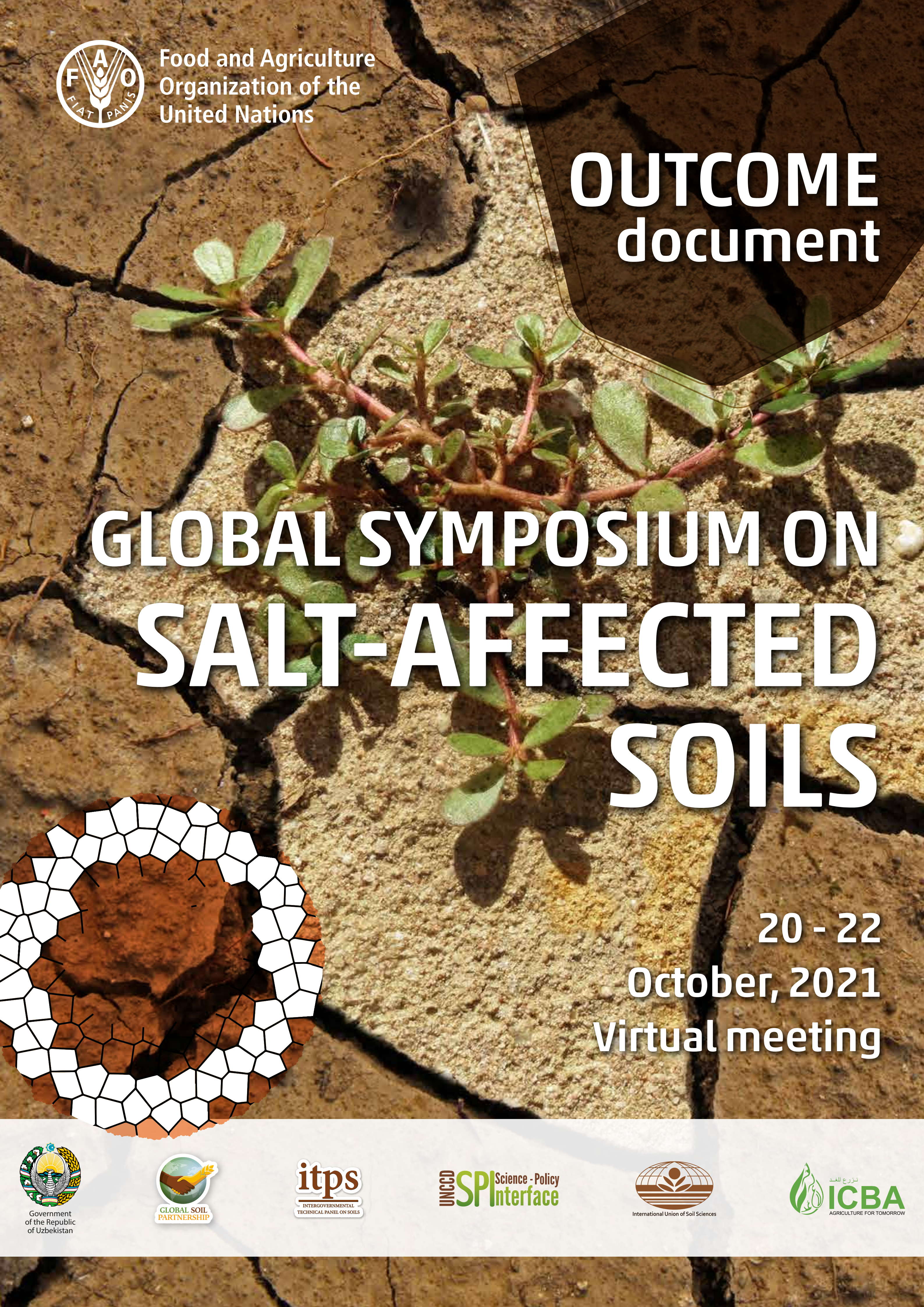


Food and Agriculture
Organization of the
United Nations

OUTCOME
document

GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS

20 - 22
October, 2021
Virtual meeting

Government
of the Republic
of Uzbekistan

GLOBAL SOIL PARTNERSHIP

itps
INTERGOVERNMENTAL
TECHNICAL PANEL ON SOILS

UNCCD SPI Science - Policy Interface

International Union of Soil Sciences

نزرع للغد
ICBA
AGRICULTURE FOR TOMORROW

OUTCOME
document

GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS

An event co-organized by:

FAO | Food and Agriculture Organization of the United Nations
GSP | Global Soil Partnership
ITPS | Intergovernmental Technical Panel on Soils
INSAS | International Network of Salt-Affected Soils
WASAG | Global Framework on Water Scarcity in Agriculture
SPI UNCCD | Science-Policy Interface of the United Nations Convention to Combat Desertification
Government of the Republic of Uzbekistan
IUSS | International Union of Soil Sciences
ICBA | International Center for Biosaline Agriculture

Food and Agriculture Organization of the United Nations
Rome, 2022

Required citation
FAO. 2022. *Global Symposium on Salt-Affected Soils: Outcome document*. Rome.
https://doi.org/10.4060/cb9929en

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

ISBN 978-92-5-136142-9
© FAO, 2022

Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode/legalcode).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons licence. If a translation of this work is created, it must include the following disclaimer along with the required citation: “This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original [Language] edition shall be the authoritative edition.”

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization http://www.wipo.int/amc/en/mediation/rules and any arbitration will be conducted in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org. Requests for commercial use should be submitted via: www.fao.org/contact-us/licence-request. Queries regarding rights and licensing should be submitted to: copyright@fao.org.

Cover photograph: © Matteo Sala

Contents

© pxhere.com

Acknowledgements

The Organizing and Scientific Committees express their sincere gratitude to FAO members, institutions, and individuals for their important contributions to the success of the symposium. Deepest thanks also go to the European Commission and the Ministry of Finance of the Russian Federation for their financial support to the symposium.

Abbreviations and acronyms

CBD | Convention on Biological Diversity

CSO | Civil society organization

GSASmap | Global map of salt-affected soils

GSP | Global Soil Partnership

FAO | Food and Agriculture Organization

NGO | Non-governmental organizations

SAS | Salt-affected soils

SDG | Sustainable Development Goals

UNCCD | United Nations Convention to Combat Desertification

UNFCCC | United Nations Framework Convention on Climate Change

VGSSM | Voluntary Guidelines for Sustainable Soil Management

Scientific and Organizing Committees

This outcome document, “Halt soil salinization, boost soil productivity”, was prepared and reviewed by members of the Scientific Committee. This document is also based on and complemented by the book of proceedings which presents the scientific abstracts and practices from the symposium’s sessions.

Scientific Committee

Intergovernmental Technical Panel on Soils (ITPS) | Salinity Working Group

Ms Rafla Attia

Ms Megan Balks

Ms Lydia Chabala

Mr Kutaiba Hassan

Mr Mohammad Jamal Khan

Mr Ashok Patra

Ms Rosa Poch

Global Soil Partnership (GSP) Secretariat

Ms Maria Konyushkova

Ms Natalia Rodriguez Eugenio

Mr Ronald Vargas

International Network of Salt-Affected Soils (INSAS)

Mr Jorge Batlle-Sales

Ms Katarzyna Negacz

Mr Meisam Rezaei

Global Framework on Water Scarcity in Agriculture (WASAG)

Mr Francisco Pedrero Salcedo

Science-Policy Interface of the United Nations Convention to Combat Desertification (SPI-UNCCD)

Mr Zahurul Karim

Mr German Kust

Republic of Uzbekistan

Ms Laziza Gafurova

Ms Gulchekhra Khasankhanova

Mr Alisher Shukurov

International Union of Soil Sciences (IUSS)

Mr Tibor Toth

International Center for Biosaline Agriculture (ICBA)

Mr Ahmed El-Naggar

Ms Fatma Rekik

Organizing Committee

Global Soil Partnership Secretariat

Mr Filippo Benedetti

Mr Sebastian Brahene

Ms Marzia Calisse

Ms Lucrezia Caon

Ms Carolina Cardoso Lisboa

Ms Rosa Cuevas Corona

Ms Maria Konyushkova

Mr Sangkyung Lee

Mr Bofei Li

Ms Julia Mousquer

Ms Carolina Olivera Sanchez

Mr Christian Omuto

Mr Yi Peng

Ms Silvia Pioli

Ms Natalia Rodriguez Eugenio

Mr Matteo Sala

Ms Vinisa Saynes Santillan

Ms Giulia Stanco

Mr Yuxin Tong

Mr Ronald Vargas

Ms Isabelle Verbeke

Ms Magdeline Camille Vlasimsky

Mr Yusuf Yigini

Ministry of agriculture of Uzbekistan

Mr Alisher Shukurov

Mr Alisher Umaraliev

FAO Uzbekistan

Mr Azizbek Eraliev

Mr Furkat Ibragimov

Mr Temurbek Reymov

Mr Sherzod Umarov

©FAO/Ronald Vargas

Summary

The Global Symposium on Salt-Affected Soils 2021 (GSAS21) was jointly organized by the:

- The Food and Agriculture Organization of the United Nations (FAO) and its Global Soil Partnership (GSP), the Intergovernmental Technical Panel on Soils (ITPS), the International Network of Salt-Affected Soils (INSAS), and the Global Framework on Water Scarcity in Agriculture (WASAG)
- The Government of the Republic of Uzbekistan
- The Science-Policy Interface of the United Nations Convention to Combat Desertification (SPI-UNCCD)
- The International Union of Soil Sciences (IUSS)
- The International Centre for Biosaline Agriculture (ICBA)

The GSAS21 was held virtually on the Zoom platform on 20-22 October 2021. The GSAS21 symposium was attended by over 4 000 participants. The Plenary session of the first day was attended by 2 315 participants through Zoom and above 1 000 on the FAO webcast. Over 1 000 participants followed the parallel sessions during the second and third days. Participation data aggregated by gender shows that 40 percent female and 60 percent male from 185 countries attended the Symposium, including representatives of FAO Members, organizing institutions, academia, research institutions, private sector, general public, farmers, and civil society and non-governmental organizations (CSO/NGO).

The objective of the symposium was to combine science, policy, and practice to evaluate the issues related to salt-affected soils and to formulate a strategy for the implementation of Voluntary Guidelines for Sustainable Soil Management in the areas affected by salinity and sodicity (FAO, 2017). This goal requires the provision of reliable examples of the successful use of sustainable management practices, processes, methods, and tools for salt-affected soils. The online symposium facilitated a multi-disciplinary examination of the challenges posed by soil salinization and sodification, thereby reinforcing the interchange between policy makers, scientists, and professional practitioners in this field. Soil health is a critical aspect of the Sustainable Development Goals (SDGs), and the symposium addressed the relationship between the realization of SDGs and the management of soils vulnerable to salinization and sodification.

The GSAS21 symposium was structured around three main themes focusing on: 1) Assessment, mapping, and monitoring of salt-affected soils; 2) Integrated soil – water – crop solutions in rehabilitation and management of salt-affected areas; 3) Agenda for action to prevent and rehabilitate salt-affected soils, protect natural saline and sodic soils, and scale-up sustainable soil management practices. The fourth session on testimonies from the field was organized to showcase the good practices illustrating the rehabilitation and sustainable use of salt-affected soils. The aim of this four sessions was to collect and share these good practices with farmers, project managers and policy makers.

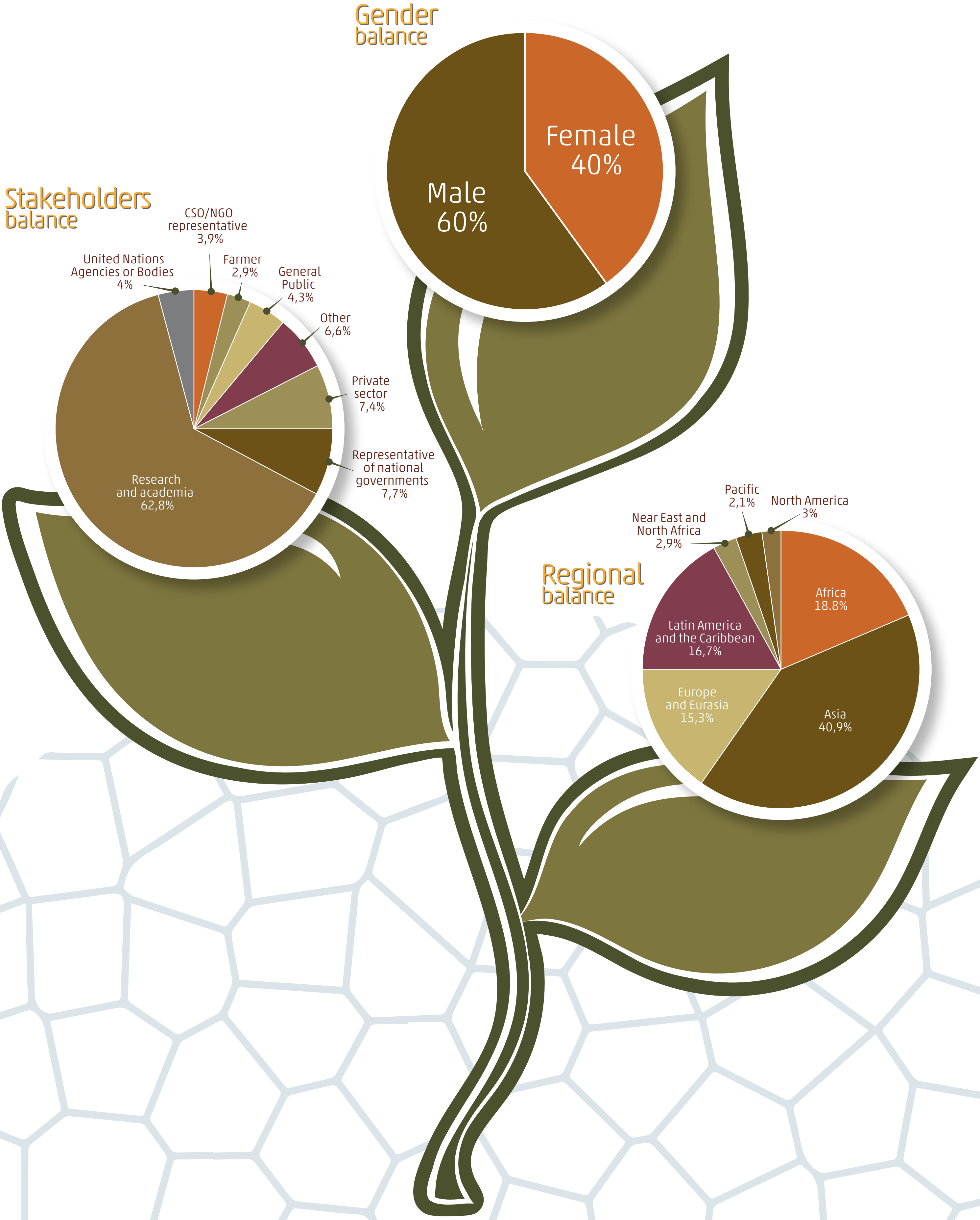
The symposium included more than 70 oral presentations, presented over 17 hours of parallel sessions. Recordings of the presentations can be accessed via https://www.fao.org/global-soil-partnership/areas-of-work/soil-salinity/gsas21-presentations. In addition, 58 posters were open for public voting during the GSAS. Over 67 000 votes have been received which helped identify three winners of the poster session. The posters are available from https://www.fao.org/global-soil-partnership/areas-of-work/soil-salinity/GSAS21-Poster-contest/en/.

Participants engaged actively in the GSAS21 by presenting the results of studies and practices demonstrating that:

- soil salinization and sodification are global threats present at all latitudes;
- the availability of data on spatial distribution, factors and severity of the problem is critical for implementation of proper management of salt-affected soils, therefore the collection, storing, processing and sharing of these data should be encouraged;
- sustainable soil management practices specific to salt-affected soils are quite diverse and shall be well documented and scaled up;
- sustainable soil management practices are efficient tools in improving soil productivity and crop growth, especially in slightly and moderately affected areas;
- capacity building programs on mapping, assessing and management of salt-affected soils are crucial for increasing the resilience and performance of programs on reclamation and use of salt-affected soils; and
- promoting the marketing of halophyte agriculture is decisive for the development of agriculture in severely salt-affected marginal areas.

The recommendations presented in this document aim to support decision-making and innovative actions to minimize the challenges posed by soil salinity and sodicity, thereby assisting in the augmentation of global food security and ecosystem protection through SAS management in impacted regions.

Statistics of attendance



Background to the Global Symposium on Salt-Affected Soils

The 2015 Status of the World's Soil Resources report (FAO and ITPS, 2015) listed soil salinization and sodification as one of the ten major threats to soil health. Specifically, this problem comprises an increase in the amount of land impacted by salt and an increase in the severity thereof.

Salt-affected soils include saline, sodic and saline-sodic soils. These soils have levels of salt and/or exchangeable sodium that impede the survival of numerous plants.

Some salt-affected soils constitute very valuable natural ecosystems colonized by specialized plants which are a genomic wealth, susceptible to show how to improve the tolerance of our crops to abiotic stress.

However, in many cases, the presence of such high levels of salts and/or exchangeable sodium disturbs the provision of ecosystem functions that are vital to support human life and biodiversity. Thus, the presence of salt-affected soils and the increase of salinity/sodicity levels in soils have multiple potential negative outcomes:

- reduced agricultural productivity;
- diminished water quality by salinization of groundwater;
- decreased biodiversity;
- elevated soil erosion arising from reduced vegetation cover and soil structure degradation;
- a reduction to the soil's defensive ability to filter contaminants by surface crusting;
- reduced ability of crops to take up water due to increase of osmotic stress;
- diminished or unbalanced micronutrient availability and resultant declines in crop yields;
- concentrations of ions that are toxic to plant life due to specific ion toxicity;
- damage to the soil structure, increased soil compaction, and a decline in soil permeability; and
- desertification that causes population migration and reduces land value.

Salt-affected soils are frequently a natural occurrence, especially in arid, semi-arid, and coastal zones where they support important, adapted ecosystems. These natural-occurring soils are the result of multiple factors, including the weathering of salt bearing rocks or mineral deposits, drainage limitations arising from hardpan or topographic causes, underground saline water that is close to the surface, marine intrusion, volcanic activity, climate aridity and the aeolian salt transport from inland and coastal saline areas.

The salinization and sodification of agricultural land is increasing due to climate change, water shortages, and unsustainable farming practices. Forecasts indicate a 23 percent increase in global drylands by the end of the twenty-first century. Moreover, 80 percent of this increase will occur in developing nations (European Commission, 2018). Furthermore, UN-Water has estimated that 27 percent of the world's population (1.9 billion people) endure severe water shortages. This figure has been predicted to increase by 42-68 percent (2.7-3.2 billion people) by 2050 (WWAP/UN-Water, 2018). These projections indicate that salt-affected soils can expand greatly by the end of the twenty-first century, obliging more farmers to modify their farming strategies in order for their land to remain productive in the context of water shortage and soil salinity.

The underlying causes of increases in the amount of salt-affected land are multiple. They include improper irrigation with poor quality water and other unsustainable irrigation practices, deforestation and the loss of deep-rooted vegetation, the inappropriate use of fertilizers, the over-pumping of water from coastal aquifers, poor drainage, and seawater intrusion in coastal areas. Global estimates show that around 77 million hectares of cultivated lands became salt-affected as a result of human-induced processes (Oldeman, Hakkeling and Sombroek, 1991). According to Qadir *et al.* (2014), salt-induced land degradation is responsible for the loss of USD 27.3 billion worth of agricultural production per annum.

Utilization of unconventional water has been proposed as a major response to water shortages in water-scarce regions (UN Water, 2020). However, uncontrolled use of poor quality water endangers the health of ecosystem, and soil in particular. There is a clear need for solutions that can both safeguard sustainable soil and water management practices and sustain the adequate level of crop production.

The prevention of human-induced soil salinization/sodification and adaptation to naturally salt-affected soils contributes substantially to the achievement of the Sustainable Development Goals (SDGs) with a significant impact on goals SDG 1 on "No poverty", SDG 2 on "Zero hunger", SDG 10 on "Reduced inequalities", SDG 13 on "Climate action", SDG 15 on "Life on land" through improving resilience of small-hold farms in marginal lands that are mainly threatened by salinity stress. Furthermore, sustainable agriculture in salt-affected environments contributes to the implementation on the ground of the Rio conventions on desertification (UNCCD), climate change (UNFCCC) and biodiversity (CBD). Moreover, sustaining soil biodiversity and sustainable soil management (SSM) in marginal lands will be pivotal to the success of the recently declared UN Decade on Ecosystem Restoration (2021-2030).

The symposium was a bold action to promote the implementation of the Voluntary Guidelines for Sustainable Soil Management (VGSSM) in terms of finding and promoting the best integrated solutions and achieving the SDGs. The symposium served to review and discuss successful case studies in combating salinization and sodification, review existing soil salinization and sodification assessment frameworks, and the status and challenges of soil salinization and sodification mitigation, reclamation and control, and to launch a global collaborative effort to promote the adoption of management practices, techniques, instruments and mechanisms that reduce and, where possible, halt or reverse the expansion of secondary soil salinization and sodification. The Symposium also served as the scenario to launch the Global Map of Salt-Affected Soils (GSASmap), a country driven product developed by over 350 experts from 118 countries.

Specifically, the objectives of GSAS21 were to:

1. Examine the current scientific understanding of salt-affected soils, and their impact on food security and the environment quality.
2. Identify options to generate, consolidate and harmonize data on salt-affected soils, taking into consideration diagnosis criteria, distribution, dynamics linked to climate change, and monitoring and mapping techniques.
3. Review and discuss existing national and international policies, strategies, agreements and frameworks addressing the prevention, management and remediation of salt-affected soils to assess their effectiveness, and propose ways to enhance them, promoting regional technical and scientific cooperation.
4. Review and discuss existing materials related to the assessment of impacts of salt-affected soils on agricultural production, food security, ecosystem services and human well-being in different agricultural production systems and fragile ecosystems.
5. Identify and review innovative management practices and technologies for the management and remediation of salt-affected soils.
6. Critically reflect on the economics of soil salinization and sodification, focusing on the sustainable soil management practices that are cost-effective; and
7. Advocate for an agenda for action on salt-affected soils to prevent, adapt to, mitigate and monitor secondary soil salinization and sodification processes as well as to protect and ensure sustainable management of natural salt-affected soils.

©FAO/Ronald Vargas

Symposium themes, key questions, and discussion summary

The symposium was organized in the following consecutive sessions: a) high level opening session with the Heads and representatives of the organizing institutions (FAO, UNCCD, IUSS, ICBA) and countries where soil salinity is an acute problem (Uzbekistan and Australia); b) launch of the global map of salt-affected soils, c) a keynote session portraying the status and challenges of mapping, monitoring and management of salt-affected soils and policy solutions; d) four parallel sessions presenting research outputs and experience from scientists and practitioners followed by poster sessions; e) a wrap-up session outlying the main session outcomes and key findings; f) closing session (see Agenda[1] for details).

The symposium's three main themes and practice sessions were designed to focus discussions on:

- Theme 1: Assessment, mapping, and monitoring of salt-affected soils.
- Theme 2: Integrated soil – water – crop solutions in rehabilitation and management of salt-affected areas.
- Theme 3: Agenda for action to prevent and rehabilitate salt-affected soils, protect natural saline and sodic soils, and scale-up sustainable soil management practices.
- Practices: Testimonies from the field – Good practices to manage salt-affected soils.

The parallel sessions were designed to review the current state of knowledge and practice in order to determine the strategies that must be applied to manage, monitor, mitigate, and prevent soil salinization, in addition to the measures required to sustain soil health in areas threatened by salinization and sodification.

The presentation and discussions held within GSAS21 themes are summarized in the relevant sections below, with respect of key questions and main recommendations.

©FAO/Ronald Vargas

Theme 1: The assessment, mapping, and monitoring of salt-affected soils

Objective

Identify options to generate, consolidate and harmonize data on salt-affected soils, with reference to diagnostic criteria, distribution, dynamics linked to climate change, monitoring and mapping techniques.

Discussion summary

> *It is crucial to harmonize the diagnostic criteria, definition and analytical methods that are used to determine the salinity and sodicity status of soils.*

Salt-affected soils are frequent in many arid, semi-arid and coastal regions of the world. Salinity and sodicity are considered as main factors limiting crop yield in these regions. Salt-affected soils cover over 10 percent of the world's cultivated land (FAO, 2021). Knowing the spatial distribution of salt-affected soils and the severity of the problem is key for managing them properly. However, the concept of salt-affected soils has a different interpretation in different countries depending on criteria and methods used to analyze and inventory these soils. There is a need to develop a harmonized approach through consultations that involve experts from different countries having salt-affected soils.

> *There should be more attention given by research and practice to monitoring changes in soil salinity and sodicity.*

The symposium presentations primarily highlighted soil assessment and soil mapping. Too few attention (less than 10 percent of presentations) was devoted to soil monitoring, even though this comprises one of principal strategies employed to address this problem.

> *Remote sensing and electromagnetic induction (EMI) techniques are most widespread for soil salinity/sodicity mapping. The most common technique at the field scale is EMI. Experts working with EMI instruments highly recommend to increase the adoption of this method for salt-affected areas as it can measure changes in salinity both laterally and vertically.*

The presentations encompassed a reasonable selection of spatial scales, such as field scales, and regional, national, and continental scales.

The mapping and monitoring of salt-affected soils is challenged by the spatially and temporally changing character of these soils. Soil cover in regions impacted by salinity or sodicity has a pronounced patchiness which presumes the extensive soil sampling. Alternatively, modern techniques such as electromagnetic induction and remote sensing together with computer data processing are widely used to reduce the time and costs spent for mapping and monitoring soil salinity status.

---

[1] Agenda of the Global Symposium on Salt-Affected Soils 2021 is available here: https://sfcs.fao.org/docs/faoeventslibraries/global-symposium-doc/agenda.pdf

Besides, the surface and rootzone salinity are often not correlated to each other. It is important to measure, map and monitor the soil salinity of the whole rootzone.

The use of remote sensing has proven to be a very efficient tool for mapping soil salinity. However, most studies stressed the need to combine remote sensing with real soil data. In this regard, one of the bottlenecks for soil data collection in highly dynamic and heterogeneous salt-affected landscapes is the choice of a proper sampling design. There is a clear need for a most cost-effective, reliable, and efficient sampling protocol for uses in regions with salt-affected soils.

> *The use of soil spectroscopy for measuring and monitoring of salt-affected soils requires further development.*

Another potentially fruitful approach is soil spectroscopy. However, its use should be elaborated further as chemical composition of salts and soil moisture content influence the soil spectra.

> *It is necessary to take into account that salinization is only partially reversible process as it may adversely affect the physical mass of soil (clay and organomineral compounds) that is much harder to rehabilitate.*

Salinization and sodification processes are not totally reversible and are subject to hysteresis phenomenon, i.e. desalinization happens in a different way than salinization. This phenomenon of hysteresis should be included within modelling of the influence of salts on soils as it gives more realistic predictions in scenarios of rehabilitation and degradation of salt-affected soils. The inclusion of hysteresis into modeling shows greater degradation risk and more difficult rehabilitation.

> *The 3-dimension models connecting major drivers and variables with soil salinity and sodicity at the field, landscape or regional levels should be elaborated.*

The spatial and temporal changes in salinity are not always a negative trend as long as salinisation and desalination are simultaneous processes. The movement of salts in the whole agricultural system is subjected to patterns that are still poorly understood and poorly predicted. The variables that play a role are soil type (including its hydraulic properties), irrigation management, crop type, climatic conditions, ground water level and many other factors that can influence the movement of water and salts. Different land uses have a strong impact on the results of mapping and overall accuracy of spatial and temporal predictions.

> *Indicators of soil salinity and sodicity as well as background factors should be incorporated into soil monitoring programs of all regions, including those already impacted and those which are traditionally considered as not at risk.*

Areas not deemed at risk of salinization or sodification are seldom evaluated in terms of salt content, electrical conductivity, exchangeable sodium and other chemical analyses typically used for salt-affected areas. This means that for non-saline and non-sodic areas worldwide, the available data on salinity and sodicity is low and accuracy of spatial and temporal prediction is poor. Nevertheless, the impact of climate change and the drying of the planet render it important to incorporate these areas within current salinity and sodicity monitoring in order to develop an early warning system that will facilitate prompt action if required.

> *Coastal areas are hot spots of increasing soil salinization and sodification and should be set as priority areas for monitoring of salt-affected soils.*

Similarly, it was stressed that coastal areas are usually affected by salinity and sodicity but are not properly measured and monitored. As these areas are hot spots of increasing soil salinization and sodification under climate change, sea level rise and coastal land subsidence causing sea water intrusion, more attention should be paid to soil salinity and sodicity monitoring.

> *Despite limitations, mapping and assessment of salt-affected soils must be carried out using digital soil mapping techniques as they help to overcome the lack of data in salt-affected areas, highly varying in-depth, laterally and temporally.*

The accuracy of predictions in mapping salt-affected soils as indicated by presenters and attendees is impeded by several limitations, including the uncertainty associated with low salinity values because some plants can grow well in low saline conditions, the problematic behaviour of halophyte reflectance, the absence of research into tree crops (complex spatiotemporal dynamics of salinity in the root zone, not least with micro-irrigation), the high cost of satellite data with high spatial and temporal resolution which are more suitable for accurate salinity predictions, and the limited accuracy of current temporal predictions and prognoses.

Theme 2: Integrated soil – water – crop solutions in the rehabilitation and management of salt-affected areas

Theme 2 aims to overview and identify the main solutions to rehabilitate salt-affected soils which can be scaled up and mainstreamed.

Objectives

Identify and review advanced practices and technologies for management and remediation of salt-affected soils;
Showcase the good practices illustrating the rehabilitation and sustainable use of salt-affected soils and having positive impact on soil health, environment and socio-economic conditions

Discussion summary

The symposium discussions emphasized several significant areas of SAS management, namely: the obstacles encountered by nations and farmers attempting to use these salt-affected soils, the range of potential interventions, current practices and technologies, and some other aspects of managing these soils applicable also to other soil types.

The principal agricultural problems in SAS zones are extreme water scarcity, population increases and the associated demand for resources, and groundwater salinity. Typical interventions are either based on technology and engineering, agriculture, politics, or management.

> *Around 60 good practices and integrated approaches were presented during oral and poster presentations. Concrete practices that were shown and discussed during the Symposium included:*

- mulches;
- straw interlayer;
- rubble barrier within the soil;
- leaching and drainage;
- surface scraping;
- compost;
- residue incorporation;
- residue retention;
- biochar;
- rice husk and rice straw application to augment water retention;
- agrobiodiversity, improved crop rotation, and crop system diversification;
- bioinoculants, biofortification and biotechnology;
- halopriming (soaking seeds in salt solution to improve germination);
- Ca-containing amendments for sodic soils, e.g., gypsum;
- land shaping and leveling;
- cropping of halophytes and other non-conventional crops;
- advanced breeding and genetic engineering;
- evaluation and adoption of a wider range of germplasm;
- deep ploughing;
- irrigation schedule adjustment; and
- phytoremediation.

Many techniques seek to reduce evaporation, as exemplified by straw interlayers, rubble barriers, and mulches. Leaching, drainage, and surface scraping are designed to remove salts from the soil, whilst compost and residue incorporation aim both to improve soil structure and to increase infiltration. Biochar, compost, residue retention, and biological techniques can improve general soil health. The chemical amelioration of sodic soils can be achieved through the addition of gypsum and other Ca-containing amendments. Decreased salt relocation and accumulation is achieved through land shaping and leveling. In addition, crop adaptation is rendered possible through multiple techniques, such as the use of halophytes and non-conventional crops, the development of breeding and genetic engineering programmes, the adoption of a wider range of germplasm, and the adoption of halopriming.

> *The use of good quality water should be adjusted to the sensitive stages of crop growth.*

Germination and the seedling stage are generally assumed to be the phases during which crops exhibit the greatest sensitivity to salinity stress. In later growth stages, crops have higher tolerance of salinity. More effective water use can be achieved through the application of good quality water during the early-season or post-harvest phases. This technique can leach salts from the root zone, thereby improving growing conditions during the most sensitive stages.

> *Slightly and moderately saline and sodic soils can provide sufficient crop production if soil practices improving soil porosity, microbiological activity, and organic carbon content are only applied.*

The productivity of slightly and moderately salt-affected soils can be managed without specific measures to reduce soil salinity if soil practices elevating soil health are applied. Those are practices that can improve soil porosity, microbiological activity, and organic carbon content. Organic fertilizer can reduce soil salinity by improving soil structure, promoting salt discharge and reducing salt surface accumulation, and reducing soil pH by organic acid produced with organic matter decomposition. However, it is also important to monitor the salinity status and avoid the practices that can lead to excessive accumulation of salts.

> *The sources of organic matter amendments are limited in arid and low income regions. Other solutions such as bioinoculants can be applied to increase the biological activity of soils.*

Productivity levels in salt-affected soils can be improved through the addition of organic matter. However, most drylands and low income areas do not have access to organic supplements. Hence, this solution is not always viable.

> *The electronic databases on halophytes should be continuously updated.*

Symposium participants emphasized the rehabilitative potential of native plants that able to flourish in excessively saline soil (halophytes). Thus, an eHaloph database was introduced, in which it is possible to locate data pertaining to the economic benefits of 625 halophyte species and around 1200 salt-tolerant species. It is important to continuously update this database.

> *Growing halophytes is the best solution for extremely saline soil conditions.*

Soil health is generally improved when halophytes are present because their canopy inhibits evaporation. Moreover, these plants also enhance microbial activity, organic carbon content, and the porosity of the soil. Halophytes have multiple uses as crops, including food, feed, and forage. Furhtermore, their nutritive value is high, thereby rendering them an appealing choice for agri-business.

> *It is necessary to control nutrient loss and excessive salt accumulation and to increase nutrient use efficiency in salt-affected farmland through better management of salinity status (sustaining optimal salinity levels at the root zone), improvement of soil quality and precise farming.*

The nutrient depletion arising from volatilization and leaching was also connected to over-irrigation, whereas inadequate irrigation, combined with the application of both organic and chemical fertilizers to arid or semi-arid soil, caused human-induced salt accumulation in the topsoil. Thus, the loss and over-accumulation of nutrients must be regulated in areas with salt-affected soils.

> *It is important to train farmers in the use of saline water or grey water through practical demonstrations.*

The use of marginal water for irrigation is a growing practice in water scarce and suburban regions. However, there is a need to improve farmers' skills to irrigate with saline or grey waters to reduce the negative impacts. It can be achieved through demonstration sites and trainings.

> *Biochar has a good effect on reducing salinity, promoting crop growth and improving nitrogen nutrient use efficiency. However, high alkalinity of biochar can worsen soil pH of salt-affected soils which are typically already alkaline. Some modifications in pyrolysis or post-pyrolysis stages can reduce biochar alkalinity.*

Biochar can be used in salt-affected soils because it decreases salinity, improves crop yields, and augments the efficiency of nutrient use. These benefits are derived from the fact that biochar improves the soil structure and raises levels of organic matter in the soil. It can also lessen the amount of exchangeable sodium by adsorption. However, the elevated alkalinity of biochar means that it can worsen pH levels in salt-affected soils, which typically have pH>7.5. By altering pyrolysis, through reduced temperatures or shorter time, the alkalinity of biochar can be kept at the lower levels. Alkalinity of biochar can also be reduced by post-processing with composting or water prior to application into soil.

> *Models on carbon sequestration that consider the influence of soil salinity, sodicity and alkalinity should be elaborated.*

Another area requiring additional research concerns the behaviour of organic matter in salt-affected soils since it is known to differ from such behaviour in non-SAS contexts. The alkalinity of soil has implications for organic carbon mobility. However, existing models for carbon sequestration in soil fail to consider the impact of alkalinity, sodicity, and salinity.

> *A novel technology of salt leaching was tested in the coastal NE China and could be scaled up in regions with cold seasons having temperatures below -5 °C. This technology uses the law of salty ice melting.*

Salt leaching was tested in coastal areas of Northeast China where cold season temperatures fall below minus 5 ° C. The ground is irrigated in the winter with saline water, which then freezes. When the ice melts, the brine is leached before the rest of the water. Hence, initial water lost from the soil profile has a high salt content. Once the brine has been leached, the remaining fresh water flows, thereby leaching the salt from the topsoil.

Theme 3: Agenda for action to prevent and rehabilitate salt-affected soils, protect natural saline and sodic soils, and scale-up sustainable soil management practices

Objectives

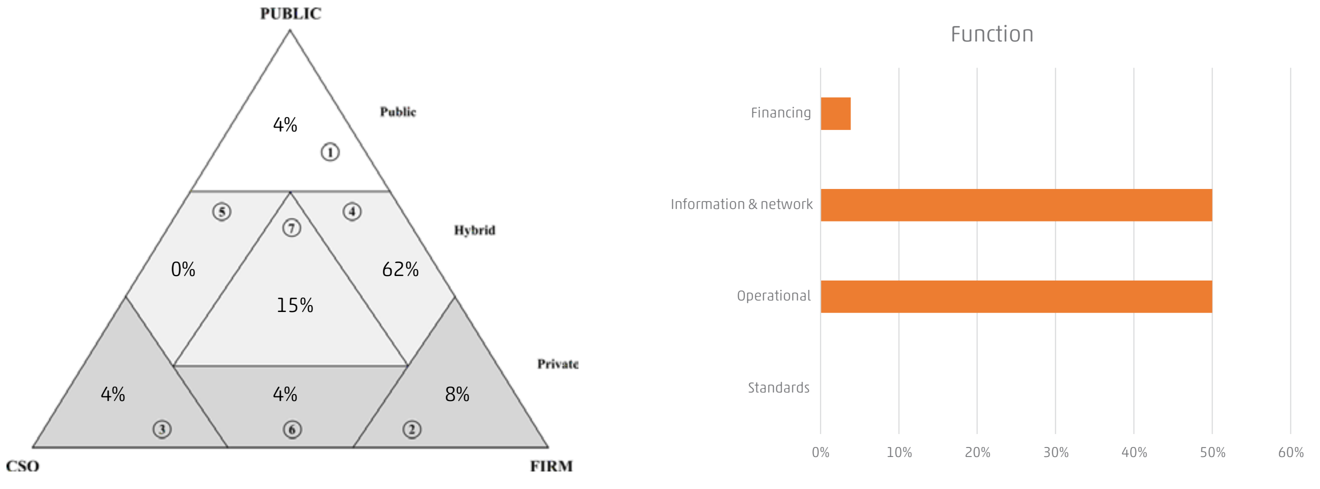
Advocate for an agenda for action on salt-affected soils to prevent, adapt to, mitigate and monitor secondary soil salinization and sodification processes as well as to protect and ensure sustainable management of natural salt-affected soils.

Discussion summary

The discussions under Theme 3 were aimed at the overview of the status on policy in the area of the management of salt-affected soils and at setting the principles of a global agenda for action to prevent and rehabilitate salt-affected soils, protect natural saline and sodic soils, and scale-up sustainable soil management practices.

> *Saline agriculture is increasingly present on the policy agenda globally.*

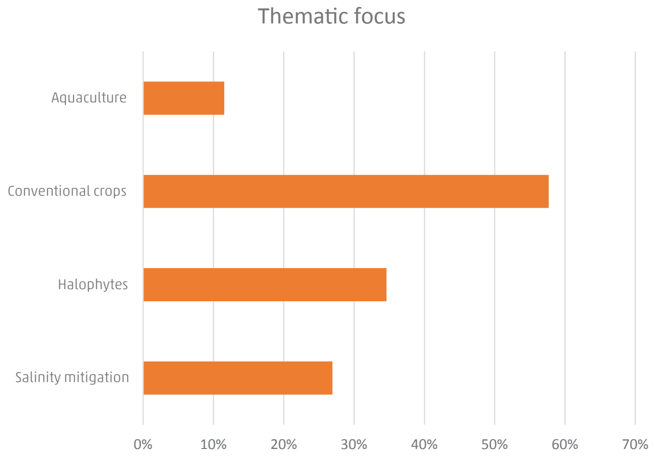
These discussions revealed that saline farming has a growing socio-economic importance due to its relevance to the subjects of land degradation and food security. The management of saline agriculture is based on a combination of public and private initiatives (see Figure 1) that involve testing, field experiments, network building, information sharing, and the raising of awareness about the issues involved. Of the 26 initiatives that were examined, none had worked on standards despite its importance for regulation and management in the areas affected by salinity or sodicity. Moreover, most remained directed at conventional crop growing, in preference to the use of non-conventional crops, such as halophytes (see Figure 2). However, the discussions also revealed that there was interest in unconventional crops. Hence, these must become more mainstream in the future.



Sample size: n=26

Note: one initiative can have more than one functionSample size:n=26

Figure 1. The governance and functions of initiatives related to saline agriculture.
Source: Negacz, K. 2021. *The Emergence of a Governance Landscape for Saline Agriculture: Presentation at the Global Symposium on Salt-Affected Soils*. 20-22 October, 2021. Virtual meeting. https://www.fao.org/fileadmin/user_upload/GSP/GSAS21/GSAS21_presentations/PS3_02_Negacz.pdf .

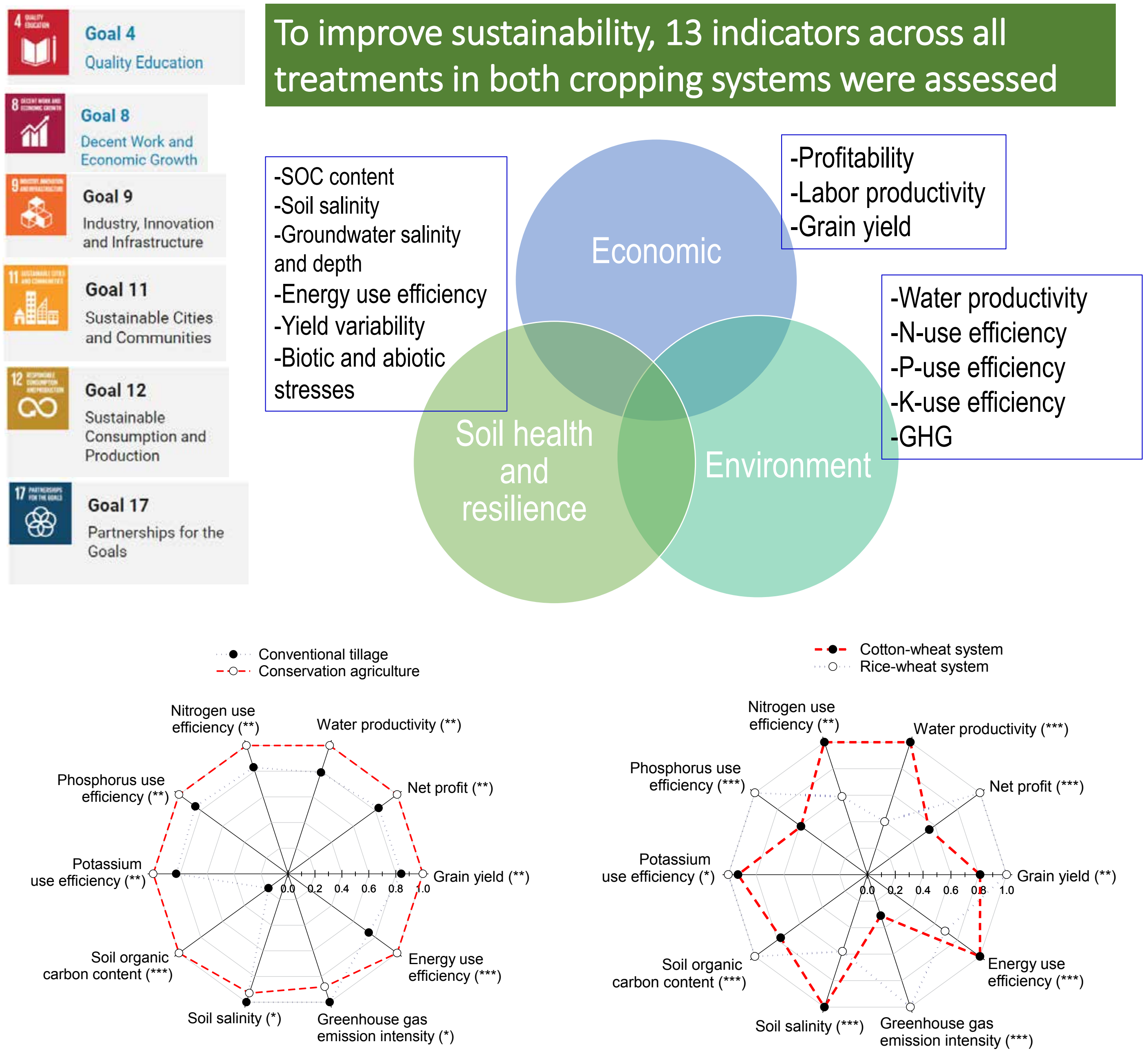


Note: one initiative can have more than one theme. Sample size: n=26

Figure 2. Thematic focus of initiatives related to saline agriculture. Source: Negacz, K. 2021. *The Emergence of a Governance Landscape for Saline Agriculture: Presentation at the Global Symposium on Salt-Affected Soils*. 20-22 October, 2021. Virtual meeting. https://www.fao.org/fileadmin/user_upload/GSP/GSAS21/GSAS21_presentations/PS3_02_Negacz.pdf .

> *Practices based on conservation agriculture improve economic, environmental, and soil health and resilience indicators of sustainability in salt affected irrigated drylands.*

Session 3 presented an exercise that outlined sustainability evaluations of various practices, which measured thirteen indicators of environmental, economic, and soil health (see Figure 3). Conservation practices are designed to increase economic, environmental, and soil health, in addition to resilience in salt affected irrigated drylands. It is important to define the benchmarking baseline and target values of sustainability in salt-affected soil to achieve advances in the sustainability indicators.



To improve sustainability, 13 indicators across all treatments in both cropping systems were assessed

-SOC content
-Soil salinity
-Groundwater salinity and depth
-Energy use efficiency
-Yield variability
-Biotic and abiotic stresses

-Profitability
-Labor productivity
-Grain yield

-Water productivity
-N-use efficiency
-P-use efficiency
-K-use efficiency
-GHG

Figure 3. The assessment of sustainability of different practices performed on saline soils. Source: Devkota, K., 2021. *Managing Soil Salinity in Irrigated Drylands of Aral Sea Basin: An Assessment Through the Lens of Sustainability Indicators. Presentation at the Global Symposium on Salt-Affected Soils.* 20-22 October, 2021. Virtual meeting. https://www.fao.org/fileadmin/user_upload/GSP/GSAS21/day3/PS3_01_Devkota.pdf .

> *Sustainable management of salt-affected soils should focus on nature-based solutions.*

Furthermore, the symposium discussion highlighted the need to render SAS management more focused in nature-based solutions, including phytoremediation, cover crops, improved rotations, microbial management, and bio-drainage (see Figure 4). Moreover, those plants that are used for the phytoremediation of salt-affected soils can also be used as food or forage. Alternatively, if the soil is polluted, the plants can be transformed into compost. Once the harmful chemicals and pesticides have been removed, this compost may be suitable for use as forage.

Phytoremediation

Problem:

- Salinity and sodicity

Goal:

- To remove Na in depth

Innovative solutions:

- Testing phytoremediation for low to medium sodicity
- Cheaper and more sustainable than chemical remediation
- Improving carbon sequestration in soil.

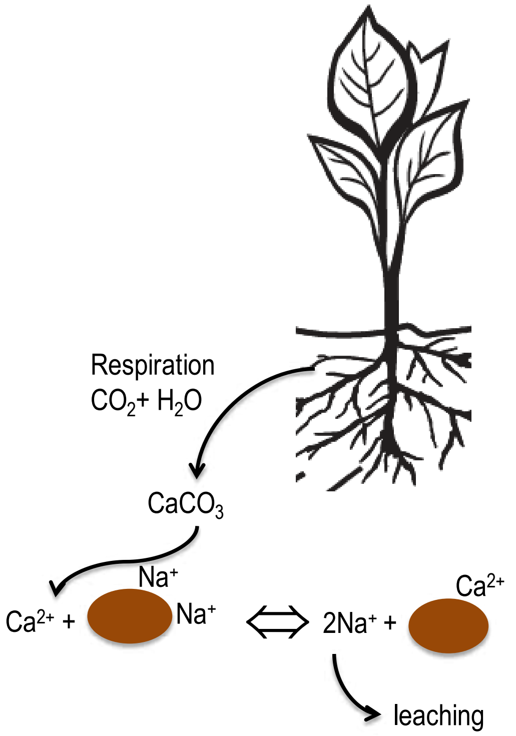


Figure 4. Phytoremediation as a sustainable way to remediate sodic soils. Source: Costantini, E.A.C. 2021. *Salt-Affected Soils at the Farm Scale: Successful Experiences and Innovation Needs: Presentation at the Global Symposium on Salt-Affected Soils.* 20-22 October, 2021. Virtual meeting. https://www.fao.org/fileadmin/user_upload/GSP/GSAS21/GSAS21_presentations/PS3-2_02_Costantini.pdf .

> *Strategy of the sustainable management of salt-affected soils is predetermined by the severity level of the salinity or sodicity problem.*

Strategy choice is essentially determined by the severity of the salinity or sodicity issue. This fact was emphasized by the symposium participants. Non-saline regions that are potentially prone to salinization or sodification require monitoring of soil salinity and sodicity status and modeling that can predict the impact of different scenarios. Regions with moderately salt-affected soils need initiatives that can ensure that root zone salinity and sodicity remain at the low or moderate levels. Hence, soft soil management techniques are suitable. Severely impacted soils may be considered for halophyte farming or, in case if farming is not viable, should be considered for conversion to ecotourism, recreation, or heritage purposes. Alternatively, natural protection may represent the most suitable use.

> *Program's success and sustainability is enhanced through cooperation with farmers and capacity building.*

The symposium participants indicated that collaboration with local farmers was essential to ensure that initiatives were implemented successfully and permanently. Farm-level capacity building initiatives should be conducted in conjunction with reclamation programmes and the introduction of sustainable farming practices. It was noted that salinity/sodicity in most cases is not a problem if the community is taking care of affected areas management and control. However, it can take up to two years to equip farmers and institutions with the expertise required to conduct systematic land reclamation and management. The discussions also noted that project ownership by stakeholders (farmers, NGOs) was more readily established through transparency and engagement in problem solving.

> *Environmental monitoring should accompany the implementation phase of projects.*

The successful performance of any project can be achieved through environmental monitoring at the implementation stage. This must include the monitoring of ground and surface water quality, biodiversity, and land use and is designed to permit modifications to the project where required.

During discussions, it was noted that the taste of food improves in saline soils because of high nutrient content but there are no scientific studies on this topic.

Thus, Session 3 indicated that multiple actions are required in order to prevent SAS issues and to rehabilitate salt-affected soils:

- combining the efforts of all stakeholders during the consultation and implementation stages;
- political support and commitment;

- increasing investment into technology and capacity building;
- promoting land reclamation through technology and capacity building amongst farmers;
- improving and extending extension services to remote farmers;
- empowering agricultural communities in rural areas, with special reference to women;
- lessening land degradation through the monitoring of areas prone to salt problems;
- ensuring that that the sodicity and salinity monitoring and modelling incorporate consideration of the whole landscape;
- paying more attention to the hotspots of growing salinization and sodification in coastal areas that experience the impacts of climate change;
- eliminating those unsustainable practices that result in SOC loss, thereby exacerbating the adverse effects of secondary salinization/sodification;
- facilitating informed decision-making through effective and accurate data collection;
- using successful case studies to inform the adoption of appropriate crop selection and management practices;
- encouraging the market and uptake of halophytes and non-conventional crops;
- creating links between smallholders and markets; and
- promoting the evaluation of value added-chains and costs analysis.

Theme 4: Testimonies from the field – Good practices to manage salt-affected soils

Objectives

Critically reflect on the economics of soil salinization and sodification, focusing on the sustainable soil management practices that are cost-effective.

The presentations under Theme 4 showcased different good practices reflecting their geographic, environmental and socio-economic context, their positive effect on soil salinity and sodicity, other benefits of the practice, costs of the practice and summarizing other challenges and recommendations for scaling up those practices.

The global trend of increasing water scarcity and salinity levels in water used for irrigation (See Figure 5) is forcing governments and farmers to find solutions to “live with” salinity and to look for innovative, both low-cost and environmentally friendly innovative interventions on salinity and sodicity management.

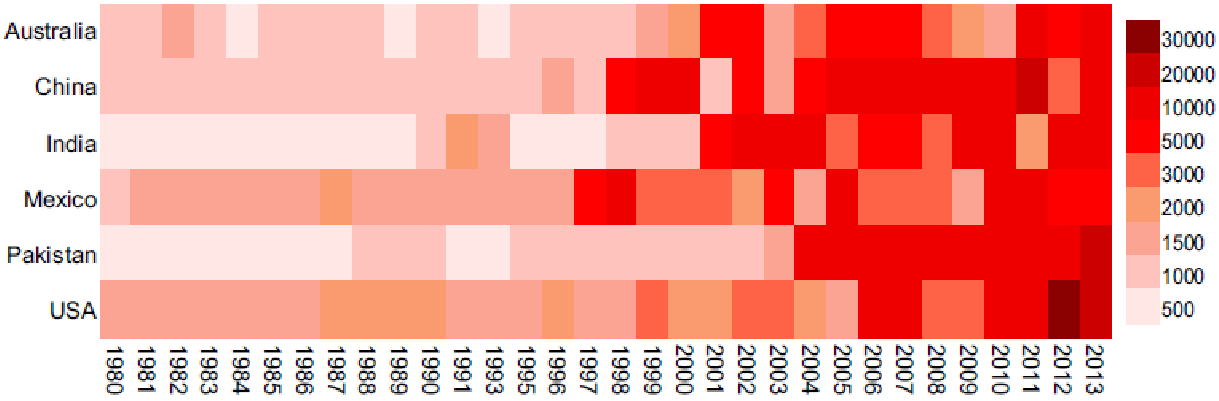


Figure 5. Heat map showing trends towards increased EC (µS/cm) in irrigation water. Source: ur Rehman, H. 2021. *Halopriming; A Low Cost and Economical Shotgun Solution for Improving Crop Stand and Productivity under Salt Affected Condition: Presentation at the Global Symposium on Salt-Affected Soils.* 20-22 October, 2021. Virtual meeting https://www.fao.org/fileadmin/user_upload/GSP/GSAS21/GSAS21_presentations/PS4-2_03_Hafeez_ur_Rehman.pdf .

There are multiple successful approaches to SAS reclamation and management, many of which are complex and require an array of human intervention related to fields such as engineering and agronomics.

The practices that are provided with economic evaluations are outlined in Table 1.

Table 1. The economic evaluation of good practices to rehabilitate and use salt-affected soils.

Name of practice	**Author(s), country**	**Economic evaluation (Cost or economic benefit) of the practice**	Page in the GSAS proceedings with more details (FAO, 2022)
Using water hyacinth as soil amendment to reclaim and boost productivity of calcareous sodic soils	Arora S., Singh Y.P., Singh A.K., Mishra V.K., Sharma D.K. **India**	5 USD/ha for labour cost (where water hyacinth is freely available in water bodies)	P. 314
Land shaping practice for management of low-lying salt affected coastal soil	Burman D., Mandal S., Mandal U.K., Sarrangi S.K., Mahanta K.K., Lama T.D., Raut S., Maji B., Sharma P.C. **India**	Cost: 1 158 – 1 921 USD/ha	P. 318
Haloculture for hyper-saline drain water reuse and combating dust prone regions	Hasheminejhad Y., Dehghani F., Ranjbar G., Rahimian M. **Iran**	35 000 USD/50 ha cost for installation; >10 000 USD/year of economic profit from the system	P. 330
Controlled subsurface drainage for the management of water table, soil salinity and nutrient losses in waterlogged saline vertisols of TBP command area of Karnataka, India	Karegoudar A.V., Vishwanath J., Rajkumar R.H., Anand S.R., Kaledhonkar M.J. **India**	The adaptation of the controlled drainage system to the existing subsurface drainage required an additional cost of about 16 USD/ha	P. 338
Addition of biochar in saline soils to increase productivity in wheat in central Mexico	Medina-Orozco L.E., Sánchez-Duque A., Mondragón-Sánchez A., Medina-Orozco I.N. **Mexico**	Cost: 45 USD (for construction of bioreactor), 0 USD (for residues) Added economic benefit: 96 USD/ton or 672 USD/ha (in case of 7 t/ha yield)	P. 346
Mix water tools for risk reductions when using non-conventional water resources	Pedrero F., Parra A., García A., Ortuño M.F., Alarcón J.J. **Spain**	Cost: around 5 000 Euro	P. 349
Agronomic management for rice cultivation in inland saline soil of northeast Thailand (Using green manure (Sesbania rostrata) for rice cultivation in saline soils of Northeast Thailand)	Pongwichian P., Arunin S. **Thailand**	Total cost: 450 USD/ha (including labor cost for land preparation, planting rice, harvesting, rice seed, green manure seed and chemical fertilizers). Separate cost for application of green manure is not available	P. 351
Laser land leveling: Enhancing water productivity in Tungabhadra command area	Rajkumar R.H., Vishwanatha J., Karegoudar A.V., Anand S.R., Dandekar A.T., Kaledhonkar M.J. **India**	Cost: 530 USD/ha Gross returns: 1 870 USD/ha Net returns: 1340 USD/ha Benefit-to-cost ratio: 3.5	P. 354

Name of practice	**Author(s), country**	**Economic evaluation (Cost or economic benefit) of the practice**	Page in the GSAS proceedings with more details (FAO, 2022)
Halopriming; a low cost and economical shotgun solution for improving crop stand and productivity under salt affected condition	ur Rehman H., Afzal I., Basra S.M.A. **Pakistan**	36 percent increase in Benefit to cost ratio over control	P. 357
The application of the effective actions for improvement the chemical and physical properties of Saline-Alkaline soils	Sahakyan S.V., Yedoyan T.V. **Armenia**	Cost: 7 000 USD (practice) + 5 000 USD (electric energy cost) per hectare	P. 360
Halophyte (Dixie grass) plantation for rehabilitation severely saline soil in northeastern region, Thailand	Sasithorn K., Chuaysanoi P., Pongwichain P., Arunin S. **Thailand**	Cost: 450 USD/ha	P. 362
The management of subsurface drip irrigation (SDI) by unconventional water in pistachio orchards in severe soil salinity and alkalinity condition	Sherafati A., Torbaghan M.E. **Iran**	Cost: 1 410 USD/ha Economic benefit: 12 800 USD/ha	P. 365
Transforming homesteads of moderately saline area to adopt climate extremes in coastal region (Bangladesh)	Shoaib J.U., Biswas A., Hossain K.T., Hoque A.F.M.M. **Bangladesh**	The cost-benefit ratio is 1:1.5 in first two years and 1: 2.5 after two years. Farmers need financial support during the installation of such technology.	P. 370
Coastal single cropped land converted to year-round cropping (Bangladesh)	Shoaib J.U., Hoque A.F.M.M. **Bangladesh**	Initial cost of establishment of this practice is about USD 2 400 and the farmer can earn about USD 4 100 per year per ha. There is a minimum cost for maintenance, amounting to USD 100 per year per ha.	P. 374
Usage of Gher boundary for cropping (Bangladesh)	Shoaib J.U.M. **Bangladesh**	Additional cost to normal “Gher” establishment of this technology were estimated in 2013 as about USD 20 and USD 1 per ha for seed/seedling. Cost of “Gher” cost about USD 1 000/ha. At present valuation outcome of the “Gher” from vegetables USD 800/ha, rice 192/ha and from fish USD 250/ha.	P. 378
Seaweed cultivation to harness the productivity of poorly drained saline lands	Singh P., Kumar S. **India**	Economic benefit: 500-1 000 USD per ton of dried seaweed (Gracilaria)	P. 384

Name of practice	**Author(s), country**	**Economic evaluation (Cost or economic benefit) of the practice**	Page in the GSAS proceedings with more details (FAO, 2022)
Large-scale barren saline-alkali land amelioration with flue gas desulfurization gypsum in Northeast China	Zhao Yonggan, Wang Shujuan, Liu Jia, Li Yan, Zhuo Yuqun **China**	Cost: 3 315 – 12 215 USD/ha (depending on sodicity severity class)	P. 386
Biological improvement of saline-alkali land by planting two cultivated species of barnyard (Echinochloa)	Zhu Lin, Xu Xing, Wang Xueqin, Lan Yan **China**	Cost: 2 616 USD/ha Economic benefit: 4 035 USD/ha	P. 390

Discussions revealed the acute need of demonstration plots of good practices where all details of technologies and interventions can be shown. This can be achieved via virtual modality which is becoming widespread now and allows people to easily share the experience from different places of the world. For wider adoption and upscaling of practices, cost and benefit evaluation of practices are much needed. Most of the presentations in Session 4 focused on nature-based practices. It was pointed out that engineering, physical and chemical methods are costly for reclamation and rehabilitation of saline and sodic soils, while biological methods can be used locally, at the farm level, and have multiple benefits (See Figure 6).

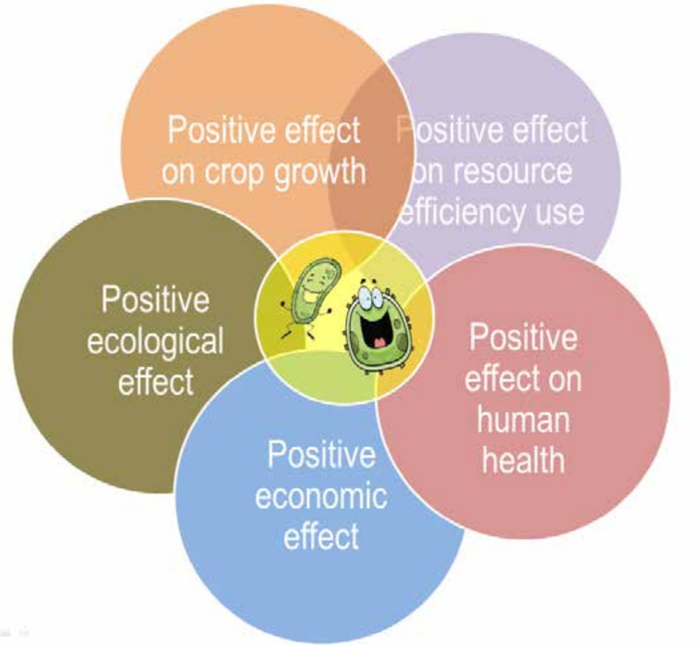


Figure 6. The multiple implications of biological methods for the reclamation and rehabilitation of salt-affected soils.

Microorganisms are central to adaptation approaches and to improving plant tolerance to abiotic stress, including salinity stress. Specifically, microbiological approaches can assist in the following ways:

Improving crop growth

- Augmenting seed germination;
- transforming phosphorus and potassium into forms available for plants;
- normalizing pH levels in alkaline soil;
- elevating microbial balance and plant nutrition through macroelements and microelements;
- stimulating root formation;
- restoring the fertility of salt-affected soils;
- eliminating toxic salts;
- improving plant immunity and resistance to stress;
- limiting incidence cases; and
- augmenting grain yields.

Improving soil health and environments

- Normalizing the balance of soil microflora and improving the biodiversity of soil flora and fauna;
- reducing the doses of mineral fertilizers by 25-50 percent in accordance with the agrochemical composition of the soil;
- decreasing or eradicating chemical pesticides for seed treatment and substituting them with environmentally friendly biopesticides;

- moderating the impact of chemicals on the agroecosystem;
- decreasing salinity and soil contamination by mycotoxins and organochlorine pesticides; and
- progressively restoring soil fertility;

Improving economic effect

- Augmenting crop yield;
- reducing the impact of pests on plants by increasing their immunity;
- truncating crop ripening times by 15-20 days; and
- decreasing fertilizer doses.

Increasing the efficient use of resources

- Improving the efficiency of fertilizer applications by rendering them more easily available;
- reducing irrigation costs; and
- reducing the costs of sowing seeds.

Improving human health

- Increasing food quality; and
- improving the overall health of the population.

In severely saline and sodic soils, a specific group of microorganisms that grow optimally in the presence of high salt concentrations (halophilic microorganisms) play an important role in adaptation and increase the tolerance of agricultural plants to abiotic stresses. Thus, applying halophilic microorganisms in extremely saline soils can induce vegetation growth, thereby augmenting soil recovery. In addition, they enhance the production of organic acids, thus reducing soil pH. Plant-microbe interaction is a beneficial association and can be an efficient method to be used for the reclamation of salt-affected soils. Moreover, halophilic bacteria assist in food processing, the production of industrial enzymes, bioremediation, the establishment of protective biomolecules, and the promotion of plant growth.

©India Water Portal

Conclusions and way forward

GSAS21 addressed one of the most acute soil threats worldwide – soil salinization and sodification - challenging the sustainable development of countries with arid and semiarid climates and extensive coastal areas. The Symposium gathered together specialists and practitioners engaged in activities with FAO, the GSP and its ITPS, INSAS, WASAG, SPI-UNCCD, Government of the Republic of Uzbekistan, IUSS, ICBA, together with independent scientists, policy makers and farmers. The ultimate goal of the meeting was to develop a roadmap that will help to concentrate and drive the joint efforts of multiple stakeholders globally in order to improve the status of salt-affected soils, increase their productivity and biodiversity, and optimize their role in mitigating the impact of climate change. The recommendations that evolved from the presentations and discussions held at the Symposium are presented in this Outcome document. UN members and especially their policy advisors and decision-makers are encouraged to use this document and to implement, support and stimulate the realization of these recommendations at national and local levels.

The International Network on Salt-Affected Soils (INSAS)[2] launched under the framework of the FAO's Global Soil Partnership will serve as a supportive tool to implement the VGSSM and the recommendations of the GSAS21 outcome document by developing guidelines, raising awareness, improving capacities, harmonizing the methods and approaches as well as upscaling good practices for sustainable soil management, specifically in areas suffering from water shortages and salinization/ sodification.

Theme 1: Assessment, mapping, and monitoring of salt-affected soils

Recommendation 1

- Support the harmonization of the procedures of soil salinity, sodicity and alkalinity **assessment;**
    - √ SOPs: Standard Operating Procedures for salinity / sodicity / alkalinity measurements;
    - √ classification: Harmonization of the criteria (ranges, values) on the assessment of salt-affected soils; and
    - √ calibration: develop calibrations between different methods.

Recommendation 2

- Refine and update the protocols for **mapping** of salt-affected soils using modern approaches[3];
    - √ facilitate the use of proximal (EMI, soil spectroscopy) and remote soil sensing techniques for mapping of salt-affected soils; and
    - √ support the development of a harmonized sampling protocol for mapping salt-affected soils.

Recommendation 3

- Promote national and regional programmes designed at **monitoring** salt-affected soils;
    - √ support the development of methodology for monitoring salt-affected soils and background factors of salinization and sodification; and
    - √ contribute to the continuous update and improvement of the GSASmap as part of the Global Soil Information system (GLOSIS) which is a federation of National Soil Information Systems (NSISs) aimed to monitor the overall soil health.

Recommendation 4

- Promote the formulation and wider use of **indicators** of soil salinity and sodicity as part of soil health, food security and desertification/aridization assessment.

---

[2] The International Network of Salt-Affected Soils (INSAS), launched in 2019 during the International Center for Biosaline Agriculture's (ICBA) first Global Forum on Innovations for Marginal Environments, is a technical network of the Global Soil Partnership (GSP). The first meeting of INSAS was held on 14-15 April 2021 where the working groups and governance of the network were established. More details can be found at https://www.fao.org/global-soil-partnership/insas/en/.

[3] Mapping of Salt-affected Soils - Technical Specifications and Country Guidelines (FAO, 2020): https://www.fao.org/documents/card/en/c/ca9203en

Theme 2. Integrated soil – water – crop solutions for the rehabilitation and management of salt-affected areas

Recommendation 5

- Promote the adoption of **good practices** that have a proven positive effect on soil health and productivity of salt-affected soils;
  - √ contribute to and support the documenting of good practices for sustainable management of salt-affected soils;
  - √ render good practices accessible for farmers and extension services, the intention being to ensure their adoption through the dissemination of information via leaflets, training, and video tutorials; and
  - √ promote halophyte agriculture in severely salt-affected areas.

Recommendation 6

- Support the development of **water quality criteria** relevant to sustainable management of irrigated soils that is designed **to avert soil salinization and sodification**. This can be achieved by developing and adhering to guidelines for the use of brackish and non-conventional water.

Theme 3. An action plan designed to prevent and rehabilitate salt-affected soils, protect natural saline and sodic soils, and scale-up sustainable soil management practices

Recommendation 7

- Design **strategies** aimed at the adoption of good practices/options by farmers in salt-affected soils through technical support, incentives, extension services (including the Global Soil Doctors program).

Recommendation 8

- Conduct an **economic assessment** of implementing good practices in the field, including short-term and long-term economic and environmental costs and benefits evaluation.

Recommendation 9

- Support the development of **policy frameworks** for fostering the sustainable management of salt-affected soils, for preventing and reversing further degradation and promoting the conservation of the valuable natural salt-affected ecosystems at the national and global levels;
  - √ advocate and raise awareness of the threat posed by salinization/sodification;
  - √ facilitate the involvement of multiple stakeholders in salt-affected soils networks, including the International Network of Salt-Affected Soils;
  - √ design and implement a capacity development programme at all levels; and
  - √ build multidisciplinary partnerships and use community-based approach at all levels for implementation of policies and strategies onsite.

References

European Commission. Joint Research Centre. 2018. *World atlas of desertification: rethinking land degradation and sustainable land management*. LU, Publications Office http://wad.jrc.ec.europa.eu

FAO. 2017. *Voluntary Guidelines for Sustainable Soil Management Food and Agriculture Organization of the United Nations*. Rome https://www.fao.org/3/bl813e/bl813e.pdf

FAO. 2021. *Global map of salt-affected soils. GSASmap v. 1.0*. Rome https://www.fao.org/3/cb7247en/cb7247en.pdf

FAO. 2022. *Halt Soil Salinization, Boost Soil Productivity - Global Symposium on Salt-Affected Soils, 20-22 October 2021. Proceedings*. Rome. DOI (available soon)

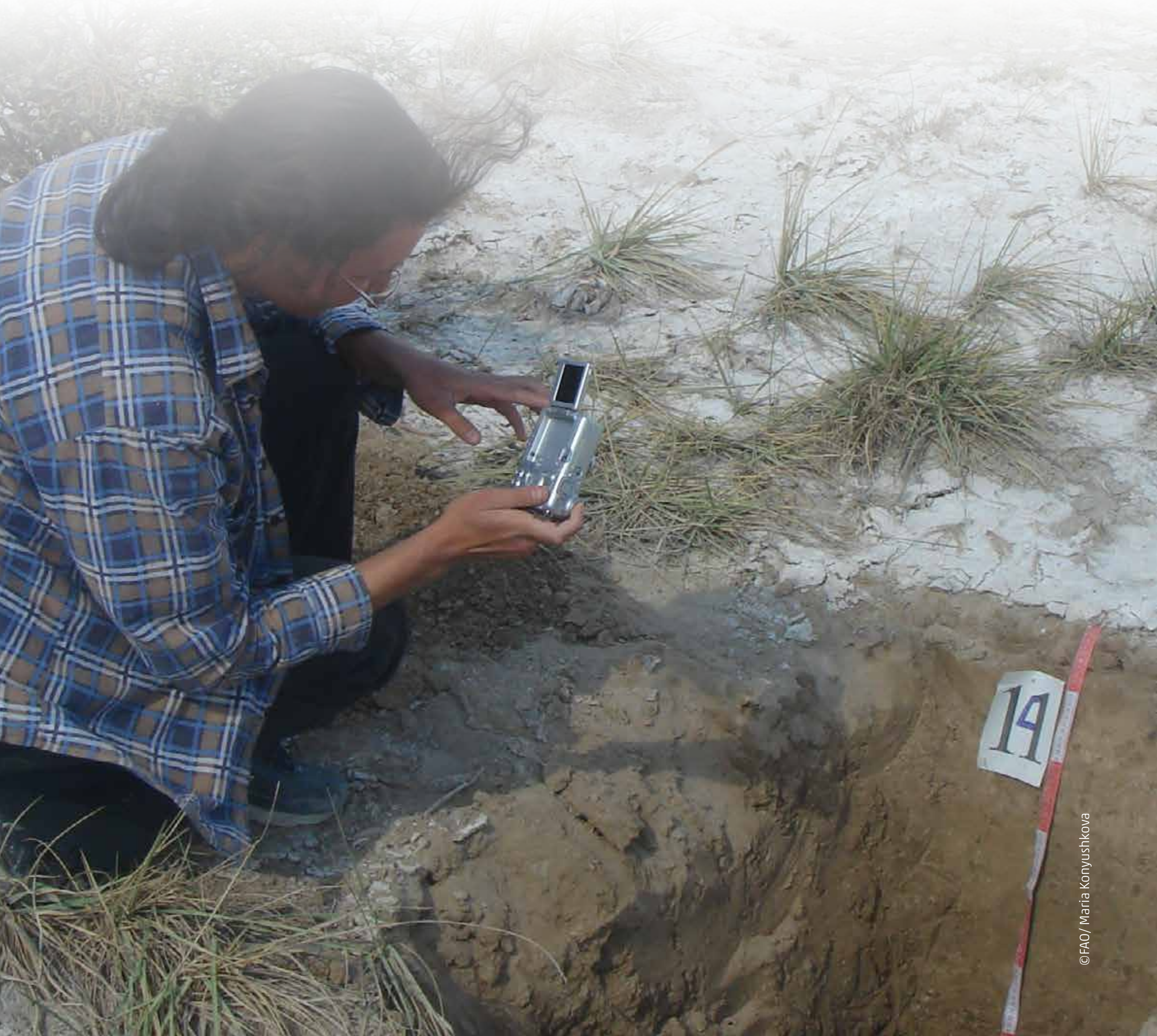
FAO & ITPS. 2015. *Status of the World's Soil Resources (Main Report)*. FAO, Rome. 608 pp. http://www.fao.org/3/a-i5199e.pdf

Oldeman, L.R., Hakkeling, R.T.A. & Sombroek, W.G. 1991. *World Map of the Status of Human-Induced Soil Degradation. An Explanatory Note*. Second revised edition. International Soil Reference and Information Center (ISRIC), Wageningen, 35 pp.

UN-Water. 2020. *UN-Water Analytical Brief on Unconventional Water Resources*. Geneva, Switzerland https://www.unwater.org/app/uploads/2020/06/UN-Water-Analytical-Brief-Unconventional-Water-Resources.pdf

Qadir, M., Quillérou, E., Nangia, V., Murtaza, G., Singh, M., Thomas, R.J., Drechsel, P. *et al.* **2014**. Economics of salt-induced land degradation and restoration. *Natural Resources Forum*, 38(4): 282–295. https://doi.org/10.1111/1477-8947.12054

WWAP (United Nations World Water Assessment Programme) / UN-Water. 2018. *The United Nations World Water Development Report 2018: Nature-Based Solutions for Water*. Paris, UNESCO.



©FAO/ Maria Konyushkova

GLOBAL SOIL PARTNERSHIP

The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote Sustainable Soil Management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

Land and Water division
GSP-secretariat@fao.org
www.fao.org/global-soil-partnership

Food and Agriculture Organization of the United Nations
Rome, Italy

Thanks to the financial support of

European Commission

Ministry of Finance of the
Russian Federation

CB9929EN/1/05.22