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Water and the Rural Poor

Interventions for improving livelihoods in Asia

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Contents

Foreword

Poverty continues to be a major concern in Asia despite the region's high economic growth and rapid rural transformation. Most of the poor live in areas where natural resource conditions are suboptimal and water-related constraints are the root cause of low production and increasing vulnerability to natural disasters and climate variability. The importance of securing water availability for rural livelihoods is therefore increasing. As water is fundamental to productive agriculture and other livelihood needs, how water is used and managed will have a significant impact on alleviating hunger and poverty.

This publication is the product of a joint effort by the Food and Agriculture Organization of the United Nations (FAO) and the International Fund for Agriculture Development (IFAD) to target rural livelihood support through water interventions in Asia. It assesses the current trends and transformations in water and rural livelihoods and maps the links between poverty and water to identify those rural areas that will benefit most from water interventions and those where water interventions will not have significant impacts on poverty levels. It shows that tremendous potential exists to improve rural livelihoods through investing in water and emphasizes the importance of securing water availability in the light of population growth, economic development and climate change projections. It equally argues for increased attention to the rural non-farm sector, and calls for investments in 'neo-agriculture' that combines both the rural farm and non-farm sectors, and facilitates rural-urban production and consumption linkages to induce rural change.

I hope that this report will contribute to improved understanding of water and poverty linkages in rural Asia, and help to guide policies and investments in innovative water interventions by mobilizing government and civil society support.

Hiroyuki Konuma

Assistant Director-General and
Regional Representative for Asia and Pacific

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Preface

Water has always played an important role in Asian agriculture, allowing the continent to keep pace with growing population and demand for food. The Green revolution, which relied heavily on irrigation, has lifted millions of poor farmers out of starvation and poverty and contributed to the fast socio-economic development of the continent. A few decades later, affordable drilling and pumping technologies have revolutionized agriculture again, providing farmers with cheap and reliable access to water for their crops.

As the livelihoods of the rural people are transforming once again, under the combined effects of rapid socio-economic development, urbanization, profound structural transformation of the national economies and increased competition for land and water resources, water still remains central to rural development policies. The issues, however, are more complex than in the past, and new interventions in water require a much more strategic approach, with much better understanding of the factors affecting the success of water investments.

Since its inception in 1945, FAO has supported water development in agriculture. The focus of its work has evolved progressively from infrastructure development to irrigation and drainage management and, later, to water governance and the management of multiple uses of water. It acknowledges the increasing complexity of the water-agriculture-poverty nexus and is developing methodologies to address it. For the last 10 years, we have joined forces with our partners at IFAD to give specific attention to investments in water that ensure sustainable and effective returns in terms of rural poverty alleviation. We have developed livelihood-based decision support tools and approaches and we have engaged with our partners in the countries to understand, with them, the key criteria of success of investments in water. Such approaches recognize the diversity and complexity of the livelihood contexts by tailoring interventions to rural population priorities and livelihood strategies.

This study has been the opportunity to share our tools and approaches with experts from selected countries in Asia and learn from them, building, together, more sophisticated and more robust approaches, adapted to the specific conditions of the continent. We are proud to have been associated with this initiative and trust that it will help designing better and more effective water-based poverty reduction programmes in the region in the future.

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List of figures

List of tables

List of boxes

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Acronyms and abbreviations

ADB	Asian Development Bank
BADC	Bangladesh Agriculture Development Corporation
BAWASA	Barangay Water And Sanitation Association
BRAC	Bangladesh Rural Advancement Committee
CIESIN	Centre For International Earth Science Network
DFID	Department For International Development, Uk
DHS	Demographic And Health Survey
ET	Evapotranspiration
FAO	Food And Agriculture Organization Of The United Nations
FMIS	Farmer Managed Irrigation Systems
GDP	Gross Domestic Product
GRUMP	Global Rural-Urban Mapping Project
ICID	International Commission For Irrigation And Drainage
ICT	Information And Communications Technology
iDE	International Development Enterprises
IFAD	International Fund For Agriculture Development
IFPRI	International Food Policy Research Institute
ILO	International Labour Organization Of The United Nations
IMT	Irrigation Management Transfer
InfoRES	Infrastructure For Rural Productivity Enhancement Sector (Philippines)
IPCC	Intergovernmental Panel On Climate Change
IWMI	International Water Management Institute
IRWR	Internal Renewal Water Resources
IRRI	International Rice Research Institute
MASSCOTE	Mapping System And Services For Canal Operation Techniques

MDG	Millennium Development Goals
MUS	Multiple-Use Water Services
NFM	Natural Flood Management
OECD	Organisation For Economic Co-Operation And Development
PES	Payments For Ecosystem Services
PIM	Participatory Irrigation Management
PPP	Public-Private Partnership
PWS	Potable Water Supply
SSA	Sub-Saharan Africa
SWSI	Social Water Security Index
TLU	Tropical Livestock Unit
WHO	World Health Organization
WPI	Water Poverty Index
WVM	Water Vulnerability Matrix
WWI	Water Wealth Indicators
WUA	Water User Association
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and Pacific
USAID	United States Agency for International Development
WLF	Water as a limiting factor

Executive summary

Investments in water have played a critical role in promoting socio-economic development in rural Asia. Sustainable management of water resources remains a prerequisite for development and reducing poverty and hunger. Water is a key factor affecting agricultural production and reduction of rural poverty. Most small farmers live in areas with poor natural resource conditions, where water-related constraints are a root cause of low production and increasing vulnerability to natural disasters and climate variability. The importance of securing water availability for rural livelihoods is therefore increasing.

This report demonstrates that there is tremendous potential for well-targeted water interventions to enhance livelihoods and support rural development even in water-scarce environments. It argues that future investments in agricultural water management should complement other interventions to support rural transformation and poverty reduction programmes. The region is confronted with a double transitional challenge of maintaining rapid economic growth and managing natural resources sustainably. Rural livelihoods are in transition and are evolving in complex ways, shaped by both global forces and local contexts.

Asian rural livelihoods have been transforming rapidly as a result of economic growth, structural transformation of national economies, well-funded poverty reduction programmes and policy reforms. The rural economy is being integrated into national and wider economic spheres. Millions of poor people have escaped poverty by pursuing new opportunities offered by this changing economic environment. The economic contribution of agriculture is shrinking, and agriculture is commercializing and diversifying, driven by urbanization and commoditization. The share of the non-farm economic sector's contribution is steadily rising in the rural economy. A vibrant rural dynamic is emerging in Asia with new hopes and opportunities, but also with risks and challenges.

This study identifies the hotspots of poverty and water constraints in Asia, and analyses them in the context of livelihood systems. It identifies and maps 14 major livelihood systems based largely on agro-ecological considerations. Two additional systems, the inland fisheries and the livestock livelihood systems are not mapped because they are non-territorial in character, but they are covered through descriptive analysis. The Asian region is complex and heterogenic. Implications between rural livelihoods, poverty patterns and water resources are diverse across the region. For this reason, the study has subdivided the region into three major sub-regions. They are: 1) South Asia; 2) East Asia; and 3) Southeast Asia. Each of 14 systems have been analysed for each sub-region.

The analysis shows that South Asia is the epicentre of rural poverty in both relative and absolute terms. Both Southeast Asia and East Asia have a similar distribution of rural poor, but Southeast Asia has much higher poverty rates than East Asia. There is no great variation in poverty among different livelihood systems: poverty rates vary between 40-50 percent in South Asia and 30-40 percent in Southeast Asia. In East Asia poverty rates are below 6 percent in all livelihood systems. Interestingly, there is not much variation in poverty distribution between irrigated and rainfed zones in East Asia: there are factors other than water accessibility for agriculture that determine poverty levels. This is clearly indicated by the increasing share of the non-farm economy in rural areas in recent times.

Another interesting feature is that poverty is more concentrated in rice-based systems than in either rainfed or other irrigated systems. Rice-based systems account for slightly more than 30 percent of the rural population. High population densities and lack of opportunities outside agriculture are the main causes of the high poverty rates. These are largely water-dependent livelihood systems, and therefore are important from a water intervention perspective. Poverty in these areas is linked not only to physical availability and access to water, but also to water-related hazards such as floods, droughts and rainfall variability.

The study focused on three factors for assessing the potential of water interventions: the extent of rural poverty, the physical potential for future water development, i.e. the amount of water still available for allocation, and the extent to which water is a limiting factor for poverty reduction. While water development potential has been computed from physical availability considerations, water as a limiting factor is judged through subjective expert evaluation, considering the role and importance of water in a given livelihood system. This, jointly with the incidence of rural poverty, represents the demand for water interventions. Both water potential and water as a limiting factor have also been assessed through water vulnerability contexts, i.e. floods, droughts and rainfall variability as well as the expected impacts of climate change.

In assessing the potential for water interventions, the study relates the physical potential (supply) with the demand for water interventions and distinguishes between water-endowed and water-constrained areas, where the physical potential cannot fully meet the demand for water interventions through additional water development. In these areas, water interventions in support of potential beneficiaries cannot include irrigation expansion or intensification, while interventions should mainly aim to manage the water demand or to exit from agriculture. The two tables below summarize rural poverty patterns and the potential for water interventions by sub-region and by livelihood system.

Sub-regions	**Rural population**		**Potential beneficiaries from water interventions**	
	Total (000)	**% rural poor**	**(000) rural poor**	**% of total rural poor**
South Asia[1]	981 364	51.5	217 953 (150 027)[2]	43.1 (29.6)[2]
East Asia[1]	954 244	4.6	32 528 (1 015)[2]	73.0 (2.2)[2]
Southeast Asia	336 788	33.8	76 637	67.1
Total	**2 272 369**	**29.3**	**327 118 (151 042)**[2]	**49.2 (22.7)**[2]

[1] In this sub-region, some livelihood systems are water constrained.

[2] These figures () represent the potential beneficiaries of water interventions which do not involve irrigation expansion or intensification, due to water availability constraints.

The analysis show that South Asia remains the area with largest share of potential rural poor beneficiaries both in number and percentage of rural population. Although water scarcity and constraints are threatening a number of livelihood systems in the sub-region, the potential for water development can still benefit a large number of people (about 60 percent of total demand) through irrigation expansion or intensification.

Looking at the livelihood contexts, the study demonstrates that rural poverty is concentrated in rice-based systems where it accounts almost 60% of the total rural poor population in the region. However, these systems have still a large potential to benefit rural poor through water development, accounting about 70% of the total potential beneficiaries in the region. In any case, in these systems about 100 million of rural poor in need for water interventions cannot be reached by further water development while it is needed to invest in programmes aiming at managing water demand and diversifying livelihoods.

Livelihood contexts	Rural population		Potential beneficiaries from water interventions	
	Total (000)	% rural poor	(000) rural poor	% of total rural poor
Groundwater irrigation (dry)	110 062	38.2	1 481 (32 329) [2]	3.5 (76.8) [2]
Rice/wheat groundwater irrigation (humid tropics)[3]	217 530	34.3	27 703 (43 046) [2]	37.2 (57.7) [2]
Rice-based surface irrigation (humid tropics)	332 877	36.2	96 261	80.0
Wheat/rice surface irrigation (dry)[3]	373 362	21.1	12 456 (59 090) [2]	15.8 (75.1) [2]
Forest-based	30 349	19.7	1 280	21.4
Rangeland pastoral areas	89 057	13.4	5 872	49.1
Sparse[3]	86 467	17.9	4 902 (431) [2]	31.6 (2.8) [2]
Cereal-based rainfed (temperate)	167 737	3.6	4 468	75.0
Highland / mountain agriculture	68 991	15.4	6 944	65.4
Lowland rice-based rainfed (humid tropics)	276 594	43.8	87 125	72.0
Rainfed (dry tropics and subtropics)[3]	153 307	49.6	25 525 (16 133) [2]	33.5 (21.2) [2]
Rainfed (humid subtropics)	262 995	21.7	32 842	57.5
Tree crops and mosaic agriculture-forest	131 487	20.8	12 958	47.5
Upland rainfed (humid tropics)	59 502	35.9	7 298	34.2
Total	**2 272 369**	**29.3**	**327 118 (151 042) [2]**	**49.2 (22.6) [2]**

[3] This livelihood system presents areas affected by water scarcity. Specifically, it is water-constrained system in some of all the different sub-regions.

This study recommends that future water interventions be directed to the following four broad areas: 1) increasing availability of, and access to, water; 2) increasing water productivity and value added of water; 3) addressing vulnerability to floods and droughts, and rainfall variability in general; and 4) promoting multiple-use water services (MUS). The relative importance of each of these areas of intervention varies among livelihood systems, depending on the level of poverty, the nature of water constraints and the livelihood context in general. Based on these areas, the study identified a range of possible intervention options. Their applicability depends on the livelihood and biophysical context and the level of water availability, and they impact poverty in different ways. The major options include:

- Intermediate forms of water control to improve rainfed farming;
- Groundwater and atomistic irrigation;
- Surface irrigation modernisation;
- Community-based farmer-managed irrigation schemes;
- Delta and lowland water management;
- Flood and drought management; and
- Enhanced water storage for managing rainfall variability.

Each of the above options involves technological choices, management options and sociopolitical and institutional contexts that shape the intervention process. Interventions will therefore involve both hardware (infrastructure) and software (policy, institutional, management, virtual water). The choice of options and the relative importance of hard and soft measures or their combination depend on the nature of the water constraints and the livelihood context. Given the complexity of agricultural water management interventions and accompanying biophysical and social impacts, both types of intervention play equally important roles in delivering services to smallholder farmers, and are complementary to each other.

In many parts of Asia, including Pakistan and western India, 'soft' measures are becoming increasingly important. These areas have already reached a high level of infrastructure development and there is no potential to develop new water control systems. The issue there is to make better use of the existing resources through a combination of policy and institutional reforms, and investments in improved water conservation and management. The livelihood systems where water is scarce and where 'soft' measures play an increasingly important role are:

- Groundwater irrigation (dry) systems in both East and South Asia;
- Rice/wheat groundwater irrigation (humid tropics) systems in South Asia;
- Wheat/rice surface irrigation (dry) systems in South Asia;
- Sparse (arid) systems in both East and South Asia;
- Rainfed (dry tropics and subtropics) systems in both East and South Asia.

The other livelihood systems still offer some potential for further developing water resources for agriculture through investments in hydraulic infrastructure; but these options must be assessed based on specific social, economic and environmental conditions. A mixture of both 'hardware' and 'software' interventions will be required to ensure that these investments contribute effectively to poverty reduction while contributing to improved agricultural productivity. Though these areas are not water scarce in overall terms, rainfall variability, especially within seasons, presents the foremost challenge for rural smallholders, and must be given high priority in designing future water intervention programmes.

Geographical targeting by itself is not enough for poverty reduction. Attention must also be given to different social groups, including the landless and women who are most vulnerable. The study develops a typology of Asian farmers based primarily on landholdings, but also looks at the nature of faming (subsistence or commercial) and the role of non-farm sectors. Farmers are classified as small, medium and large, depending on landholding size. The small farmers are further subdivided into 'commercial', 'diversified' or 'subsistence', depending on their share of income from agriculture and the nature of farming. Both medium and large farmers exhibit a commercial character (they produce primarily for the market), whereas diversified farmers range from being semi-commercial to fully commercial.

Different categories of farmers need different policy responses, and the choice and type of the particular set of options depend on the livelihood context. Interventions should be context-specific, taking into consideration the specific needs of different groups. Some types of interventions are relevant to most groups, whereas others can only benefit specific groups; in particular, targeting policy interventions to specific groups is usually less difficult than targeting physical interventions to specific groups. The table below summarizes possible interventions for different groups of farmers. It also includes interventions that may be designed to specifically target women and landless farmers.

Type of farmers	Typical interventions in water	Typical intervention beyond water
Large	Modernization of irrigation infrastructure and management, adoption of sustainable groundwater governance mechanisms, disaster risk management	Facilitating market linkages
Medium	Conjunctive use of canal water and groundwater, investments in technologies and management models that contribute to improved water productivity	Facilitating market linkages
Commercial, small	Adoption of sustainable groundwater governance mechanisms, adoption of more effective management models in community-based irrigation schemes	Development of entrepreneurship skills, facilitating market linkages, promote linkage with large agribusinesses, improved access to and quality of financial services
Subsistence, small	Rainwater management through intermediate forms of water control, access to groundwater, access to small-scale technologies to capture, store and distribute water	Access to basic services, rural infrastructure, diversification of income, social safety nets.
Diversified	MUS for domestic water and household gardens, livestock, atomistic irrigation	Rural infrastructure, training and support for non-farm activities
Women farmers	Empowerment: involvement in water users associations and decision-making processes, development of irrigation technologies adapted to their specific needs	Enhanced capacity and skills in farming, marketing, access to microcredit,
Landless	Design of water services that consider the specific needs of the landless	Training to support non-farm activities

In most cases, investing in agricultural water management per se will not be sufficient to improve rural livelihoods: the enabling environment is also critically important. This environment must offer the institutional conditions and economic incentives required to initiate and sustain water intervention programmes. In agricultural water management, these generally involve favourable policies on rural credit markets, targeted input subsidies, investment in physical infrastructure, communication technologies, enhanced water management institutions, strengthened land and water rights, and social safety nets.

From a livelihood systems perspective, the rainfed lowland rice based systems in South and Southeast Asia and the rainfed systems (dry tropical and subtropical; humid subtropical) in South Asia are those where water interventions are expected to have the highest impact on the improvement of rural livelihoods. These regions suffer from high rainfall variability and are subject to recurrent floods, and they account for a substantial percentage of the rural poor in Asia. Water interventions targeting these two factors will not only enhance rural livelihoods, but also improve the water environment and ecological services. As argued earlier, such interventions must include a combination of 'hardware' and 'software' measures to ensure water access and enhance productivity.

South Asia, in particular, needs to enhance seasonal and interannual storage to cope with rainfall variability, and adopt sound management and policy responses. In the past, groundwater has provided a buffer to counter rainfall variability but its sustainability is increasingly threatened by overdraft in many areas.

This study shows that it is important to look beyond agriculture, and also focus attention on role water plays in the rural non-farm sector. Poverty and rural livelihood issues have gradually moved beyond the agrarian domain; the non-farm sector's contribution to the rural economy is growing, and diversified forms of rural livelihood patterns are emerging both as coping and thriving mechanisms. Rural diversification is now a dominant factor in rural livelihood strategies in the region. Multiple livelihood strategies are widespread among rural families, and will continue to dominate the Asian rural landscape.

The study argues that the goal of any intervention should not be to search for alternatives to agriculture, but to look at how best to integrate agriculture innovation, expansion and change into the wider economy to stimulate production and consumption linkages, and encourage rural transformations. Agriculture should not be seen any more in isolation from other spheres of the economy: it shapes and is shaped by the non-farm sector, depending on the nature of agrarian development, geographical factors and the broader economic context. A vibrant rural economy that combines both the rural farm and non-farm sectors and facilitates rural-urban linkages should be the priority for future rural poverty reduction programmes.

Asian rural livelihoods continue to be shaped by both global forces and local contexts. The continent is in transition, and the landscape of human activities is getting more complex. Though current trends have brought new opportunities to the poor, improved and better integrated water management remains central to rural livelihoods because of its strong links to society, agricultural growth, environmental management and climate change adaptation.

Introduction: water and rural livelihoods

Poverty, agriculture and water in Asia

Poverty is a major problem in Asia despite its high economic growth and rapid rural transformation. Asia still accounts for two-thirds of the world's 1.4 billion poor, most of them concentrated in South Asia. The prevalence of poverty based on the head count ratio is higher in South Asia than in any other region of the world except Sub-Saharan Africa (SSA). Although the percentage of people below the poverty line has been declining, the trends in poverty reduction are still alarming in absolute terms as the population continues to grow. While East and Southeast Asia have made striking progress in reducing rural poverty over the past three decades, progress has been restricted in South Asia.

Most of Asia's 4.2 billion people still live in rural areas, and poverty is largely a rural phenomenon. While about a third of the rural people are considered poor, they account for up to 70 percent of the total poor (IFAD 2011). The rural population has been declining in both East and Southeast Asia since 1995, but is expected to continue growing in South Asia until 2025. Within East Asia, the rural poor account for just over half of the poor, while in South and Southeast Asia, they make up approximately three-quarters of the poor (ibid.). On current trends of growth, poverty reduction and population growth, poverty is likely to remain a predominantly rural phenomenon for the next few decades (Ravallion *et al.* 2007). Rural poverty alleviation will therefore remain a key priority in Asian development agendas.

The poorest and most helpless communities live in areas that are difficult places to farm. They are characterized by various combinations of uncertain rainfall, steep slopes and poor soils, marginal land and natural resources that are under pressure. Typically these are mountainous and highland areas, or semi-arid severely water-scarce zones. They are often remote with limited access to markets, infrastructure and services. Widespread poverty is often the direct result of inequitable property rights and unequal distribution of assets. Most poor rural households survive by cultivating a small parcel of land, though many are either landless daily labourers, or they farm tiny plots inadequate to feed a family (IFAD 2011).

Agriculture is the mainstay of rural livelihoods, it employs a large segment of the population in many countries and contributes significantly to the national economy. The importance of agriculture in poverty reduction is derived from the following facts:

- The incidence of poverty is disproportionately high in those developing countries that still rely heavily on agriculture for employment and income generation;

- The poorest households typically rely most on agriculture for farming or employment; and
- Because the poor have few assets and no skills other than manual labour to sell, they generally face many obstacles in connecting with the non-agricultural economy for jobs. Agricultural growth can provide them some employment – often at very low subsistence wages – where they live (Grewal and Ahmed 2011).

Though the contribution of agriculture has been sharply declining as a proportion of the overall economy, agriculture still provides a large portion of employment in rural settings. This has been one of the key differences in the structural transformation process in Asia compared to more developed countries: employment in agriculture has not declined at the same pace as economic expansion. Small farm sizes, low wages and lack of opportunity for the growing population in other sectors of the economy have all contributed to the continuation of high levels of engagement in agriculture despite rapid economic transformation. Agriculture-based rural livelihoods will continue to play a critical role in the rural economy and poverty alleviation for many years to come.

The central role of agriculture in rural poverty reduction has been well recognized in recent years. The *World development report for 2008* (World Bank 2008) observed that agricultural growth is twice as effective for rural poverty reduction compared to growth in other sectors. IFAD (2011) recognizes that agriculture, if better suited to meeting new environmental and market risks and opportunities facing smallholders, can remain a primary engine of rural growth and poverty reduction. But Asian agricultural growth and productivity are largely dependent on access to water, an increasingly contested resource.

Water is often the main limitation to improving agricultural production and thus reducing rural poverty. Most smallholder farmers live in areas with poor natural resource conditions, where lack of water has been a root cause of low production as well as increasing vulnerability to natural disasters, climate variability and recently, the effects of climate change. Access to water for poverty reduction has two dimensions: water is a basic necessity for daily survival and for a productive life; and it is critical for productive agriculture (Ahmed et al. 2010; IFAD 2011; Kemp-Benedict *et al*. 2011). Lack of sufficient controlled water and its effective management is a critical constraint facing Asian farmers, not only for food production, but also for local livelihoods, socio-economic development and environmental sustainability.

Water is possibly the most critically stressed natural resource. A good deal of attention is now being paid to global water stress and the water needs of the poor. Water-related poverty occurs when people are either denied dependable access to water, or they lack the capacity to use it because they have insufficient or degraded land, or have poor access to markets, capital and other production factors (Cook and Gichuki 2006). The poor do not have access to financial capital, i.e. cannot purchase a pump or other equipment. In other words, the water-poor are an often substantial subset of the socio-economically poorer sections of society (Frans and Soussan 2004). An additional challenge is that Asia must substantially increase its food production in the future. Increasing access to water combined with raising its productivity on both irrigated and rainfed lands will be necessary to meet future demands for food. This challenge also offers an opportunity for reducing rural poverty through well-targeted water interventions.

Water interventions in Asia, however, must be situated within the broader context of economic transformation and environmental challenges. The region is facing multiple water challenges including water scarcity and degradation of its quality. Poor smallholder farmers are the most vulnerable to water shocks. Asia is undergoing rapid economic, demographic and dietary transformation, the population is growing, and both land and water are becoming scarce. This is leading to rising competition for water. Furthermore, climate change is expected to alter water supply regimes, adding further complexities to the existing challenges. Future water interventions must be able to respond to these challenges, and not only protect but enhance the livelihoods of the rural poor.

Goals of the study

This study is guided by two central goals. The first is to understand the water and poverty linkages in rural Asia in order to provide guidance for policies and investments in innovative water interventions and to mobilize government and civil society support. Through mapping the links between poverty and water, this study contributes to identifying those rural households that will benefit most from water interventions and those where water interventions will not have significant impacts on poverty levels. Further, suitable water interventions are identified and assessed against the specific livelihood and agro-ecological zones where the water-poor are located. Interventions for different economic groupings will differ, as will their depth of poverty and vulnerability.

The second goal is more academic: to contribute to interdisciplinary understanding of water and poverty linkages. This understanding will enhance our ability to design effective targeted interventions. Rural poverty and its linkages with natural resources were initially studied through the farming systems approach during the 1970s and early 1980s. This approach yielded important insights, but was farm- rather than people-centred. The more recent evolution of the livelihood framework for poverty reduction has transformed the ways in which rural poverty is perceived and addressed, especially recognizing how access to, and control over, assets impact peoples' livelihoods. Improved understanding of the conceptual ideas behind water and poverty linkages through a livelihood lens will help design water interventions that are more specific and targeted. The purpose therefore, is not to generate new theories; rather it is to improve knowledge as a basis for finding solutions to real world problems such as identifying the hotspots of water constraints underlying poverty, and ultimately suggesting targeted water interventions for rural poverty alleviation.

Methods used

This study relies mainly on a review of the growing body of existing literature combined with analysis of secondary data. Most of the data has been derived from FAO databases, especially AQUASTAT and FAOSTAT. It also uses data from both IFAD and the World Bank on poverty and economic indicators. In addition, two consultative workshops were held at the beginning and towards the end of the study to consolidate the methodological framework and to validate the data and maps produced. The feedback, suggestions and experts' judgements from these workshops have been valuable in strengthening the analysis.

The study framework largely builds on FAO's previous work on water and poverty in SSA (Faurès and Santini 2008), the experience of the AgWater Solutions project funded by the Bill and Melinda Gates Foundation (Giordano, *et al.* 2012), as well as on other water and livelihood initiatives. It draws on recent IFAD-supported studies that have highlighted the growing complexity of rural livelihood systems – the 'new rurality' (Rauch 2008; Huppert 2009; Cleveringa *et al.* 2009). Most of the major findings of the study, especially the analysis of poverty, livelihoods and water constraints in chapter 3, have been derived using an approach developed by the previous FAO-IFAD work and the AgWater Solutions project (http://awm-solutions.iwmi.org/), and are based on GIS spatial analysis to produce a series of maps. These maps show the current spatial distribution of poverty and its relationships with water.

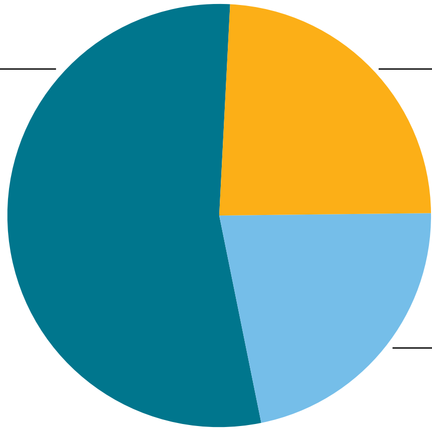
The subregions of Asia

The Asian region is complex and diverse both biophysically and socio-economically. Rural livelihoods, poverty patterns and water resources exhibit significant diversity, particularly regarding rural poverty. For this reason, the study has subdivided the region into three major subregions. They are: 1) South Asia, comprising India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka and the Maldives; 2) Southeast Asia, comprising Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, Viet Nam, Indonesia, Malaysia, Papua New Guinea, Philippines and Timor-Leste; and 3) East Asia, comprising the People's Republic of China, Mongolia and the Democratic People's Republic of Korea (DPRK). The study does not cover the Pacific Islands or Central Asia, which have their own unique issues, and does not include the more developed countries of East Asia (e.g. Japan and Republic of Korea).

The total area of Asia is 44 million km^2, about 30 percent of the world's landmass and 8.66 percent of the Earth's surface. Figure 1.1 shows the land distribution among the three subregions. Spatial distribution of people in Asia is very uneven, with over 1.3 billion people in China and 1.24 billion people in India together accounting for more than half of the Asian population and a quarter of the world's population. Population density depends on the availability of suitable natural resources for growing industries and suitable land for agricultural production. In the last five decades, the population has grown considerably, especially in South Asia. The rural population has grown significantly in South Asia and moderately in Southeast Asia, but began decreasing in East Asia during the 1990s as a result of more rapid urbanization. Table 1.1 contains basic data on land, population and irrigation and water in the three Asian subregions.

Asia has abundant natural resources. Agricultural land accounts for more than 1 billion ha. Over the past 50 years, while Asia's total population increased by about 73 percent, the total agricultural area increased by only 21 percent. In East Asia, agricultural land grew slightly faster at 30 percent. This expansion has largely been at the expense of lowland forests. Over the past 50 years, water use in Asia has more than tripled. As shown in Table 1.1, by far the largest share of total water consumption goes to agriculture - 81 percent overall and more than 90 percent in South Asia. Industrial use accounts for another 10 percent and domestic use 9 percent. The critical importance of irrigated agriculture is discussed in more detail in chapters 2 and 3.

FIGURE 1.1 TOTAL LAND IN ASIA BY SUB-REGION



Source: FAOSTAT (2013).

TABLE 1.1 ASIAN SUBREGIONS IN FIGURES

Categories	Indicator	Subregion			Total
		South Asia	East Asia	Southeast Asia	
Land	Total area (1 000 ha)	447 884	1 128 466	495 807	2 072 157
	Cultivated area (1 000 ha)	204 500	129 433	111 269	445 202
	As % of total area	45.7%	11.5%	22.4%	21.5%
Population	Total (1 000 inhabitants)	1 621 320	1 405 757	607 040	3 634 117
	Rural population (1 000 inhabitants)	1 128 670	726 594	351 547	2 206 811
	As % of total population	69.6%	51.7%	57.9%	60.7%
	Population density (inhabitants/km^2)	362	125	122	175
	Rural population density (inhabitants/ha)	2.5	0.6	0.7	1.1
	Total economically active population (1 000 inhabitants)	665 540	842 471	308 778	1 816 789
	Total economically active population in agriculture (1 000 inhabitants)	346 497	502 017	142 514	991 028
	% active pop. in agriculture	52.1%	59.6%	46.2%	54.5%

1

Categories	Indicator	Subregion			Total
		South Asia	East Asia	Southeast Asia	
Water and irrigation	Total internal renewable water resources (RWR) per capita (m^3/inhabitants/yr)	1 194	2 074	9 545	2 929
	Agricultural water withdrawal as % of total actual RWR (%)	30.1%	12.4%	4.3%	11.2%
	Agricultural water withdrawal as % of total withdrawal	91.0%	64.2%	84.9%	81.3%
	Irrigation potential (1000 ha)	170 481	70 518	47 207	288 206
	Area equipped for full control irrigation: total (1 000 ha)	92 424	64 455	22 763	179 642
	% of remaining potential	54.2%	91.4%	48.2%	62.3%
	% of cultivated area	45.2%	49.8%	20.5%	40.4%
	Area equipped for full control irrigation: actually irrigated (1 000 ha)	85 952	55 605	21 207	162 764
	Area equipped for full control irrigation by surface water (1 000 ha)	31 973	44 810	21 414	98 197
	% of total irrigation	34.6%	69.5%	94.1%	54.7%
	Area equipped for full control irrigation by groundwater (1 000 ha)	47 775	19 605	932	68 312
	% of total irrigation	51.7%	30.4%	4.1%	38.0%
	Total agricultural water managed area (1 000 ha)	95 939	64 482	26 625	187 047
	% of cultivated area	46.9%	49.8%	23.9%	42.0%

Source: FAOSTAT-AQUASTAT (2013).

The sustainable livelihoods framework

This study uses the 'sustainable livelihoods framework' to analyse rural development issues, as it provides an objective approach to organize the complex issues surrounding poverty. It offers a more holistic people-centred analysis compared to conventional farming systems frameworks. While farming systems analysis focuses on production, the livelihoods framework enables us to understand poverty in the context of lack of opportunities in economic, political and social life. The pathways out of poverty lie in people's capabilities to exploit opportunities using their own assets, while also overcoming their vulnerabilities. These factors form the foundation of the livelihoods framework.

The sustainable livelihoods approach recognizes that farm household livelihoods are often diverse. The various activities of household members using diverse assets lead to multiple priorities and strategies, and therefore multiple outcomes. It seeks to overcome the compartmentalization of people's lives based on the arbitrary sectoral divisions of government departments and policies: urban/rural, formal/informal, education/health/industry/agriculture (Moller *et al.* 2010). The approach also recognizes the interconnectedness of development and poverty issues, ensures that cross-sectoral linkages are taken into account and helps to identify key entry points, resulting in more focused interventions. It offers a way to analyse problems holistically, while identifying specific interventions.

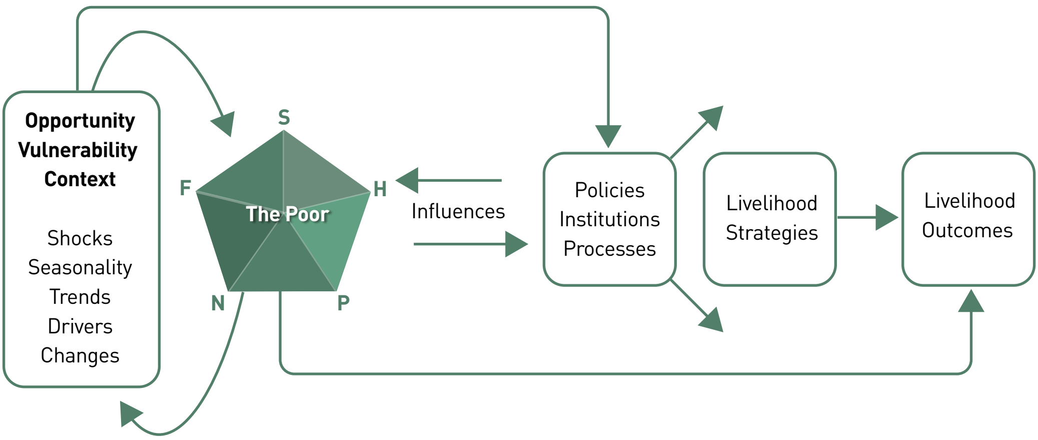
The sustainable livelihoods approach has evolved over time; there is an extensive body of literature on the approach and its application (Chambers and Conway 1992; Carney *et al.* 1999; Batterbury 2008; Ashley and Carney 1999; Ellis 2000; and Scoones 1998). Development NGOs have adopted or modified the framework based on their areas of engagement (e.g. Oxfam, CARE), as have donors and international agencies (e.g. IFAD, UNDP, ILO and FAO). The United Kingdom's Department for International Development (DFID) was the earliest pioneer in developing and applying the sustainable livelihoods framework (Solesbury 2003). All these approaches share basic principles and common elements.

First, livelihoods are defined as ways of obtaining the necessary assets for living. For example, based on Chambers and Conway (1992), the Institute of Development Studies defines livelihoods in terms of the capabilities, assets (both material and social resources) and activities required to make a living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, as well as maintain or enhance capabilities and assets, while not undermining the natural resource base.

Second, all of them make use of the concept of 'five capitals': natural (e.g. water), physical (e.g. infrastructure), financial, social (e.g. social networks) and human (e.g. skills). The human, physical, natural, financial and social capitals that people possess – or have access to – affect their prospects for escaping poverty because possessing several of these capitals can enable them to take advantage of opportunities. Expanding the capitals of poor people can strengthen their position and their control over their lives. Given a particular context (policy, politics, history, agroecology and socio-economic conditions), various combinations of livelihood resources (the five capitals) can enable a household to follow a variety of livelihood strategies, such as agricultural intensification or extension, or livelihood diversification and migration, to achieve a set of diverse outcomes.

The approach adopted in this study is based on the IFAD framework (Figure 1.2).

FIGURE 1.2 THE LIVELIHOOD FRAMEWORK



Key: **F** = financial; **S** = social; **H** = human; **P** = physical; **N** = natural.

Source: Sustainable livelihoods framework, available at: http://www.ifad.org/sla/background/index.htm.

Our analysis is focused on the context of potential water interventions for agricultural development to address rural poverty. Two critical questions may be raised here. First, is it appropriate to use the framework with a sectoral focus on water and agriculture, whereas the framework normally demands a holistic analysis with no predefined intervention? This study recognizes that the relationship between water and poverty is complex, and analyses the relationship itself in a holistic context. It therefore does not limit the application of the framework; rather it helps narrow the focus, and also helps identify options beyond water and agriculture. As will be argued in subsequent chapters, agriculture itself should not be seen through a sectoral lens, given that rural poverty and agriculture are interconnected to the wider economic and environmental dynamics.

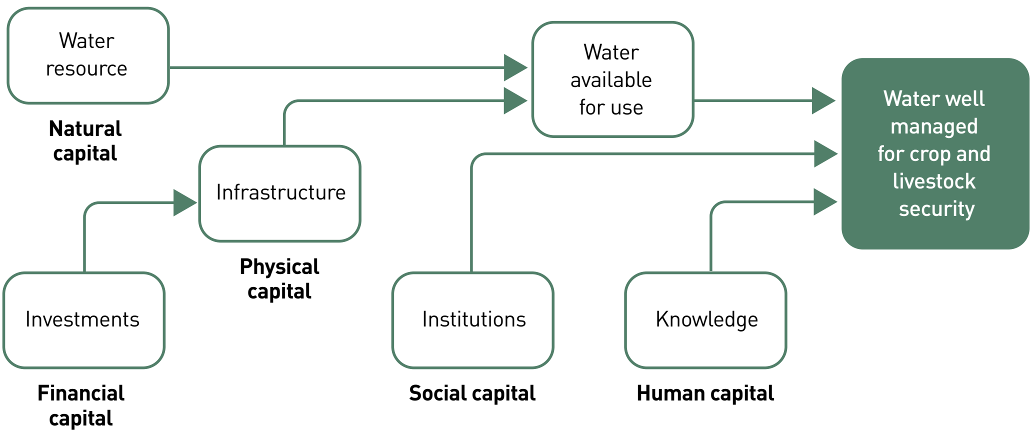
The second issue is how to situate water interventions within the livelihood framework. This requires understanding of the assets and their linkages with water and how they contribute to crop-supported livelihood outcomes. Water is a natural capital, but requires both social and human capital linked by physical capital (infrastructure) to deliver the desired services. The services therefore result from the interaction of at least three capitals, and are measured in terms of water availability and productivity. The functioning of these capitals helps people to choose specific agriculture-based livelihood strategies, most often intensification and diversification, that enable them to achieve expected livelihood outcomes and ultimately help build the (mostly financial) capitals they need to sustain their livelihood. The livelihood outcome could be increased through more stable income, improved nutrition and health, and/or reduced poverty, for example. Often it is a combination of them.

Sullivan *et al.* (2006) have proposed a 'rural water livelihood index' in an attempt to capture the different dimensions of the relationship between water and livelihoods. The index is constructed on the basis of four indicators which capture the four main relationships between people and water in rural areas: 1) access to water and sanitation services; 2) crop and livestock water security; 3) a clean and healthy water environment; and 4) secure and equitable water entitlement.

The four dimensions of the rural water livelihood index are directly linked to the five capitals. Clearly, access to water supply and sanitation requires physical infrastructure and the financial resources to build it. Crop and livestock security, in areas subject to water shortages, require the availability of water as a resource, the capacity to store and distribute it, and the financial, technical and organizational capacity to manage it. It therefore draws on all five livelihood capitals. A clean and healthy water environment, as well as secure rights to access water requires both a well-functioning institutional and legal environment and the rule of law, and therefore strong social capital.

Water interventions are essential, either to create new capitals or to improve the existing capital base, but communities often lack the necessary financial capital to create or maintain the other forms of capital. Most water interventions involve injection of external financial capital to create or improve physical assets. The role of financial capital is critical, as this capital is convertible into other forms of capital or can be used to create other forms of capital. In recent years, the importance of social capital has been widely recognized as an especially critical element of water interventions. Figure 1.3 illustrates possible linkages between water and livelihood outcomes.

FIGURE 1.3 WATER AND LIVELIHOOD LINKS



Two conditions are essential for water interventions. First, there must be potential to develop water-based assets or to improve the existing asset base. The second is that water is in reality the key limiting factor or 'binding constraint' for people's livelihoods, and water interventions can help build the needed assets for people to initiate and sustain improved livelihoods. The first condition is necessary but not sufficient for water interventions, as it only reveals that there is potential for water resources development. The first condition identifies the scope for possible water interventions whereas the second identifies the opportunity or need for the intervention. Both are essential for water interventions to be appropriate. These two situations are further explained in terms of supply and demand contexts of water and poverty linkages in the next sections.

Livelihood zoning

This study has adopted livelihood zoning as a tool for analysing water and poverty in Asia. A livelihood zone map shows areas within which people broadly share the same pattern of livelihoods. It provides a geographical snapshot of livelihood systems as a baseline and a sampling frame for future livelihood zone profiling to document changes. Livelihood patterns vary spatially, which is why the preparation of a livelihood zone map is a useful first step for a livelihood-based analysis. For agriculture-based livelihood systems, zoning helps to classify areas of similar soil, productivity, climate, water resources and land forms, enabling an assessment of the agricultural potential and constraints. These can be used as a basis for identifying suitable interventions, as was done in the SSA study (Faurès and Santini 2008). The livelihood zoning methodology is explained in detail and applied in chapter 3.

Most livelihoods are complex and are shaped by a wide range of factors. They usually take into account geography, production systems (which reflect climatic conditions) and other forms of economic activities. For regional-level assessments, livelihood zoning is largely based on production systems (as in the case of the SSA study), as incorporating other forms of economic activity is extremely complex. Zoning at the country level is more detailed and includes both geography and production systems (e.g. in India, Afghanistan and FEWS NET zoning in Africa [http://www.fews.net]/). Only at the local level does livelihood zoning combine geography, production systems and other economic activities.

Poverty and water linkages

Water is used in many productive and consumptive activities and contributes to livelihoods in many different ways. It plays a key role in agricultural production and hence directly contributes to food security and poverty reduction. For example, access to good irrigation has the potential to enable poverty reduction and improvements in people's well-being. Reliable irrigation enables farmers to adopt new technologies and intensify cultivation, leading to increased productivity, higher production and greater returns from farming. This, in turn, opens up new employment opportunities, both on and off farm, and can improve incomes, livelihoods and the quality of life in rural areas. Overall, irrigation water, like land, can have an important wealth-generating function (Hussain *et al.* 2004).

Hussain *et al.* (2004) identified five key interrelated dimensions of the relationship between access to good agricultural water, socio-economic uplifting of rural people and poverty reduction. They are: production, income/consumption, employment, vulnerability/food security and overall welfare. Namara *et al.* (2010) built on that study and identified ten pathways through which agricultural water management impacts on poverty:

1. Production and productivity
2. Employment
3. Consumption and food prices
4. Output and income stabilization

5. Backward linkages and second round effects
6. Non-farm rural output and employment
7. Nutrition
8. Multiple uses of agricultural water supply to satisfy other basic needs
9. Equity
10. Environment and health, i.e. improved income can enable farmers to make investments to protect and enhance sustainability.

While the role of water in agricultural production and poverty alleviation is well recognized and visible, the prevalence of poverty and the availability of water are not necessarily linked; many other factors play a critical role. Not all poor people lack adequate water, and not all people living in water-poor areas are poor. The water resource endowment of the most poverty-stricken regions compares reasonably well with that of better-off regions. The incidence and severity of poverty depend far more on the level of control over, and access to, water resources, than on the water resource endowment. For instance, eastern India, dubbed as India's poverty square, is endowed with a very large groundwater reservoir and substantial surface water resources, yet people lack the resources needed to exploit these water sources (Shah 2001) and remain poor. This study also shows that this part of Asia has the most potential for water interventions to reduce poverty (see chapter 3). Many irrigated areas with large-scale irrigation systems, particularly in India and Pakistan, remain home to large numbers of poor people in both absolute and relative terms, largely because of substantial inequities in access to land and water resources. As a result, productivity is low.

Although the underlying causes of poverty vary by farming system, the increasing scarcity of and competition for water pose a threat to future advances in poverty reduction in many countries. Most of the areas of persistent poverty can be described as 'water scarce' or 'water constrained, i.e. there is a gap between demand for and supply of water. Improved understanding of the linkages between water and poverty is therefore crucial, but defining that relationship is challenging. The nature and direction of causal linkages between water and poverty are complex, unclear and non-linear, and interact with each other in different ways.

Water and poverty linkages have been defined and studied in multiple ways. They broadly fall into two categories (Kemp-Benedict *et al.* 2011). The first deals with water-specific forms of deprivation, and is therefore called 'water poverty'. The second is more generic and links how water-related constraints and opportunities contribute to poverty and its alleviation. It conceives poverty in broad terms, and is more relevant for policy implementation. The water poverty approach has been dominant in the water field; however, the more generic approach to water and poverty relationships has recently been getting more attention in prioritizing development interventions.

Water poverty is a relatively a new concept that moves beyond the physical aspects of water availability and incorporates socio-economic conditions and patterns of water use. Many studies have contributed to understanding water scarcity beyond the traditional concept, for example the

Falkenmark indicator or 'water stress index' (Falkenmark *et al.* 1989); the inclusion of demand in water-poverty analyses (Seckler *et al.* 1998); the Social Water Security Index (SWSI, Ohlson and Turton 1999); and more recently, the Water Poverty Index (WPI, Sullivan 2002). The WPI has gained wide attention in recent years, and the concept continues to evolve with refined concepts like the Water Wealth Indicators (WWI) or Water Vulnerability Matrix (WVM) (Sullivan *et al.* 2006). Analysis of the evolution of the WPI is beyond the scope of this study; Fenwick (2010) offers a detail account of this transformation.

The WPI uses five indicators to measure water poverty: resources, access, capacity, uses and environment. One limitation of the WPI has been that resources and capacity, which determine water access and uses, are used as independent variables. Both the quantity of water and the way it is managed act as constraints on the effectiveness of water delivery and therefore impact all other variables. More recently, further conceptualization of the WPI has been called for, especially to address growing concerns regarding food security and agricultural water management. The newly developed concept of Water Wealth Indicators (WWI) seeks to address these concerns. It comprises a measure of water resources as constraints on the following components: food security, health, productivity and environment. This approach is more suitable to studying water interventions as it helps to examine how access to resources (which depends on water availability and physical and institutional arrangements) constrains livelihood outcomes involving food security, productivity and environmental management. It therefore requires analysis at two levels: 1) the amount of resources available for use; and 2) how the resources affect people's livelihoods (Sullivan *et al.* 2006).

This study follows this approach to understanding how water-related constraints impact livelihoods and the potential relevance of improved agricultural water management to address the problem. It develops water and poverty linkages through supply and demand perspectives, and the priority for water intervention is determined based on both. The supply side considers the degree of water availability, and is therefore dependent on hydrology, current patterns of water use as determined by institutional capacity and water-related infrastructure. It therefore evaluates the extent of water scarcity and potential for its further utilization. This will ultimately determine the scope for water interventions. The methodological approach for assessing this 'supply' side consideration is further explained in chapter 3.

The 'demand' perspective identifies the extent to which water is the limiting factor leading to poverty and the extent to which it may be a route for its alleviation. It thus reflects the need and opportunities. Two factors are important regarding the demand perspective. The first is the degree of poverty (need) and the second is the degree to which water is the limiting factor for poverty alleviation (opportunity). This study maps the degree of poverty using child malnutrition as an indicator, as explained in chapter 3. The judgement that water is the limiting factor for economic growth in a given area and has potential to bring development and change is complex; this study largely relies on expert opinion on this issue. However, a major criterion for such judgements is whether agriculture-based livelihoods will likely remain as key economic activities in the area for the foreseeable future.

Organization of this report

Chapter 2 presents the overall trends and transformations in water, poverty and agriculture in Asia. It argues that rural livelihoods should be seen within the broader context of ongoing economic and agricultural transformations, and future water control should facilitate this change process. Chapter 3 maps poverty, water and agriculture and develops water and poverty linkages based on demand and supply perspectives. It identifies areas where water interventions will benefit the most rural poor, and where water interventions will not have significant impacts on poverty alleviation. The possible water interventions, their likely impacts in different livelihood systems and for different groups of farmers, and the necessary enabling environments for such interventions to succeed are presented in chapter 4.

The report concludes in chapter 5 by examining options beyond water and agriculture. The non-farm sector contribution to rural poverty reduction is rising and often even surpasses agriculture. However, both sectors are strongly interconnected and inseparable, and sustainable growth of the non-farm sector is crucial for the growth of the rural farm sector (Timmer 2010). Chapter 5 explores the scope of this neo-agriculture, and how it contributes to the rural farm sector and ultimately to rural poverty alleviation.

2. Rural livelihoods, water and agriculture: trends and transformations in Asia

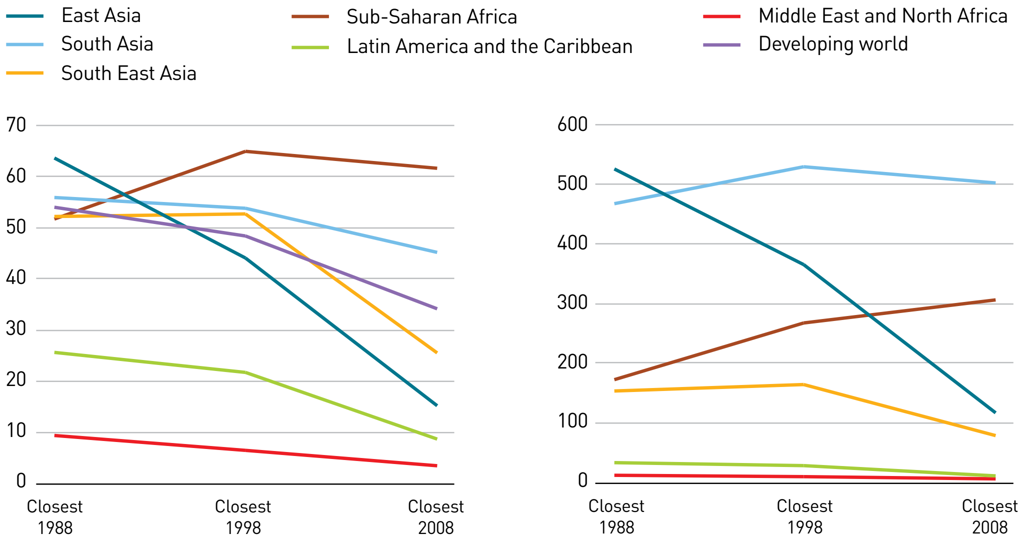
Rural livelihoods in transition

Asian rural livelihoods have been changing rapidly as a result of economic growth, structural transformation of national economies, poverty reduction programmes and policy reforms. Rural economies are being integrated into national and wider economic spheres. Millions of poor people have escaped poverty through new opportunities offered by the changing economic environment. As a percentage of GDP, the economic contribution of agriculture is shrinking, and agriculture is commercializing and diversifying, driven by urbanization and commoditization. The share of the non-farm economic sector's contribution to the rural economy is steadily rising. A vibrant rural dynamic is emerging with new hopes and opportunities, but also with risks and challenges.

The past few decades have seen remarkable progress in poverty reduction worldwide. Rural poverty in the developing world declined from 54 percent in 1988 to about 35 percent in 2008. This was largely due to massive reductions in poverty in East Asia, where rural poverty now stands around 15 percent (IFAD 2011). This is clearly seen in Figure 2.1, which shows the rural poverty trends over the last 30 years in different regions of the world. It also shows that South Asia remains the primary home of Asian rural poverty, a trend that is expected to continue for the foreseeable future. However, even in South Asia, poverty in relative terms is declining at a much faster rate than in the past. The remarkable progress in poverty reduction in both East and Southeast Asia is linked to the reform-driven economic expansion of the past decades, which played an important role in restructuring the rural economies.

Asian economies continue to expand and globalize. Rural economies are becoming complex, a result of rapid urbanization and increased rural-urban and farm-non-farm linkages. The economic gains are also raising serious environmental management issues: there is concern that economic growth is resulting in exploitation of natural resources beyond their limits; and climate change is adding further complexities. Shaped by both economic and environmental factors, new patterns of poverty are emerging: what an IFAD study calls the 'new rurality' (Rauch 2009). This calls for new responses to poverty reduction to achieve sustainable economic development and ecological conservation while also addressing the growing inequity (Box 2.1).

FIGURE 2.1 RURAL POVERTY TRENDS IN (A) RELATIVE AND (B) ABSOLUTE TERMS (PERCENTAGE OF RURAL PEOPLE LIVING ON LESS THAN US$1.25/DAY)



Source: IFAD (2011).

BOX 2.1
What is the 'new rurality'?

The rural poor face rapidly changing agricultural markets and major technological and institutional innovations, including changing roles of the state, civil society and the private sector. On the one hand, agricultural producer prices are likely to increase, so there will be more incentives to invest in agriculture and hence in rural areas. This will lead to intensifying agricultural production wherever possible, including areas where the rural poor reside. On the other hand, in many of these locations, diminishing natural resources, including water, are already limiting production. In addition, increasing prices for basic food items is affecting the nutrition of those poor people who are net food buyers. As a result, livelihoods are changing rapidly, but most poor rural households are poorly prepared to take advantage of new opportunities. Farming is often only a part of their livelihood systems. Rural markets are becoming dominated by large agribusiness companies, which control value chains. New niche markets are developing for agricultural products such as fruit, vegetables and fish, but they depend on water and investments in water management. The 'winners' are usually found close to airports and among resource-rich rural households; the 'losers' are often in remote areas and have sparse resources.

All these and other changes create uncertainty and risk. Poor rural people are losing the race to gain access to and make good use of limited water supplies and rapidly changing market opportunities.

Sources: Rauch (2009); Cleveringa *et al.* (2009).

The new rurality offers both opportunities and threats to the poor. The opportunities come from emerging markets, new technologies, and prospects of commercialization and diversification to meet the increasing and variable demand. As discussed further below, the rural poor can also benefit from the emerging non-farm sector, which has gradually come to dominate rural income in recent years. The risk is that many of the rural poor may not be able to cope with changing market demands due to lack of capacity, lack of resources to capture new investment or geographical constraints.

In overall terms, agricultural producer prices will increase and there will be more incentives to invest in agriculture and hence in rural areas. This will lead a push towards intensifying agricultural production in rural areas wherever possible. On the other side, the growing demand for high-value foods, such as livestock, fish, vegetables and fruits, will put further pressure on natural resources. Bioenergy demands will introduce new competition for land and water resources. These demands will likely adversely affect food security and human well-being (IFPRI 2008). Pressure on water resources from high economic growth and demand can have an especially negative impact on the poor (Ahmed *et al.* 2010).

These trends and transformations clearly show that long-term rural poverty reduction directly depends on sustainable economic growth or, in Timmer's (2010) words, on successful structural transformation. The future challenge is how to exploit opportunities arising from the new global realities, while minimizing the threats. This may also require short-term measures to protect those poor smallholders who could be adversely affected in the changing context. Future pro-poor water intervention strategies should be seen within the wider context of this new rurality. It requires improved understanding of the trends and transformation in water and agriculture and their wider linkages to poverty reduction. These are discussed in the following sections.

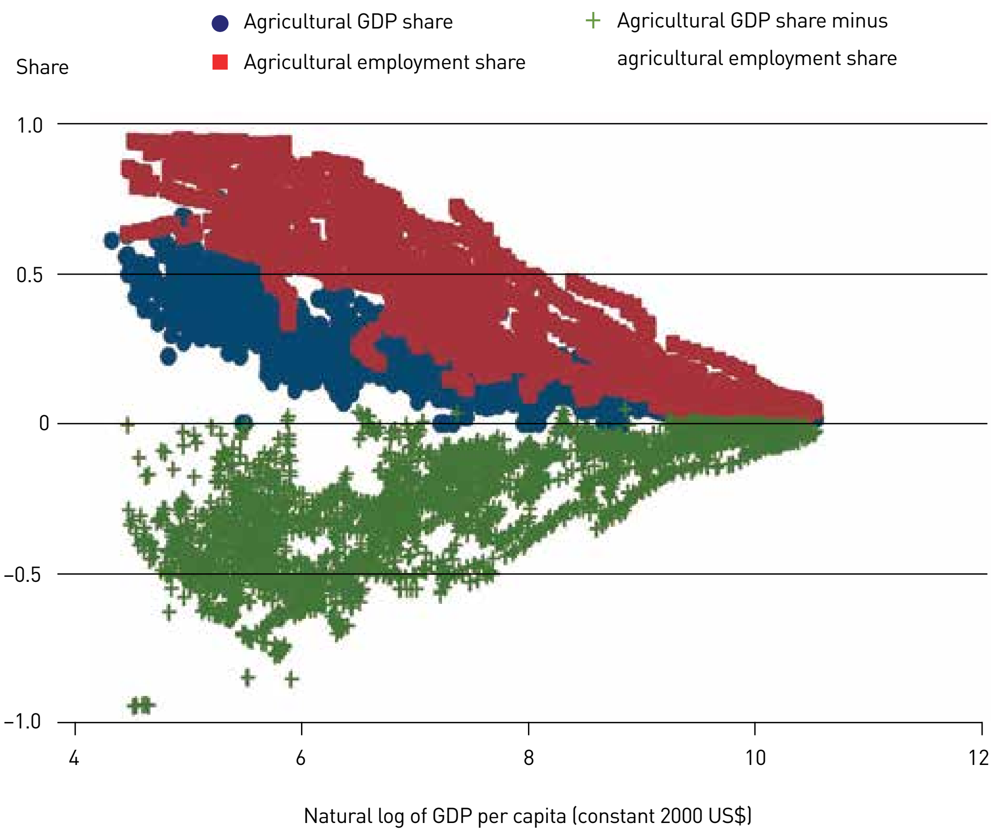
The ongoing transformations: agriculture, diet and economy

Rural livelihoods have been shaped by three interrelated transformations: structural, agricultural and dietary, driven by both global forces and local context. As explained by Timmer (2010), the process involves a *successful structural transformation* in which agriculture, through higher productivity, provides food, labour and even savings to the processes of urbanization and industrialization. A dynamic agricultural sector raises labour productivity in the rural economy, pulls up wages and gradually eliminates the worst dimensions of absolute poverty.

Structural transformation is defined as the reallocation of economic activity from the agricultural sector to manufacturing and services. This is the essence of modern economic growth (Herrendorf *et al.* 2013) and is the defining characteristic of the development process. It is both the cause and effect of economic growth (Syrquin 2006). Four quite relentless and interrelated processes define structural transformation (Timmer 2010): 1) a declining share of agriculture in gross domestic product (GDP) and employment (Figure 2.2); 2) rural-to-urban migration that stimulates the process of urbanization; 3) the rise of a modern industrial and service economy; and 4) a demographic transition from high rates of births and deaths (still common in poor rural areas) to low rates of births and deaths (associated with better health standards in urban areas).

The final outcome of structural transformation, visible in rich countries, is an economy and society in which agriculture as an economic activity, at least in terms of the productivity of labour and capital, is similar to other sectors. The gap in labour productivity between agricultural and non-agricultural workers approaches zero when incomes are high enough and the two sectors have been integrated by well-functioning labour and capital markets. Two trends characterize this process, clearly visible in Figure 2.3 and Table 2.1: both the share of agriculture in GDP and agricultural labour employment decline with economic growth. However, the second trend is not as strong in Asian countries as elsewhere: the decline in agricultural labour employment does not follow the trend found in developed countries. While the contribution of agriculture to GDP is a little over 10 percent in Asia, almost 55 percent of its population still depends on agriculture for their livelihoods (Figure 2.3). Similarly, Table 2.1 shows that agriculture still employs a significant portion of the population in many Asian countries. Agriculture will therefore remain central to the rural economy in Asia and the agrarian question will remain at the centre of economic and political discourse.

FIGURE 2.2 THE FINAL OUTCOME OF STRUCTURAL TRANSFORMATION



Source: Timmer (2010).

The main reason for higher labour engagement in agriculture is that Asian governments have provided incentives, including massive investments in irrigation, to remain in the agriculture sector. Asia did not experience the rapid urbanization seen in the West; agriculture has continued to provide most of the employment in rural areas. The region has been experiencing massive population expansion, and the majority depend on cultivating small parcels of land in the absence of alternatives. Farming has remained the only way to sustain their livelihoods for most of the population.

TABLE 2.1 POVERTY AND SHARE OF AGRICULTURE IN THE ECONOMY AND EMPLOYMENT IN SELECTED ASIAN COUNTRIES

Note: PPP = purchasing power parity.

	Contribution of Agriculture to GDP (%)		Poverty based on $1.25 PPP (%)		Agricultural Employment (% of total)	
	1990	2010	1990	2010	1990	2010
Bangladesh	30	19	66.7 (1989)	43.3	65	48 (2005)
Cambodia		36	44.5 (1994)	18.6 (2009)	78 (1998)	54
China	27	10	60.2	11.8 (2009)	60	37
India	29	18	53.6 (1988)		61(1994)	51
Philippines	22	12	30.5 (1988)	18.4 (2009)	45	33
Viet Nam	39	21	63.7 (1993)	18.9 (2008)	70(1996)	48
Sri Lanka	26	13	15 (1991)	4.1	48	33

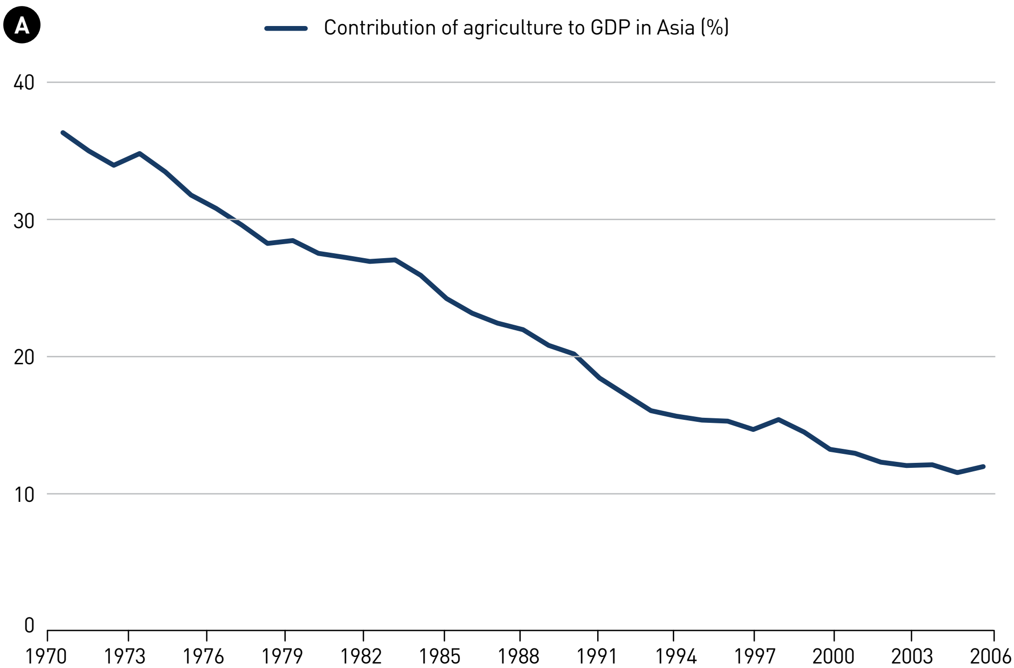
Source: World Bank data (http://data.worldbank.org/indicator).

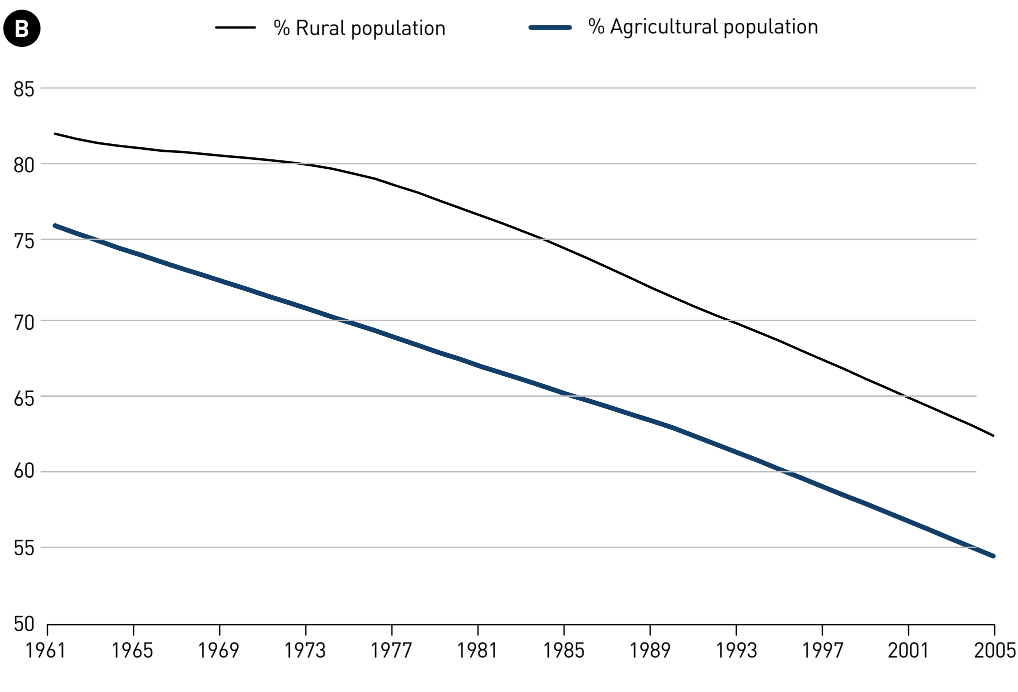
Asian agriculture has some distinct features compared to other parts of the world. Most farmers are smallholders operating on a family basis. Small owner cultivation is supplemented by tenancy transactions that facilitate land transfers from relatively land-abundant households to households with labour but little land. This rationalizes allocation of operational farmland to family labour (Otsuka 2007). Sharecropping is more prevalent than fixed rent leasehold tenancy.

The average farm size has declined over the years for both socio-economic and political reasons. Rapid population growth in rural areas, land division through property transfer and stagnant growth of rural non-farm sectors in the past have all contributed to the decline in farm size. Indeed, from 1980 to 2010, available agricultural land per capita in South Asia has decreased by almost 50 percent whereas in Southeast and East Asia the decrease has been around 30 and 20 percent, respectively.[1] There is now substantially less agricultural land available to feed each person in Asia compared to past decades.

[1] http://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC, accessed 16 January 2014.

FIGURE 2.3 (A) CONTRIBUTION OF AGRICULTURE TO GDP AND (B) RURAL AND AGRICULTURAL POPULATION





Source: Credit Suisse (2008)

Politically, radical land reform programmes limiting land possession at a specific threshold together with redistribution of farm land have also resulted in declining farm size. Except in Indonesia and Thailand, where rapid economic transformation and the expansion of cultivated area have restricted the rate of decline, most Asian countries have experienced sharp declines in farm size. In the long run, farm size may rise as people migrate to cities, labour wages rise, markets for land rentals and sales develop, and consolidation takes hold. In rapidly growing areas such as China, Indonesia, Thailand and Malaysia, there may be significant farm consolidation by 2020. However, farm size in much of South Asia is expected to continue declining for at least a generation to come. Raising productivity and incomes therefore remains crucial for rural livelihoods.

Agricultural and dietary transformations

Continued growth, urbanization and commercialization are having profound impacts on both food consumption and production patterns in Asia. The overall trend has been that the intake of high quality food stuffs like meat, poultry and horticultural products has been rising whereas that of grains like wheat and rice has been declining. This is clearly visible in Table 2.2. However, the trend varies in different parts of Asia, driven by economic dynamics and local food habits. Except for wheat consumption in Southeast Asia, per capita consumption of both rice and wheat is almost stagnant across the region.

TABLE 2.2 DIETARY TRANSFORMATION IN ASIA (KG PER CAPITA PER YEAR)

East Asia | Southeast Asia | South Asia

		2009	2000	1990	1980
Rice	East Asia	111.8	115.6	121	116
	Southeast Asia	193.5	190.8	183.1	189.3
	South Asia	106.3	109.6	116.10	100
Wheat	East Asia	63.8	70.2	73.7	56.5
	Southeast Asia	20	16.3	9.3	11.1
	South Asia	63	64.6	53.2	53.5
Fruit (excluding wine)	East Asia	70	44.3	20.9	13.10
	Southeast Asia	73.3	57.6	49.4	53.6
	South Asia	49.8	38.3	30.7	27.8
Vegetables	East Asia	297.4	227.1	106.9	63.4
	Southeast Asia	56.00	49.2	36.6	34.5
	South Asia	67.7	59.3	50.5	44.1

	2009	2000	1990	1980
Poultry	12.8	10.6	4.3	2.5
	10.4	6.9	4.3	2.9
	2.8	1.6	1.0	0.5
Meat	56.4	47.8	26.8	16.2
	26.4	18.1	13.4	9.8
	7.0	5.7	5.7	4.80
Fish	33.5	28.3	18.0	12.6
	31.6	24.2	19.3	16.30
	6.6	5.2	4,10	3.5

Source: FAOSTAT. http://faostat.fao.org/.

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Consumption of horticultural products in East Asia rose almost fivefold between 1980 and 2009. Similar trends characterize the consumption of meat, poultry and fish. Southeast Asia has broadly followed similar trends in consumption of fish and meat, but the pace is much slower in the case of fruits and vegetables. South Asia is yet to see major changes in consumption of meat and vegetables; it is increasing at a much slower rate. Its consumption of these items remains much lower than in other regions, due to poverty and food preferences. It has the highest consumption of milk per capita, again largely for cultural reasons.

The impact of dietary transformation and population growth is clearly reflected in the production of agricultural products in Table 2.3. Production of rice and wheat is increasing at a much slower rate, despite the massive increase in population, whereas production of meat, milk and poultry is increasing rapidly. Some analysts predict that production of rice will stabilize around 2020 and decrease by 2050. The declining trends in rice and wheat (in relative terms when compared with 1980) started from the early 1990s in China, whereas both rice and wheat production in Southeast and South Asia are still rising.

Changing production and consumption patterns have direct implications for rural poverty alleviation programmes. Changing diets in China have largely been due to the growth of rural markets and production triggered by structural changes in the agriculture sector, driven by growth and urbanization (Huang *et al.* 2010), and have therefore had profound impacts on the rural economy. The weaker dietary transformation in South Asia may be linked to the depth of poverty in the region. Increased intake of high value and processed food also triggers the growth of the rural non-farm sector, potentially bringing new opportunities to the rural poor.

TABLE 2.3 TRENDS IN MAJOR FOOD PRODUCTION (MILLION TONNES)

East Asia | Southeast Asia | South Asia

		2011	2000	1990	1980
Rice	East Asia	219.85	210.56	214.21	163.02
	Southeast Asia	206.75	152.40	111.37	84.48
	South Asia	224.78	181.65	151.60	112.20
Wheat	East Asia	118.76	100.51	99.89	56.21
	Southeast Asia	0.186	.094	0.124	.090
	South Asia	132.56	110.03	75.58	52.35
Palm oil	East Asia	0.250	0.213	0.180	0.160
	Southeast Asia	41.98	18.48	8.78	3.32
Cattle meat	East Asia	7.04	5.76	1.92	0.89
	Southeast Asia	1.44	.917	.69	0.58
	South Asia	2.50	2.05	1.82	1.47
Poultry meat	East Asia	43.60	24.22	14.11	10.66
	Southeast Asia	6.64	3.67	1.96	1.01
	South Asia	4.98	2.17	1.01	0.44
Cow milk (fresh)	East Asia	46.67	19.85	14.66	8.41
	Southeast Asia	3.53	1.64	1.00	0.46
	South Asia	74.69	48.37	30.14	18.75

Source: FAOSTAT.

In addition to agricultural transformation driven by economic expansion, climate change and the drive for energy security are also changing the agricultural landscape in the world and Asia is no exception. Biofuel production is increasing rapidly, triggering a new debate on food security versus energy needs. Understanding the food-energy nexus is a new challenge in development agendas.

Food vs fuel: expanding biofuel production

Biofuels are seen as a major energy diversification strategy and an integral part of energy security and climate mitigation measures in many countries. Globally, there was a 300 percent increase in ethanol production from 2000 to 2007 (Hoogeveen *et al.* 2009) and biofuel production is projected to continue to expand rapidly over the next ten years. Ethanol production is expected to increase by almost two-thirds and biodiesel by twofold in the next ten years. By 2022, biofuel production is projected to consume a significant amount of the total world production of sugar cane (28 percent), vegetable oils (15 percent) and coarse grains (12 percent) (OECD-FAO 2013).

The rapid growth of the biofuel market is driven by rising oil prices, environmental regulations, biofuel quotas and increasing concern over energy security. This trend is producing very significant agro-environmental transformations. Its socio-economic impacts on rural people's livelihoods and on food security have received increased attention recently, especially after the food crisis of 2008. Some fear it will transform food for the poor into fuel for the rich, while others believe that it is a solution to the twin problems of poverty and climate change, as it offers an opportunity for smallholders to diversify their crops and obtain a return equal to that of high-value agriculture – which will ultimately help them to escape from the poverty trap. The challenge for the future is therefore how to maintain and grow the industry and enhance its benefit to the rural poor, while limiting unintended outcomes.

The trends in biofuel expansion have to some degree followed the same path as the palm oil industry of Southeast Asia in the early 1980s. Despite a raft of complex economic, social and environmental issues, the palm oil industry has continued to expand at an unprecedented rate amid strongly growing demand. Palm oil production increased from 5 million tonnes in 1980 to 44 million tonnes in 2010, an annual growth rate of 7 percent. About 3 million labourers are employed in the sector in different roles (Cramb and Curry 2012). This has provided livelihood opportunities to the rural poor through both farming and farming-based migration strategies (World Bank 2008). But the dynamics of change due to biofuel expansion will be much stronger than Southeast Asia's palm oil boom because of global interests and wider markets.

The growing non-farm sector: neo-agriculture

Rural livelihoods, once confined to the domain of subsistence farming, have now become diversified. Subsistence farming has gradually been transformed into commercial farming, and the share of the non-farm sector income in rural areas has also increased tremendously. The non-farm sector has become a dominant and growing component of the rural economy in recent years. More farmers now derive their income from diversified sources than from agriculture, whose share has been decreasing as seen in Table 2.4.

TABLE 2.4 LIVELIHOOD STRATEGIES IN SELECTED COUNTRIES

Country	Farm-oriented			Diversified	Labour	Migration
	Subsistence	Commercial	Total			
Bangladesh	2	4	6	48	40	6
Nepal	8	17	25	42	29	4
Pakistan	2	29	31	28	34	8
Viet Nam	4	38	42	39	18	1

Source: World Bank (2008). The data show the percentage of households who derive at least 75 percent of their income from the respective activities.

The data in Table 2.4 are almost a decade old, but show two important trends in rural livelihoods. First, commercial farming now dominates over purely subsistence farming; and second, most farmers have diversified income sources. Recent literature shows that the share of non-farm sector household income is increasing, and is higher than that of the agriculture sector in many countries (Pandey *et al.* 2010; Otsuka *et al.* 2009; Headey *et al.* 2010). However, the change has occurred at different paces, driven by local agro-ecological and sociopolitical contexts. While the transformation in China and many Southeast Asian countries took place much earlier, the process has been much slower in South Asia, particularly in India, where this trend became more dramatic only after 2004/2005 (Himanshu *et al.* 2013).

The increasing role of the non-farm sector is not independent from agriculture. For example, increasing commercialization is a major contributor to growth in the non-farm sector and its growth in turn fuels the commercialization process. Because of the ripple effect of one sector to another and strong synergistic linkages between the two, the rural non-farm sector is now referred to by some as 'neo-agriculture' (Timmer 2010), rather than an activity independent of agriculture. The rural non-farm sector has thus become an integral part of the agricultural transformation process and is a major contributor to rural development as well as poverty alleviation. Achieving harmonious growth of both the farm and non-farm sectors will remain an important pathway for rural poverty alleviation efforts in Asia.

Trends in water resource management

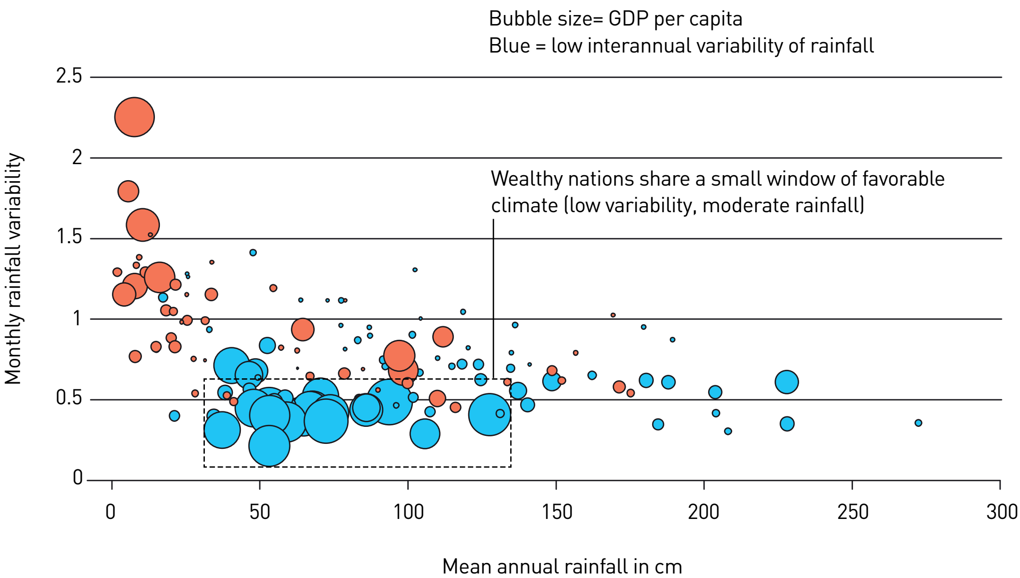
Growing water scarcity will be a formidable challenge to future advances in food security and poverty reduction both globally and in Asia. The World Bank puts the cost of China's water problems – mostly damage to health – at 2.3 percent of a year's GDP (*The Economist*, October 12, 2013). This is a clear indication of how future poverty might be impacted by water scarcity conditions. While water is not a scarce resource in overall terms, its spatial and temporal variation fuels regional scarcity. Water resources are already stressed in many areas, yet demand continues to rise for food, fibre and fuel production. At the same time, competition for water among different users and uses resulting from economic expansion, population growth and urbanization is reshaping the pattern of water use and management. The impact of climate change will further compound the complexities and all these factors are expected to result in a perfect storm with dark clouds emerging towards 2030 (Kay 2011).

Overall, the region is relatively well-endowed with water resources: with a total area representing 15 percent of the Earth's land surface, Asia receives 22 percent of its precipitation and produces 28 percent of its water resources. However, water availability per capita is lower than in many parts of the world; its large population means the region has far higher domestic and agricultural water needs than other regions. The large range of climates characterizing Asia generates a variety of hydrological regimes. The region is host to some of the most humid climates giving rise to the major river systems of Asia (the Ganges, Mekong, Indus, Irrawaddy, Yangtze), while other areas have a very arid climate, with closed hydrological systems- there is no additional water available to exploit. As a result, the region exhibits a very uneven distribution of its water resources and water-use conditions.

The hydrology of the region is dominated by a monsoon climate which induces large interseasonal variations in river flows. On average, the southwest monsoon rainy season, lasting for about four months (June through September in South Asia, May to August in East and Southeast Asia), contributes 80 percent of the total annual river flow. The remaining eight months are dry in much of Asia. In this situation, average annual values of river flows are a poor indicator of the amount of water resources available for use. Despite having high annual average rainfall, many Asian nations suffer from poor agricultural outputs due to the variability of rainfall. The success or failure of the annual Indian budget has always been linked to the timeliness of monsoon rains in the past.

Managing the seasonal and interannual variability of rainfall will therefore be crucial to secure water availability for future agricultural growth and economic development in Asia. The analysis of global datasets already reveals a statistically significant relationship between greater rainfall variability and lower per capita GDP (Brown and Lall 2006), as seen in Figure 2.4. The small oil-producing states are the exception (large brown circles). This correlation of rainfall variability with economic development of nations highlights the need for storage infrastructure to mitigate the impacts of rainfall variability. Various storage options are further discussed in chapter 4.

FIGURE 2.4 RAINFALL VARIABILITY AND GDP



Source: Brown and Lal (2006).

Almost 82 percent of Asian water withdrawals are used by agriculture, compared to 70 percent globally (Table 2.5). The Indian subcontinent and East Asia have the highest levels of water withdrawals for agriculture with 92 and 77 percent, respectively. The two regions together represent about 82 percent of the total irrigated area in Asia.

TABLE 2.5 WATER WITHDRAWALS BY SECTOR IN ASIA

Region	Sub region	Total withdrawal by sectors						Total water withdrawal	Freshwater withdrawal	Freshwater withdrawal % of IRWR
		Municipal		Industrial		Agricultural		Total		
		km³/yr	%	*km³/yr*	%	*km³/yr*	%	*km³/y*	*km³/yr*	
		429	11	723	19	2 710	70	3 862	3 856	9
Asia		217	9	227	9	2 012	82	2 456	2 451	20
Near East		25	9	227	9	227	83	271	268	55
Central Asia		5	3	200	10	1 635	81	2 021	2 021	17
South & Eastern Asia		186	9	200	10	1 635	81	2 021	2 021	17
	South	69.9	7	19.5	2	914.1	91	1 003.5	1 003.5	56.8
	East	93.4	14	149.8	22	434.2	64	677.5	677.5	19.9
	Mainland Southeast	8.9	5	20.4	12	139.8	83	169.0	169.0	9.5
	Maritime Southeast	14.1	8	10.1	6	146.9	86	171.1	171.1	3.6

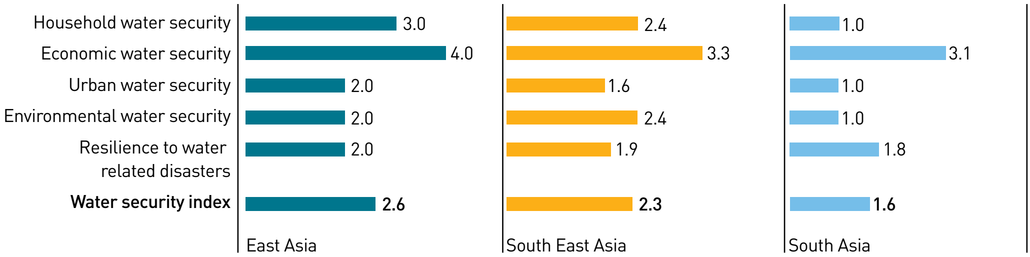
Note : IRWR = internal renewable water resources.

Source: FAO AQUASTAT. http://www.fao.org/nr/aquastat

Assessments of trends and future scenarios, especially for agricultural water, generally present encouraging views of the region. A recent study on water security (ADB 2013a) in the region shows favourable and uniform results, especially for economic water security (Figure 2.5). The three areas of economic water security are the agricultural, industrial and energy sectors, representing the major productive and consumptive water-use sectors. Agriculture accounts for about 80 per-cent of total water withdrawals and will therefore remain a major determinant of overall economic water security. Most of the increases in future water demand are expected to be in the industrial and domestic sectors, resulting from accelerating industrialization and urbanization.

The ADB study, however, does not adequately account for the environmental dimensions of water flows. Therefore, Figure 2.5 overstates the degree of economic water security by ignoring environmental flows and water quality issues. Figure 2.5 also shows that both environmental water security and the resilience to water-related disasters are weak in all regions, and very alarming in South Asia. As future poverty reduction is strongly linked to managing both environmental and water hazards (droughts and floods), water interventions must respond to this problem. The current status of economic water security must be increased, while improving environmental and disaster-related water security. This will not only support poverty alleviation, but also support building the green economy – though it may have implications for current water-use patterns.

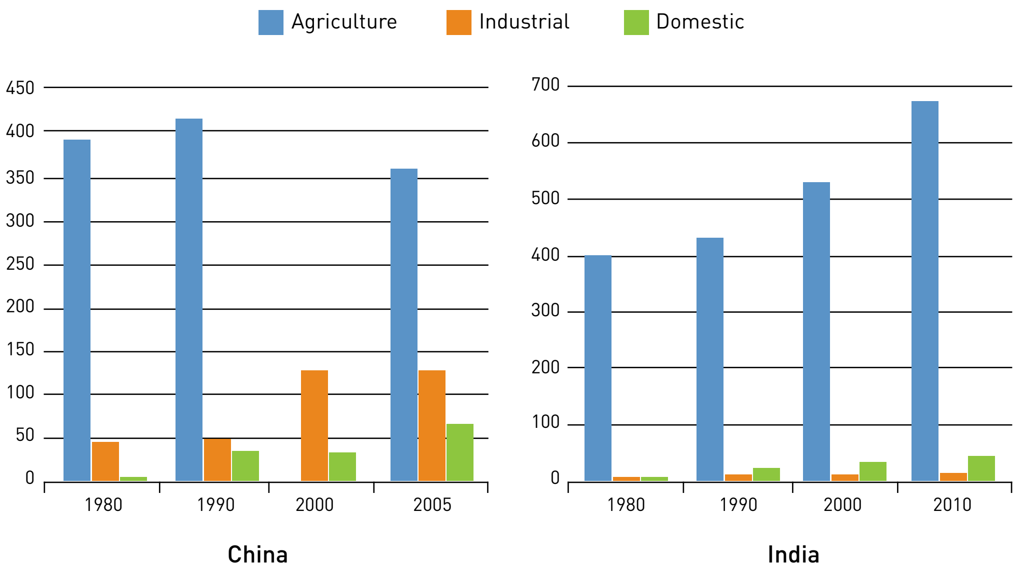
FIGURE 2.5 WATER SECURITY INDEX IN ASIA



Source: ADB (2013a). The water security index for each category is measured on a scale from 1 to 5, where 1 is for hazard stage whereas 5 is for the best or model case. The sub-regional index values are population-weighted averages of the values for individual countries. The composite National Water Security Index values are the simple averages of the five key dimension index values.

The available literature shows that the demand for agricultural water will increase at a much slower rate than in other sectors (FAO 2011a; ADB 2013a). The two largest countries, China and India, show somewhat similar trends in domestic water use, but greatly differ in agricultural and industrial uses (Figure 2.6). Agriculture water use is stabilizing in China, whereas it continues to rise in India. This suggests that China has already achieved a higher degree of water productivity than India and South Asia generally. As water use in other sectors is increasing, improving agricultural water management will be crucial for overall water management because of its larger share.

FIGURE 2.6 TRENDS IN WATER WITHDRAWALS FOR CHINA AND INDIA (KM^3)



Source: FAO AQUASTAT. http://www.fao.org/nr/aquastat. Agricultural withdrawal for China in 2000 is not available.

The pattern of agricultural water withdrawals shown in Figure 2.6 is also consistent with FAO's analysis (2012) of future irrigation withdrawals (Table 2.6): it shows that the pressure on water resources will increase only marginally due to irrigation.

TABLE 2.6 TRENDS IN AGRICULTURAL WATER WITHDRAWALS

	Precipitation mm	Renewable water resources* Km^3	Water-use ratio** %		Irrigation water withdrawals Km^3		Pressure on water resources due to irrigation %	
			2006	2050	2006	2050	2009	2050
South Asia	1602	1766	55	58	914	889	52	50
East Asia	634	3410	37	42	434	458	13	13
SE Asia	2400	6490	19	21	287	342	4	5
World	809	42 000	44	47	2710	2858	6	7

*Refers to internal renewable water resources; excludes incoming flows at the regional level

**ration of the irrigation water requirement to the amount of water withdrawn for irrigation

Source: FAO (2011a).

Many factors underlie the slower increase in demand for agricultural water. First, irrigation expansion has nearly reached its limits in most of Asia, but tremendous potential exists to increase water productivity, especially in South Asia. Irrigated agriculture (40 percent of its cultivated lands are irrigated) is at the centre of its economic activity, but its agricultural water productivity is relatively low, as is clearly reflected by the higher yield gaps in South Asia as compared to other Asian regions (Lobel *et al.* 2009).

Second, much of the additional food demand is expected to be met through improvements in rainfed agriculture. The vast untapped potential of rainfed agriculture could be unlocked through knowledge-based management of land and water resources, bridging the yield gaps (a factor of two to four) between the current farmers' yield and the researcher-managed or commercial plot yields (Rockström *et al.* 2007). In India, estimates suggest that an average increase of 50 percent in total production can be achieved through better management of rainfed farming with a single supplemental irrigation (Sharma *et al.* 2010). The critical challenge for Asia is therefore to find ways to increase the productivity of existing land and water resources. Irrigation system modernization and management will remain central to achieving and maintaining food security and reducing poverty.

Irrigation development trends and challenges

Irrigation has been the backbone of rural economic growth in Asia, contributing substantially to food security, employment and poverty reduction. It has driven rural economic growth by increasing agricultural production and productivity and providing employment, especially through intensification and diversification of agriculture. Massive investments in irrigation have made it possible to feed Asia's growing population and protect it from famine and starvation, as well as enabling transformation of national economies. While irrigation has been practised since ancient times, it was the green revolution that really transformed the landscape of irrigated agriculture. Asia now has by far the largest area of irrigated land (Table 2.7), with the most extensive irrigation networks of any continent, and it hosts some of the largest and oldest irrigation systems on Earth.

TABLE 2.7: AREA EQUIPPED FOR IRRIGATION AND PERCENTAGE OF CULTIVABLE LAND IRRIGATED

	Area irrigated (million hectares)			Area irrigated (% of cultivable land)		
Year	**1980**	**1990**	**2003**	**1980**	**1990**	**2003**
World	193.0	224.2	277.1	15.8	17.3	17.9
Africa	9.5	11.2	13.4	5.1	5.7	5.9
Asia	132.4	155.0	193.9	28.9	30.5	34.0
Latin America	12.7	15.5	17.3	9.4	10.9	11.1
Caribbean	1.1	1.3	1.3	16.4	17.9	18.2
North America	21.2	21.6	23.2	8.4	8.8	9.9
Oceania	1.7	2.1	2.8	8.6	4.0	5.4
Europe	14.5	17.4	25.2	3.4	12.6	8.4

Source: FAO AQUASTAT. http://www.fao.org/nr/aquastat.

Asia's irrigated agriculture accounts for more than 70 percent of freshwater withdrawals world-wide (Mukherji *et al.* 2009). More than two-thirds of the world's irrigated land is in Asia. Today, about 40 percent of the world's food comes from the 18 percent of cropland under irrigation. Since Asia's agricultural revolution began, the irrigated area has tripled. This reliance on irrigation is reflected in its extent and productivity: an estimated 39 percent of South Asia's cultivated land is irrigated, producing 60-80 percent of its total agricultural output.

In many parts of Asia, surface irrigation development has reached its limit, with no scope for developing new areas. However, increasing the productivity of land, water and labour remains a viable intervention option. Atomistic irrigation, i.e. the use of small pumps and other irrigation equipment by individual farmers, is booming. This is largely due to energy subsidies (especially in India) and the availability of cheap pumping sets. Millions of rural poor people have benefited from this. However, its sustainability in the long run is a major issue. As will be seen in the next sections, Indian and Chinese farmers are using groundwater faster than nature can replenish it, and disputes over water are becoming increasingly common.

As a result of the green revolution, most Asian countries became food self-sufficient by the 1980s. Cereal production has more than doubled during the past 30 years, boosting calorie availability per person by 24 percent even as the region's population grew by a billion people. The large-scale irrigation projects developed during this period, which were frequently linked with land reform and settlement programmes, played a key role in increasing production, raising the volume of crops produced (through higher productivity and cropping intensity) and reducing poverty. India has not faced a serious famine since the 1960s, and rural poverty rates in intensively irrigated areas such as the states of Punjab and Haryana are far lower than in predominantly rainfed states, such as Orissa and Madhya Pradesh (Faurès and Mukherji 2010). In East and Southeast Asia, agricultural productivity more than tripled, and rural poverty decreased rapidly. A study conducted by the International Water Management Institute (IWMI) found the incidence of poverty in irrigated areas to be half as much as that in non-irrigated areas (Hussain 2005).

Between 1961 and 2009, Asia's irrigated area more than doubled, with an average annual growth rate of 2.6 percent (Figure 2.7). By 2009, South Asia accounted for the bulk of irrigated land (90.51 million ha), followed by East Asia (59.6 million ha) and Southeast Asia (22.73 million ha). Since the late 1980s, the rate of expansion has generally slowed, but recently in India and China it has begun to increase again. In 2009-2010, India's net irrigated area was 63.2 million ha and the gross irrigated area was 84.7 million ha [2]. In China, some 59.0 million ha were irrigated in 2009, up from a mere 16.0 million ha in 1949 (Xiaoyun *et al.* 2013). Expansion in irrigated area has kept pace with the growth in population and enabled most Asian countries, including India and China, to increase their food production dramatically.

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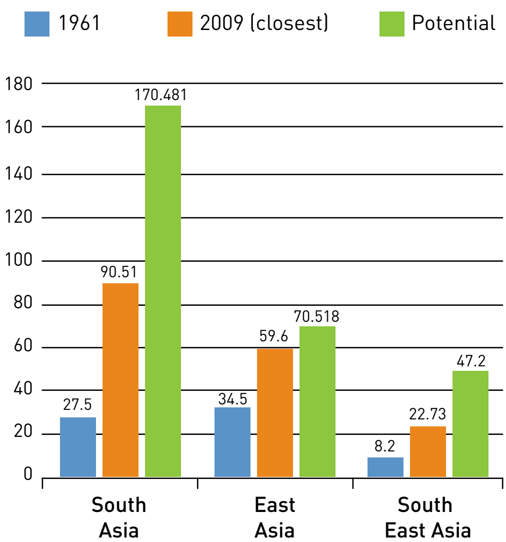
FIGURE 2.7 CHANGES IN IRRIGATED AREA IN ASIA 1961-2009 AGAINST POTENTIAL



Source: Data for India and China have been obtained from respective government databases. For the rest of the countries data were obtained through FAO's database AQUASTAT. http://www.fao.org/nr/aquastat.

Figure 2.7 further shows that irrigation development in East Asia compares well with its potential, whereas it lags behind in both South and Southeast Asia. The large gap in South and Southeast Asia indicates that there is considerable physical potential in both these regions for irrigation development. However, factors such as changing socio-economic priorities, high development costs, land acquisition and resettlement issues, and environmental limitations, both in ground and surface water, limit the scope for further expansion of irrigated areas – especially via the construction of large-scale surface irrigation schemes. Most future public irrigation investments will therefore focus on improving the performance of existing irrigation systems rather than the construction of new ones. Private irrigation investments are described below.

While irrigation has been an engine of rural growth in Asia, its long-term benefits are threatened on several fronts. The benefits in many cases have been realized without acknowledging both social and environmental costs. The IWMI study (Hussain 2005) on the impacts of irrigation on poverty found that the benefits of irrigation are not evenly shared; those at the tail-ends of canal

[2] www.data.gov.in/dataset/net-area-under-irrigation-sources, accessed 18 December 2013.

networks are deprived of the benefits compared to the head-enders. Degrading water quality is another major concern. For example, the Indus system is facing high levels of salinization, which is reducing production. Many surface schemes are characterized by low levels of service delivery as a result of poor operation and maintenance, and their sustainability in the longer term is questionable. Finally, increasing water scarcity and competition for water have also made irrigation management more complex.

Irrigation in Asia is at a crossroads and future irrigation development must respond to the challenges outlined above while also supporting the growth and transformation discussed in earlier sections. The dilemma for the irrigation sector is that it should fulfil today's needs and respond to future demands using systems developed yesterday. The type of future approaches to irrigation intervention will therefore be crucial. Rethinking of conventional approaches to irrigation development is needed to find ways to make irrigation socially equitable, economically viable and environmentally sustainable.

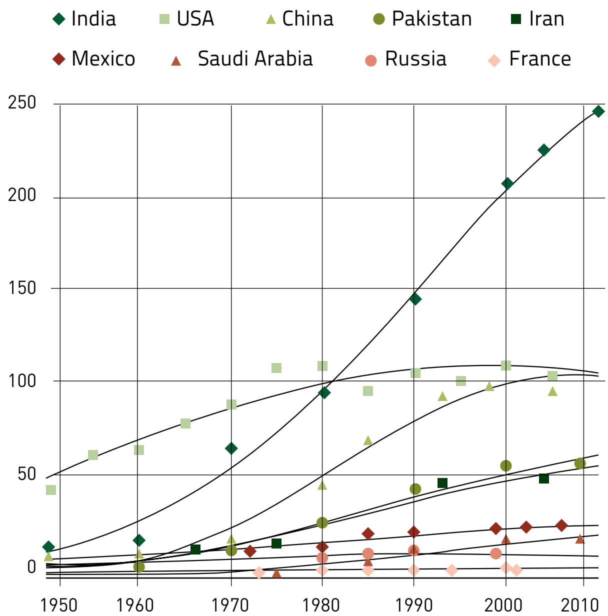
Irrigation interventions will continue to be important because of their strong linkages with rural poverty and the role in overall water resources management. Past approaches to irrigation development were focused largely on technological change to improve management performance and water resource utilization, whereas the focus of current interventions has shifted to achieving sustainability through participation, governance reform and raising economic returns. Participatory Irrigation Management (PIM) and Irrigation Management Transfer (IMT) have been important intervention strategies since the 1990s. The results of these policy reforms have been mixed, largely because they were too narrowly focused (Merrey *et al*. 2007; Mukherji *et al*. 2009). The world needs to look beyond these conventional recipes to address both current problems and tomorrow's needs. While the search continues to find better approaches to irrigation innovation, the debate on irrigation has largely shifted towards the *dark zone*, i.e. groundwater resources. Groundwater development has been shaping the evolution of irrigated agriculture, especially in northern China and South Asia.

The booming groundwater economy

The world has witnessed exponential growth in groundwater irrigation over the last 40 years. This began in China, where firms perfected the manufacture of low-cost pumps for the domestic and export markets and in South Asia, particularly in India, and has continued to expand rapidly in other regions. Its affordability and effectiveness quickly attracted farmers, and has been instrumental in improving the livelihood of millions of smallholders. The number of wells, only a few thousand in 1960, had reached nearly 20 million by 2000, and the process has continued. Available evidence suggests that during the early years of the new millennium, a million new wells were installed in the region every year, though a major slowdown in rate of growth has been observed in India in recent years (Mukherji *et al.* 2013). In India alone, groundwater extraction has increased by 500 percent since 1960 and over 50 percent of India's irrigated area is based on groundwater (Shah *et al.* 2007). Figure 2.8 shows the trends in groundwater extraction for selected countries.

FIGURE 2.8 TRENDS IN GROUNDWATER UTILIZATION IN SELECTED COUNTRIES

Groundwater abstraction trends in selected countries (in km³/year, based on Margat, 2008, with modifications)



Top ten groundwater abstracting countries (as per 2010)

Country	Abstraction (KM³/year)
1. India	251
2. China	112
3. USA	112
4. Pakistan	64
5. Iran	60
6. Bangladesh	35
7. Mexico	29
8. Saudi Arabia	23
9. Indonesia	14
10. Italy	14

Source: van der Gun (2012).

The main attraction of groundwater irrigation is that it enables individual water control, unlike the collective control characterizing surface irrigation. Farmers can therefore match their water supply to changing crop demands. It has therefore contributed significantly to the rapid commercialization and transformation of the agriculture sector discussed in previous sections. Several factors, on both the supply and demand sides, have contributed to the rapid expansion of the groundwater boom, both within the command areas of existing surface irrigation systems as well as in new areas.

The expansion of groundwater use within surface schemes has been in response to several factors: the poor water delivery services provided by existing schemes, the shift from 'protective' to 'productive' irrigation and rising groundwater levels that make low-cost pumping feasible. Most large-scale irrigation schemes in South Asia were designed for 'protective irrigation', to protect against crop failure by providing supplementary irrigation during the monsoon season, especially for staple crops like rice, wheat and barley. These systems were therefore based on 'scarcity by design' (Mollinga 1998) and equity; maximizing productivity was not a major goal. The growing need for productive agriculture has led farmers to search for more flexible demand-driven water management and to switch to groundwater irrigation.

Technological change has also played a central role in the expansion of groundwater. Technological limits were a barrier limiting groundwater extraction until the last quarter of the twentieth century; farmers had to rely on muscle power to lift groundwater. The evolution of cheaper technologies, especially small mechanical pumps, and their widespread availability in the market, often combined with subsidized energy, enabled farmers to own and use pumps. This allowed millions of smallholders to create their own mini-irrigation systems. The rise of this new atomistic irrigation economy dominates irrigated agriculture in the North China plains and much of South Asia today. The same trend is now also evident in the rice economies of Southeast Asia, long home to gravity flow irrigation communities. For example, in the Chao Phraya delta of Thailand, 80 percent of farmers are said to have at least one pump, and in Thailand's Mae Klong project, the World Bank estimated that in the early 1990s, a million pumps were drawing water from canals, drains, ditches and ponds to irrigate dry-season crops (Faurès and Mukherji 2010).

Another factor contributing to the expansion of the groundwater economy was government policy of providing subsidies for construction of shallow tubewells, purchase of pumps and energy subsidies both for diesel and electricity. Many of the rural electrification programmes in South Asia have been driven by the smallholder demand for low-cost energy for shallow groundwater irrigation. Low-cost reliable energy is a critical requirement for successful groundwater irrigation, but subsidies have also led to overexploitation of aquifers and financial crises for electricity service providers. In recent years, the rate of growth of groundwater irrigation has slowed significantly in India, and in eastern India where farmers must use more expensive diesel fuel, the number of pumps has actually declined (Mukherji *et al.* 2013) – even though the groundwater resource is abundant. Increased knowledge and information on groundwater potential has also contributed to the expansion of groundwater irrigation – and is beginning to enable better planning of interventions.

Groundwater irrigation has become a vital tool for maintaining livelihoods and food security for the poor, as well as being an engine of economic growth. It has benefited millions of farmers owning small plots of land and thus has largely been a pro-poor intervention. It has brought major socio-economic benefits to rural communities and in many countries has helped to alleviate agrarian poverty through increasing food security by ensuring water availability at critical times for crop growth, mitigating the devastating effects of drought on crop yields (Shah *et al.* 2007).

The groundwater boom, while bestowing substantial benefits, has also created its own set of intractable problems in terms of overexploitation and depletion of groundwater resources. These have received increased attention in recent years. Some areas of northwestern India and eastern China have already exceeded the limits to water withdrawal by 54 and 26 percent respectively. The poor will be impacted the most, as the rich will continue to access the resource by digging deeper. This trend of meeting today's food demand using future water is not sustainable in the long run.

Natural resource degradation

The growing shortage of land combined with Asia's rising population is resulting in greater intensification of land use. Pastures are overgrazed, rivers, lakes, and coastal areas are overfished, and more crops are produced from the same fields every year, using more irrigation water, chemical fertilizers and pesticides. Every year, some of the land under cultivation is degraded through non-sustainable farming practices, and some is lost to industrial and infrastructure development and urban sprawl. As a result, the area of productive farmland in Asia may actually decrease in the coming decades. Throughout Asia, it is estimated that about one-third of all cropland has already been damaged by agricultural practices that are not sustainable.

Global assessments indicate that the percentage of total land area that is highly degraded has increased from 15 percent in 1991 to 25 percent by 2011 (UNCCD Secretariat 2013). If the current land degradation trend continues over the next 25 years, it may reduce global food production from what it otherwise would be by as much as 12 percent, resulting in world food prices as much as 30 percent higher for some commodities (Nkonya *et al.* 2011). The economic losses due to land degradation and its corresponding ecosystem services are difficult to measure, but the available information demonstrates that they are substantial and growing. Countries with high population growth rates are likely to experience the greatest land degradation in the coming decades. Desertification, land degradation and drought are global challenges which pose serious obstacles for the rural poor in developing countries.

Preservation of biological diversity is an important goal in its own right. The diversity of plant and animal species provides a key input for medical and agricultural research. The greatest threat to biodiversity is not destruction of plants and animals *per se*, but the destruction of their habitat. Asia is home to diverse ecosystems that host many plant and animal species. More than two-thirds of the planet's biological resources are found in 17 countries and five of these – China, India, Indonesia, Malaysia and the Philippines – are in Asia. Indonesia alone is home to more than 30 000 plant species.

Population growth leads to expanding human settlements and increasing demand for food, fuel and building materials; rising global demand for forest products leads to destruction of natural forests. As a result, forests and wetlands that were once home to indigenous species have been cleared and drained, resulting in massive loss of wildlife habitat. Modernization of agriculture also threatens potentially valuable local crops. For example, in Indonesia some 1 500 local varieties of rice have disappeared in the past two to three decades as farmers plant a single, improved variety. In addition, habitat destruction and pollution threaten freshwater and marine fish as well as coral reefs in the region.

Irrigated agriculture uses large quantities of water. With current irrigation practices, an estimated 60 percent of water is lost – though a portion of this is reused by others. Over the past century, the use of freshwater increased more rapidly in Asia than in any other region of the world due to high population and agricultural expansion. Today, Asia has the least fresh water available per person of any region, and water scarcity is projected to worsen in the future. Water pollution is also a serious problem, mainly caused by the disposal of untreated sewage and industrial waste, urban and agricultural runoff, and the intrusion of seawater. Levels of suspended solids in Asia's rivers have grown more than fourfold since the early 1970s and are now about four times the world average and about 20 times the levels typically found in developed countries. Lakes and other water systems are heavily polluted. Largely because of widespread pollution, one out of three Asians does not have access to safe drinking water, defined as a reliable source within 200 metres of the home. Polluted, unsafe water causes millions of deaths every year, particularly among infants and young children. Based on 2008 estimates, 466 million people lack access to an improved water source and 1.87 billion people lack access to improved sanitation in Asia and the Pacific (UNESCAP 2013).

Climate change and its uncertainties

The Intergovernmental Panel on Climate Change (IPCC)'s recent initial report (2013) states that human influence has been the dominant cause of the observed warming since the mid-twentieth century. Its findings show that each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The atmosphere and oceans have warmed, the amount of snow and ice has diminished, the global mean sea level has risen and concentrations of greenhouse gases have increased. The increase in global surface temperature by the end of the twenty-first century is projected as likely to exceed 1.5°C relative to 1850-1900 in all but the lowest scenarios considered, and likely to exceed 2°C for the two high scenarios. Heat waves are very likely to occur more frequently and last longer. As the Earth warms, it is expected that currently wet regions will receive more rainfall, and dry regions will receive less. As the ocean warms, and glaciers and ice sheets are reduced, global mean sea level will continue to rise, but at a faster rate than experienced over the past 40 years (ibid).

Climate change therefore represents a serious challenge to poverty reduction and development efforts. It is superimposed on existing vulnerabilities and exacerbates current challenges in the rural production system, especially in the management of land and water resources. Its impacts are more severely felt by the rural poor because of their high degree of vulnerability and low coping capacity. Oxfam (2013) warns that the world faces a real and imminent risk of major setbacks in efforts to combat hunger because of climate change and without immediate action, past development gains in poor countries will be permanently lost.

The rural poor may be affected by climate change in several ways. Changes in agriculture are the primary means by which the impacts of climate change are transmitted to the rural poor, because of its dependence on climatic conditions and direct and indirect dependence of the rural poor on farming. Agriculture is simultaneously both the cause and victim of climate change impacts. Analysis of the climate change-agriculture-poverty nexus is therefore critical to identifying strategies to combat rural poverty in the coming decades. In addition, the increased risks of climate-related hazards like floods, drought and cyclones will have a profound impact on infrastructure and natural resources. There are different approaches to understanding the potential impacts of climate change on agriculture and more broadly rural production systems. Generally, these impacts are likely due to one or a combination of both:

- Changes in production due to alteration of biophysical processes; and
- Increased vulnerability due to changing water supply scenarios and increased incidences of extreme weather conditions.

These two factors are not independent of one another in the wider climatic cycle, but they may impact crop production and rural assets differently. For understanding water and poverty interactions, the second factor is more important because it is directly linked to water and production assets. It will affect the rural poor through both changing water availability for crop production systems, and by destroying the rural assets supporting their livelihoods.

Crop production is a complex biophysical process highly dependent on temperature, precipitation, CO_2 concentration, sunshine, humidity, wind and other climatic factors. Among them, the first three are highly sensitive to climate change. Shifts in temperature and precipitation also mean a shift in the growing period. All these factors will affect production systems. A study by Nelson *et al.* (2009) using a crop growth simulation model predicts that by 2050, climate-induced reductions in developing country crop yields will range from 1 percent in the case of rainfed rice and wheat to 18 percent for irrigated rice and 34 percent for irrigated wheat. The results of the analysis suggest that agriculture and human well-being will be negatively affected by climate change:

- In developing countries, climate change will cause yield declines for the most important crops. South Asia will be particularly hard hit.
- Climate change will have varying effects on irrigated yields across regions, but irrigated yields for all crops in South Asia will experience large declines.
- Climate change will result in additional price increases for the most important agricultural crops – rice, wheat, maize and soybeans. Higher feed prices will result in higher meat and milk prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereal consumption.

A study by Ericksen *et al.* (2011) on climate change and food insecurity in the global tropics shows the worst scenario for South Asia, especially the Indo-Gangetic plains, in terms of vulnerability to climatic variation. Vulnerability in this study was assessed using the three domains recommended by the IPCC which are a function of exposure, sensitivity and coping capacity. The worst scenario in South Asia results largely from its low coping capacity. The study finds that the growing period will shorten in South and East Asia, and many tropical zones will experience increased rainfall variability. The number of reliable crop-growing days will decrease to critical levels, below which cropping might become too risky to pursue as a major livelihood strategy in many places, especially in the Indo-Gangetic plains. Much of the tropics already experiences highly variable rainfall, above the median of 21 percent for cropped areas. Thus any increases in this variability will make agriculture even more precarious. This will require adaptation of current agricultural systems to cope with these changes.

The increase in water vulnerability will be largely induced by the changing hydrological regime, resulting in higher variability in the water supply and increased incidence of floods and droughts as well as a rise in sea level. The hydrological cycle itself will be impacted in two ways. At the first level, changes in precipitation patterns and rising temperatures will result in higher evaporation and will affect the recharge process and groundwater-surface water interactions. This will alter both surface flows and groundwater regimes, causing changes in water supply both spatially and temporally.

At the second level, climate change will affect existing water storage capacities. Rising temperatures means more rapid melting of the snow-capped mountains and reduction in the snow coverage area, which so far have provided natural water storage. Though studies have shown that there will be no reduction in total runoff, climate change is expected to alter spatial and temporal variation. A recent study (Immerzeel et al. 2013) shows that glaciers will recede and net glacier melt runoff is on a rising trend at least until 2050; water availability during this century is therefore not likely to decline. The study concludes that river basins that depend on monsoon rains and glacier melt will continue to sustain the increasing water demands expected in these areas.

However, a major impact will be the increased seasonal variability of available water resources which will demand additional water storage. Glacier melt in the Himalayas is also projected to increase flooding and rock avalanches. In addition, it is projected that in the middle and high mountain areas, such as the Hind Kush region where most of Asia's large river systems originate, a shift toward more rainfall with less snowfall may occur due to rising temperatures. Likewise, the permanent snow line is expected to shift to higher elevations, resulting in lower snow storage. All these factors will contribute to increasingly severe spatial and temporal variations in water, with a concomitant change in flood and drought risks. Water supply in areas fed by glacial and snow melt water from the Hindu Kush and Himalayas, on which hundreds of millions of people in China, Pakistan and India depend, will be adversely affected (Barnett *et al*. 2005).

Floods and droughts have been the result of extreme climatic events since early historical times, and their impacts are also partly caused by human factors. There is a growing recognition that climate change may already be affecting the frequency and intensity of droughts and floods. Asia has witnessed large-scale flood havoc in the past few years (e.g. floods in Thailand in 2010, Pakistan in 2010 and again in 2011, and the Yangtze River in China in 2010, as well as the most recent Himalayan floods in North India and northwest Nepal). Researchers even argue that more than 50 percent of agricultural output could be affected due to severe flood and drought events in the next three decades.[3]

The rise in sea level and increased frequency and intensity of cyclones will have profound impacts on the deltas, i.e. the low-lying coastal zones and the islands of Asia where the population is dense and cultivation intensive. The severest impacts will be realized in the Ganges-Brahmaputra delta (Bangladesh and India) due to its high population densities and intensive agriculture, followed by the Mekong and the Irrawaddy deltas. They are vulnerable to erosion, inundation and flooding, and general land and water degradation due to saline and brackish water intrusion from rising tides. The economic and social impacts will be immense; those most at risk are the rural poor living in these areas. Asia's island nations including the Philippines and Indonesia will also face more serious threats from storms and rising sea levels.

Climate change is now an accepted reality, and in some cases, is predicted to cause heavy damage to the region. South Asia is among the most vulnerable regions in the world to natural disasters related to climate change because of its exposure to water hazards, high dependency on agriculture and high incidence of poverty combined with a low coping capacity. The vulnerability of the

[3] http://thinkprogress.org/climate/2012/04/16/463231/drought-flooding-and-outbreaks-of-pests-threaten-to-reduce-asian-agricultural-output-50/, accessed 18 December 2013.

Philippines to major typhoons was illustrated recently by the devastation wrought by Typhoon Haiyan. Future pro-poor water interventions in the region must be responsive to these impacts of climate change. Effective adaptation strategies through awareness raising and capacity development, technology innovation and new approaches to management of agricultural water will be critically important.

Managing the transition: a key challenge for future water control and rural livelihood

A new approach to agricultural water management is needed that complements ongoing livelihood transformations and supports dynamic rural change processes, while ensuring sustainable ecological and economic development pathways. Agriculture is rapidly transforming: the agriculture sector will shrink as a percentage of GDP, but it will be more commercialized, diversified and integrated with the growing non-farm sector and the overall economy. A shrinking agriculture sector also means that labour absorption will decline, and the region will increasingly face a mass exodus of workers from agriculture. They will need to be accommodated in other parts of the economy. These changes do not mean that the role of agricultural water management will decline; but it does mean that agriculture and agricultural water must be seen within the wider economic context, not through a sectoral lens.

Poverty in many instances is a result of vulnerability to shocks. Building resilience against water-related hazards is a crucial area needing greater attention in the design of future water interventions. The frequency of floods, droughts, cyclones and other water hazards has increased, and is expected to be exacerbated further by the impact of climate change. The rural poor are the most vulnerable because of their limited asset base and hence are likely to suffer the most. Climate change will make water security complex and costly to achieve.

A critical question is what the future role of agricultural water management in the changing economic and ecological landscapes of Asia will be. While the role will vary depending on the livelihood context in a given rural setting, the main point is that it must be responsive to ongoing change processes and address the environmental concerns discussed earlier. As argued by Mukherji *et al.* (2009), future water control should be designed to address tomorrow's needs and be responsive to farmers' criteria and preferences. It should not be limited to but rather move away from traditional subsistence farming towards more productive commercial farming responding to evolving market needs. It therefore demands more individual control and flexibility over water use.

The next two chapters explore the potential of water interventions for poverty alleviation in this changing context. Chapter 3 maps the existing water and poverty situation and identifies the scope for water interventions. Chapter 4 presents the types and nature of water intervention options and the enabling environment needed for their implementation. The data and figures in chapter 3 should not be seen on their own, but within the context of the wider transformations described in this chapter. The discussion in this chapter also shows that pathways out of rural poverty in Asia increasingly rely on the growth of the non-farm sector. Chapter 5 examines options beyond water and agriculture.

3. Mapping poverty, water and rural livelihoods in Asia

Introduction

This chapter uses multiple sources of data to map patterns of poverty, water and rural livelihoods in the three major subregions of Asia: South, Southeast and East Asia, and in the major livelihood systems found in these subregions. Chapter 2 has discussed the scale and dimensions of poverty, rural livelihoods and water resources; this chapter adds a spatial dimension to that discussion.

Child malnutrition as an indicator of poverty

Poverty and food security are heterogeneous phenomena in most countries; the types and depth of poverty, measured in different ways, vary between and within countries and regions. Poverty is multidimensional, with factors such as income, education, water/sanitation, food security and access to the political process affecting poverty rates (Makoka and Kaplan 2005). This makes the study of poverty challenging; generation of a single indicator comparable across countries is difficult because of social, cultural and economic differences, inconsistent data, and political decisions on how to count poverty among countries (Bigman and Fofack 2000; Elbers *et al*. 2004).

Poverty mapping involves techniques that permit disaggregation of a poverty measure to local administrative levels or small geographical units. All poverty-mapping techniques imply alternative schemes for weighting a particular poverty index, and may imply alternative poverty ranking of the chosen unit. The methods used vary from participatory poverty profiles to sophisticated econometric techniques; most are under continuing development. Each has different data requirements and implementation costs, and their advantages and disadvantages vary (Davis 2003).

The levels and dimensions of poverty are important in an analysis that claims to contribute to poverty reduction. It is therefore important to be able to map both the prevalence and absolute numbers of the rural poor. This analysis has adopted rural child malnutrition – more specifically, the prevalence of being underweight among children under five years of age – as a measure of rural poverty. Child malnutrition represents a good proxy for rural poverty and food insecurity (Setboonsarng 2005). Although an income-based or expenditure-based measure of poverty is also an important indicator, we consider nutrition-based measures to be more appropriate for this analysis for several reasons.

First, health is recognized as an important dimension of poverty in its own right. The health status of children is known to have significant long-term effects on human productivity during adulthood. Malnutrition has long been recognized as a consequence of poverty. It is widely accepted that higher rates of malnutrition will be found in areas with chronic widespread poverty (ADB 2001).

Malnutrition is the consequence of a limited dietary intake, often compounded by chronic infections. Limited dietary intake is an outcome of several issues including household food insecurity, lack of safe drinking water, poor knowledge of the basics of sanitation and lack of alternative sources of income. Health status as measured by the level of child malnutrition encompasses all these dimensions.

Second, a significant advantage of using child malnutrition rather than income level as a poverty indicator is that this measure does not have to be adjusted for inflation and is not affected by gaps or distortions in the price data. Measuring child nutrition can help capture aspects of welfare that are not sufficiently revealed by other indicators. Child malnutrition standards are universal and pertinent across cultures. Nevertheless, it is important to recognize that there is a strong correlation between income level and nutritional status. Studies show that the relationship is especially strong among lower income households.

As a basis for the analysis, the study has adopted the FAO datasets on rural poverty expressed by the proxy indicator 'children underweight' rate.[4] Figure 3.1 shows the global distribution of undernourishment, while Figure 3.2 shows the distribution of rural poverty in Asia using the FAO data.

As expected, rural poverty is most prevalent in South Asia, though parts of East Asia and Southeast Asia also have high numbers of rural poor. As noted by ADB (2012), pervasive hunger remains a problem in Asia despite the recent declines in poverty incidence. South Asia accounts for 60 percent of Asia's hungry, 65 percent of its extremely poor people and 81 percent of its underweight children (World Bank 2009). By conventional measures, South Asia accounts for more than 75 percent of Asia's total poor population, compared to 17 percent in Southeast Asia and 7 percent in East Asia. Moreover, about 45 percent of the total rural population in South Asia is poor, compared to 32 and 6 percent in Southeast and East Asia respectively. The high population density and growth rate and, as a consequence, the high pressure on natural resources is a major cause of the high poverty prevalence. In addition, slow growth of the non-farm sector resulting in lack of opportunities outside agriculture has also resulted in the high rate of poverty in South Asia.

[4] This indicator of rural poverty distribution has been produced by combining several datasets:

1) Center for International Earth Science Information Network (CIESIN), Columbia University, Palisades, NY, USA; 2008 Global subnational rates of child underweight status. CIESIN. [http://sedac.ciesin.columbia.edu/data/collection/povmap].

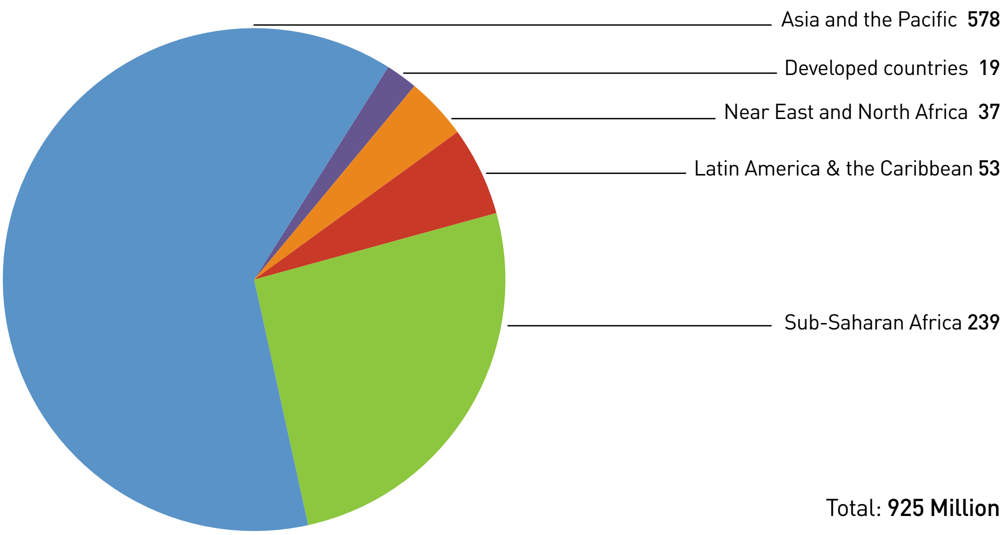
2) Global Rural-Urban Mapping Project (GRUMP) [http://sedac.ciesin.columbia.edu/data/collection/grump-v1];

3) LandScan 2007 Global Population Database [http://web.ornl.gov/sci/landscan/];

4) DHS (Demographic and Health Survey 2008, http://www.measuredhs.com/data/available-datasets.cfm) and WHO Prevalence of Child Malnutrition database [http://www.who.int/nutgrowthdb/database/en/].

The CIESIN data have been differentiated between rural and urban poverty by using data from the Demographic and Health Survey (DHS 2008). Country-level data are available for about 55 countries. The findings for the available countries were extrapolated for countries without data. The data were randomly checked against data from the global database of the World Health Organization (WHO) on child growth and malnutrition. Where necessary, corrections were made. The result of this exercise was a map of rural child malnutrition.

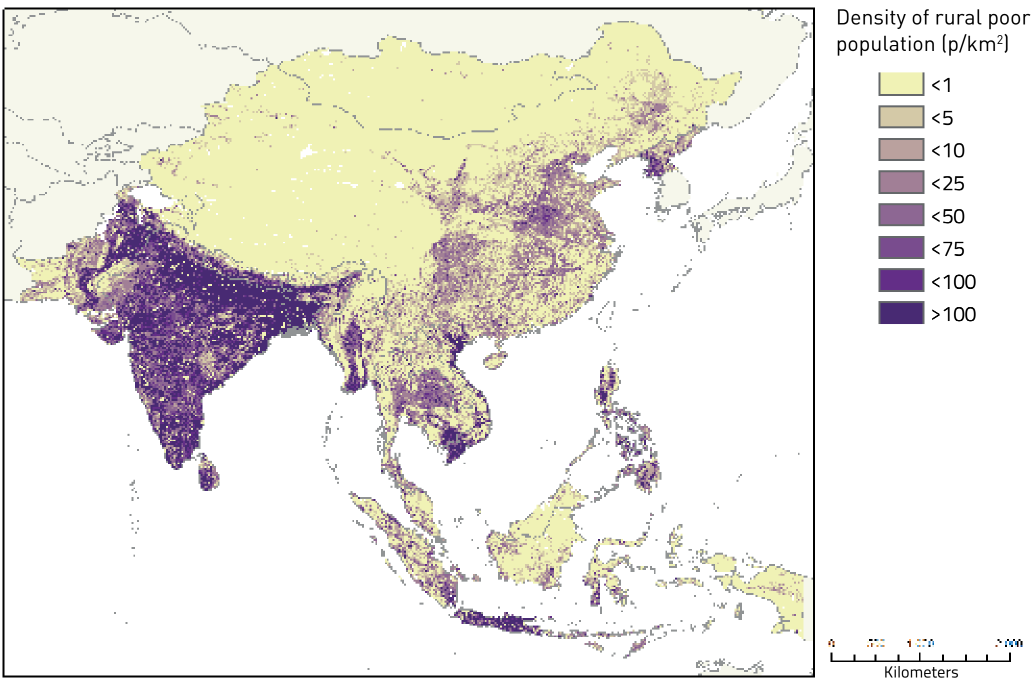
FIGURE 3.1 GLOBAL UNDERNOURISHMENT IN 2010 BY REGION



Source: FAO (2010a).

3

FIGURE 3.2 DENSITY OF RURAL POVERTY IN ASIA



Source: FAO (2010a).

Mapping livelihoods in rural areas

This study builds on the conceptual framework and methodology developed for the earlier study of water and the rural poor in Sub-Saharan Africa (Faurès and Santini 2008). It adopts livelihood zoning as the basis for the analysis of the linkages between water and rural poverty in Asia. Livelihood zoning consists of identifying areas with homogeneous livelihood conditions, based on both biophysical and socio-economic factors. The main measures are:

- The predominant livelihood activities in an area or region;
- The natural resources available to people; and
- The prevailing agroclimatic conditions.

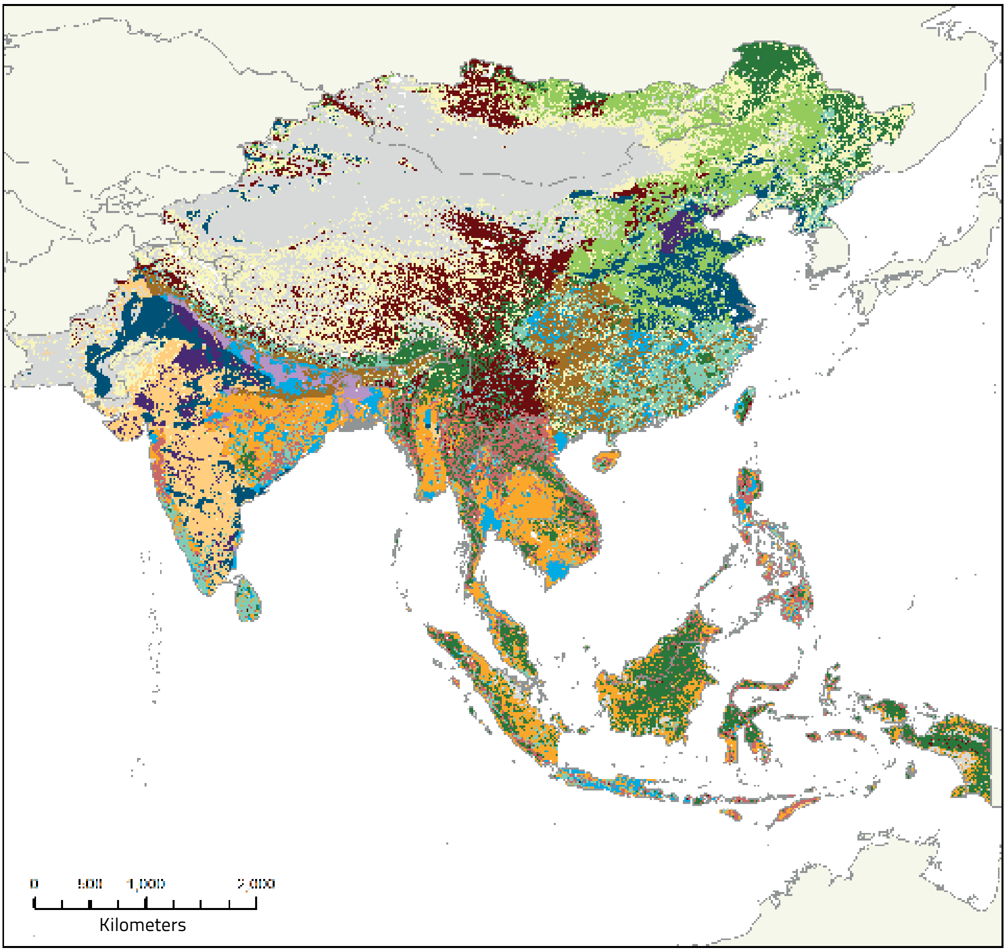
Livelihood patterns vary from one area to another. Livelihoods are affected by many factors, including climate, soil, access to markets and cultural preferences. Delineation of geographic areas based on people who share similar patterns of access to food, cultivate the same crops, have the same types of livestock and have the same access to markets is the first step in mapping livelihoods.

The agro-ecological zone and its natural resources such as land and water are the main determinants of livelihood options. Livelihood options in a particular zone are limited as well as enabled by the resources available. Once it is confirmed that a group of people in a certain area share a predominant way of securing their food, it is possible to characterize the area as, for example, a maize farming zone or a camel pastoralist zone (USAID 2008). Livelihoods can be mapped at different scales with different criteria and parameters. Regional processes for characterizing livelihood patterns are different from identifying livelihood systems at local or country levels. At the regional scale, there is greater heterogeneity than at local levels; therefore livelihood mapping is based predominantly on agroclimatic conditions that dictate major farming practices. At such a scale, it is difficult to account for the variety of socio-economic conditions influencing livelihoods locally (Faurès and Santini 2008). Delineation of more homogeneous livelihood systems involves a downscaling process to the local or country level which can take account of socio-economic conditions as well as political and institutional parameters.

Livelihood systems as the unit of analysis

Agriculture-based activities remain the primary source of livelihood for rural households, either directly or indirectly. However, it is important to recognize the dynamics of rural livelihood patterns and the increasing importance of off-farm activities in the household economy, particularly in the Asian region. Therefore, the regional livelihood systems identified in this study build on previous work conducted by FAO (2011a). That study produced a global map of 'major agricultural systems'; an expanded version of the Asian component is presented in Figure 3.3. It was based on earlier work done by Dixon *et al*. (2001), which was based on an interpretation of global land cover data, as well as thematic datasets showing irrigated land and the extent of paddy rice.

FIGURE 3.3 LIVELIHOOD SYSTEMS IN ASIA



Livelihoods systems

- Rice/wheat groundwater irr. (humid tropics)
- Groundwater irrigation (dry)
- Rice – based surface irr. (humid tropics)
- Wheat/rice surface irrigation (dry)
- Rainfed (dry tropics and sub-tropics)
- Rangelands/pastoral areas
- Tree crops and mosaic agriculture-forest
- Lowland rice-based Rainford (humid tropics)
- Upland rainfed (humid tropics)
- Rainfed (humid sub-tropics)
- Serial-based Rainfed (temperate)
- Highand/mountain agriculture
- Sparse
- Forest based

Source: Expanded from FAO (2011a).

Dixon *et al.* (2001) identified 70 major farming systems characterizing the developing world. These were used as a basis for understanding the challenges and opportunities faced by rural people in their attempts to cope with poverty and hunger. They define a farming system as "a population of individual farm systems that have broadly similar resources bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate". The details of farming patterns within a zone are strongly influenced by the external rural environment, social networks, institutional contexts and market access and linkages. Farms are organized to produce food and to meet other household targets through the management of available resources within the existing social, economic and institutional context (Faurès and Santini *et al*. 2008). A farming system is a resource management strategy to achieve economic, social and subsistence goals on a sustained basis to meet the diverse requirements of the farm household while preserving the resource base and maintaining environmental quality (Lal and Millar 1990). In addition, a farming system is a decision-making unit comprising the farm household and its cropping and livestock system that transform land, capital and labour into useful products that can be consumed or sold (Fresco and Westphal 1988).

While the approach used by Dixon *et al*. (2001) is highly relevant to this study, where context-specific issues and solutions are discussed, their maps have several shortcomings: they have a low spatial resolution, they are continental with no harmonized legend and they do not cover the whole world.

This study has expanded the concept of FAO's (2011a) 'major agricultural systems' map and conceptual framework as a proxy to characterize and map rural livelihoods in the region, given the strong link between agriculture and livelihoods and the necessity to identify a manageable number of distinct livelihood systems. While such a reductive approach is helpful for regional analysis, at national and subnational scales the range of assets and constraints and the heterogeneity of situations that characterize livelihoods in rural areas go beyond agriculture and encompass off-farm activities. Expert consultations have enabled identification of major livelihood systems in the region that are geographically located by reclassifying the agricultural systems map and including additional criteria and mapping layers. Specifically, the livelihood systems are based mainly on the following biophysical and socio-economic criteria:

- Land cover and land use;
- Agricultural water management and use;
- Climate;
- Topography;
- Dominant crops; and
- Population density.

Seventeen regional livelihood systems have been identified, representing the major livelihood typologies of the region. There are four broad categories in which the major zones can be grouped:

- Zones characterized mainly by rainfed conditions:
  - Rainfed zones in dry areas with tropical and subtropical climate, where millet, sorghum and oilseeds are the dominant crops – *rainfed (dry tropics and subtropics)*;

- Rainfed zones in humid areas with a lowland topography and tropical climate, where rice and oilseeds are the dominant crops – *lowland rice-based rainfed (humid tropics)*;
- Rainfed zones in humid areas with a hilly topography and tropical climate, where rice, maize and oilseeds are the dominant crops – *upland rainfed (humid tropics)*;
- Rainfed zones in humid areas with a subtropical climate, where rice, maize and wheat are the dominant crops – *rainfed (humid subtropics);*
- Rainfed zones with a temperate climate and where wheat, maize and soybean are the dominant crops – *cereal-based rainfed (temperate)*; and
- Rainfed zones with mountain agriculture, where maize and wheat are the dominant crops – *highland/ mountain agriculture.*

• Zones characterized mainly by irrigated conditions:

- Irrigated zones serviced by groundwater (>75 percent) in the humid tropics, where rice and wheat are the dominant crops – *rice/wheat groundwater irrigation (humid tropics)*;
- Irrigated zones serviced by groundwater (>75 percent) with a dry subtropical or temperate climate, where wheat, maize and rice are the dominant crops – *groundwater irrigation (dry)*;
- Irrigated zones with surface water in the humid tropics with rice as the dominant crop – *rice-based surface irrigation (humid tropics)*; and
- Irrigated zones with surface water and a dry subtropical or temperate climate, where wheat and rice are the dominant crops – *wheat/rice surface irrigation (dry)*.

• Zones characterized mainly by rangelands and forest with a population density >50p/km^2 and rice and oilseed crops as the dominant crops – *rangeland/ pastoral areas*.

• Zones characterized mainly by arid conditions. These are sparse and often dispersed zones with very low current productivity or potential because of extreme aridity or cold.

These systems have been delineated by adapting and reclassifying the agricultural system maps. Moreover, three additional systems have been identified but cannot be geographically located as they are not correlated to specific spatial parameters such as land cover, climate, population, etc. These systems are:

• Peri-urban agriculture-based systems around major urban centres;

• Intensive livestock-based systems; and

• Inland fisheries and aquaculture systems.

Table 3.1 describes the key biophysical and socio-economic parameters that enable identification, characterization and mapping of homogeneous livelihood systems.

TABLE 3.1 MAJOR LIVELIHOOD SYSTEMS IN ASIA

Input datasets							Livelihood system	Additional information
System delineation						**System description**		
Land-use objectives & management			**Biophysical conditions**			**Dominant crops**		
Main land use/cover class	**Management**		**Aridity Index**	**Climate**	**Topography**			
Cropland	**Irrigated**	Serviced by groundwater	Humid	**Tropics**		Rice, wheat	**Rice/wheat groundwater irrigation (humid tropics)**	Irrigated rice, wheat, vegetables, livestock including dairy, off-farm activities.
			Dry	**Subtropics / temperate**		Wheat, maize, rice	**Groundwater irrigation (dry)**	Wheat, maize, rice, pulses, oil crops, livestock, off-farm work.
		Surface water	Humid	**Tropics**		Rice	**Rice-based surface irrigation (humid tropics)**	Wetland rice (both seasons), vegetables, legumes, off-farm activities. Often combined with livestock (pigs in China, sheep and goats in Indonesia, Bangladesh and India), inland fisheries/aquaculture.
			Dry	**Subtropics / temperate**		Wheat, rice	**Wheat/ rice surface irrigation (dry)**	Wheat, maize, pulses, oil crops, livestock, off-farm work.
	Rainfed		Dry	**Tropics**		Millet, sorghum, oil crops	**Rainfed (dry tropics and subtropics)**	Drought-resistant cereals such as sorghum and millet. Livestock consists often of goats and sheep, especially in India.
				Subtropics				
			Humid	**Tropics**	Lowland	Rice, oil crops	**Lowland rice-based rainfed (humid tropics)**	Wetland rice (both seasons), vegetables, legumes, inland fisheries/aquaculture, off-farm activities.
					Hilly	Rice, maize, oil crops	**Upland rainfed (humid tropics)**	Rice, pulses, maize, oil seeds, fruits, vegetables, livestock, inland fisheries/ aquaculture, off-farm work.
				Subtropics		Rice, maize, wheat	**Rainfed (humid subtropics)**	Rice, maize, wheat. Cattle are the most dominant livestock, While pigs are dominant in China.
			Temperate			Wheat, Maize, soybean	**Cereals based rainfed (temperate)**	Wheat, maize, pulses, oil crops, livestock, Inland fisheries/aquaculture, off-farm work
			Mountain agriculture			Maize, wheat	**Highland / mountain agriculture**	Low productivity, small-scale subsistence (low-input) agriculture; a variety of crops on small plots plus few animals. Summer grazing of livestock
Rangeland						Not relevant	**Rangeland / pastoral areas**	Very scattered extensive and low productive livestock grazing. Pastoral areas dominated by nomadic livestock keeping and migration

Input datasets						Livelihood system	Additional information
System delineation					System description		
Land-use objectives & management		Biophysical conditions			Dominant crops		
Main land use/cover class	Management	Aridity Index	Climate	Topography			
Forest	Population density > 50 p / km²				Rice, oil crops	**Tree crops and mosaic agri-culture-forest**	Extensive forest-based subsistence agriculture (rice, livestock) and com-mercial tree crops such as rubber, oil-palm, coconuts, tea, spices.
	Population density < 50 p / km²				Not rel-evant	**Forest-based**	Hunting, gathering, off-farm work
Other land							
Systems not geographically mapped							
					Vegetables	**Peri-urban agriculture**	Horticulture, dairy, poultry, other work
					Not relevant	**Livestock intensive**	Intensive commercial live-stock production (cattle, pigs)
					Not relevant	**Inland fisheries/ aquaculture**	Intensive fish farming and inland fisheries activities

Source: This study.

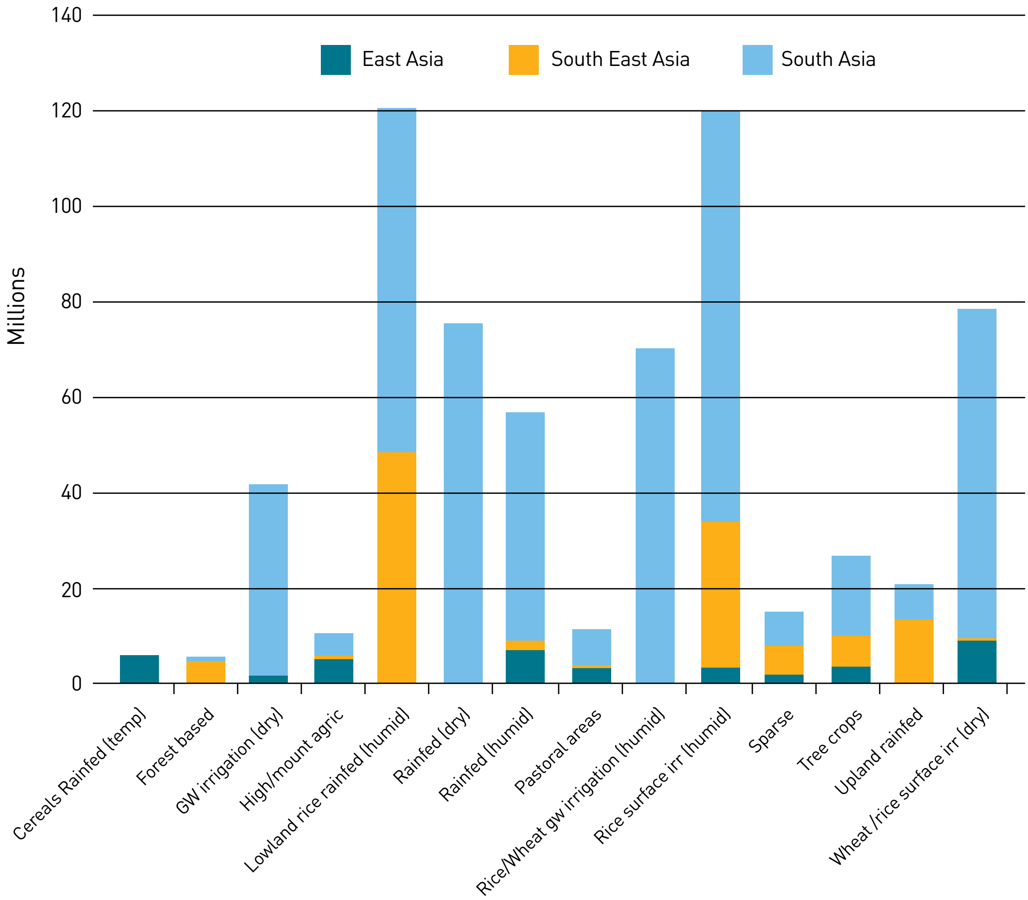
Analysing poverty, water and agriculture across livelihood systems

Poverty

As explained above, this study has adopted the FAO datasets on rural poverty expressed by the proxy indicator 'children underweight' rate. We have combined poverty and livelihood data to quantify the level of poverty for each of Asia's major livelihood systems. These are expressed as a percentage of the total population that is poor in Figure 3.4. Table 3.2 provides the figures on rural poverty by livelihood system.

It is clear that South Asia exhibits by far the highest level of rural poverty. There is no great variation among different livelihood systems in South Asia: poverty rates are over 40 percent and in some cases over 50 percent in all zones apart from the forest-based zone (which has relatively few people). There is also not much difference between irrigated and rainfed zones. This shows that for agriculture there are factors other than water accessibility for determining poverty in this subregion. In East and Southeast Asia, poverty is far less severe than in South Asia. In East Asia, the poverty levels vary between 4 and 8 percent in all livelihood systems. Southeast Asia has relatively high levels of poverty compared to East Asia.

FIGURE 3.4 RURAL POVERTY ACROSS LIVELIHOOD SYSTEMS



Source: This study.

One interesting feature of the poverty distribution is that the rural poor are mainly concentrated in rice-based systems, both rainfed and irrigated, totalling more than 30 percent of the rural population. These are largely water-dependent livelihood systems and therefore are of importance from a water intervention perspective. Poverty in these areas is linked not only to physical availability of and access to water, but also attributable to water vulnerabilities such as floods and droughts. This is discussed further in chapter 4.

Increasing population density, degrading natural resources as well as unequal income distribution, conflict and hunger are major factors underlying poverty. Hunger is a consequence as well as a cause of poverty because poor health, low levels of energy and mental impairment reduce people's ability to work and to learn. The total production of world agriculture is actually more than sufficient to feed everyone at least 2 720 kilocalories per person per day (FAO, IFAD and WFP 2002).[5]

[5] This remains the case as of 2013; see http://www.fao.org/docrep/x0262e/x0262e05.htm, accessed 16 January 2014.

TABLE 3.2 RURAL POVERTY ACROSS LIVELIHOOD SYSTEMS

Livelihood system	Region	Rural population		
		Total (000)	Poor (000)	% rural poor
Groundwater irrigation (dry)	East Asia	30 658	1 334	4.4
	South Asia	79 404	40 762	51.3
Rice/wheat groundwater irrigation (humid tropics)	East Asia	77	30	39.0
	South Asia	129 532	70 750	54.6
Rice-based surface irrigation (humid tropics)	East Asia	87 921	3 772	4.3
	South Asia	157 548	85 831	54.5
	Southeast Asia	87 408	30 757	35.2
Wheat/rice surface irrigation (dry)	East Asia	230 169	9 588	4.2
	South Asia	142 435	68 764	48.3
	Southeast Asia	758	285	37.6
Forest-based	East Asia	14 061	863	6.1
	South Asia	2 585	1 005	38.9
	Southeast Asia	13 703	4 111	30.0
Rangeland pastoral areas	East Asia	72 692	3 843	5.3
	South Asia	15 398	7 755	50.4
	Southeast Asia	967	360	37.2
Sparse	East Asia	49 369	1 937	3.9
	South Asia	14 906	7 079	47.5
	Southeast Asia	22 192	6 504	29.3
Cereal-based rainfed (temperate)	East Asia	167 737	5 957	3.6
Highland / mountain agriculture	East Asia	56 729	5 441	9.6
	South Asia	10 372	4 509	43.5
	Southeast Asia	1 890	673	35.6
Lowland rice-based rainfed (humid tropics)	East Asia	3 370	190	5.6
	South Asia	131 001	71 928	54.9
	Southeast Asia	142 223	48 971	34.4
Rainfed (dry tropics and subtropics)	East Asia	211	20	9.5
	South Asia	151 210	75 432	49.9
	Southeast Asia	1 886	646	34.3

Livelihood system	Region	Rural population		
		Total (000)	Poor (000)	% rural poor
Rainfed (humid subtropics)	East Asia	168 056	7 551	4.5
	South Asia	90 991	47 989	52.7
	Southeast Asia	3 948	1 570	39.8
Tree crops and mosaic agriculture-forest	East Asia	70 518	3 803	5.4
	South Asia	41 371	16 985	41.1
	Southeast Asia	19 598	6 502	33.2
Upland rainfed (humid tropics)	East Asia	2 676	213	8.0
	South Asia	14 611	7443	50.9
	Southeast Asia	42 215	13 711	32.5
Total		**2 272 396**	**664 864**	**29%**

Source: This study.

3

But the principal problem is that many people lack land and other resources to produce food, or have insufficient income to purchase food. Lack of access to markets as well as alternative sources of food such as livestock also contributes to poverty. Access to or adequate management of water is an additional important factor: the zones with the highest share of poverty face serious water problems. These include poor water management even when available seasonally, lack of access to water, climatic variability, inadequate assets and droughts.

The impact of irrigation on poverty is a controversial and complex issue. Factors such as scheme size, type of operation and maintenance, and the system of water allocation play important roles in determining the eventual impact on beneficiaries (Lipton and Litchfield 2003). Many arid and semi-arid regions offer excellent farming conditions suitable for intensive cultivation except they have no water. In South Asia, groundwater development has had little to do with the availability of recharge; the groundwater 'revolution' has been driven primarily by the capacity of bore-well irrigation to make multiple cropping of land possible and thereby serve as a land-augmenting technology (Mukherji and Shah 2005).

Lowland rice-based rainfed and irrigated zones also have high levels of poverty, partly because of limited water resources and interannual variations in rainfall. This results in droughts in some areas, producing fluctuations in agricultural production. Civil conflict, political instability and migration are also important drivers. The inaccessibility of rural areas and the deficiencies in infrastructure and markets also contribute to making life difficult for the poor.

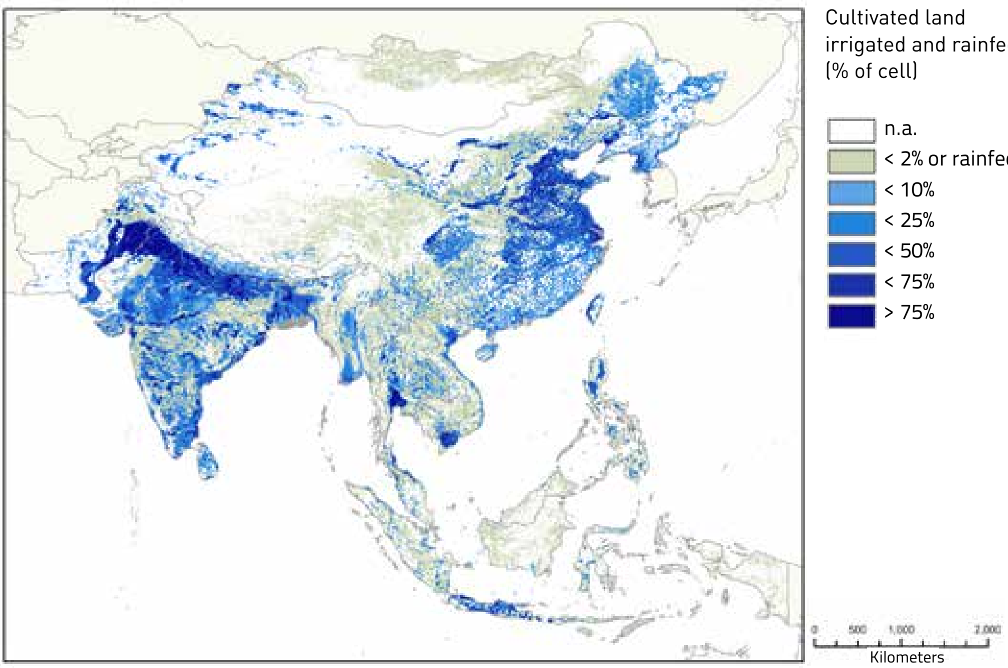
Agriculture and irrigation

Figure 3.5 is a map showing the proportion of rainfed and irrigated land in Asia. Table 3.3 provides a more detailed breakdown of the characteristics of agriculture by subregion.

Table 3.3 shows, not surprisingly, that the most intensively cultivated livelihood systems are the irrigated systems, both from surface and groundwater, located primarily in South and East Asia. Although irrigation plays an important role in Asia compared to other regions, most agricultural land is still rainfed. Irrigated land occupies about 40 percent of the total cultivated land. Livelihood systems characterized mainly by rainfed agriculture account for most cultivated land (240 million ha of which 12 percent is irrigated), while systems characterized mainly by irrigated agriculture cover about 110 million ha of which 72 percent is irrigated. Sparsely populated arid and pastoral zones are the least cultivated systems with about 3 and 8 percent of agricultural land, most being rangelands or other land. Figure 3.6 provides a breakdown of irrigated, rainfed and rangeland by livelihood systems.

Figure 3.6 shows that two rainfed systems, lowland rice, and humid tropics, account for large areas; combined, they represent more area than the current irrigated systems. As discussed below in the section on physical potential for water interventions, these areas have good water resource endowments; therefore they offer high potential for increased agricultural production and productivity, which in turn will contribute to poverty reduction. The dry tropical and subtropical areas also offer high potential for improved agricultural water management.

FIGURE 3.5 RAINFED AND IRRIGATED LAND IN ASIA



Source: FAO (2011a).

In terms of livestock resources, cattle, poultry and pigs play important roles in Asian livelihoods, though their specific distribution among livelihood systems varies considerably. They complement crop production in rainfed and irrigated systems as well as other systems such as the forest-based system. In pastoral and arid systems cattle are the basis for livelihoods and represent the main asset. Figure 3.7 and Table 3.3 show the relative importance of livestock in the different livelihood systems. The high density of livestock in certain areas is determined by the presence of the livestock-based intensive system which has no specific spatial distribution but is scattered across the other systems with no clear geographical characterization.

TABLE 3.3 OVERVIEW OF AGRICULTURE ACROSS LIVELIHOOD SYSTEMS

Livelihood system	Region	Total area (000 km²)	Cultivated land[1]			Irrigated areas		Livestock density		
			000 ha	% of cultivated land	Available land (ha/pers.)	000 ha	% of cultivated land	Pigs (km²)	Cattle (km²)	Poultry (km²)
Groundwater irrigation (dry)	East Asia	73	5 125	70	0.17	3 978	78	170	41	5239
	South Asia	254	20 346	80	0.26	12 934	64	3	55	814
Rice/wheat groundwater irrigation (humid tropics)	East Asia	0	0	0	-		0	2	61	400
	South Asia	171	13 604	80	0.11	9 343	69	3	111	785
Rice-based surface irrigation (humid tropics)	East Asia	191	10 064	53	0.11	7 043	70	73	32	882
	South Asia	272	20 202	74	0.13	10 061	50	3	90	1009
	Southeast Asia	215	14 490	68	0.17	13 731	95	55	22	442
Wheat/rice surface irrigation (dry)	East Asia	550	35 599	65	0.15	25 317	71	68	19	1580
	South Asia	470	34 709	74	0.24	27 857	80	3	53	171
	Southeast Asia	3	190	61	0.25	90	48	2	30	254
Forest based	East Asia	714	3 290	5	0.23	779	24	15	12	933
	South Asia	95	1 144	12	0.44	339	30	5	21	1037
	Southeast Asia	1 366	10 822	8	0.79	72	1	8	6	475
Rangeland / pastoral areas	East Asia	2 335	15 165	6	0.21	3 244	21	12	10	327
	South Asia	291	5 242	18	0.34	756	14	3	42	821
	Southeast Asia	23	284	12	0.29	31	11	39	9	395
Sparse	East Asia	3 419	5 651	2	0.11	1 952	35	11	5	266
	South Asia	480	3 345	7	0.22	650	19	4	33	510
	Southeast Asia	279	5 046	18	0.23	663	13	22	7	399
Cereal-based rainfed (temperate)	East Asia	1 242	33 776	27	0.2	4 455	13	33	16	208

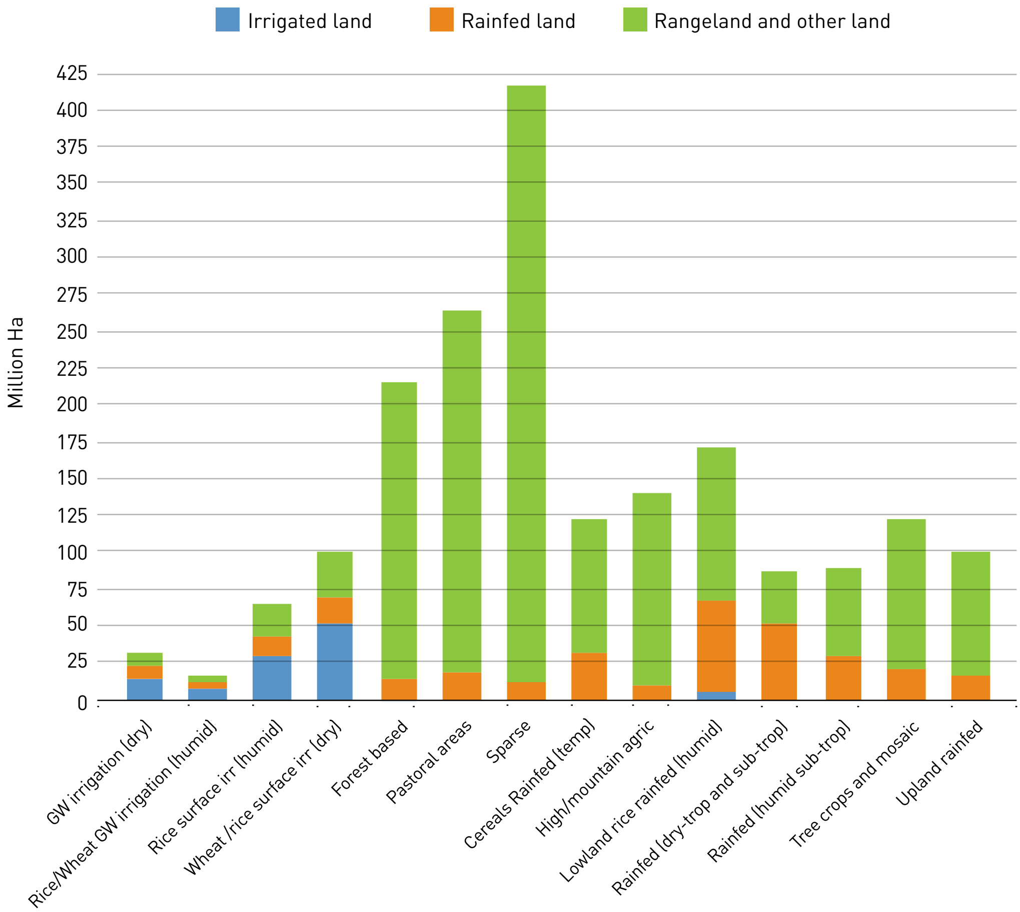
Livelihood system	Region	Total area (000 km²)	Cultivated land[1]			Irrigated areas		Livestock density		
			000 ha	% of cultivated land	Available land (ha/ pers.)	000 ha	% of cultivated land	Pigs (km²)	Cattle (km²)	Poultry (km²)
Highland / mountain agriculture	East Asia	1 283	8 826	7	0.16	2 385	27	16	14	499
	South Asia	89	2 409	27	0.23	37	2	8	32	1035
	Southeast Asia	57	510	9	0.27	301	59	12	6	993
Lowland rice-based rainfed (humid tropics)	East Asia	17	393	24	0.12	128	33	40	35	333
	South Asia	457	24 127	53	0.18	3 634	15	1	95	378
	Southeast Asia	1 253	45 089	36	0.32	2 522	6	17	11	511
Rainfed (dry tropics and sub-tropics)	East Asia	1	50	54	0.24	6	12	66	29	672
	South Asia	866	52 565	61	0.35	5 607	11	1	44	442
	Southeast Asia	13	645	51	0.34	70	11	9	26	299
Rainfed (humid sub-tropics)	East Asia	652	18 326	28	0.11	3 656	20	61	34	397
	South Asia	231	12 744	55	0.14	1 417	11	5	83	288
	Southeast Asia	23	639	27	0.16	95	15	125	20	624
Tree crops and mosaic agriculture-forest	East Asia	696	9 741	14	0.14	2 523	26	53	19	590
	South Asia	288	6 192	21	0.15	375	6	5	44	492
	Southeast Asia	248	6 138	25	0.31	931	15	19	10	647
Upland rainfed (humid tropics)	East Asia	46	465	10	0.17	98	21	31	20	521
	South Asia	156	4 205	27	0.29	982	23	2	52	492
	Southeast Asia	825	13 451	16	0.32	342	3	21	10	450

[1] The cultivated land total figures reported in the table are slightly inconsistent with the figures from FAOSTAT. This is due to the land cover spatial dataset whose spatial resolution impedes distinguishing agricultural land from other land cover classes in some cases.

Source: This study.

The data in Table 3.3 show that livestock are more concentrated in crop-based systems, both irrigated and rainfed. They also show that poultry are more widespread and evenly distributed in all the regions and across different livelihood systems. Pigs are more concentrated in East Asia whereas South Asia holds more cattle than any other regions. In both East and Southeast Asia, livestock include more pigs and poultry than cattle. Cultural values and dietary preferences are the main reasons for the concentration of particular groups of livestock in subregions; for example the distribution of poultry and pigs by subregion is shown in Figure 3.8. Intensive livestock production systems dominate both East and Southeast Asia with more than 75 percent of production under intensive systems, whereas extensive production still dominates South Asia.

FIGURE 3.6 RAINFED AND IRRIGATED LAND ACROSS LIVELIHOOD SYSTEMS

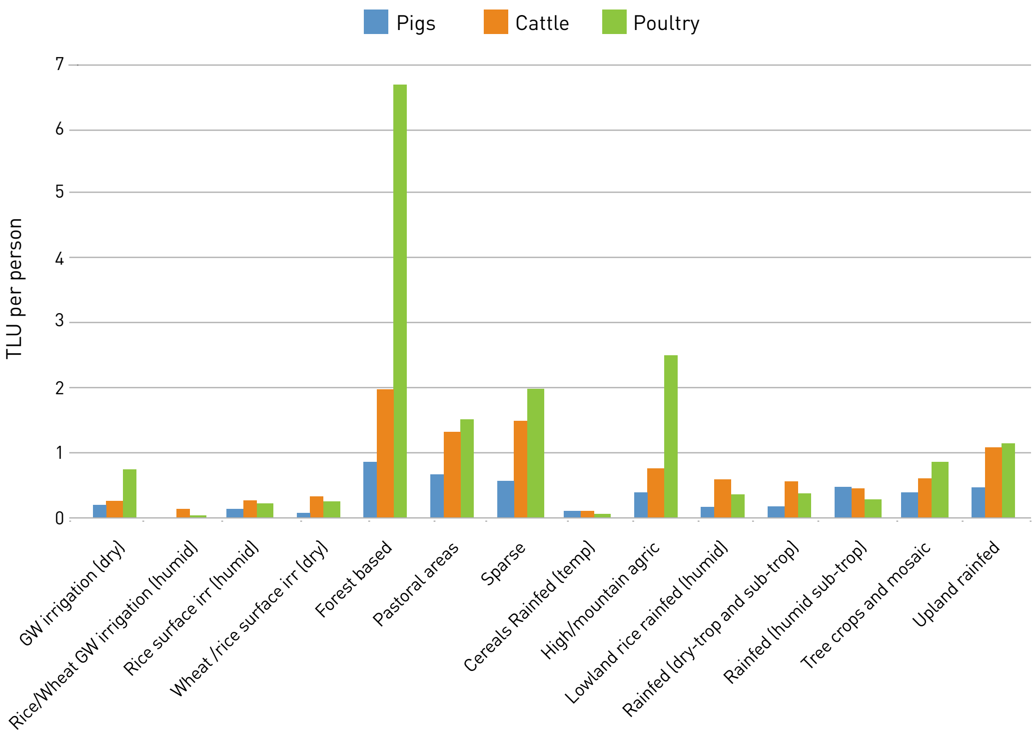


Source: This study. Note: 'Other land' refers to non-agricultural land.

Currently, livestock is one of the fastest growing agricultural subsectors in the developing world, accounting for nearly a third of agricultural GDP growth – and this is increasing (Thornton 2010). The growth is in response to the rapidly increasing demand for livestock products driven by the economic and dietary transformations discussed in Chapter 2. Given the increasing share of livestock and integrated nature of crop and livestock production, the crop-based systems as defined in this study are essentially mixed crop-livestock livelihood systems.

Livestock have greater economic and social importance in poor households than their less poor counterparts. In many countries livestock holdings are more equitably distributed than landholdings. For example, in India smallholders with less than 2 ha of land make up 62.5 percent of the rural households, possess only 32.8 percent of the cultivated land, but account for 74 percent of poultry, 70 percent of pigs, 67 percent of bovines and 65 percent of small ruminants (Taneja and Birthal 2004). Livestock support the livelihoods of 600 million poor smallholder farmers in the developing world (Thornton *et al.* 2006), providing many benefits including food, fuel, fertilizer and transportation. Keeping livestock is also an important risk reduction strategy for vulnerable people.

FIGURE 3.7 LIVESTOCK ACROSS LIVELIHOOD SYSTEMS (TLU[6]/PER PERSON)



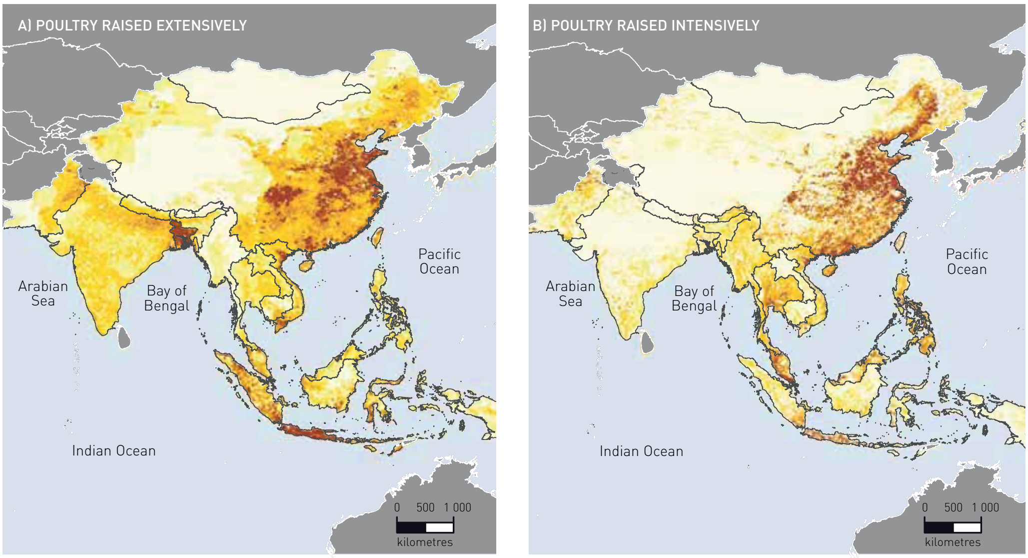
Source: This study.

While livestock are concentrated in crop-based systems, per capita livestock holding is higher in the forest and rangeland systems. This means people favour livestock-based livelihood options in water-scarce environments where options for crop-based livelihood options are restricted. These are therefore essentially livestock-dominated livelihood systems. This observation also provides important guidance on where to prioritize crop production and where to prioritize livestock in designing future poverty reduction programmes.

Livestock production can be highly water-intensive. Meat production requires between six and twenty times more water than cereals if specific fodder crops are grown, depending on the feed/ meat conversion factor (FAO 2003). On the other hand, crop residues provide a large portion of feed in mixed crop-livestock systems, in essence therefore increasing water productivity. Nevertheless, urgent attention needs to be focused on improving livestock water productivity, given its increasing share in agriculture and the potential to improve rural livelihoods. Intervention options to improve livestock water productivity are discussed in chapter 4.

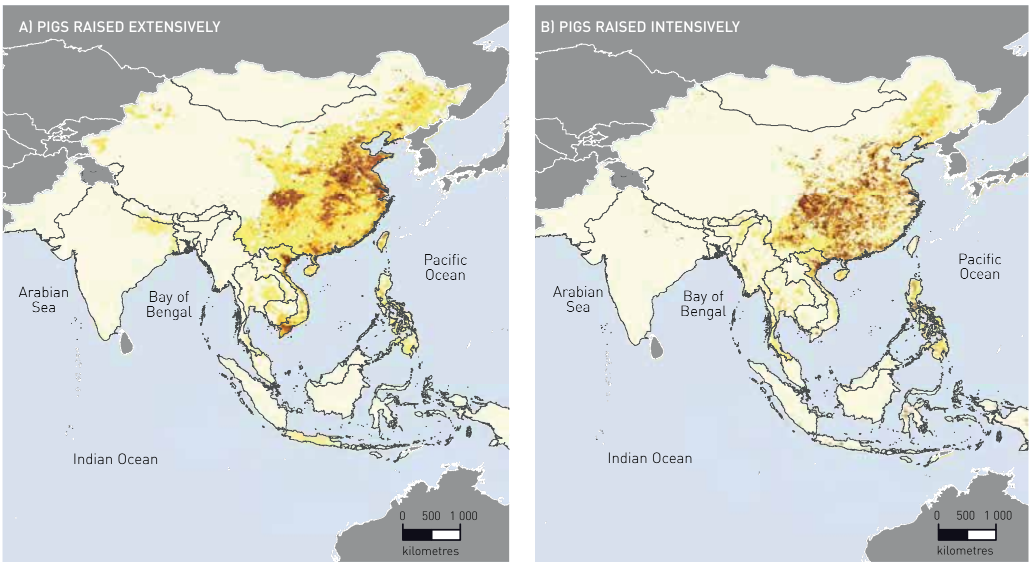
[6] Tropical Livestock Unit. This study has adopted the following average values: cattle = 1, pig = 0.5 and poultry = 0.05.

FIGURE 3.8 DISTRIBUTION OF POULTRY (ABOVE) AND PIG (BELOW) DENSITIES ON SMALLHOLDER FARMS



Birds per km²

- < 10
- 10 – 50
- 50–100
- 100–250
- 250–500
- 500 –1 000
- > 1 000



Head per km²

- < 10
- 10 – 50
- 50 – 100
- 100 – 200
- > 200

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

Assessing the potential for poverty reduction through water interventions

Given the central role of agriculture in Asian livelihoods, the potential to achieve poverty reduction through water interventions should be assessed based mainly on agricultural needs. Water investment policies must be designed appropriately and targeted to areas where water interventions have the highest potential to contribute to improved livelihoods and alleviation of rural poverty. But water plays a key role in multiple aspects of rural livelihoods. Therefore, agricultural water interventions should be accompanied by complementary interventions that recognize the multiple uses of water. Areas combining high agricultural potential and high rates of poverty should be targeted because the potential impacts on poverty are great. Contrary to conventional views, targeting arid and semi-arid agro-ecological zones, despite their apparent need, is not necessarily the most effective poverty-reducing option. Greater scope for reducing poverty and hunger, in terms of population density and incidence of poverty, exists in areas of high agricultural potential, such as subhumid and humid zones, while alternative livelihood programmes might be needed in areas with less agricultural potential (Faurès and Santini 2008).

Water supply: assessing the potential for water interventions

This assessment is focused on identifying where water investments can have the greatest impact on poverty alleviation. More specifically, its scope is to match suitable biophysical with livelihood conditions, and more precisely the **supply**, i.e. physical potential for water development or improvement in the use of water, and the **demand** for water interventions based on the livelihood conditions.

'Water supply' is defined in two ways:

i. Areas where there is still a physical water potential, i.e. available water resources that can be developed; and

ii. Areas characterized by water scarcity where improvements in management of existing water supplies are possible.

The potential for water interventions is based on matching physical supply and livelihood-based demand, expressed as the share of the rural poor population that could benefit from water interventions in these two kinds of zones.

Water demand: assessing the need for water interventions

The first step in assessing where water can be the main entry point to alleviate rural poverty is to understand where there is a demand for water interventions from the population. The demand is determined by different factors but primarily by population density, the prevalence of rural poverty, agro-climatic conditions and livelihood patterns. In this study, the demand has been defined by a combination of the following factors:

- The prevalence of rural poverty (as defined above; see Figures 3.2 and 3.4 and Table 3.2); and
- The extent to which water is a limiting factor for livelihoods.

The second factor identifies where water is the principal binding constraint, mainly for agricultural production but also other livelihood activities. It helps identify where and how water investments can make a significant difference to improving agriculture and other livelihood activities. Its application is based primarily on regional expert advice[7] on the importance and roles of water in rural livelihoods. It is therefore qualitative and not based entirely on quantitative data. However, available data have been used to support and consolidate the experts' perspectives. By combining this quantitative and qualitative information, a more meaningful understanding of the relationships among water, population and livelihoods has been achieved. Particularly, we have a better insight into rural people's dependence on water and their vulnerability to its uneven and uncertain availability (Santini *et al.* 2012). Population pressure on land and water, seasonal and erratic rainfall, and vulnerability to droughts and floods are examples of situations where the lack of secure access to sufficient water represents a major constraint on rural livelihoods.

In the analysis, 'water as a limiting factor' (WLF) represents the potential role of water management interventions in reducing rural poverty and is expressed as the percentage of the rural poor population that can benefit from water interventions; 100 percent means that water interventions can have a positive impact on the entire rural poor population, whereas 10 percent means that water management interventions will have a marginal role in poverty reduction. The 'demand' is a function of 'rural poverty prevalence' combined with WLF, and represents the total rural poor population who could potentially benefit from water management interventions in each livelihood system and subregion. However, it is important to emphasize that the demand does not take into account the current use of water resources. It represents the total rural poor population that are in need of water-related interventions.

Table 3.4 shows the demand for water interventions in the different livelihood systems and subregions. It clearly shows that water is a critical factor, particularly in densely populated systems (South Asia), in rice-based systems and areas and systems that are affected by uneven or insufficient rainfall, mainly in dry and moist semi-arid climates. Rice-based systems are intensive water-use systems, highly dependent on the availability of water, and vulnerable to unreliability of water supplies.

[7] As discussed in chapter 1, two regional expert consultations were organized to analyse the role of water for reducing rural poverty.

TABLE 3.4 DEMAND FOR WATER INTERVENTIONS TO SUPPORT RURAL LIVELIHOODS

Livelihood system	Region	Rural poor		WLF (%)	Demand: rural poor demand for water interventions	
		%	(000)		(000) people	% of rural population
Groundwater irrigation (dry)	East Asia	4.4	1 334	90	1 201	3.9
	South Asia	51.3	40 762	80	32 610	41.1
Rice/wheat groundwater irrigation (humid tropics)	East Asia	39.0	30	0	0	0.0
	South Asia	54.6	70 750	100	70 750	54.6
Rice-based surface irrigation (humid tropics)	East Asia	4.3	3 772	30	1 132	1.3
	South Asia	54.5	85 831	75	64 373	40.9
	Southeast Asia	35.2	30 757	100	30 757	35.2
Wheat/rice surface irrigation (dry)	East Asia	4.2	9 588	100	9 588	4.2
	South Asia	48.3	68 764	90	61 888	43.4
	Southeast Asia	37.6	285	25	71.25	9.4
Forest-based	East Asia	6.1	863	0	0	0.0
	South Asia	38.9	1 005	25	251	9.7
	Southeast Asia	30.0	4 111	25	1 028	7.5
Rangeland / pastoral areas	East Asia	5.3	3 843	100	3 843	5.3
	South Asia	50.4	7 755	25	1 939	12.6
	Southeast Asia	37.2	360	25	90	9.3
Sparse	East Asia	3.9	1 937	100	1 937	3.9
	South Asia	47.5	7 079	25	1 770	11.9
	Southeast Asia	29.3	6 504	25	1 626	7.3
Highland / mountain agriculture	East Asia	9.6	5 441	80	4 353	7.7
	South Asia	43.5	4 509	50	2 255	21.7
	Southeast Asia	35.6	673	50	336.5	17.8
Lowland rice-based rainfed (humid tropics)	East Asia	5.6	190	25	47.5	1.4
	South Asia	54.9	71 928	70	50 350	38.4
	Southeast Asia	34.4	48 971	75	36 728	25.8
Rainfed (dry tropics and subtropics)	East Asia	9.5	20	40	8	3.8
	South Asia	49.9	75 432	55	41 488	27.4
	Southeast Asia	34.3	646	25	161.5	8.6

Livelihood system	Region	Rural poor		WLF (%)	Demand: rural poor demand for water interventions	
		%	(000)		(000) people	% of rural population
Cereal-based rainfed (temperate)	East Asia	3.6	5 957	75	4 468	2.7
Rainfed (humid subtropics)	East Asia	4.5	7 551	75	5 663	3.4
	South Asia	52.7	47 989	55	26 394	29.0
	Southeast Asia	39.8	1 570	50	785	19.9
Tree crops and mosaic agriculture-forest	East Asia	5.4	3 803	30	1 141	1.6
	South Asia	41.1	16 985	60	10 191	24.6
	Southeast Asia	33.2	6 502	25	1 626	8.3
Upland rainfed (humid tropics)	East Asia	8.0	213	70	149.1	5.6
	South Asia	50.9	7 443	50	3 722	25.5
	Southeast Asia	32.5	13 711	25	3 428	8.1
Total					**478 144**	**21**

Source: This study.

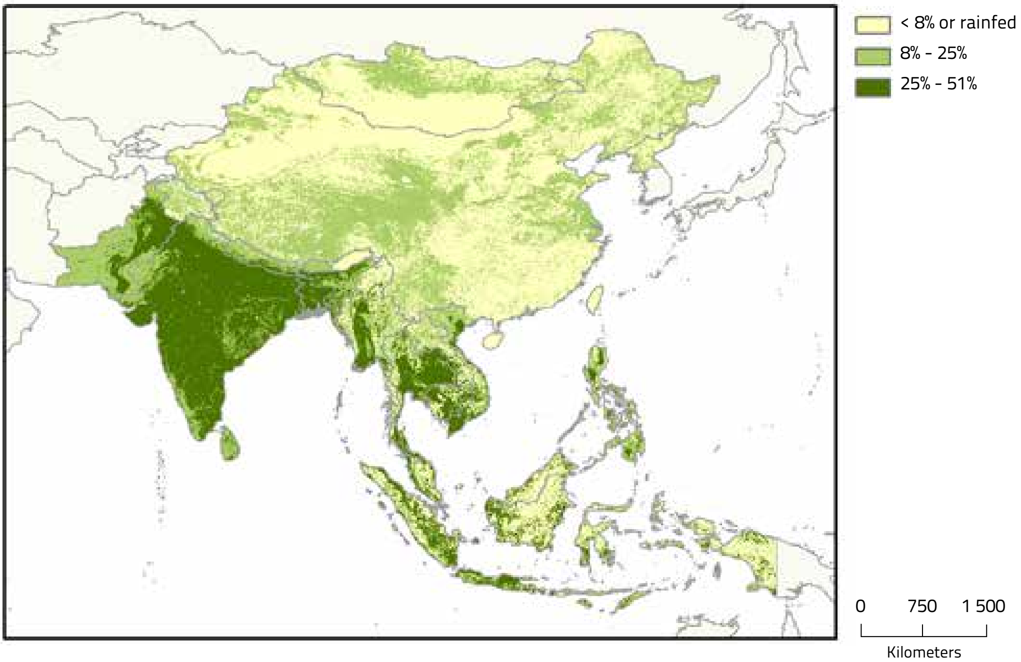
Looking at the demand (Figures 3.9), given the highest poverty rates, it is clear that South Asia represents the highest density and percentage of the rural population that could benefit from agricultural water management interventions. Nevertheless, there is a relatively strong demand in Southeast Asian systems, while in absolute terms densely populated areas of East Asia also present a significant demand. At the livelihood systems level, rice-based systems present the highest demand both in number and percentage of the poor population. Forest-based, mountain, pastoral and arid systems have little demand for water-related interventions. Irrigated and rain-fed systems have more or less equal demand with 36 and 32 percent of potential beneficiaries respectively. The other systems less dependent on farming activities have very limited scope, at about 7 percent of potential beneficiaries.

Assessing the physical potential for water interventions

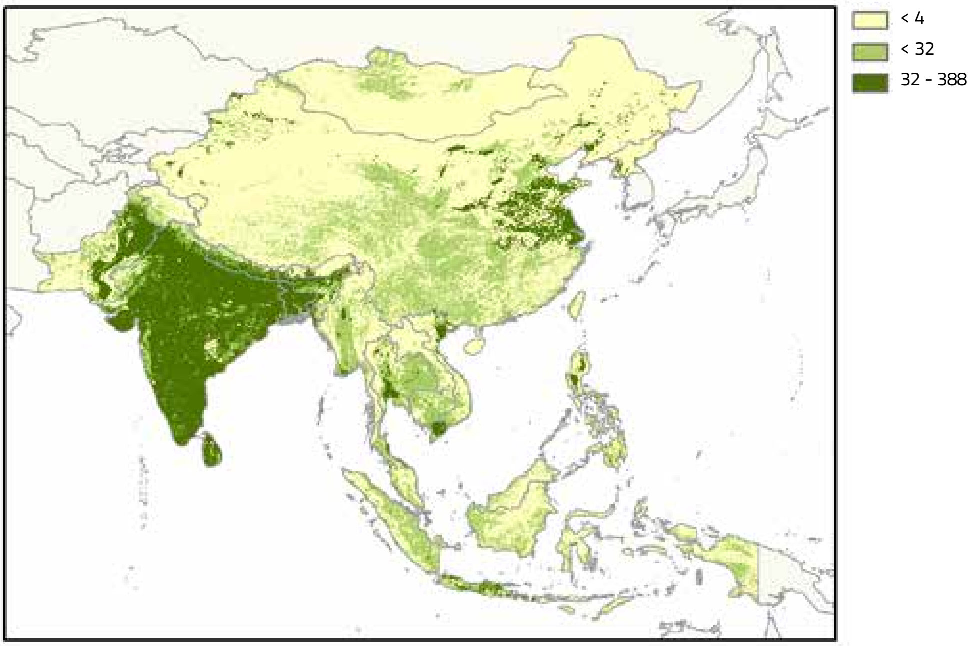
The physical potential for water interventions is based mainly on the availability of water for agriculture. Water resources are abundant in the Asian region, but their distribution is spatially and temporally irregular. Agriculture is by far the major water consumer and irrigation is practised extensively and intensively. In many areas, irrigation development has reached its maximum and the anthropogenic pressure on water resources is quite significant.

FIGURE 3.9 DEMAND FOR WATER INTERVENTIONS

Demand for water interventions (% of rural poor)

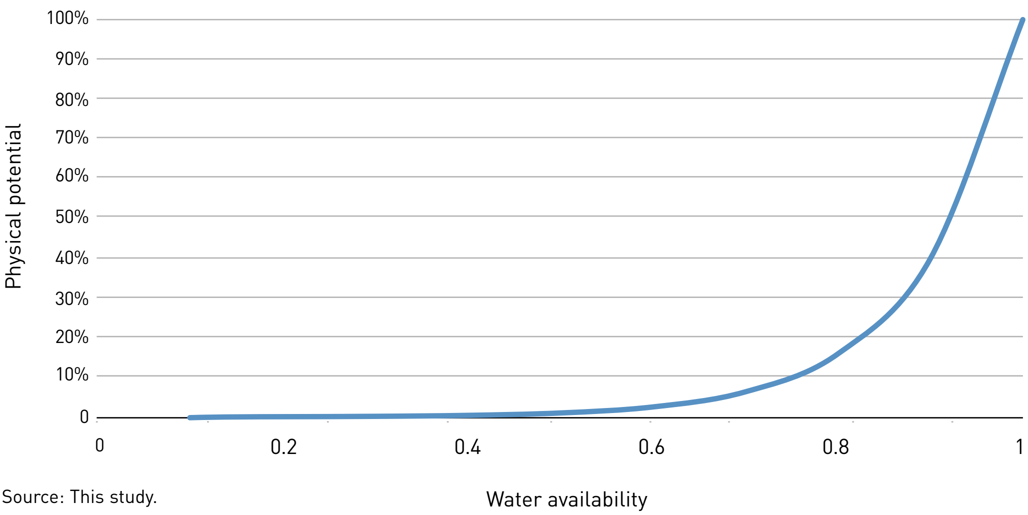


Demand for water interventions density of rural poor (p/km2)



Source: This study.

FIGURE 3.10 PHYSICAL WATER POTENTIAL AS FUNCTION OF WATER AVAILABILITY



Source: This study.

This study considers the physical water potential as a function of water availability: it estimates the share of population which could potentially benefit from agricultural water interventions under given water availability conditions. The physical potential is assessed in two ways:

1. In irrigated livelihood systems

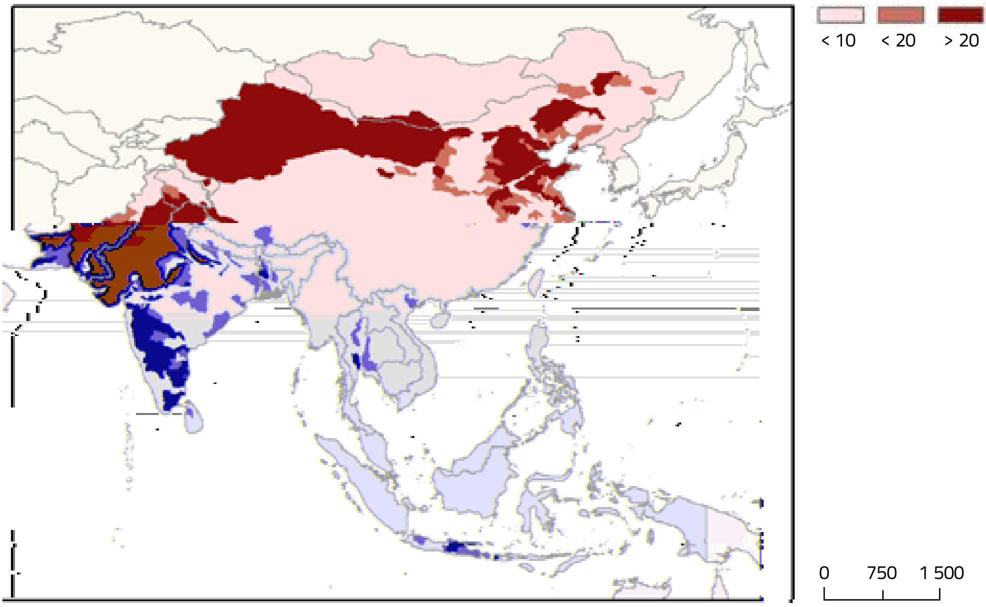
In irrigated livelihood systems (see Table 3.5), the physical water potential is assessed using the ratio of water consumed by irrigated crops over internal renewable water resources (IRWR) by subbasin {WA = [100-(ET_{irr}/IRWR)]/100}, where ET is evapotranspiration and the subscript irr refers to irrigation. The physical water potential is then calculated by applying a power function to water availability (WA): physical potential = f^ (WA-1). The power function represents the share of the rural population that could potentially benefit from water development, given the limited water availability. Figure 3.10 shows the behaviour of the physical potential in relation to water availability, where, for example, up to the value of 0.7 of WA, there is very little potential for further water development: 0.7 means that 30 percent of IRWR is already consumed by irrigated crops, which, corresponds to about 60 percent of water withdrawals (based on the globally-valid assumption that withdrawals correspond to twice the water consumed from irrigation. Figure 3.11 shows the physical water scarcity situation where the ET of irrigated crops is over 20 percent of IRWR.

2. In non-irrigated livelihood systems

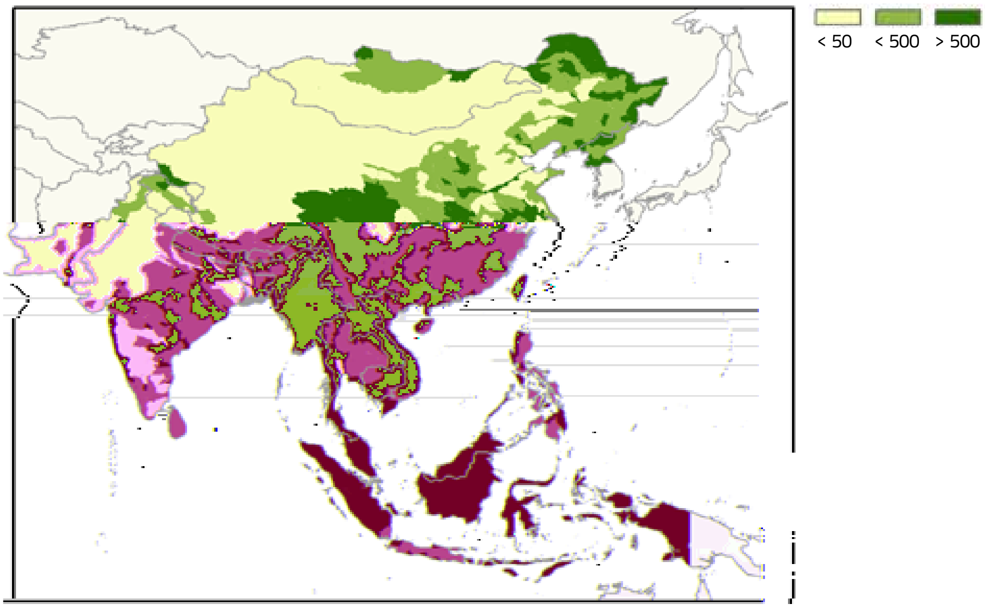
In non-irrigated livelihood systems (Table 3.5), physical water potential is assessed in terms of water availability per capita; more precisely, it is calculated using the specific discharge of each subbasin, divided by the rural population in each basin (see Figure 3.11). Values derived from subbasin analysis are then averaged over the livelihood systems at the subregional level and expressed as the percentage of the population that can benefit from water management interventions.

FIGURE 3.11 PHYSICAL WATER SCARCITY AND POTENTIAL IN ASIAN IRRIGATED SYSTEMS

Physical water scarcity by river basin: ET_irr/IRWR



Water Resources by basin: specific discharge/rural population



Source: This study.

Table 3.5 summarizes the physical water potential (water supply) by livelihood system and by subregion, in terms of the percentage of the rural population that could potentially benefit from water interventions.

TABLE 3.5 PHYSICAL WATER POTENTIAL ACROSS LIVELIHOOD SYSTEMS

Livelihood system	Region	Water availability	Physical water availability: potential beneficiaries		
			% of total rural population	(000) rural people	Density person/ km²
Groundwater irrigation (dry)	East Asia	0.27	0.70	218	3
	South Asia	0.40	1.60	1 269	5
Rice/wheat groundwater irrigation (humid tropics)	East Asia	0.14	0.30	0	2
	South Asia	0.78	21.40	27 683	162
Rice-based surface irrigation (humid tropics)	East Asia	0.97	78.50	69 036	362
	South Asia	0.89	46.10	72 557	267
	Southeast Asia	0.91	53.10	46 357	216
Wheat/rice surface irrigation (dry)	East Asia	0.67	10.10	23 095	42
	South Asia	0.43	2.00	2 823	6
	Southeast Asia	0.99	90.10	683	219
Forest based	East Asia	0.60	59.60	8 571	12
	South Asia	0.62	61.70	1 607	17
	Southeast Asia	0.96	96.00	13 662	10
Rangeland / pastoral areas	East Asia	0.28	28.40	21 011	9
	South Asia	0.13	13.00	2 036	7
	Southeast Asia	0.86	86.40	836	36
Sparse	East Asia	0.05	5.30	3 419	1
	South Asia	0.09	9.00	1 439	3
	Southeast Asia	0.90	89.80	19 828	71
Cereal-based rainfed (temperate)	East Asia	0.21	21.00	34 780	28
Highland / mountain agriculture	East Asia	0.41	40.70	23 096	18
	South Asia	0.27	27.40	2 861	32
	Southeast Asia	0.94	94.20	1 764	31
Lowland rice-based rainfed (humid tropics)	East Asia	0.70	69.90	2 357	141
	South Asia	0.43	43.10	56 252	123
	Southeast Asia	0.80	80.00	113 991	91
Rainfed (dry tropics and subtropics)	East Asia	0.02	2.30	5	5
	South Asia	0.17	16.80	25 128	29
	Southeast Asia	0.97	96.80	1 825	144
Rainfed (humid subtropics)	East Asia	0.52	51.90	87 314	134
	South Asia	0.50	49.70	45 187	196
	Southeast Asia	0.76	76.10	3 000	129

Livelihood system	Region	Water availability	Physical water availability: potential beneficiaries		
			% of total rural population	(000) rural people	Density person/ km²
Tree crops and mosaic agriculture-forest	East Asia	0.47	46.50	32 710	47
	South Asia	0.40	40.40	16 726	58
	Southeast Asia	0.77	77.40	15 151	61
Upland rainfed (humid tropics)	East Asia	0.69	68.50	1 836	40
	South Asia	0.56	56.10	8 253	53
	Southeast Asia	0.85	84.50	35 464	43

Source: This study.

Priority for action: potential for poverty reduction through water interventions

The priority for action is identified by combining water demand and supply. It represents the potential for poverty reduction through water-related interventions in the different livelihood systems. Assessment of the water supply enables identification of physically water-scarce areas where the physical potential is constrained. According to FAO's definition, water scarcity is defined as the gap between available supply and expressed demand for freshwater in a specified domain, under prevailing institutional arrangements. Scarcity is signalled by unsatisfied demand, tensions among users, competition for water, overextraction of groundwater and insufficient flows to the natural environment (FAO 2012). This study has emphasized the distinction between areas affected by water scarcity and areas where there is still physical water potential, as these imply two different approaches to defining the potential for poverty reduction through water interventions and the intervention options. The priority for poverty reduction through water interventions in areas affected by physical water scarcity, i.e. where irrigation expansion is not feasible, is distinguished from areas where physical water availability would allow further expansion and intensification of irrigation.

Priority in water-constrained areas

Despite the abundance of water resources, water scarcity is becoming quite critical in many areas in the region and a serious challenge for poverty reduction. Overall, about 30 percent of the total poor in the region live in water-constrained livelihood systems.

This study defines a water-constrained area as one where the physical potential, i.e. the amount of water still available for allocation, cannot meet the demand for water interventions through additional water development. The livelihood systems characterized by these conditions are considered water-constrained and the potential for poverty reduction is assessed in a different way. Water-constrained systems include the following:

- Groundwater irrigation (dry) system in both East and South Asia;
- Rice/wheat groundwater irrigation (humid tropics) system in South Asia;
- Wheat/rice surface irrigation (dry) system in South Asia;
- Sparse (arid) system in both Eastern and South Asia; and
- Rainfed (dry tropics and subtropics) system in both East and South Asia

In water-constrained systems, the potential is calculated as the difference between demand and supply. It represents the share of demand which cannot be fulfilled simply by increasing the water supply. Overall in these systems, water supply can meet about 29 percent of the total estimated demand which is represented by the number and share (percent) of the rural poor in need of water interventions. Table 3.6 shows the systems in the different subregions affected by water scarcity and the share of the rural poor population where demand for water interventions cannot be met due to inadequate physical water potential.

TABLE 3.6 POTENTIAL BENEFICIARIES IN WATER-CONSTRAINED SYSTEMS

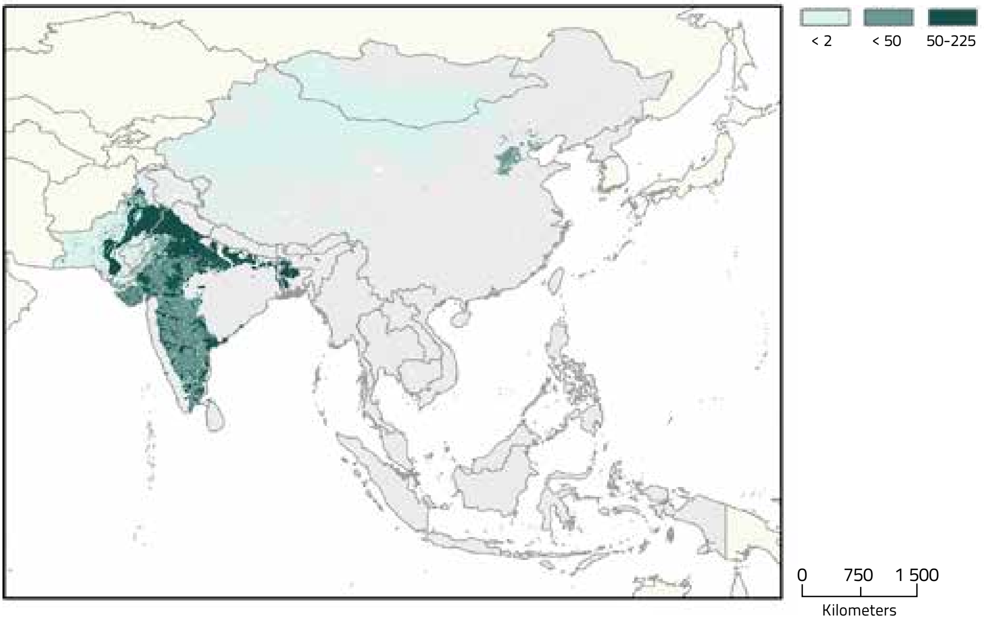
Livelihood system	**Subregion**	**Water demand satisfied by supply**		**Water demand not satisfied by supply**	
		(000) rural poor	% of total demand (rural poor)	(000) rural poor	% of total demand (rural poor)
Groundwater irrigation (dry)	East Asia	202	16.8	999	83.17
	South Asia	1 279	3.9	31 330	96.08
Rice/wheat ground-water irrigation (humid tropics)	South Asia	27 703	39.2	43 046	60.84
Wheat/rice surface irrigation (dry)	South Asia	2 797	4.5	59 090	95.48
Sparse	East Asia	1 937	99.3	13	0.67
	South Asia	1 339	75.7	431	24.35
Rainfed (dry tropics and subtropics)	East Asia	5	61.3	3	38.67
	South Asia	25 358	61.1	16 130	38.88
Total		**60 620**	**28.6**	**151 029**	**71.4**

Source: This study.

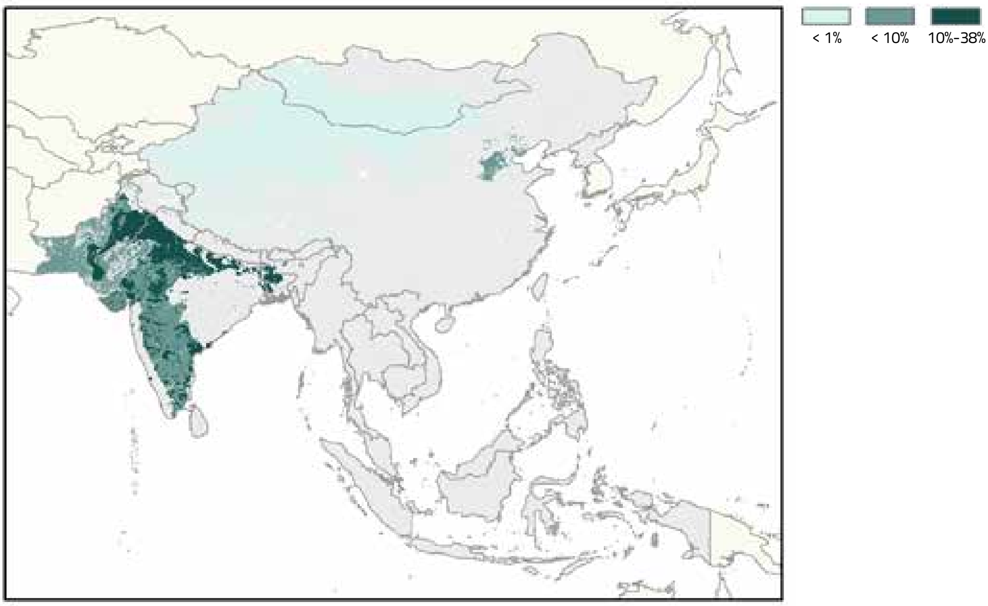
The most water-constrained systems are all concentrated in South Asia, particularly in western India, and to some extent in East Asia. Groundwater, and to some extent surface irrigation systems, mainly rice-based, are the systems where water scarcity is mostly severe. The highly intensive production combined with the high population density is the main cause of water scarcity. Figures 3.12 represent the areas with potential for poverty reduction through water interventions in water-constrained systems both in terms of the density of the rural poor population and percentage of total rural poor. The maps shows the share of rural poor that are in demand of water interventions but this cannot be fully satisfied by expansion or intensification of irrigation.

FIGURE 3.12 POTENTIAL BENEFICIARIES IN WATER-CONSTRAINED AREAS

Potential beneficiaries in water constrained areas: density of rural poor (p/km²)



Potential beneficiaries in water constrained areas:percentage of rural poor (%)



3

Understanding the potential for water interventions to support poverty reduction in water-constrained areas requires a different perspective than the normal supply-based perspective. Water management investments have typically focused on the supply side, i.e. development of technology and infrastructure and expanding irrigation in response to demand. The paradigm of supply enhancement has tended to view demand simply in terms of needs to be satisfied. In the new era, where water-scarce regions are embarking on demand-management programmes, it is evident that demand, which depends on human needs, behaviour and values, and the way that societies operate and organize themselves, represents a far more complex challenge than supply (FAO 2012).

Nevertheless, any water intervention to improve livelihoods in water-constrained areas should take into account both supply and demand management. Managing the supply can be done by increasing access to conventional water resources, including storing harvesting rainwater and, to some extent, groundwater withdrawals, although most of the groundwater-based systems, where water resources are overexploited, are seriously affected by water scarcity. It can also be done through re-using wastewater and drainage water or through developing 'non-conventional' sources of water, for example desalination of brackish or saltwater and the use of fossil groundwater (FAO 2012). Looking at the demand side, the general aim of demand management is to ensure that a given supply of water is distributed to accord more closely with its 'optimal' use pattern. In general terms, demand management aims at improving the efficiency of water use and reallocating water resources among different sectors.

FAO (2012) has identified a series of measures to cope with water scarcity focusing on both supply and demand management. These are presented in Table 3.7. Chapter 4 analyses in detail the major water intervention options in support of poverty reduction that suit most the livelihood systems in the different subregions.

Priority in water-endowed areas

These are areas where the water supply exceeds the demand, i.e. where the physical water availability could potentially benefit more people and may therefore allow for irrigation expansion. Specifically, all the rural poor population demanding water interventions can potentially benefit from the available supply. Therefore, the potential for poverty reduction is calculated as the minimum value between demand and supply in each livelihood system at the subregional level. It represents the demand (percent of beneficiaries) constrained by the supply availability (physical potential for water resources development) and expresses the share of the rural poor population that can benefit from water interventions. Figure 3.13 shows the areas with the highest number of potential beneficiaries from water interventions, both in terms of density of the rural poor and percentage of the total rural poor population. Table 3.8 summarizes the number and density of potential beneficiaries by livelihood zone.

The greatest scope to reduce poverty through water interventions is concentrated in the livelihood systems of South Asia. Rice-based systems in South as well as Southeast Asia have a great scope for poverty reduction. In these systems, rural population, poverty prevalence and water supply are very high. They therefore represent a priority for poverty reduction strategies through water resource development and irrigation expansion. These two systems alone host almost 70 percent of the total potential beneficiaries in non-water scarce systems and almost 30 percent of the total rural poor in the region. Agriculture is particularly significant in these zones – most of the rice and other cereals that feed South and Southeast Asia come from these areas. At present, water in these zones is sufficient, but it is a strong limiting factor due to the high population density and therefore pressure on water resources. Livelihoods, and more specifically agriculture, in these areas depend on water availability and are vulnerable to water shocks. Indeed, these areas are often affected by floods that increase population vulnerability.

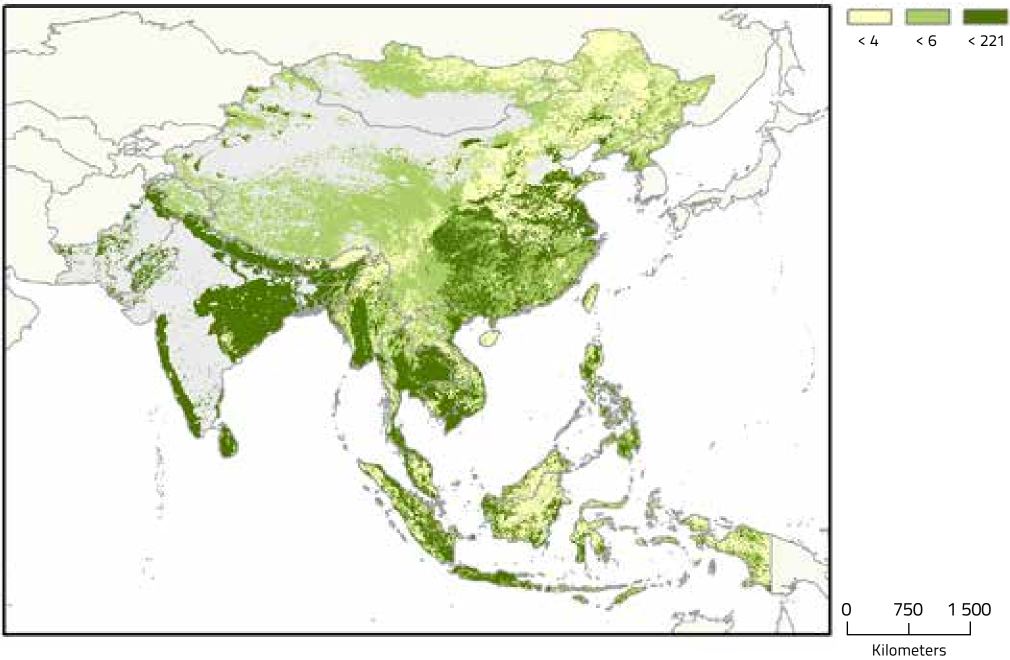
TABLE 3.7 SUMMARY OF OPTIONS TO COPE WITH WATER SCARCITY

		Measure	All sectors	Agriculture
Supply-side options		Reducing interannual variability of river flow	Increased storage (multipurpose dams)	On-farm water conservation
		Enhancing groundwater supply capacity	Groundwater development, management and artificial recharge	Aquifer recharge enhancement in irrigation
		Water recycling and re-use	Closed loop re-use and recycling	Re-use of urban wastewater for crop production
		Pollution control	Point source pollution control (industry, cities)	Integrated plant production and protection, control of pollution from agriculture (including payment for ecosystem services)
		Importing water	Interbasin transfer, desalination	
Demand-side options	Within the water domain	Reducing water losses	Improved monitoring, leakage control, closing circuits (industry)	Pressurized conveyance and application of water (drip), improved irrigation scheduling and moisture control, canal lining
		Increasing water productivity	Better water management mechanisms, enhanced predictability of supply, early warning	Improved water delivery service in irrigation (increased reliability and flexibility of water delivery through modernization of infrastructure and management), precision irrigation, deficit irrigation, drainage in irrigation
			Dry cooling (power)	Yield gap reduction through improved agricultural practices (fertility management, pest control), improved genetic material
		Water re-allocation	Intersectoral transfer (through water markets or other water allocation mechanisms) Intrasectoral transfer (including restraining demand)	Shift to higher value crops in irrigation and/or limiting evapotranspiration by reducing areas under irrigation
	Outside the water domain	Reducing losses in the value chain	Waste control, improved processing and distribution	Reduction of postharvest losses: storage, processing, distribution, final consumption
		Reducing demand for irrigated products and services	Import of manufactured products	Reduced yield gap in rainfed production (improved agricultural practices; fertility management; pest control; soil moisture management: mulching, weeding; drainage, improved genetic material, seasonal forecast and crop insurance schemes).
				Import of food and other agricultural products (virtual water trade)
		Reducing water use per capita	Changes in consumption habits	Changes in food consumption patterns – less water intensive diets

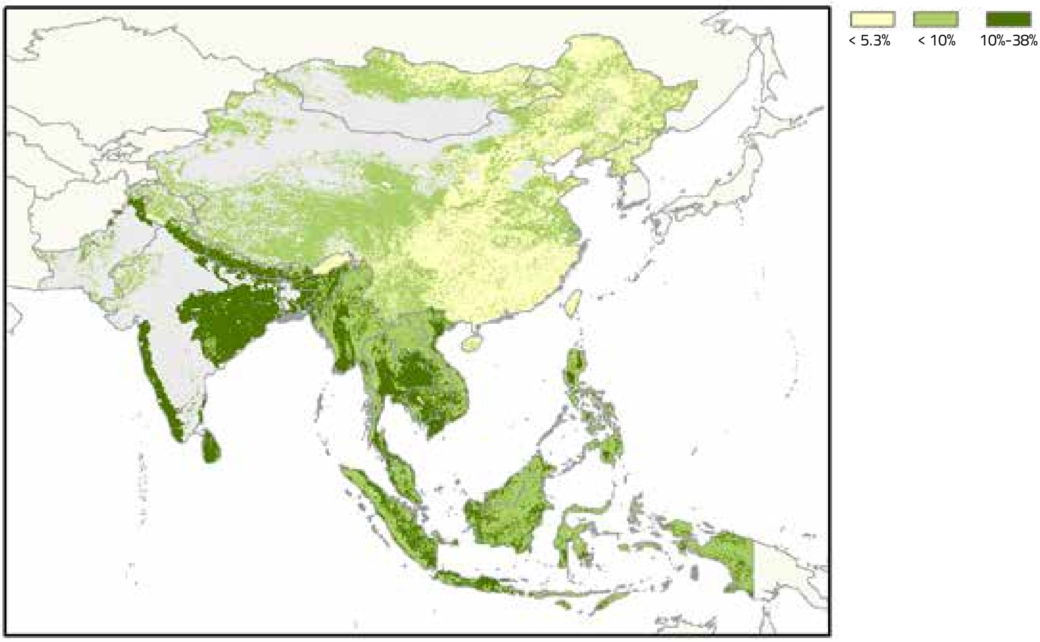
Source: FAO (2012).

FIGURE 3.13 POTENTIAL BENEFICIARIES IN WATER-ENDOWED AREAS

Potential beneficiaries in water endowed areas: density of rural poor (p/km²)



Potential beneficiaries in water endowed areas: percentage of rural poor (%)



Source: This study

TABLE 3.8 POTENTIAL BENEFICIARIES IN WATER-ENDOWED SYSTEMS

Livelihood system	Region	Potential beneficiaries		
		(000) rural poor	% of total rural people	% of total rural poor
Rice/wheat groundwater irrigation (humid tropics)	East Asia	0	0.0	0
Rice-based surface irrigation (humid tropics)	East Asia	1 131	1.3	30
	South Asia	64 373	40.9	75
	Southeast Asia	30 757	35.2	100
Wheat/rice surface irrigation (dry)	East Asia	9 588	4.2	100
	Southeast Asia	71	9.4	25
Forest-based	East Asia	1	0.0	0
	South Asia	251	9.7	25
	Southeast Asia	1 028	7.5	25
Rangeland / pastoral areas	East Asia	3 843	5.3	100
	South Asia	1 939	12.6	25
	Southeast Asia	90	9.3	25
Sparse	Southeast Asia	1 626	7.3	25
Cereal-based rainfed (temperate)	East Asia	4 468	2.7	75
Highland / mountain agriculture	East Asia	4 353	7.7	80
	South Asia	2 255	21.7	50
	Southeast Asia	336	17.8	50
Lowland rice-based rainfed (humid tropics)	East Asia	47	1.4	25
	South Asia	50 350	38.4	70
	Southeast Asia	36 728	25.8	75
Rainfed (dry tropics and subtropics)	Southeast Asia	162	8.6	25
Rainfed (humid subtropics)	East Asia	5 663	3.4	75
	South Asia	26 394	29.0	55
	Southeast Asia	785	19.9	50
Tree crops and mosaic agriculture-forest	East Asia	1 141	1.6	30
	South Asia	10 191	24.6	60
	Southeast Asia	1 626	8.3	25
Upland rainfed (humid tropics)	East Asia	149	5.6	70
	South Asia	3 721	25.5	50
	Southeast Asia	3 428	8.1	25
Total		**266 496**	**15.9**	**66.8**

Source: This study.

Conclusion

This chapter has analysed the relationships between poverty, livelihoods and water resources. The analysis has used available evidence to show where water-related interventions can have high impacts on rural livelihoods and are a key entry point for alleviating rural poverty. The approach adopted has been to understand and characterize the livelihood-based demand for water interventions and the physical supply available for interventions, described in terms of water availability. To define the demand, the analysis has described and mapped the livelihood typologies and has located the rural poor in order to better characterize the needs and priorities in term of water interventions. On the supply side, the study has identified in broad terms where available water resources can meet the demand under irrigation and rainfed conditions. Finally, matching supply and demand has enabled the study to locate priorities for action, i.e. the areas where water interventions are critical for poverty reduction and where the largest number of poor population can be reached. The analysis has also shown that in water-constrained areas, further water development and irrigation expansion is not possible, but other interventions could enhance the benefits derived from water.

TABLE 3.9 SUMMARY OF WATER INTERVENTION POTENTIAL IN WATER-CONSTRAINED AND WATER-ENDOWED LIVELIHOOD SYSTEMS

Water demand satisfied by supply			Water demand not satisfied by supply		
(000) rural poor	% of total demand	% of total rural poor	(000) rural poor	% of total demand	% of total rural poor
327 116	68.4	49.2	151 029	31.6	22.7

Source: This study.

There is clearly great potential for poverty reduction through water interventions in the region. Table 3.9 summarizes the potential in water-constrained and water-endowed areas. While this chapter has provided a geographical overview of the potential for water interventions in support of rural livelihoods and poverty reduction, the next chapter analyses the specific water interventions and their relevance in the various livelihood contexts. The range of water interventions proposed takes into consideration the biophysical, socio-economic and institutional aspects that have been analysed in the previous chapters.

4. Water interventions for improving rural livelihoods

The changing context of water investments in Asia

Investments in water interventions have played a critical role in fostering economic development in rural communities. While sustainable management of water resources remains a prerequisite for development and addressing poverty and hunger, the context is changing rapidly, requiring major adjustments in investment strategies. As discussed in chapter 2, two major shifts will shape the future of water management in Asia. The first is that agricultural water management cannot be considered independently of changes occurring in the wider economy and environmental setting. The second is that Asia has experienced massive rural employment shifts linked to larger socio-economic transformation processes, of which agricultural development is only one dimension. Future water management interventions in Asia therefore need to adjust to these changing contexts.

While it is evident that water management is not the only option for poverty reduction, agricultural water management is still central to rural Asian livelihoods. The data and maps on poverty and livelihood systems in chapter 3 show that there is significant potential for improving rural livelihoods through water management interventions, though the details vary depending on the nature of water constraints, the potential and poverty levels. The agro-ecological characteristics of these systems and their socio-economic settings offer a range of possible options for water interventions to improve productivity of land and water resources for crop, livestock and fisheries production; many of these options can contribute to poverty reduction. However, they are context-specific and require appropriate policy and institutional settings.

The changing context of rural livelihoods described in chapter 2 and the livelihood contexts mapped in chapter 3 together support the potential importance of water interventions to either increase poor people's access to water or enhance its productivity, or both. Better access to and control over water will reduce vulnerability to drought, floods and impacts of climate change; increase productivity of agriculture, fisheries, and livestock; and provide more opportunities for both on- and non-farm employment.

Future water interventions in Asia will largely focus on improving the performance of existing systems, rather than developing new ones. The potential for further expansion of irrigation, especially through construction of large-scale surface schemes, is limited for several reasons. Most of the suitable lands are already developed and lower grain prices have reduced returns on investment in irrigation. The focus is now shifting towards high-value crops, livestock farming and aquaculture which need more localized water control systems. Priorities now include increasing water productivity, facilitating diversification to high-value crops and supporting already booming livestock production and fisheries, while also adapting to growing water scarcity. This means future water interventions should be targeted at localized water control systems that ensure flexible on-demand water supply for farmers.

Although water interventions alone are not sufficient for poverty eradication and betterment of rural livelihoods, water provides a platform around which other kind of interventions can be structured. The extensive review by Hussain *et al.* (2004) suggests that irrigation is one of the important water interventions, while also emphasizing the role played by land resources, infrastructure such as roads and markets, and education for poverty reduction. Hanjra *et al.* (2009) identify the linkages between rural infrastructure, irrigation water, education, markets and poverty, and show a strong positive correlation between infrastructure and aggregate agricultural productivity. Well-functioning markets contribute to the well-being of poor people through access to farm and non-farm goods, timely access to farm inputs and access to services like health care, education and training. Gyimah-Brempong *et al.* (2006) conclude that education has had positive effects on the per capita growth rates of income in African countries: the impact is twice as large as the growth impact of physical capital. Education has played a crucial rule in economic growth and poverty reduction in Asia as well. The World Bank notes that "rising education levels were important in boosting Asian growth on average by 0.75 to 2 percentage points" (World Bank 2006). Lack of markets and storage facilities at the village level reduce local prices during the harvest when the poorest producer households are most in need of income (Burney and Rosamond 2011). These points highlight the need for more integrated approaches to water intervention for poverty reduction.

A combination of water and other infrastructure interventions would together achieve more than any single intervention. The relationships between irrigation and other forms of infrastructure are complementary; water interventions should therefore be linked to other forms of infrastructure investment. Provision of basic infrastructure to support agriculture, such as rural roads, reliable electricity supply, irrigation and affordable communications is an important precondition for agricultural growth and achieving optimal benefits from investments. Synergies among complementary investments are the key.

Targeting interventions to different farmers' groups

Designing water interventions for poverty reduction requires understanding three important factors: (1) accurate identification and targeting of the poor; (2) identifying the specific needs of different groups of farmers; and (3) identification of interventions or investments that will suit the farmers' needs and have the highest impact on poverty (i.e. pro-poor investments). Chapter 3 has already analysed the first two issues. This section explores how different farming groups could benefit from specific water intervention options. It also discusses additional measures required to maximize the benefits of the proposed interventions. The following sections then describe various intervention options that will contribute to poverty reduction in the different livelihood settings of Asia.

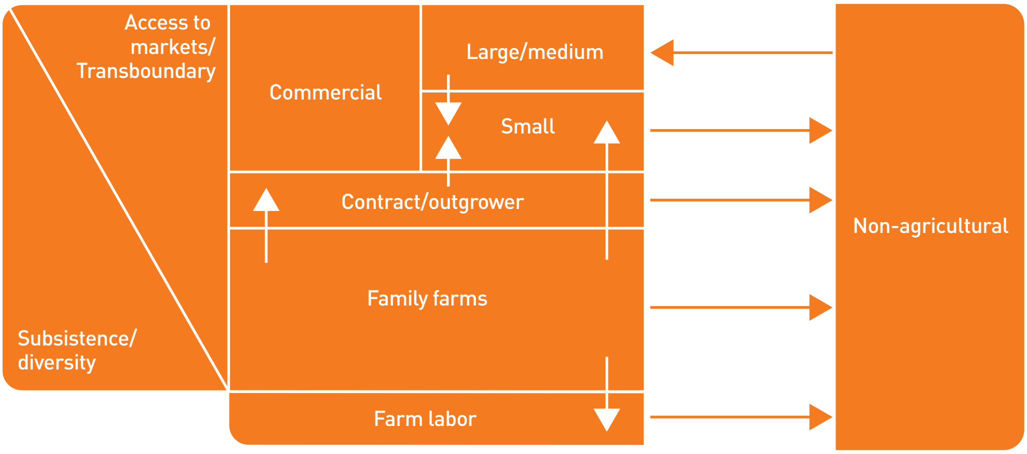
A variety of farm typologies have been used in the literature to identify different categories of farmers. This study adopts three important features that dominate Asian farming: small farms, diversification and commercialization, and rapid growth of the non-farm economy. Small farms are a basic distinguishing feature of Asian agriculture. About 87 percent of the world's small farms (less than 2 ha) are located in Asia (Chand *et al.* 2011). China stands first in its concentration of smallholdings followed by India, Indonesia, Bangladesh and Viet Nam. For example, in China and Bangladesh, about 98 percent of the farms are less than 2 ha, whereas in India and Indonesia about 80 percent meet this criterion (Thapa and Gaiha 2011). Within the small farm domain, the majority (more than two-thirds) have marginal holdings of less than 1 ha. In rapidly growing countries such as Thailand, Indonesia and China, there may be noticeable farm consolidation in the near future, but farm size is expected to continue declining in most of South Asia for at least another generation. Small scale farming will therefore remain dominant in Asia for the foreseeable future.

The emergence and evolution of small-scale commercial farmers is another dominant feature of Asian agriculture in recent times. As shown in chapter 2, the proportion of small-scale commercial farmers is much higher than the proportion of purely subsistence farmers in Asia. It is estimated that more than 40 percent of small farms are already fully commercial, while most of the remaining farms are at least semi-commercial. A thriving economy, commoditization, rapid urbanization, increasing rural-urban linkages and massive investment in rural infrastructure have all played crucial roles in this process. This has also triggered the growth of peri-urban agriculture.

Most farmers in Asia can be categorized as diversified farmers. They earn their livelihoods from different sources: farm/non-farm, labour and migration. The increasing trends towards diversified livelihoods are due to both the small size of farms and the opportunities in the growing non-farm sector. As farming alone is not sufficient for livelihoods, farmers pursue diversified options for their living. There is also a sizeable landless population in Asia who earn their livelihood as sharecroppers, labourers or migrant workers. Due to the high percentage of landless people as well as the very small landholdings of most farmers, a sizeable number earn their livelihoods mostly working as labourers, as shown in chapter 2.

The continuing transformations of rural farm enterprises are broadly described by Figure 4.1. Whether a farmer remains focused on subsistence or becomes more commercial is largely determined by the market and its access, including other infrastructure facilities. Large and medium farmers are usually commercial farmers, whereas small farmers (including marginal farmers) may be both, depending on the factors mentioned above. There is also a strong linkage between the farm and non-agricultural sectors through exchange of labour and services. Growing agricultural commercialization means that the non-agricultural sector is also entering into the agricultural domain through establishing large commercial farms (for example large-scale livestock farming), contributing to the development of new agro-industries. In view of these dynamics, developing a farm typology is complex.

FIGURE 4.1 FARM DYNAMICS IN ASIA

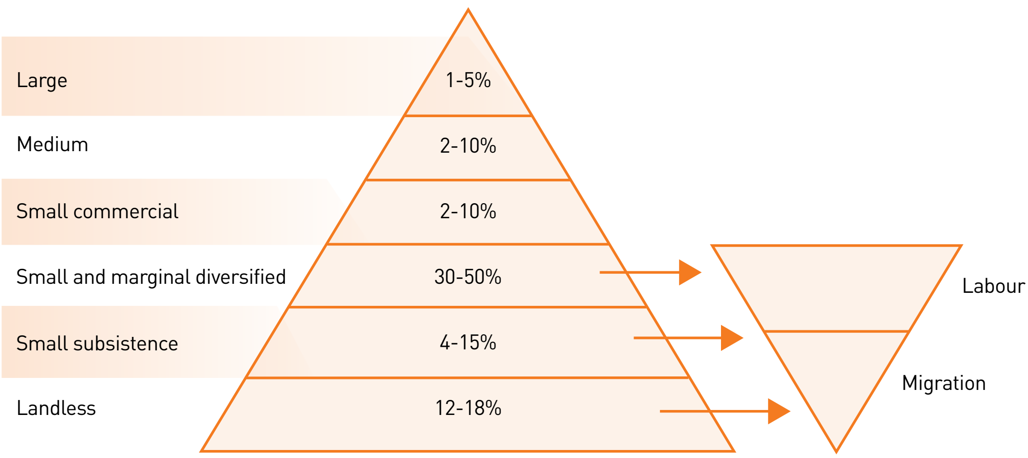


Source: This study.

While different farm typologies can be proposed, this study uses a typology based on the characteristics of Asian farmers described above. At the first level, farms are classified based on the size of holding: small (<2ha), small to medium (2-5 ha) and large (>5 ha). Most Asian small farmers own less than 0.4 ha of land (almost two-thirds); they are classified as marginal farmers. Both medium and large farmers exhibit a more commercial character (always having a surplus to sell in the market). The small farmers are either 'commercial', 'diversified' or 'subsistence', depending on their share of income from agriculture and the nature of the farming system. The typology, divided into five different categories, is shown in Figure 4.2.

4

FIGURE 4.2 RURAL FARM TYPOLOGY IN ASIA (NUMBER OF FARMERS)



Source: This study.

The percentages assigned closely reflect the situations in all three regions (FAO 2010a; Bangladesh Bureau of Statistics 2008; China Statistics Press 2009).

Small farmers, accounting for more than 80 percent of the total, are the main target group for poverty reduction. The commercial groups range from 40 percent of the total farmers (as in the case of Viet Nam) to only 4 percent (as in the case of Bangladesh), as discussed in chapter 2. They derive most of their income from agriculture. As they are commercialized and diversified farmers, they need a flexible water supply, and therefore will benefit from better management of groundwater resources and multiple-use water interventions. They need service-oriented water control based on their criteria and preferences. They will also benefit from modernization of existing surface irrigation systems by establishing service-oriented water control. In addition, they need information on markets, capacity enhancement in entrepreneurship development and improved rural infrastructure.

Diversified farmers represent most farmers in Asia. No single source of income exceeds 50 percent of the total household income in the case of diversified farmers. Most of the diversified farmers are marginal, having less than 0.4 ha of land. They represent more than two-thirds of the small farmers. Given the small size of the farms, agriculture provides adequate livelihoods for only a very limited number of farmers and for short durations, depending on the type of land (irrigated/rainfed, lowland /upland, etc.), holding size and market opportunities. Most farmers therefore derive a portion of their livelihoods from the non-farm sector, and hence have a diversified income base.

The diversified farmers exhibit a semi-commercial character. Usually there are two types of farmers in this group. The first are the 'progressive' farmers, who are emerging from the subsistence zone and trying to adjust to commercial agriculture. The second group includes those who once were commercial/subsistence farmers, but are now in the process of leaving agriculture or 'ready to exit' farmers in search of better opportunities outside agriculture. Water interventions are more relevant to the first group, which would benefit from flexible small-scale water management programmes. The second group needs training and support in non-farm activities, entrepreneurship development and managed agricultural exit programmes.

Subsistence farmers are the most deprived group. Topographic limitations, harsh climatic conditions, weak land tenure, poorly developed infrastructure, ethnic discrimination and low agricultural potential all constrain their livelihood options depending on the context. The same factors also limit their capacity to find opportunities outside farming. These groups need focused attention such as social safety nets and rural infrastructure, combined with small-scale water conservation and utilization projects and programmes like community-based irrigation, intermediate forms of water control and non-conventional irrigation technologies such as low cost drip irrigation. They also need to be protected from water hazards (events like floods and droughts). Access to credit and subsidies for fertilizer and agricultural inputs will also be crucial for sustaining their livelihoods, at least until they find alternative livelihoods.

Both medium- and large-scale farmers are commercial farmers. Though the percentage of farmers in these groups is lower, their total landholdings are high. For example, in India they hold more than 40 percent of the land; in Pakistan it is more than 50 percent. These farmers would benefit from programmes that increase water productivity and that enable sustainable management of groundwater. However, the relevance for poverty reduction is largely indirect: improved production and productivity measures through water interventions and other policy measures may provide increased employment opportunities in both the farm and non-farm sectors. These farmers need functional market linkages, trading opportunities, better information on commercial products and improved technical and managerial options to facilitate production, storage and marketing.

A sizeable population, especially in South Asia, is landless. Available data show that in South Asia, i.e. in India, Pakistan and Bangladesh, about 10 percent of rural households are in this category. These people earn their livelihoods working as labourers in both the agricultural and non-agricultural sectors or as sharecroppers to large farmers. These people will not directly benefit from water interventions, though some indirect benefits through agricultural employment, lower food prices and agriculture-induced non-farm employment may result. They need other kinds of support, especially focusing on access to land and water through land transfers and subsidized land purchases where applicable.

It is clear that at the present level of productivity, most smallholders, especially the marginal farmers, cannot meet their livelihood needs from farm income alone. Table 2.4 in chapter 2 clearly shows that most farmers have diversified sources of income. There are mainly two ways to improve their incomes and livelihoods. One is an increase in the land-person ratio, which is possible only if a sizeable segment of smallholders is moved out of agriculture and employed in other sectors of the economy. Another is to provide alternative sources of employment to smallholders. Both situations require diversifying livelihood options outside agriculture. Failure to do this will result in continuing poverty. The main reason for the high levels of poverty in the rice and rice-wheat systems even under irrigated conditions, as discussed in chapter 3, is the lack of employment opportunities outside agriculture. Most farmers are landless or marginal farmers who cannot survive on agriculture alone.

Targeting interventions to women

Experience has shown that interventions targeting women are effective in poverty alleviation. Although gender mainstreaming in agriculture is not new, past approaches have not been adequately translated into practice; they have been limited to 'involvement' in 'sharing' the process and resources, and have had only modest success. The conventional view that agriculture is largely a male domain has also played a role in poor recognition of women in agriculture. Gender disparities continue to persist everywhere, and remain most acute in the poorest countries. The fourth UN Convention on Women asserted that 70 percent of the poor in developing nation were women. Asia continues to witness increasing poverty of women. This "feminisation of poverty" (Pearce 1978) calls for more radical targeted interventions. As argued by Zuckerman (2002), poverty reduction strategies must be engendered to effectively reduce poverty.

There are various cultural, social and political reasons behind the feminization of poverty. Women labourer's wages tend to be lower than men's. In general, matriarchal households in the region are poorer than patriarchal ones. Poverty is more severe and binding for women in that it is harder for them and their children to escape it. Despite their major contributions to agricultural work and other rural economic activities, women's economic roles remain largely invisible and unrecognized in statistics, in public policy and in the governance process (IFAD 2011).

The recent *State of food and agriculture* (FAO 2011b) highlights the need to close the gender gap in access to agricultural resources, education, extension, financial services and labour markets; to invest in labour-saving and productivity-enhancing technologies and infrastructure to free up women's time for more productive activities; and to facilitate women's participation in flexible, efficient and fair rural labour markets. Where women represent the majority of smallholder farmers, failure to release their full potential in agriculture is a significant contributing factor to low growth and food insecurity (World Bank 2008).

While water projects that meet multiple livelihood objectives and take gender issues seriously are more likely to be sustainable, targeting women in agricultural water management also requires innovation in technology and favourable policy and institutional environments. Increased involvement in decision-making process through water users' associations (WUAs) and other relevant platforms, access to information, knowledge and capacity building in various aspects of agriculture water management, credit facilities, market information, and compatible rural infrastructure all will play pivotal roles in facilitating women-targeted interventions.

Women-friendly technology can play a crucial role. The simple drip irrigation technologies introduced in rural Nepal by International Development Enterprises (iDE)[8] is a clear example of how technology can play an important role in targeting rural women. Thousands of rural Nepali women have benefited from the programme in building their livelihoods through vegetable cultivation from small patches of land (Bhattarai 2011). FAO emphasizes that appropriate farm tools, improved crops, integrated pest management techniques, conservation agriculture, biological nitrogen fixation and other context-specific technologies should also be targeted for development of and enhanced access by women (FAO 2011b).

Securing land and water rights is another key policy intervention required to ensure women's access. A critical constraining factor for targeting women in agriculture, especially in South Asia, has been that land rights are usually attached to men in both customary and formal legal systems, resulting in built-in inequalities. As water rights are usually attached to land rights, women are therefore deprived of both rights, which are the most essential productive non-labour assets to sustain rural livelihoods. Access to these rights would help women to participate more broadly in land and water management programmes and share the benefits of such interventions.

Prioritizing interventions to different categories of farmers

The different types of farmers identified above need different policy responses. Interventions should be context-specific and targeted. Some interventions are broad in nature and will impact

[8] Now simply iDE; see www.ideorg.org, accessed 16 January 2014.

all groups, whereas some can be designed to focus on specific groups. Policy interventions can be targeted to specific groups; physical interventions are often more difficult to target in this case. Table 4.1 summarizes possible interventions for different groups or types of farmers. The table also includes interventions that may be designed to specifically target women as well as landless farmers. The choice and type of the particular set of options will depend on the livelihood context discussed in chapter 3. Box 4.1 provides a concrete example of a project that addressed gender issues successfully.

TABLE 4.1 TARGETING INTERVENTIONS TO DIFFERENT FARMER GROUPS

Type of farmers	Typical interventions in water	Typical intervention beyond water
Large	Modernization of irrigation infrastructure and management, adoption of sustainable groundwater governance mechanisms, disaster risk management	Facilitating market linkages
Medium	Conjunctive use of canal water and groundwater, investments in technologies and management models that contribute to improved water productivity	Facilitating market linkages
Commercial, small	Adoption of sustainable groundwater governance mechanisms, adoption of more effective management models in community-based irrigation schemes	Development of entrepreneurship skills, facilitating market linkages, promote linkage with large agribusinesses, improved access to and quality of financial services
Subsistence, small	Rainwater management through intermediate forms of water control, access to groundwater, access to small-scale technologies to capture, store and distribute water	Access to basic services, rural infrastructure, diversification of income, social safety nets.
Diversified	MUS for domestic water and household gardens, livestock, atomistic irrigation	Rural infrastructure, training and support for non-farm activities
Women farmers	Empowerment: involvement in water users associations and decision-making processes, development of irrigation technologies adapted to their specific needs	Enhanced capacity and skills in farming, marketing, access to microcredit,
Landless	Design of water services that consider the specific needs of the landless	Training to support non-farm activities

Source: This study.

4

Intervention strategies

As shown in chapter 3 (Table 3.8), large parts of Asia still have potential to exploit water resources and therefore offer opportunities to develop new water control schemes. In other areas, there is no potential for further expansion and parts of these areas already suffer from water scarcity.

BOX 4.1
Philippines: promoting gender equality through irrigation and rural infrastructure

The Infrastructure for Rural Productivity Enhancement Sector (InfRES) project has been implemented in 779 municipalities in 41 provinces in the Visayas and Mindanao (Philippines) for the past seven years. It aims to reduce poverty through the construction of basic infrastructure – farm to market roads, irrigation and potable water systems – in poor rural areas with high agricultural potential.

Potable water supply (PWS) and sanitation play an important role in empowering women. Because of the new PWS in their barangay (village), Neila and her neighbours now have access to safe drinking water throughout the day at a convenient distance from their homes. This has reduced time spent on collecting and boiling water and also looking after sick children and family members as incidences of diarrhoea and other water-borne diseases are now much lower. This has meant that women in the community now have more time to grow vegetables and raise chickens and hogs, or run small enterprises that provide them with financial independence, while their family's diet is supplemented with fresh greens and meat, encouraging better health.

The project's investments in improved irrigation infrastructure have increased agricultural productivity and resulted in higher incomes for the farming communities. Prior to the investments, irrigation water used to be rationed and its delivery was erratic and unreliable. Farming families like Neila's had to waste a lot of time during the day to wait for water to come, open the earthen canal when water was available and close it again after irrigating their crops. Limited access to water meant that farmers could plant rice only once a year and no other crops during the dry season. These conditions constrained farmers' ability to diversify, improve farm output and increase their earnings. With reliable irrigation water, farmers now grow two crops of rice totalling 8 500 kilograms, giving a gross annual income of 93 500 pesos (US$1 574.00). Increased irrigable land has also led to an increase in farm work opportunities for women, specifically in transplanting, weeding and harvesting of crops, expanding women's sources of income.

Like Neila, many women are members of the Barangay Water and Sanitation Association (BAWASA) and Irrigation Water User Association (WUA). BAWASA and WUA are responsible for day-to-day management of their systems, including membership and service fee collection, resolving member/household/farm disputes in water distribution, and repair and maintenance of the PWS and irrigation systems. The project found that women more effectively resolved concerns, particularly in arranging potable water distribution schemes and scheduling irrigation water distribution. The project supported women's transition from water collection tasks to leadership and engagement in community water management and utilization activities.

To date, the project has provided safe water to almost 17 000 households and supplied reliable irrigation to 1 500 ha of productive land.

Source: ADB, 2011a.

Interventions in these areas should focus on demand management, including management of existing systems to increase water productivity or value addition to water. In other areas, like those irrigated with groundwater, the problem is environmental sustainability as a result of over-draft and rising salinity. In most of the livelihood systems, people also suffer from flood and drought hazards. These different water constraint situations together with the poverty and economic context will determine the nature and pattern of water interventions.

Many Asian farmers will continue to practice rainfed agriculture for several reasons. First, in many areas there are very few opportunities to develop new water control systems as water supply is constrained. Second, there are other socio-economic and technical constraints despite the physical potential. Third, harsh topographical conditions, for example in mountain agriculture, and unfavourable climatic situations also limit the development of irrigated agriculture. However, these areas may offer potential to develop various forms of intermediate water control systems, such as rainwater harvesting and on-farm water storage. The type and nature of such systems will depend on the amount of rainfall and other agro-ecological parameters.

Water hazards are omnipresent in Asia; therefore investing in resilience is another important focus area for water interventions. More than 30 percent of natural catastrophes, 50 percent of deaths and 31 percent of costs of natural catastrophes are due to floods. Droughts in some parts of the world have hurt global grain production and contributed to food price spikes virtually every other year since 2007, highlighting the need to transform the way water is used – and wasted – throughout the entire food chain. Drought and its impacts have historically been addressed through a reactive, crisis management approach, and through the provision of relief measures. While important for saving lives, this approach has the limitation of creating dependency on food aid; the affected livelihoods remain vulnerable to subsequent droughts.

Based on this discussion, water interventions in Asia can be broadly grouped into the following five categories:

1. Increasing access to water through new water control systems;
2. Increasing productivity and value added of water from existing systems;
3. Rainwater management through intermediate forms of water control;
4. Developing multiple-use water systems to satisfy multiple demands; and
5. Building resilience against water vulnerabilities and improved management of the water environment.

While the first three are focused on agricultural water management, the fourth is about increasing productivity and adding value to water by recognizing its multiple values in designing the water intervention programmes. The final intervention category is about building resilience and sustainable resource management. The purpose of water interventions could be one or a combination of the above, and there can be various technological options involving both ground and surface water in each of them. This is discussed further in the next sections.

Interventions can be broad or focused (Hussain *et al.* 2005). Many water interventions are broad in nature as they target geographically or hydrologically defined areas and involve different groups of farmers. In some cases, the development objectives may not be directly focused on the poor, but they will also benefit through increased employment, lower food prices and higher productivity. Some interventions, however, can be designed with a focus on specific groups employing a particular technology. These can be directly targeted to the poor. Though focused interventions seem more appealing from a poverty reduction perspective, broad interventions play equally important roles given the interconnectedness of poverty to the wider economic setting.

Past approaches to water interventions were often dominated by engineering, with cosmetic additions of participation and institution-building. They were largely confined to the level of the water control system. Given the competition for and scarcity of water, and its multiple roles, future water interventions should begin with appropriate water accounting and auditing followed by allocation to different sectors. This will help design interventions from both supply and demand perspectives and also facilitate multiple water-use perspectives. Perry (2013) suggests a framework based on a multidimensional perspective on water resource management and follows the sequence:

A: *Accounting* for the available resources;
B: *Bargaining* through the political process to determine priorities and allocation;
C: *Codification* of the agreed priorities and allocations into rules, statutes and laws;
D: *Delegation* of implementation to appropriate institutions and agencies; and
E: *Engineering* to create the necessary infrastructure to deliver agreed services.

The various water control options described in the next sections should therefore be designed and implemented based on the results of appropriate water auditing and accounting, and recognize its multiple roles and uses. This can be done from watershed to subbasin to river basin scales, depending on the nature and scale of the proposed interventions. Successful interventions also require favourable regulatory and institutional environments to get the engineering right.

From a livelihood perspective, the objective of interventions is to build capital. Intervention programmes should therefore consider all the components of the livelihood framework, not only physical (engineering infrastructure), natural (water) and financial capitals, but also building human and social capitals and improving the institutional and policy framework. The relative importance of technology or infrastructure compared to policy and institutional reforms varies depending on the development context. For example in groundwater, policy and regulatory interventions may often be more important than infrastructure investments.

Intervention options

Future water interventions should begin with a multisectoral perspective. That means agricultural water management should be analysed in a broader perspective, including domestic and industrial water demand as well as environmental requirements and provisions for ecosystem services. These demands are growing. The priority is determined by socio-economic and political considerations. Access to domestic water is a fundamental human right. Similarly, water for food production should also be protected as a right.

Within the agricultural water sector, the demand for water for livestock production and fisheries is rapidly increasing. Water for crop production must gradually adjust to these trends, in many cases through better integration of crops, livestock and fish. As livestock operations intensify, farm operators can no longer depend on traditional means of watering their grazing herd. In addition, improved pasture management practices such as rotational and strip grazing require a more flexible watering alternative.

As Asian economies continue to grow, the pressure for reallocation of water among and within sectors will intensify. As human needs diversify, the importance of recognizing these trends and designing water control systems to satisfy multiple water demands will increase. The concept of multipurpose or multiple-use water services is not new. Many large-scale water storage schemes in the past have been designed as multipurpose systems for power generation, flood control, irrigation and domestic purposes. However, the importance of designing water systems for multiple uses in small-scale water control systems has only recently been well recognized (van Koppen *et al.* 2009).

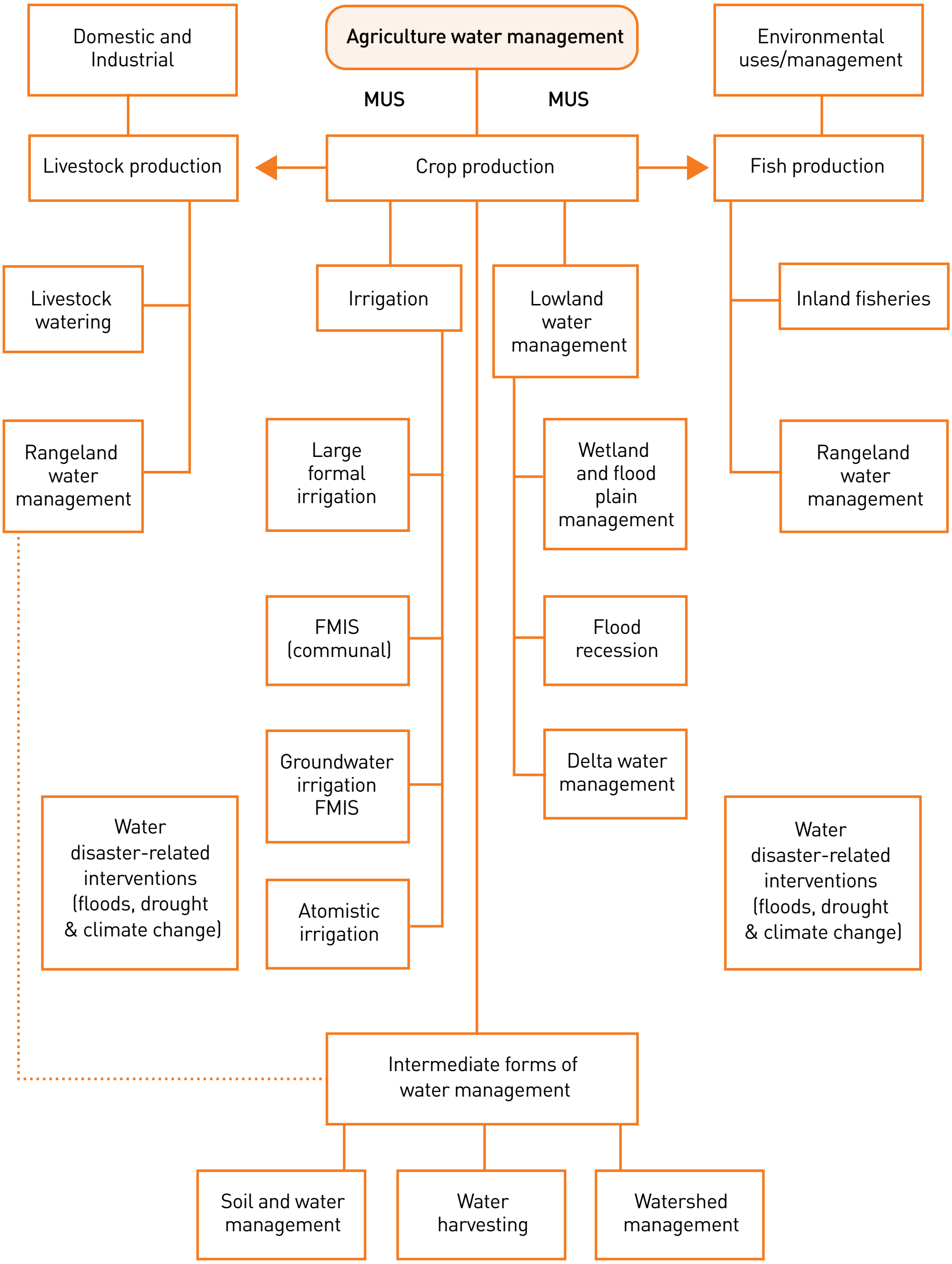
The hydrological regime and socio-economic conditions in various livelihood zones offer a range of possible options for development. These options are summarized in Figure 4.3 and further elaborated in the following sections.

Rainwater management through intermediate forms of water control

Improved water management in rainfed agriculture offers a high potential for increasing agricultural production and productivity and contributing to poverty alleviation in several ways. According to the Comprehensive Assessment of Water Management in Agriculture, investments in rainfed agriculture can have large payoffs in yield improvements and poverty alleviation through income generation and greater environmental sustainability. The need to invest in rainfed agriculture in order to address poverty and malnutrition, especially in the arid, semi-arid and dry subhumid regions of the world that are hotspots of poverty and hunger has been well argued in recent times (Rockström *et al.* 2007; Falkenmark and Rockström 2004; Wani *et al.* 2009).

However, the potential for achieving gains through better water management in rainfed systems differs across livelihood systems. It is clear that various forms of water control are possible in rainfed agriculture; we refer to these as 'intermediate forms of water control' in this study. They vary from simple soil moisture management techniques to managing surface runoff by combining these techniques with water harvesting and small-scale diversion. Small-scale diversion and storage of runoff combined with the use of 'non-conventional' irrigation technologies like drip and sprinkler systems have also been adopted by small farmers, especially in South Asia. These intermediate forms of water control in rainfed agriculture involve both physical and non-physical measures.

FIGURE 4.3 POSSIBLE WATER INTERVENTION OPTIONS



Note: FMIS = farmer-managed irrigation system.

Physical measures: Physical measures broadly fall into three categories: soil moisture management, watershed management and water harvesting, and non-conventional irrigation technologies. Interventions can be designed combining the elements from all three, depending on the context. They all contribute directly to raising agricultural production and productivity by increasing water availability for crop growth. The overall aim will be context-specific, and may include multiple interrelated interventions across subsectors like agriculture, livestock and horticulture through land development, organic matter build up, crop production enhancement and livestock development.

Soil moisture management involves both structural and non-structural measures. The structural measures are not new; many have been practiced since antiquity. They basically involve *in situ* water harvesting through terracing, contour farming or other appropriate water retention methods. Non-structural measures mainly involve improved management techniques like mulching, reduced tillage, crop rotation and agroforestry. These measures are the foundation of 'conservation agriculture'. They are most relevant in the livelihood zones of East and South Asia characterized by sparse rainfall as well as in rangeland systems of East Asia.

Watershed management and water harvesting are the most widely adopted water management strategies in rainfed agriculture. While watershed management has much broader objectives of resource conservation and utilization, water harvesting is focused on storage of available runoff through small dams and ponds and making the stored water available as needed. In some cases, the objective may be water retention through check dams for groundwater recharge. A combination of different technical options can contribute to increasing runoff and storage, and may provide benefits approaching those of irrigated agriculture. Watershed management programmes are relevant for many of the rainfed livelihood systems in Asia: highland/mountain agricultural systems of East and Southeast Asia, rainfed dry tropics and subtropics, cereal-based temperate zones, and rainfed humid tropics. These programmes could be designed in combination with the *in situ* water management techniques described in the previous paragraphs as well as with non-conventional irrigation systems.

Low-cost drip and sprinkler micro-irrigation technologies have emerged as important pro-poor interventions in recent years. They have been used in areas constrained by topography and climatic conditions where irrigation through conventional technologies is not feasible. Thousands of small-scale farmers living in isolated remote mountainous areas, especially in South Asia, have benefited from this kind of intervention. These technologies were once viewed as being modern equipment appropriate only for technology-savvy commercial farmers. However, in recent years, there have been efforts to promote and mainstream a nearly opposite notion that these technologies are particularly well-suited to very small, resource-poor farmers. In small plots, they require surprisingly little capital, are easy to manage, save labour and most importantly, they can significantly enhance productivity of land and water (Shah and Keller 2002; Mikhail and Yoder 2008).

Expansion of these technologies in the past was restricted because of high capital costs and problematic maintenance such as clogging of filters. Both of these issues have been largely addressed, thanks to the hard work of several NGOs working in this sector. Among them, iDE and

Netafim (a private Israeli company) have played crucial roles in reducing their costs and making them more widely available. A key advantage of these low-cost micro-irrigation technologies is they can be targeted to those who are marginally poor, including women.

Reduction in capital costs and technological innovations favouring marginal farmers have resulted in rapid expansion of micro-irrigation technologies in remote and isolated regions of South Asia, for example the hills of Nepal and Himachal Pradesh in India, poverty-stricken provinces of India like Jharkhand and Madhya Pradesh, and also in parts of Pakistan. They offer new means of income generation to the rural poor living in difficult terrains and extreme water-scarce conditions. They have proven useful in high mountain cereal production (like wheat and maize) and for vegetable production. They can be designed as an independent system or in combination with other technologies; for example pedal-powered treadle pumps can be used with low pressure sprinkler systems for vegetable or cereal cultivation (Mikhail and Yoder 2008).

These technologies are most suitable for vegetable and tree crops. As the demand for fruits and vegetables is growing rapidly, there is potential for rapid expansion of these technologies. It brings the twin advantages of poverty alleviation and improved land and water management practices. A typical micro-irrigation kit for vegetable production in two districts of Maharashtra, India, resulted in 55 percent savings in water applied, 58 percent reduction in labour-days, 16 percent savings in fertilizer and pesticides, 97 percent increase in output and 142 percent increase in gross income as compared to conventional surface irrigation methods (Shah and Keller 2002, citing iDE's work). In addition to agricultural and environmental benefits, localized micro-irrigation also helps to increase rural non-farm employment through increased scope in manufacturing, trading, installation and transportation of the technologies.

Non-physical measures: These are relatively new, and their wide application at the field level is yet to be realized. They include payment for ecosystem services (PES), risk management measures and providing better climatic information. While the application of the first two measures is constrained by policy and economic factors, the third is the most direct and simple to implement.

The concept of PES in water management is based on the notion that hydrological systems and services are interconnected, such that actions at one place have implications for other places, and benefits and costs should therefore be shared. A clear example is the case of watershed management, where watershed conservation by upstream farmers may result in increased water flow or reduced sediment flows to downstream farmers, increasing their income. There may be scope to monetize the benefits to the downstream farmers in the form of payment to upstream farmers. Likewise, wetlands provide biodiversity conservation services through which many people may derive their livelihood (e.g. fishing in wetlands of the deltas). Similarly, there can be other non-hydrological services like tourism benefits from better wetland management. Though PES has been strongly advocated in recent years (e.g. Greiber 2009), verifying, quantifying, legalizing and monetizing the benefits remains extremely challenging as a basis for translating the concept into practical reality. The documentation of PES experiences in Asia is limited, and those described involve mostly examples of upper catchment management and sharing of downstream benefits; its large-scale implementation in Asia is still in the future.[9]

[9] Nevertheless, one estimate suggests that by 2030 the market for watershed protection could benefit 80 to 100 million people; similar large numbers could benefit from markets for biodiversity, carbon and landscape beauty and recreation (Milder et al. 2010).

Risk management is basically an insurance scheme to protect farmers against crop failure. It can involve measures like packages of social security products, for example deficit rainfall insurance, crop insurance, livestock insurance and human insurance to mitigate the risks and vulnerabilities of rainfed agriculture. It ensures farmers of a higher income in poor rainfall years after paying a minimum premium each year. While the concept looks appealing from a sociopolitical perspective, it is challenging from institutional and economic perspectives. Paying premiums has proven problematic for poor farmers living in fragile environments. Nevertheless, large-scale crop insurance programmes have been initiated in India (World Bank 2012) and China has recently adopted several policy measures to increase crop insurance coverage. Many nations in Asia are working towards establishing functional crop and livestock insurance schemes (e.g. Bangladesh [ADB 2013c], United Insurance schemes for crops and livestock in Pakistan[10] and Nepal [Mahul *et al.* 2009]).

Accurate and timely climate information can help farmers plan their crops and crop management. It is the most implementable intervention in terms of both cost and management as already established hydrometrological services can be used. However, this requires strong databases on climatic conditions at local levels and appropriate information systems for the farming community. A carefully designed climatic information system will not only help farmers in crop planning but also be very helpful in designing early warning systems against water vulnerabilities and strengthening resilience. Each nation has its own flood and drought early warning systems in Asia; at present there is no formal common platform for early warning systems.

Groundwater management

Groundwater interventions are critically important, especially in South Asia and parts of East and Southeast Asia. Despite economic and environmental concerns raising questions over the sustainability of groundwater use, it will continue to expand for reasons explained in chapter 2. Asia must find ways to better control and manage its groundwater resources to sustain the economic gains of the past and maximize future benefits. Because of its potential to offer individual control over water, groundwater interventions can be targeted to specific groups of farmers, including the poorer and less-advantaged segments of society. There is a wide range of groundwater interventions applicable to different livelihood zones. The focus of such interventions, however, is changing from resource development to resource management. There are several options, both at physical and policy levels: shallow tubewell expansion, management improvements through awareness and capacity building, and policy interventions for regulation and control.

In many parts of Asia, there are still possibilities to expand groundwater irrigation by adding new mostly shallow wells. The high priority areas include the rainfed dry tropical and subtropical zones of South Asia as well as the lowland rice-based systems of both South and Southeast Asia (see chapter 3). These areas have high concentrations of poverty, but also high potential for water resource development. Expansion of groundwater development in these areas also needs rural electrification programmes, as the rising cost of fuel is rendering the use of diesel-powered pumps too expensive (Mukherji *et al.* 2013).

[10] http://www.theunitedinsurance.com/livestock; http://www.theunitedinsurance.com/crop-insurance, accessed 16 January 2014.

While capacity development of the local farming community has always been central to surface irrigation development programmes, capacity development in groundwater management has been neglected. The importance of enhanced local knowledge and capacity is that it helps communities to implement voluntary arrangements to avoid overdraft and increase recharge to aquifers. Voluntary agreements are mechanisms that users undertake by themselves to reduce extractions and protect the resource (Madani and Dinar 2011). Building capacity for improved management will be crucial for future management, as past groundwater policy interventions have often not achieved the expected results.

Field-based practical examples of improved groundwater management through enhanced local capacity are rare. Van Steenbergen (2006) has documented local groundwater management experiences in India, Egypt, Pakistan and Mexico that exhibit a mixture of success and failure. The study recommended making hydrology less esoteric and focusing on building awareness and promoting demand and supply measures, while emphasizing the role of informal rules and norms. A successful example exists in a project assisted by FAO in Andhra Pradesh in southern India, where local communities have been successful in managing overexploitation of the aquifer by increasing recharge and contributing to sustainable groundwater management through improved knowledge and understanding of groundwater resources (Goverdhan Das and Burke, 2013). These examples demonstrate that better groundwater management can occur without formal regulation and control mechanisms.

Large-scale groundwater irrigation expansion in Asia was made possible in the past by a favourable policy environment and by technological innovation. However, overexploitation, aquifer collapse and ecosystem disasters are now common problems facing many groundwater systems. This situation calls for regulation and control to protect aquifers and ecosystems, so that the resources are available for future generations. Regulation and control in groundwater management, however, have always been a complicated sociopolitical and technical problem.

In the past, efforts have been made to remove subsidies for tubewells and electricity and to apply 'polluters pay' principles. These have had mixed results in deep tubewell areas, but have been ineffective in shallow tubewells areas, which account for about 70 percent of overall groundwater use. Many farmers, poor implementation of the regulatory framework and the informal nature of the groundwater economy all make regulation and control of groundwater problematic (Shah 2009).

Recent advances in digital technology are proving promising in regulating groundwater resources. The use of smart cards as a way of regulation and control in Bangladesh and China (Aarnoudse *et al.* 2012) has shown promising results. This involves the use of prepaid smart cards to pump water, a process organized through WUAs. The Bangladesh Agriculture Development Corporation (BADC) system can monitor the operation of 30 000 deep tubewells. In Bangladesh pumping is regulated only through a tariff, but in China it is done by both quotas and tariffs. Though the concept of water fees is not new in groundwater, its application has been largely a failure because of poor monitoring and ineffective control mechanisms. The use of digital technology combined with local institutional mechanisms has largely overcome this problem, at least for deep tubewells. Its application to numerous small-scale shallow wells is challenging.

Localized management as well as conjunctive use of surface and groundwater resources offer better options to manage and use the resource. These interventions are applicable to many existing groundwater-based livelihood systems: rice-wheat groundwater irrigation (humid tropics) of South Asia, and groundwater irrigation (dry) in South Asia (parts of northwest India) and East Asia (parts of northeast China). In addition, irrigated rice- and wheat-based surface schemes also benefit from such interventions.

There are no single-factor simple solutions to the complex problems of groundwater management. Combinations of one or all of the above measures, depending on the livelihood context, will however help address the problems. Researchers have argued that applying a single policy to govern an aquifer may neither be effective nor efficient. They suggest using a combination of several policy instruments (Esteban and Dinar 2013). This has already been demonstrated by the Chinese case which employs both quotas and tariffs and management through WUAs. The policy options can also be combined with technological and managerial options. For example, combining tubewells with micro-irrigation technology will result in less pumping and higher water productivity, while achieving the same or better returns.

Modernization of surface irrigation

Interventions in large-scale surface irrigation systems are broad in nature. It is difficult to target them only to the poor. However, given the interconnectedness of water control and rural poverty, large-scale schemes offer considerable potential for poverty alleviation through several pathways explained in chapter 2. The focus of such interventions is directed at making water distribution more equitable and increasing the productivity of water, especially in the large surface schemes in South Asia. These interventions are most relevant for two livelihood systems: rice-based surface irrigation systems, especially in South Asia and Southeast Asia, and rice-wheat-based irrigated systems of South Asia.

There are several reasons for investing in modernization of existing large-scale irrigation schemes. FAO has proposed four types of modernization interventions: technical, social/institutional, economic/financial and environmental, as shown in Table 4.2. The relative importance of one over another depends on the type and nature of the systems. By considering these four elements, the modernization process recognizes the importance of different sectors beyond engineering. Ultimately, the aim is to target physical, managerial and institutional improvements for effective delivery of irrigation services to farmers.

Within the four intervention domains, a variety of issues affect irrigation performance; solutions need to be based on the specific problems in a given system. For example, a technical intervention may be to enhance the availability of water resources or enhance the functionality of the infrastructure. Likewise, poor planning of water delivery (a water management problem) or inappropriate cropping patterns (an agronomic problem) require their own solutions. Table 4.2 helps assess the problem in a holistic way and design interventions effectively.

TABLE 4.2 IRRIGATION MODERNIZATION INTERVENTION DOMAINS

Technical	Social/institutional	Financial/economic	Environmental
Water availability	Governance	Water fee structure	Ecosystem conservation
Infrastructure	Conflict management	O&M costs	Soil degradation
Water management	Unskilled human resources	Subsidies and fund mobilization	Water quality
Agronomic	Policies and legally-related issues	Agricultural profitability, land value	Water table

Source: http://www.fao.org/nr/water/irrigation/backgroundmod4.html

There have been many efforts to improve the performance of Asian surface irrigation systems in the past. Investment programmes in the early 1980s were directed at improving technical control at local levels (for example, the command area development initiatives in several countries, the On-Farm Water Management Programme in Pakistan). These programmes emphasized training farmers and improving infrastructure at the outlet level. The focus later shifted to farmer participation and transferring management of lower levels of schemes to farmer organizations. All these programmes assumed the main performance issues were at local, not main canal or higher levels, a view that ignored a classic paper identifying the main system as the 'blind spot' of irrigation management (Wade and Chambers 1980); and they ignored the impact of the broader institutional, policy, economic and agro-ecological context on irrigation performance (Merrey *et al.* 2007). Irrigation systems have come to be seen as sociotechnical systems embedded in complex agro-ecological settings (Vincent and Khanal 2003; Huppert 2009; Mukherji *et al.* 2009). Single dimensional interventions such as engineering improvements will not address the complex problems characterizing large-scale irrigation systems.

Despite the massive investments of the past, low water productivity, poor maintenance, unreliable water supplies, and the financial burden of subsidized operations and maintenance on governments continue to be major problems. The area irrigated by these systems, especially in South Asia, has actually been declining. India and Pakistan alone lost some 5.5 million ha in recent decades (Mukherji *et al.* 2009) as a result of poor maintenance and salinization. There is substantial scope to improve the performance of these systems, building on past investments, for example by establishing service-oriented water control services for farmers to meet changing demands.

In response to the failure of previous technical rehabilitation programmes, programmes like Participatory Irrigation Management (PIM) and Irrigation Management Transfer (IMT) were initiated in the late 1980s. IMT programmes have dominated surface irrigation interventions until recently. IMT was a response to the neoliberal policies of the 1990s, but was also encouraged by apparently successful cases of farmer-managed irrigation systems (FMIS, Khanal 2003) as found in several Asian countries (e.g. Nepal, Sri Lanka, the Philippines and India). The results of IMT have been mixed, at best. A major weakness was that it was seen as a new way to justify more funding for rehabilitation, and many countries failed to implement the broader policy and institutional reforms required to support the process. Participation and governance reforms remained largely cosmetic, while investments continued to emphasize conventional technical rehabilitation (Merrey *et al.* 2007).

IMT interventions could still be an important component of programmes to improve the performance of irrigation systems. However, important changes are needed, building on the lessons learned from previous interventions. At the same time, as argued by Mukherji *et al.* (2009), it is also essential to move beyond such conventional recipes to look for better options that address current and future needs. In recent years, public private partnerships (PPPs) are being considered in response to the disappointing outcomes of past approaches. PPPs are relatively new in the irrigation sector of most Asian countries but have been practised in China and advocated for India (e.g. ADB 2011b). The Asian Development Bank is considering the approach in its upcoming surface irrigation management project, Bangladesh Irrigation Management Improvement Investment Program (ADB 2013b).

The main constraints in implementing irrigation policy reforms like PPP and IMT are both technical and political. Most Asian irrigation systems are upstream-control supply-driven systems delivering water to numerous small-scale plots owned by individual farmers. This makes it extremely difficult to provide quality irrigation service at the individual farm level. In addition, the political nature of irrigation service fees makes it difficult to implement cost recovery. Powerful vested interests often resist major institutional reforms. Irrigation problems therefore need to be addressed following a comprehensive sociotechnical approach supported by a strong political commitment.

Another critical issue for implementing future interventions in large-scale systems is the capacity of irrigation professionals to transform emerging concepts and ideas into practical reality. There is a wide gap between theory and practice and knowledge and action. While understanding in the field of water resources has improved on both the technology and resource management dimensions in the last two decades, project design and implementation have remained largely conventional, with only cosmetic attention to participatory approaches to satisfy donor needs. There is therefore an urgent need for capacity development among water professionals to design and implement future programmes.

Two factors are of critical importance in enhancing capacity in the water sector. First, the emerging ideas and concepts of water resource management must be made part of university teaching. Water and irrigation are still taught from a conventional development-oriented engineering perspective, whereas the current water problems largely demand reforms in management. Second, capacity development is a long-term and continuous process and usually falls outside the scope of funding agencies and government budgets. This should be reversed.

New tools and approaches are being developed to support future irrigation modernization programmes. FAO has developed the Mapping System and Services for Canal Operation Techniques (MASSCOTE), which offers a comprehensive methodology for irrigation system modernization using service-oriented management approaches (Renault *et al.* 2007). The tool moves beyond diagnosis, and offers solutions to improve system performance based on the management objective. FAO and the International Congress on Irrigation and Drainage (ICID) are also in the process of establishing centres of excellence in several locations in Asia to train professionals in irrigation modernization through MASSCOTE. More details on the MASSCOTE methodology and case studies are documented at: http://www.fao.org/nr/water/topics_irrig_masscote.html.

Improving FMIS and developing new community-based irrigation schemes

Community-based irrigation schemes are very common in Asia, for example, farmer-managed systems in Nepal, the 'tank' systems in India and Sri Lanka, communal irrigation in the Philippines and the *subak* systems of Bali, Indonesia. These systems, collectively called 'farmer-managed irrigation systems' (FMIS), are known for their longstanding successful traditions of collective action in water management. The designs of the IMT and PIM programmes were inspired by successful FMIS cases and their underlying principles. Modernization of existing FMIS schemes as well as development of new community-managed systems, are still priority water interventions in many of Asia's livelihood systems. They need to adapt to new stresses threatening their water and crop systems – climate change, population pressures and the unintended effects of globalization – as well as to new market opportunities.

A variety of 'participatory' approaches were initiated in the 1980s and 1990s to revitalize FMIS. Though termed participatory, these programmes often involved farmers participating in a government-led project rather than being based on the user community's priorities. Such top-down programmes therefore disrupted the existing local institutional arrangements for operation and maintenance, and in many cases increased farmers' dependence on government support. In general, there is now greater awareness among governments and financing agencies that institutional strengthening should be the focus, and the technical improvement process should be designed to facilitate institutional innovation, rather than institutions being created to support the technical rehabilitation processes.

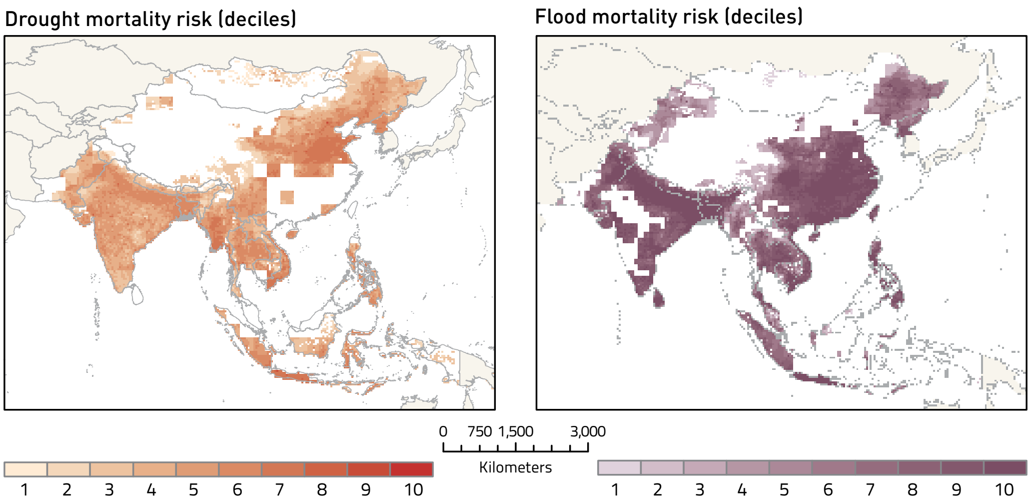
FMIS still cover large areas in Asia, and remain one of the key priority sectors in the rural development agendas of major donor agencies. Interventions in such schemes are well-researched and documented; therefore there is no need to repeat their findings (e.g. Yoder and Thurston 1990; Vincent 2001; Ostrom *et al.* 2011). Considering the changing rural context, these programmes should, however, broaden their focus to include new development objectives of growth, equity and sustainability while facilitating ongoing diversification and commercialization processes. Addressing the problems of FMIS in a broader agro-ecological or 'landscape' perspective offers one way of reconciling the competing demands on water and land resources (Sayer *et al.* 2013).

Addressing water vulnerabilities

Floods and droughts are the most common types of natural disaster globally, and management of both are aspects of water management. Floods have been among the most costly disasters in terms of both property damage and human casualties; they represent more than 70 percent of the natural disasters in the world. Floods are natural phenomena which cannot be prevented, but human activities including changes in land-use management practices and global changes like climate change are contributing to an increase in the likelihood and adverse impacts of flood events. While flood interventions are usually capital intensive, involving both hard and software measures, interventions responding to drought are more management-oriented. Appropriate interventions to cope with both floods and droughts are essential to protect rural livelihoods.

The flood and drought mortality risk in Asia are shown in Figure 4.4. They suggest that flood risk is much higher than drought risk in Asia. Most parts of the region are affected by both floods and droughts, and even areas having high average rainfall often have moderate drought risks. Erratic rainfall and dependence on rainfed farming are the main reason for drought vulnerability. Given the high vulnerability to both floods and droughts, large parts of Asia need investments in improved agricultural water management options to ensure rural livelihoods.

FIGURE 4.4 AREAS WITH DROUGHT (A) AND FLOOD VULNERABILITY (B)



Source: CIESIN (2008).

A flood management strategy that is appropriate in the context of one catchment will not be in another catchment. Past approaches to flood management were more adaptive, i.e. simply living with floods. As human activity has intensified along river banks and in deltas, hard core engineering measures have been adopted to protect life and property. Experience has shown that they often have limitations, and more holistic flood management approaches are needed. Emerging holistic flood control measures include management solutions combining both hardware (engineering) and soft methods and recognize the importance of the 'go with nature' concept of the past. In the modern era where many of the urban centres and economic hubs of Asia are on the banks of major river systems, the application of hard core engineering measures is needed and justified in many instances.

Engineering approaches to flood control involve physical measures like channel modifications, retention ponds, levees, dykes, spurs and floodways. These measures have been debated on several grounds in recent years, but they are still the most effective flood control measures in many cases, especially in high-value economic zones. For example, Bangkok generates more than 45 percent of Thailand's GDP; the economic activities in such zones need to be protected. Engineering approaches are therefore relevant in the Asian urban centres prone to flooding. But where feasible, they should be combined with non-physical measures.

In recent years, biogeomorphological measures have been advocated for flood control in rural areas, in line with the go with nature concept. It is a relatively new discipline within the study of water systems, and combines ecology and geomorphology. Though appealing to environmentalists, this is not always a welcome response locally when peoples' lives and property are in immediate danger from floods. However, it offers a more stable solution in the longer term and is more effective when combined with other appropriate interventions like levees and dykes. These interventions are most appropriate in unstable geological terrains, and are thus more relevant to upland rainfed (humid tropics), rainfed humid tropics and high mountain agricultural livelihood zones.

Management of catchments, especially upper catchments, plays a crucial role in river morphology and flood management. It is part of a 'natural flood management' (NFM) approach aimed at reducing runoff rates in the uplands and reducing rates of flow in watercourses. Johnson (2008) advocated the following techniques:

- Reforestation of hill slopes;
- Planting dense woodlands in gullies;
- Blocking artificial drains;
- Restoring wetlands;
- Restoring river channel meanders;
- Controlling excessive erosion; and
- Managing large woody debris in watercourses.

These techniques use natural processes and are relatively low cost compared with engineered techniques. Some techniques such as blocking drains have an immediate effect while others such as woodland restoration take years to become effective. Therefore it is not just about the spatial distribution of NFM techniques but considering their short- and long-term effectiveness, i.e. developing a menu of measures. These tools are more applicable to upper catchments and to small and medium river systems which are part of the large river systems: upland rainfed systems, high mountain agricultural systems and rangeland systems.

The aforesaid methods of flood control and management are physical measures. Equally important in flood management are soft measures like information management systems or early warning systems. Timely information on rain and flooding patterns can help mitigate their adverse effects. They may include real time flood prediction and information dissemination to the people likely to be affected. The current trends in floods combined with the likely impacts of climate change indicate that the lowland rainfed rice-based systems, rice-based irrigated systems, rice-wheat surface irrigation (humid) systems and wheat-rice surface irrigation (dry) systems are likely to be more affected by flood damage and hence need sound flood management plans combined with early warning systems. These areas are mostly located in the Indo-Gangetic Basin, Mekong Delta, lower end of the Yangtze Basin and the Yellow River (Huang He) Basin.

The impacts of droughts are realized over a longer term and are less devastating to infrastructure compared to flood damage. But they can be devastating in human terms if mitigation and adaptation measures are not properly planned. Like flood control measures, drought management strategies also involve prevention, protection and preparedness. The first two are part of wider water management intervention; many of the interventions discussed in this chapter will contribute to building resilience against the impact of droughts. Past trends and expected climate change scenarios indicate that groundwater irrigation livelihood zones (Western India) and the rice- and wheat-based livelihood zones in South and Southeast Asia will be most impacted by drought and need appropriate strategies, including water storage measures.

Enhancing water storage

Most agriculture-based livelihood systems, both irrigated and rainfed, are vulnerable to moderate drought, largely due to temporal variations in rainfall. This highlights the need for increased water storage. Increased storage is essential to manage the stress resulting from rainfall runoff variability as well as for climate change adaption. The type and nature of such storage facilities, however, depend on the nature of rainfall, agriculture and water demand scenarios, including from other sectors. They may involve various options: construction of dams, aquifer recharge and non-conventional storage as explained earlier in this chapter.

Dams have traditionally been the primary means of water storage, and once were a symbol of modernization in Asia. The late Indian Prime Minister Jawaharlal Nehru once famously said dams are the temples of modern India. While the western world, especially the United States, aggressively invested in dams in the previous century, the process began slowly in Asia. The construction of new dams again decelerated during the 1990s, largely on environmental and social grounds. Another reason for this slowdown is that the most favourable sites have already been developed. Construction of new dams now involves complex issues and needs to be justified in economic, environmental and social terms. Nevertheless, there is a strong argument for the critical importance of water storage as a foundation for water security and long-term economic growth (Grey and Sadoff 2007).

There are still potential sites for development of dams, especially in South Asia. Recent studies have justified both their need and potential. According to a World Bank study (Briscoe and Malik 2006), the Himalayan region offers one of the world's "most benign environments" for dam building. This observation is based on claims that there are fewer social and environmental impact issues (resettlement issues, lower submergence area, etc.) to deal with. South Asia's per capital water storage is the lowest in the region, and its hydrological pattern demands more storage: in India, half the annual rainfall comes in 15 days and 90 percent of total river flow comes during just four months. Yet India has built only a fifth as much water storage capacity per capita as China (and about 4 percent as much as the United States or Australia; Pomeranz, no date). While dams are still options for increased water storage, they must be carefully assessed from economic, environmental and social perspectives, including alternative options where feasible.

In addition to water storage through dams, there are also two more approaches to enhance storage: groundwater recharge and non-conventional storage methods. Invisible underground storage through increased recharge offers several advantages over more visible surface reservoirs: lower evaporation losses, no land submergence and a large storage potential. Assuming that 20 percent of the global land area is underlain by aquifers that are pumped during the dry season with an average seasonal groundwater level fluctuation of 1 metre, this natural storage capacity is on the order of 3 000 km^3 per year. This is about the same order of magnitude as the actual annual withdrawal from all major dams on earth (Tuinhof and Heederik 2003). Likewise, it is believed that 1 metre of additional groundwater recharge in the Gangetic plains will store more water than the entire reservoir storage potential of Nepal! In recent times, the concept of groundwater banking (Christian-Smith 2011) has been also promoted as a valuable management tool to better coordinate ground and surface water management.

Localized community-based water harvesting and small-scale storage offers another way to increase water storage (McCartney *et al.* 2013). Small-scale storage offers the benefit of more local control and fewer externalities in terms of submerged area or other environmental impacts. Surface impoundments (farm ponds) and small water harvesting works all have significant potential to help increase yields and productivity through supplemental irrigation and extending the growing season. Improved water control may also be achieved through methods that focus on the control of evaporation, such as conservation farming, drip irrigation, furrowing and levelling of fields. These methods are often the most economical. The importance of such non-conventional storage schemes is demonstrated by the success of water harvesting in India (Box 4.2).

Delta and lowland water management

The data on poverty and livelihoods in chapter 3 clearly show that rainfed lowland rice systems predominate in areas of greatest poverty in South Asia and parts of Southeast Asia, largely due to their difficult water environments. The uncertainty of occurrence, duration and amount of rainfall substantially affects the productivity of the rainfed lowland rice ecosystem. According to the International Rice Research Institute (IRRI), about 60 million ha of rainfed lowlands supply about 20 percent of the world's rice production.[11] Some 27 million ha of rainfed rice are frequently affected by drought. Up to 20 million ha may suffer from uncontrolled flooding, ranging from flash floods of relatively short duration to deep water areas that may be submerged under more than 100 cm of water for a few months. Further constraints arise from the widespread incidence of problem soils with poor physical and chemical properties. Salinity is widespread in coastal areas.

Different varieties of rice are cultivated depending largely on the water environment and land topography, and are subjected to flooding at least over part of the cropping season. All fields are exposed to drought and floods; however, delta areas near the river mouth often experience prolonged periods of flooding. In such areas, deep water rice varieties are sown, which grow rapidly as the floodwater rises, and are harvested after the water recedes. In many areas, a late dry season flood recession rice variety is cultivated. Because the environments are so difficult and yields so unreliable, farmers rarely apply fertilizer and tend not to grow improved varieties. Thus, yields are very low (1-2.5 t/ha) and farm families remain trapped in poverty (ibid).

[11] http://zaraimedia.com/2013/04/07/international-rice-research-instituteirri/, accessed 16 January 2014.

BOX 4.2
Water harvesting in India

In one area of Madhya Pradesh, the Collector had a dream. It was a simple idea but within a year it had proved to be very effective. He suggested farmers give over a tenth of their land to build a pond which would capture the water in the rainy season and save it for the dry one.

Those who took up the plan benefited almost immediately. Now they can grow crops in both seasons and are seeing good returns for their investment. Such schemes are rising all over India though many farmers remain reluctant to develop ponds on their precious land and cannot afford the structure. Farmers need financial and technical support to overcome these hurdles.

Source : http://awm-solutions.iwmi.org/Data/Sites/3/Documents/PDF/publication-outputs/learning-and-discussion-briefs/rainwaterharvestingindia.pdf

In West Bengal, the Mahatma Gandhi National Rural Employment Guarantee Scheme is being used to build hapas – small reservoirs to store rainwater. They have contributed to improved livelihoods.

Source : http://awm-solutions.iwmi.org/Data/Sites/3/Documents/PDF/rainwater-harvesting-in-west-bengal.pdf

Past approaches to water interventions in these areas were largely engineering solutions, i.e. construction of dykes, embankments, tidal sluices and polders. While they help secure rice farming in many instances, they have also led to widespread damage verging on extinction of the wetland ecology and resources. This has had significant negative impacts on the livelihoods of the people dependent on these resources. In addition, they were targeted for monorice-based agriculture. Future water interventions should therefore seek better alternatives, recognize the diversity of production systems that preserve the ecological environment, enhance water productivity and allow the poor to pursue multiple livelihood strategies.

The types and nature of interventions will differ according to the topography and water environment. In areas with low to medium water depths which are also subjected to drought, low-level water retention embankments with appropriate irrigation networks are useful. The reservoir created counters the temporal variation in rainfall and provides regulated water to the fields downstream. In most cases, the reservoir area is also cultivated, with flood recession rice varieties. This approach has been practised by local communities in Cambodia for many years.

Interventions that promote polyculture (multiple crops in the same space) and diversification are another option. Small-scale irrigation works can be integrated with fish refuge ponds. In FAO's food facility project in Cambodia, all irrigation works also involved construction of such ponds which provided shelter for fish during the dry seasons. Approaches that promote shrimp-rice and fish systems, shrimp and crabs (for the delta) or rice-fish in lowland systems have proven promising (Ni *et al.* 2010). Likewise, considerable opportunities exist for the diversification of rice-based systems in saline coastal areas (Singh *et al.* 2010) and rice and legume or maize systems in non-saline zones.

Most of these systems are characterized by either too much water during the wet season to add non-rice crops into the 'bunded' and anaerobic rice fields, or too little for planting non-rice crops to follow late-maturing rice varieties. Atomistic irrigation therefore offers high potential in these areas for several reasons. First, they are less affected by the impacts of cyclones or other forms of water-related disasters. Vast expanses in these systems are exposed to cyclones and river flooding, and traditional surface schemes are prone to damage from these events. Second, they provide irrigation in the dry season and facilitate crop diversification. Third, in addition to utilizing shallow aquifers, these areas contain numerous small-scale surface waterbodies and therefore provide favourable environments for pump irrigation. Crop diversification and *boro* (winter dry season) rice expansion in Bangladesh has been largely possible due to the expansion of atomistic irrigation.

Livestock-water interventions

Livestock-water interventions have received less attention by researchers than crop water requirements. Livestock drinking water needs are a fraction, perhaps 2 percent, of the water needed to produce feed and fodder. Livestock production therefore is strongly embedded in the crop production system, and livestock water management mostly is a component of generic agriculture water management practices (Peden *et al.* 2007).

There are several ways water is utilized in feed and forage production. A large portion of the water used is environmentally insignificant, with little or no opportunity costs. This includes evapotranspiration by grazing lands, and is lost if not used. Use of crop residues as fodder also does not 'cost' additional water – indeed it may increase the overall water productivity of crops. It is only intensive production systems that consume valuable irrigation water to produce coarse grains and oil crops as fodder where livestock water productivity is a critical issue. However, in such systems, a large part of the water requirement may be compensated by using virtual water to manage the spatial distribution of feed resources. Considering all these factors, water consumed by the livestock sector is well below that consumed by the crop sector. The share of irrigation water in feed production is estimated by FAO (2006) to be around 6 to 7 percent in East and Southeast Asia and 16 to 18 percent in South Asia. However, the Comprehensive Assessment of Water Management in Agriculture cautions that too little is known about livestock water productivity to make firm estimates (Peden *et al.* 2007).

Water interventions for livestock production are therefore diverse and complex. The primary focus is to improve livestock water productivity (defined as the ratio of net beneficial livestock-related products to water depleted in the process). This involves a range of activities linked to crop, water and livestock management practices. The potential to improve livestock water productivity ranges from 4 to 94 percent, depending on the agro-ecological system (Descheemaeker *et al.* 2010). There are many ways in which livestock affect water productivity across a landscape, but the two most important areas are through the feed they consume, and the damage they can potentially cause to a landscape's hydrology (Amede *et al.* 2009). Accordingly, the following options can be adopted for livestock sector water interventions:

Integrated management of grazing lands. The key actions involve rainwater management through various forms of intermediate water control. The aim is to capture, store and efficiently use water and nutrients on pasturelands, farms and watersheds. Options may include improved conservation practices like rotational grazing and introducing community-based pasture management practices. Encouraging such changes requires clear policies and a regulatory framework on land tenure and user rights of the pastureland, especially targeting the poor and landless people. These options are most relevant to pastoral-based and sparse land livelihood systems.

Improving water productivity in feed production. Water use in livestock production will continue to be strongly dominated by the intensive livestock sector through the production of feed crops, mainly coarse grains like barley, maize, wheat, sorghum and protein-rich oil crops. The options here are therefore similar to those of generic agriculture water interventions. This is most relevant to the intensive irrigated production systems.

Increasing use of crop residues. There is considerable scope for increasing water productivity by making better use of crop residues for feeding livestock. Crop improvement programmes need to include traits that increase the nutritive value of crop residues. Investment in technologies, such as second-generation biofuel technology, can also lead to large increases in the amount of animal feed available by breaking down lignin to digestible compounds (Wright 2010). This option is relevant for rainfed extensive production systems as well as intensive irrigated systems.

Enhancing animal productivity. There is a large 'yield gap', i.e. difference between potential and actual levels of productivity, in most livestock systems in developing countries. Narrowing this yield gap to produce greater animal outputs with the same feed and water will result in higher water productivity. This involves measures that increase productivity through better feeding, nutrition, breeding or improved animal health leading to lower mortality rates. The objective is to produce higher outputs (milk, meat or poultry products as the case may be) per animal. This applies to all the livelihood systems.

Protecting the water environment. Water pollution, especially from animal waste, is a growing concern, in both industrialized and intensive livestock-crop production systems. Poor management of the waste results in depletion of available water resources. A sound waste management strategy, especially in intensive production systems, involves employing effective management techniques at all stages: production, collection, storage, processing and utilization.

Water management for aquaculture and fisheries

Fisheries are one of the most important sectors in the rural economy; it is the only sector that provides opportunities for open access livelihoods for the rural poor and ultra-poor. In some countries, it accounts for a large share of agricultural GDP. For example, in Bangladesh fisheries contribute up to 21 percent of agricultural GDP and provide employment to 12.5 million people, most of whom are poor. It therefore contributes substantially to poverty reduction (Mustafa *et al.*

2010). Fisheries play an important role in many Southeast Asian countries, for example Cambodia, Viet Nam and Myanmar. The demand for aquatic products is rapidly rising, especially in Asia, as discussed in chapter 2.

With the demand for aquatic products growing rapidly, the only option available to meet this demand is through aquaculture. There are few opportunities to increase the catch from the sea. The freshwater catch prognosis is no better, as many inland waterbodies have already been overexploited. Though Asia is still experiencing nominal increases in capture fish due to the increase in fishing effort, the expansion of the geographical range of fishing activities and the increase in overall biomass (for example by removing larger, longer-lived species and achieving a higher biomass by encouraging shorter-lived, small, fast-reproducing species; see Funge-Smith *et al.* 2012), the scope for expansion is very limited. This means that most of the future demand for aquatic products must come from aquaculture. This will have important implications for freshwater resource management.

Aquaculture is already one of the fastest growing sectors in Asia: India has experienced about a six-and-a-half-fold growth over the last two decade, with freshwater aquaculture contributing to 95 percent (Sharma *et al.* 2013); and China showed even faster growth until the beginning of this century. In 2010, the Asia and Pacific region produced 53.1 million tonnes of aquaculture products (excluding aquatic plants). This accounts for 89 percent of the global aquaculture production of 59.9 million tonnes (Funge-Smith *et al.* 2012). The region's production grew by 6.5 percent per year between 2000 and 2010. In terms of value, the region's share amounts to some US$95.2 billion (growing by 10.5 percent annually since 2000). This value accounted for 80 percent of the total value of global aquaculture, which was US$119.6 billion in 2010. Eight out of 10 leading aquacultural nations are in Asia (ibid).

Water interventions in fish production broadly fall into two categories. The first is to better manage the water environment for sustainable production of inland capture fish. The second focuses on water management in freshwater aquaculture ponds. Several options are discussed below.

Enhancing aquatic ecosystem services. The objective is to increase the water flow and flushing conditions to restore waterbodies through interventions such as re-excavation of ponds and establishing fish sanctuaries and fish refuge ponds. In addition, more attention should be given to allowing free passage for fish and migration when constructing hydraulic structures. Possible measures include provision of fish ladders in the construction of river diversion structures and provision of adequate sluice gates in polders for access to fish migration. Hydraulic structure design should consider the nature of the aquatic environment.

Protect fishing rights of poor farmers. According to FAO (2005), small-scale fisheries account for almost two-thirds of the total fishers/fish farmers. Fishing and the fishing trade, especially at local levels, have been a safety net for the rural poor. FAO further argues that from a poverty prevention point of view, it is important to realize that open access is the key mechanism which permits the 'safety valve' function of fisheries to operate and allows people to engage, temporarily or permanently, in the sector. Fishing rights of the rural poor, particularly those engaged in subsistence, small-scale and artisanal fisheries must therefore be clearly defined and protected. A recent field study in the Northeast Region of Bangladesh shows that many poor farmers have lost their fishing rights due to a poor regulatory framework and are trapped in poverty (CEGIS 2013).

Future intervention should therefore examine how to exploit fisheries resources to support rural fishers and conserve the resources for use by future generations. In this direction, community-based ecosystem approaches to management of local waterbodies have been very successful in many parts of Asia (Islam and Yew 2013; FAO 2005). Such approaches ensure participation of the local fishers and protect their rights while also facilitating sustainable management of the waterbodies. Community-based water-sharing systems need to be considered as a basis for far reaching benefits to achieve agricultural and fisheries water productivity.

Promotion of polyculture. In lowland rice based systems, polyculture offers another option to increase water productivity as already discussed earlier in this chapter.

Freshwater aquaculture ponds. Pond-based freshwater production systems are of prime importance as they consume valuable freshwater resources. This is water intensive, requiring much more water than conventional crop-based agriculture. Up to three-quarters of this water is associated with evaporation, seepage and water exchange loss. Seepage and water exchange losses recharge the groundwater, and if treated and recycled, the water used in aquaculture can be reduced significantly. A further reduction in freshwater use is possible through development of intensive and superintensive cultural systems and aqua-feeds (Sharma *et al.* 2013).

The issue in both livestock water management and fisheries is not so much their consumption of freshwater resources, as a large part of this comes from existing ecosystem services, and in many cases (especially the pasture and grazing land) is environmentally insignificant or has low opportunity costs. The real issue is accounting for this consumption in future water management plans, because of the increasing share of aquaculture in agriculture and the strong links to environmental water management. Most often livestock and aquaculture do not require any new water infrastructures, and could be well integrated through designing water control systems as multipurpose-use systems.

Climate change considerations

Future climate change impacts will be most immediately felt through direct impacts on water resources. They are expected to affect agriculture by altering both the supply of and demand for water resources and through more extreme events like floods and droughts. The worst scenario would be that of increased demand and reduced supply. The way water is managed and utilized will largely determine the nature and pattern of future production risks. Suitable adaptation strategies are urgently needed to minimize production risks, environmental sustainability and livelihood diversification.

Water-related climate adaptation measures include both hardware and software measures. The hardware measures, mostly targeted at supply enhancement, are infrastructure-based, e.g. dams, water transfers, new tubewells and flood levees. The soft solutions are directed at demand management, including ecosystem-based measures. The choice of options depends on how different livelihood systems are going to be affected and may involve combinations of several measures, both hard and soft. The relevance of different water intervention options described in previous sections will therefore depend on the nature of climate change impacts and the livelihood context. FAO (2011c) has developed a risk typology based on the importance of irrigation and other forms of agricultural water management that will be impacted by climate change. Those applicable to Asia include:

1. Large surface irrigation systems fed by glaciers and snowmelt (notably northern India and China) may see a decline in water supply;

2. Large deltas may be submerged by rising sea levels and will be increasingly prone to flood and storm (cyclone) damage or experience salinity intrusion through surface and groundwater;

3. Surface and groundwater systems in arid and semi-arid areas, where rainfall will decrease and become more variable; and

4. Humid tropics with seasonal storage systems in monsoon regions, where the proportion of storage yield will decline but peak flood flows are likely to increase.

The aforesaid agricultural systems closely represent the rice and rice-wheat-based irrigation systems, lowland rice based systems, rainfed (dry and humid tropic) and groundwater-based systems (see Figure 3.3). Building on this typology, Table 4.3 summarizes options for water interventions to adapt to climate change. The table lists only those livelihood systems where agricultural water management is highly vulnerable to climate change impacts.

Contextualizing interventions

The relevance of intervention options described in the previous sections depends on the livelihood context, as summarized in Table 4.4. Given the scale of analysis in this study, these interventions can be fully contextualized only after detailed analysis of specific sociopolitical and agro-ecological situations. The suggestions here offer only broad guidance. In many livelihood systems, the potential for water interventions is still high, but they should also consider complementary non-agricultural options because of the high concentration of rural population and small landholdings. Table 4.4 matches the priority water interventions discussed in chapter 3 with the type and nature of water intervention options discussed in this chapter. It presents options for water interventions for each livelihood system. As the priorities may vary across the region even within the same livelihood context, the options are discussed separately for each major region: South Asia, Southeast Asia and East Asia.

TABLE 4.3 OPTIONS FOR CLIMATE CHANGE ADAPTATION IN HIGHLY VULNERABLE LIVELIHOOD SYSTEMS

Systems	River basin/ geographic area	Climate change drivers	Adapt-ability	Response options
Rice or rice-wheat-based surface irrigation	Large surface irrigation systems fed by glaciers and snowmelt such as those found in the Indo-Gangetic Basin, Mekong Basin and north China	Increased flow for a few decades followed by reduction in surface and groundwater, changes in runoff and peak flow	Low to medium	Increase water storage, demand management, groundwater management, drought and flood management
Rainfed low land rice-based systems	Mekong, Ganges and Brahamaputra deltas; lowland rice farming in these basins in South and Southeast Asia	Flooding, salinity (in coastal areas) damage to infrastructure, expected increase in groundwater recharge	Medium to high	Flood management, conjunctive use, atomistic irrigation, small-scale irrigation
Rainfed dry tropics and subtropics; humid subtropics	Central Indian Plateau, northeast India, north central part of Southeast Asia	Increased drought and flooding	Medium	Increase storage in Indian subcontinent, groundwater recharge and atomistic irrigation
Cereal-based (rainfed)	Eastern China	Variable rainfall, drought, flooding	Medium	Groundwater recharge, drought management
Groundwater-based systems	Western India, northeast China	Increased incidence of drought	Medium	Groundwater interventions, participatory management

Source: adapted from FAO 2011c.

TABLE 4.4 MATCHING INTERVENTION OPTIONS WITH LIVELIHOOD CONTEXT

Livelihood system	Region	Rural poverty context	Potential/ water con-straints	Water as a limiting factor	Suggested options	Priority/ impact	Need to invest in non-farm sector	Typology of main benefi-ciaries
Groundwater irrigation (dry)	East Asia	Moderate	Water scarcity; low-moderate	High	Conjunctive use, GW* regulatory intervention, GW storage	Low	Low	MF, SFC
	South Asia	High	Low	High	GW regulatory interventions, storage, watershed management and harvesting	Moderate to high	High	LF, MF, SFC
Rice/wheat groundwater irrigation (humid tropics)	East Asia	Low	Low	Low	GW management options	Low to moderate	Low	LF, MF
	South Asia	High	Water scarcity, low-moderate	High	GW regulatory interventions, CBGM, conjunctive uses,	High	High	LF, MF, SFC

4

Livelihood system	Region	Rural poverty context	Potential/ water con-straints	Water as a limiting factor	Suggested options	Priority/ impact	Need to invest in non-farm sector	Typology of main benefi-ciaries
Rice-based surface irrigation (humid tropics)	East Asia	Low to moderate	High	Moderate	Irrigation modernization	Low to moderate	Low	LF, MF, DF, SFC
	South Asia	High	Low	High	Irrigation modernization, flood control options conjunc-tive uses, community-based schemes	High	High prior-ity for non-farm sector	LF, MF, DF, SFC
	Southeast Asia	High	Moderate	High	Irrigation modernization	High	High	LF, MF, DF, SFC
Wheat/rice surface irrigation (dry)	East Asia	Low to moderate	Moderate to high	Moderate	Irrigation modernization, drought management interventions	Moderate	Low-moderate	LF, MF, DF, SFC
	South Asia	High	Water scarcity,	High	Irrigation modernization, conjunctive uses, storage	High	High	LF, MF, DF, SFC
	Southeast Asia	Low	High	Low	Community-based schemes, atomistic irriga-tion	Low	Low	LF, DF,
Forest-based	East Asia	Low	High	Low	Watershed management, NC irrigation technology	Low	Low	LF, DF, MF
	South Asia	Low-moderate	Moderate	Low	Watershed management, NC irrigation technology	Low	Moderate-high	LF, DF, MF
	Southeast Asia	High	High	Low	Watershed management, NC irrigation technology	Low	High	LF, MF, DF
Rangeland /pastoral areas	East Asia	Moderate	Low	High	Soil water management	Low	Low	DF
	South Asia	Moderate	Low	Low	(1) Soil moisture management; (2) Livestock watering	Low	Low	DF
	Southeast Asia	Low	High	Low	WSM	Low	Low	DF

Livelihood system	Region	Rural poverty context	Potential/ water con-straints	Water as a limiting factor	Suggested options	Priority/ impact	Need to invest in non-farm sector	Typology of main benefi-ciaries
Sparse	East Asia	Low	Low	High	Soil moisture management, in situ harvesting	Low	Low to moderate	DF
	South Asia	Moderate	Low	Low	Soil moisture management, in situ harvesting	Low	Low	DF
	Southeast Asia	Moderate	High	Low	Soil moisture management, in situ harvesting	Low	Low	DF
Cereal-based rainfed (temperate)	East Asia	Low	Low	High	Community-based schemes, MUS	Low to moderate	Low to moderate	SFS, DF
Highland mountain agriculture	East Asia	Low-moderate	High	Low-moderate	NCs, com-munity-based schemes, WSM	Low to moderate	Low to moderate	SFS, DF
	South Asia	High	Low-mod-erate	Low-moderate	NC, WSM	Low to moderate	Moderate to high	SFS, DF
	Southeast Asia	Low-moderate	High	Moderate	NC, WSM	Low to moderate	Moderate to high	SFS, DF
Lowland rice-based rainfed (humid tropics)	East Asia	Low	Moderate	Low	Atomistic irrigation, polyculture	Moderate	Low	DF
	South Asia	High	High	Moderate	Atomistic irrigation, flood management	High	High	SSF, DF
	Southeast Asia	High	High	High	Atomistic irrigation, polyculture, flood management	High	High	SSF
Rainfed (dry tropics and subtropics)	East Asia	Low	Low	Moderate	NC WSM	Low	Low	DF
	South Asia	High	Low	Moderate	NC, WSM, atomistic irrigation	Low-moderate	High	SFS, DF
	Southeast Asia	Low-moderate	High	Low	WSM, NC	Low	Low	DF
Rainfed (humid sub-tropics)	East Asia	Low to moderate	Moderate	High	CBIS, atomistic irrigation	Moderate	Moderate	DF
	South Asia	High	Moderate-high	Moderate	CBIS, atomistic irrigation, NC	High-moderate	High	SFS, SFC, DF
	Southeast Asia	Low-mod-erate	Moderate	Moderate	CBIS, atomistic irrigation	Low to moderate	High	DF, SFS

4

Livelihood system	Region	Rural poverty context	Potential/ water con-straints	Water as a limiting factor	Suggested options	Priority/ impact	Need to invest in non-farm sector	Typology of main benefi-ciaries
Tree crops and mosaic agriculture-forest	East Asia	Low	High	Low-moderate	WSM, NC irrigation	Low	Low	DF, SF
	South Asia	High	High	High-moderate	WSM, NC irrigation tech	High-moderate	High	LF. DF, SFC
	Southeast Asia	High-moderate	High	Low-moderate	WSM, NC irrigation tech	Low-moderate	High-moderate	LF, DF
Upland rain-fed (humid tropics)	East Asia	Low	Moderate	Moderate	NA	Low	Low	DF
	South Asia	High-moderate	Moderate	Moderate	Water harvesting, community-based schemes, MUS	Moderate	Moderate	DFS
	Southeast Asia	High	High	Low	Water harvest-ing, community-based schemes, MUS	High	High	DF, SFS

Key: LF: large farmer, MF: medium farmer, SFS: small farmer-subsistence; SFC: small farmer-commercial, DF: diversified farmers; WSM: watershed management, NC: non-conventional irrigation technologies, CBIS: community-based irrigation schemes. * GW = groundwater.

Source: This study.

Water intervention priorities are determined by three factors: the extent of poverty, water intervention potential and water as a limiting factor. The *extent of poverty* is assessed through the rural poverty distribution as shown in Figure 3.2 and Table 3.2. The *water intervention potential* is assessed through: the supply context, degree of water vulnerability (based on the likelihood of floods and droughts) and likely climate change impacts and potential for adaptation. The *supply context* is judged through the data and discussion in chapter 3. Other issues are assessed based on the discussion in this chapter (the sections on water environment and on climate change). Water as a limiting factor is assessed largely through professional judgement, considering water dependency in each livelihood context. The extent of cultivation as well as potential will therefore define the extent of water as a limiting factor.

Water as a limiting factor is more visible in some livelihood zones than in others. For example, the rainfed lowland rice-based systems host some of the poorest regions in Asia, largely due to the constraints imposed by the water environment. Low productivity coupled with a high ratio of cultivated area clearly indicates that water interventions have the potential to change rural livelihoods. As the water intervention potential is also high, this area offers a promising context for future water interventions to reduce poverty and hunger and promote rural development. In contrast, people's dependence on agriculture is very limited in forest-based systems, and water therefore is not necessarily a limiting factor, even though there is potential to harness water resources.

Water and poverty situations are assigned high, moderate and low indicators in Table 4.4, depending on the gravity of problems. This means high poverty, high potential for water interventions and high likelihood that water is a limiting factor offer the best scenario for water interventions. Likewise, lower poverty rates, lower potential for water interventions and water as such not being a limiting factor offer a poor scenario for water interventions. Efforts have been made to include the types of farmers who would mostly benefit from the proposed intervention. Generally, it is the small diversified and small subsistence farmers who will benefit most from such interventions. The benefits to landless rural people are indirect and are not included here.

Table 4.4 also suggests additional measures beyond water control. As discussed previously, in many of the livelihood zones, especially the rice-based irrigated and rainfed zones, the depth of poverty is very high. While water interventions play an important role in these areas, high priority should also be given to investments in the non-farm sector, as agriculture alone will not be able to absorb the labour force. The rural farm-non-farm sectors and their integration as 'neo-agriculture' is further discussed in chapter 5.

Finally, the success of any intervention depends on the enabling environment facilitating appropriate targeting, design and actual implementation of rural development programmes. This environment should take into account the institutional arrangements and economic incentives required to initiate and sustain development interventions. In agricultural water management, these may include rural credit markets, input subsidies, land and water rights, social safety nets and other areas discussed in the next section.

Conditions for the success of water interventions

Reducing rural poverty requires an enabling environment and resources. The availability of human, physical, financial, natural and social capitals determines the type and nature of resources and most relevant water investments for each livelihood zone. Markets, land tenure, property rights, water allocation procedures and methods for resolving conflicts over land and water resources have a substantial influence on the motivation, ability and success of smallholders in maximizing the value of investments in the water sector. Human capacities, technologies, physical infrastructure, financial support and input access are fundamental to the success of water development programmes. A few important conditions for success are discussed in the following paragraphs.

Enabling policies

Khan (2001) highlights three major ways in which policies affect the rural poor: *markets*, *infrastructure* (including public services) and *transfers*. Competitive markets, macroeconomic stability and public investment in physical and social infrastructure are widely recognized as important requirements for sustained economic growth and reduced poverty. Infrastructure directly affects the rural sector's productivity and rural poor people's lives. Transfers, both private and public, provide some insurance against anticipated and unanticipated economic shocks. Khan further highlights that these channels – markets, infrastructure and transfers – do not work in the same way for all of the rural poor because each group has quite different links to the economy.

Policies at both macroeconomic and microeconomic levels influence farm-level access to inputs and the ability to sell farm products at prices that provide sufficient revenue to sustain crop production. Where needed, governments must allow the importation of farm inputs and technologies that boost crop production at lower costs than is possible using only domestically-produced inputs or existing production methods. Policies on imports of food and fibre should be carefully reviewed. Causes of increasing food prices should be studied carefully as population as well as economic growth normally create pressures for more food. In most cases, policies that promote investments in local agricultural production will generate greater long-term benefits than efforts to increase imports of lower-cost food products available on the international markets.

The effective operation of markets for food and agricultural products requires:

- Appropriate legal frameworks and efficient institutions to support markets, the enforcement of contracts and property rights;
- Institutional frameworks for monitoring and supporting the emergence of competitive markets, for example by providing market information and advice; and
- Well-operated and well-maintained infrastructure to provide transport and communication networks, postharvest handling and storage, and physical markets.

Public policies should ensure that pricing, taxes and credit markets do not penalize agriculture and encourage or subsidize labour displacement. Past experiences show that rural people have far less access to formal credit programmes due to lack of assets and high borrowing costs; targeted rural credit has largely benefited the non-poor in many cases. More specific community-based targeted credit programmes at reasonable costs can benefit the rural poor.

Rural infrastructure

Infrastructure is the basis for poverty reduction as well as economic growth. According to the Global Poverty Project,[12] it is important not just for the provision of basic services, or for the economy, but also to allow the poorest communities to gain access to a wider array of social services, health care and greater possibilities for livelihoods. Lack of adequate infrastructure perpetuates poverty, as the rural poor cannot make the best use of their resources, including their human capital, if either the quantity or the quality of physical infrastructure like irrigation, transport, storage, electrification and support services (research and extension) is inadequate. In recent years, the importance of digital infrastructure (communication, Internet services) has been rapidly increasing and transforming rural societies.

Postharvest crop losses and waste are major impediments to the global food supply especially in rural areas. Inadequate availability of storage, processing, refrigeration and packaging facilities, and lack of roads and market access are partly responsible for the excessive postharvest losses in many rural areas (up to 30 percent of harvested fruit and vegetables), and limit opportunities for adding value to agricultural products. Especially in situations where there is a food deficit, it is unacceptable to have high postharvest losses. Serious attention should be paid in future to investing in rural infrastructure to minimize postharvest losses.

[12] http://www.globalpovertyproject.com/infobank/infrastructure, accessed 17 January 2014.

Rural electrification is another area that needs more attention. Many rural areas in South Asia do not have access to electricity. For agricultural development, there is a strong debate on the role of rural electrification to improve access to water and contribute to poverty reduction. The impact of rural electrification is usually positive, as demonstrated by the West Bengal case (Box 4.3).

The evolution of Information Communication Technology (ICT) has revolutionized the world and largely been responsible for global economic transformation in recent times. Once considered a luxury, cell phones and Internet access have become almost a necessity, even in rural societies. The Millennium Declaration 2000, a unanimous resolution adopted by the world community against poverty, has also highlighted the importance of ICT for poverty alleviation by making it a part of the Millennium Development Goals (MDGs). The role of ICT is catalytic in the complex task of poverty reduction by leveraging the effects on earning opportunities, educational and health services, good governance and promoting democracy (Viitanen 2005).

There are many examples illustrating the role of ICT in strengthening rural livelihoods, providing market information and lowering transaction costs of poor farmers and traders. The Grameen Bank and Bangladesh Rural Advancement Committee (BRAC) initiatives in Bangladesh

BOX 4.3
Impact of rural electrification

In West Bengal, boro paddy has been declining because farmers face difficulties tapping the groundwater. This is generally not a function of physical scarcity but of high diesel costs and low rates of rural electrification for tubewells. Natural recharge of groundwater supplies is high, yet misconceptions persist and have led to restrictive policies. Carefully crafted revisions to policies governing groundwater and provision of electricity could return West Bengal to the high rates of agricultural production it achieved in the late 1980s and early 1990s.

The State Water Investigation Directorate has already changed a provision of the West Bengal Groundwater Resources Management, Control and Regulation to release some smallholders from the requirements to obtain permits. And the State Electricity Distribution Company now only requires farmers to pay a fixed fee for new connections instead of the full cost of wires, poles and transformers.

Further policy changes could encourage farmers to make efficient use of groundwater, such as strict and intelligent rationing of power supply to farmers in the boro season, and charging farmers a judicious mix of pro-rata and metered tariff.

Providing affordable electrical connections to half a million more electric pumps would allow irrigation of an additional 3.7 million ha of farmland. If only 50 percent of this potential is reached, the irrigated area would increase from 2.98 million ha to 4.83 million ha; 88 percent of the cultivated land.

Source : http://awm-solutions.iwmi.org/Data/Sites/3/Documents/PDF/rainwater-harvesting-in-west-bengal.pdf (http://www.infodev.org/infodev-files/resource/InfodevDocuments_877.pdf), the Gyan Doot Community Network in Madhya Pradesh, India (http://www.gyandoot.nic.in/) and the information access centre project in China (Soriano 2006) are examples. Increasing funding of ICT in rural areas will help narrow the digital gap between rural and urban areas and help reduce rural poverty, if its design, language and pricing are compatible with the needs of rural people.

Land tenure and water rights

The livelihoods of poor rural people critically depend on two key assets: land and water. In general, water rights for agriculture are attached to land rights; hence the two are not independent. A broad-based land reform programme – including land titling, land redistribution and fair and enforceable tenancy contracts – is often critical for reducing rural poverty. It leads to increased investment and contributes to economic growth and more equitable development. It helps reduce uncertainty and increase efficiency in credit and land markets, and smallholders can use their land as collateral for agricultural inputs, improvements, innovations and expansion of their enterprises. Secure access to land is therefore crucial to reducing vulnerability to hunger and poverty in rural areas. As argued in earlier sections, women are more vulnerable to insecure land tenure as their land rights may be obtained through kinship relationships with men or marriage. If these links are severed, women can lose their rights.

Weaker land tenure systems both in South and Southeast Asia have often been considered to be a hindrance in reducing rural poverty. IRIN (2010) stresses that, "Drastic land reforms that give more rights to poor families who labour on others' land are needed in Nepal to stave off hunger among the poorest and boost agricultural production." It goes on to say that agricultural problems will always persist if we do not address the land reform issue seriously. India, Pakistan and Bangladesh as well as Nepal face this challenge (see for example USAID 2010 for Pakistan; Besley *et al.* 2013 for India; and Raihan *et al.* 2009 for Bangladesh). Appropriate land reform to address poverty and hunger has been central to the political agenda since independence in these countries. In South Asia, the problems are also due to a culture of feudalism, poorly enforced land distribution and an informal caste system that has exploited landless tenants.

Disputes over land tenure systems have also emerged in Southeast Asia. The conflicts are largely over commercial interests: land grabs by large-scale plantations for the cultivation and processing of agricultural commodities. These lands are usually occupied by smallholder subsistence farmers. The recent allocation of 280 000 ha for rubber plantations in Lao PDR and Cambodia has received world-wide attention. In Viet Nam, the government owns the land and only use rights are granted for a specified time period. Many South and Southeast Asian countries still lack appropriate land tenure policies and the poor continue to be marginalized in favour of commercial interests. The common features throughout the region are an inadequate legal framework dealing with landownership and occupancy, the dilemma between customary land occupancy and formal landownership, and market forces driving policies in support of large agribusiness and other major development projects on these lands.

Land tenure is a very complex issue and the specific context varies from country to country and perhaps even case-by-case. It is also highly political and contested (Hall 2011). IFAD (2012) stresses that policies and legislation must recognize the many facets of land rights and usage. Poor rural people must be empowered to participate in policy formulation to ensure that their needs and rights are addressed and protected. Securing land rights, however, is complex due to the various forms of tenure systems practised in Asia: formal and informal, statutory and customary, permanent and temporary. Some are legally recognized, others are not. Some involve private ownership; others are based on common property. IFAD therefore recommends that it is often better to strengthen traditional administrative systems than to establish new, formal systems of landownership. This is particularly true of communal and common-property lands, which are very important to the livelihoods of poor rural people.

Water rights for agriculture are usually linked with land rights. Agricultural water management programmes therefore do not directly benefit the rural poor who do not have land access or have nominal landholdings. There are very rare examples where water rights have been granted to landless people who in turn sell or rent their right to the agricultural users, thereby benefiting those who do not own or cultivate land. Examples include the United Mission to Nepal funded the Andhi Khola Irrigation Project in the early 1990s in Western Nepal (van Etten *et al.* 2002) and a case documented in north India at Sukhomajri (Seckler and Joshi 1985). Such efforts should continue so that the most vulnerable people, including women, will benefit from future water intervention programmes; unfortunately there is rarely the political will for expanding such programmes.

Providing targeted subsidies and financial packages

While some of the rural poor may benefit within the context of the new rurality by taking advantage of new opportunities, knowledge and the markets, many are deprived of such benefits. These vulnerable groups are not able to benefit because of knowledge and geographical restrictions. They need, at least in the short term, social safety nets and targeted subsidies on agricultural inputs and rural credit and enhanced market access to mitigate the anticipated adverse short-term effects of change. Financial tools and packages to support water investments in rural areas that cannot otherwise benefit from the new opportunities need to recognize the importance of such subsidies in the short term.

While it is well recognized that long-term poverty reduction is best achieved by sustained and broad-based economic growth and successful structural transformation, a segment of the rural poor is always affected in multiple ways and needs support. This is also well recognized by the financial institutions. For example, the *World development report 2008* (World Bank 2008) acknowledges the importance of well-targeted input subsidies as an element of poverty reduction strategies in rural areas. Social safety nets and targeted subsidies are also part of IMF-supported reform policies to mitigate the anticipated adverse short-term effects on vulnerable population groups.

The issue of agricultural subsidies has always been controversial and problems always plague their implementation (Dorward *et al.* 2008). The main criticisms include: they are not cost effective, they trigger waste and overuse, and they strain public finances. Other problems emerge at local levels: in targeting the poor, inefficiencies in the distribution mechanisms and inequality in distribution due to local power structures. Subsidy policies should therefore be well targeted and designed and implemented with good information and a strong political will to minimize these externalities. The solution is not to have no subsidy, but to target the subsidy as well as possible.

In addition to targeted subsidies, social safety nets and assistance should be available to the very poor, particularly landless (casual) workers and rural women, in the form of public works programmes, microfinance and food subsidies. Recognizing this, India has taken two major policy initiatives in this direction: a recent food security bill ensuring massive food subsidies to the poor, and the rural employment programme which guarantees a minimum of three months of employment to the rural population. The Mahatma Gandhi National Rural Employment Guarantee Scheme has been set up to address chronic rural poverty, and has been effective at developing water-harvesting and storage structures (Verma 2011). Well-targeted subsides for specified time periods for the most vulnerable groups will continue to play important roles in addressing poverty and hunger issues in rural Asia.

Conclusion

This chapter has presented various water intervention options and their relevance to the different livelihood contexts and subregions of Asia. Different groups of farmers have different needs and priorities, and water interventions should be prioritized recognizing the needs of different groups of farmers. There is a high potential for poverty reduction through 'smart' water interventions; water will always be a key resource affecting the livelihoods of rural people, both in terms of basic production assets, and in terms of strengthening resilience and reducing vulnerability to shocks.

Asia now finds itself facing new challenges and opportunities which, if effectively addressed, will enable the region to continue to reduce hunger and malnutrition. Smallholder farmers are the biggest beneficiaries of water interventions which also offer important opportunities for promoting economic and social development. Rural societies are evolving and the dynamics of this evolution need to be understood and internalized in order to design effective poverty reduction programmes. The new dynamism should also look at options beyond water, as the rural non-farm sector is rapidly emerging and shaping rural livelihoods, as discussed in chapter 5.

5. Conclusions: water, agriculture and beyond

Water and rural livelihoods: the new dynamism

Rural livelihoods are in transition, and are evolving in complex ways shaped by both global and local forces. Though rural livelihoods have always been dynamic, the emergence of a 'new rurality' is bringing both opportunities and challenges. Poverty and rural livelihood strategies should not be seen in isolation, but within the context of ongoing socio-economic changes. Future agricultural water management interventions should complement these global dynamics of change by designing effective poverty reduction programmes and protecting and enhancing the livelihoods of the rural poor. As a basic human need, and as a major production factor in rural areas, water has a central role to play in helping rural communities meet new challenges and benefit from new opportunities.

The ongoing trends and transformations in agriculture and in rural livelihoods discussed in chapter 2 and the livelihood contexts and poverty situations discussed in chapter 3 demonstrate that there is a tremendous potential for water interventions to enhance rural livelihoods in Asia. The potential for such interventions in terms of people reached, water mobilized and land productivity enhancement is huge. In total, it is estimated that almost 480 million rural poor people (about 21 percent of the rural population and 72 percent of the total poor of Asia) can benefit from water-related interventions to support their livelihoods. For these people, water is a major factor affecting their livelihoods, both in terms of basic services and in terms of building resilience and reducing vulnerability. Considering the available water supply, about 330 million rural poor can benefit from water interventions aimed at developing additional water resources, while in water-scarce areas about 150 million rural poor cannot be satisfied by the available supply. Indeed, in these areas, water supply cannot be further enhanced, but there is both a need and scope to manage the demand for water in ways that will enable the rural poor to improve their livelihoods.

The type and nature of such interventions depend on the livelihood context. There is a range of possible intervention options that are applicable to specific livelihood systems, as discussed in chapter 4. These intervention options broadly fall into two groups: those targeting the building of communities' resilience against risks and vulnerabilities, and those targeting increased productivity and value of water. They contribute to rural livelihoods in different ways, depending on the poverty-water linkages. The ongoing changes in Asia also have four major implications for water interventions in the future.

First, agricultural changes tend to be reactive in nature. This means agriculture needs to adjust, reform and modify in line with changes in other spheres of the economy. The era of agriculture-led poverty alleviation of the past is gradually transforming to more diversified forms of livelihood strategies. Agriculture still plays crucial roles, but should be seen in the wider context of economic development and has to find new balances between producing food, managing natural resources, promoting growth and providing a livelihood base for the rural population. Future water interventions should accordingly respond and adjust to these changes and redefine its space in the broader context of urbanization, industrialization and environmental concerns.

Second, potential water interventions in Asia will largely be 'management-driven' rather than development-driven both in surface and groundwater schemes. Asia has already developed a large portion of its water resources, and as shown in chapter 3, many of the livelihood systems are based on irrigated agriculture. Achieving sustainable management of water resources and increased productivity of existing systems remains a key priority, not development of new schemes. Though large parts of Asia are not water scarce and physical potential for new development exists in many cases, these options confront environmental, political and economic limitations. Development of large-scale water control systems will therefore be rare in the future.

Possible interventions in groundwater systems are also largely management options. Many groundwater systems are already overstressed and confronted with salinity and other forms of degradation. These stressed systems' problems need to be addressed through better demand management, increased local capacity and appropriate regulation and control, as discussed in chapter 4. New developments in both surface and groundwater are limited and will mostly be targeted at community-based localized systems and individually controlled atomistic (pump) irrigation. The design of these new developments and their expansion will be strongly dictated by management considerations.

Third, Asia must pay greater attention to building resilience against water vulnerabilities and the impacts of climate change. The poor condition of the water environment, continuing water disasters (chapter 2) and the increasing threat of water scarcity and environmental degradation discussed in chapters 3 and 4 justify this. Economic water security in Asia has largely been achieved at the cost of the environment. Environmental water security is low and vulnerability to water disasters rather high. Future economic water security will be threatened unless more attention is paid to managing the water environment.

Fourth, as rural livelihoods transform with changing economic and agricultural conditions, the future will need more demand-based flexible water control systems and multiple-use water services. This means the supply-oriented irrigation systems developed in the past to boost cereal crop production must be modernized to increase water productivity. Expansion of small-scale surface schemes and individually controlled atomistic irrigation will continue where feasible. While the expansion of atomistic irrigation can be largely considered a pro-poor measure, its environmental aspects (especially those pumping groundwater) should be properly regulated for long-term sustainability.

While the dynamics of agriculture and water management and their linkages to rural livelihoods continue to change, poverty and rural livelihood issues have also gradually moved out of the agrarian domain as more diversified livelihood patterns emerge. Diversification has emerged both as a coping and a thriving mechanism (Start and Johnson 2004) – thriving where it is driven by a growing and more flexible economy and 'coping' where diversification is an enforced response to failing agriculture, recession and retrenchment. In both ways, rural diversification will be a key determining factor in future poverty reduction programmes.

Investing in neo-agriculture

The rural economy has already diversified substantially, moving beyond agriculture, which is no longer the primary occupation or income source of most rural inhabitants. Diversification of rural livelihoods is not new; it has always been an appropriate way for rural poor people to adapt and cope with unfavourable conditions. However, diversification has become the dominant household strategy in recent times. For example, the rural non-farm sector has emerged as the largest source of new jobs in the Indian economy: six out of every ten new jobs are in the non-farm sector (Binswanger-Mkhize 2012). Future poverty reduction programmes should therefore look beyond agriculture and focus equally on development of the rural non-farm economy.

Three closely related factors analysed in this study strongly support an increased focus on the rural non-farm economy. First, as discussed in chapter 2, most Asian farmers are now diversified farmers in all three subregions. Several other studies also support this observation (e.g. Reardon *et al.* 2007; Haggblade *et al.* 2009). Reardon *et al.* (2007) found that in 14 rural income surveys in Asia within the period of 1990-2000, the non-farm share of rural income accounted for almost 51 percent of total rural income. The figures are surely much higher currently, given recent economic growth. As Asian economies grow with increased urbanization, farm families will continue to diversify their livelihood strategies in ways that will depend less (or in different ways) on land and water.

The second factor is that the poverty incidence is higher in irrigated and intensively cultivated parts of Asia, as discussed in chapter 3. The high levels of rural poverty are more visible in irrigated livelihood systems and particularly in rice or rice and wheat based systems, which, however, offer one of the best agro-ecological environments for crop production in the world. Around 65 percent of the total rural poor reside in irrigated livelihood system zones. Inequality and competition in land and water access, dense population and lack of investment are some of the contributing factors to this situation. Another reason is that large parts of irrigated livelihood systems are facing water scarcity issues; the demand of more than 70 million rural poor for water interventions cannot be satisfied by the available water supply. This represents 27 percent of the rural poor population's demand and 22 percent of the total rural poor population within irrigated livelihood systems. At the same time, these figures also indicate that labour absorption in agriculture in these areas has nearly reached its limits; absorption of surplus labour elsewhere will be crucial to reduce rural poverty. Non-farm sector growth is therefore crucial to address rural poverty in these areas.

Third, as shown in chapter 4, most of the rural population in Asia is landless and around two-thirds of those who do own land have holdings of less than 0.4 ha, enough to sustain households only for a few months. These groups depend heavily on non-farm income for their survival. According to Haggblade *et al.* (2009), non-farm sector income accounts for about 50 percent of rural income in Asia. Non-farm income sources are also important for other agriculture-based households to diversify risks and ensure income stability.

The growth in the non-farm sector in the past was largely led by agriculture, especially in the postgreen revolution era when rapid agricultural growth provided a powerful motor for stimulating the non-farm sector. However, the evolution of the new rurality due to globalization, liberalization and urbanization has opened new avenues. The dependence on agriculture to spur growth has been declining. These forces are increasingly dominant in densely populated and rapidly growing countries like India and China, where the correlation between agricultural growth and growth of non-farm income and employment has become weaker in many rural areas (Haggblade *et al.* 2009). Detailed accounts of the dynamics of rural change due to the non-farm economy are beyond the scope of this study; but this trend offers promising pathways out of poverty, and should be considered in planning future poverty reduction programmes.

As the non-farm sector's contribution to rural livelihoods has increased, understanding of rural-urban linkages has become more important. In recent times, the geographical barrier between the rural and urban sectors has been largely eliminated by new physical and digital infrastructure. Lives and livelihoods span the rural and urban sectors, and are strongly integrated in both production and consumptions linkages. As argued by IFPRI (Garrett 2005), policies built on the presumption of separateness or on traditional notions of urban and rural livelihoods diminish the possibilities for economic growth and poverty reduction. More effective policies will take the diversity of livelihoods along the rural-urban continuum into account, and appreciate the differences among urban and rural areas and the links between them.

The evidence clearly shows that the rural non-farm economy has become an important mechanism for connecting the poor to economic growth. However, the issue is not to search for alternatives to agricultural innovation, expansion and change, but to look at how best to integrate agriculture into the wider economy as a way of stimulating production and consumption linkages and promoting rural change. Agriculture shapes and is shaped by the non-farm sector, depending on the specific nature of agrarian development, geographical factors and the broader economic context. A vibrant neo-agriculture should be the priority for future rural poverty reduction, rather than looking at agriculture in isolation.

Towards the future

Rapid globalization has brought about not only wealth and new opportunities, but also environmental damage and depletion of natural resources, undermining social resilience and generating new risks to national food security. This has generated new forms of poverty and vulnerability and has been reshaping livelihoods. The net outcome is complex, depending largely on the domestic political and economic policy environment. At the same time, globalization is a reality, and as argued by the United Nations (UN 2012), managing globalization will be the foremost challenge to poverty reduction in the postMDG era.

As not all rural poor people will benefit from the new opportunities, specific policies need to be targeted at the rural poor, especially those clustered in fragile environments and remote areas, as they are most vulnerable to the new rurality. This will require involving the poor in these areas in payment for ecosystem services, targeting investments directly to the rural poor, reducing their dependence on exploiting environmental resources and tackling their lack of access to affordable credit, insurance, land and transport.

This study has attempted to map and analyse rural livelihoods and water linkages at a broad level, covering three large subregions of Asia, i.e. South, Southeast and East Asia that have highly varying levels of rural transformation and complex agro-ecological settings. Though the livelihood contexts discussed in chapter 3 and the various water intervention options discussed in chapter 4 will help identify potential intervention strategies, field-level intervention projects and programmes need area-specific livelihood analyses to identify the best intervention strategies. The diversity of livelihood contexts in which the rural poor reside requires context-specific and targeted interventions, where rural people's constraints and opportunities are recognized and addressed. This study therefore recommends implementing more specific localized studies on water and poverty linkages in selected poor regions, especially in South Asia and parts of Southeast Asia, where rural poverty levels are highest.

This study did not look at peri-urban livelihood systems. Asia has been experiencing rapid urbanization and thus massive growth of peri-urban centres. Peri-urban centres are the interface between rural and urban areas. They are the centres of market-oriented agricultural production systems and thus are the platform for agricultural diversification because of their market links and migration prospects. Livelihood strategies should be viewed from a rural-urban rather than 'rural' and 'urban' perspective; the peri-urban centres act as the bridge between the two. Study of peri-urban-based livelihood systems, their dynamics and linkages to agriculture and water management will be important for designing future poverty reduction programmes.

The rural livelihood systems described in this study have been derived from agro-ecological settings, reflected in territorial terms, and thus did not fully capture inland fisheries and livestock systems. These are non-territorial livelihood systems, but have strong linkages with water management and poverty reduction. Context-specific studies on these non-territorial systems and linkages to water management are another area of interest for designing poverty reduction programmes.

Finally, economic forces of change and emerging environmental contexts, including the impacts of climate change at both global and local levels, will shape and reshape rural livelihood strategies in the future. Asia is in transition, and the landscape of human activities is getting more complex. The dynamics of rural change will determine the pattern of agricultural growth, livelihood strategies and poverty contexts and the most appropriate type and nature of water interventions. The dynamics of this transition need to be understood and capitalized on to design successful poverty reduction strategies and programmes. Agricultural water management remains central to poverty reduction because of its strong links to humanity, agricultural growth and environmental management. Nevertheless, water-related interventions alone are not sufficient for poverty alleviation, without also acting on the political, institutional, market, knowledge and financial dimensions of the challenge.

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Poverty continues to be a major concern in Asia despite the region's high economic growth and rapid rural transformation. Most of the poor live in areas where natural resource conditions are suboptimal and water-related constraints are the root cause of low production and increasing vulnerability to natural disasters and climate variability. The importance of securing water availability for rural livelihoods is therefore increasing. As water is fundamental to productive agriculture and other livelihood needs, how water is used and managed will have a significant impact on alleviating hunger and poverty.

This study identifies the hotspots of poverty and water constraints in Asia, and analyses them in the context of livelihood systems. It identifies and maps 14 major livelihood systems based largely on agro-ecological considerations. The study demonstrates that there is tremendous potential for well-targeted water interventions to enhance livelihoods and support rural development even in water-scarce environments, arguing that such interventions must be situated within the broader context of economic growth and environmental sustainability. Therefore there is an urgent need for a new approach to agricultural water management that complements ongoing livelihood transformation and supports dynamic rural change processes, while ensuring sustainable ecological and economic development pathways. It is hoped that this report will provide guidance for policies and investments in innovative water interventions to enhance rural livelihoods in Asia.

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