Food and Agriculture Organization of the United Nations

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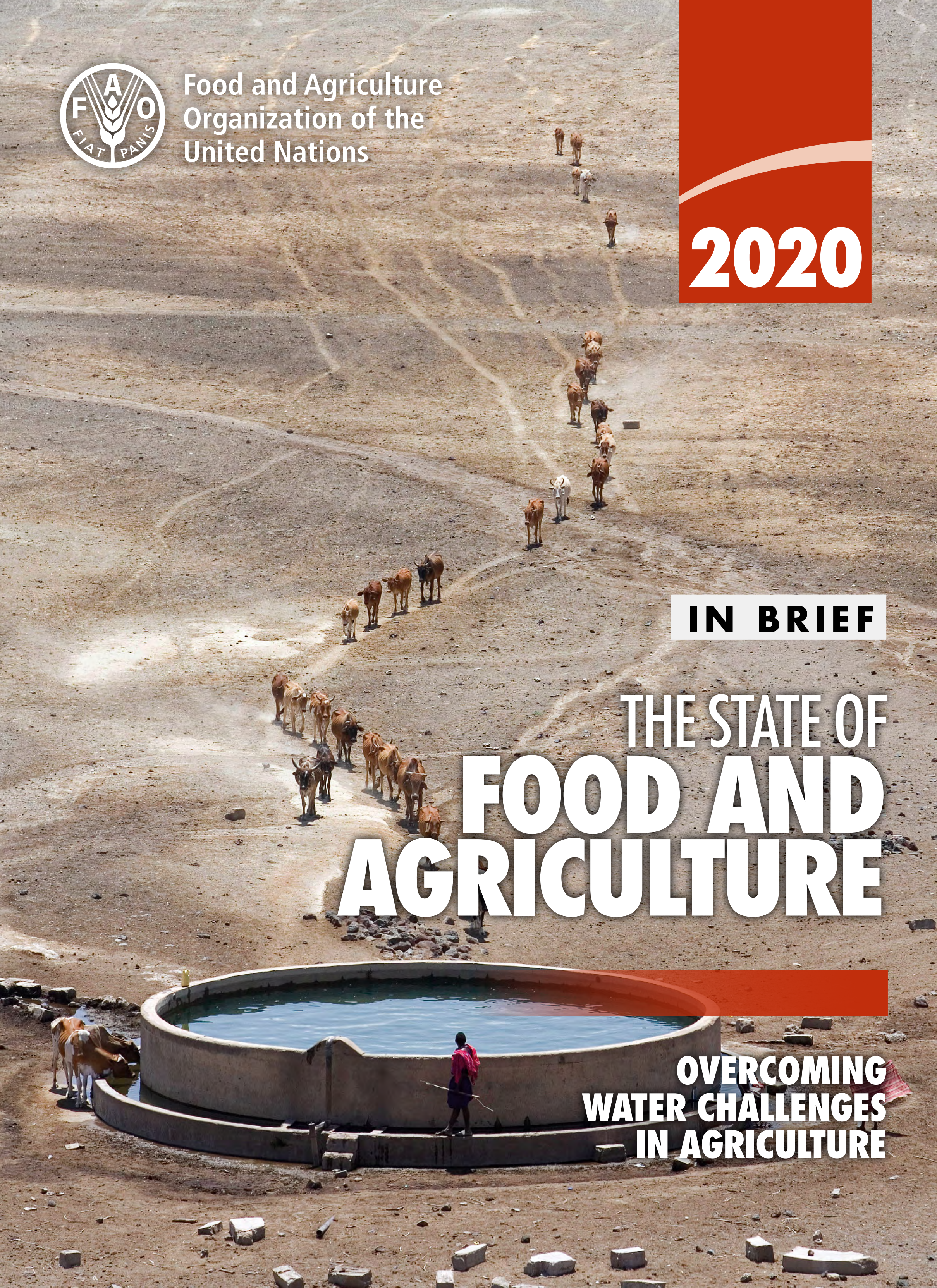

IN BRIEF

THE STATE OF FOOD AND AGRICULTURE

OVERCOMING WATER CHALLENGES IN AGRICULTURE

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COVER PHOTOGRAPH ©FAO/Giulio Napolitano
KENYA. Pastoralists and herds of livestock gather at a water well in a dry area of Lake Magadi.

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CORE MESSAGES

➔ Achieving sustainable development faces a key challenge: 3.2 billion people live in agricultural areas with high to very high water shortages or scarcity, of whom 1.2 billion people – roughly one-sixth of the world's population – live in severely water-constrained agricultural areas.

➔ Population growth is a key driver of water scarcity as it implies rising demand for this precious natural resource. Consequently, the annual amount of available freshwater resources per person has declined by more than 20 percent in the past two decades.

➔ Socio-economic development is another important driver of increasing demand for water, as it contributes to shifting diets towards more water-intensive foods (e.g. meat and dairy products). Healthy diets that include sustainability considerations at the food systems level can reduce the associated water consumption.

➔ Rising competition for water and the effects of climate change are leading to tensions and conflicts among stakeholders, thereby exacerbating inequalities in access to water, especially for vulnerable populations, including the rural poor, women and indigenous populations.

➔ With ten years to go until 2030, first estimates for Sustainable Development Goal (SDG) Indicator 6.4.2 on water stress, together with persistent water shortages in rainfed agriculture, suggest that ensuring sustainable management of water for all remains a challenge. As water is closely linked to several other SDGs, not least that of achieving Zero Hunger, managing scarce water resources well will be a critical determinant for fully achieving them.

➔ Success is still achievable, but only by ensuring more productive and sustainable use of freshwater and rainwater in agriculture, the world's largest water user, accounting for more than 70 percent of global withdrawals.

➔ Improving sustainability of water use in agriculture will mean guaranteeing environmental flow requirements to sustain ecosystem functions, which are often overlooked – it has been estimated that 41 percent of current global irrigation water use occurs at the expense of environmental flow requirements. This will entail reducing withdrawals and improving water-use efficiency in those watersheds where environmental flow requirements are not guaranteed.

➔ Water accounting and auditing, which are rarely done, should therefore be the starting point of any effective strategy for addressing water shortages and scarcity. FAO's recent sourcebook provides a good starting point for all those wishing to implement water accounting and auditing.

➔ Producers – many of them small-scale farmers – working on 128 million hectares (or 11 percent) of rainfed cropland affected by recurring drought can greatly benefit from water-harvesting and water-conservation techniques. By one estimate, these practices could boost rainfed kilocalorie production by up to 24 percent and, if combined with irrigation expansion, by more than 40 percent.

➔ For herders working on 656 million hectares (or 14 percent) of drought-affected pastureland, a variety of farming measures can buffer the impact of drought and improve water productivity. Many of these measures are indirectly related to water, including disease control and animal health, livestock feeding and drinking management, mobility and stratification of production to reduce grazing pressure in arid areas.

➔ For the 171 million hectares (or 62 percent) of the world's irrigated cropland under high or very high water stress, priority should be given to incentivizing practices that increase water productivity – including rehabilitation and modernization of existing irrigation infrastructure and adoption of innovative technologies. These should be combined with improved water governance to guarantee equitable allocation and access to water, as well as environmental flow requirements. In sub-Saharan Africa, irrigated areas are expected to more than double by 2050, benefiting millions of small-scale farmers.

➔ Investing in non-consumptive uses of water – as can be done in aquaculture – and in non-conventional sources of water, such as water reuse and desalination, is an increasingly important strategy to offset scarcity; however, examples in this report show that innovations must be economically efficient, socially acceptable, environmentally sustainable and appropriate to the context.

➔ Policies and regulations play a central role in boosting the implementation of technologies and innovations, for example, through financing, capacity-development programmes and enforcing environmental flow requirements. However, they require appropriate allocation of water rights and secure water tenure to enable secure, equitable and sustainable access to water, especially for the most vulnerable, while ensuring environmental flow requirements.

➔ Policy coherence and governance mechanisms across administrative scales and sectors are essential for efficient, sustainable and equitable water resources management. In agriculture, specifically, coherent and inclusive strategies are needed across rainfed and irrigated cropland, livestock production systems, inland fisheries, aquaculture and forestry.

FOREWORD

Our very existence depends on water – water to drink and water to grow food. Agriculture relies on freshwater from rivers, lakes and aquifers. Rainfed agriculture and much of livestock production depend on the water from limited rainfall. Moreover, water-related ecosystems also sustain livelihoods, food security and nutrition by, *inter alia*, supporting inland fisheries and aquaculture. Supplies of uncontaminated freshwater are needed for safe drinking water, and to ensure hygiene and food safety standards to guarantee human health. In addition, water has numerous other uses and supports other human activities.

Against this backdrop, no doubt, water underpins many of the Sustainable Development Goals (SDGs). SDG 6, in particular, seeks to ensure availability and sustainable management of water and sanitation for all. Unfortunately, this report shows that achieving this objective by 2030 will be a challenge. The need to "produce more with less" is underscored by the fact that, with growing population, the freshwater resources available per person have declined by more than 20 percent in the last two decades. As demand rises, freshwater becomes increasingly scarce, competition for it intensifies, and excessive water withdrawals threaten water-related ecosystems and the ecosystem services they provide. Agriculture has an important role to play on the path to sustainability, as irrigated agriculture accounts for more than 70 percent of global water withdrawals, and, globally, 41 percent of withdrawals are not compatible with sustaining ecosystem services. Rainfed agriculture is called on to complement irrigation from scarce freshwater resources, yet rainwater also arrives in finite amounts. In addition, climate change is already seriously disrupting rainfall patterns. Increased drought frequency and consequent water shortages in rainfed agriculture represent significant risks to livelihoods and food security, particularly of the most vulnerable populations in the least developed parts of the world.

We must take very seriously both water scarcity (the imbalance between supply and demand for freshwater resources) and water shortages (reflected in inadequate rainfall patterns), for they are now the reality we all live with. Thanks to work by the Food and Agriculture Organization of the United Nations (FAO), we can assess how many people and how much land are experiencing water scarcity and water shortages. This report estimates that 1.2 billion people live in agricultural areas experiencing very high levels of water stress (affecting irrigated areas) or very high drought frequency (affecting rainfed cropland and pastureland). Of these, 520 million live in rural areas, while 660 million live in small urban centres surrounded by agricultural land. If we also include areas that experience high (in addition to very high) levels of water stress and drought frequency, the overall number increases to 3.2 billion, of whom 1.4 billion live in rural areas. In relative terms, about 11 percent of total cropland and 14 percent of pastureland experience recurring droughts, while more than 60 percent of irrigated cropland is highly water-stressed. These first estimates for SDG Indicator 6.4.2 on water stress, and the evidence of persistent water shortages in rainfed agriculture, underscore the need for urgent action to ensure that water is managed sustainably. In the absence of such action, the rising demand for water and the increasing effects of climate change risk worsening the situation.

Beyond SDG 6, addressing water shortages and scarcity is essential for many other goals of the 2030 Agenda for Sustainable Development (2030 Agenda), not least that of achieving Zero Hunger. The world still has ten years to achieve these objectives, but we can only succeed if we make better and more productive use of our limited water resources, both freshwater and rainwater. Agriculture is central to this challenge, not only because it is seriously affected by water constraints, but because it is the world's largest water user. This means that the way agriculture uses freshwater is crucial to ensuring availability for other activities and preserving water-related ecosystems. As the world aims to shift to healthy diets – often composed of relatively water-intensive foods, such as legumes, nuts, poultry and dairy products – the sustainable use of water resources will be ever more crucial. Rainfed agriculture provides the largest share of global food production. However, for it to continue to do so, we must improve how we manage water resources from limited rainfall.

With this report, FAO is sending a strong message: water shortages and scarcity in agriculture must be addressed immediately and boldly if our pledge to commit to achieve the SDGs is to be taken seriously. Global food security and nutrition are at stake. Water shortages and scarcity jeopardize the environment that is necessary to enable and ensure access to food for millions of people who are hungry in many parts of the world and to reduce the cost of nutritious food so as to ensure billions of people will be able to afford a healthy diet. Growing competition for water – including among sectors, among users and, sometimes, among countries – also leads to serious challenges. In the absence of appropriate governance, the increased competition can exacerbate already severe inequalities in access to water. Again, those most at risk are the poorest and most vulnerable groups, such as small-scale farmers and women. Communities and individuals reliant on water-related ecosystems, such as inland fisherfolk, also risk losing out as they are frequently neglected. In the worst case, increased competition can lead to conflicts at all levels – from local to international – and among different groups.

For this reason, a key emphasis of this report is on improved water governance, which aims at ensuring the most productive use of limited water resources, while safeguarding water-related ecosystem services and ensuring equitable access for all. While water governance in agriculture has focused on irrigation, this report broadens the scope to cover the challenges in rainfed agriculture, including pastoral systems. It further recognizes the importance of restoring and maintaining environmental flows and ensuring environmental services. It places water accounting and auditing at the centre of any programme to overcome water constraints. The report takes the view that water accounting and auditing are best designed and implemented as mutually supportive processes. By connecting people and their relationship with water resources to the broader water balance, this report also highlights the potential of water tenure in addressing water constraints and complementing auditing and accounting. With the importance of governance as the underlying theme, the report lays out suggested courses of action at three different levels: (i) technical and management; (ii) institutional and legal; and (iii) broader policy.

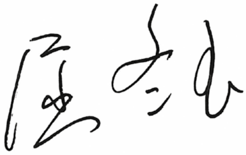
At the technical and management level, a key challenge is to unlock the potential of rainfed agriculture through improved water management. This involves either better conservation of water in soils or the adoption of rainwater harvesting techniques. The productivity of irrigated systems can be significantly enhanced through investments in new irrigation systems or the rehabilitation and modernization of existing ones. In all instances, improved water management practices are most effective when combined with improved agricultural practices, such as the use of drought-tolerant varieties. Options also exist in livestock production to improve water productivity, such as through improved grazing and animal health. However, actions at the farm level must be part of a broader landscape-level approach to account for effects on water balances in catchments and river basins.

This calls for effective institutional and legal frameworks that, once adapted to each specific context, will enable improved water governance and, consequently, innovative management strategies. The starting point for any effective water management and governance strategy should be water accounting and auditing. Subsequently, effective institutions and regulations that promote coordination among actors are required to manage competing demands for water, ensure equitable access and safeguard ecosystems. A cornerstone of this approach is secure water and land tenure, which – also in combination with water trading and pricing mechanisms – can establish incentives for efficient water use. Often, community-based water users associations can contribute to improved water management. However, solutions must be adapted to local conditions and developed by or with the stakeholders concerned.

Finally, at the level of the broader policy environment, policy coherence and coordination are crucial. This applies across and within sectors and locations. Coherent strategies are needed across rainfed and irrigated cropland, livestock production systems, forestry, and inland fisheries and aquaculture. Incentives represent a key element of policy coherence and should promote water productivity and ecosystem protection. However, subsidies on inputs, energy and production may promote inefficiencies and unsustainable use of water; for example, in the form of excessive groundwater abstraction.

There is no "one-size-fits-all" approach to addressing water shortages and scarcity. Different countries – and even different regions within countries – have different characteristics and face different challenges. Therefore, the solutions proposed by the report are consistent with the territorial approaches adopted by FAO's Hand-in-Hand Initiative to target problems and challenges at the territorial subnational level. The report proposes potential policy priorities in different types of production that can be tailored, for both irrigated and rainfed agriculture, using geospatial data available through FAO.

To paraphrase Benjamin Franklin, who was also a distinguished scientist, let us not wait until the well is dry to understand the worth of water. This report highlights the urgency of the problem at hand, and the important role that the agriculture sector must play to address growing water shortages and scarcity. I invite all stakeholders to read the report and, from their perspective, take from it appropriate options for addressing water-related challenges and, more importantly, implement them so as to improve food security and nutrition, and environmental sustainability, in the spirit of the 2030 Agenda.



Qu Dongyu
FAO Director-General

SUMMARY

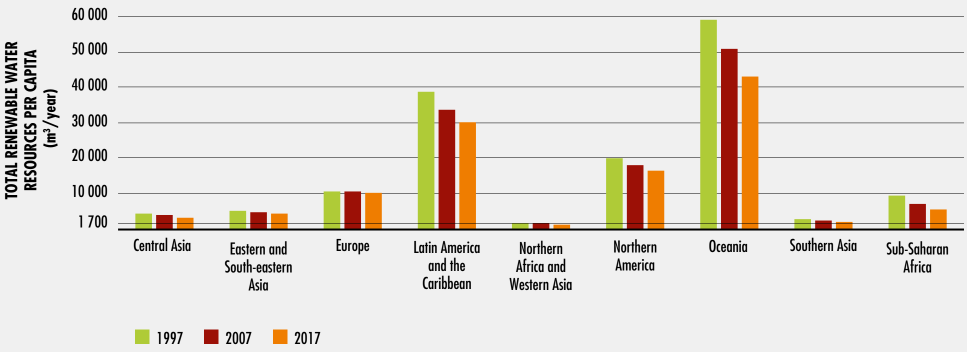
WATER SHORTAGES AND SCARCITY AROUND THE WORLD – WHAT DO WE KNOW?

Critical water resources are under increasing pressure worldwide

Sustainable and equitable management of water resources is a key element of sustainable food systems and essential for achieving Zero Hunger. However, water scarcity (the imbalance between supply and demand of freshwater) and water quality issues are increasingly threatening food security and nutrition through their impacts on food systems – from agricultural production, through food processing to households and consumers. At the same time, persistent and severe droughts, exacerbated by climate change, are causing increasingly serious water shortages in rainfed agriculture, posing a risk to the livelihoods of rural people by reducing crop and livestock yields. Population growth is a key driver of water scarcity. In the last two decades, the annual amount of available freshwater per person has declined by more than 20 percent (Figure 2). This is a particularly serious issue in Northern Africa and Western Asia, where the average annual volume of water per person barely reaches 1 000 m^3, which is conventionally considered the threshold for severe water scarcity. Other important drivers are rising incomes, urbanization, and climate change. The situation will only grow worse if immediate action is not taken – the reason why *The State of Food and Agriculture 2020* report addresses the two main water challenges affecting agriculture and food production: water shortages in rainfed agriculture and scarcity, affecting irrigated agriculture.

For the challenges it presents not only to achieving Zero Hunger but also to meeting a myriad of other Sustainable Development Goals (SDGs), the urgent need of ensuring sustainable management of water for all features prominently in the 2030 Agenda for Sustainable Development. In particular, SDG 6 – Ensure availability and sustainable management of water and sanitation for all – covers many key dimensions relating to the availability and management of water. Growing concern over water scarcity and misuse is reflected more specifically in SDG Target 6.4, which calls for increasing water-use efficiency and ensuring

FIGURE 2 PER CAPITA RENEWABLE FRESHWATER RESOURCES BY REGION, 1997–2017



NOTES: Average renewable freshwater resources per person are measured in cubic metres per person per year. Population data refer to the World Population Prospects: The 2019 Revision from the United Nations Department of Economic and Social Affairs (UN DESA). Oceania includes Australia and New Zealand.
SOURCE: FAO elaboration based on FAO. 2020 and UN DESA. 2019.

sustainable withdrawals and supply of freshwater to address water scarcity.

This report presents new findings on the progress towards SDG Target 6.4 and estimates how many people and how much agricultural land are experiencing water scarcity (through SDG Indicator 6.4.2 on water stress) and water shortages (through the historical drought frequency indicator).

Climate change will exacerbate water-related challenges

The challenges of water shortages and scarcity must be addressed together with the anticipated impacts of climate change, which are expected to increase the risk of extreme weather events, such as floods and climate variability. This, in turn, will increase pressure on agricultural production, as crop growth and yields are highly sensitive to climate conditions. Although there is uncertainty as to their location and magnitude, climate change impacts are expected to exacerbate water constraints, and negatively affect agricultural production, especially in low-latitude and tropical regions. Climate change also affects freshwater ecosystems, fish and other aquatic populations.

How many people and how much agricultural land are experiencing water constraints, and where?

About 1.2 billion people – roughly one-sixth of the world's population – live in severely water-constrained agricultural areas, with about 15 percent of the rural population being at risk. Around 520 million of such people live in Southern Asia, and about 460 million live in Eastern and South-eastern Asia. In Central Asia and in Northern Africa and Western Asia, about one-fifth of the population live in agricultural areas with very high water shortages or scarcity. In Europe, Latin America and the Caribbean, Northern America and Oceania, only 1–4 percent live in extremely water-constrained areas. In sub-Saharan Africa, only about 5 percent of the population live in affected areas. There, most areas are rainfed, suggesting that water constraints are driven by severe drought or lack of irrigation. While 5 percent might seem negligible, it implies that about 50 million people live in areas where severe drought has catastrophic impacts on cropland and pastureland.

In terms of agricultural land affected, 128 million hectares (or 11 percent) of rainfed cropland (Figure 5) and 656 million hectares (14 percent) of pastureland (Figure 6) face frequent droughts, while 171 million hectares (more than 60 percent) of irrigated cropland are subject to high or very high water stress (Figure 7). More than 62 million hectares of cropland and pastureland experience both severe water stress and drought frequency, affecting about 300 million people. In these areas, unless demand and user practices change or alternate water resources are found, people may be driven to migrate.

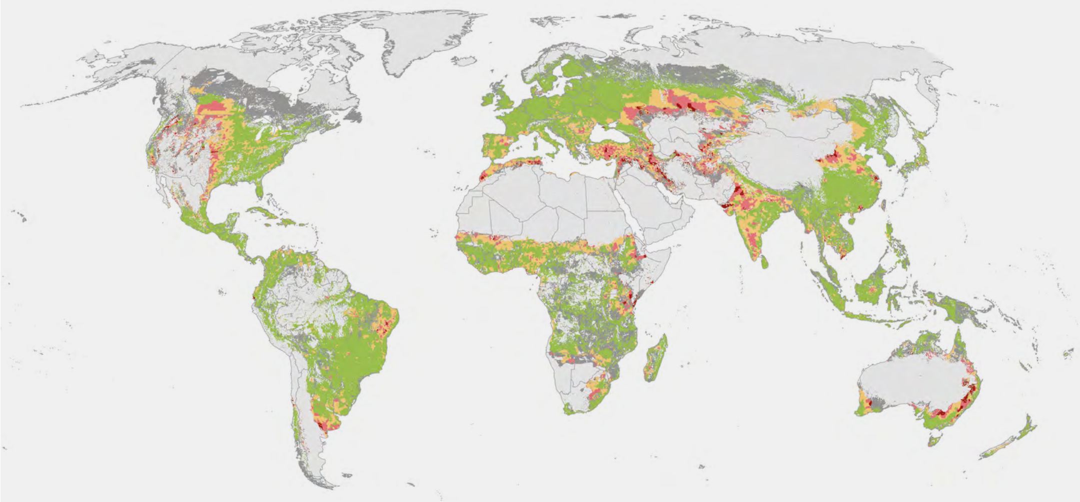
Levels of water stress and drought frequency can vary substantially within countries, and the same areas can experience different levels of water stress and drought. Some countries face the dual challenge of severe drought frequency and water stress, all of them in Northern Africa and Asia (Figure 9). Spatial analysis is essential to identify hotspots and the most appropriate interventions.

Agricultural production systems cope with, and are affected by, water constraints in different ways

Within rainfed and irrigated agriculture, different production systems may differ both in terms of how they are affected by lack of access to water and in their capacity to address it. This report distinguishes between three broad types of crop production systems: (i) irrigated; (ii) high-input rainfed production; and (iii) low-input rainfed production. Their prevalence within countries provides an indication of a country's level of agricultural development and ability to address water-related risks.

High-income countries in Europe and Northern America – which have a capital-intensive and efficient agriculture sector as well as a high rate of public expenditure on agricultural research and development (R&D) – have

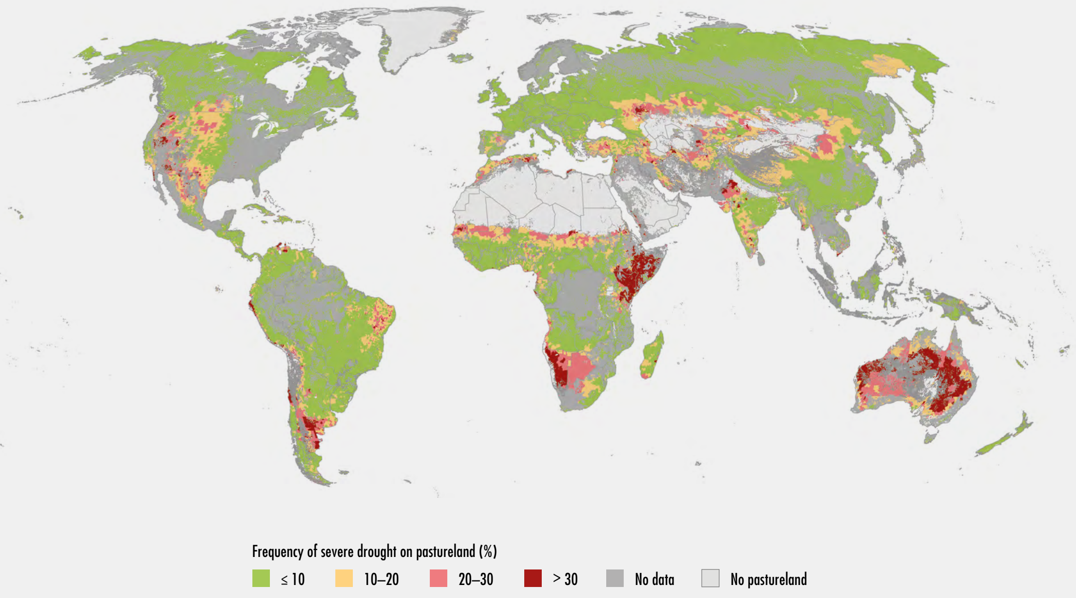
FIGURE 5 HISTORICAL DROUGHT FREQUENCY ON RAINFED CROPLAND, 1984–2018



NOTES: The map depicts the frequency with which more than 30 percent of cropland (where crop areas occupy at least 5 percent of the pixel area) was affected by severe drought as follows: low when the probability of severe drought affecting cropland is less than or equal to 10 percent; medium when it ranges between 10 and 20 percent; high for between 20 and 30 percent; and very high when it surpasses 30 percent. The indicator includes two crop-growing seasons, combined by selecting the highest drought value of the two. When there is only one season, the single value is used instead. "No data" accounts for pixels for which no level of drought is available but there is rainfed cropland, according to FAO & IIASA. 2020. The historical frequency of severe droughts is based on the entire time series (1984–2018).
SOURCE: FAO elaboration based on FAO. 2019, and FAO & IIASA. 2020.

a considerable share of cropland under high-input rainfed production (Figure 11). Consequently, they have a greater capacity to address the challenges associated with severe drought frequency. By contrast, in sub-Saharan Africa, where countries have lower levels of agricultural capital intensity and of R&D, more than 80 percent of cropland is low-input rainfed production, while only 3 percent of land is irrigated. In these countries, farmers have difficulty in accessing irrigation equipment, modern inputs and technologies, including technologies to optimize water use

FIGURE 6 HISTORICAL DROUGHT FREQUENCY ON RAINFED PASTURELAND, 1984–2018

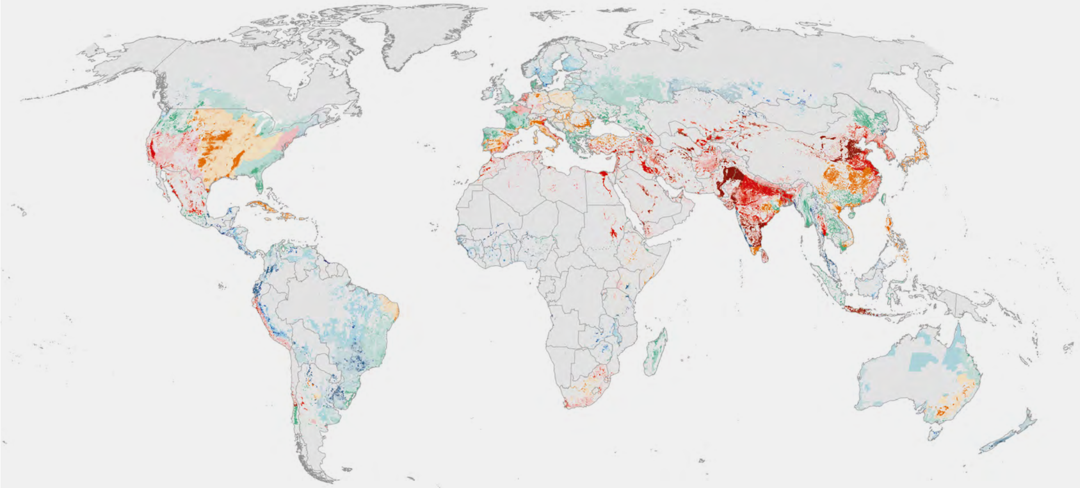


NOTES: Pastureland includes areas classified as grassland and woodland (as per FAO & IIASA. 2020), which, in turn, include grassland, shrub-covered areas and herbaceous vegetation (as per Latham *et al.* 2014). The sum of pastureland area in a pixel may be smaller than the pixel size. The map depicts the frequency with which more than 30 percent of grassland was affected by severe drought as follows: low when the probability of severe drought affecting pastureland is less than or equal to 10 percent; medium when it ranges between 10 and 20 percent; high for between 20 and 30 percent; and very high when it surpasses 30 percent. The indicator includes two crop-growing seasons, combined by selecting the highest drought value of the two. When there is only one season, the single value is used instead. "No data" accounts for pixels for which no level of drought is available but there is pastureland. The historical frequency of severe droughts is based on the entire time series (1984–2018).
SOURCE: FAO elaboration based on FAO. 2019, and FAO & IIASA. 2020.

efficiency. On a more positive note, only a relatively small share of rainfed cropland is subject to severe drought frequency. Conversely, countries in Southern Asia irrigate and employ modern inputs on about half of the region's cropland – despite the low level of development of many – while most irrigated areas are highly water stressed. ■

VIET NAM
A worker watering seedlings at an acacia tree nursery.

FIGURE 7 SDG INDICATOR 6.4.2 – LEVEL OF WATER STRESS ON IRRIGATED AREAS, 2015

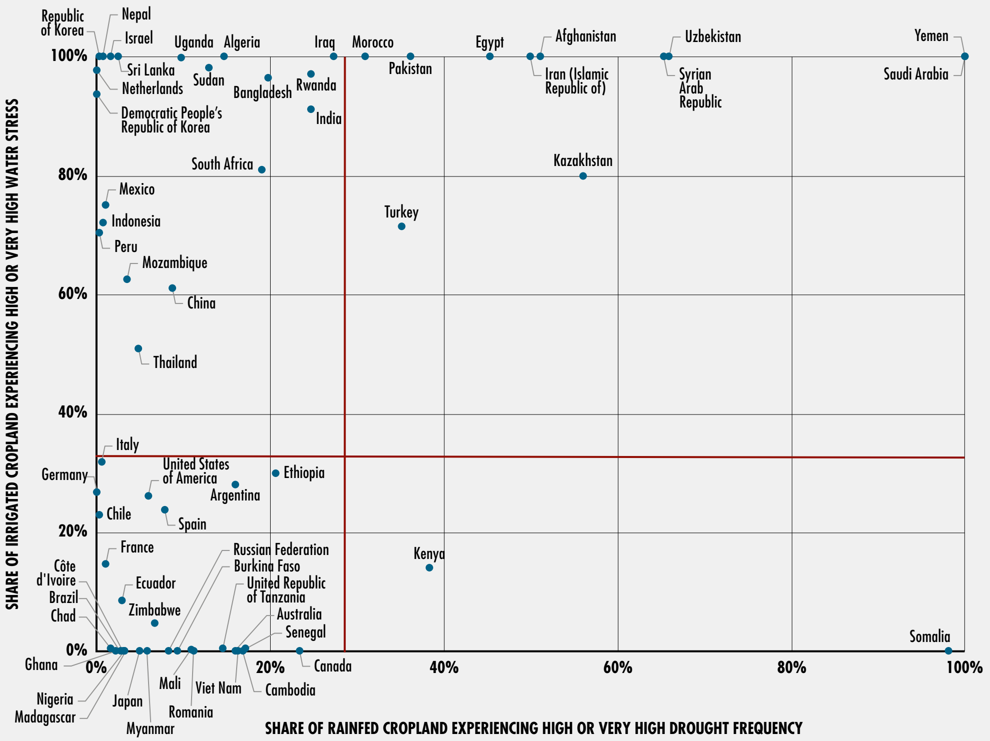


NOTES: The colour gradient shows the extent of irrigated cropland per pixel, with darker colours representing a higher number of irrigated hectares in a 10 km × 10 km pixel. SDG Indicator 6.4.2 is defined as the ratio between total freshwater withdrawn by all major sectors (agricultural, industrial and municipal) and total renewable freshwater resources, after considering environmental flow requirements. SDG Indicator 6.4.2 measures the level of water stress as follows: no water stress when the proportion of water withdrawal by all sectors in relation to available water resources is less than or equal to 25 percent; medium when it ranges between 25 and 50 percent; high for between 50 and 100 percent; and very high when it surpasses 100 percent. The level of water stress refers to 2015. For more information on the index construction and methodology, see FAO. 2018.
SOURCE: FAO elaboration based on FAO. 2020, and FAO & IIASA. 2020.

WHAT INNOVATION AND INVESTMENTS ARE NEEDED FOR SUSTAINABLE AND PRODUCTIVE WATER USE?

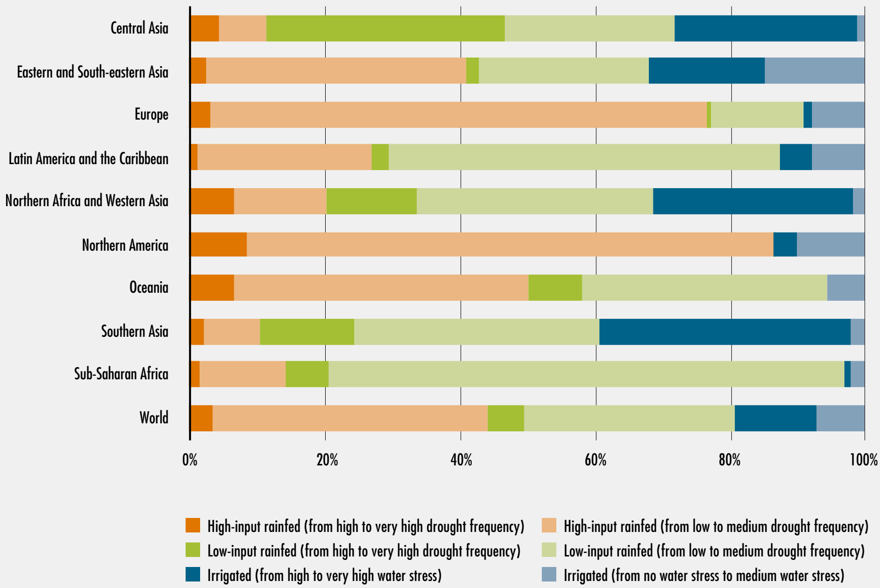
The challenge posed by increasing water shortages and scarcity calls for integrated water management strategies and technologies. These, in turn, are widely influenced by the overall institutional and legal framework – encompassing water rights, licensing, regulations, incentive measures and the institutional setup – and the overall policy environment – including societal choices, priorities, and relevant sectoral policies. The report provides a review of these different dimensions, starting with technologies and management strategies (Figure 13). »

FIGURE 9 PLACEMENT OF SELECTED COUNTRIES BASED ON THE SHARE OF RAINFED AND IRRIGATED CROPLAND EXPERIENCING HIGH TO VERY HIGH DROUGHT FREQUENCY OR WATER STRESS, RESPECTIVELY



NOTES: Countries were selected by population (more than 12 million people). Countries with 0–1 percent of cropland under high or very high water constraints were excluded (i.e. Angola, Cameroon, Colombia, Democratic Republic of the Congo, Guatemala, Guinea, Malawi, Malaysia, Niger, Philippines, Poland, Ukraine, United Kingdom of Great Britain and Northern Ireland, Venezuela [Bolivarian Republic of] and Zambia). The figure only considers hectares with an available level of historic drought frequency or water stress. The horizontal axis represents a country's share of rainfed cropland where the probability of severe drought is high or very high (i.e. greater than 20 percent). The vertical axis is a country's share of irrigated cropland under high or very high water stress (i.e. total water withdrawals more than 50 percent of renewable freshwater). A level of 0.33, or 33 percent, is taken as a threshold to separate countries with more than one-third of cropland under high or very high probability of severe drought or water stress. The level of water stress refers to 2015, and historical drought frequency is based on the entire time series (1984–2018). Global disaggregation of agricultural production system statistics is based on the 2010 version of the Spatial Production Allocation Model (SPAM) dataset by the International Food Policy Research Institute (IFPRI).
SOURCE: FAO elaboration based on FAO. 2020; FAO. 2019; FAO & IIASA. 2020; and IFPRI. 2019.

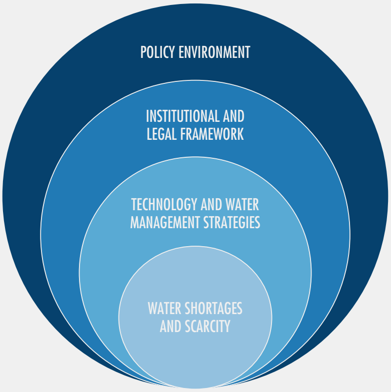
FIGURE 11 SHARE OF CROPLAND BY PRODUCTION SYSTEM AND LEVEL OF WATER SHORTAGES AND SCARCITY, BY REGION



NOTES: High to very high drought frequency refers to a probability of severe drought higher than 20 percent, affecting more than 30 percent of cropland. High or very high water stress refers to total withdrawals being more than 50 percent of renewable freshwater. Only cropland hectares with available levels of drought frequency and water stress are considered. The level of water stress refers to 2015, and the historical drought frequency is based on the entire time series (1984–2018). Global agricultural production system statistics are based on the 2010 version of IFPRI's SPAM dataset. Oceania includes Australia and New Zealand.
SOURCE: FAO elaboration based on FAO. 2020; FAO. 2019; FAO & IIASA. 2020; IFPRI. 2019.

» Improved water management strategies – where combined with agronomic practices, such as improved varieties – will be crucial to reducing water risks and attaining potential yields in agriculture. These strategies are expected to help deal with climate change, although considerable uncertainty about the impacts and the effectiveness of adaptations remains. Farmers' incentives to adopt water management strategies, and to change their water use and management behaviour, will depend on the level of

FIGURE 13 PLACING WATER SHORTAGES AND SCARCITY RESPONSES WITHIN THE BROADER POLICY CONTEXT



SOURCE: FAO elaboration based on FAO. 2012, Figure 2.

water accessibility, the magnitude of water shortages and scarcity, and the level of uncertainty under a changing climate, as well as on the availability and cost of other inputs, including labour and energy.

Water management includes a range of options – from entirely rainfed to fully irrigated conditions, to supporting livestock, forestry and fisheries, to interacting with important ecosystems – and not all water risks can be addressed by farmers alone. Some may require public-sector intervention, for example, in the form of investments, information and support to farmers to overcome constraints to adoption.

Unlocking the potential of rainfed agriculture calls for improved water management

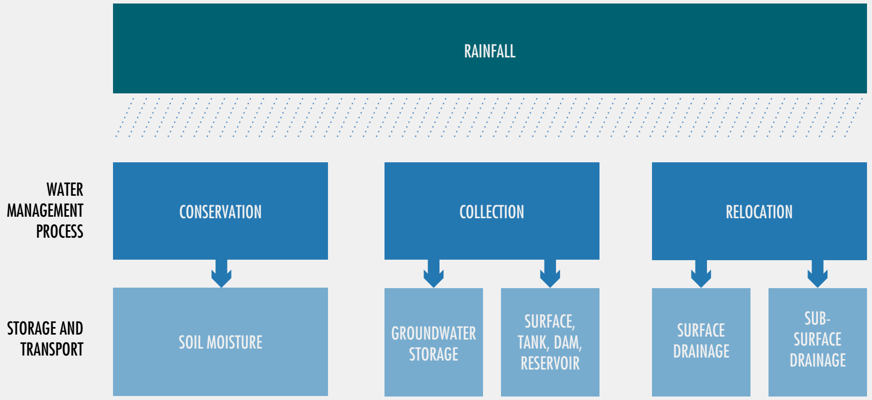
There are two broad strategies for increasing yields in rainfed agriculture: (i) collecting or harvesting more water, and infiltrating it into the root-zone; and (ii) conserving water by increasing plant uptake capacity and/or reducing root-zone evaporation and drainage losses (Figure 16). According to one study, water harvesting and conservation could boost rainfed kilocalorie production by up to 24 percent and, if combined with irrigation expansion by more than 40 percent. Almost 20 percent of global cropland is suitable for water harvesting and conservation strategies, with hotspots in large parts of Eastern Africa and South-eastern Asia.

Investing in irrigation for improved water productivity will be key to addressing scarcities

Making more productive use of irrigation can help save water by increasing crop yields and/or reducing evapotranspiration. Differences in water productivity (output per unit of water consumed) across countries are explained by farmers' access to modern agricultural inputs, efficient irrigation systems, and better soil and water management. Despite improvements in water productivity, yield gaps remain. Closing or reducing these gaps can improve food security and nutrition, as well as livelihoods, and reduce vulnerability to climate variability.

Doing so will require investment in new irrigation systems or the rehabilitation and modernization of existing ones. The

FIGURE 16 MAIN WATER MANAGEMENT PRACTICES IN RAINFED AGRICULTURE



SOURCE: FAO elaboration based on Barron. 2020.

most appropriate system will depend on climatic conditions, sources and prices of energy, labour availability, depth of groundwater sources and infrastructure costs. In sub-Saharan Africa, many small-scale farmers are developing small-scale irrigated equipment with lower unit costs and better performance relative to those managed by government agencies. There is considerable potential to expand profitable small-scale irrigation in the region, and one study has projected a doubling of irrigated areas between 2010 and 2050. Irrigation modernization must be preceded by policy instruments such as water allocation to maintain or reduce basin-wide water use after the introduction of new technologies.

Improving water productivity in animal production can ease pressure on water resources

The water productivity – in physical and nutritional terms – of animal products is commonly lower than that of crop products, and highly dependent on the type of animal product and production systems. For example, livestock may rely on rainfed pastureland for feed – often with no alternative productive use of water – or on irrigated cropland. In mixed production systems, livestock may consume crop residues. Various options exist for improving the sector's water productivity, including proper control of grazing, improved animal health and changes to diets and drinking systems.

Another area for improvement in productivity is that of integrated fish–irrigation systems. Irrigation can change physical aquatic habitats and nutrient contents, and contribute to the decline of fisheries. However, opportunities for fish production to be integrated into irrigation systems exist and will depend to a large extent on national and regional policies and governance structures.

Agricultural water management goes beyond the farm level and requires innovative approaches

Agricultural production systems are major drivers of desirable and undesirable environmental impacts. Decentralized water management approaches, such as some water harvesting schemes, can negatively affect water balances in catchments and river basins and, consequently, riverine fisheries. However, agricultural water management strategies can bring beneficial environmental impacts. For example, reducing or interrupting periods of flooding can substantially reduce rice-related methane emissions. Nature-based solutions – which use natural processes to improve water management and conserve or rehabilitate natural ecosystems and processes – are another case in point. Water management practices, such as vegetation strips and aquaculture–crop integrated systems, can further help retain excess nutrients and reduce pollution.

In situations where water supply is severely constrained, innovation in non-conventional sources of water – such as treated wastewater and desalinated water – is gaining momentum. When treated according to the needs of end users, wastewater may be a realistic option for non-conventional sources of water. Desalination represents another attractive option for increasing water supplies. Globally, there are about 16 000 desalination plants, producing about 100 million m^3/day. Thanks to rising demand and technological advances, dramatically falling costs are making this technique more feasible than ever for agricultural activities, particularly for the production of high-value crops. Benefit–cost estimates of desalination plants are very context-dependent; however, several countries are already profitably using desalinated water for agriculture. ■

IF EFFECTIVE SOLUTIONS ARE WITHIN REACH, WHY ARE THEY NOT BEING ADOPTED?

The different roles, attitudes and responsibilities of stakeholders involved in water policy and management are dispersed across sectors, locations and jurisdictions, but they all need to be clearly understood. One concern is that of affordability and ensuring the human right of access to water. Another is that of ensuring environmental flows, ecosystems services and non-consumptive use of freshwater resources, e.g. for inland fisheries.

Hence, good water governance is critical and calls for adaptive management at the catchment level to address the needs of all water users. This requires complex collaboration across several stakeholders, locations and entities and improved coordination both vertically and horizontally. Water users associations that bring farmers together (particularly small-scale farmers) for the purpose of managing a shared irrigation system, can play a role in both planning and implementation. A key challenge is to include and safeguard the interests of groups with less power and influence but reliant on ecosystems services (e.g. fisherfolk).

Transparent water accounting and auditing, and clear water tenure are key building blocks

Effective water management strategies must be based on a better understanding of how much water there is, how it is used and whether current patterns are sustainable. Water accounting – the systematic study of the current status and trends in water supply, demand, accessibility and use – will be key to achieving this. However, water accounting must form part of a broader process of improving governance. Combining water accounting with water auditing – the process that places the findings of water accounting into the broader societal context of water resources – can provide the basis for more realistic, sustainable, effective and equitable water management.

The overall cost of water accounting and auditing programmes varies enormously, but advances in remote sensing and metering technologies, as well as a number of open-access global and regional databases, reduce costs and make it easier to share information. A recent FAO sourcebook provides a good starting point for all those wishing to implement water accounting and auditing.

Water tenure – the relationship, whether legally or customarily defined, between people, as individuals or groups, and water resources – can be a strong building block for efficient water use and equitable and sustainable access to water when based on sound water accounting and an equitable allocation system. The development of community organizations to manage water allocations can also contribute to the effective establishment of water rights. Well-defined water rights can empower users and increase the economic value of water, while providing farmers with the incentive to invest in new technologies and to reduce resource degradation. However, in most cases water tenure systems are not formally recognized and enforced, and water tenure may not be respected. Improving irrigation technology for conveyance, diversion and metering can improve compliance through better monitoring.

Water markets and water pricing can ensure productive use of water, but equitable implementation is challenging

In areas where freshwater allocations are in place, it may be possible to introduce market instruments that allow producers to transfer their current entitlements among themselves. Water market mechanisms can effectively allocate water because they are economically efficient and encourage users to direct water to its most productive use through voluntary transactions. For example, groundwater markets may improve farmers' access to groundwater irrigation if implemented with caps on withdrawal. Negative aspects include the possibility of monopoly power by water sellers in some locations. In this respect, from the standpoint of equity, water markets are only as good as the initial allocation system on which they are based. Of particular relevance is the incentive that markets can create for some stakeholders to disenfranchise more vulnerable water rights holders and appropriate the rent from water as a resource, creating a conflict with the concept of water as a basic necessity and as a human right. To this day, there are very few actual functioning water markets.

Independently of whether water rights are traded, when water prices reflect its true economic value, there is an incentive to put water to its best economic use. Water pricing can also help avoid excessive use, depletion and quality degradation of water resources. Water pricing is not just a cost recovery mechanism and a means for ensuring economic efficiency, but also a tool to address social and environmental dimensions, including the impact of water pricing on lower-income groups.

Raising water prices should occur over several years to give farmers time to adapt, with integrated management involving communities to make sure no one is left behind. Encouraging payment for water management and services also requires consistent quality of water services and a clear explanation of how revenue is used to benefit users, in addition to regulations and sanctions.

Lack of focus on governance issues in rainfed areas has led to missed opportunities

To date, policy and governance on water resources management for agriculture has remained focused on irrigation. This has resulted in limited investment and innovation in rainfed areas – including pasturelands – and non-consumptive uses of water, such as inland fisheries. Water-resource planning needs to promote investment options across the continuum from rainfed to irrigated agriculture and include water management in rainfed areas with impacts at the catchment and river-basin scale. As in irrigation systems, attention to land tenure, water ownership and market access is also needed, together with community-based watershed management approaches for addressing water shortages and land degradation, which cannot be tackled at the farm level alone. These approaches need to extend to forest conservation and restoration at the watershed level. Finally, public support is required by investing in infrastructure and subsidizing water capturing and conserving technologies to help attenuate the effects of drought while contributing to agricultural development.

A range of other institutional and governance strategies can improve water management of livestock. Involvement of community representatives and local and indigenous institutions can help ensure effective design of interventions and management of natural resources. In some countries, national guidelines for livestock-based interventions in emergencies, such as drought events, already exist and can provide rapid assistance to affected communities. The identification and mapping of water resources and the use of early warning systems in drought-prone areas are also important.

Strengthening policy coherence is a must, both across sectors and within agriculture

The behaviour of actors is affected by policy choices in (often disconnected) sectors. Ensuring policy coherence across sectors and policy domains is the first condition for improving water management. This calls for coordination across the various policies, items of legislation, and fiscal measures that affect water management and water supply and demand, including energy prices, trade agreements, agricultural subsidy regimes and poverty reduction strategies. There is also a need to integrate decision-making by different entities on water resources and related policies – including on irrigation, and on industrial and municipal use of water.

Greater policy coherence across agricultural subsectors is a further necessity. Often, the impact of policies is uneven across agricultural subsectors, with a tendency to favour irrigated farming. While the expansion of irrigation has improved food security and nutrition in low-income countries, it has also contributed to the loss of inland fisheries, excessive groundwater withdrawals and changes in surface water flows and ecosystems. There are opportunities to obtain greater synergies for improved productivity and nutritional benefits from irrigated agriculture, while ensuring water connectivity, flows and habitat preservation. Examples include aquaculture–irrigation integrated systems, forest conservation and upstream management. Innovations that improve rainfed agriculture productivity may also reduce the need for irrigation.

Reform is needed for greater policy coherence

Strengthening policy coherence and improving water management will require the aligning of incentives. General subsidies should be replaced by targeted ones to spur adoption of new irrigation technology and the provision of environmental services, such as fish-friendly irrigation structures that mitigate the impacts of irrigation development and dam construction. Payments for environmental services – payments to farmers or landowners who agree to manage their land or watersheds for environmental protection – can also help ensure the proper valuation of well-functioning ecosystems.

A more integrated approach based on water accounting and auditing that takes into consideration all the different water users is also needed. Examples include irrigation scheme management that maintains food production levels while providing other environmental and ecosystem services.

Finally, policy coherence calls for strong mechanisms and processes to manage and coordinate policy, budgeting and regulatory development. Steps include capacity strengthening for public institutions; coordination across ministries (water, agriculture and energy); improved planning and monitoring tools; and upgraded and integrated databases. Improving the design of irrigation investments to include gender, health and nutrition outcomes can make irrigation an integral part of strategies to reduce poverty, hunger and malnutrition. ■

THE STATE OF THE WORLD

2020 THE STATE OF FOOD AND AGRICULTURE

OVERCOMING WATER CHALLENGES IN AGRICULTURE

Intensifying water constraints threaten food security and nutrition. Thus, urgent action is needed to make water use in agriculture more sustainable and equitable. Irrigated agriculture remains by far the largest user of freshwater, but scarcity of freshwater is a growing problem owing to increasing demand and competition for freshwater resources. At the same time, rainfed agriculture is facing increasing precipitation variability driven by climate change. These trends will exacerbate disputes among water users and inequality in access to water, especially for small-scale farmers, the rural poor and other vulnerable populations.

The State of Food and Agriculture 2020 presents new estimates on the pervasiveness of water scarcity in irrigated agriculture and of water shortages in rainfed agriculture, as well as on the number of people affected. It finds major differences across countries, and also substantial spatial variation within countries. This evidence informs a discussion of how countries may determine appropriate policies and interventions, depending on the nature and magnitude of the problem, but also on other factors such as the type of agricultural production system and countries' level of development and their political structures. Based on this, the publication provides guidance on how countries can prioritize policies and interventions to overcome water constraints in agriculture, while ensuring efficient, sustainable and equitable access to water.

The State of Food and Agriculture 2020 (full text)

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