ability to invent solutions and accumulate knowledge that humans succeed in adapting to change. For many years, innovation has been closely related to sustainable development and it is now high time to position it more clearly (Lacirignola, 2015). The adoption of innovations is decisive for development strategies in the Mediterranean. Traditional linear approaches have proved to be less effective; the necessity to build systems capable to put needs and solutions into perspective is widely recognised (Adinolfi *et al.*, 2015).

Innovation is a complex phenomenon, involving the production, diffusion and translation of scientific or technical knowledge into new or modified products and services as well as new production or processing techniques (Menrad and Feigl, 2007). Food innovation refers to the addition of new or unusual ingredients; new combinations of product; different processing systems or elaboration procedures (Vanhonacker *et al.*, 2010).

Different models for the innovation process can be found in scientific literature, such as the sequential or linear model and the integrative model. In the last forty years we have assisted to a shift from a concept of innovation centred on research to innovation as a result of interactions among several actors establishing diverse linkages (World Bank, 2007). Innovations can be classified under the term of object or under that of profundity. When systematising innovations under the term of object usually one distinguishes between product innovations and process innovations, but also organisational and social innovations. The OECD and Eurostat (2005) distinguish product, process, marketing and organisational innovations. *Product innovations* can be understood as the application of new production (Wegner, 1991). Important product innovation attributes include: improving useful properties of the product, increasing quality, changing of design and reducing environmental impacts. *Process innovations* are changes in the field of production that are applied within the enterprise (Hauschildt, 1997). New production techniques allowing new product innovations, process innovations, could be seen as an investment in skills, resources and competences of a company. Process and product innovation are often closely related and the distinction between them is not always clear-cut. *Organisational innovations* improve or modernise the administrative and process organisation of a company (Pleschak and Sabisch, 1996), such as the reduction of hierarchy levels and the solution of co-operation and interface problems. *Social innovations* concern changes in the field of human resources management of companies such as the provision of specific training for employees (Eherer, 1994). Social innovations are distinct from other forms of innovation. They are defined as new ideas (products, services and models) that meet social needs (more effectively than alternatives) and create new social relationships or collaborations (Murray *et al.*, 2010).

In terms of profundity and degree of novelty, radical innovations and incremental innovations can be generally distinguished. Usually, innovations only bring about many small improvements in a continuous upgrading process and involve a combination of technical, institutional and other sorts of changes (Poun and Essegbey, 2008). *Radical innovations* are characterised by a high degree of novelty. Product innovation is considered radical if it leads to the creation of a new market and if the innovator manages to gain a monopoly position at least temporarily. This kind of innovation often means complex changes in different fields of the innovating company, high financial expenditures and a high market risk (Kotler and Bliemel, 1999; Wittkopp, 2004). *Incremental innovations* do not create a monopoly position and have only a low degree of novelty. They are often characterised by an improved benefit-cost ratio or improvements in the utility pattern for consumers (Bessau and Lenk, 1999; Pleschak and Sabisch, 1996). For incremental innovations less technical application is needed which means there is a lower risk in product development than for radical innovations. Accordingly, incremental innovations may be produced faster and with lower financial expenditures. Incremental innovations rather target on success for a short period, while radical innovations are expected to provide success for longer periods.

Innovation arises in a particular socio-economic, political and institutional context and is shaped by the environment (either enabling or disabling) in which it can thrive (IICA, 2014). *Political and institutional innovations* are important drivers of the agri-food system with implications also in terms of food losses and waste. Political innovation is the development of new political systems and public policies and is often strongly linked to institutional innovation processes. Institutional innovations entail a change of policies, standards, regulations, processes, institutional practices or relationships with other organisations, so as to create a more dynamic environment that encourages improvements in the performance of an institution or system (IICA, 2014; OECD, 2011).

Innovative integrated strategies for FLW management

The High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014) distinguished three levels of FLW causes: micro-, meso- and macro-levels. The importance of meso- and macro-causes stems from the fact that quite often, causes of FLW of a physical, technical or behavioural nature are induced by broader economic, social and institutional causes. A wide range of causes organised in different levels calls for a wide range of solutions, also organised in different levels, which concern investments, good practices, behavioural change, coordination within food chains, valorisation of food and by-products or coordination of policies and actions. Post-harvest solutions range from improved practices in crop and animal production and investment in storage to the adoption of technical innovations in transport, processing and packaging. Technical and behaviour-driven solutions to reduce consumer waste include food service solutions in the hospitality sector (hotels, restaurants, canteens, catering, etc.) and household-level solutions.

Integrating FLW concerns in policies can take two complementary forms: (1) integrate FLW concerns in all policies which can have an impact on them; (2) devise a specific FLW reduction policy to address the interdependencies of actions that end up creating FLW (HLPE, 2014). In OECD countries (2014), existing legal frameworks with a FLW component are mostly focused on waste management and environmental concerns in general, aspects of prevention and improved re-use of waste, all waste taken into account, the food parts within the waste being only one aspect of the problem.

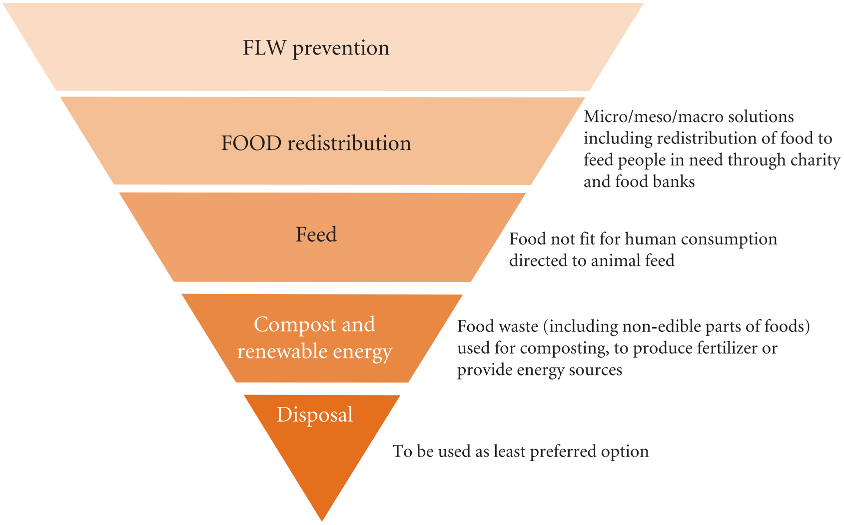
Policies are aimed at setting priorities or coordinating actions of various actors or sectors. One of the important dimensions of such priorities is to give clear directions among the "competing" uses of food waste. Specialised publications have presented many "*food use hierarchies*" (HLPE, 2014). These include the *Food Waste Pyramid for London*, presenting a hierarchy of approaches to tackle food waste, in order of priority, the *Food Recovery Hierarchy* developed by the US Environmental Protection Agency (US-EPA), the Netherlands' *Ladder of Moerman*, the *Food Waste Hierarchy* of the Public Waste Agency of Flanders (OVAM), FoodDrinkEurope's *Food Waste Hierarchy* (FoodDrinkEurope, 2013). These food waste management hierarchies or "pyramids" prioritise reduction of FLW at source and present a list of preference for use, re-use, recycling and waste treatment.

In line with an overall pattern of waste management, all these pyramids more or less follow the same structure (see Figure 1): 1) support FLW prevention; 2) facilitate the distribution of still edible but not marketable food such as by means of food banks or other institutions; 3) use residual food as animal feed; 4) use what is left as compost and/or energy. Using disposal in landfills is the least preferred option (HLPE, 2014).

Food-related waste (including edible and non-edible parts) represents an important proportion of waste. In rural areas it can be used easily as feed or organic fertiliser, either directly or through compost. In urban areas, organic waste can be also an important source of methane. Sorting, composting and methane valorisation could reduce the environmental impact of FLW (HLPE, 2014).

In a study commissioned by the European Commission (Directorate General for Environment – DG ENV), the Bio Intelligence Service identified a wide range of food waste prevention initiatives that can be applied at different scales (Monier *et al.*, 2011): awareness campaigns; informational tools (e.g. sector specific prevention guidelines and handbooks); training programmes about FLW prevention (e.g. for food service staff or consumers *via* waste-free cooking workshops); logistical improvements (e.g. stock management improvements for retailers, reservation requirements for cafeterias, ordering flexibility of meals in hospitals); regulatory measures (such as separate collection of food waste); unused food redistribution programmes (to charitable groups).

Figure 1 - A food-use-not-waste hierarchy of actions to minimise FLW along the food chain



Source: Adapted from the Food Waste Pyramid for London (www.feeding5k.org) by HLPE (2014).

Since the causes of FLW are not the same in all countries, potential solutions to food waste and loss reduction are also quite different across countries and even across different socio-economic groups in the same country. Improving food supply chain efficiency such as improving production techniques and infrastructures seems to be the key for developing countries (Kader, 2004), while developed countries should improve their management of the downstream food supply chain by conducting consumer education campaigns, and facilitating increased donation of abundant food (to food banks) (Monier *et al.*, 2011).

Product and process innovations for FLW prevention and reduction along the food chain

Food losses at post-harvest and processing stages are high especially in developing countries (Gustavsson *et al.*, 2011). When appropriately applied, good agricultural practices and good veterinary practices can protect food at the primary stages of production. The quality and safety of food intended for manufacturing or processing can be ensured by applying good manufacturing practices (GMPs) and good hygienic practices (GHPs) to food processing. A key intervention all along food chains is to improve storage conditions. Various solutions and post-harvest technologies exist for this purpose (HLPE, 2014).

Reducing FLW would require substantial additional investments in the limited storage capacity of SEMCs. Dry storage in general and capacity to handle cereals in particular are at the heart of this problem. In several countries of the region the majority of farmers still store their grains using traditional methods, with rodents, insects and birds being responsible for the bulk of cereal losses. For instance, Egypt loses between 13% and 15% of the available cereals between harvesting and final consumption (FAO, 2015).

Post-harvest losses can be reduced with the adoption of innovative techniques and practices in refrigeration, manufacturing and transport technologies. Waste is minimised by modifying packaging and through other approaches that either prolong the shelf life of foods or help consumers reduce food waste in other ways (WRAP, 2012). According to Foresight (2011), reducing post-harvest losses and waste can be achieved through: deployment of existing knowledge and technology in storage and transport infrastructure; investment in new, appropriate technology; and infrastructure, financial and market reforms.

Technical solutions in transport, processing and packaging need to be adapted to local situations, including the availability of infrastructures, economic and human resources, as well as operating conditions of the rest of the food chain. The development of food processing requires appropriate processing technologies and infrastructure in a concerted food chain approach (as for example in atmosphere packaging) (HLPE, 2014). At almost every stage of the food chain, FLW may be reduced by using appropriate packaging, as a key element of a set of technologies and processes to protect food (Olsmats and Wallteg, 2009). Therefore, the packaging industry has indeed a key role to play in addressing food losses. Packaging solutions should take into account the need to reduce waste in general and be adapted to local producers/packagers as well as to consumers' needs (FAO, 2011b). Including information on the packaging on how food should be best conserved and stored also leads to FLW reduction (HLPE, 2014). Preservation processes such as canning, pasteurisation and sterilisation, and packaging technologies contribute to increasing the shelf life of products, thereby reducing FLW in the food chain (Langelaan *et al.*, 2013).

According to the International Institute of Refrigeration (IIR), 23% of perishable foods are lost in developing countries due to the lack of use of refrigeration (IIR, 2009). Therefore, appropriate temperature is a key element for the reduction of FLW. Cold chain management often depends on broad interventions involving actors all along the food chain with the support of public authorities (HLPE, 2014; Albisu, 2014). In perishable foods supply chains, effective cold chain management starts with pre-cooling, cold storage, refrigerated transport and refrigerated display during marketing. Strategies to reduce food losses could also start with interventions by public authorities and development partners to improve the cold chain infrastructure in developing countries. In Tunisia, the food security strategy includes a national plan for the cold chain, which includes investments and incentives with a particular focus on fruits and vegetables, mainly for export (HLPE, 2014).

Very often, and this is particularly true in the Mediterranean area, FLW are a result of inadequate infrastructure and connections. The latest *Mediterra* report of the CIHEAM (2014c) clearly shows that the development of Mediterranean infrastructure and logistics (ports, corridors, multimodal platforms, cold chain, etc.) related to the agri-food sector is important not only to foster exchanges and trade in the Mediterranean but also to address issues related to food system sustainability such as the struggle against FLW. In fact, the optimisation of the transport of agri-food products can significantly contribute to reducing losses and waste.

Political, organisational and social innovations for FLW prevention and reduction

The possibility of reducing food waste depends on several institutional (legislation and policy) initiatives[1]: improvements in current legislation and policy; new non-regulatory initiatives undertaken by governments; new initiatives voluntarily undertaken by stakeholders. It is therefore essential to change the legislation in order to: stimulate the utilisation of food products presently destined for disposal; increase tax on waste disposal and improve separate waste collection; limit by-catches in fisheries; and sanction unfair deals of big retailers with suppliers. These institutional (legislation and policies) actions can have a realistic effect on behaviours affecting food waste (see Table 1).

Mediterranean countries have now begun to take into account these institutional priorities and to act consequently to encourage FLW reduction at different levels. The Regional Programme, established by the FAO in Egypt, Lebanon and Jordan, aimed at building capacities for food loss reduction in the Near East region (2014-2016), also includes institutional and legislative aspects. The 32nd edition of the FAO Regional Conference (Rome, 24-28 February 2014) for the Near East on Reducing FLW in the Near East & North Africa Region endorsed the "*Strategic framework for the reduction of Food Losses and Waste in the Near East and North Africa*" whose objective is the reduction of FLW in the region by 50% during the next 10 years.

1 - EU-Fusions, August 2014 (www.eu-fusions.org).

Many global and regional initiatives aiming to reduce FLW have already been launched. One of the most important ones, the SAVE FOOD initiative (Global Initiative on Food Loss and Waste Reduction) led by the FAO and *Messe Düsseldorf* (Germany), has many objectives (FAO, 2013): awareness raising on the impact of FLW and solutions for reducing them; collaboration and coordination of world-wide initiatives on FLW reduction by establishing a global partnership of public and private sector organisations and companies; policy, strategy and programme development for FLW reduction; and support to investment programmes and projects.

Table 1 - Drivers of food waste generation, increase and reduction related to the institutional and policy context category

Food supply chain segments	Drivers of current food waste generation	Drivers of threats of increase	Drivers of possibilities of reduction
Primary production	– Grading & overproduction – Market conditions/price – Tax policy	– Fishery policies – Public policy on bio-fuel production – Contracts between supplier and retailers	– Fishing policy reform – Information / awareness – Farm to shop cooperation – Selling by weight not by piece (fruit and vegetables)
Processing of farm staples	– Profitability – Access to finance	– Public policy on bio-fuel production	– Use of by-products (for animal feed production)
Food processing and packaging	– Legislative measures – Taxation policies	– Legislative and taxation measures – Public policy on bio-fuel production	– Policies for resale/use of ‘sub-standard’ products – Food standards related to safety
Wholesale and logistics	– Specific marketing standards – Legal restrictions with respect to best before/consumption dates – Blemish of packaging – Low cost for discarding food	– Disposal costs – Decrease of financial support non-profit distribution – Blockages in alternative use chains	– Disposal costs (landfill tax increase) – Tax incentive for donations – Improving distribution logistics – Encouraging research into advanced packaging – Encourage the development of new business models around imperfect produce

Retail and markets	– Marketing standards – Dates for preservation labelling – Measurement and pricing of food waste – Rejection of delivery/returns – Lack of policies to encourage redistribution	– Food safety standards – Redistribution (hindrances related to health risks and new fiscal policies) – Cost of food waste – Ending of voluntary agreements (related to food waste prevention/reduction)	– Food redistribution programmes – Reduce prices according to sell before/best before date of products – Raising-awareness initiatives – Alternative use of products – Encourage closer contact between farm production and consumers – Limits to price promotions with discounts on volumes (by retailers' initiatives) – Eco-labelling of stores – Improved packaging
Food services	– Ban on feeding animal by-products (ABP) and catering waste to animals – Expiry dates	– Contracts – Public procurement laws (which do not take care of food waste concerns)	– Encourage separate collection of food waste and quantification – Encourage consumption of leftovers and use of doggie bags (voluntary initiatives)
Households	– Price of food/proportion of income spent on food – Waste collection infrastructure – Dietary guidance	– Public funding – Food skills and diet guidance (related to public education policy and public health campaigning)	– Application of date marks (new regulation on food information for consumers) – Waste collection infrastructure (improving waste separation) – Dietary guidance (education programmes)

Source: Adapted from Canali *et al.* (2014).

In January 2012, the EU Parliament adopted a non-legislative resolution calling upon the European Commission (EC) and Member States to take “radical measures” to reduce waste from farm to fork by 50% by 2025. It is estimated that up to 50% of edible food is wasted in EU households, supermarkets, restaurants and along the food supply chain each year (BIO Intelligence Service, 2013; Segrè, 2013). The EP therefore called on the commission to implement a coordinated strategy combining EU-wide and national measures to improve the efficiency of the food supply and consumption chains sector by sector, and to tackle food waste as a matter of urgency[2]. The resolution identified areas that need to be addressed by such a strategy.

European Union launches landing obligation to drive greater selectivity and reduced waste in the fisheries sector

In fishing, discards refer to the unwanted catch returned to the water due to size, species, appearance (blemished or damaged catch) or vessels having achieved their quotas (Clucas, 1997). In the European Union, fishing discards have been a contentious concern, with calls for stronger regulations to combat this waste being echoed across the region. The large-scale food waste is largely untracked and affects Europe’s ability to assess the impact of fishing on the marine environment and populations of different species. To make up for this lack of evaluation, in January 2014, the European Union’s new Common Fisheries Policy (CFP) introduced a landing obligation, commonly referred to as a “discard ban”. This new regulation requires that all catch is kept on the vessel, landed and then counted according to quotas. This regulation is intended to encourage higher selectivity among fishing vessels and provide more reliable catch data. This data is then used to estimate the state of specific fish stocks. Moreover, through modelling, the data is studied to determine the health of the stock and how much can be caught sustainably in the following year (European Commission, 2015b). To ensure the smooth applicability of the new regulation, it is being implemented gradually between 2015 and 2019. The European Commission adopted five discard plans in October 2014 (applicable from 2015), which affect pelagic and industrial fisheries in all Union waters, and fisheries for cod in the Baltic (European Commission, 2015b).

The Waste Framework Directive requires Member States to establish National Waste Prevention Programmes and to determine concrete objectives by December 2013. France has already announced its 50% reduction goal of the volume of food waste by 2025 and, furthermore, proposed a national pact against food waste to be signed by a wide range of leading stakeholders to signal their shared commitment (BIO Intelligence Service, 2013). In 2013, Spain also set up food losses and reduction targets.

2 - www.waste-management-world.com/articles/print/volume-13/issue-1/regulars/news/european-parliament-aims-to-resolve-food-waste.html

"More food, less waste" initiative in Spain

Following the request by the European Parliament for its Member States to develop action plans against food waste, the Spanish Ministry of Agriculture, Food and Environment has developed the "*More food, less waste*" initiative that is based on recommendations, voluntary agreements and self-regulation. It aims to decrease the amount of waste and encourage dialogue and coordination between stakeholders within the food chain and public authorities. The ambitious programme includes several actions: carrying out studies on FLW; reporting and promoting good practices and actions to raise awareness among wholesale, retail distributors and consumers; establishing administrative rules in order to improve quality standards and by-products management for non-food use; promoting voluntary collaboration among agri-food agents between the public and private sector including food banks to gather useful food that could be distributed among the needy; and developing new technologies for FLW reduction. In addition, the strategy supports the "*What can I do?*" campaign that provides all actors within the food chain with advice on how to reduce food waste. Under the same framework, the Ministry of Agriculture organised between 4-10 November 2013 the "*Waste Reduction Week*" during which there were seminars and activities targeting, among others, food service professionals, catering schools, primary schools and consumers.

Source: MAGRAMA (2012); Vay (2014).

The Italian Ministry of Environment has also set up a task force for the reduction of food waste. On the occasion of the national day against food waste (5 February 2014), the task force met to develop a national plan for waste prevention (Last Minute Market, 2014). Cities play a key role in the generation, management and prevention of food waste and are in a strategic position to work with citizens, schools, restaurants and food businesses to promote and support food waste reduction. Their activities could focus on awareness raising and communication, education and training and separate collection of food waste for energy recovery and composting[3]. Over five hundred Italian municipalities have signed the "*Charter for a network of local and regional authorities with zero waste*", promoted by Last Minute Market, thus pledging to reduce waste and losses along the food supply chain. Following this initiative, the "*National Network of Municipalities against Waste*" (Association Sprecozero.net) coordinated by the city of Sasso Marconi (province of Bologna) was created in December 2013 (Last Minute Market, 2014).

The other Mediterranean countries, including SEMCs, can adopt similar food waste prevention and reduction programmes and strategies. The final declaration of the 10th meeting of the Ministers of Agriculture of the thirteen Mediterranean Member Countries of the CIHEAM dedicated to "*Sustainable food security in the Mediterranean: situation and outlook*" that was held in Algiers on the 6 February 2014, proposed the CIHEAM to strengthen instruments and networks and to encourage regional initiatives that addressed the issue of food waste (CIHEAM, 2014a).

The efficiency of FLW reduction often depends on broader interventions involving private actors all along the food chain and/or public actors. Collective storage, which can include the mutualisation of risks of post-harvest losses, is also a solution for

3 - European Union, Report from the Second Meeting of the Working Group on Food Waste, February 2013.

food losses reduction. Its effectiveness depends on the local institutional context (existence of local institutions, cooperatives or producer organisations) (HLPE, 2014). Producer organisations such as cooperatives and associations as well as their federations can play an important role in reducing losses of their members' produce through organisational and management innovations, by supporting collective activities mainly for production planning, sorting, grading and logistics (Kelly, 2012). The FAO has been working closely with various forms of producer organisations and cooperatives to develop different mechanisms and tools for reducing losses early in the supply chain (FAO, IFAD and WFP, 2012). The warehouse receipt system is a good example of the role of producer organisations and cooperatives. The system ensures that food is stored properly so that losses are reduced. This model should therefore also be promoted in the Mediterranean region.

There is great concern among food chain actors (e.g. industries, retailers, etc.) to apply better norms to reduce FLW and to incorporate them as part of their social corporate responsibility. This is for instance the case of food services in Algeria or food and beverage firms in Turkey (CIHEAM, 2014b). In this regard, the inclusion in annual corporate businesses reports of a section on the environmental impacts resulting from their activities could be useful to reduce FLW. Businesses can commit and report on the monitoring of FLW and indicate how they intend to reduce them in their activities or support activities that lead to the reduction of FLW outside this framework (with their suppliers, at consumer level or elsewhere) (HLPE, 2014).

Moreover, the reduction of FLW implies the governance and organisation of new supply chains. The development of closed-loop models (WEF, 2010 and 2014) is meant to coordinate all actors for concerted actions. Losses or waste of all forms are fed to the extent possible back into the value chain. Food graded as lower quality by retailers or manufacturers for cosmetic reasons and food that is surplus would be made available through alternative routes (as cheaper alternatives), while food waste would be utilised as a by-product (HLPE, 2014).

Several studies (such as Quested *et al.*, 2013) have detailed measures that consumers could implement to reduce their own food waste:
– Better planning of purchases to avoid buying more than is needed;
– Avoid impulsive or advance purchasing of food that is not required immediately;
– Better understanding of the distinction between "best before" and "use by" dates;
– Better storage practices and stock management in the home;
– Better evaluation of the portions that need to be prepared;
– Better knowledge on how to use the leftovers on other recipes instead of discarding.

The Egyptian government has started to implement several reforms and strategies for both food and fuel subsidies in order to reduce losses and budget deficit. A new smart card system, which replaces the ration card system, can record data on the household head's monthly quota of subsidised goods and other household information as well (Ramadan, 2014). Such reform would enable the government to reduce wastage and leakage and reduce corruption (World Bank, 2010).

The Egyptian social smartcard

Egypt currently imports twice as much wheat than the whole of the EU to produce subsidised bread that unfortunately is often wasted or fed to animals. The Egyptian government has taken many measures to cut down on massive waste and in April 2015 it has introduced a smartcard system that aims to modernise the country's long-established tradition of bread subsidies. Around 70 million of Egypt's 90 million inhabitants are eligible for the smartcard system, which entitles each family member to receive five rolls of bread a day. If cardholders opt not to claim all of their daily allowance, they gain tradable points that can then be used to purchase other staples or non-foodstuffs in government registered stores. According to the Ministry of Supply, this point system provides poor Egyptians with an additional supplement for food purchases of between 40-50 Egyptian pounds a month (5-6 euros). Meanwhile, the demand of bread has reportedly dropped by between 15% and 20% as the population started to rationalise their consumption. Other countries in the region, such as Jordan, are interested in adopting a similar approach.

Source: The Guardian, *"Bread Rationing and Smartcards: Egypt Takes Radical Steps to Tackle Food Waste", 20 March 2015 (www.theguardian.com).*

Food banks are among the most important social and organisational innovations for food waste prevention. They acquire donated food, a large part of which would otherwise be wasted, from farms, manufacturers, distributors, retail stores, consumers, and other sources. They then make it available to those in need through a network of community agencies (school feeding programmes, food pantries, soup kitchens, hospices, substance abuse clinics, after-school programmes and other non-profit programmes).

Food banking in Italy

The world's first Food Bank was founded in 1967 in Phoenix, Arizona. John Van Hengel, known as the "*Father of Food Banking*", was volunteering in a soup kitchen when a mother with ten children gave him the idea of a place where surplus food could be stored and made available to the poor. Food Banks were then developed in Canada and Europe. Today, they operate worldwide. The *Fondazione Banco Alimentare Onlus* was established in Italy in 1989 and since 1990 it is a member of the European Federation of Food Banks. With the help of a network of 21 Food Banks across Italy, it collects and distributes surplus food from the food chain to 8,669 charitable organisations that help 1,909,986 poor people every year, raises awareness on food waste and food poverty and advocates for policies that sustain food poverty. Its daily activity contributes to food security, improves the sustainability of food systems and reduces the impact of food waste on the environment. The initiative was presented as a best practice entitled "*Food is a Resource to Secure Tangible Assistance and Inclusion to the Deprived*" in the framework of the call for best practices of Expo Milan 2015.

Source: www.feedingknowledge.net/02-search/-/bsdp/6204/en_GB

In Lebanon, important initiatives tackling food waste have been launched by civil society organisations. Among them, those of the Lebanese Food Bank are worth mentioning.

Initiatives of the Lebanese Food Bank against food waste

The Lebanese Food Bank (LFB) is a non-profit organisation created in 2011 by a group of businessmen, and officially launched in May 2013. It can be considered among the most important organisations operating against food waste thanks to the scale of its actions, its continuity in time, its size and the advertising of its work through media campaigns. It is a member of the Arab Food Banking Regional Network. The organisation's main objective is to eliminate hunger from Lebanon by 2020 by building strong partnerships in the public and private sectors as well as strengthening cooperation and increasing donations of food or money from individuals. The LFB has more than thirty partners (banks, hotels, bakeries, etc.) and its actions are divided into four main axes: the feeding programmes aimed at feeding the needy; the development programmes which aim to develop the capacities of the needy; encouraging volunteering to provide various services thanks to many different and specialised talents and skills; the awareness programme "*Not To Waste Food*". The awareness campaigns target hotels, restaurants, catering companies, food factories and individuals. Awareness is being also raised in schools and universities. Instead of throwing away excess food, the LFB distributes it to orphanages, nursing homes and NGOs. The LFB supports more than thirty NGOs.

Source: Oneissi (2014).

Food banks have also proliferated in Spain after the economic crisis. There are nearly 54 across Spain and they gather around 100 million tonnes of food per year. They usually collect uncooked food that is not used or given on purpose to be distributed among poor people (Albisu, 2014). New communication initiatives can also serve as social innovations for food waste prevention. Innovative communication tools to raise awareness among consumers on FLW are increasingly necessary as a complementary device to support educational initiatives at policy level. An example is the one created with the participation of the CIHEAM-Bari.

"*Once upon a time: food waste*": an educational conference-drama on food waste in Italy

On the basis of the paradoxes of our times related to food and nutrition, in collaboration with Massimo Melpignano and Antonio Cajelli, the group of researchers from the CIHEAM-Bari, created a conference show entitled "*C'era una volta il... UEIST (Food)*" (Once upon a time there was... UEIST [Food]), an original training and dissemination path that aims to guide the audience – consumers – through a reflection on topics related to food production and consumption (health, ethical, political, cultural, moral and financial aspects). These issues were identified through a real "construction site of ideas" where the CIHEAM-Bari experts played a leading role with the authors of the play, civil society and local institutions representatives. Massimo Melpignano (lawyer and financial adviser), who for several years was committed to defend citizens' and consumers' rights and Antonio Cajelli (independent financial educator) represent the Articolo 47 – Liberi dal debito (Article 47 – Free from debt), a social association involved in creating awareness pathways on the issues of financial education, food waste and related social phenomena.

Innovative solutions and good practices for food waste recycling and re-use

Food waste can be recycled as animal feed, or used for the production of compost or renewable energy. Within the food-processing sector, substantial parts of the raw materials that enter the factory are ultimately traded as by-products. Utilisation of these streams for food would require alternative processing to the chains' primary product. Hence, a large part of these side streams is only poorly valorised: for animal feed, technical applications and fertiliser production (through composting) (HLPE, 2014).

The NOSHAN Project – Turning food waste into animal feed

Food waste is characterised for its nutritional potential. It can therefore contribute to the production of functional feed ingredients (additives). Nevertheless, this production would require appropriate technologies that stabilise and convert the waste into suitable raw materials for bulk feed. The main aim of the NOSHAN project (Seventh Framework Programme for Research and Technological Development of the European Union, grant agreement No. 312140) with partners from 4 Mediterranean countries (France, Italy, Spain and Turkey) is to address the process and technologies needed to use food waste for feed and feed additives production at low cost, low energy consumption with maximal valorisation of waste materials. The project includes two different groups of activities: the replacement of bulk feed ingredients with starting waste materials to cope with part of the huge amounts of food waste generated in Europe; and the valorisation of active ingredients in food waste to convert them into more valuable feed additives. Forty-two food waste streams have been analysed to identify those that have the potential to be transformed in high quality feed or to be used to obtain feed additives. Drying, extraction and acidification were chosen as best solutions for the stabilisation of selected starting materials. Cost-effective as well as environmental friendly technologies will be scaled-up.

Source: Projet NOSHAN (http://noshan.eu/index.php/en).

After being selected and processed, food-related waste can be valorised differently according to where it is generated. In rural areas, it can be easily used as feed or organic fertiliser, either directly or through compost. In urban areas, organic waste can also represent an important source of methane. In both cases, this valorisation reduces the environmental impact of FLW with economic gains (HLPE, 2014). Technical innovations can enable the processing of fruits, vegetables and root by-products into juices and jams (Verghese *et al.*, 2013), feed, bioenergy and/or compost, especially in rural areas (HLPE, 2014). Food waste side streams could also be used to feed insects having a potential for nutritious feed or food (Van Huis, 2013).

Using eggshells as biocatalyst for biodiesel production

Biodiesel is being more frequently used and considered as an alternative fuel to replace the existing petroleum-based diesel. The advantages of biodiesel are good combustion efficiency, high lubricity, biodegradability and low toxicity. Conventional ways of biodiesel production use homogeneous catalysts[4], which create environmental problems since they imply large amounts of water waste. Environmental-friendly and effective methods of biodiesel production use the heterogeneous catalyst. Heterogeneous catalyst can be extracted from biowaste such as eggshell. By introducing the heterogeneous catalyst base, such as calcium oxide made from waste material, chicken eggshell, quail eggshell or ostrich eggshell, the excessive washing problem to remove excessive reactants and glycerol is solved. Biodiesel production is cheap and environmentally convenient. It requires no mechanical change of the standard diesel engine. It is also an environmental-friendly way of recycling waste eggshells.

Source: El-Gendy and Deriase (2015) and www.researchgate.net/publication/275042850

The livestock sector could use more of the industrial and catering reflux of foods that cannot be redirected to human consumption through redistribution and food banks. Such foods include for instance bread, broken biscuits, products safe to eat but with an appearance default, incorrectly packed products and food leftovers of big events (HLPE, 2014). Virtuous examples of innovative solutions and good practices for FLW recycling and re-use exist in many countries especially developed ones. In Japan, a law for the promotion of recycling and related activities for the treatment of cyclical food resources aims at preventing food waste and at promoting recycling of food waste into animal feed and fertilisers as well as energy recovery. In Ireland, a household food waste regulation promotes the segregation and recovery of household food waste, directing separated food waste to composting, and imposing obligations on waste collectors as well as on households. Furthermore, the catering sector has obligations in terms of segregation and processing of food waste (OECD, 2014).

Conclusion

It is clear that the reduction of FLW is necessary to generate multifaceted long-term benefits in terms of food and nutrition security and food system sustainability required by the Mediterranean to ensure its sustainable development. Innovations are therefore highly needed and several cross-cutting strategies must be developed. Food waste reduction is a collective and social imperative requiring the commitment of government agencies, NGOs, producer organisations/cooperatives, the private sector, and the food and drinks industry to engage with consumers. Solutions to reduce food waste at one stage often involve actors upstream or downstream the food chain. Thus, implementing them often requires relations between various actors including farmers and their organisations, consumers, processors, retailers, public organisations, research institutes, and civil society organisations. The feasibility,

4 - Catalysts can be divided into heterogeneous and homogeneous. In a heterogeneous reaction, the catalyst is in a different phase from the reactants (e.g. catalyst is solid and reactant is liquid). In a homogeneous reaction, the catalyst is in the same phase as the reactants.

efficiency and sustainability of operations for FLW reduction in the medium and long term therefore depend on an institutional effort involving all actors in the food supply chain.

Mediterranean researchers and policy makers should devote more attention to FLW. Addressing this multifaceted problem requires a comprehensive regional research and innovation agenda supported by integrated and multi-sectoral policy interventions and instruments. FLW can only be reduced with an integrated, holistic and systemic food supply chain approach that takes into account the multiple and multidimensional linkages and relations between the different food chain actors. The role of governments, consumers, social actors and other food system stakeholders as well as private sector social responsibility are vital in reducing FLW.

Through the introduction of appropriate technical and soft (organisational/social) innovations, the improvement of the management and governance of the whole food system is crucial for the reduction of food waste. Given the extent of the problem, Mediterranean countries should urgently adopt food waste prevention and reduction strategies. Research results should help design adequate policies, guidelines and recommendations for the main actors of the Mediterranean food system. Regulatory, economic/fiscal, informational/communication and behavioural and technological instruments should be combined to mutually strengthen their effects and emphasise policy coherence. Research, innovation and policy activities must be well coordinated if sustainable qualitative and quantitative results are to be achieved.

In order to effectively and efficiently address the issue of FLW it is vital to bridge the current knowledge gap. The CIHEAM and the FAO are joining efforts to meet this objective. This work stream specifically aims to improve knowledge on FLW in the Mediterranean (extent, causes, proven solutions in order to identify knowledge gaps, priorities for research and action) and support countries in designing their own strategies and plans of action by providing them with available knowledge, good practices and innovative solutions.

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CHAPTER 13

CONSUMER BEHAVIOUR WITH RESPECT TO FOOD LOSSES AND WASTE

Luis Miguel **Albisu**, *CITA*

At the G20 meeting held in Turkey in May 2015, the Agricultural Ministers decided to incorporate the reduction of food losses and waste as a common objective for collective action. They thus confirmed the importance of this issue for the most powerful countries in the world while being aware that this group of countries is expected to provide global leadership in this regard.

There is an increasing trend to analyse the cycle of agrofood products from farm to fork along the supply chain. The results of these studies provide insights enabling to better measure the significance of the different supply stages but also to understand the interaction between them (Fischer *et al.*, 2009). Generally, food waste is related to consumers and food losses affect the entire food chain. This is why in this chapter, we have chosen to focus on the responsibility of consumers in this regard, while being aware that there is also a close link between food losses and waste and retail behaviour.

The first part of this chapter provides some elements on consumer behaviour with respect to food losses and waste. The second part gives grounds to analyse recent trends regarding developed and developing countries across the Mediterranean. The aim is to distinguish the problems they face which arise in accordance to the economic development of different countries but also as a result of diverse legal frameworks. Lastly, conclusions and recommendations are provided to encourage their consideration in policy-making.

Consumer behaviour with respect to food losses and waste

It is important to understand the differences between food losses and waste and their connection with consumer behaviour. Food losses take account of all the food lost along the supply chain, that is, the amount of edible food that is not consumed after being harvested. Food waste is the part of the food losses resulting from consumer behaviour such as cooking loss, plate waste and other causes. Thus, consumer behaviour has an impact on the rest of the agrofood supply chain. The interaction between consumers and retailers is crucial and enables a better comprehension of food waste along the supply chain.

Consumption waste is estimated to amount to 35% of the total food losses all over the world (Cuesta, 2014). In industrialised countries, consumption waste accounts for more than half of the total losses whereas in poor countries it drastically diminishes to the extent that it amounts to around 5% of the total losses in Sub-Saharan African countries. There is a high correlation between high per capita income and high food waste. At the consumption stage, the difference is greater than at other stages of the agri-food supply chain in different countries all over the world.

The food consumption decision-making process is an important application of behaviour economics (Just, 2011). Many of the decisions made by consumers on a daily basis occur without much thought. Impulse is an importer driver and in many occasions, reasoning does not contribute to decision-making even through decisions are sometimes based on past experiences. Decisions sometimes happen due to previous established habits, lack of knowledge, poor appreciations or many other reasons.

Food consumption decisions undertaken by adults are the result of a learning process since their childhood. It is difficult to change habits because consumers receive information from many different sources. There are public concerns but also private interests, which are sometimes in conflict. For example, do children eat cereals sold in attractive boxes because of the gift included inside or because of the cereals' taste? Packages are extra large to make them appealing but they have a negative impact on the environment.

In many countries, children do not have the habit of eating fruits and vegetables. This habit is difficult to change later in life. Promotions aimed at influencing these habits have limited results. The elderly might take their intake of fruits and vegetables more seriously because they feel the immediate effects. In these cases, it might be a combination of better information and special health circumstances that forces them to change food habits.

Although the income elasticity might be very low, in some special occasions such as in times of economic crises, consumers change their food habits due to economic restrictions. Food waste can be diminished and consumer awareness is increased. Likewise, the sensitivity of some segments of the population to ethical issues such as poverty in the developing world impacts their food waste habits.

The shaping of habits is therefore crucial to understand food consumption. It is a continuous development with current preferences depending on past consumption patterns and important changes occurring only under special circumstances. These changes are either brought by drastic economic changes or many other reasons such as environmental and health concerns. In developed countries, policies dealing with environmental impact contribute to raising awareness more effectively than policies related to health information. This explains why the citizens' concerns have increased in recent years.

Environmental impacts related to food consumption have been directly and indirectly influencing consumers' food choice (FAO, 2013). The excessive use of natural resources or the amount of discarded packaging material are two well-known examples. Producing only the required amount of food represents a great challenge but unfortunately this is constrained by the complexities along the agrofood chain that are difficult to resolve.

Consumer behaviour is also driven by ethical factors that contribute to their decision-making processes when buying or disposing of food. Consumers have greater awareness of the constraints that exist in the developing world in comparison to the excess supply in wealthy economic countries. They therefore take ethical issues in consideration when making decisions.

Consumers' decisions are related to other decisions undertaken by other agrofood supply chain stakeholders. For example, when consumers make the decision to throw a food item into the bin, they are also influenced and affected by a multitude of factors and decisions made at an earlier stage of the food supply chain, such as aesthetic standards imposed by suppliers (Stuart, 2009). According to Jean C. Buzby *et al.* (2014) consumers' food waste could be the result of the treatment of food (spillages, excessive trimming, inadequate storage, biological aging in fruit), industry or government standards (that lead to the rejection of some food) and seasonal factors. It could also be the result of their confusion between the "use-by" and "best before" dates, lack of knowledge about food preparation, inappropriate portion sizes, psychological attitudes, habits and preferences leading to plate waste, uneaten or leftover food. All these issues can be explained thoroughly but we will focus on clarifying one of them that has caused a lot of confusion. The "best before" date indicates the date until when the food is expected to retain its optimal conditions. Whereas, the "use by" date indicates the date after which eating the food may be unsafe. Consumers confuse both terms and this could lead to the consuming of food after the "use by" date.

Recent trends in southern and eastern Mediterranean countries

In developing countries most food losses occur at the farmer-producer end of the food supply chain and less food is wasted at consumer level (EPRS, 2014). Yet, these countries have little information about consumers' food waste at home and outside. The main approaches used to deal with collective restoration were defined at the Eating City workshop held in Algeria (Lacourt *et al.*, 2014). The Workshop was aimed at achieving a common understanding of comparative problems taking place in different countries from the North and South of the Mediterranean. In 2015, a waste management plan involving different political parties and civil society organisations has been approved in Lebanon, the waste crisis in Beirut having led to the increased awareness of Lebanese citizens on issues related to waste. With the support of the FAO, Morocco is also planning to implement a strategic plan with the aim of reducing losses and waste by half until 2024.

Developing countries share some common features with respect to food losses and waste but there are also some specific activities in each one of them. Some interesting experiences and approaches regarding staple diet products in Tunisia and Turkey are presented in the following boxes. The development of food banks in eastern and southern Mediterranean countries is described in another box.

Cereal products losses and waste related to consumption: the case of Tunisia

Changes and new trends in Tunisian food consumption

Tunisia has a high per capita consumption of cereals that represent, on average, 52% of the energy needs of the Tunisian population. This percentage is greater among medium and low-income population groups. Cereals are therefore at the centre of the price policy, not only because of the place they occupy in the daily food intake of the population but also because of their importance in the subsidy system.

Despite this high consumption of cereals, the average amounts consumed per capita have declined in recent years. On the contrary, there has been a significant increase in the consumption of animal products as well as fruit and vegetables. Although the daily ration required is met in terms of quantity, the quality levels could be unsatisfactory. According to the last Household Budget Survey carried out in 2010, the quantity of cereals has decreased by 8% since 2000, with a specific greater decrease for durum wheat (-31%). The consumption of soft wheat, primarily used for bread making has increased significantly (+15%). Some professionals explain this increase by its staple nature, while others think that it is due to the maintained low subsidised price levels. According to the National Statistics Institute, a Tunisian consumes averagely 119 large loaves and 84 baguettes per year. Flour used for making bread is for the most part derived from mainly imported soft wheat. This has led to increasing import expenditure with adverse impacts on the government budget.

Waste of subsidised bread: a growing phenomenon

Accurate estimates of waste in the overall Tunisian food system are unavailable. According to the National Consumer Institute (NCI) the cost of wasted bread in bakeries, hotel units, households and university restaurants is estimated at 100 million Tunisian Dinars per year. Globally, around 900,000 loaves of bread every day return to bakeries without being consumed. Subsidised bread is the most wasted product. Moreover, the Tunisian consumer purchases quantities of bread that exceed by far its real needs and does not adopt appropriate means to preserve it. Bakeries produce amounts that exceed their commercialisation potential.

To cope with this waste and the cost that is generated, the NCI has developed a strategy that aims to rationalise the subsidising cost of basic consumer products and to change consumer behaviour. This strategy to fight against bread waste is based on three pillars: the reduction of waste at production and consumption levels, the rationalisation of bread purchasing according to real needs and the adoption of adequate means for its preservation. The strategy also recommends the improvement of a single bread subsidy to replace the two current categories.

In the same context, in 2015, the NCI planned to focus its activity on the rationalisation of bread consumption through awareness campaigns, field studies and training for restaurants and bakeries. Also, the reform of the distribution channels for cereal products as well as better targeting of food subsidies beneficiaries will contribute to the rationalisation of consumption, management of subsidy costs and cereal waste reduction. Agricultural and food policies reforms are therefore expected to focus more on this topic in the coming years.

Source: Abderraouf Laajimi, National Agronomic Institute of Tunisia (INAT) and National Observatory of Agriculture (ONAGRI) (Tunisia).

Food waste in Turkey

According to Turkish retailers, 10% of food waste occurs due to shopping habits, which are related to non-packaged and un-standardised/graded products, and consumer self-service increases the percentage of damaged products. For example, the total potato losses and waste from farm to household/food service roughly reach up to 30% (Ministry of Food, Agriculture and Livestock, General Directorate of Strategy, 2015).

Purchasing more than required is one of the main factors leading to food waste. Based on a survey conducted in 500 households in Ankara in July 2005, it was found that food waste at household level accounted, on average, for 9.8% of the daily energy intake per person and the average amount of discharged food per person was 318.8gm per day (FAO, 2006). Food waste is also an important issue for processed foods such as bread and meals consumed at food services. On 18 April 2013, Önder Arsan, CEO of Unilever Food Solutions in Turkey presented in the *Vatan* newspaper, the results of the research conducted by the company: every one of the 4,000 consumers eating food at their food service facilities at least once a week wasted 100gm of food.

Bread is a staple food in Turkey, with 11% share in household food expenditure and 104kg per capita annual consumption in 2013 (TurkStat, 2014). A research on bread consumer behaviour and factors affecting bread waste in Turkey conducted in 2008 and 2012, respectively found 5% and 6% of waste. In 2012, 5,950 bread loaves were wasted (250gm per bread). Purchasing more than required and lack of knowledge for bread preservation were the main reasons given by households, individual consumers, bread makers and grain mills operators to explain this large amount of waste. In 2012, about 81% of the total bread was purchased by households. The per capita daily disappearance quantity amounted to 0.319kg, i.e. 116kg per year while waste amounted to 2.9%. Bread waste amounts to 3.1%, 2.7% and 7.1% respectively in hotels and restaurants, employees' food restaurants and student food courts.

NGOs and private sector organisations are also very active and strongly contribute to the reduction of food losses and waste with the implementation of projects and programmes. In this respect, the FoodWard Project, Unilever Food Solutions food service actors training projects and food bank practices (Israf) are the main initiatives that should be mentioned. The first food bank opened in the Diyarbakır province in January 2004 and there were 50 in 2015. The amendment of the Turkish Income Tax Law (No. 5035, on 2 January 2004) enabled donors to deduct the cost of food delivered to the food bank from income and corporation tax statements.

Mahmet Mehdi Eker (2014) stated that the campaign had remarkable outcomes in Turkey although it was carried out without legal sanctions and only with voluntary support. It has encouraged the inclusion of two subjects in the Tenth National Development Plan of Turkey as a general call to the public for further saving: increasing domestic savings and waste prevention; the reduction of waste and prevention of repeated consumption.

Source: Ahmet Ali Koç, Akdeniz University, Department of Economics (Turkey).
FoodWard (http://foodward.mkv-consulting.com/tr); Israf (www.israf.org); Unilever Food Solutions (www.unileverfoodsolutions.com.tr)

The emergence of food banks in eastern and southern Mediterranean countries

Most eastern and southern Mediterranean countries are considered to be developing countries. Most of the food losses in these countries occur at the production and post-harvest stages of the food chain. However, the rapid socio-economic and demographic changes that these countries have experienced in the last few decades, in addition to the rapid urbanisation and the changes in the ways food is produced, procured and consumed, have led to a significant increase in food waste at the consumer end of the food chain problem. This increase has yet to be scientifically quantified.

Civil society initiatives have emerged in the region to reduce food waste and support vulnerable food needs. The food prices hikes in 2007 have significantly contributed to the growing food waste problem in these countries and the growing number of needy people. The Egyptian Food Bank (EFB) is an example of a not-profit organisation that was founded in 2006 by a group of businessmen driven by a sense of social responsibility to eliminate hunger and reduce food waste. The main mission of this Food Bank is to collect éxcess' food from hotels, restaurants, food factories and individuals and distribute it to the needy. At the same time, it conducts campaigns to raise awareness on food waste reduction at national level.

While food banks in Europe and North America have a long history behind them, the phenomenon is very new in eastern and southern Mediterranean countries. The establishment of the EFB and its support has given way to the development of other food banks in the region, including Jordan, Lebanon, Syria and Tunisia but also in Mauritania, Iraq, Saudi Arabia and United Arab Emirates thus establishing a regional network of food banks operating with the same model (Food Banking Regional Network, FBNR).

Most of these food banks operate through protocols with multinational hotels and restaurants to save food waste, where food surplus is packed in foil trays, labelled and professionally transported at appropriate temperatures to the nearest orphanages and elderly homes for immediate use. Advocacy work with hotel managers and other food businesses to raise their awareness on the need of saving food is an essential component of these initiatives. However, it is also important to provide incentives for staff members who will stay after working hours to fill in the boxes and make them ready for distribution.

In addition, food banks accept donations in kind, in cash from businesses, individuals or donors and also establish links with the Zakat programme (a tax on wealth which is mandatory for Muslims), governmental income tax-exemption programmes and the organisation of lamb offerings on the occasion of Eid al-Adha, when a huge amount of animals are slaughtered and meat is normally wasted. Awareness campaigns targeting consumers are also an integral part of this initiative especially during festive seasons like Ramadan for Muslims when a lot of food is wasted, or during social events like wedding celebrations. A year after the launch of the Egyptian Food Bank, 5.4 million meals were saved from hotels and distributed to the needy on a monthly basis. This number reached 17.2 million meals a month in 2010, with 400 hotels in Egypt participating in this initiative (*The Cyprus Weekly*, 2013). By partnering with 4,000 NGOs in Egypt and through a network of 47,000 volunteers, the EFB operates as a "front line" model distributing food directly to end users thus feeding 180,000 families across Egypt with an average of five to six persons per family.

Source: Fatima Hachem, FAO Nutrition and Consumer Protection (Egypt).
FBNR (www.foodbankingregionalnetwork.com).

Recent trends in developed countries

European non-Mediterranean countries and the United States

Around 56% of total food losses and waste occurs in the developed world (Cuesta, 2014). A large share of food waste in developed countries occurs at the consumer stage (FAO, 2013). In those countries with a high income per capita, the concern about food losses has been small because the percentage of the income dedicated to food is very small (between 10% and 15%). So a high percentage of food waste corresponds to a small quantity of money for affluent consumers. However, food waste has received increasing attention in the past years. Consumers become more motivated and try to minimise their waste in periods of economic crisis. Besides these temporary reasons, there is an increasing awareness and concern on environmental issues. Social behaviour influences individual behaviour and ethical concerns are increasing among citizens in developed countries.

In 2012, it was estimated that around 100 million tonnes of food were wasted in the EU. This amount could rise by 20% till 2020. Societal values have influenced political decisions in Europe and there are plans to reduce food waste by 50% by 2025 (European Parliament, 2012). Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS) is a programme implemented to drastically reduce food waste in the European Union[1].

According to Savy Vanham *et al.* (2015), Europeans waste an average of 16% of all the food-reaching consumers. Almost 80% of it is edible food, i.e. an amount of 47 million tonnes of avoidable food waste annually. This has significant impacts on water and nitrogen resources. Findings show great differences between countries because of the different life styles and purchasing power.

Vegetables, fruits and cereals have the highest wastage rates as they tend to have a shorter shelf life and are often over-purchased because they are generally cheaper than other product groups like meat. Strict norms about product appearance induce consumers to avoid buying damaged fruits and vegetables. These norms should be

1 - FUSIONS (www.eu-fusions.org).

reviewed. Although the amount of meat wasted is smaller, it accounts for the largest avoidable food waste footprint because its production is very resource intensive. In other words, a small reduction of wasted meat equates to a large reduction of wasted water and nitrogen resources.

As an example, in Germany, it is estimated that 81kg of food is wasted per person per year out of the 456kg consumed at home, which amounts to 18% of the total food waste. Buying only the necessary amount, cooking leftovers in creative ways and improving storage are ways by which consumers can minimise waste (Ritcher, 2015). Food services and catering services are other places where waste could be improved as these represent one third of food consumption. Food banks collecting products that retailers are unable to sell are becoming very popular in Germany where more than 900 food banks help around 1.5 million people.

Food consumer behaviour with respect to food losses and waste in the US

It is estimated that roughly 20% of the total supply of food at consumer level in the United States is uneaten. Food losses include cooking loss and spoilage due to inadequate storage after purchase in addition to plate waste from meals consumed in restaurants or at home (Buzby *et al.*, 2014). In 2013, municipalities collected more than 37 million tonnes of food waste accounting for over 20% of the total material incinerated or landfilled after the recovery of recyclable components.

The value of food waste at consumer level averaged around USD 370 per capita in 2010 or more than 9% of total food spending. But food is relatively inexpensive in the United States so, for many consumers, there are limited economic incentives to reduce waste. Less than 10% of average consumer income is spent on food, which is substantially less than the amount spent on transportation. Nevertheless, there is evidence of increased awareness on food waste. In a survey of more than 1,000 consumers conducted in 2014 (Neff *et al.*, 2015), 42% indicated that they had seen or heard information about food waste in the last year and 16% had sought information about reducing it. Respondents overwhelmingly reported discarding less food than was reported in national data. Over 70% indicated that they discarded “less food than average”; 13% indicated that they did not discard any food and 56% indicated that they discarded only 10% of the food they purchased.

Some organisations, including the US postal service, are involved in the collection of unused packaged food from consumers to supply organisations that distribute food to the poor. Roughly 50% of expenditure is on food prepared outside the home and it is a common practice for patrons of restaurants to request packaging for unconsumed items to take them home. Whether or not the food thus saved is ultimately consumed rather than being discarded can be questioned.

As in many other countries, there has been an increased emphasis on recycling in the United States to reduce the amount of material that has to be incinerated or landfilled and to reduce disposal costs (tipping fees). Many municipalities provide for the separate collection of recyclables, although only a limited number provide facilities for composting organic waste. Often prompted by pressure from students, many universities are implementing comprehensive recycling initiatives for food waste with the aim of reducing landfill to a minimum. The US Environmental Protection Agency (EPA, 2015) documented 3,560 community-composting programmes for food and other organic waste in 2013, although there was only a slight increase from the 3,227 programmes in 2002. The EPA also reported that roughly 2.7 million households were served by food composting collection programmes in 2013, but this only merely represents 2% of US households.

Efforts are being made by government agencies to increase public awareness on food waste. In 2013, the US Department of Agriculture (USDA) and the EPA launched a joint effort to change perceptions about food waste and the way this is managed by the food industry. The EPA operates a programme to help businesses and organisations to measure and reduce food losses. The food industry, hunger alleviation groups, and non-governmental organisations with environmental interests are also active in attempting to change habits.

Source: David Blandford, Penn State University (Penn.), Agricultural and Environmental Economics Department.

COSUS: Behaviour research on consumers and food waste in Europe

The research project COSUS (COnsumers in a SUStainable Food Supply Chain) conducts research on why consumers waste suboptimal food and how consumers' willingness to accept such foods could be increased. Suboptimal food is defined as food that deviates in sensory characteristics (odd shape, size, colour) or that has a best-before date that is approaching or has passed, but is still perfectly fine to eat. Expert interviews, focus groups and case studies were conducted and the results summarised to identify which consumer-related factors have the most impact on the generation of food waste at the consumer stage of the supply chain. Discussions were conducted on how typical retailer actions against food waste currently observed across Europe are contributing to resolving these problems. Thirty articles, published in English between 2000 and 2014 exploring consumer household behaviour and habits, were studied. Furthermore, eleven expert interviews were conducted in order to discuss causes of food waste at the consumer stage. On this scientific basis, a model highlighting the interacting factors was developed (Aschemann-Witzel *et al.*, 2015).

At consumer level, these factors can be grouped as follows: firstly, the degree to which consumers have the motivation to avoid food waste (ethical or economic reasons) is a crucial factor; secondly, because of other conflicting goals (taste, convenience, safety concerns etc.) and thirdly, a lack of food provisioning and handling capabilities, the weighing of priorities leads to wastage of food. Furthermore, all these factors (motivation, goals and handling capabilities) depend on 1) the context of their surrounding (assortments, marketing, infrastructure), 2) their social environment (family habits and social norms) and 3) the greater macro-environment (economic situation, technological, legislative and cultural background).

The consumer-level and contextual factors described emphasise that actions conducted at retailer level such as the immediate supply chain actor interacting with consumers can have an impact on food waste within households. Across Europe, the retail sector has started to take action against food waste within the supply chain and at consumer level. These actions mostly involve pricing strategies such as abolishing multiple unit discounts, reducing prices for foods with close use-by and best-before date labels or with suboptimal features, increasing the assortment depth of suboptimal foods or proposing processed foods made from suboptimal foods, and directing suboptimal foods to alternative retail. While evaluations of the effectiveness are yet lacking, experts believe that actions have been successful in creating greater consumer awareness and attention to the issue as well as shifting perceived social norms.

Source: Aschemann-Witzel et al. *(2015), Centre for Research on Customer Relations in the Food Sector (MAPP), Aarhus University (Denmark).*
COSUS (http://cosus.nmbu.no).

EU Mediterranean countries

Issues related to consuming patterns in countries like France, Greece, Italy and Spain do not differ from those observed in other developed countries although specificities related to consumer habits and programmes can be noted.

In France, it is estimated that 67% of the food is wasted by consumers and another 15% by restaurants, while shops and distributors waste 11% of the total. According to the estimates of the French Environment and Energy Management Agency (*Agence de l'Environnement et de la Maîtrise de l'Énergie – ADEME*), every person in France throws away 20kg of food on average, of which around 13kg are leftovers and damaged and unconsumed fruit and vegetables and wastes a total of 21% of food purchased. In 2013, the Ministry of Agriculture elaborated a plan to reduce food losses and waste with the objective, among others, to raise public awareness and encourage responsible habits. The plan included educational initiatives in the agricultural and in the hotel industry training colleges; terms and conditions for reduced waste in contracts for the public procurement of institutional catering; a national day against food waste; a legal clause providing for the inclusion of the fight against food waste as part of corporate social responsibility (RSE); an advertising campaign against waste and a year-long experimental citizens' food donation programme based on a digital platform. France has also taken a leading approach towards the control of food waste in supermarkets. There are attempts to implement a new law stipulating that it will be compulsory for supermarkets above 400m^2 to donate unsold food to charity or food banks. This law is enforced in July 2016 and it is also aimed at influencing other European countries. So far, civil society organisations have established contracts with food distribution chains, which are willing to improve their good practices and to structure the entire process. However, there are also concerns that recipient institutions will not be able to handle the distribution of the expected large quantities of food.

The National Food Waste Prevention Plan (PINPAS)[2], established in Italy, is also another initiative aimed at food recovery through donation to charity organisations. This plan is at the centre of the political agenda from local to European level and it was developed to increase and spread knowledge about the environmental, social and economic impacts of food waste and raise awareness among consumers.

Andrea Segré *et al.* (2014) conducted a survey dealing with household food waste in Italy in the framework of Waste Watcher, the Italian Observatory of Food Waste. The data collected, which is composed of self-appreciations and estimations, shows, like in other countries, a close correlation between the amount of money spent on food and the quantity wasted. Food waste patterns differ between countries even though there are similarities between regions and households with equal income levels, but Andrea Segré *et al.* (2014) also found that household behaviour varies significantly between the North and the South of Italy. Economic factors but also factors related to demography, household size and composition, culture, habits and attitudes explain these differences. Cosimo Lacirignola *et al.* (2014) express their concerns for the situation in the Mediterranean area.

2 - PINPAS (www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Andrea_Segr%C3%A8_final_02042014.pdf).

In Spain, the economic crisis has resulted in the change of some habits with a clear impact on food waste (Albisu, 2014). Today, there is greater awareness and consumers are committed to save food. We can therefore state that economic factors have been determining in Spain. It is estimated that consumers waste around 18% of the food they buy even though they think that they only waste 4%. This shows that they are not aware of the extent of this phenomenon. Bread, grains and pastry products amount to 20% of the total consumers' waste, followed by fruits and vegetables with 17%. Greater efforts should be undertaken to increase awareness and strengthen education. In 2013, the Spanish Ministry of Agriculture, Food and Environment launched a campaign called "More food, less waste" that identified five areas of actions with several activities planned for each area. The strategy established was evaluated by a committee (MAGRAMA, 2015). The Spanish economic crisis together with the citizens' awareness on food waste has boosted the implementation of food banks. The Spanish Federation of Food Banks (FESBAL) coordinates the efforts and activities of various local food banks across Spain. FESBAL manages the relations with central government agencies, international organisations, private companies and other non-profit organisations that provide food assistance. It is nearly totally run (99%) by voluntary staff.

Like in Spain, the economic crisis and the severe recession in Greece has also significantly led to an increased solidarity among citizens, who, by force of circumstances, had to be more careful with their spending and became more aware about the extent of food waste (see behaviour analysis of Greek households during the economic crisis of Abeliotis *et al.*, 2014). Non-governmental organisations have created sophisticated logistics networks run by volunteers to manage food donations. The distribution chains and the restoration sector were also involved in this movement. Some municipalities have even made stores and fridges available to the public to store food. Consumers have appreciated this attitude and became more willing to make extra efforts so that food reaches people living in difficult conditions. This collective effort may serve to further promote food waste prevention at the household level and also strengthen environmental and social awareness that may outlast the economic crisis.

Conclusion

Since consumers' waste in developed countries is greater than in developing countries, policies should be different to address the local specificities. Today, national policies complement and expand the recommendations given by international institutions such as the EU and the FAO. The EU provides ten tips or good practices to reduce consumers' food waste: appropriate shopping planning; good understanding of consumption dates; concern about the budget; practice of a healthy fridge; good storage; appropriate rotation in the fridge; food servings in small portions; use of leftovers; freezing and compost production[3].

3 - European Commission, "What Can I Do in my Daily Life to Limit Food Waste?" (http://ec.europa.eu/food/safety/food_waste/library/docs/tips_stop_food_waste_fr.pdf).

The FAO is promoting a global initiative entitled SAVE FOOD aimed at addressing food losses and waste reduction[4]. The third action of this initiative deals with "Supporting legislative and policy development" and part of it is dedicated to sustainable food consumption and dietary guidelines to save waste. Public organisations cannot directly reduce food loss and waste, but they play a crucial role in facilitating actions.

Several authors have reviewed food saving programmes and approaches to deal with it. Some have analysed several programmes implemented in the Mediterranean countries (Charalampopoulou *et al.*, 2014). Others have provided some solutions to minimise food losses and waste (Gustavsson *et al.*, 2011; HLPE, 2014). A report focusing on this issue presented at the Expo Milano 2015[5] stresses the importance of effective inter-sector co-operation from farm to fork, where consumers play an important stakeholder role.

Food waste is mainly caused by consumer behaviour and therefore policy makers should set the appropriate rules to encourage consumers to change their behaviour or their perception of food. For instance, teaching them to evaluate the quality of fruit and vegetables and encouraging them to avoid disposing of fresh produce. Public policies also have an impact on the private sector. They should therefore apply to retailers and their understanding of how to handle food in order to satisfy consumers but also to comply with citizens' overall needs. In this respect, French policies are a step forward towards complying with these objectives. The economic crisis and the increasing awareness of citizens on food waste have led to the development of initiatives, such as the creation of food banks. Public policies should protect, facilitate and encourage these initiatives.

Companies involved in building social responsibility should evaluate their social impact by analysing their relationship with citizens, governance and environmental matters (Albisu, 2012). Food waste at retailers' outlets should be an integral part of the social responsibility programmes that food chains incorporate in their business plans. This will in turn enhance their role in society.

Most of the public policies implement educational programmes intended for consumers. Awareness campaigns have an immediate effect on adults but they have not reached their sustainable goals, that is, make children understand the implications of food savings and make their education shape their future consumer behaviour. Likewise, consumers in developing countries should learn from the excess waste occurring in developed countries and try to form appropriate habits. In many countries, the economic crisis has shown the important role solidarity can play via social networks. Public policies should reinforce initiatives of unconsumed food redistribution to poor people. Let us hope that the understanding of food disposal dates increases and that consumers differentiate more between optimum and adequate food and start eating sub-optimal food that can still be consumed. They should be encouraged to change their habits in order to largely contribute to reducing waste both at household and retail level.

4 - FAO, SAVE FOOD (www.fao.org/save-food/fr).
5 - Expo Milano 2015 (www.expo2015.org/en/news/all-news/2014-report-on-food-waste--its-findings).

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3 PART THREE

KNOWLEDGE AND KNOWHOW in the Mediterranean

CHAPTER 14

WASTE OF KNOWLEDGE AND HUMAN RESOURCES

Pascal **Bergeret**, *CIHEAM*
Nora **Ourabah Haddad**, *FAO*
Rodrigo **Castañeda Sépúlveda**, *FAO*

The third part of this edition of *Mediterra* looks at a subject that is rarely discussed, even though it is a crucial one: wasted knowledge and human resources. It asserts that a substantial body of knowledge exists throughout the world, that new knowledge is constantly being generated, and that one of the accelerators of development lies in our collective capacity to ensure a better fit between knowledge that is available or being developed to the needs of people, especially the most disadvantaged, who are themselves a source of knowledge, although their capacities are currently undervalued.

This chapter focuses on the way in which food and agricultural knowhow have been accumulated historically, over time. It shows how the scientific process has accelerated the development of knowledge and its mobilization to drive technical progress, and how the industrialization of agriculture and food systems, coupled with the globalization of trade, have produced imbalances that now threaten some traditional knowledge.

Exploring such cognitive dimensions is essential. Indeed, rediscovering, safeguarding and mobilizing empirical local knowledge, combined with scientific knowhow in new systems of knowledge and innovation, is – together with the implementation of inclusive policies – currently one of the most effective and important levers for reducing inequalities and unemployment, especially among young people, consolidating a dynamic for rural and agricultural development that can respond to the many challenges of our time.

The slow generation of food and agricultural knowledge

Reserves of global agricultural knowledge now constitute an irreplacable human patrimony. Since time immemorial, food and civilization have gone hand in hand. Food systems have progressively improved and become more secure as a result of opening up to new knowledge. The invention of agriculture in Neolithic times, 10,000 years ago, starting in a few locations especially in the Middle East, combined with the population growth of the human species and its sedentarization, was the fruit of a long and slow process of accumulating knowledge based on observing the morphology and biology of harvested plants (especially cereals and legumes), whose grains were used for human consumption before gradually being used as seeds. The beginnings of livestock rearing also display evidence of extensive knowledge of the biology of certain wild species, their behaviour and the quality of their products (meat, milk, hides), with a view to their domestication.

Human ingenuity has enabled almost all land-based ecosystems (with the exception of the most extreme ones, such as those of the poles or very high mountains) to be exploited through the adoption of adapted forms of agriculture and livestock keeping. Down the centuries, a massive reserve of food and agricultural knowhow has been amassed, as a result of long-term observation of natural environments and ecological mechanisms conducive to agriculture and livestock rearing. Today, there is much talk of ecological knowledge, at the heart of agricultural and livestock practices, revealing a detailed knowledge of biodiversity and of balances within ecosystems.

Very early on, trade in agricultural products over long distances led to an exchange of knowledge between different regions of the world. Consider the Mediterranean Bronze Age (second millennium B.C.), with its documented trade in agricultural products between civilizations from the Minoan, then Mycenaean periods in Greece, the Hittite Empire based in Anatolia, Egypt and the countries of the Levant. Later, in the Middle Ages, via the Crusades or the gardens of Muslim horticulturists in Andalusia or Sicily, a number of species were transferred from the Middle East to Europe, among them rice, cotton, buckwheat, sugarcane, mulberry tree, silkworms, asparagus, lettuce, aubergines, melons, squash, pears, plums and peaches.

Since Neolithic times, the history of food and agriculture has been punctuated by periods of acceleration that may be termed agricultural revolutions, separated by long periods, not of immobility, but of transition, during which the way was paved for the next revolution. Marcel Mazoyer and Laurence Roudart (1997) have carefully analysed the different agrarian systems through the ages: the slash-and-burn of forested areas and post-forest savannah systems, hydraulic farming systems (Mesopotamia, Nile Valley), mountain farming systems (e.g. the Inca system), fallow systems and animal-drawn cultivation from the temperate regions of Mediterranean antiquity, fallow systems and heavy animal-drawn cultivation of the Middle Ages in north-west Europe, the end of fallowing in temperate regions during more modern times (from the 16th to 19th centuries), the development of mechanization linked to the industrial revolution in wealthy regions during the 19th century, and finally, the agricultural revolution of the 20th century, with the motorization of agriculture and intensive use of synthetic inputs (fertilizer, phytosanitary products).

Each of these revolutions marked the appearance of different forms of agriculture and the mobilization of new knowledge to develop techniques whose dissemination depended on social and economic changes affecting society as a whole, including those outside the agriculture sector. So the spread of mechanization from the 19th century onwards, mainly in Europe and North America, followed later by that of motorization, was driven by the energy revolution (hydraulics, steam engines), which was itself at the heart of the industrial revolution in these parts of the world. From then on, agricultural and industrial knowledge became inextricably linked and developed in tandem: industry required a growing volume of agricultural products for its textile and sugar mills, etc., and agriculture very quickly modernized, in keeping with the rapid pace set by progress in the mechanical (motorization) and chemical industries (fertilizer, phytosanitary products). Triumphant science lent a uniform and homogeneous flavour to the knowledge of that time, with the effect of accelerating technological progress. The industrialization of European and North American economies, linked with the rural exodus in Europe, led to a return to larger farm sizes which, together with technical progress, generated substantial gains in productivity.

Today, we are witnessing a new agricultural revolution, with our societies entering the bio-economy era, when biomass has become a raw material for cutting-edge industries (materials, fuels, green chemistry), within agri-food systems that are demanding more and more knowledge. Globally, an essential feature of agriculture is its heterogeneity, with a wide divergence between the different types of farming systems. After decolonization and independence, agricultural industrialization mainly occurred in the wealthy western economies, with very little taking place in tropical countries. African agriculture remained largely based on hand tools with, in some places, use of animal traction. This small-scale family farming, which used little in the way of inputs, constituted a precious reservoir of local ecological knowledge. It continues to offer capacities for adaptation and a degree of flexibility not seen in the industrial agricultural sector. Such factors are an asset, given the disadvantages and the extreme vulnerability of industrial agricultural systems faced with the challenges of climate change, natural resource destruction (soils, biodiversity) and increasingly scarce water resources. For this reason, the growing fragility of small-scale household agriculture – which, despite still showing some signs of vitality, finds it difficult to compete with industrial agriculture within the globalized economy – coupled with the erosion of local agroecological knowledge, is a grave cause for concern. It is crucial to combat this trend towards wastage, which is threatening the diversity of farming systems and their sustainability.

Threats to knowledge linked to traditional and sustainable practices

Different types of agriculture

The advent of industrialized agriculture coupled with increasingly globalized markets poses the question of how to conserve and ensure the survival of local knowledge that is often generated by family farming. This sector's ability to adapt to local conditions offers a reservoir of sometimes ancient knowledge, enriched through trade and migration, which it is critical to safeguard and shape to suit development in the world. Rather than setting industrialized agriculture and household farming in opposition against each other, this is a question of respect for diversity based on sustainability. The major difference between these two types of agricultural production lies in the fact that industrialized agriculture relies on a salaried labour force with almost all the output destined for market, while family farming, rather than a production model is, strictly speaking, the expression of a lifestyle.

Although difficult to define due to its diversity, family farming can be described as "a means of organizing agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labour, including both women's and men's.? Family farming has an important socio-economic, environmental and cultural role.[1]". Despite their predominance – more than 513 million farms out of a total 570 million are family-run, accounting for 80% of the value of global food production (FAO, 2014b) – family farms are often considered as archaic systems destined to die out or even as competiton to be eliminated, depending on the context and the agricultural historical backgournd against which they are set. In the Middle East and North Africa, they account for 85% of all farms, and 40% of the region's population is made up of rural communities whose livelihoods are directly or indirectly linked to agriculture, mainly of the family variety. At the same time, it is important to stress that the vast majority of the region's people living in poverty are family farmers. Women play a predominant role in this type of agriculture. In developing countries, they make up 43% of the agricultural labour force, producing a very large share of global food crops. Yet they have nothing like the same access to productive resources as their male counterparts (FAO, 2010-2011).

According to the 2010 agricultural census, family farms in southern Europe dominate both in numbers (12.2 million farms accounting for 97% of all farms) and agricultural labour (86.2% of the regular agricultural workforce). For their part, non-family production methods linked to global markets have emerged under the influence of four main phenomena: financialization, urbanization, the globalization of trade and the development of marketing standards.

Family and non-family production models have, over time, either drawn closer together in a complementary manner, or moved into competiton with each other, especially on the issue of access to land. The diversity of the links between the two types of farming underscores the diversity of situations. Meanwhile, political choices determine the development of this or that type of production format (Marzin *et al.*, 2014). The dual nature of agricultural systems can be seen in the Mediterranean – in the Middle East and North Africa just as in southern Europe. Family farms dominate in terms of numbers, while the large "industrial" farms (Hervieu and Purseigle, 2013) dominate in terms of cultivated surface area. Family farms tend to produce for household consumption, unlike the big modern farms, which supply food products to national and international markets. Such duality is the result of political agricultural choices in favour of developing modern large-scale farms, with a tendency to uniformize knowledge, at the expense of local knowhow.

The diversity of family farms reflects that of the natural environments in which they are located. They contribute in differing degrees to the management of ecological and social systems, in so doing adapting to local constraints while making the best

1 - According to the international steering committee set up for the International Year of Family Farming in 2014.

possible use of available resources (Feintrenie and Affholder, 2014). The territories and land are their foundations. According to Max Weber, family farms have taken on growing significance due to increased market access linked to the proximity of towns. Despite a global trend towards agricultural industrialization, these small farms continue to survive. There are a number of factors behind this resisilience, particularly their capacity to integrate into markets, responding to growing local demand for food.

Family farms also endure thanks to the economies of scale that they achieve when small-scale producers group themselves into efficient professional organizations and invest in the downstream sector of the supply chain. In this way, they can express their full potential, both as a modern production model and as a reservoir of local knowledge. By assuring their integration both upstream and downstream of production, these professional agricultural organizations enable farmers to collectively overcome the challenges that each of them faces, namely the globalization of food systems, the effects of climate change and poor access to financial services, markets and production resources. In so doing, they compensate for the incapacity of policies to respond to their specific needs.

In the Mediterranean, as in all regions of the world, autonomous producer organizations and the common projects that they develop need support, so that they can maintain their place in increasingly complex food systems. By strengthening their economic power, efficiency and autonomy, family farmers who are organized into groups can acquire political weight and participate effectively in the decision-making process. For this reason, they do not just need support in strengthening their organizational capacities, but also a supportive institutional, legislative and policy framework, so that their organizations can develop autonomously, in the best conditions possible.

Ecological knowledge linked to fisheries and aquaculture

According to the latest report on the State of World Fisheries and Aquaculture, fisheries, and particularly small-scale fishing and aquaculture, make a significant contribution to eradicating hunger, promoting health and reducing poverty in the world. Global fish consumption is undergoing unprecedented growth. This sector also generates wealth by creating jobs at a rate that exceeds that of the world's population. Tens of millions of people earn their livelihood from fisheries and aquaculture, providing food for hundreds of millions of others. Between 10 and 12% of the world's population is dependent on the sector for their livelihoods. According to FAO (2014), the sector mobilizes 4.4% of the 1.3 billion people active in the global agricultural sector (compared with 2.7% in 1990). In 2012, women accounted for more than 15% of people working directly in primary fisheries operations.

Fisheries and aquaculture do not have a purely economic contribution to make. They provide social and environmental benefits, offering a source of sustainable prosperity in the process. Like family farming, small-scale fishing is particular for its social dimension and its concern for environmental balance. As a result, it too is a source of ecological knowledge. With the aim of conserving ecosystems and local traditional knowledge, FAO is promoting sustainable socio-economic management of aquatic resources through an initiative for blue growth. Such management is centred on capture fisheries, aquaculture, ecosystem services and trade and social protection for coastal communities. The initiative seeks a balance between the demand for growth and the need for conservation, but also between industrial and small-scale fisheries and aquaculture. This is an integrated approach that links all stakeholders, the ultimate goal being that of meeting the needs of communities of fishers and fish farmers and their organizations, giving civil society organizations and public authorities greater scope for action by strengthening their capacities to improve the institutional environment.

Small-scale fishing helps to reduce poverty and increases food security worldwide. In order to foster the efforts of vulnerable communities of small-scale fishers and protect their livelihoods, FAO has actively supported the development of voluntary guidelines aimed at ensuring the sustainability of small-scale fishing. It is encouraging and supporting various public and private actors in implementing the guidelines on responsible governance of tenure of land, fisheries and forests in the context of national food security, by raising awareness among different stakeholders and promoting dialogue between them. CIHEAM is backing this effort.

Erosion of knowledge about food

The lowering of transport costs and dissemination of food conservation technologies – core components of globalization – are gradually putting an end to the era of food as a "total social fact" (Mauss, 1950). Fundamentally, dietary practices are a reflection of societies and their place in their natural environment, with the preparation of food ensuring the link between nature and culture (Levi-Strauss, 1968). In many parts of the world, a significant share of food is still made up of locally produced resources and reflects a social order, right up to the setting out of meals. Dietary practices are charged with symbols, marked by religious injunctions (taboos, bans or festive meals). People who travel can witness the huge diversity of eating habits that there are on the planet. Communities often accept monotonous diets, when they do not have to deal with alternating periods of food abundance and scarcity, or even famine. As already observed, there have always been exchanges between the world's different cuisines, amid the acclimatization of exotic plants or animals (in the time of the Crusades, the Age of Discovery, etc.), but these exchanges were rare and extremely slow. They have not destabilized the original template of local diets, but they have enriched these by offering new possibilities.

For the past 150 years, the agri-food industry has offered a growing proportion of the world's population a range of food options that would previously have been unthinkable. In recent decades, this trend has accelerated, with the advent of low-cost new foods that are easy to prepare. This has gone hand-in-hand with the implosion of former lifestyles, starting in the West in the 19th century and since spreading much further afield. Part of the food we eat is now produced and distributed on a global scale, based on principles that respect industrial norms (standardization of products, sanitary, process and distribution standards). The former situation, characterized by much dietary uniformity at local level and strong diversity at global level, has been replaced by a reverse scenario, with diversification of dietary options at individual level and uniformity at global level (Rasse and Debos, 2006). Growing urbanization is helping to drive a massive market of more than 4 billion consumers, which needs to be supplied on a daily basis. Cooking is becoming industrial and technological, impairing the value of local culinary knowhow.

Of course, in this confrontation between uniformization and dietary variation, some forms of resistance persist or emerge. The proliferation of fast food outlets open around the clock has not stopped restaurants from offering typical dishes at set times. The tradition remains of family and festive meals. Dietary practices observed during the period of Ramadan have regained ground during the past decade. Symbols of quality that link products and locations (AOC, PDO, IGP) are growing in number. Alternative agri-food circuits are developing (fairtrade, short supply circuits, community-supported agriculture [CSA]). French gastronomy and the Mediterranean diet have been included in the world heritage by UNESCO.

However, it must be said that these forms of resistance only involve a few niche sectors, which are often linked to high purchasing power. In Africa, food globalization has not yet suppressed local practices. It has not, for example, eliminated *attiéké* from Abijan, *thiéboudienne* from Dakar or *ndolé* from Douala. But the overall trend is towards uniformization. In supermarkets, 20% of the best-selling products alone account for 80% of food product sales. Hard discount stores, which are proving increasingly attractive to European consumers, only offer 10% of products sold in supermarkets (Rasse and Debos, 2006). For poor communities, wherever they may be, consuming globally, mass produced industrial food means exposing themselves to the risks of becoming overweight and obese. According to WHO, levels of obesity in the world doubled between 1980 and 2008, by which time there were 500 million obese adults (11%), 1.4 billion overweight adults (35%) and 44 million overweight children (6.7%). By 2030, the number of overweight adults is expected to reach 3.3 billion. Mediterranean countries have not been spared from this phenomenon. For example, in Egypt, three-quarters of women are overweight and one-third of children suffer from stunted growth, while child malnutrition has started rising again since 2003 (Al-Riffai, 2015). "Food modernization" is constantly advancing in Algeria, especially among young urban people, both men and women, with a regular increase in consumption levels of industrial foodtsuffs: bakery products, fizzy drinks, sweets, fried food and milk-based desserts. Also evident is the increased popularity of fast food chains – some of them local – a growing tendency to snack between meals and a reduction in the time allotted each day to meals and cooking (Chikhi and Padilla, 2014).

Wasted human resources

We live in a world which, while producing greater and greater wealth, continues to generate more and more socio-economic inequalities. These affect entire segments of society, which are marginalized, or even excluded from the development process. As a result, social and economic exclusion have become chronic. The majority of the world's poor live in rural areas and depend on agriculture for their livelihoods.

Socio-economic exclusion translates into growing numbers of job seekers and lack of education, but also inadequate participation in the process of policy development and implementation. It is critical to invest in education programmes for young people, reinstate reasoned agricultural approaches based on the preservation of reservoirs of local knowledge and promote policies of co-construction designed to combat wastage of human resources.

This unequal distribution of wealth also raises the issue of jobs in the world. The number of job seekers rose to 204 million in 2015 (5.9% of the world's active population), with an additional 30 million since the crisis of 2008. According to *World Employment and Social Outlook – Trends 2015* published by the International Labour Organization (ILO), this figure will continue rising to reach 212 million in 2019 (ILO, 2015b): "Unemployment will continue to rise in the coming years, as the global economy has entered a new period combining slower growth, widening inequalities and turbulence." (ILO, 2015b). Income disparities are set to increase, with 10% of the richest people earning between 30 and 40% of total global revenue and 10% of the poorest earning between 2 and 7% of this revenue. While the job situation has improved in the United States of America and Japan, unemployment continues to be widespread in a number of advanced economies, especially in Europe. Three-quarters of vulnerable employment[2] worldwide is concentrated in South Asia and sub-Saharan Africa. This latter region has failed to take advantage of economic growth to create sufficient jobs. In some parts of Latin America and the Caribbean, job prospects have deteriorated. Likewise, the employment situation remains very negative in the Mediterranean, especially in Arab countries and southern Europe.

The forecast for this highly uncertain scenario is that youth will be particularly affected by the crisis. After a period of rapid progress between 2007 and 2010, the global rate of youth unemployment stabilized at 13% between 2012 and 2014, and will probably stay the same for the period 2015-2019[3]. Among the world's regions, the Middle East and North Africa has the highest rates of youth unemployment, which were as much as 28.2% and 30.5% respectively in 2014, a situation that has affected one in four members of the labour force since 1991 (ILO, 2015a). These figures are considerably higher than the global average. Young women face even greater difficulties, with a labour force participation rate of 25% in the region, beating even the record of the world's lowest employment rate. There can be no doubt that this scourge represents a waste of human resources that is without precedent.

While all regions of the world show a fall in the number of poor workers, or those in vulnerable jobs, it is unacceptable that nearly half of the world's working people are still without access to basic products and services and decent work. The situation for women's employment raises the issue of gender equality, with all the socio-economic consequences that this implies. As has already been seen, this global trend

2 - According to the *Guide to the new Millennium Development Goals Employment Indicators* published by the ILO in 2009, vulnerable employment is a new metric that measures the number of people working in relatively precarious conditions due to their employment situation. Two types of status are considered as "vulnerable": unpaid family workers and the self-employed, for they are less likely to have formal employment, generally have less access to social advantages or social protection programmes and are more exposed to economic cycles.

3 - Global and regional estimates are based on a definiton of young as those under 24 years of age.

towards greater inequalities, which affect both rural and urban areas, is partly due to the employment crisis and has the effect of increasing the risk of social instability, which is particularly acute in countries and regions such as the Mediterranean, where youth unemployment is either high or rising.

This tendancy towards wasted and under-utilized human capital (a combination of varied intangible elements that include experience, knowhow, skills and creativity) calls for responses that place individuals at the centre of development programmes (Sullivan, 2000). Rural areas, where the highest poverty rates are concentrated, must be moved higher up the agenda once more, and this is the thinking behind the new Sustainable Development Goals (SDG). Rural dwellers, farmers, livestock keepers, fishers, foresters and their organizations are capable of innovation and finding local solutions that will allow them to adapt to all kinds of changes. One response to this job crisis is to ensure the best possible conditions for rural areas, so that they can once again take their place as engines for social and economic development. Rehabilitating sustainable and reasoned agricultural approaches, in which family farming is a source of provision, can help rural communities, especially the young, to earn a living on their own home ground. Massive investment in this sector, particularly in small-scale family farming with the aim of creating productive employment, represents an effective strategy for combating growing inequalities.

The fight against wasted human capital also involves safeguarding and developing new knowhow, defined as a wealth of knowledge that is constantly evolving. It is important to work to establish a balance between documenting existing knowledge and creating new knowledge. Rural areas are reservoirs of considerable knowledge, and there is an urgent need to make this known and to share it, in order to protect it. While the importance of such knowledge may seem evident, attention has only been paid to this issue fairly recently. In 1996, Anne Stuart (1996) spoke of the transition from an industrial economy to a knowledge-based economy. But, as the OECD observes, when speaking of the knowledge-based economy, it is only in recent years that its growing importance has been acknowledged. Knowledge has now been recognized as a driver of productivity and economic growth.

Towards new knowledge systems and inclusive policies

A new knowledge system based on agricultural innovations

At the beginning of this chapter we mentioned that the accumulation, transmission and exchange of knowledge has always been at the core of agricultural practice and the development of production systems. Scientific progress, which was one of the causes of the industrial revolution, has opened the way for the industrialization of agriculture and the development of a food industry, and has shaped the current globalized food system. Gradually, but with increasing intensity, technical advances in agriculture are being developed in laboratories, and centres of research and experimentation, which are public or, more and more often, private. These centres of knowledge and economic power have systematically offered technological packages whose adoption has rapidly become a prerequisite for strong economic performance on the part of farmers, and their survival in the face of global competition. The source of agricultural knowledge has therefore progressively eluded farmers, who have become receivers of technologies designed by others and delivery agents in an economic order dominated by the agri-food industries, which are becoming ever more concentrated and powerful. In Europe and the United States of America, the industrialization of food and agriculture has received massive state backing (subsidies and tariff protection, but also training, technical and economic support for farmers) which, after the Second World War, helped to shape an efficient, industrialized agriculture sector, but one that is of declining demographic importance as the rural exodus becomes more and more acute, and land is concentrated in fewer and fewer hands.

The same is not the case in tropical areas of Africa, where scientific progress has only served to modernize cash crop production dominated by the interests of mainly English and French colonial powers. As a result, the vast majority of the world's farmers have been sidelined by science-based technical progress, either because the discoveries could not be applied to agriculture due to particular material conditions (soils, climate, infrastructures, etc.), or because the economic conditions of small-scale subsistence farming, which is predominant in tropical areas, would not allow advances to be implemented (investment capacity, terms of trade and unfavourable price relationships, etc.). Following independence in Africa, development gaps between the old colonial powers and their former colonies led to worldwide demand for a new, less unequal economic order. While the socialist camp gave priority to giving the state back control of means of production and, more specifically, land reform, major investments and training for farmers, the liberal camp focused more on the notion of take-off, outlined by the linear development theory drawn up by American economist Walt Whitman Rostow (1960). The Bretton Woods institutions (MFI, World Bank) were tasked with giving financial support to this vision, in which economies were designed to progress in stages.

In the case of the agriculture of poor tropical countries, the linear development theories took the form of a notion that the accumulated delay could be countered by setting up a chain of top-down linear knowedge, linking science and its discoveries to farmers, along which the knowledge needed for development would be transmitted at an accelerated rate. Technical packages designed by international agronomic research and adapted to tropical conditions were disseminated by public extension agents, whose job it was to convince farmers to use them. This training and visit method, which was formalized by Daniel Benor in 1977, was widely implemented in the 1970s and at the start of the 1980s. It went hand-in-hand with what was known as the Green Revolution and contributed to a marked increase in agricultural production and greater food security. But such progress was restricted to tropical agricultural areas with the best resources, particularly those with irrigation or heavy rainfall in East and Southeast Asia and Latin America. Elsewhere, and especially in Africa, the revolution was virtually non-existent. In places where it was implemented, it accelerated social differentiation, concentration of land and the rural exodus, or the impoverishment of small-scale farmers without the means to invest in new technical packages. But the main obstacle that prevented a wider rollout of the Green Revolution began to make itself felt as the years progressed: the extension systems called for by the Benor method, which required an army of agents, quickly became a consierable drain on state budgets, especially towards the end of the 1970s, when the world entered a phase of structural adjustment and the dismantling of public services. The big financial institutions that had helped to fund these systems called on governments to make drastic spending cuts in exchange for budget support to reduce their public deficit. The Green Revolution was over and small-scale farmers in tropical areas found themselves on their own, faced with the challenges posed by globalization and international competition.

The inadequacies of the Green Revolution and the failure of extension systems in tropical areas on the one hand, and the excesses agricultural industrialization in rich countries on the other, challenged the idea of technical progress driven by science and transmitted to farmers through top-down knowledge chains. The notion of technical progress was replaced by one of innovation, which once again positioned economic actors at centre stage: the question was no longer how to transfer the results of science to users, but how farmers and entrepreneurs could themselves promote change and innovation. This was the approach developed by FAO with its Farmer Field Schools, which, through a trial-based system, helps small-scale farmers to gain a better understanding of how things work. The initiative enables them to jointly identify problems, find solutions and develop common strategies for change. However, experience shows that this community of small-scale producers needs the active engagement of all its members, through shared values and full backing for a common mission, which generates mutual benefits that are equitably distributed (Herbel *et al.*, 2012).

Since then, there has been a renewed appreciation of the value of empirical knowledge and farmers'practices, since innovation can only be effective if it is grafted on to knowledge. As a result, new types of knowledge and innovation systems have been developed, combining both the empirical knowhow of practitioners and the scientific knowledge of researchers. At the same time, the need to protect natural resources, adapt to climate change and combat inequalities calls into question the scientific gains of the past few decades, which focused more on the intensive exploitation of resources and the creation of artificial environments. Henceforth, traditional knowledge, or rather ecological knowledge accumulated by farmers over time, was seen as an irreplaceable asset for the development of an alternative type of agriculture, one that respects the equilibrium within agroecosystems and provides opportunities for decent work. Social innovation, based on values of solidarity, equity and emancipation, has become firmly established as an urgent necessity. The notion of strengthening capacities has tended to replace the more top-down ones of instruction or extension: knowledge transfer has given way to knowledge sharing. The role of the knowledge broker has become central. New knowledge and innovation systems bring together, on an equal footing, grassroots practitioners (farmers or entrepreneurs), researchers and knowledge brokers around common projects, where everyone's interests are served. The idea is not to blur the lines between the different trades, but to ensure that each of these can be carried out, drawing on the skills and achievements of others. Only in this way can there be a rapid flowering of sustainable and effective innovation, including social and organizational innovation, that will correct disparities.

It is interesting to note that the European Commission has set itself the objective of launching knowledge and innovation systems within the European Union that answer these criteria, through a pioneering initiative called the European Innovation Partnership (see Box). Tested in various parts of the world[4], other initiatives like this one form a foundation for experience and a source of inspiration, conducive to the emergence of new agricultural models, of which the planet and humanity are so greatly in need.

The European Innovation Partnership

The European Innovation Partnership (EIP), set up by the European Commission's Directorate-General for Agriculture and Rural Development, aims to increase the impact of science on development by combining scientific and practical knowledge. It provides for the setting up of:

– operational groups that bring together different actors around the same project (farmers, entrepreneurs, researchers, teachers, technicians, etc.);

– thematic networks bringing together EU operational groups working on identical and similar topics to promote exchanges of experience;

– online resources with updated details of scientific and technical research on topics of common interest;

– multi-stakeholder research projects focused on the development of technical and/or social innovations.

These components are funded by the budget of the second pillar of the common agricultural policy (operational groups and their networks, online resources) and by the Commission's research budget (*Horizon 2020*), a rare and highly interesting example of an explicit and deliberate convergence between two EU strands of policy.

Towards integrated food and agriculture policies

Many of the world's regions, beginning with the Mediterranean, are marked by various political, economic, environmental and social crises. The nature of these raises the issue of food security as a decisive factor in stability and hence the importance of paying close attention to public agricultural policies. Given the wastage that is occurring in all sectors – of knowledge, food and natural resources – and given the growing disparities evident in rural and urban areas, a single sectoral policy would seem inadequate to respond to these challenges. It is therefore critical to turn to intersectoral and inclusive policies based on participatory approaches, in which all actors, including non-state ones, form an integral part of the

4 - For example, participatory research efforts, experiences of farmer-researchers, the Combined Technology Networks of the French Ministry of Agriculture, established projects seeking to promote exchanges between farmers (the *de campesino a campesino* movement), uncontrolled field-testing methodologies, etc.

decision-making process. While remaining the main driver of reforms, public authorities must mobilize all forces possible to ensure that these policies are balanced, innovative and inclusive, as well as being developed and implemented in a participatory manner.

A paradigm shift is therefore called for. In the field of agricultural and rural development, this would enable a switch from a technical approach to a holistic and territorial one, while taking into account the social, economic and political dimensions of development. In this way, local communities would become real actors for development in their area. To do this, national and local governments must develop policies that are more focused on adding value to products and rural development in synergy with urban development, rather than concentrating solely on agricultural production. These policies must also contain specific measures to promote small-scale and family farming, while setting in place a legislative framework that offers legal status and support to both types of agriculture.

Access to funding and investment resources poses the biggest hurdle for Mediterranean family farmers. The share of funding for agriculture in public budgets is very low, compared with the contribution that agriculture makes to the economy. If the new paradigm based on inclusive and functional agricultural approaches (family farming and agroecology) is to develop, governments in the Mediterranean and elsewhere will have to increase responsible agricultural investments[5] in rural areas, to build the infrastructures needed and set in place a favourable environmental, economic and social policy. As such, several actions are needed.

– On the financial level, existing finance institutions should be strengthened, and there is a need to promote mechanisms for inclusive financial services by setting in place simplified loans that are suited to the situations of family farmers and to develop microfinance institutions in rural areas. Other imperatives include putting in place government credit procedures, so as to encourage banks to lend to small-scale family farmers, alongside insurance and guarantee systems to reduce credit risks. Public finance should be steered towards support for various forms of sustainable agriculture, including family farming, by offering rewards to producers in exchange for the environmental services they provide to society.

– For the development of producer organizations, greater negotiating space should be offered to them, with special attention paid to those that represent small-scale and family farming; there should be more support for developing producer organizations and cooperatives that are economically and financially autonomous, as well as greater efforts to leverage partnerships with civil society to supply services to family farmers. These organizations can play an important role in supplying extension, marketing and social protection services, which in rural areas are often the target of projects that are too fragmented to be effective.

5 - The Committee on World Food Security (CFS) approved “principles for responsible investment in agriculture and food systems” on 15 October 2014.

– For youth, it is critical to ensure greater investment in developing rural infrastructures to attract new enterprises and create new off-farm job opportunities; it is also key to develop programmes that target young farmers, giving them privileged access to land, credit and technical information.

– Finally, it is important to implement the voluntary guidelines for responsible governance of tenure of land, fisheries and forests, in an effort to ensure national food security; there is a need to develop economic incentive programmes for farmers, which encourage reasoned agricultural approaches based on conserving reservoirs of local knowledge. These programmes could be part of policies jointly designed together with key actors, especially family farmers and their organizations.

Conclusion

Combating wasted knowledge and human resources is a theme that still receives too little attention and discussion. This chapter has attempted to explore the different types of knowledge and their development over time, highlighting some changes and innovations needed, including at policy level. Although eroded by globalization, which encourages uniformity, local knowledge systems are proving resilient, and there is growing awareness of their contribution, especially to the sustainability of food systems. The exchange and pooling of knowledge, together with the setting in place of inclusive policies, can offer a valuable response to various severe crises currently facing the world. Knowledge only exists if it is put into practice. Protecting it contributes to the production of new knowledge, since paying heed to reservoirs of knowledge available can have the effect of promoting innovation.

The global economic situation is aggravated by income disparities. The gap between rich and poor continues to widen in a world which, nevertheless, has sufficient resources, including those needed to produce food. Food insecurity, which is acute in rural areas, is now spreading towards urban centres. This trend makes it critical to adopt a global approach to the problem, as well as a traditional sectoral one (urban, rural, agricultural), which should in any case be retained.

As part of this new integrated and functional paradigm, it is crucial to strengthen the governance of food security by setting in place territorial approaches, while encouraging the inclusion and connectivity of regions and marginalized communities. Such a critical, synergistic approach, based on recognition of the diversity of knowledge, offers the advantage of taking into account context specific particularities. It also makes it possible to optimize connections, while promoting the development of integrated food systems. Lastly, by being based on the development of decentralized governance systems, it enables local actors to strengthen their capacities and ability to participate in decision-making. Setting in place spaces for dialogue will therefore make it possible to reduce the gap between decision-makers and local communities.

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CHAPTER 15

SAVING TRADITIONAL KNOWHOW IN AGRICULTURE

Pascal **Bergeret**, *CIHEAM*
Juliette **Prazak**, *FAO*
Caterina **Batello**, *FAO*

Developed down the ages, traditional knowhow[1] in agriculture, livestock keeping and fisheries is an integral part of the Mediterranean people's heritage. Rich and diverse, it is for the most part little known, since often it is limited to the communities in which it is implemented. Given the current threat, due to a variety of reasons that are described in this chapter, it is essential to do everything possible to protect this traditional knowhow, for it could well hold the key to the sustainability of Mediterranean agriculture – currently facing a range of challenges that are rapidly becoming more acute. Such knowhow, which is rarely written down, must not be wasted in the Mediterranean region, where oral culture is still dominant and where all human capacities are needed in order to mount an agronomic and technical response to the growing problem of producing enough food.

First of all, we examine how this traditional knowhow is created, then subsequently, we explore the reasons behind its erosion or neglect. Finally, in the third section, we discuss signs of a potential renewal of Mediterranean agriculture, partly driven by mobilization of traditional and other forms of knowhow, within new systems of knowledge and agricultural innovation.

Traditional knowhow in food and agriculture in the Mediterranean region

Despite the vicissitudes of its history, the Mediterranean region has sustained a very characteristic way of life based on agriculture, for more than several thousand years. This enduring identity is not the result of a coherent and static Mediterranean concept, but of profound changes, even devastation, which have occurred throughout the region's history, in biological, but also technical and cultural terms (Butzer, 2005). In particular, trade within the Mediterranean region has strongly helped to

1 - In this chapter, the notion of traditional knowhow is taken by commodity, to refer to reserves of knowhow accumulated by farmers, livestock keepers and fishers throughout history – knowhow which, far from being static, has evolved through trade or exchanges between cultures and civilizations.

shape the territory. Commercial exchanges of agricultural products, directly linked to the primary needs of governments and communities, serve as a valuable marker of centres of power, the advance of techniques and developments in the cultivation of certain varieties (Blanc, 2014).

Modeling Mediterranean landscapes from Antiquity to the Industrial Revolution

Use of territory in the Mediterranean during the Neolithic period appears to have been sedentary and diversified, servicing a varied economy based on the intensive exploitation of forests – abundant in the region at that time – and their resources (Williams, 2000). This period saw the first instance of the domestication and diffusion of endemic species (a wide range of cereals, legumes, nuts, oilseeds, fruit and vegetables, and animal species), which continued up to the the classical era (500 BC) and was widely practised in the region down the centuries. But it was also during the Neolithic period that intensive deforestation of Mediterranean territory began, continuing until the Middle Ages. This period was marked by population growth, urban development, mineral extraction and regional trade, which transformed agriculture and the knowledge linked to it, gradually shaping the territory, ultimately producing the clearly recognizable Mediterranean landscape that exists today.

A commentary by Plato in the 3rd century BC assesses accelerated deforestation in Attica (the ancient city-state of Athens): "what remains now, compared with what existed before, is like the skeleton of a sick man, all the fat and soft earth having wasted away, and only the bare framework of the land being left." Later, some Italian writers spoke of the *polpa e ossia* of the land – the flesh and bones. The Mediterranean region, defined by the original nature of its climate and vegetation and the uniqueness of its biodiversity, but also by its fragility in the face of environmental constraints, especially hydric stress and erosion (Council of Europe *et al.*, 2006), is in reality a formerly heavily forested area, mainly by conifers, which later suffered from the loss of protective forest cover. Its regeneration is problematic, especially given the risks of fire and overgrazing.

A massive producer, consumer and exporter of wheat, olive oil and wine – traditional and characteristic food products from the region – the Roman Empire went so far as to subsidize the purchase of wheat at different times in its history. It sold the surplus to other territories, such as Gaul and Spain (Kingsley and Decker, 2001). From the 9th to the end of the 13th centuries, the medieval economy enjoyed rapid growth. This period is considered to have been the greatest era of agricultural expansion since Neolithic times (Georges Raepsaet, quoted in Andersen *et al.*, 2014). At the same time, intra-regional trade and exchanges saw a massive increase. Trade with the Middle East, Asia, the Indian subcontinent and sub-Saharan Africa introduced the cultivation of peaches, apricots, aubergines and some citrus fruits, as well as that of hemp, cotton, rice and black-eyed peas (cowpeas) (Heywood, 2012), which, to varying degrees, shaped the Mediterranean territory and created new agricultural traditions. In terms of the age of the territory, and its long history, these upheavals are relatively recent. Between the 15th and 19th centuries, European agriculture showed fairly low levels of productivity and generally relied on rivers for irrigation.

This small-scale family farming was disrupted by the Industrial Revolution, urbanization of the European population and the transformation of agricultural products into objects of mass consumption.

Traditional knowhow in the Mediterranean region

The intensity and continuity of exchanges between cultures and civilizations, throughout the history of the region, slowly led to the emergence of traditional knowhow, although the reserves available only grew slowly when measured against the scale of a human lifetime or several generations. This knowhow can be classified as ecological, since it is the result of observations made over time on interactions between cultivated plants or animals. Adaptive by nature, it allows farmers and livestock keepers to adjust their techniques to the state of their environment and its changes (climate, soils, availability of water resources, etc.). New elements are only admitted once they have demonstrated their relevance in a specific local setting. Scientific knowhow is different, since universal. A scientific truth is independent of its context and is based on unalterable principles. Moreover, such knowledge is mobile and can be applied everywhere. These two types of knowledge are therefore clearly complementary, and there is no reason to suggest that one is more legitimate than the other.

Integrating local species in a territory and cultural fabric: the example of traditional pig rearing in the northern Mediterranean

Agroforestry, combining cultivated terraces, trees and pigs, is an ancient and widespread model in the northern Mediterranean. Pigs were allowed to roam free over large areas, where their presence represented the dominant economic activity, which conditioned all other types of landscape use. Humans deliberately sought this co-dependency of exchanges between animals, crops, soil fertility and trees, a complementary relationship between robust local breeds and their agroecosystem, and its implementation was refined down the centuries. A large number of these complex systems have been abandoned or simplified since the mid-20th century, particularly as a result of mass mechanization – poorly suited to terraced tree farming systems – the rural exodus, an outbreak of swine flu and successive crises in the price of pork meat. Local breeds were mostly replaced by high-yielding breeds. However, today, the market is seeing a clear renewal of consumer interest in regional and artisanal meat, reviving a niche sector that was previously very restricted, and encouraging growing official recognition of certain breeds by the competent national authorities (Kizos and Plieninger, s. d.). Local breeds reared in these particular systems represent an asset for future generations. For this reason, it is imperative that the wealth of their genetic patrimony, like the local cultural traditions that they represent, be preserved (Matassino, 2007).

Immersed in the culture, social practices and organizational methods of Mediterranean societies, traditional knowhow covers every aspect of material life. Much of it reflects the intimate relationship carved between farmers and their surroundings: this applies to water management and irrigation practices in oases of arid or semi-arid environments, which are key elements of cultural patrimony. In these same areas, nomadic pastoralism offers another example of traditional knowhow that is closely linked to the culture and lifestyle of a society fully connected to its environment. The field of processing and adding value to agricultural products also benefits from traditional knowhow. Examples include the making of juices and jams from dates in southern Morocco, which is based on a deep knowledge of the characteristics of different varieties of date palms. Also worth mentioning is the rediscovery of Dittany of Crete (*Origanum dictamus L*), a plant used in infusions since time immemorial and now reintroduced by modern cuisine into sweet and savoury recipes, reflecting the typical nature of Mediterranean ingredients. There is no end to the number of wild food plants that grow exclusively in the Mediterranean area, which are threatened to a greater or lesser degree and are still used in the cooking of the countryside – evidence that this ecological knowhow is still alive (Ali-Shtayeh *et al.*, 2008). An essential part of the social fabric of communities and a connecting and balancing factor between humans and their environment, traditional knowhow constitutes a veritable heritage for Mediterranean societies.

Loss and neglect of traditional practices in the Mediterranean region

In the northern Mediterranean

The European Union's (EU) common agricultural policy (CAP), launched in the 1960s against the backdrop of post-war economic development, was initially deployed in a rural setting characterized by a fundamentally traditional and family-run form of agriculture. This world was already suffering from the effects of long-standing depopulation of the countryside, due to the massive death toll of rural men in the two world wars of the 20th century, coupled with a slowing of population growth, strong industrialization – which was providing jobs in urban settings – and emigration towards countries in the New World (SESAME 2, 2014). While, as such, loss of traditional knowhow in Europe, and in the northern Mediterranean in particular, began well before the creation of the CAP, it is worth highlighting that this move certainly accelerated the process.

The sudden availability and massive use of synthetic inputs and agricultural machinery have enabled crops to be grown on historically poor or unstable soils in areas that were previously considered to be non-cultivable (Van Zanten *et al.*, 2014). With a longstanding goal of achieving agricultural self-sufficiency in Europe, the CAP strongly encouraged the concentration of land through a system of awarding subsidies per hectare or per head of liverstock, in this way rewarding the biggest farmers (Jacquet, 2003), who showed little inclination to engage in traditional agriculture. In the Mediterranean, the effects have been heterogeneous, for the region has always been a "difficult" territory, characterized by severe water constraints and by a relief that is "devoured by mountains" (Fernand Braudel in SESAME 2, 2014), scattered with small-scale family farms with limited arable land where mechanization is often difficult and clustering farms together is not cost effective. More generally, it is modernity which, through a combination of social factors, has radically transformed Mediterranean agriculture. The advance of supermarkets, known for imposing suppliers with stringent specifications to achieve uniformity and consistency (in appearance, taste and colour) that are incompatible with traditional and local varieties, has fostered the homogenization of horticultural varieties (Dedeire, 2009). Meanwhile, the globalization of the agri-food market and a new CAP reform in the 1990s have resulted in some of the less productive arable land in the more marginalized regions being simply abandoned (Van Zanten *et al.*, 2014).

Traditional hunting or poaching? When tradition counters nature protection: the case of songbirds in Malta and Cyprus

Malta, Cyprus and Italy are transit points for most migratory birds. Hunting these birds, many of which are from species that are actively protected in countries of northern Europe, is a traditional pastime that is part of the cultural and (at times) culinary patrimony of these countries (*ambelopoulia* in Cyprus, *pulenta e osei* in Brescia, Italy). The conservation status of large numbers of such birds has become very worrying in the past three decades. It has now been clearly demonstrated that the decline in populations of such migratory birds is in large part caused by their being trapped and hunted in Mediterranean countries, far more than by the destruction of their natural habitat due to agricultural intensification (Franzen, 2010). Paradoxically, far from bringing about a change of mindset and a shift towards a more developed ecological conscience, EU membership and greater prosperity have led to increased hunting and poaching of migratory birds in these regions, due to better roads and greater supplies of weapons. “Traditional” poaching has thus been established as a manly leisure pursuit, a marker of elevated social status and a symbol of rebellion in the face of the “foreign” power of Europe (McCullogh *et al.*, 2008).

Between 1970 and 2000, the 880 municipalities along the French coastline saw their total area of cultivated land decline by 20% – a loss of 200,000 hectares over thirty years. The main cause was pressure on land from construction (Daligaux *et al.*, 2013). Indeed, agricultural territories have been partly abandoned due to the explosion of land markets over the same period (General Council on Agriculture, 2009, quoted in Daligaux *et al.*, 2013), following the advent of paid leave and a leisure society, as part of the post-war boom. This phenomenon explains the virtual disappearance of agriculture in the urban area of Marseille and on the Côte d’Azur (Daligaux *et al.*, 2013). Although in poor condition, the hinterland has managed to survive. These fragile and marginalized areas have become “fall-back territories” – landscapes, but also reservoirs of traditional knowhow, which is often at the heart of tensions created by new social and economic challenges. There is now a shift towards a “rural renaissance” driven by new urban expectations of authenticity in rural territories, and a general rethinking of the functions assumed by agricultural spaces (Linck *et al.*, 2015) – all this in a context of extremely precarious access to land. This form of landscape reclamation mainly involves plots that cannot easily be worked by machinery, into which traditional varieties have been reintroduced. The process is frequently started by local actors keen to take advantage of tourist-related opportunities and strong gastronomic traditions (“culinary patriotism”) in a region that was a very early participant in the protection of various traditional systems producing typical food products (Dedeire, 2009).

In the southern Mediterranean

The current agricultural scenario in the southern and eastern Mediterranean is generally divided into two categories. Alongside large-scale agriculture that is "modern", productive and linked to globalized trade, small-scale agriculture, which is often described as "archaic" and made up of smallholder family farms, revolves around subsistence requirements or sells off surplus output at very local markets. Onto this dual system, another has been added, which rejects irrigated agriculture – with high value addition per hectare (if not per litre of water used) – in favour of rainfed agriculture that produces lower and above all more uncertain yields. This is not the place to go into the history behind this duality – one that has seen a mix of local social dynamics and upheavals imposed by successive dominations: Persian, Greco-Roman, Arab and Ottoman empires, French and British colonization. Modern Mediterranean states have to manage these dualities in a particularly delicate context of social instability, market volatility and uncertain security. It is true that, since the end of the first decade of this century, several countries have embarked on a policy of agricultural revival, which tends to blur the agricultural duality, replacing it gradually with a more complex situation, where strong inequalities endure. As in the case of Morocco or Turkey, some countries have made a priority of the agriculture sector, while others, such as Algeria, are rediscovering its importance. Still others, such as Égypt, are attempting to claim new agricultural land from the desert, in the hope of boosting domestic output and reducing their strong dependence on food imports.

Common to all agricultural policies and strategies in countries of the southern and eastern Mediterranean is the fact that they attach little importance to traditional knowhow, which is mostly considered as archaic and an obstacle to the sector's modernization. While the same observation can be made at global level, countries of the southern and eastern Mediterranean appear to be more closely touched by the trend, due to their geographical position at the gates of ultra-modern agricultural Europe and their strong involvement in globalization. There is now a common blend of traditional knowhow and the survival of forms of agriculture from a bygone age, which do not answer present needs in terms of agricultural production, food security and export promotion. Such "obsolete" agriculture accounts for the vast majority of farms, occupying the largest agricultural surface area and constituting the primary source of employment for rural communities. Far from gradually disappearing to make way for modern and "scientific" farming, traditional small-scale agriculture is developing in terms of numbers of farms. It does, however, remain marginal in terms of access to resources and markets. Confined to the often isolated hinterland, far from urban markets, let alone export markets, Mediterranean smallholder crop farmers and livestock keepers are crammed onto small plots of land, with exhausted and eroded soils, in a setting where natural resources (water and biodiversity) are increasingly exploited, engaged in agricultural production or in supplementing farmers' income (food-gathering, non-timber forest products). Naturally, modern and "scientific" agriculture must also deal with the depletion of natural resources on which it depends: erosion and reduced soil fertility due to dry farming in rainfed areas, declining levels of groundwater due to overexploitation for irrigation, conflicts over use of surface water – all these factors also affect modernized agricultural entrepreneurs. Climate disruptions only serve to amplify these imbalances, generating challenges of unprecedented proportions.

Traditional fishing in the Mediterranean

Practised from small-sized vessels, traditional fishing offers definite benefits to the sustainability of the sector. Indeed, for small-scale fishing communities, the work of humans aligns with the laws of nature and water.

Small-scale fishing gains from comparisons with industrial practices, not just in terms of impact on species caught individually, but also in overall consistency with the wealth and biodiversity of marine environments. However, these practices are jeopardized by the triple impact of industrial fishing, pirate fishing and globalization (Jacquet and Pauly, 2008). Traditional tuna fishing, which is far less damaging to stocks, is practically extinct in the Mediterranean.

While small-scale fishing and industrial fishing each capture 30 million tonnes of fish per year for human consumption, the former employs 12 million people while the latter only employs half a million. Small-scale fishing captures 4 to 8 tonnes of fish per tonne of fuel used, while industrial fishing only captures 1 to 2 tonnes for the same energy input. Each year, industrial fishing discards 8 to 20 million tonnes of fish and other marine animals, while discards are almost non-existent for small-scale fishing.

Given such a situation, it would be folly not to try to use the entire reserve of available knowledge – both scientific and traditional – that has proven ecological value and is adapted to specific contexts. The challenge of agricultural and rural development lies in knowing how to draw on this knowledge and to give farmers the chance to put it into practice in decent conditions. For variable factors in agriculture (market access, price relationships, availabilty of infrastructures, organization of supply chains) are naturally still decisive. With its rich stock of genetic material, and crop farming and livestock keeping practices that have proved their resilience in adapting to local conditions, traditional agriculture is not necessarily negative. On the contrary, it can be a source of solutions. Unfortunately, this is not the path that has been pursued. One has only to look at the many examples of agricultural "development" that have been introduced despite existing knowhow, with unfavourable results: salinization of soil due to intensive irrigation around oases in the southern Maghreb or the destruction of traditional palm groves planted in lowland areas due to excess water.

Wasted traditional knowledge under colonial influence

One unfortunate example of this "wasted knowledge" can be seen in the case of misguided colonial agricultural policies in Algeria (Bessaoud, 2002): attempts to acclimatize exotic plants such as cocoa, coffee and groundnuts, or the subsequent policy of specializing in sheep production using the Australian model, were all conducted without regard for the realities of the country and ended in resounding failure. It was only later, with the appearance of agronomists who were attentive to local farming practices, that recognition of local agronomic conditions led to the design of far more pragmatic measures. These were closely aligned with the reality of local production systems (improvement of small tools, adapted techniques to prepare soil for sowing with cereal seeds, use of local varieties, irrigation of food crops etc.).

Can agroecology help to renew Mediterranean agriculture?

A new generation of Mediterranean farmers

In the north: the emergence of innovative agricultural systems, often introduced by young people, in response to new social demand. One of the major problems currently facing agriculture in the northern Mediterranean is generation renewal. This is exacerbated by the rural exodus, prohibitive prices for land access, and, to a certain extent, lack of social recognition for farming as a profession. Together, these factors have threatened an entire swathe of the Mediterranean economy over the past twenty years. While this wave of withdrawal from the agriculture sector has largely taken place unobserved, it is very much a reality, as can be seen by the case of France, which loses about four farms on a daily basis.

However, there are signs of a renewal of interest in agricultural activity within society, driven especially by young people in search of new career challenges or who feel "called" by the sector, although they do not themselves come from farming families. Today, this is the case for 30% of young people in France who have become heads of farm (SESAME 2, 2014). However, they must have strong ambition and a great deal of tenacity in order to gain access to the land they need to set themselves up. A recent survey commissioned by the French Ministry of Agriculture (Ministry of Agriculture, 2015) revealed that 13% of farmers plan to engage in agroecological activities in the next five years. In an encouraging trend, there are twice as many under-35s as other age groups seeking to achieve this ambition. These young farmers, who have made a deliberate choice to follow such a career path, view their job in a way that is closely aligned with a desire to practise agriculture in a more ecological manner.

This new generation is also highly connected and has instant access to information through Internet websites, which young people consult with a critical eye. They link up with virtual communities of young (and not so young!) farmers who are following a similar path. The agricultural history of France shows that young farmers have always been a critical force in the sector's progress, for example urging successive governments to introduce laws on land tenure and to offer help in setting up farms or suitable training schemes. "When young people grow, so does agriculture" (SESAME 2, 2014). If these young farmers can be called pioneers, that is first and foremost because their agroecology is not something invented by technocrats (Hervieu, 2015), but the reflection of a desire within society as a whole.

In the south: the challenge of generation renewal and of implementing broken production systems by mobilizing the Mediterranean agricultural heritage. The agricultural challenges facing countries of the southern and eastern Mediterranean require innovative solutions. In the modernized as in the traditional sector, continuing the current trend of overexploiting resources that are increasingly scarce due to climate change can only lead to an impasse. Worryingly, alternatives being implemented that break with dominant production systems are rare, or at best, little known. However, a few exceptional but interesting examples can be found on the southern shores of the Mediterranean.

The beginning of conservation agriculture in the Maghreb

In the Maghreb, producer groups, supported by the FERT association, have been set up to pursue rainfed conservation agriculture, which is based on reduced working of the soil – right up to zero tillage – setting in place various crop rotations (cereals, legumes, forage crops) and permanent soil cover. These systems, which restore soil fertility, have shown their ability to perform better in periods of drought. They enable regular yields to be obtained and strengthen the sustainability of production. Their disadvantages lie in the difficulty of overcoming weeds and in the fact that direct sowing with zero tillage requires specific seeders, which are heavier and more expensive (Benaouda *et al.*, 2015).

The development in the southern and eastern Mediterranean region of agroecological production systems involves overcoming a range of difficulties. To date, only a few pioneers who head large farms and have a high level of education have made the attempt. The risks involved in shifting to this type of agriculture, coupled with the investments required (especially in material) discourages the majority of farmers, especially the smallest ones. Lack of professional agricultural structures, which through a collective approach to sharing risks and investement costs could help to develop agroecology, is also hampering the spread of breakthrough innovations. Another major obstacle is the fact that the agriculture sector, and particularly small-scale farming, is currently controlled by ageing farm owners. Members of the younger generation who have remained in rural areas, and are open to innovation, lack power and have to give way to the prudence and strong risk aversion of their elders. Therefore, as in the northern Mediterranean, albeit in a different context, there is an acute problem of generation renewal for agriculture. Detecting and identifying traditional knowhow, onto which agroecological principles could be grafted, could lead to the design and testing of new suitable production systems that are easier for farmers to assimilate.

Labels to rescue local knowhow?

Systems for controlled designation of origin were first developed to protect threatened products. The threat may be economic, linked to the appropriation of a name or the trivialization of a product. It may equally involve the intangible heritage or a terroir' in danger of disappearing: traditional practices, biodiversity or local landscapes. Thus the first designation of origin and protected geographical indication (AOP-IGP) in France, for olive oil from Nyons, was the result of a dynamic initiative launched by the Tanche trade union (named after a variety of local olives) which, sensing a growing decline in business due to economic competition from colonial oil, together with the rural exodus and weather events that were catastrophic for olive trees between 1929 and 1956, obtained a judicial designation of origin in 1956.

Today, geographical indications are mainly economic policy tools – a form of economic and emotional soft power for a terroir' that has become protagonist and protector of its own typicality, against the backdrop of globalization. Southern Europe alone accounts for 76% of geographical indications in the EU. Italy boasts 22% of joint AOP-IGPs (Ilbert, 2009), followed by France (18%), Spain (14.5%), Portugal (11%) and Greece (8.5%). The products protected are mainly wine, cheese, fruit and vegetables, meat and oils (Antonelli and Ilbert, 2012). With a food supply that is increasingly standardized, labels and geographical indications offer an alternative for consumers by pinpointing recognizable local products that have a strong identity, offering a sign of typical knowhow and a lively tradition in their terroir' of origin. It has been said that "there was more history than geography in a bottle of wine", for a good wine is the result of cultural and traditional knowhow that has survived over time (Del Canto Fresno, 2009). Although it has endured an identity and chronic social crisis for a long time now, European and Mediterranean family farming has become an element of traditional culture, a sort of safe haven worth protecting. Throughout history, the banner of a strong, proud cultural identity (Bessaoud, 2009), the Mediterranean diet finds in geographical indications the means to unite an entire country behind it, way beyond the region of origin.

A people of citizens-consumers, often far removed from the world of farming, has made a symbolic and emotional investment in this traditional agriculture, participating through its purchasing decisions in the conservation of rural areas and terroirs', which it sees in a positive light, particularly through tourism, contributing to a certain "stage setting" and making a link between these territories and the products that hail from them (Rieutord, 2002). These new consumption patterns also reveal the erosion of dietary differences between northern and southern regions (Durbiano, 2000), fostered by greater ease of movement within a country (particularly for leisure), allowing repeated exposure to the regional characteristics of a terroir', which tourists-consumers want to rediscover once they return home.

By contrast, the "Mediterraneanization" of non-Mediterranean diets poses a problem of identity for typical products from the region. The global success of certain pillars of the Mediterranean diet, such as olive oil, olives, grapes and wine, leads to a massive increase in their export (particularly to China, Japan, the United States of America, Canada and Australia), and at the same time to an increase in their production outside the region. As Palma and Padilla (2012) put it: "international consumers have no soul: they demand more and more emblematic Mediterranean products but do not particularly care about their origins." Such international demand against a background of growing competition leads to the export of the best traditional products, while at the same time depriving local consumers, who no longer find them on regional markets, or only at extremely high prices.

Need for a new knowledge system of agricultural innovations

The agricultural challenges faced by the northern and southern Mediterranean, and the issues that are linked to them, require that all types of knowhow be mobilized so as to resolve the problems as and where they arise. It must be said that this knowhow is currently either sidelined and undervalued (in the case of traditional knowledge) or highly inaccessible to a large proportion of farmers (in the case of scientific knowledge). Combining these types of knowledge holds the best prospects for Mediterranean agriculture, provided that conditions favourable to the emergence of new production systems – breaking with the current trend of resource degradation and marginalization of rural areas – can be put in place.

One of these conditions is the development of new agricultural knowledge and innovation systems (AKIS), dedicated to resolving concrete problems, such as climate change adaptation or mitigation, by adopting new agricultural production methods. Clearly, at the heart of these new systems are the farmers and entrepreneurs who are implementing the knowhow. Also making a contribution are researchers, so long as they pay heed to the questions and needs expressed by the actors involved in food and agricultural production. Training institutions play a major role here, since teaching and strengthening capacities in individuals and producer organizations are essential prerequisites for mobilizing, transmitting and using knowledge. Lastly, knowledge brokers – extension agents and advisors of all kinds – have an important part to play.

These new AKIS operate in networks, linked to each other around a common issue or project. Information and communication technologies are used intensively as vessels of knowledge and support for its rapid circulation. Even more importantly, the multi-stakeholder nature of AKIS fosters the joint development of new knowhow, which is the fruit of cross-fertilization between different types of knowledge. The result is a new coordinated and synergistic way of doing research, teaching and disseminating knowledge.

Conclusion

Mediterranean agriculture faces a new turning point in its eventful history. Although the challenges differ between the north, south and east of the Mediterranean, the pathways for exploring and finding solutions draw the two shores closer together more than they drive them apart. In both contexts – that of an agriculture on the road to modernity and that of a small-scale agriculture that is marginalized and static in its development – agroecology appears to offer a middle way. Growing demand for food authenticity by northern consumers is slowly altering industrial production methods, while the south is becoming painfully aware of the impasse to which agricultural dualism is leading. Among other sustainable agricultural approaches with which it is often compatible, agroecology is an interesting avenue to explore. By blending traditional and cultural agricultural practices that have helped to shape the melting pot of identities – which are strong and inseparable from their context – with the scientific principles of modern agronomy to produce and understand natural phenomena and interactions within a biotope, agroecology appears to be an option capable of reconciling the imperatives of production and traditional knowhow. Today, it is important that political initiatives reflect the findings that have been identified in its favour for a number of years now by specialist research institutes in both the south and north of the region. Field research has shown agroecology to offer a viable and lasting solution to the production challenges facing Mediterranean agriculture, together with those of protecting habitats and social justice.

At a time when the EU is asking itself questions about the future of its agriculture, as well as the evolution of the CAP and the research policy it needs to pursue, at a time when the southern and eastern Mediterranean countries are searching for new approaches to agricultural and rural development, so as to respond to issues of food and territorial security, it is not unreasonable to suggest that coordinated or even joint efforts aimed at setting in place new agricultural knowledge and innovation systems may be an important part of the solution. This offers an interesting path to explore in the debate about the new neighbourhood policy that the EU and its partners are currently promoting.

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CHAPTER 16

FAMILY FARMING TO BOLSTER HUMAN KNOWHOW AND RESOURCES

Pascal **Bergeret**, *CIHEAM*
Nora **Ourabah Haddad**, *FAO*
Sara **Hassan**, *FAO*
Francesco Maria **Pierri**, *FAO*

With good reason, 2014 was declared the International Year of Family Farming by FAO. Involving nearly 2.6 billion people, or 40% of the world's population, this form of agriculture is the primary source of employment at global level. Accounting for 500 million of the world's farms, family farms produce about 60% of global agricultural output and represent 80% of the total value of food production (FAO, 2014a). These figures alone testify to its importance.

Family farming is a means of organizing agricultural production, characterized on the one hand by strong operational links between families and production units, and on the other, by predominant reliance on family labour. This type of farming is distinct from industrial agriculture, which is marked by its strong financialization and complete separation of labour and capital. While agribusiness is currently booming, its weight in global terms can in no way be compared with that of family farming, which remains the dominant form of agriculture. Also noteworthy is the development of an intermediary form, landowner farming, which differs from the model of family farming in that it mainly uses non-family salaried labour.

A common principle of uniqueness shared by ordinary farming and family farming conceals a wide diversity of forms of family farming that are closely linked to the regional or local context in which they are located. In this respect, family farming is a reflection of the social organization and values that prevail in the places where it is practised. For example, family-run structures that vary widely from one region of the world to another leave their mark on the technical and economic operation of those production units. The rationales that underlie such operations are very often far removed from the economic motivation of a business attempting to maximize its profit in the short and medium term. They are hard to grasp for anyone not familiar with the family system of production and decision-making. Paradoxically, the result is widespread misunderstanding of this type of agriculture, including in countries where it exists. Standard statistical classification, by size of farm and the nature and volume of production, does not adequately convey their impact. This fact is too often ignored, even though it should be the primary factor to consider when developing policies that target this type of agriculture (CIHEAM-FAO-CIRAD, 2016).

Family farming is predominant in the Mediterranean region, where it still strongly conditions socio-demographic and territorial equilibrium. In a study exploring the issue of waste in the Mediterranean, attention must be given to family farming as a source of employment, an opportunity for inclusive development and an incubator for rural and agricultural knowhow. Yet although it represents an important resource for addressing the region's economic, social and environmental challenges, this type of farming is particularly vulnerable to threats, especially in the east and south of the Mediterranean. With varying degrees of proximity to the swathe of political crises stretching from Syria to the Maghreb, the countries of the region are seeing their economic development hampered, with high unemployment and the dual afflictions of land and water insecurity that are partly linked to climate change – very prevalent in this part of the world. Such factors of social, economic and environmental vulnerability have an impact on economic activities and communities, first and foremost on family farming, whose knowhow and knowledge, either real or potential, is wasted.

In this chapter, we first attempt to analyse the characteristic features of Mediterranean family farms, revealing their importance compared with other forms of agriculture. We go on to describe the challenges that they are or will be facing, and their strengths in helping to address these (in terms of food security, protection of the environment, fighting poverty, underemployment and social and territorial inequalities). In conclusion, we question the agricultural policies set in place by different countries in the Mediterranean region and discuss some that should be implemented. In this regard, special attention should be paid to women and young people, whose potential is still largely untapped, but who could become key players in agricultural and rural development. Such an approach involves reformulating and reinvigorating state intervention in rural areas, but also strengthening producer organizations that encourage the spread of good practices and knowledge, acting as a communication conduit between the public authorities and the most vulnerable family farms, so as to maximize their potential and productivity.

The importance of family farming in the Mediterranean

Although there are undeniable similarities between agriculture in the north and south of the Mediterranean region, for the purposes of analysis, Mediterranean countries that are members of the European Union (EU) must be considered separately, since the effects of the common agricultural policy (CAP) are determining factors for this group of nations. Family farming is by far the dominant form here, especially in comparison with countries of northern Europe. According to the agricultural census of 2010, family farms in southern Europe prevail both in terms of numbers (12.2 million, accounting for 97% of total farms) and in terms of their contribution to agricultural employment (86.2% of the regular agricultural labour force). These ratios are respectively 94% and 83% taking an average for the EU with 15 member states – before the entry of the new member countries from Central and Eastern Europe – clearly illustrating the distinct nature of the Mediterranean countries (FAO, 2013). Family farming is also predominant in terms of agricultural surface area, but to a lesser extent: while it accounts for 80% of agricultural surface area in Italy, the proportion is 70% in Greece and Portugal, 60% in Spain and 40% in France (FAO, 2013). These figures clearly show the coexistence, alongside family farming, of vast production units, comprising agribusiness or landowner agriculture.

From the outset, the CAP identified family farming as the model for development of European agriculture. Price support (border protection, aid for exports, supply management) enabled considerable development and modernization of farms, leading to a concentration of land ownership and a rural exodus, without compromising their family-run character. Then, gradually a modernized model of family farming began to emerge, which adopted business rationales while retaining the fundamental link between the household and production unit. Starting in 1992, CAP reforms moved towards dismantling price support and supply management in favour of direct income support based on agricultural surface area and linked to environmental criteria (greening). This development within the CAP, based on the liberal principle of making productive decisions subject to market signals (prices) – dictated by the demands of the rules of international trade (World Trade Organization) – has led to increased concentration of production units and the accelerated development of non-family forms of agriculture, which now account for 60% of agricultural surface area in a country like France.

The Mediterranean part of the EU has been less affected by this process. Examples include Italy, where the model of modernized family farming is still widely predominant, or Greece, where the existence of family farms has helped to cushion the impact of the economic crisis by offering a living and jobs to large numbers of unemployed young people and city dwellers who have returned to the land. The strength of Mediterranean family farming in the EU lies in the fact that it has been able to retain a social purpose and assign this an economic value: short supply circuits, recognized quality products that are rooted in territories and often linked to the Mediterranean diet, organic agriculture, etc. It has also taken advantage of opportunities offered by certain provisions of the CAP and their implementation at national level, in favour of less favoured areas and producer or rural development organizations. New demand by a growing number of consumers seeking local, quality products is strengthening this momentum, to the point of offering an alternative to a shift towards the chemical intensification and financialization of agriculture. Family farms that have not embarked on this latter path are currently the most vulnerable within the EU, and are the most seriously threatened with disapperarance due to competition from landowner agriculture and agribusiness.

In southern and eastern countries of the Mediterranean, family farming has not benefited from price support, as it has done within the EU. As large-scale agricultural importers, these countries are generally more concerned about access to cheap food for urban populations than about the revenues of local producers, and for this reason they strongly restrict the extent of protection of agricultural products at their borders. Depending on the the countries under consideration, small-scale family farms receive varying degrees of attention. Here, it is worth mentioning the Green Morocco Plan, one of whose pillars focuses on support for vulnerable agricultural areas and small-scale units of family-run production, as part of projects with a strong territorial dimension. Likewise, the Algerian policy of rural renewal favours territorial approaches in the form of local development projects, whose impacts can be beneficial to small-scale family farming. The land tenure situation of these countries is also very different from that of EU member states. Their land tenure systems are still strongly influenced by the dual legacy of the Ottoman Empire and measures taken after decolonization. They are characterized by the strong grip of state control and by the complexity and variety of land tenure status bequeathed by history, which is the cause of substantial inequality in land distribution.

Family farming in the southern and eastern Mediterranean region represents a reservoir of jobs and labour, often employing more than 10% of the total population: 30% of the active workforce is employed in agriculture in Egypt, 40% in Morocco and 20% in Algeria and Tunisia (FAO, 2014b). Mostly practised on small suace areas, it easily dominates in terms of numbers of farms (compared with large landowner estates or industrial farms), but much less so in terms of agricultural surface area. In Egypt, small-scale family farms of fewer than 5 hectares account for 98.2% of total farms, but only occupy 70.7% of agricultural surface area. In Algeria, the figures are respectively 55.4% and 11.3%, in Tunisia, 53.5% and 10.9%, and in Morocco, 69.8% and 23.9% (FAO, 2014b). This observation, however, should be tempered by the fact that figures on agricultural land use fail to convey the use of free range grazing areas by small ruminants, which represent an important activity for family farming in the Mediterranean. And they say nothing about non-agricultural surface areas that supply food products which can be sold in addition to specifically agricultural production (gathering wild food plants, aromatic or medicinal plants, hunting, collecting non-timber forest products).

So there is a real agricultural dichotomy here, with, on the one hand, large landowner estates or agro-business farms that are firmly linked to national and international markets, and, on the other, small-scale family farms that are poorly connected to markets, and which are becoming increasingly fragmented due to the system of intergenerational inheritance, with a high level of poverty. In Egypt, for example, 83% of the very poor and 63% of the poor are concentrated in agricultural areas of Upper Egypt (Ghanem, 2014). Naturally, these different forms of agriculture are not isolated from one another. They interact, along with the flow of labour or products. Such exchanges are sometimes actively encouraged, particularly by the Green Morocco Plan, which promotes the aggregation of small-scale producers around a large-scale farm. The case of Turkey should be singled out. An important agricultural country, it has the budget to implement an agricultural policy that adopts certain features of the European CAP: progressive dismantling of border protection to make way for direct aid to producers' revenues, support measures for certain sectors, crop insurance programmes, etc. Although marked by substantial disparity in land distribution – 79% of farms have fewer than 10 hectares of land and only cover 34% of agricultural surface area (OECD, 2012) – family farming has strong development potential, not least because the country is the only one in the region where climate change could have a beneficial effect, allowing the cultivation of new land at higher altitudes.

Challenges and strengths of family farming in the Mediterranean

Multiple and varied challenges

As previously mentioned, the first challenge facing family farming in the Mediterranean lies in the political crises and conflicts experienced by a number of countries, which directly affect the daily lives of people, including farmers. More generally, the poor economic growth of many Mediterranean countries does not allow them to offer an effective framework for developing family farming. These considerations also apply, albeit to a lesser degree, to Mediterranean countries in the EU, which are similarly suffering the effects of a major economic crisis.

Access to resources and lack of recognition. To these challenges, which are strictly speaking external to the agriculture sector, should be added others that are more directly linked to its internal operations, starting with access to resources. Aside from the disadvantage that it suffers in terms of land, family farming must contend with the unequal distribution of water resources, which goes hand in hand with inequality of land distribution, especially in irrigated areas. Access to capital, and especially formal credit, poses a major challenge. The share of credit allocated to the agriculture sector in percentage of agricultural GDP is 27.5% in Tunisia, 14.2% in Algeria, 7.9% in Egypt and 7.4% in Morocco, while that of credit allocated to the private sector in percentage of total GDP in the same countries ranges between 30% and 65% (FAO, 2014b): loans to agriculture are clearly not on a par with the sector's contribution to national economies. If one adds that the loans granted are mainly given to large-scale farms, the extent of the problems encountered by family farming in financing its activities becomes even clearer. It should be noted that the history of land management in the EU, coupled with the effects of the CAP, have combined to significantly attenuate constraints to accessing resources for family farming in Mediterranean countries of the EU. Poor access to resources and lack of financial means are also related to scant recognition of family farming in countries of the southern and eastern Mediterranean, where this activity is often regarded as informal and archaic. This lack of social recognition is compounded by lack of judicial recognition, with heads of farming families and agricultural workers on family farms frequently having no legal status. Very often, land titles do not exist and land use rights are confused. The strong state of precariousness that results acts as a brake on capacities for innovation and risk-taking in family farming – factors which are essential if farmers are to adapt to climate change. The Mediterranean basin is one of the areas on the planet that will be worst affected by global warming. Market access is also difficult for family farms which, taken individually, are of low economic weight. With weak resources that do not enable them to invest in exploring remunerative markets, small-scale farmers are often prisoners of trade circuits that give them limited negotiating power with buyers of their products. They receive little benefit from training and extension services, which struggle to reach them, and they remain cut off from sources of scientific, technical and economic information. They must constantly juggle between the food requirements of their families, steering them towards self-sufficiency, and core cash flow needs, which force them to sell their output for low prices. Ultimately, very often neither of these needs is adequately covered, with all the consequences in terms of poverty and malnutrition that this entails.

The issue of succession for family farms. One challenge with worrying implications for the future is that of ageing heads of family farms, and their renewal. In countries of southern Europe, 64% of farms of fewer than 5 hectares are held by farmers of more than 55 years-of-age. This ratio becomes 50% for farms of more than 5 hectares. By comparison, in countries of northern Europe, the figures are respectively 51% and 38% (European Parliament, 2014). Access for younger generations to the status of head of farm can often only come about through successions and inheritance, since entering agriculture as a business requires high start-up capital. In addition, many small-scale farmers continue to work well after the retirement age, in order to provide supplementary income. In countries of the southern and eastern Mediterranean, young people are not readily attracted by family farming, which is generally associated with poverty, and they seek to to secure a better future in the cities or abroad. Control of land by older people, coupled with their risk aversion, discourages the younger generation, who would like to develop innovative activities within family farms.

The issue of gender equality and the role of women farmers in family farms. The social organization and values reflected by family farming generate strong gender inequality in the southern and eastern Mediterranean, since women's position is inferior to that of men in the public sphere, outside the family. Of the many indicators of gender inequality, we limit ourselves to mentioning that women account for barely 5% of total agricultural land owners (4.1% in Algeria, 5.2% in Egypt, 7.7% in Lebanon), while they represent 23% of agricultural workers on family farms in Algeria and 34% in Egypt (FAO, 2014b). The issue of gender in family farming is central and complex, for women often play a leading role in households. Women's strong potential has yet to be developed in family farming. One of the most glaring inequalities needing to be addressed is unquestionably that linked to the level of women's education, especially rural women. Despite efforts made in this sector, literacy levels of Moroccan women older than 15 were below 50% in 2015, with an average national literacy rate of 67% (Index Mundi, 2014), and this figure is even lower in rural areas. Nonetheless, it would be unfair to paint an entirely negative picture of family farming in the Mediterranean. Fortunately, the long list of challenges that it faces is compensated by a great many significant strengths

Strengths of family farming

Between resilience and adaptability. Among these, special mention should be made of family farming's strong resilience. Indeed, this type of agriculture can absorb shocks and withstand poor conditions, by accepting under-compensation for work done – something an agro-business or landowner farm can never countenance. Moreover, a family farm has no obligation to ensure a return on capital that is at least equal to the opportunity cost, since it mobilizes funds belonging to the family, which can here too accept under-compensation in order to overcome a difficult period. This is in marked contrast to the shareholders of a firm, who are ready to resell their shares if a more lucrative opportunity presents itself. Such resilience naturally has its limits: that of the subsistence threshold for poorly capitalized family farms, and that of covering fixed costs, especially borrowing costs, for more capital intensive ones. A major cause for abandoning agriculture in Europe remains the inability to pay back loans. This resilience is undoubtedly a strength, for although it involves a sacrifice on the part of the family, it enables the household to weather periods of adversity and bounce back when conditions improve. Agri-businesses or landowner farms meanwhile are far more vulnerable to economic downturns. For this reason, family farming plays a role in mitigating crises and providing refuge, when a country's national economy is affected by recession and unemployment (Goussios, 2016).

Another key strength of family farming, which goes hand in hand with that of resilience, is its considerable flexibility and adaptability. Conducive to rapid and robust decision-making mechanisms, it is particularly reactive to signals from its surroundings. Whether in response to producer prices or incentives from agricultural policies, family farming can instantly adjust decisions on production or use of labour, and modify its technical-economic strategy, while agri-business or landowner farming must cope with the strictures of governance or labour laws (Marzin *et al.*, 2014). That is good news for political decision-makers, who can be certain of seeing their measures on family farming put into effect. It also reveals the considerable responsibility that they bear on the matter. The resilience and flexibility of family farming is equally linked to the fact that family members engaged in agriculture, including heads of farm, very often have sources of revenue other than that generated by the farm. On-farm diversification, which is one of the features of this type of agriculture, also makes a contribution, reducing risks and enabling opportunities to be seized. The development of agro- tourism is one striking example, of particular interest in the Mediterranean region, as is linkage to short supply circuits for high added value products.

Family farming: a sustainable model. Unlike industrial or landowner farming, the specific way in which family farms operate makes them a sustainable model, in every sense of the word. Heads of farm manage their patrimony in such a way that the current use of resources does not jeopardize the assets of future generations. In favourable conditions, family farming therefore represents a major tool for the sustainable management of the resources it mobilizes (land, water, biodiversity). Clearly, in the Mediterranean, as elsewhere, there are plenty of examples showing that family farming can destroy natural resources (soil erosion, deforestation, disappearance of high-value species). But this negative impact is only the result of the unfavourable conditions in which the activity is practised, leaving farmers no alternative in order simply to survive, unlike other forms of agriculture, for which the exploitation of natural resources is sometimes an integral part of the economic model (Clavel *et al.*, 2014).

Potential for development and social ripple effect. Family farming's major strength lies in its potential for development and the ripple effect that this can have on entire societies where it is operating. We have seen the importance of this sector in providing jobs and occupations to members of the workforce. Any improvement in the incomes of members of the workforce engaged in family farming, however modest, has an immediate impact on effective demand for consumer products and represents a source of economic growth for the productive fabric as a whole, at local or national level. Family farming is a dominant activity in rural areas of the southern and eastern Mediterranean, and when it prospers, it becomes a powerful engine for local development. It strengthens food security, creates value that benefits the majority of inhabitants and kickstarts a virtuous circle of job creation and higher standards of living. Rural areas become attractive, including and especially for young people, as sources of opportunities for entrepreneurs.

In these troubled times, such scenarios are worth pursuing, for they more than anything else can make a valuable contribution to bolstering local livelihoods and preventing involuntary migration, whose origins, it is well known, often lie in the deep malaise found in rural areas of the Mediterranean and beyond. For this reason, family farming is a way of conserving agricultural knowledge and knowhow and avoiding their loss and waste. As observed in Chapter 15 on traditional knowhow, family farming in the Mediterranean is a repository of extremely valuable knowhow, built up over the years and enriched by exchanges with other parts of the world. This type of agriculture offers a framework for its transmission from one generation to the next. Loss of knowhow is today unacceptable, at a time when the challenges facing Mediterranean agriculture, starting with climate change, demand that all forms of knowledge be mobilized. A repository of knowhow that has been accumulated, family farming is also an incubator of new knowledge, developed through practice and whose emergence is activated by the appearance of new conditions. Through its flexibility and capacity for adaptation, it becomes an extraordinary laboratory, a melting pot for local knowledge and exogenous knowledge, traditional knowledge and scientific knowledge, a legacy for the future of Mediterranean agriculture. The challenge is to ensure that these flows of knowledge and information can reach family farming.

Policy recommendations

The extraordinary potential offered by family farming for the development of countries of the southern and eastern Mediterranean, and for the setting in place of more sustainable agriculture on both shores of the Mediterranean, calls for the design and implementation of policies which can help it to become a reality. To this end, rural and agricultural policies should mitigate the challenges facing family farming and build on its strengths.

The development of the CAP will determine the future of family farming in the EU Mediterranean countries. The dismantling of the milk quota system at the end of 2015 brought an end to one of the last European mechanisms for supply control. It is not realistic to think of returning to the days of price support. Family farming in the Mediterranean has shown that it held up rather better than agriculture in northern Europe to the emergence of other more capitalist models. As a result, it should be able to retain its dynamism, if the CAP pursues and increases its efforts to develop good environmental practices, typical products and the link between production in a particular territory and areas with a natural handicap. The evolution of the share of the CAP's second pillar (rural development) in the total aid given to agriculture will be an indicator of commitment to pursuing this approach. In France, the priority given to agroecology and territory-based food projects also goes in this direction.

The International Year of Family Farming offered an opportunity for CIHEAM to explore these new approaches. During its 10th meeting held in Algiers on February 6 2014, the Ministers of Agriculture from CIHEAM's thirteen member countries made a clear recommendation to support family farming, "particularly on the southern shore of the Mediterranean – which makes a strong contribution to ensuring the food security of rural households as well as to the sustainable management of natural resources and the promotion of human development, especially for women and young people" (CIHEAM, 2014a). This is a powerful theme for strengthening relations between Europe and countries of the southern and eastern Mediterranean, at a time when it is important to defend the conviction that the future of regional and Euro-Mediterranean cooperation must necessarily involve more projects, networks and initiatives that have an agricultural, food-based and rural scope.

In countries of the southern and eastern Mediterranean, the future of family farming is also very closely linked to the content of agricultural and rural policies and their degree of priority in government agendas. As we have seen, some countries have embarked on a move towards family farming, such as Morocco (Green Morocco Plan) or Algeria (rural renewal). Given the demands of economic diversification, concerns over food security and public and social disorder provoked by the discontent of a rural youth without prospects, a return of agricultural and rural issues to the forefront of national agendas may lead to an upsurge in leadership and trigger awareness of the value of family farming. The International Year of Family Farming has played an important role in this awareness-raising. Now the challenge lies in putting sufficient and adequate measures into practice.

The most important political step to be taken involves ensuring that family farming obtains a social and legal status and that family farmers can defend their interests within professional organizations that are representative and democratic. Beyond their recognized union functions, these organizations must play an economic role in marketing family farming products by concentrating their supply, so as to collectively strengthen family farmers' bargaining power on prices. The same applies to supplying farms with inputs and equipment. When strengthened and recognized, such professional organizations can also serve as an interface between family farmers and other sources of agricultural knowledge (research, extension, enterprises, etc.). It should be stressed that here we are talking about interface, and not a vertical, top-down knowledge chain, with family farmers as the receptacle. What is important is to foster cross-fertilization of knowledge, capitalizing on the knowhow of farmers and jointly developing new useful and functional knowledge, based on sharing everyone's contributions. This kind of effort is critical to developing relevant solutions to challenges posed by climate change. On this issue, family farmers in countries of the southern and eastern Mediterranean possess knowhow and experience that can be valuable, including for agriculture in European countries. As observed in Chapters 14 and 15, there is a need for multi-stakeholder partnerships and projects to develop, so as to set in place new knowledge and innovation systems, with professional organizations positioning themselves at the centre. Likewise, these can play a leading role in empowering rural Mediterranean women, helping them to realize their potential, which can never be fully expressed in current conditions.

Promoting access to productive resources for family farming

Another major facet of policies favourable to family farming involves access to productive resources, first and foremost land. The issue is a thorny one and attempts at agrarian reform in countries of the southern and eastern Mediterranean have produced results that fell well short of expectations (for example in Egypt and Algeria). A number of problems have been raised by the allocation to private individuals of land which is part of private state property (Tunisia, Algeria, Egypt). The urgency of an agricultural revival, so as to diversify the national economy in countries like Algeria calls for massive investment in family farming and the country's rural areas, which would undoubtedly have positive repercussions for the economy as a whole. Access to credit for family farms also poses a problem that is hard to resolve, given the way the banking system works in a number of countries of the southern and eastern Mediterranean. In this respect, the many well tested experiences of microfinance in the region (Tunisia), and to an even greater extent further afield (sub-Saharan Africa, Asia), merit investigation, assessment and mobilization, setting in place an ambitious financing mechanism for family farms and other emerging microenterprises in rural areas. In order to achieve their full effect, these measures must be accompanied by massive investment in the rural sector, to serve as a framework for the practising of family farming. It is unrealistic to expect to interest young people in agriculture if there is no road linking rural areas to markets and the outside world, and if there are no schools, hospitals or even health care centres and Internet connections.

These recommendations have already been announced and are mentioned here by way of reminder. One sector that is rapidly expanding, and for which the intervention of the public authorities as regulator will be of paramount importance to the future, is that of digital agriculture. Essentially neutral, the digitalization of agriculture, which is in the process of revolutionizing production techniques, does not offer an agricultural model. It consists of producing and enhancing a massive volume of digital data that enables agriculture to be piloted (precision agriculture, decision support tools), or information to be instantly exchanged between different actors. It can equally well be applied to agribusiness, landowner agriculture or family farming, promoting the emergence of an agroecological agriculture, just as much as it can foster the development of agriculture that focuses on short-term profit. It all depends on the mode of data management and its use. The role of public authorities in this is decisive. They must ensure both that the new agricultural era does not bypass the great majority of farmers – who are family farmers – and that digital agriculture is put at the service of protecting the planet and tackling waste. They should also ensure that this digital data, like the infrastructure that will be set up to manage it, is accessible to all, and that the skills needed to implement the digital revolution in family farming emerge, by directing fresh and greater efforts towards the training of young people. Let us set ourselves the objective of achieving this vision, in which family farms and intelligent rural development offer opportunities, jobs and an attractive quality of life to future generations.

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CHAPTER 17

ENHANCING KNOWLEDGE FOR FOOD SECURITY

Biagio **Di Terlizzi**, *CIHEAM*
Mohammed **Bengoumi**, *FAO, SNE*
Hamid **El Bilali**, *CIHEAM*
Alberto **Dragotta**, *CIHEAM*

According to the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009), agricultural knowledge, science and technology (AKST) are of paramount importance to address different development and sustainability issues: hunger, poverty, rural livelihoods, human health, and sustainable development. AKST become even more important when considering that achieving development and sustainability goals has to be placed in the context of a rapidly changing world of urbanisation, growing inequities, human migration, globalisation, changing dietary preferences, climate change, environmental degradation and the growing use of alternative energy sources such as bioenergy including biofuels and an increasing population. Therefore, achieving development and sustainability goals would entail increased funds and more diverse funding mechanisms for inter- and multi-disciplinary agricultural research and development as well as associated knowledge systems.

According to Tara Garnett (2013), the food "problem" has become a global obsession. Feeding the growing world population requires new strategies and new multicultural and multi-sectoral rethinking capable of generating new forms of dialogue, at different specialist levels, to ensure food and nutrition security (Godfray *et al.*, 2010). An answer to this challenge is undoubtedly represented by the development of the research and innovation sectors and by an increase in the degree of the awareness of their actors on the needs for involving all the food chain operators in decisions pertaining to food and nutrition security. Accordingly, knowledge and innovation transfer should be effective and supported by appropriate policies and investments. This implies the creation of stronger linkages between researchers and producers thus shortening the knowledge chain (Adinolfi *et al.*, 2015). In order to elaborate tangible solutions, it is important to promote effective cooperation and dialogue among the agri-food system actors, established by innovative and evidence-based policy instruments that not only foster knowledge generation but also its multi-directional and circular flow. Policies should also help creating an enabling environment for innovation.

In this chapter we will explore options aimed at better linking supply and demand in the agri-food knowledge chain in relation to food security in the Mediterranean area, which would in turn make the agri-food research system more effective and efficient in the reduction of knowledge waste. The first section provides an overview of agricultural knowledge generation and dissemination and an analysis of the role of agricultural extension and advisory services within the agricultural innovation system. The second section highlights the main needs related to the four dimensions of food security (i.e. availability, access, utilisation, stability) in the Mediterranean with a particular focus on southern and eastern Mediterranean countries (SEMC). The third section presents different options and strategies for the development of an effective knowledge system for sustainable food security. We will see that these would include the adoption of a new transdisciplinary science of sustainable food systems and the participation and involvement of the different stakeholders in the governance and management of the knowledge chain.

Knowledge, technology and innovation in Mediterranean agriculture and the agri-food sector

Farmers' knowledge is continuously developing as a result of new insights, their day-to-day experience and their access to information. "Indigenous knowledge", which is not limited to technology, refers to knowledge that is unique to a given culture, society or environment, which forms the basis on which local decisions are made. It is dynamic and in a continuous process of change and therefore does not command the same status as what is referred to as "formal scientific knowledge" (Salm *et al.*, 2010). As David Millar *et al.* (2006) emphasise, we should be careful not to use western standards to measure traditional knowledge. Different worldviews, belief systems and visions of leadership, for example, influence not only which knowledge is relevant and prevalent in rural areas, but also how knowledge is developed and transferred. A type of education that is not linked to local views runs the risk of being irrelevant and disconnected from people's realities. This disconnection between formal education and indigenous knowledge, that is more context-specific and linked to reality, is one of the causes of knowledge waste as well as the ineffectiveness of education systems in many countries in solving real-world problems and addressing societal challenges.

Preserving and promoting traditional food knowledge in Lebanon: the TerCom project

As part of its activities, the TerCom cooperation project (*Activation of Mechanisms to Sustain Rural Territories and Communities*) in Lebanon prepared an Atlas of Traditional Products. The project was financed by the Italian Ministry of Foreign Affairs and International Cooperation and the Apulia Region. Published by the Lebanese Ministry of Agriculture, the Atlas represents a new initiative to promote local and traditional knowledge with regards to food preparation and culinary traditions. Divided into seven sections it gathers 88 fact sheets about typical products (cereals, beverages, culinary specialties, animal and vegetal products and desserts) and 72 typical traditional recipes identified through several visits made jointly by the project team and the experts of the Lebanese Ministry of Agriculture. This recovered knowledge has been also made available for the three Local Action Groups (LAGs) created by the same project in Tyr, Baalbek and Byblos. Thanks to this Atlas, small producers can be recognised at the local level and participate in the process of the development of the region. Promotion of Lebanese traditions at local and international level is also possible through this Atlas.

Source: Annarita Antonelli, CIHEAM-Bari.

According to the IAASTD (2009), the scope of agricultural knowledge goes beyond the narrow confines of science and technology (S&T) and encompasses other types of relevant knowledge (e.g. knowledge held by agricultural producers, consumers and end-users). Therefore, any assessment of agricultural knowledge should adopt a multidisciplinary and multi-stakeholder approach requiring the use and integration of information, tools and models from different knowledge paradigms including local and traditional knowledge. The IAASTD assessed both formal S&T and local and traditional knowledge, addressed agricultural production and productivity but also the multifunctionality of agriculture[1], and recognised that multiple perspectives exist on the role and nature of AKST. Once AKST are directed simultaneously toward production, profitability, ecosystem services and local food systems, then formal, traditional and local knowledge need to be integrated. Traditional and local knowledge constitutes an extensive realm of accumulated practical knowledge, especially by farmers and rural population, and has a knowledge-generating capacity that is needed if sustainability and development goals are to be reached (IAASTD, 2009).

Involving coastal communities in knowledge conservation and natural resources management: the NEMO initiative (Tunisia)

The NEMO project ("Cross-border rural coastal communities development in Libya and neighbouring countries – Egypt and Tunisia") is a cooperation initiative for the development of the region funded by the Italian Ministry of Foreign Affairs (Directorate General for Development Cooperation) carried out through a voluntary contribution of the CIHEAM-Bari, which is the implementing agency of the project, jointly with the General Direction of Fishery and Aquaculture and some Tunisian institutions. The project includes three main areas for local development: improving local governance, stopping the migration of local fishermen and enhancing local production.

The multi-purpose fishing centre in Zarzis archives local and traditional knowledge that has been discovered during the implementation of the project. This centre is to become the core of a development strategy for the local coastal communities and hosts activities to promote the main fishery knowledge and products, local foods and craftsmanship. Ancient knowledge and innovation are disseminated through meetings and training sessions targeting especially young fishermen.

Source: Daniele Galli, CIHEAM-Bari.

1 - The terms "multifunctionality in agriculture" or "multifunctional agriculture" are generally used to indicate that agriculture can produce various non-commodity outputs (e.g. environmental services, positive externalities, public goods) in addition to its primary function i.e. food production.

In many areas, traditional agricultural knowledge systems have evolved in the last years towards an innovation systems approach. In this approach, innovation is regarded as an interactive process between individuals and organisations possessing different types of knowledge within a particular social, political, policy, economic, and institutional context. This approach has seen its origins in the 1970s and 1980s when production had become more knowledge-intensive with a greater role played by non-material assets (research, training, management, etc.). This kind of knowledge has been defined as "tacit", often embedded in skills, beliefs or ways of doing things. Mastering tacit knowledge requires a conscious effort at learning by doing, using, and interacting (World Bank, 2007a). The innovation system approach should be considered as complementary to previous approaches (NARS and AKIS) that are still valid when analysing or promoting agricultural development.

In the 1980s the "National Agricultural Research System" (*NARS*) approach was applied focusing on strengthening research supply by providing infrastructure and developing capacity, management and policy support at the national level. The NARS comprises all the entities in a given country that are responsible for organising, coordinating, or applying research that contributes explicitly to the development of its agriculture and the maintenance of its natural resource base (World Bank, 2007a). In the 1990s, the "Agricultural Knowledge and Information System" (*AKIS*) concept appeared that recognises that research is not the only means of generating or gaining access to knowledge. This approach gives much more attention to the links between research, education, and extension and the farmers' demand for new technologies. The AKIS links people and institutions to promote mutual learning and to generate, share and utilise agriculture-related technology, knowledge, and information. An AKIS integrates farmers, agricultural educators, researchers, and extensionists to harness knowledge and information from various sources (World Bank, 2007a).

Besides farmers, the main components of any agricultural knowledge chain including agricultural innovation systems are research, training, education and extension. The linear model and the agricultural innovation system perspective have different views on the role of actors in innovation. The linear model emphasises on research and extension organisations to promote agricultural development. Nevertheless, experience has proved that multiple sources of innovation actors outside government have significant contribution to the creation, diffusion and application of knowledge. For instance, the World Bank (2007a) revealed that the private sector and farmers play a central role in the innovation process. The adoption of a linear model, which assumes that research centres are the only source of knowledge (scientific and formal), is also one of the causes of knowledge waste as it does not give the other types of knowledge (local, traditional, indigenous) the importance they deserve.

In the innovation system perspective, the role of research is different. It bases innovation on the diverse and interactive generation of knowledge in the public and private sectors and in civil societies (World Bank, 2007a) and supports the fact that research must focus more on developing strong interactions and linkages between research and relevant sectors. It is essential that the research system engages universities and research institutions, the private sector, producer organisations and cooperatives as well as civil society organisations and stimulates the scaling-up of farmers' local innovations (Hall *et al.*, 2007; World Bank, 2007b). According to Norman Clark (2002), the Agricultural Innovation System (AIS) concept recognises that the innovation process involves not only formal scientific research organisations, but also a range of other organisations and other non-research tasks. Moving from the formal, linear agricultural innovation model towards transient interactive knowledge networks has very considerable implications for the role of public research and development (R&D) organisations that need to accept that science is by no means the only driver of innovation and that innovation can result from new social, economic and environmental challenges and opportunities (Daane, 2010). Traditional R&D must evolve towards Agricultural Research for Development (AR4D), which integrates research much more into the processes of transforming the agricultural sector (Daane *et al.*, 2009).

"Agricultural extension" is the defining metaphor for all technology transfer activities and models in agriculture. In the context of the innovation system, this transfer does not only include the dissemination of "pre-defined" technologies but also interactive and learning approaches. According to Cees Leeuwis (2004), communication for innovation should serve as a "two-way" or "multiple-way process", in which several parties involved in the process of knowledge generation and dissemination – not only research centres – can be expected to contribute with relevant insights. Agwu Ekwe Agwu *et al.* (2008) emphasise that the new approach should promote not only technical innovations, but also institutional, organisational and managerial innovations. Extension needs to provide a wider range of services to a more diverse clientele to improve their capacity to access, adapt, and use knowledge, inputs, and services. So, extension systems must be flexible, user-driven, and focused on local problems. Developing better habits and practices that promote wider interaction and learning is perhaps the greatest challenge for extension organisations (World Bank, 2007b). Extension must serve as a bridge to link farmers with other farmers and the research world, the private sector, training organisations, input and credit suppliers and policy makers to demand-driven innovations.

The education system also needs to adapt to meet the needs of the enhanced dynamics of agricultural innovation. Education institutes must offer more relevant subject matter for agricultural innovation, but this is not enough. It is also important to foster co-innovation initiatives, which entail working in inter-organisational and multi-actor teams. Effective co-innovation teams require competent individuals, not only in their profession's subject matter, but also in solving complex problems jointly with people from complementary professions and with non-professionals by exchanging knowledge and mutual learning. Performance will depend on the soft skills of the team's members (teamwork, communication, leadership, facilitation, negotiation and conflict-management skills) (Daane, 2010) but can also be enhanced by abilities in systems thinking and the adoption of a soft system methodology (Checkland *et al.*, 1990) or the multi-actor and participatory management of processes (Daane, 2010).

Investments in agricultural research and development (R&D) have paid off abundantly. Information from the Agricultural Science and Technology Indicators (ASTI) database suggest that R&D spending produced average returns in the order of 36%

(Alston *et al.*, 2000). Still, investment in agricultural R&D in SEMC is very low compared with the world average (FAO, 2015). In 2012, the highest agricultural R&D spending as percentage of agricultural GDP and number of agricultural researchers per 100,000 farmers was recorded in Lebanon and the lowest in Algeria (Table 1).

Table 1 - Agricultural R&D indicators in public institutions for selected Mediterranean countries in 2012

Country	Spending (millions of constant 2005 USD) at purchasing power parity (PPP)	Spending as percentage of AgGDP	Total number of agriculture researchers (in fulltime equivalents, FTEs)	Number of researchers per 100,000 farmers
Algeria	91.6	0.21	593.4	17.6
Egypt	528.4	0.44	8,419.7	133.3
Morocco	147.3	0.49	556.3	19
Lebanon	38.2	0.95	209.2	747.1
Tunisia	63	0.64	541.6	66.1
Turkey	537.3	0.51	3,009.4	38.5

Source: ASTI database (www.asti.cgiar.org/data).

In most SEMCs the traditional approaches of agricultural knowledge generation and dissemination based on technology transfer and delivery have gradually changed, fostering decentralisation, involving private actors and civil society organisations and improving institutional capacity. However, despite the various reform processes of innovation and knowledge systems, there are still several constraints that limit the concrete possibility for some groups to adopt innovations (e.g. smallholder farmers, marginal livestock producers and women farmers). Also, this process presents some criticalities due to constraints of the institutional, economic and financial context of some Mediterranean countries. In this regard, literature case studies show that the presence of the following key conditions might lead to interesting experiences of innovations adoption: effective participatory approaches, activation of appropriate financial and credit facilities, reactive institutional framework (Adinolfi *et al.*, 2015; Feeding Knowledge, 2015).

Knowledge and research needs for food security in the Mediterranean

The Rome Declaration on World Food Security in 1996 defined its three basic dimensions as: availability, accessibility and utilisation. In 2009, the World Summit on Food Security completed this definition by adding the dimension of stability/vulnerability (Berry *et al.*, 2014). Therefore, food security is built on four pillars (CFS, 2012; UN-HLTF, 2011; Ericksen *et al.*, 2010; FAO, 2008): *availability* of sufficient quantities of food on a consistent basis; *access* for everyone to the necessary resources to obtain appropriate foods for a nutritious diet; appropriate *use* based on knowledge of basic nutrition and care; and *stability* in food availability, access and utilisation.

According to Tara Garnett (2013), three perspectives are broadly emerging on how to achieve sustainable food security and food system sustainability: efficiency orientation focuses on changing patterns of production, demand restraint focuses on reducing excessive consumption; food system transformation considers both production and consumption. These perspectives are neither rigid nor mutually exclusive. A composite approach to tackling the food sustainability problem, drawing upon all three perspectives, is needed.

A comprehensive approach for tackling the issue of food and nutrition security requires: 1) taking into account the interconnectedness and interactions between the four food and nutrition security dimensions mentioned above (availability, access, utilisation and stability); 2) integrating all the stages of the food chain, including food production, sourcing and distribution; and 4) ensuring multi-sectoral engagement and coordination of sectoral policies (e.g. agriculture, trade, health, education, nutrition) (UN-HLTF, 2011). Achieving sustainable food security requires transition towards more sustainable food consumption patterns and diets. It requires also efforts on both sides of the food chain: food production and food consumption (Capone *et al.*, 2014).

The main challenge of AKST is to increase the productivity of agriculture in a sustainable manner. This knowledge must address the needs of small-scale farms in diverse ecosystems and create realistic opportunities for their development where the potential for improved area productivity is low and where climate change may have its most adverse consequences. Sustainable agricultural production can be established by expanding and extending the use of local and formal AKST to develop and deploy cultivars adaptable to site-specific conditions; improving access to resources; improving soil, water and nutrient management and conservation; pre- and post-harvest pest management; and increasing small-scale farm diversification.

Ensuring food security in arid areas: the MARSADEV project for promoting community management of natural resources (Egypt)

The MARSADEV project is funded by the Italian Ministry of Foreign Affairs (General Directorate for Cooperation and Development, IMFA-GDCD) through the Italian Food Aid Fund. Implementing agencies are the Ministry of Agriculture of Egypt and the Desert Research Center (DRC of Marsa Matrouh, Egypt). The CIHEAM-Bari is the executing agency. The project has developed several key activities to improve the living conditions of the Bedouin rural communities in the North West region of the Matrouh Governorate. The recovery of irrigation systems in Wadi systems helped to provide water for crops and families, and thus ensure food security of the population. By merging valuable local knowledge with modern technologies, typical crops yields (figs, olives) have increased by improving agro-processing quality and safety. To achieve its goal, local researchers have been involved in a productive dialogue merging technical and traditional knowledge with beneficiaries whereas local plants and crops such as *Opuntia ficus-indica*, *Atriplex litoralis spp.*, *Moringa oleifera*, *Medicago arborea*, which are used for both income generation and erosion control were promoted.

Source: Ivan Virtuosi and Pandi Zdruli, CIHEAM-Bari.

With virtually no spare land and water resources left for agriculture expansion, except in very few SEMCs (Bruinsma, 2009), growth in agricultural production will be primarily driven by increases in agriculture productivity, increases in value addition and reduction in food losses (FAO, 2015).

Palm dates and fig value chain enhancement: a community-based approach in Tunisia

The Tunisian project is based on a new approach aiming to add value to local products and reinforce capacities of concerned vulnerable communities including women and youth. At a first stage, the analysis of the palm dates and fig value chain identified stakeholders and partners that could develop these local products and facilitate their market access. Many training and awareness-raising workshops were organised to implement an action plan through a participatory approach involving rural youth and women. The methodology was based on a "participatory analyses of competitive advantages" aiming to implement a concrete action for a sustainable rural development. The SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) was an important tool used to perform a diagnosis of the advantages and difficulties of each locality involved in the value chains of palm dates and figs. At each stage of the study, the local community was involved in the diagnosis and the decision making through investigation meetings, interviews, capacity-building workshops, discussion of results, main findings and recommendations.

Source: Mohammed Bengoumi, Subregional Office for North Africa (SNE), FAO.

Addressing food and nutrition challenges in the Mediterranean region requires many actions. One of these is a better involvement of food chain actors in the research cycle management and food system governance.

Involving research institutions and producer organisations to ensure food security: a participatory approach in Morocco

The Moroccan agricultural strategy, Green Morocco Plan, established in 2007 by the Ministry of Agriculture and Fisheries aims to consolidate the success achieved by Moroccan agriculture and to meet the new challenges of competitiveness related to the opening of markets. The programme set up to establish an enabling environment for producer organisations includes a new legal framework governing inter-professional organisations and gathering all the value chain actors and new institutional partnerships with the Ministry of Agriculture. The inter-professional organisation is the only representative of the value chain with the Government. It contributes to the formulation and implementation of the national value chains development strategies. Programme agreements are signed between the Ministry of Agriculture and each inter-professional organisation mainly for extension activities and also applied research. Considering this, tripartite agreements have been concluded between the Ministry of Agriculture, inter-professional organisations and research and academic institutions. Inter-professional organisations play an important role in the design of applied research and innovation. They contribute to funding some research activities using allocated funds in support to the value chain by the Ministry of Agriculture. The results are transferred to farmers using adapted extension programmes including Farmer Field Schools.

In support of the Green Morocco Plan, the FAO has initiated several projects in Morocco to establish an enabling environment for the better contribution of professional organisations to food security (reform of the legal framework) the establishment of the new national Office for Agricultural Advice and the design of a national platform for extension using new technologies for information and communication.

Source: Mohammed Bengoumi, Subregional Office for North Africa (SNE), FAO.

The use of new information and communication technologies (ICT) is also a key factor in increasing productivity while reducing food losses especially those caused by pests and diseases.

Supporting local cooperatives in the main olive producing regions: the *Olio del Libano* project

The "Social and economic support for the families of producers in olive-growing marginal regions in Lebanon", also named "*L'Olio del Libano*" project, was implemented from 2008 to 2012 by the CIHEAM-Bari in partnership with the Lebanese Ministry of Agriculture and funded by the Italian Cooperation. The main objective of the project was to improve the economic conditions of the Lebanese olive growers through actions of support for the olive industry. In an Internet portal (www.oliolibano.net), users can find useful technical documents and news about the Lebanese olive oil chain as well as technical information resulting from the demo plot experiences. The portal describes the main goals; the calendar (trainings, workshops, field days and events), the monitoring of pests and diseases, the field's activity, downloadable information sheets, phytosanitary bulletins, technical brochures and other materials; 27 regional satellite imagery olive maps (maps); pictures and press releases; updated information. Data may be inserted online in the technical access area (intranet) available for the project's technicians.

Source: Enrico Azzone, CIHEAM-Bari.

The focus of knowledge generation and dissemination in the Mediterranean should not only be on crop production because the contribution of animal production is also crucial to achieve food and nutrition security. This also implies actions regarding the increase of aquacultural production of fish that would reduce pressure on marine ecosystems.

Developing innovative technologies for the production of quality fingerlings: the MADE projects in Egypt

Fish is healthy and reduces the risk of coronary heart disease up to 36% thanks to omega-3 fatty acids. Egyptians usually have a high consumption of fish and this consumption is increasing. Therefore, the country's fish production models require new adaptive strategies. Marine aquaculture could play a greater role in increasing fish supplies and strengthening the national economy. This is a completive sector as production costs are much lower than in Europe. The *Marine Aquaculture Development in Egypt* (MADE) projects – funded by Italy and Egypt (Debt for Development Swap Programme) and coordinated by CIHEAM-Bari and the General Authority for Fish Resources Development (GAFRD) – aim at consolidating marine aquaculture through the development of new hatchery technologies for the production of fingerlings of sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*). The new plant, Agami K21/Alex, produces 5-7 million of 1.5g fingerlings a year, thus supporting the private sector in the Nile Delta area. The MADE projects promote among Egyptian investors to foster the dissemination of innovative technologies and soft knowledge related to aquaculture, thus contributing not only to achieving food and nutrition security in the country but also to the economic development of coastal areas.

Source: Roberto Ugolini, CIHEAM-Bari.

The Feeding Knowledge programme, carried out in the framework of Expo Milan 2015, is aimed at identifying knowledge and research needs for food security in the Mediterranean area.

Feeding Knowledge programme for the Expo Milano 2015

Launched in 2012, the Feeding Knowledge programme has been developed by the CIHEAM-Bari in partnership with the Politecnico of Milan in the framework of the 2015 Expo Milano with the theme "Feeding the Planet, Energy for Life". The Feeding Knowledge Programme is part of the intangible legacy of Expo Milan 2015 (www.feedingknowledge.net). It already led to many important outcomes: a Mediterranean network of skills on food security in 10 countries with a Local Point placed at ministries and scientific institutions; an International Network on research and innovation for food security with over 3,000 members (and a database with over 1,000 researches); an International Technology Platform to share information, ideas and researches; five white papers and one policy paper on research and innovation policies for food security; 786 Best Sustainable Development Practices for Food Security candidates at the international competition of Best Practices for Sustainable Development (BPSD) for Food Security (Expo Milano 2015) (more than half of the eligible applications by Euro-Mediterranean countries); models of agricultural enhancement and exploitation experimented with 18 best practices selected among the winners of the competition. Feeding Knowledge assisted National Extension Services in the transfer of knowledge to operators and farmers. The final aim of the programme is the creation of a Euro-Mediterranean Centre of Knowledge for Food Security: a hub of knowledge and expertise based on a consolidated network of research organisations and national institutions.

Source: Damiano Petruzzella and Marinella Giannelli, CIHEAM-Bari; Feeding Knowledge (www.feedingknowledge.net).

The policy paper of the Feeding Knowledge programme has been built following a comprehensive analysis of different elements of the knowledge chain in the Mediterranean region, with a particular focus on the main dimensions of food security: availability, access, utilisation and stability. Table 2 briefly summarises the results of this activity (Adinolfi *et al.*, 2015; Feeding Knowledge, 2015).

Table 2 - Main research needs related to food security in the Mediterranean area

Food security dimension	Research theme	Description
Availability	Managing ecosystem services	The main challenge seems to be the enhancement of ecosystem services, whilst maintaining a productive agriculture. Intensifying production, within environmental boundaries, requires research on the practical assessment and application of technologies such as conservation agriculture, no till or reduced tillage, agro-forestry, mulching, cover crops, controlled grazing, integrating crop and livestock production, well-designed terracing to control soil erosion and the use of halophyte crops in saline areas. Agricultural and innovation policies should be based on the principle of "sustainable intensification", requiring significant efforts in research as well as in knowledge transfer. There is need to manage scarce water resources in a sustainable manner.
Availability	Enhancing quality and quantity of crops and products	Sustainable integrated management and control of biotic and abiotic factors (both during preharvest and postharvest stages) are fundamental to enhance quantity and quality of products. To this aim, research should focus on the efficiency of Integrated Pest Management and organic production systems under an eco-functional intensification approach. This objective needs to be accompanied by actions aimed at developing a better knowledge about food losses throughout the supply chains.
Access	Fostering sustainable development of small rural communities in marginal areas	The lack of human, financial and structural resources in remote communities and isolated households living in low potential areas has implications in terms of food accessibility and affordability. In these contexts the mechanisms of learning and innovation transfer are of pivotal importance in maintaining the wellbeing of local communities.

Utilisation	Promoting sustainable food consumption patterns	There is an urgent need to assess the environmental, economic, social, cultural, health and nutritional sustainability of the current food consumption patterns and diets in order to design comprehensive, coherent and multifaceted nutrition-sensitive policies. These research activities should deal, among others, with: diet nutritional and health implications, food-related environmental footprints, economics of Mediterranean food consumption patterns, food cultures and sociology in the Mediterranean, food system governance and food policies.
Stability	Managing food in an increasingly globalised food system	A main topic for future research in this domain is to strengthen the availability of information as a prerequisite to afford appropriate policy analysis. In this regard, an important priority is to set up tools that help understand how local and regional food systems might be affected by hitherto inexperienced events such as multiple breadbasket failure and what would then happen to trade, price, food access and local land-use decision.

Source: adapted from Adinolfi *et al.* (2015); Feeding Knowledge (2015).

Matching research needs and results

The need for a "short" knowledge chain is becoming increasingly urgent in SEMCs. It is certainly easier to measure the effectiveness of research that is able to address the needs expressed by operators and that is better tailored to the regional context, and able to identify its criticalities and to trace its future developments. Thus, innovation becomes the result of the creation of a network, of an interactive learning process, of a negotiation among heterogeneous stakeholders (Adinolfi *et al.*, 2015).

Successful innovation requires both the "supply-push" of the research community and the "demand-pull" of the users of new knowledge. Indeed, a successful system of innovation requires constant interaction between many organisations and individuals in both camps. Innovation can only take place within an interactive social system, composed of research and researchers, but also of networks of actors that provide communication channels linking organisations and individuals. Such networks can be both formal and informal (Arnold and Bell, 200; Roseboom, 2004; Hall *et al.*, 2005).

According to Cosimo Lacirignola (2015), in order to achieve food security, we should also fight against the waste of knowledge. Traditional agricultural skills deserve greater attention and locally found solutions should be better and more broadly disseminated thanks to modern communication technology. Encouraging the sharing of knowledge, experiences, good practices and ideas is essential. The circular economy of knowledge is incredibly powerful. Innovation is above all the power of federating energies and intelligence put at the service of common goals. To avoid knowledge waste, it is also important to improve access to knowledge by end-users. Thus, the decentralisation of knowledge systems is a key element not only to achieve an effective dissemination of agricultural knowledge but also for the fostering of local innovation systems. However, that may make the governance of the knowledge system more complicated without forgetting the financial implications of a move in this direction.

To avoid knowledge waste, Felice Adinolfi *et al.* (2015) called for the development of an effective knowledge system for food security in the Mediterranean by exploring all the possible options. Feeding Knowledge shares the same aim and tries to enhance dialogue among researchers, policy makers, farmers and all the other stakeholders involved in the food security domain: the needs of local stakeholders gathered in target countries of Feeding Knowledge and the perspectives for research outlined by its network of experts are consistent with each other. The need to bridge a gap of awareness and the adaptation of research results to the local context has clearly emerged. This requires not only the strengthening of services for the transfer of information, but also the adoption of new formulas through which knowledge is mediated and made available for use. Accompanying the introduction of technical innovations with the possible functional organisational adjustments is therefore possible. The divide between knowledge and production systems deepened by the small size of holdings. This pushes towards specific policies for small farmers and towards the adoption of transfer models, which can connect research to family and small-scale agriculture.

Some options for the development of an effective knowledge system for food security in the Mediterranean area

– *Renewing tools and approaches for the re-formulation of social and agricultural policies*: fostering innovation and knowledge development in building agricultural and social policies is a priority. Indeed, in order to make these policies effective and mutually coherent, the decision-making process should be based on accurate and comprehensive information and should be re-organised according to innovative strategies.

– *Supporting new paradigms for access to innovation*: there is a need to strengthen the decentralisation processes of national systems for the spread of innovations, to promote local institutional capacity-building and to develop a participatory approach able to link needs and solutions thereby enhancing formal and informal knowledge resources. This option would lead to several benefits: a shorter knowledge chain, new mechanisms of knowledge co-creation and the transfer of research results also to marginal organisations.

– *Opening up knowledge for food security*: all the potential of new tools and methods for the collaborative creation and sharing of knowledge should be exploited. The common objective should be the inclusion in the knowledge chain of every person who holds knowledge that really matters regarding food security and nutrition. At the same time, access to knowledge should be guaranteed to whoever is interested in it. Massive online open courses allowing social learning, event-based learning paths, peer-to-peer learning processes, citizen science initiatives developed in an integrated way might set the toolbox for the opening up of a new knowledge eco-system for food security.

Source: adapted from Adinolfi et al. *(2015); Feeding Knowledge (2015).*

Feeding Knowledge experts explored several options to build a sustainable approach for research and innovation on food security in the Mediterranean including:

– Reducing knowledge waste: we talk a lot about food waste and the reduction of losses but knowledge waste should also be avoided. Research is often duplicated, repeated or not promoted and enhanced. It is time to produce a useful and innovative body of knowledge and analyses, capable of helping political and economic decision makers.

– Enhancing research complementarities: researching on all issues in all countries at the same time is not sustainable. Yet, research facilities and funds are limited. The pooling of research efforts and scientific capacities is essential. Given the constant reduction of funds for research, international scientific diplomacy should be promoted. Greater attention should be paid not only to technical options for improving efficiency and promoting food security, but also to policy options that ensure cross-institutional collaboration.

– Improving research investments targeting: improving food security in the Mediterranean countries also means providing support family farming and smallholders in rural areas. Optimising investments in research could only have an impact on productivity and profitability if the farmers are directly involved and targeted. Dissemination of knowledge to farmers, young people and women, should be improved. In order to achieve this, a more inclusive approach for territorialised food security strategies should be adopted.

These recommendations clearly show that a new science considering the food system in its entirety and taking into account relations and interactions between the different actors is needed.

The need for a new transdisciplinary science of sustainable food systems

According to IPES-Food (2015), a one-way street of knowledge transmission, from scientists to policymakers, will not suffice to foster a genuine transformation of food systems to make them more sustainable. What is needed is a multi-directional flow of knowledge between the worlds of science, policy and practice. This shift is urgently required for many reasons: food systems are complex "social-ecological" systems that require different sources of knowledge to be combined; political and ethical choices cannot be made by scientists alone; scientific methodologies are not immune from biases and assumptions, and must be subject to deliberation; the recommendations made by scientists must be context-specific and adaptive in order to succeed; and social actors hold unique knowledge that can catalyse change. So, there is a need for a real food-related knowledge revolution to overcome persistent paradigms.

Food systems have to be considered in their entirety, acknowledging the interdependency of sustainable consumption and production. An analytical lens is needed in order to understand the various problems in food systems as the component parts of wider systemic problems. Food systems also refer to the vast web of sectoral policies and regulatory frameworks (agriculture, environment, health and safety, trade, energy, etc.) that shape the food arena (IPES-Food, 2015).

Significant progress has been made over recent years in accommodating different actors, framings and sources of knowledge in leading science-policy initiatives – the IAASTD and also the Intergovernmental Panel on Climate Change (IPCC); the Millennium Ecosystem Assessment (MA); the High Level Panel of Experts (HLPE) of the Committee on World Food Security (CFS). These initiatives have been equally open to diverse sources of knowledge and the diverse worldviews underpinning them. However, initiatives at the science-policy interface have struggled to capture all the aspects of food systems. Assessments have been disproportionately centred on boosting food production, a focus that has found a new incarnation in "sustainable intensification", now widely adopted as a means of squaring environmental concerns with the imperative to grow more food. This tendency to narrow the analytical lens risks perpetuating the agronomic knowledge bias and agro-industrial political bias of the "green revolution". It may also reflect a tendency to prioritise technological innovations over social innovations (IPES-Food, 2015).

In addition to highlighting the importance of access to food, the more holistic concept that recent definitions of food security embody identifies a wide range of research challenges spanning the humanities and social and economic sciences (Pálsson *et al.*, 2011), as well as nutritional sciences. In order to achieve sustainable food security a food system approach is required. Polly J. Ericksen *et al.* (2010) argue that as food systems encompass social, economic and political issues as well as ecological ones, different disciplines must be bridged in order to develop a holistic analytical and research framework.

As most food comes from crops, research has historically concentrated on agronomy and its associated sciences, although livestock and fisheries also received considerable attention. However, the fact that so many people are still facing food insecurity despite global production currently being sufficient for all, indicates that research which considers multiple aspects of food security and food systems is needed (Ingram, 2011). While research on producing food has allowed remarkable gains, the dominance of this research has overshadowed many other important aspects related to the entire food system. While production increase continues to be an important goal, other activities such as food processing, packaging and distributing food, and retailing and consuming food are now all receiving increased attention, and the whole food chain concept is now well established (Maxwell and Slater, 2003; ESF, 2009). More effective policies, practices and governance (institutions and organisations) are needed at a range of levels including spatial, temporal, jurisdictional and other scales (Cash *et al.*, 2006; Termeer *et al.*, 2010). Research has an important role to play in providing knowledge (Ingram, 2011).

In order to improve the sustainability of Mediterranean food consumption patterns a multidisciplinary and holistic regional research agenda is needed. Research results should help in designing adequate policies, guidelines and recommendations for the main Mediterranean food system actors. Research and policy activities must be well coordinated if sustainable qualitative and quantitative results are to be achieved (CIHEAM and FAO, 2015).

Involving farmers and producers in agricultural and food-related knowledge generation and dissemination

Investments in public R&D are not sufficient to boost agricultural productivity. For these investments to pay off, a sound system that brings new knowledge to the farm is required. Unfortunately, this is not happening at the right pace and extent in SEMCs. There are both deficiencies in the extension system and a lack of incentives for farmers to apply new technologies. Key elements of a comprehensive approach to increasing agricultural productivity in the region include: 1) public-private partnerships in extension services and up-scaled farmer field schools; 2) strengthening farmer associations and cooperatives and putting the farmer at the centre of the agriculture productivity enhancement programme; 3) ensuring that expenditures in R&D are sustained over time; and 4) promoting regional collaboration to spur investments, reduce unit costs, and accelerate dissemination and adoption of new and existing technologies (FAO, 2015).

Involving actors from outside the traditional bounds of the scientific community in devising food systems reform is essential, in order to bring in knowledge that scientists may not hold. Agroecology, with its focus on innovation in the field, is a striking illustration of why this matters, and how it can be a catalyst for change (IPES-Food, 2015). While traditional systems marry researchers, popularisers, educators and farmers, numerous studies have highlighted the value of opening the field to other actors, such as consumers, decision makers, industry or other stakeholders, to maximise the impact of innovations (FAO, 2005).

In the last decades, the resources allocated to R&D in agriculture have increasingly been invested in knowledge transfer, reflecting the growing attention given to this issue in developing and developed countries. At the same time, there has been a gradual shift from the traditional linear model of innovation transfer to systemic approaches, where innovation is seen as a complex interactive process involving not only the technological and scientific sphere, but also the social one. As a consequence, the importance of communication and of the involvement of end users through specific activities (e.g. brokerage) has significantly increased. A valuable support to this development can today originate from new forms of spreading information: in the agricultural sector, enhancing or even creating new links between agriculture, local area, and consumers, allows the sharing of innovations and continuous updating, but also helps reach directly the user with precise and personalised messages (Adinolfi *et al.*, 2015).

Investments are needed in agricultural knowledge systems to promote interactive knowledge networks (farmers, scientists, industry and actors in other knowledge areas) and improved access to ICT (IAASTD, 2009). Thanks to new communication systems and to the development of web networks and communities in all SEMCs, users – from passive or uninformed actors – are becoming active participants and promoters of information. This represents a crucial asset for the Mediterranean, where the main problem today does not seem to be the lack of knowledge but rather the need to make good use of it. Therefore, strengthening local capacities to use modern information systems at a wider scale should become one of the policy priorities of knowledge transfer and innovation in agriculture, in order to fill the "information gap", so often mentioned by research stakeholders (Adinolfi *et al.*, 2015; Feeding Knowledge, 2015).

Participatory collaboration in knowledge generation, technology development and innovation has been shown to add value, for instance in Farmer-Researcher groups (IAASTD, 2009). The role of modern ICT in achieving effective collaboration is critical to evolving culturally appropriate integration and therefore merit larger investments and support. Collaboration and integration should be supported by international intellectual property for example, which allow more scope for dealing effectively with situations involving traditional knowledge, genetic resources and community-based innovations (IAASTD, 2009).

Role of producer organisations

Evidence shows that for the development of effective agri-food innovation systems, skills and capacities of individual actors in the agri-food system are important as well as their ability to create synergistic relations and to act collectively. As a matter of fact, innovation presupposes a capacity to innovate at both individual and collective levels. The existence of effective networks and partnerships among the individuals and groups within the system is of paramount importance for building collective innovation capacity. Producer organisations can play an important role in the innovation system especially in areas characterised by the prevalence of smallholders and family farms (FAO, 2014). They can generate business models with a high level of economic efficiency. In addition to mere commercial activity, these producer organisations and cooperatives stand at the core of the development process (World Bank, 2007b), and can also play a key role as actors of change and innovation. Historically, they have often had the ability to find and adopt technical or economic solutions to the problems faced by their members such as difficult access to markets for inputs and outputs, to technologies and to financial services such as credit. They can also serve as an interface between farmers and other actors of the innovation system such as extension and advisory services, research institutions and policy makers. They also help better defining the farmers' service demand and monitor the quality of service supply (FAO, 2014).

Agricultural producers from both shores of the Mediterranean consider farmer organisations as key actors in the drawing up of agricultural policies (IFAP, 2008). Today, due to the pressures on Mediterranean agriculture, rural producers are forced to innovate constantly (El Dahr, 2012). According to Kees Blokland and Christian Gouët (2007), producer organisations represent an effective means of communication and information due to their social network and the many links woven between the members. A consensus is now emerging on their role in the innovation process: they can contribute important innovations at different levels (Gouët *et al.*, 2009) and are part of the social capital, which is the vector of change (El Dahr, 2012).

Promoting knowledge sharing and providing services to small farmers: the COPAG cooperative (Morocco), a success story

COPAG was created in 1987, initially, to support dairy producers. Today it supervises 72 small cooperatives and 14,000 members and deals with the dairy sector, "*primeurs*" and "*agrumes*". Farmers ensure a high quality product to small cooperatives who in turn provide services to all its members (milk collection and storage, use of agricultural material, provision of dairy cattle with high milking ability, capacity building, awareness, etc.).

COPAG provides direct services to small cooperatives such as animal feed and agricultural input supply. It also ensures the processing, packaging and marketing of product. By adopting this monitoring system, COPAG guarantees a better management and supervision of the organisation and also an efficient control of the value chain thus allowing producers to sell good quality milk at a higher price.

Actually, COPAG is the main operator dealing with livestock and dairy products and represents about 20% of the total milk processes. The quality of its products (milk and dairy products) has been recognised and its market is increasing. COPAG is also improving its material capacities, providing to its members, a cattle feed manufacturing unit, a slaughterhouse and other equipment. COPAG provides all technical and marketing services to its members in addition to social activities.

Source: Mohammed Bengoumi, Subregional Office for North Africa (SNE), FAO.

Despite progress in various fields of research concerning them, small-scale farmers and the rural world, especially in the southern Mediterranean, are often excluded from the main currents of innovation. Apart from the lack of financial resources, the chief obstacle hampering innovation by farmer organisations in the region, especially in SEMCs, is the problem of access to certain essential services, namely training, extension services and research. To alleviate these shortcomings, and rely on the potential of agricultural organisations for creating and disseminating innovation, specific "farmer-to-farmer" support and advice schemes have been put in place in recent years especially in the North Mediterranean (El Dahr, 2012).

Peer education allows sharing of information and knowhow or other types of experience in the sphere of technologies, markets. This form of cooperation for sharing "layman's" agricultural knowledge has proved more effective than other forms of support such as extension, often criticised for its top-down and one-way approach (El Dahr, 2012). Producers and their organisations are now placed at the centre of the knowledge triangle which defines the "Agricultural Knowledge and Information Systems for Rural Development" (AKIS/RD) (FAO and World Bank, 2000; FAO, 2005). By making them active partners in these systems, rather than mere beneficiaries, the approach is participatory in that it gives producers a driving role in the process of production and adoption of innovations. Unfortunately, at a time when this form of farmer-to-farmer cooperation is taking off in many geographical zones, supported by European agri-agencies, SEMCs are a long way behind with very few organisations involved in these innovation systems (El Dahr, 2012).

Gender-sensitive approaches in agricultural knowledge, science and technology

Gender, that is, socially constructed relations between men and women, is an organising element of existing farming systems worldwide and a determining factor of ongoing agricultural restructuring. The largest proportion of rural women worldwide continues to face deteriorating health and work conditions, limited access to education and control over natural resources, insecure employment and low income (IAASTD, 2009). Gender inequalities are stronger in rural areas than in cities, despite the great involvement of women for agricultural development and food security. It is therefore essential that employment in agriculture and in rural areas be better considered, services in rural worlds improved and activities diversified.

The elaboration of social and agricultural policies in the Mediterranean should consider more the role of women in agriculture and in all the sectors linked to food security. To achieve food and nutrition security, it is of paramount importance to design and implement gender-sensitive policies that mainstream the role of women in the policy and governance arenas. This should be supported by actions for women's empowerment as only in doing so women will have all the necessary skills to achieve gender equality/equity. Adopting mechanisms that enhance women's skills and knowledge and provide support to forms of women's aggregations, and to the promotion of female entrepreneurship in the agrofood sector, may be effective actions for achieving this goal (Adinolfi *et al.*, 2015).

Enhancing food security in Egypt, Lebanon, and Tunisia through gender mainstreaming: the GEMAISA regional initiative

The regional programme "Enhancing Gender Mainstreaming in sustainable rural development and food Security – GEMAISA" is part of the activities started by the Directorate General for Development Cooperation (DGCS – Italian Ministry of Foreign Affairs and International Cooperation) and implemented by the CIHEAM-Bari, to promote the role of women in rural development and food security actions in three target countries (Egypt, Lebanon and Tunisia) and to foster gender mainstreaming capacity-building of partner institutions. The actions are performed at national level by promoting an institutional recognition of gender mainstreaming for food security through platforms that will involve Ministries of Agriculture as well as representatives of national and local institutions, universities, civil societies, women's associations and the private sector. With the support of the CIHEAM-Bari expertise, the platforms will contribute to the programme's implementation by setting up a grid of analysis and consequently building an approach that could represent a model of multidimensional empowerment of rural women in the Mediterranean region.

Source: Silvia Barbatello and Daniela Palermo, CIHEAM-Bari.

The role of extension and advisory services in agricultural knowledge circulation

The need to increase the efficiency with which scientific knowledge is translated to farmers and other resource managers is well recognised. So, food security is strongly linked to the performance of agricultural and rural extension and advisory services (Ingram, 2011). Easy and timely access to reliable and updated information is crucial for agricultural and rural development and thus for achieving food and nutrition security. Good extension is recognised as a key to agricultural development (USAID, 2012) and can contribute to improving the welfare of farmers and other people living in rural areas (3ie, 2010). Agriculture multifunctionality and rural economy diversification are changing dramatically the classical crop production-centred mission of agricultural extension and advisory services. They need to provide a wider range of services to a more diverse clientele to improve their capacity to access, adapt, and use knowledge, inputs and services (World Bank, 2007b). For extension to be successful, it needs to include credible content, effective delivery and be relevant to and applicable by clients (USAID, 2012). The FAO recognises the important role played by extension in agricultural and rural development processes and therefore, it implemented many initiatives for the improvement of agricultural extension and advisory services in SEMCs with the final aim to develop a pluralistic, decentralised, gender-sensitive, bottom-up and demand-driven extension and advisory service.

The VERCON initiatives of the FAO

Knowledge and information are essential to improve the agricultural sector, but in order to be useful, they must be effectively communicated to farmers. In collaboration with the World Agricultural Information Centre, the FAO developed the VERCON network (Virtual Extension, Research and Communication Network), which is a powerful tool based on ICT and whose objectives are to improve communication between research, extension and farmers (two-way communication), reinforce linkages within agricultural research and extension institutions and close the gap between researchers and extension specialists by improving the generation, flow, sharing and collaborative use of agricultural knowledge and information. Concretely, when a farmer detects a problem causing damage to his production, he/she shares this information with the extension office, the extension worker will identify the problem by consulting the VERCON database and discuss its control with researchers connected to the network. Relevant information is compiled and shared with all extension officers in the region that would communicate it to concerned farmers directly, during awareness meetings or in farmer field schools.

Source: Mohammed Bengoumi, Subregional Office for North Africa (SNE), FAO.

Agricultural extension services in the Mediterranean have evolved towards pluralistic supply models, where the public component is increasingly giving way to private agents and NGOs. An assessment in this regard has been carried out during the Feeding Knowledge initiative: representatives of eight Mediterranean countries have been invited to draw the National Extension Services (NES) features (see Table 3).

Table 3 - National Extension Services (NES): some indicators

Country	No. of Officers: Central Level	No. of Officers: Regional Level	District/Caza/ Municipality Levels	Type of NES	Other Key Actors in NES	Food Security	Trends
Albania	4	60	220	Partially decentralised	Universities, NGOs	Approach for main commodities	– Top-Down with feedback – Setting up more specific financial support – ICT Development
Bosnia	8		61	Partially decentralised	Ministry of Agriculture, Water and Forestry	Market oriented	Interactive Participatory Research and Extension involving private sector
Lebanon	3	15	96	Partially decentralised	University (American University of Beirut), NGOs	– VC approach – Promotion of local products – Market oriented (export) – PPP Approach	– ICT Development – Reinforcing farmer organisations
FYROM*	24	20	80	Partially decentralised	Private Sector Traders	– Strongly market oriented to enhance export and fulfil traders' needs – Rural development approach	– Interactive Participatory Research and Extension with active involvement of private sector – ICT Development

Table 3 - National Extension Services (NES): some indicators (continued)

Country	No. of Officers: Central Level	No. of Officers: Regional Level	District/Caza/ Municipality Levels	Type of NES	Other Key Actors in NES	Food Security	Trends
Morocco	50	200		Partially decentralised	–	Value Chain Approach	Stronger ICT tools usage
Serbia	8	15	247	Partially decentralised	Top-Down	Specific Law on Extension	Interactive Participatory Research and Extension involving private sector
Tunisia	30	50	550 (40% of their time for extension)	Participatory Partially decentralised	– Interactive Participatory Research and Extension (79%) – Active involvement of private sector (21%)	Aiming for self-sufficiency in strategic commodities (wheat)	– Reinforcing link with research – Decentralisation
Turkey	55	918	10,000	Partially decentralised	Interactive Participatory Research and Extension involving private sector	Market oriented	Local and national "Extension Projects"

FYROM*: Former Yugoslav Republic of Macedonia.
Source: Virginia Belsanti, William Critchley, Alberto Dragotta, National Extension Services (NES) orientation paper, Feeding Knowledge programme.

The changes in modern agri-food systems, as well as issues regarding food safety, climate change, the role of multi-functional agriculture and the development of rural areas, are redrawing the boundaries of knowledge information in agriculture, fuelling the complexity of the governance of extension services. However, as highlighted on the occasion of an intensive workshop organised at the CIHEAM-Bari in 2014 in the framework of the Feeding Knowledge programme and attended by representatives of the agricultural extension services of several Euro-Mediterranean countries, there are other constraints which negatively affect the effectiveness of extension process, such as weak relations and coordination among researchers, extension staff and farmers; limited budget allocation; low acceptance of changes in some farming systems; no tradition of on-farm experimentation. Surprisingly, according to the extensionists interviewed, there is little articulated connection between extension and food security (Adinolfi *et al.*, 2015; Feeding Knowledge, 2015). The use of ICT tools can help to overcome many of these obstacles.

Morocco: The National Internet Portal of the Ministry of Agriculture to support farmers as good practice ICT application

The National Office of Agricultural Advice (ONCA) has been created in 2012 in Morocco to implement the new government strategy on agricultural advice. It also ensures monitoring, coaching and professional advice to farmers in technical and management aspects, which are important tasks especially for small-scale agriculture. The new strategy of the ONCA also takes into account the institutionalisation and organisation of the private segment of agricultural extension. More generally, this new strategy highlights the importance of development and modernisation of extension, training and technology transfer for the benefit of various stakeholders in the agricultural sector, particularly farmers. With the aim to support the implementation of its action plan (training, information, awareness and communication), the ONCA has set up broadcasting emissions as well as agricultural ads using its website, radio and TV. In addition Farmer Field schools are developed in close collaboration with professional organisations and private extension experts.

Source: ONCA (www.onca.gov.ma).

Conclusion

The need to support research revolving around food security is nowadays widely admitted as well as the urgency to improve the interface between science and policy as a means to reduce knowledge waste and to move towards more sustainable food systems. The real challenge for science-policy initiatives dealing with food and nutrition security is to resist the narrowing of the analytical lens, and to overcome the fragmentation of food governance and policy spaces (as shown by the prominent role of agriculture ministries and dichotomy between food and health policies) by adopting a systemic, inclusive and holistic approach. In order to contribute to food systems reform, a critical mass of evidence must be gathered and transposed into policy recommendations. Furthermore, this emerging concept of sustainable food systems must take into consideration the voices of academic experts and social innovators and be informed by the knowledge of practitioners, and appropriated by those to whom it seeks to be useful.

Many of the challenges regarding the food system are common to all Mediterranean countries. Therefore it is of paramount importance to set up a joint research agenda to address them in a collaborative way. Cooperation and dialogue on research and innovation, if carried out through the involvement of all actors concerned – from farmers to officers – might contribute to building-up long-term initiatives, tailored to the needs and specificities of each country. In addition, it is of paramount importance to design a sound strategy for reducing knowledge waste in the Mediterranean, building up on the unique features and potentials of this region. After years of intense activities, the Feeding Knowledge programme called for the creation of a permanent Euro-Mediterranean Centre for knowledge development and sharing on food security, able to intervene at all levels of the short knowledge chain, from assessment of needs to the development of solutions and transfer of research results.

To better match the knowledge needs and offer – which is a prerequisite for avoiding knowledge waste – it is necessary to act on both the demand and supply sides of the knowledge system. As for the demand side, research priorities should be better defined in a concerted way and with the active participation of the representatives of the food system (i.e. producers, processors, retailers, consumers as well as policy makers). As for the supply side, the research system should be endowed with the necessary human and financial resources to act on the defined priorities. Resources should not only be dedicated to knowledge generation but also to communication and dissemination. For that, the capacity of bridging actors and knowledge brokers (e.g. extension services, media) should be strengthened along the knowledge chain. Moving towards a circular knowledge system seems to be the best option although it encompasses many challenges.

Agricultural extension and advisory services are widely recognised as critical to agricultural development. More attention should be paid to supporting extension and advisory services to allow them to fully assume their role in achieving food security. It is necessary to develop a pluralistic, participatory, bottom-up, decentralised, farmer-led and market-driven advisory system. The involvement of other actors in the rural extension work is then crucial if the system is to meet the expectations and needs of rural people.

The multiple threats and risks to food insecurity and malnutrition in the region call for strengthened regional collaboration and agricultural and food diplomacy. Countries must develop and implement comprehensive and consultative food security agendas and put food and nutrition security at the top of their policy agenda. In this sense, the CIHEAM and the FAO can play a key role: they offer a privileged arena for exchanges and analyses aimed at developing cooperation between the countries and can, in collaboration with other regional and international organisations, play a lead role in identifying and catalysing partnerships with other intergovernmental organisations, national governments, UN and EU agencies, private sectors and NGOs, to achieve sustainable food and nutrition security. Facing huge and increasing challenges, this is strategic for the future of the Mediterranean countries, underlying the strong necessity to share experiences, adopt collective behaviour and draw a more convergent approach to enhance food security in the region.

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BIOGRAPHIES

Sébastien Abis (coordinator) works as an Administrator at the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), in charge of the strategy, the programming and the publications. He also participates in the work of diplomatic coordination among the thirteen member states of the Organization, attending the Secretary General of CIHEAM. He is also an associate researcher at the *Institut de relations internationales et stratégiques* (IRIS) and scientific advisor for Futuribles International. Besides, he is a member of the editorial board of the journal *Futuribles* and *Confluences Méditerranée*. He is also a member of the scientific committee of the Euromed-IHEDN Association. He regularly contributes to debates and strategic consulting through interventions in media, public lecture, specialized training or towards the private sector.

Luis Miguel Albisu (focal point and author – chapter 13) holds a Ph.D. in Agricultural Economics from Cornell University (United States) and a doctorate in Agricultural Engineering from the Polytechnic University of Madrid (Spain). He also holds an M.Sc. in Agro-Food Marketing from Newcastle University (United Kingdom). He is the Chairman of the Scientific Committee at the Agro-Food Research and Technology Centre of Aragon (CITA) (Spain). He has published in the most important European journals. His research work focuses mainly on food marketing, agro-food industries, agro-food supply chains and knowledge transfer.

Jessica Aschemann-Witzel (author of box – chapter 13) is Associate Professor at the MAPP Centre of Research on Value Creation in the Food Sector and Department of Management, Aarhus School of Business and Social Sciences BSS, Aarhus University (Denmark). She finalized her studies as Dipl-Ing. agr. at University of Giessen (Germany) in 2002 and was awarded the Dr.agr. degree from University of Kassel (Germany) in 2009. She has previously worked as researcher at the Research Institute Organic Agriculture (FiBL) (Switzerland). Her research interests are consumer behaviour and marketing in the fast moving consumer goods market, especially food, with a focus on the issues of health and sustainability. She teaches marketing management, marketing communication and sustainable production and consumption. Jessica has participated in more than twelve research projects in the past ten years, two funded by the EU under FP7 and the others nationally funded German or Danish projects. She is currently leading MAPP's contribution in the project COSUS on consumer food waste perception and behaviour, and starting projects on food pricing and food waste and on potato protein products.

Bernardo Basurco (focal point and co-author – chapter 2) holds a BSc and a PhD (1990) in Veterinary Medicine from the University Complutense of Madrid, followed by postdoctoral stays at the University of California, Davis, and at the INRA, Jouy-en-Josas, France. Since January 1995, he has been working as an administrator of the Fisheries and

Aquaculture research department of the CIHEAM-Zaragoza (Spain). Since he joined the CIHEAM, Bernardo has broadened his knowledge on aquaculture and fisheries issues mainly through the organisation of international courses and workshops both on technical and socioeconomic issues, many of them organized in close collaboration with the FAO Fisheries and Aquaculture Department. From 2002 to 2004, he was a member of the Board of Directors of the European Aquaculture Society (EAS) and more recently, in 2015, he was appointed President of the Spanish Aquaculture Society for the period 2015-2017.

Caterina Batello (focal point and co-author – chapter 15) leads the FAO's Team in Agriculture Plant Production and Protection Division on Agroecology and Ecosystem Management. She has an M.Sc. in Agriculture and is specialized in Tropical Pastures. She was also the lead organizer of the FAO International Symposium on Agroecology for Food Security and Nutrition held in Rome 2014 and of three agroecology events organized in Brasilia, Dakar and Bangkok in 2015 dealing with practices, policies and programmes on agroecology. She is also the Project Manager of many projects in Africa related to climate change and capacity building of farmers and chairs several technical working groups.

Aurore Bénassy (coordinator) is holding a Master in International Relations and International Program Management at the *Institut de relations internationals et stratégiques* (IRIS) in Paris. She is currently Project Officer at the Publication Division of the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) Secretary General in Paris. Specialist of the agricultural, food and climate change issues, she also contributes to communication activities of the CIHEAM Secretary General.

Mohammed Bengoumi (focal point and co-author – chapter 17) is an FAO regional officer in charge of animal production and health and support to professional organizations and e-learning programmes in the FAO Office for North Africa in Tunis. Before joining the FAO in 2008, he was a professor at the Agronomic and Veterinary Institute in Rabat for more than 22 years.

Anthony Bennett (focal point and co-author – chapter 9) is the Agro food Industries group leader (AI) of the Nutrition and Food Systems Division FAO (Rome, Italy). With over twenty years of international experience in inclusive food systems development he is specialized in livestock products processing, dairy industry development and food losses.

Pascal Bergeret (focal point and co-author of chapters 14, 15 and 16) is a Bridges, Water and Forests general engineer and holds a Ph.D. in agricultural economy. He is the former deputy director of innovation at the Directorate General for Education and Research at the French Ministry of Agriculture and is currently director of the CIHEAM-Montpellier (France).

Miguel Bernal (co-author – chapter 2) is a fisheries scientist with a mixed background in marine sciences and statistics, holding an M.Sc. in Statistics from the University of St. Andrews (United Kingdom) and a Ph.D. in Marine Sciences from the University of Cádiz (Spain). Since 2012, He has served as Fisheries Officer at the General Fisheries Commission for the Mediterranean (GFCM) of the FAO, leading activities to improve advice on Mediterranean and Black Sea stocks and the implementation of sub-regional management plans.

Badi Besbes (focal point and co-author – chapter 6) is an Animal Production Officer with more than 25 years of experience in the management of animal genetic resources, with a special focus on characterization, animal identification and recording and breeding, on which he has published extensively. He holds a Master's degree in Animal Science and a Ph.D. in Animal Genetics. Before joining the FAO in 2006, he worked in the poultry breeding industry for 14 years. He also has good experience in supporting intergovernmental policy processes. He is currently based in FAO-Kenya working on pastoral and agro-pastoral systems.

Elena Craita Bita (co-author – chapter 11) graduated in Plant Biotechnologies at the University of Agronomic Sciences and Veterinary Medicine (USAMV) of Bucharest (Roumania) in 2001 and continued with a Master Degree in Horticultural Biotechnologies at CIHEAM-Chania (Greece) in 2003. Later on she took on postgraduate research projects at several laboratories in Germany and the Netherlands, using molecular markers and transcriptomics tools to investigate the molecular response of environmental effects on plant growth and reproductive development. She started her Ph.D. project in 2006 on fingerprinting the effects of heat stress during tomato anther development. During this period, she was also involved in additional activities such as the organization of several scientific events, acting as reviewer for several scientific journals and as guest editor for a special edition of *Frontiers of Plant Sciences* (Nature Publishing Group). In 2014 she returned to the Horticultural Biotechnologies Department in CIHEAM-Chania (Greece) where she investigated various aspects of growth and development in tomato fruits while remaining committed to her responsibilities as scientific editor and reviewer. At present she is working at the James Hutton Institute in Dundee (United Kingdom), on developing potato varieties with improved yield performance under heat stress conditions.

Pierre Blanc (focal point and co-author – chapter 1) is a chief IPEF (*ingénieur des ponts, des eaux et des forêts*), and holds a Ph.D. in Geopolitics (HDR) and an M.Sc. He is a teacher-researcher at Bordeaux Sciences Agro and Sciences Po. Bordeaux (LAM), chief editor of the journal *Confluences Méditerranée* and director of the collection "La Bibliothèque de l'iReMMO" (*Institut de recherche et d'études sur la Méditerranée et le Moyen-Orient*). He is a consultant for the CIHEAM and other research and international cooperation organizations. He is the author of numerous books and articles dealing with the Near-East and the Mediterranean. His work focuses mainly on the rivalries among the main actors in the region, and the links between these rivalries and agricultural issues.

David Blandford (author of box – chapter 13) is a professor of agricultural and environmental economics in the Department of Agricultural Economics, Sociology and Education at the Pennsylvania State University (United States). He was formerly a division director at the Organization for Economic Cooperation and Development in Paris and a professor at Cornell University (United States). Blandford was president of the Agricultural Economics Society of the United Kingdom in 2010-2011. He teaches courses in agribusiness at Penn State and conducts research into food and agricultural policies, including their environmental, trade and rural development aspects.

Francesco Bottalico (co-author – chapter 9) is a Scientific Consultant in the Sustainable Agriculture, Food and Rural Development department of the CIHEAM. He is a Ph.D. candidate in environment, resources and sustainable development. His fields of interest include Mediterranean diets and food consumption patterns, sustainable food consumption and production, traditional products, and food quality and safety.

Matthieu Brun (author – chapter 1) is a Ph.D. student at the Institute of Political Science in Bordeaux. He is currently working in the laboratory *Les Afriques dans le monde* (LAM-CNRS) on development aid in Africa. He has gained expertise in the fields of development and food and agricultural policies and has a strong professional experience with several research centres (*Centre de coopération internationale en recherche agronomique pour le développement* – CIRAD ; *Centre Jacques-Berque* – CJB), with an intergovernmental organization (CIHEAM) and with a think tank specialized in sustainable development (*Institut du développement durable et des relations internationales* – IDDRI).

Camelia Adriana Bucatariu (co-author – chapter 9) is a Technical Officer at FAO, focusing on nutrition sensitive and sustainable food systems; policy and regulatory development; food loss and waste; resource use efficiency; public procurement; and recovery and redistribution of safe and nutritious food for human consumption. She holds a Postgraduate Advanced Diploma from the European College of Parma (Italy).

Sally Bunning (co-author – chapter 4) is a geographer (Nottingham University) specialized in soil and water management. She has an M.Sc. from the National College of Agricultural Engineering in Silsoe (United Kingdom) and a DAA (*Diplôme approfondi en agronomie*) from ENSAM (*École nationale supérieure d'arts et métiers*, France). She spent ten years working in Malawi, Ethiopia, Benin and Guinea Bissau with the Department for International Development (DFID) (Official Development Assistance – ODA), University of Malawi, ILCA-CGIAR, EuroAction Accord and FAO. She joined the FAO in 1989 and after 5 years in Benin, Guinea Bissau and Rome was seconded for 2 years to the Secretariat, Convention on Biological Diversity (CBD) to develop the CBD work programme on agricultural biodiversity. She has contributed to field projects and to the development of guidelines/manuals, worked in favour of field schools on land and water management and agro-biodiversity in Africa, and promoted sustainable land management and local level assessment of land degradation/sustainable land management, in collaboration with the World Overview of Conservation Approaches and Technologies (WOCAT) and other partners. She has also taken part in other watershed/agro-ecosystem management projects.

Roberto Capone (focal point and co-author – chapters 9; co-author – chapter 10) was a principal administrator at the General Secretariat of CIHEAM from 2000 to 2008. Since 2008, he has been holding the same position at CIHEAM-Bari (Italy), where he is also head of the Sustainable Agriculture, Food and Rural Development Department. His fields of interest include food losses and waste, Mediterranean diets and food systems sustainability, and traditional/typical products.

Anna Carlson (co-author – chapter 2) holds an M.Sc. in Environmental Policy and Regulation from the London School of Economics and currently serves as a Consultant at General Fisheries Commission for the Mediterranean (GFCM) of the FAO. Her work focuses on socio-economic issues in Mediterranean and Black Sea fisheries.

Rodrigo Castañeda Sepúlveda (co-author – chapter 14) holds a Master's degree in Rural Local Development from the Polytechnic University of Madrid, a Bachelor's degree in Civil Engineering and a certificate in Public Policies. He is Chief of the Partnerships Unit of the Partnerships, Advocacy and Capacity Development Division in the FAO. Since he joined the Organization in 2007, he has been Special Advisor to the Director General on non-state actors, National Coordination Officer for the Brazil Fund in the FAO Regional

Office for Latin America and the Caribbean (RLC), and Advisor to the Cabinet of the Assistant Director General in FAO-RLC. Before joining FAO, he worked in Fundación Telefónica in Spain; the Ministry of Planning of the Chilean Government; the Fundación para la Separación de la Pobreza in Chile.

Daniela D'Agostino (co-author – chapter 4) holds a Ph.D. in Agro-Forestry and Environment Engineering from the University of Bari (Italy). Scientific interest in surface hydrologic modelling at catchment and regional scale, diagnosis of the ecological state of water courses, semi-quantitative modelling for the analysis and management of qualitative data in the participatory and stakeholders driven processes, elaboration, management and analysis of cartographic data using modern GIS techniques (geographic information system), statistical analysis and management of climatic data. She has been involved in many international and regional research projects and has authored and co-authored publications in scientific journals, books and conference proceedings.

Andre Daccache (co-author – chapter 3), is Senior Consultant at the Land and Water Resources Management department, CIHEAM-Bari (Italy). He has 9 years' research experience in agricultural water management and irrigation engineering. He is an agricultural engineer with an M.Sc. and a Ph.D. in land and water resources management. Before joining the CIHEAM-Bari (Italy) in February 2015, he occupied the role of academic fellow within the Centre for Water Science at Cranfield University (United Kingdom). He worked on several projects, investigating climate change impacts on crop productivity and water resources. He worked closely with the agro-industry and with growers to improve their water use efficiency and appraise the environmental impact of irrigation abstraction. His other research interests include crop modelling, precision irrigation and benchmark crop productivity and water use efficiency. He developed several GIS (geographic information system) based software for the design and analysis of on-farm and large-scale irrigation systems. He is the author of more than twenty-five articles published in international peer-reviewed journals. He is also Member of the Institution of Agricultural Engineers (IAgrE, Cranfield) and a visiting fellow at Cranfield University (United Kingdom) and associate fellow at the Higher Education Academy.

Philipp Debs (co-author – chapter 9) is a Scientific Consultant in the Sustainable Agriculture, Food and Rural Development department of the CIHEAM-Bari (Italy). He holds a Master's degree in Mediterranean organic agriculture and a Ph.D. in Agro-food economics and politics. His fields of interest include food losses and waste, Mediterranean diet and traditional and typical products.

Sandro Dernini (co-author – chapter 10) has been an FAO senior advisor on sustainable food systems and sustainable diets since 2010. In 2002 he became the coordinator of the Forum on Mediterranean Food Cultures (FMFC), and since 2014 he has been the general secretary of the International Foundation of Mediterranean Diet (IFMeD).

Biagio Di Terlizzi (focal point and co-author – chapters 12 and 17) is the Director of the Cooperation and Planning office of the CIHEAM-Bari (Italy). He is responsible for the coordination of several international cooperation projects in the Mediterranean, Africa and Asia. He is also strongly involved in activities of technical assistance provided to ministerial institutions dealing with agriculture, fishery and rural development.

Yvette Diei-Ouadi (co-author – chapter 9) is a Fishery Industry Officer at the Products, Trade and Marketing Branch, FAO. She has over twenty years of experience in post-harvest fisheries. She holds a veterinary doctorate, in the areas of hygiene and processing of food of animal origin. She joined FAO in 1996 where she has been involved in activities relevant to reducing post-harvest losses and value chain efficiency, in particular through innovations in technological processes and improvements in hygienic practices. She was the coordinator in 2006-2008 of the regional programme in Africa which led to the establishment of the post-harvest loss assessment methodology in small-scale fisheries, then mainstreamed in the FAO approach to assessing losses across food commodities.

Alberto Dragotta (co-author – chapters 12 and 17) is a Senior Agronomist consultant at the Cooperation office of the CIHEAM-Bari (Italy). His fields of interest include sustainable technology for agriculture, knowledge management, rural communication and institutional building.

Olivier Dubois (focal point and co-author – chapter 7) is a Senior Natural Resources Officer and Coordinator of the Energy Group within the Environment, Climate Change and Bioenergy Division of FAO. An Agronomist, Land Use and Natural Resource Management Specialist, he has a Master's in Agronomy, Certificates in Tropical Agriculture, Rural Economics and Sociology from the Faculty of Agronomy of Gembloux (Belgium) and a Master's in Environmental Management from the European Community Environment Programme. He has worked on land use intensification, forest management and institutional aspects of rural development in more than 40 countries in Africa, Asia-South Pacific, Latin America, the Middle East and CIS countries, through both long term assignments with the Belgian Cooperation Agency, the German Consulting Company DFS (Deutsche Forest Service), the International Institute for Environment and Development (IIED) and the FAO and several short term missions for the World Bank and the European Commission among other organizations.

Hamid El Bilali (co-author – chapters 9, 12 and 17) is a Scientific Consultant in the Sustainable Agriculture, Food and Rural Development department of the CIHEAM-Bari (Italy). His fields of interest include food losses and waste, food and nutrition security, sustainability of Mediterranean food systems and diets, traditional and typical products and sustainable rural development.

Maha Abdelhameed Elbana (co-author – chapter 3) is an Assistant Professor at the Agriculture College of Beni-Suef University (Egypt) and an Associate Trainer certified by the International Board of Certified Trainers (IBCT) (Netherlands). Before that, for two years, she served as On-Farm Water Management Specialist at the International Centre for Agriculture Research in Dry Areas (ICARDA). She holds a Diploma in Rural Development and Environmental Management from the CIHEAM-Zaragoza (Spain), an M.Sc. and a Ph.D. in agriculture engineering from the University of Lerida (Spain) (2008 and 2011 respectively). She worked as an assistant researcher at the University of Girona (Spain) for two years. She is a reviewer for *Desalination Journal* and the *Irrigation and Drainage Journal*. She has multiple publications in peer reviewed journals dealing with agricultural irrigation and water management.

Christine Farcy (co-author – chapter 5) Université catholique de Louvain (UCL) (Louvain-la-Neuve, Belgium). She has a Ph.D. in Agricultural Sciences and Biological Engineering from the UCL. She is a researcher and a guest lecturer at the UCL. She is member of the board of the European Forest Institute, vice-chair of the European Forestry Commission of the FAO and she was chair of the international panel in charge of the 2013 external evaluation of FAO (Silva Mediterranea).

Nicola Ferri (focal point – chapter 2) holds a Ph.D. in International Law and currently serves as Legal and Institutional Officer of FAO (General Fisheries Commission for the Mediterranean – GFCM). Before joining FAO, he worked for several years as a legal consultant for the Italian Ministry of Foreign Affairs. In this capacity, he represented Italy in numerous fora, including at UN General Assembly meetings relating to oceans and fisheries. He has also dealt with several other legal issues in the context of the work of the 6th Committee of the UN's General Assembly in New York. He has authored several publications on various international law topics, including a monograph entitled, *Conflicts over the Conservation of Marine Living Resources: Third States, Governance, Fragmentation and Other Recurring Issues in International Law*.

Abdelouahid Fouial (co-author – chapter 3) is a Ph.D. student and a research assistant at the Land and Water Resources Management department, CIHEAM-Bari (Italy) and University of Bologna (Alma Mater Studiorum). He is a Ph.D. candidate in civil engineering at the University of Bologna (Italy). He holds two Master's degrees, one in Water Resources Management from the CIHEAM-Bari (Italy), and the second in Agricultural Engineering from Universiti Putra Malaysia. His main research focuses on the hydraulic modelling, analysis and optimisation of pressurised irrigation distribution systems and the development of computer decision support systems and performance indicators for the hydraulic analysis. His research interests also encompass irrigation engineering and water management.

Christini Fournaraki (focal point and co-author – chapter 6) is a biologist and holds a Master's degree in the management of Mediterranean ecosystems and a Ph.D. in the conservation of native plant species. She is Chief of Research at the Mediterranean Plant Conservation Unit (MPCU) of the CIHEAM-Chania (Greece). She participates in several research projects in collaboration with other conservation centres in the Mediterranean and in Europe and has more than twenty-five years' experience in issues relating to biodiversity conservation in the Mediterranean.

Valentina Garavaglia (co-author – chapter 5). After graduating in Analysis and Management of Natural Resources (2006), she obtained a Ph.D. from the Doctoral School on Earth, Environment and Biodiversity (2010) at the University of Milan (Italy). She is currently working for the Secretariat of the FAO-Silva Mediterranea, and is involved in the implementation of activities on Mediterranean forests. She is also the scientific secretary of COST Action FP1202 on the adaptation of marginal populations of forest trees to climate change in Europe (MaP-FGR).

Fatima Hachem (focal point and co-author – chapters 10 and 13) is the Senior Nutrition and Consumer Protection Officer at the FAO Regional Office for the Near East and North Africa. In this capacity, she provides technical assistance to member countries in areas related to nutrition, household food security and food safety. Over the past fifteen years, she has worked extensively with national and regional institutions on building the capacity of senior and mid-senior officials for generating data and analysing the causes of key nutrition and household food security and food safety issues with the aim of providing the evidence needed by policy-makers for informing the relevant strategies and interventions.

Sara Hassan (co-author – chapter 16) is graduated in Cooperation for Development and holds a Master in Development Planning. She has worked as a researcher (in the areas of development policies, food security, rural development, empowerment of rural women, family farming) and in conducting impact evaluations of complex development programs in the Mediterranean Europe, North Africa and the Middle East, West Africa and the Sahel. Currently, she is working with the FAO's Family Farming Knowledge Platform, as the regional focal point for the Near East and North Africa region.

Martin Hilmi (co-author – chapter 11) works as a mechanization systems and services development economist for the Rural and Urban Crop and Mechanization Systems Group (AGPML) in the Plant Production and Protection Division of the FAO. He is currently working on developing sustainable mechanization systems and services, developing hire services as a business, developing mechanization strategies and policies and green food value chain development. Prior to this position, he worked as an enterprise development officer, still for the FAO, working on farm business management, farming as a business, the development of small and medium agri-food enterprises (SMAE), green food value chain development, gender sensitive food value chains, the informal food sector, agri-food sub-sector development, rural and urban food systems development and food losses and waste. He developed the FAO approach to green food value chain development. Before joining the FAO, he lectured at university for eight years on small enterprise development and prior to this he worked in the agri-food private sector for nine years.

Irene Hoffmann (co-author – chapter 6) is Secretary of the Commission on Genetic Resources for Food and Agriculture at the FAO, where she held previous positions as head of the Animal Production Service and of the Animal Genetic Resources Branch within the Agriculture and Consumer Protection Department. She holds a Ph.D. from Hohenheim University and an M.Sc. in Animal Science from Göttingen University (Germany). Before joining the FAO, she was assistant professor at the Institute of Livestock Ecology at Giessen University (Germany) where she coordinated several international research programmes. She has organised international conferences and published extensively in peer scientific journals, books and conference proceedings on scientific and policy topics. She was also member of various scientific advisory committees and review panels.

Nahla Hwalla (co-author – chapter 10) is Professor of Human Nutrition since 1995 and Dean of the Faculty of Agricultural and Food Sciences at the American University of Beirut (Lebanon) since 2006. Her research focuses on obesity, its prevalence, determinants and dietary manipulation to curb its effects. She is involved in the national and regional strategic planning for nutrition, and in building capacity for food security nationally and regionally.

Chariton Kalaitzidis (focal point and co-author – chapter 10) has been the head of the Geoinformation in Environmental Management Department of CIHEAM-Chania (Greece) since 2012. His interests include the spatial distribution and variability of Mediterranean diet elements across the Mediterranean.

Panagiotis Kalaïtzis (focal point and co-author – chapter 11) holds a Ph.D. from the University of Maryland (College Park, United States) in the field of Molecular & Cell Biology and is currently Studies/Research Coordinator of the Horticultural Genetics and Biotechnology Department at the CIHEAM-Chania in Crete (Greece). His research interests focus on the characterization of the physiological significance of genes involved in the biosynthesis of cell wall glycoproteins and particularly on developmental programmes such as fruit ripening, abscission and abiotic stresses such as salinity. Moreover, the group has extensive experience in authenticity and traceability of processed foods such as olive oil and recently wine using DNA-based approaches and molecular markers such as SNPs (Single-Nucleotide Polymorphism). He has authored more than forty publications in peer-reviewed journals and either coordinated or participated in more than twenty research and development projects.

Dorian Kalamvrezos Navarro (focal point and co-author – chapter 8) studied International Relations in the University of Birmingham (United Kingdom) before pursuing postgraduate studies in International Law, Public and European Policy, Economic Development and International Agri-Food Policy. He participated in the European Commission's traineeship programme in 2012, working for the International Cooperation Directorate of the Directorate-General for Research and Innovation. He joined FAO's Gender, Equity and Rural Employment Division in early 2013, and since September 2013, has worked as Consultant in FAO's Corporate Task Team on Post-2015.

Fawzi Karajeh (co-author – chapter 3) is Senior Water Resources and Irrigation Officer at the FAO Regional Office for the Near East and North Africa. He holds an M.Sc. in Irrigation from Jordan University and a Ph.D. in Water Resources Management/Soil Physics from the University of California in Davis (United States). Prior to joining FAO, he was a Principal Water Resources and Irrigation Management Specialist at the International Center for Agricultural Research in the Dry Area (ICARDA) and the Regional Coordinator for the Nile Valley and sub-Saharan African region for five years. From 2001 to 2008, he was the Chief of the Recycling and Desalination Branch, California Department of Water Resources (DWR). From 1999 to 2001, he was Senior Marginal-Quality Water Scientist at ICARDA. He has served in developed and developing countries with a focus on water resources planning and management, including non-conventional water resources (water recycling and desalination). His work also involved the treatment and safe use of recycled water for irrigation, hydro-salinity modelling, field irrigation and salinity management projects. He has authored and co-authored over eighty publications and received eight recognition and professional awards.

Roula Khadra (co-author – chapter 3) is a Scientific Administrator and Lecturer at the Land and Water Resources Management department, CIHEAM-Bari (Italy). She is a rural engineer and holds a Master's in land and water resources management and a Ph.D. in Mediterranean Agriculture. Under the Fulbright Scholar Program, she conducted her postdoc research on combined effects of water and salinity stress on crop productivity at the University of California in Davis (United States) in 2008. Her main research interests are in the fields of design, rehabilitation and modernisation of large-scale pressurised irrigation systems. Involved in many European and cooperation projects (in Asian and Middle Eastern countries) she is a specialist in Participatory Irrigation Management, stakeholders driven processes, Monitoring and Evaluation (M&E) systems, and the development and use of simulation models for large-scale irrigation systems design and performance analysis. Her expertise includes the development of M&E systems and of Decision Support Systems (DSS) for irrigation and water distribution in GIS environment.

Ahmet Ali Koç (author of box – chapter 13) received his Bachelor's, Master's and Ph.D. degrees in AgriEcon from Çukurova University (Turkey) and also a Master's degree in Agro-food Marketing from CIHEAM-Zaragoza Master (Spain). He worked as a Research

Assistant, Assistant Professor and Associate Professor over the period 1989 to 1999 at the department of AgriEcon of the Çukurova University (Turkey). He was a visiting scholar at the Iowa State University (CARD/FAPRI) (United States) during September 1997-1999. He worked as a policy analyst at the Agricultural Economics Research Institute in Ankara from September 1999 to May 2001. He joined the Akdeniz University (Department of Economics) (Turkey) as a Professor in August 2003. He has published over twenty articles in refereed journals, over twenty-five proceedings and six contributions to edited volumes and also conducted several international research projects. He was appointed as Director of the Centre for Economic Research on Mediterranean Countries (CREM) in March 2016.

Katerina Koutsovoulou (co-author – chapter 6) is a Biologist and holds a Ph.D. in Plant Physiology. Since 2005, she has been working on numerous projects for plant conservation in collaboration with the University of Athens (Greece), the CIHEAM-Chania (Greece) and the Institute of Mediterranean Forest Ecosystems. She recently completed her post-doctoral thesis on Forest Genetic Resources.

Abderraouf Laajimi (author of box – chapter 13) is Director General at the National Observatory of Agriculture, in the Ministry of Agriculture, Hydraulic Resources and Fishery of Tunisia. He graduated as an Agricultural Engineer in Tunisia and was awarded an M.Sc. in Agro-Food Marketing by CIHEAM-Zaragoza (Spain) in 1991. In 1995 he completed his Ph.D. in Applied Economics at the University of Zaragoza. He has held several responsibilities at INAT (Institut National Agronomique de Tunisie) where he also works as a Professor of Agricultural Economics. He has collaborated with CIHEAM in several projects and networks and has published extensively on topics related to food marketing and agro-food policy.

Fadila Lahmer (co-author – chapter 4) graduated as an engineer in rural planning at the National Institute of Agronomy in Algeria, holds a Master's in non-conventional water resources in application on the halophytes crops and a Ph.D. in watershed management specifically combating soil erosion awarded by the University of Bari (Italy). She monitors Master's theses at the CIHEAM-Bari (Italy) on a large variety of themes including salinity control in relation to irrigation, crop productivity in saline-drought conditions, effects of soil texture and soil salinity on the plant water relationships, water use efficiency and crops productivity in saline-drought environments. She also has an experience in soil erosion control at plot scale using different species such as the vetiver grass. She is author and co-author of several publications in scientific journals, books and conference proceedings.

Nicola Lamaddalena (focal point and co-author – chapter 3) is head of the Land and Water Resources Management Department, CIHEAM-Bari (Italy), since 2007. He holds an M.Sc. in Hydraulic Engineering from the Polytechnic University of Bari (Italy) and a Ph.D. in Irrigation Engineering from the Technical University of Lisbon (Portugal). He has been working for more than twenty years on agricultural engineering and water resources management, with a focus on design, performance analysis and management of large-scale distribution systems, new delivery technologies and governance models of water users' associations. He is a rapporteur at the Policy Round Table on Water for Food Security and Nutrition at the FAO-UN. He was also a professor at the Polytechnic University of Bari (Italy) from 2007 to 2012, visiting professor at INAT (*Institut national agronomique de Tunisie*, Tunisia) and at the Technical University of Lisbon (Portugal).

He has been coordinating various European and international projects in the Mediterranean region. He is the author of more than eighty publications in scientific journals and books, reviewer for several scientific journals and author of the *FAO Irrigation and Drainage Paper* No. 59 and the designer of the COPAM model. He joined the CIHEAM-Bari (Italy) in 1986.

Warren T.K. Lee (co-author – chapter 9) Ph.D., RD, RNutr (Public Health) is Senior Nutrition Officer and Group Leader, Nutrition Assessment and Scientific Advice Group, Nutrition and Food Systems Division, FAO. He obtained his B.Sc. degree in Human Nutrition at Trinity College, Dublin (Ireland), and a Ph.D. degree from the Chinese University of Hong Kong (Hong Kong). He is also a Registered Dietician and Public Health Nutritionist qualified in the United Kingdom. He works on nutritional aspects of food losses and waste under the SAVE FOOD Initiative. His team recently has completed a study on micronutrient losses in food loss and waste. He is also a co-investigator of a recent European Commission (FP7) FUSIONS project on the impacts of food waste on health and nutrition.

Grégoire Leroy (co-author – chapter 6) is a population geneticist, with main interests in management, characterisation and conservation of animal genetic resources. He is a lecturer at the INRA-AgroParisTech joint unit on Animal Genetics and Integrative Biology, and currently seconded by French government to the FAO.

Antonio López-Francos (focal point – chapter 5) graduated as Agronomist from the Polytechnic University of Madrid and holds a CIHEAM-Montpellier (France) postgraduate degree in Rural Development and Projects. Since 2004, he has been Cooperative research administrator and Head of publications at the CIHEAM-Zaragoza (Spain). He has been involved in the conception and management of fourteen European research projects (FP6, FP7 and H2020 as well as Interreg and Meda-Water programmes), in the promotion of Mediterranean research networks and the organization of international scientific meetings on agriculture related topics, as well as in the coordination and edition of many collective publications as a result of the mentioned cooperative research activities. He also has a wide field experience as a development worker in the Andean region of Peru and in managing commercial farms in Morocco and in Spain.

Inazio Martínez de Arano (co-author – chapter 5) is head of the Mediterranean Regional Office at the European Forests Institute. In his previous life he has been involved in international forest policy discussion as CEO of the Union of Foresters of Southern Europe and coordinated forest research at the Basque Institute for Agricultural Research (NEIKER).

Francesc Maynou (co-author – chapter 2) received his Ph.D. in Marine Science from the Polytechnic University of Catalonia in 1995. He has published more than hundred scientific contributions in specialized journals or books. He is a tenured scientist at Spain's National Research Council (CSIC) since June 2007 and has headed the "Fisheries Bioeconomic Modelling" research group since its inception in 2003. He carries out his research at the Marine Science Institute of Barcelona, working on the structure, dynamics and conservation of marine living resources, with a special interest on higher trophic levels which are directly or indirectly subject to human activity in marine ecosystems. He is currently the coordinator of the European research project MINOUW, a Research and Innovation Action of Horizon 2020, investigating technical and bioeconomic solutions to mitigate the discards problem in European fisheries.

Enrico Nerilli (co-author – chapter 4) holds a Master's in water use efficiency from the CIHEAM-Bari (Italy) and a Ph.D. in eco-physiology from the University of Castilla La Mancha (Spain). His areas of expertise include design and monitoring of irrigation systems, GIS, crop modelling, plant protection and nursery management, food production systems, climate change adaptation and mitigation. He has managed rural development projects in Lebanon, Kenya, Haiti, Ethiopia, Egypt, Tunisia and other parts of the world.

Halka Otto (focal point and co-author – chapter 1) a national of Germany, served as an international civil servant for various non-governmental organizations and United Nations agencies for over twenty-five years. Since October 2013 she has been working as Senior Advisor to the Deputy Director-General, Coordinator for Natural Resources of the FAO. She also served as Senior Attaché in the Cabinet of the Director-General of FAO (2006-2013). Prior to this, she worked in FAO's Technical Cooperation Department covering a variety of technical programs in Asia and Pacific, Eastern Europe and Africa (2004-2006). From 2002 onwards she led FAO's emergency operations in Tajikistan as Emergency Coordinator. From 1999 to 2002 she worked for a German NGO in Tajikistan as Programme Coordinator for Agriculture Programs. She started her career as a junior Professional Officer at UNDP Belarus in 1994. She holds a Master's Degree in Agriculture Sciences (Soil Sciences and Agro-chemistry) from the Timiryasev Academy in Moscow (Russia).

Nora Ourabah Haddad (coordinator, focal point and co-author – chapters 14 and 16) is an economist by training and holds a diploma in Business Administration from the École supérieure de commerce of Grenoble (France) and a Master's degree (MBA) in International Management from Laval University (Quebec). She worked at the International Federation of Agricultural Producers (IFAP) on policy analysis related to food security and rural development. In 2010, she joined FAO's Economic and Social Development Department as team manager on rural institutions and people's empowerment. She is currently working at FAO's Partnerships, Advocacy and Capacity Development Division.

Nicolas Picard (focal point – chapter 5) is currently the secretary of the FAO Committee Silva Mediterranea. He has a Ph.D. in forest sciences from the French school on forest and water and has twenty years' experience in research on tropical forestry in the Neotropics and in Africa, with successive positions in Mali, Gabon and Cameroon.

Francesco Maria Pierri (focal point and co-author – chapter 16) holds a degree in Politics and a Doctorate in History and Theory of Economic Development. Since October 2013, he has been Family Farming Officer and Head of the Advocacy Unit (OPCA), in the Partnerships, Advocacy and Capacity Development Division (OPC) of the FAO. From 2003 to October 2013, he worked in the Ministry of Agrarian Development of Brazil, where he led the International Relations Office and the Brazilian Section of the Specialized Meeting on Family Farming of MERCOSUR.

Patrina Pink (co-author – chapter 12) is a Communications and Partnerships Consultant with the Global Initiative on Food Loss and Waste Reduction within the FAO. She holds a Master's degree in Human Development and Food Security and her fields of interest include communication for development, rural institutions and participatory research.

Juliette Prazak (focal point and co-author – chapter 15) has graduated in organic agriculture at the University of Wageningen (Netherlands). She was a former technical consultant on projects focusing on agroecology funded by the GEF-FEM in Sub-Saharan Africa. She is currently a project manager among the team of emergency assistance at the Red Cross in London.

Mélanie Requier-Desjardins (focal point and co-author – chapter 8) is an Environmental Economist at the CIHEAM-Montpellier (France), where she runs a Master's on the value chain of development projects and policies. Since 1998, her research focuses on socio-economics and environmental change in dry land areas from two main perspectives: long-term understanding of the interactions between land tenure systems and natural resources availability; and the valuation of social and economic costs and benefits of the desertification process and of actions to combat desertification. She is member of the French Scientific Committee on Desertification and has followed up the UNCCD negotiations since 2005. Prior to joining the CIHEAM-Montpellier (France) in 2009, she coordinated the Environmental and Research Development programmes for the Observatory of Sahara and Sahel (OSS, Tunisia).

Ramy Saliba (co-author – chapter 3) is a Ph.D. student at the Land and Water Resources Management department, CIHEAM-Bari-University of Naples-Parthenope (Italy). He graduated as an agriculture engineer in 2009 at the Lebanese University in Beirut. He obtained his Master's in Land and Water Resources Management from CIHEAM-Bari (Italy) in 2011 and is currently a Ph.D. student working on wastewater treatment and reuse in agriculture. His main area of research is the assessment of the application of low quality waters and the associated risks under irrigation management options and climate scenarios. He has been collaborating in various Italian and European projects on water reuse in agriculture and tutoring international study tours on participatory irrigation management and the modernization of irrigation systems.

Alessandra Scardigno (co-author – chapter 3) is Scientific Administrator and Lecturer at the Land and Water Resources Management, CIHEAM-Bari (Italy). She holds a Ph.D. in Rural Development and Economic Systems and since 1997 she works at the CIHEAM-Bari where she conducts research and teaching activities in the fields of farm economics, socio-economics of agro-forestry systems, agricultural policy and environment, economics of land resources. She has been developing the study of the bio-economic modelling approach as a tool to analyse the complex interactions between agriculture, natural resources and environment. Involved in several European projects on water resources management in Mediterranean countries, she is actually working on the sustainability evaluation of water policies in the Mediterranean countries and impacts of climate change on water resources and their use in Mediterranean agriculture.

Jennifer Smolak (co-author – chapter 9) is an Agro-Industry and Infrastructure Officer with FAO Regional Office for the Near East and North Africa in Cairo (Egypt) working on food loss and waste reduction, agro-industry and value chain development, and food security. Her prior experience spans the private sector, international and national NGOs, and UN system, and she holds degrees in business, economics, and international development.

Pasquale Steduto (focal point and co-author – chapter 3) is Deputy Regional Representative at the FAO. He holds a University Degree in Agricultural Sciences from the University of Bari (Italy), an M.Sc. in Water Science (Irrigation) and a Ph.D. in

Soil-Plant-Water Relation from the University of California, Davis (United States). In 1991, he was a team leader for Water saving in Mediterranean agriculture issues at the CIHEAM-Bari (Italy). In 1998, he led a CIHEAM-ICARDA (International Center for Agricultural Research in the Dry Areas) team working on drought preparedness in the Near East, the Mediterranean and Central Asia. He also led another team that was set up to assess water governance and policies in the Mediterranean agricultural sector. He joined the FAO in 2003 as head of the Water Resources Development and Management Service in Rome. From 2007 to 2010, he also served as Chair of UN-Water on behalf of the FAO. In July 2010, he became Principal Officer of the Land and Water Division, NRL. In 2013, he took up the position of Deputy Director/Officer-in-Charge of the Liaison Office with the United Nations (LOG) in Geneva (Switzerland).

Florence Tartanac (focal point – chapter 11) is Senior Officer in the Nutrition and Food Systems Division and Group Leader of the Market Linkages and Value Chain Group in FAO in Rome. Her areas of expertise are the following: sustainable value chain development and inclusive business models; voluntary standards and geographical indications; institutional procurements; small and medium food enterprises development. She joined the organization in 2001 posted at the FAO Regional Office for Latin America and the Caribbean, before coming to Rome in 2005. Before that, she worked ten years in Guatemala, for the French Cooperation, INCAP (Institute of Nutrition for Central America and Panama) and UNIDO (United Nations Industrial Development Organization). As academic background, she is a food engineer and has a Ph.D. in Economical Geography from Paris University.

Francesca Marina Tavolaro (co-author – chapter 6) is an FAO consultant. She holds a Master's degree in Veterinary Sciences from the University of Bristol (United Kingdom). Before working at the FAO, she worked as a researcher at Onderstepoort (Veterinary Institute of the University of Pretoria, South Africa) focusing on the livestock-wildlife interface with rural communities across Southern Africa.

Mladen Todorovic (co-author – chapter 3) is a Scientific Administrator and lecturer at the Land and Water Resources Management Department, CIHEAM-Bari (Italy). He holds a B.Sc. in Civil Engineering (hydro-technical constructions), an M.Sc. in Irrigation and a Ph.D. in Agro-Meteorology and Water Management. He is a visiting Professor at the University of Belgrade (Serbia). His main topics of interest include irrigation, water use eco-efficiency, crop water productivity, climate change impact, adaptation and mitigation and the use of modern technologies in water and land management. He is a leading scientist of numerous EC-funded research projects and cooperation projects in the Mediterranean region and Balkan area. He is the supervisor of more than forty M.Sc. theses and Ph.D. dissertations and the author of more than eighty publications in scientific journals and books. He holds the ASCE best research paper award and a number of CIHEAM recognitions. He is also an associate editor of the journal *Agricultural Water Management*.

Jogeir Toppe (co-author – chapter 9) is a Fishery Industry Officer at the Products, Trade and Marketing Branch, FAO. His academic background is in chemical engineering and human nutrition, with particular focus on fish as food and source of micronutrients and essential fatty acids. Before joining FAO, he was doing research on feed for novel aquaculture species with focus on alternatives to traditional fishmeal and fish oil. In recent years his area of work has been in areas such as promotion of fish consumption as a tool in combatting malnutrition, handling and processing of fisheries products, improved use of fish by-products and reduction of post-harvest losses and waste.

Robert Van Otterdijk (focal point and co-author – chapter 12) has worked in the European and African food industry as well as with international development organisations in Africa and the Pacific. He currently works at the FAO Headquarters in Rome (Italy), as an agro-industry officer. He coordinates the Global Initiative on Food Loss and Waste Reduction, and more specifically the conduct of research and the implementation of projects.

Sara Vicari (coordinator) holds a PhD in Development Economics. She is currently consultant at the Cooperatives and Producer Organizations Team of the Partnerships, Advocacy and Capacity Development Division (FAO). She is also lecturer in the Roma Tre University Master Programme "Cooperatives: Economics, Law and Management". Between 2012 and 2013, she was Research Associate at the Cooperative College (United Kingdom) and Visiting Research Associate at the Open University (United Kingdom). Previously, she was policy officer at the International Relations Office of Legacoop (Italy). Her main research interests involve the role of cooperatives in poverty reduction, human development, and gender equality.

John Vourdoubas (focal point and co-author – chapter 7) holds a degree in Chemical Engineering from the National Technical University of Athens (1974) and an M.Sc. from Loughborough University of Technology (United Kingdom). He is a researcher at the CIHEAM-Chania (Greece) and has been teaching at the Technological Educational Institute of Crete since 2005. He is the author and co-author of many scientific articles and books in the field of renewable energy resources. He has actively participated in the implementation of many EU funded international projects over the last fifteen years. He has also been working as a consultant in various private and public organisations for many years.

Mary Yannakoulia (co-author – chapter 10) is an associate professor of Nutrition and Eating Behaviour at the Harokopio University of Athens (Greece). Her scientific interests are related to the factors influencing food choices as well as the effects of food choices on health.

Pandi Zdruli (focal point and co-author – chapter 4) works with the CIHEAM-Bari (Italy) since 1999. Before, he was a visiting scientist (for two years) with the European Commission's Joint Research Centre at Ispra (Italy), a Senior Fulbright Research Scholar (for five years) at the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) in Washington, D.C., and Head of the Pedology Department of the Soil Science Institute of Albania. He graduated in 1981 from the Agricultural University of Tirana in Albania and pursued graduate studies and research in the United States sponsored by the Fulbright Foundation. He has published extensively and is editor in chief of twelve books. He is also member of several national and international organisations, institutions and associations dealing with natural resources management and environmental protection.

Feras Ziadat (focal point and co-author – chapter 4) holds a Ph.D. from Cranfield University (United Kingdom) on land resources management, GIS and remote sensing and an M.Sc. on land management and soil conservation from the University of Jordan. He joined the University of Jordan between 2000 and 2008 as an assistant and associate professor at the International Centre for Agricultural Research in the Dry Areas (ICARDA). Between 2008 and 2014 he was a senior scientist on soil conservation and land management. He is currently a land and soil resources officer at the FAO. His work focuses on the application of GIS and remote sensing on soil-landscape modelling, soil mapping, integrated and participatory land use planning and land evaluation, land degradation and desertification, integrated watershed management and supporting the establishment of global and regional soil partnerships. He has an experience in Central and Western Asia, East and North Africa, with several publications in the area of land and water resources management.

Table OF DOCUMENTS

Chapter 3: Management of water resources

Chapter 4: Sustainable development of land resources

Chapter 5: Forests: facing the challenges of global change

Chapter 6: Plant and animal resources diversity

Chapter 7: Energy and agri-food systems: production and consumption

Chapter 9: Food losses and waste: global overview from a Mediterranean perspective

Chapter 10: The Mediterranean diet: a sustainable consumption pattern

Chapter 11: Innovative postharvest technologies for sustainable value chain

Chapter 12: Innovation for the reduction of food losses and waste

Chapter 17: Enhancing knowledge for food security

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