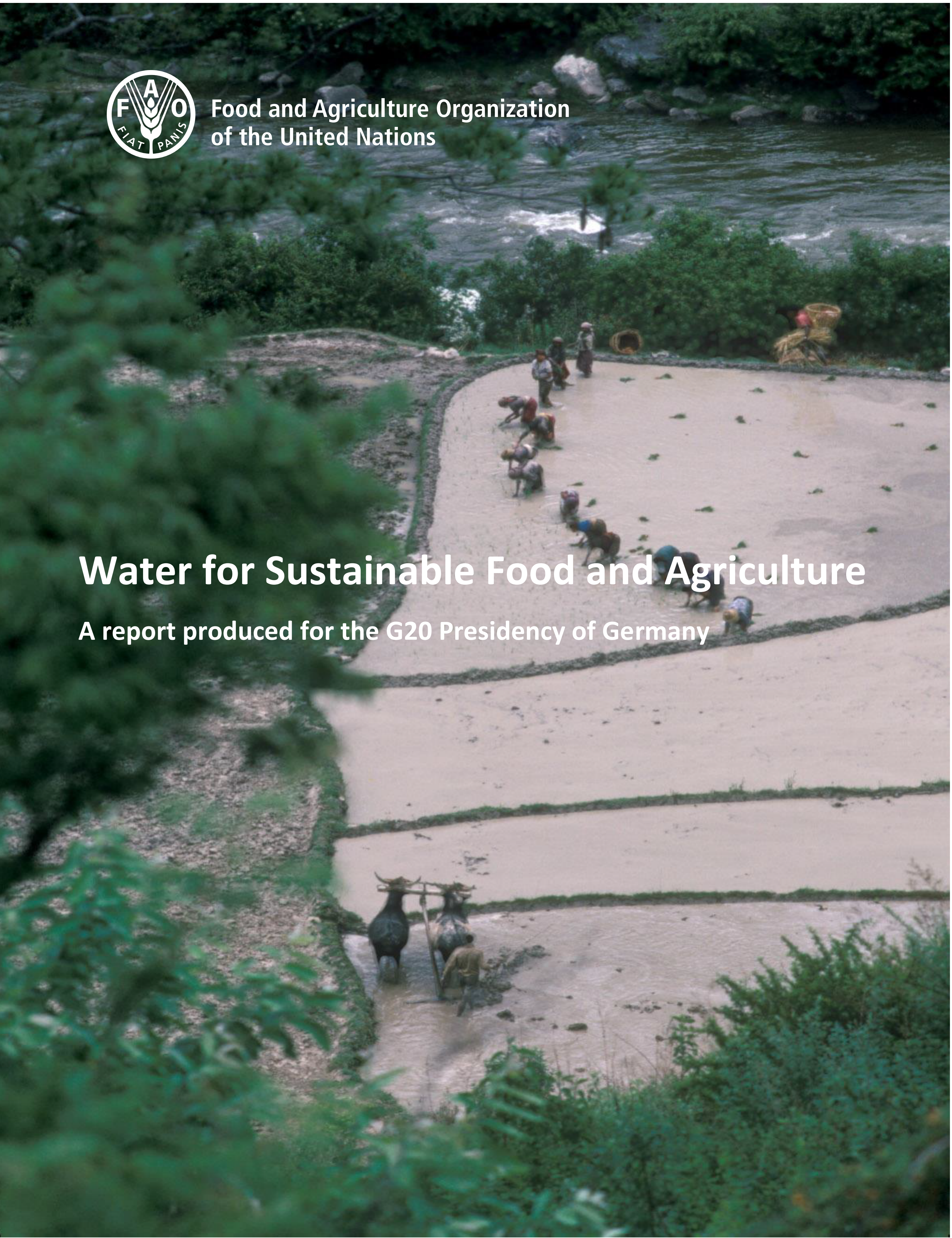
Food and Agriculture Organization
of the United Nations



Water for Sustainable Food and Agriculture

A report produced for the G20 Presidency of Germany

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Food and Agriculture Organization of the United Nations

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Contents

1. Introduction

2. Water is essential for every form of life, for all aspects of socio-economic development, and for the maintenance of healthy ecosystems. While there are sufficient freshwater resources at the global level to enable continued agricultural and industrial development, the long-term sustainable use of water resources is of growing concern.[1] This is particularly the case when considering the intrinsic disparity in water quality and availability across regions.

Box 1: Water facts and figures[2]

Water use grew at almost twice the rate of population increase in the last century. Although there is no global water scarcity as such, an increasing number of regions are chronically short of water. Other regions suffer the consequences of unmet demand due to infrastructure or institutional inadequacies.

On average, agriculture accounts for 70 percent of global freshwater withdrawals. In the last 30 years, food production has increased by more than 100 percent. FAO estimates that about 60 percent more food will be needed by 2050 to meet the food requirements of a growing global population.

Water demand is therefore set to increase. FAO projects that irrigated food production will increase by more than 50 percent by 2050, but the amount of water withdrawn by agriculture can increase by only 10 percent, provided that irrigation practices are improved and yields increase.

The world contains an estimated 1 400 million cubic km of water. But only 0.003% of this vast amount, about 45 000 cubic km, are "fresh water resources" that could be used for drinking, hygiene, agriculture and industry. But not all of this water is accessible because part of it flows into remote rivers during seasonal floods.

It takes between 1 and 3 tonnes of water to grown 1kg of cereal. A kilogram of beef takes up to 15 tonnes of water to produce. FAO estimates that between 2 000 and 5 000 litres of water are needed to produce a person's daily food.

3. The 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs), and the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) provide both the framework and the targets that should guide global efforts towards more inclusive growth and sustainable livelihoods. Agriculture, through its links to food security, nutrition and health, rural development and growth, and the environment, is a major driver in the attainment of these

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[1] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).

[2] FAO*. Water at a Glance: the relationship between water, agriculture, food security and poverty.* Rome. 15 pp. (also available at http://www.fao.org/nr/water/docs/waterataglance.pdf)

targets. In the current environment of changing global agricultural markets, agriculture faces a triple challenge. First, it has to increase the production of safe and nutritious food to meet a growing demand driven by population increase. Second, agriculture has to generate jobs and incomes and contribute to poverty eradication and rural economic growth. Finally, agriculture has a major role to play in the sustainable management of natural resources and the adaptation to, and mitigation of climate change which is already affecting the livelihoods of many people, especially the most vulnerable.

4. Agriculture is the largest water user worldwide, accounting for 70 percent of total freshwater withdrawals on average[3] – but these amounts can reach as much as 95 percent in some developing countries.[4] Agriculture is also a major source of water pollution from nutrients, pesticides and other contaminants, which if unmanaged can lead to significant social, economic and environmental costs.

5. Improving agricultural productivity, while conserving and enhancing natural resources, such as water, is an essential requirement for farmers to increase global food supplies on a sustainable basis. The role of smallholder farmers and their families in increasing agricultural productivity growth sustainably will be crucial. Farmers are at the centre of any process of change involving natural resources and need to be encouraged and guided, through appropriate incentives and governance practices, to conserve natural ecosystems and their biodiversity, and minimize the negative impact agriculture can have on the environment.

6. This report is submitted to the G20 Presidency of Germany by FAO in response to Germany's request for information and advice on practical actions that could be undertaken by G20 members to sustainably improve water productivity in agriculture, reduce water pollution and cope with water scarcity in the context of climate change.

7. The approach taken reflects the view that agriculture is an integral part of sustainable development and is in line with the framework established by the Sustainable Development Goals and the Paris Agreement.

8. The SDGs call for innovation and new combinations in the way policies, programmes, partnerships and investments should pull together to achieve common goals and produce the most needed public goods. The Paris Agreement recognizes the particular vulnerabilities of food systems and the importance of food security as part of the international response to climate change. Both water and agriculture are widely regarded as crosscutting issues that must be prioritized when implementing these two pillars of sustainable development.

9. The report first provides an outlook for the agricultural and food market and highlights the challenges that population trends, rising global incomes and climate change present to agriculture and water. The following section focuses on two broad areas that require attention and presents

[3] FAO. 2011. *The state of the world's land and water resources for food and agriculture (SOLAW): managing systems at risk.* Food and Agriculture Organization of the United Nations, Rome and Earthscan, London. (also available at: http://www.fao.org/docrep/017/i1688e/i1688e.pdf).
[4] FAO. *Water at a Glance: the relationship between water, agriculture, food security and poverty.* Rome. 15 pp. (also available at http://www.fao.org/nr/water/docs/waterataglance.pdf)

recommendations on: (i) policies within the agricultural domain that apply specifically to the sector, such as water supply enhancement, water loss reduction, crop productivity, water re-allocation, and options for rainfed agriculture; and (ii) actions within the water domain that relate to water management for all sectors, not only agriculture.

2. Critical issues affecting the global outlook for water and food security

Growing demand

10.The United Nations Department of Economic and Social Affairs projects global population to reach between 8.4 and 8.6 billion people by 2030 and between 9.5 and 13.3 billion in 2100, when it is possible that numbers stabilize and start declining.[5] FAO estimates that over the last century the global water withdrawal grew 1.7 times faster than population, which aggravates the concern over the sustainability of water use as demand for agricultural, industrial, and domestic uses continues to increase.[6]

11. By 2050, in order to meet growing demand agricultural production will have to increase by 60 percent from 2005/2007 levels.[7] Rising incomes and economic development are also expected to skew food demand growth towards meat, fish, and dairy products, including additional demand for feed, in particular from coarse grains and protein meals.[8] This trend will have an important impact on water resources since meat and dairy production are more water-intensive than that of cereals.

12. About 90 percent of the global food production increase needed by 2050 is projected to take place in developing countries, whose share of global food production will rise to 74 percent in 2050 (from 67 percent in 2007).[9] Agricultural output increase in developing countries will be particularly strong for livestock production, with their share in global production growing from 55 percent in 2005/2007 to 68 percent in 2050. Graph 1 shows the projected agricultural production growth per region, with production levels nearly doubling in South Asia and tripling in sub Saharan Africa.

13. Most of the net increase in global population between 2015 and 2050 will occur in the urban areas of low income countries. [10] Since the bulk of food consumed worldwide is produced locally – on average only 19 percent of production is traded internationally[11] – improved productivity in developing countries will be crucial in ensuring food security, although pockets of poverty and hunger will persist in many regions. Much of the persistent food insecurity in 2050, as for today, will be found in poor households in countries with lower incomes, and in areas where depleted or degraded natural resources no longer support viable livelihood activities for smallholders. The primary cause of food insecurity will be

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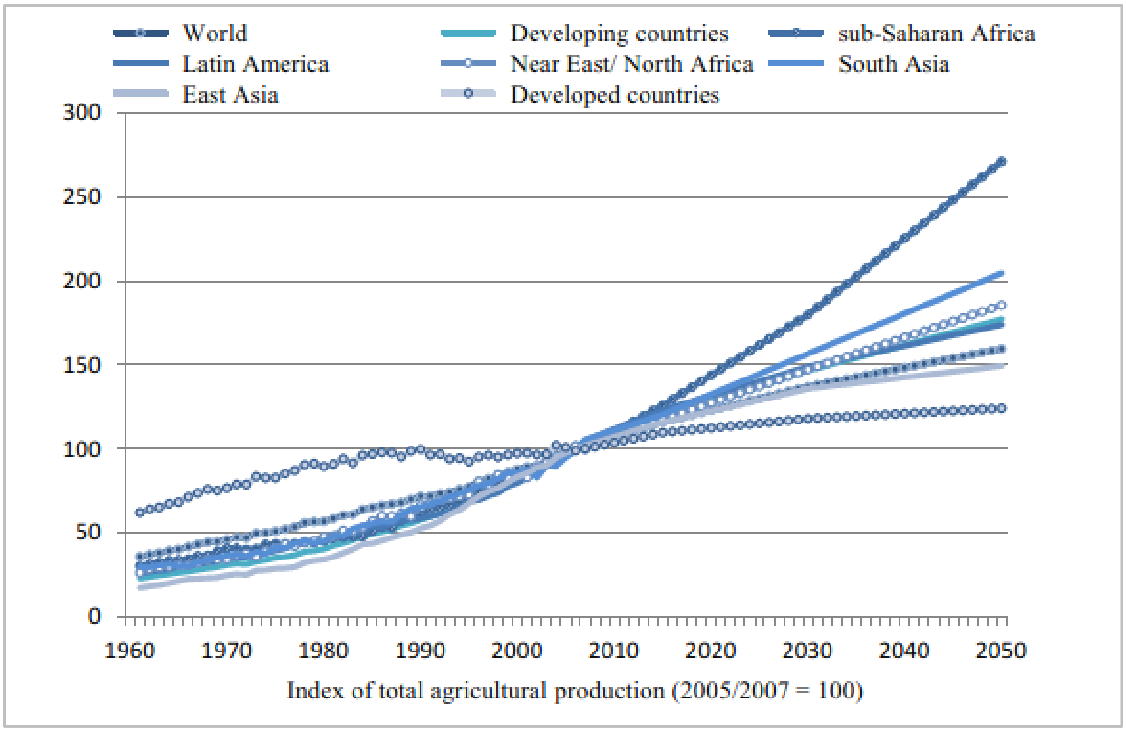
[5] United Nations. Department of Economic and Social Affairs, Population Division. 2015. *World population prospects: the 2015 revision, key findings and advance tables.* Working Paper No. ESA/P/WP.241. (also available online at: https://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf).
[6] FAO AQUASTAT: http://www.fao.org/nr/water/aquastat/water_use/index.stm.
[7] Alexandratos, N. and J. Bruinsma. 2012. *World agriculture towards 2030/2050: the 2012 revision.* ESA Working paper No. 12-03. Rome, FAO. (also available at: http://www.fao.org/docrep/016/ap106e/ap106e.pdf).
[8] OECD/FAO. 2016. *OECD-FAO Agricultural Outlook 2016-2025.* OECD Publishing, Paris. (also available at: http://dx.doi.org/10.1787/agr_outlook-2016-en).
[9] Alexandratos, N. and J. Bruinsma. 2012. *World agriculture towards 2030/2050: the 2012 revision.* ESA Working paper No. 12-03. Rome, FAO. 154 pp. (also available at: http://www.fao.org/docrep/016/ap106e/ap106e.pdf).
[10] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).
[11] Alexandratos, N. and J. Bruinsma. 2012. *World agriculture towards 2030/2050: the 2012 revision.* ESA Working paper No. 12-03. Rome, FAO. 154 pp. (also available at: http://www.fao.org/docrep/016/ap106e/ap106e.pdf).

persistent poverty, which prevents households from purchasing sufficient food, particularly during periods of scarcity or high prices.

Graph 1: Agricultural Production by region[12]



Inter-sectoral competition

14. As population growth and rising incomes continue to drive demand for water, increasing competition between water, energy, agriculture, fisheries, livestock, forestry, mining, transport and other sectors may have unpredictable impacts for livelihoods and the environment. Large-scale water infrastructure projects, for instance, provide electricity through hydropower and water storage for irrigation, flood management and urban uses, but can have large adverse impacts on the environment, downstream agro-ecological systems, and on local communities and their livelihoods.

15. Global freshwater resources are expected to be further strained in many regions, with over 40 percent of the world's population projected to be living in river basins experiencing severe water stress by 2050.[13] As pressure on water resources intensifies, it leads to tensions among users and industries, and excessive pressure on the environment.

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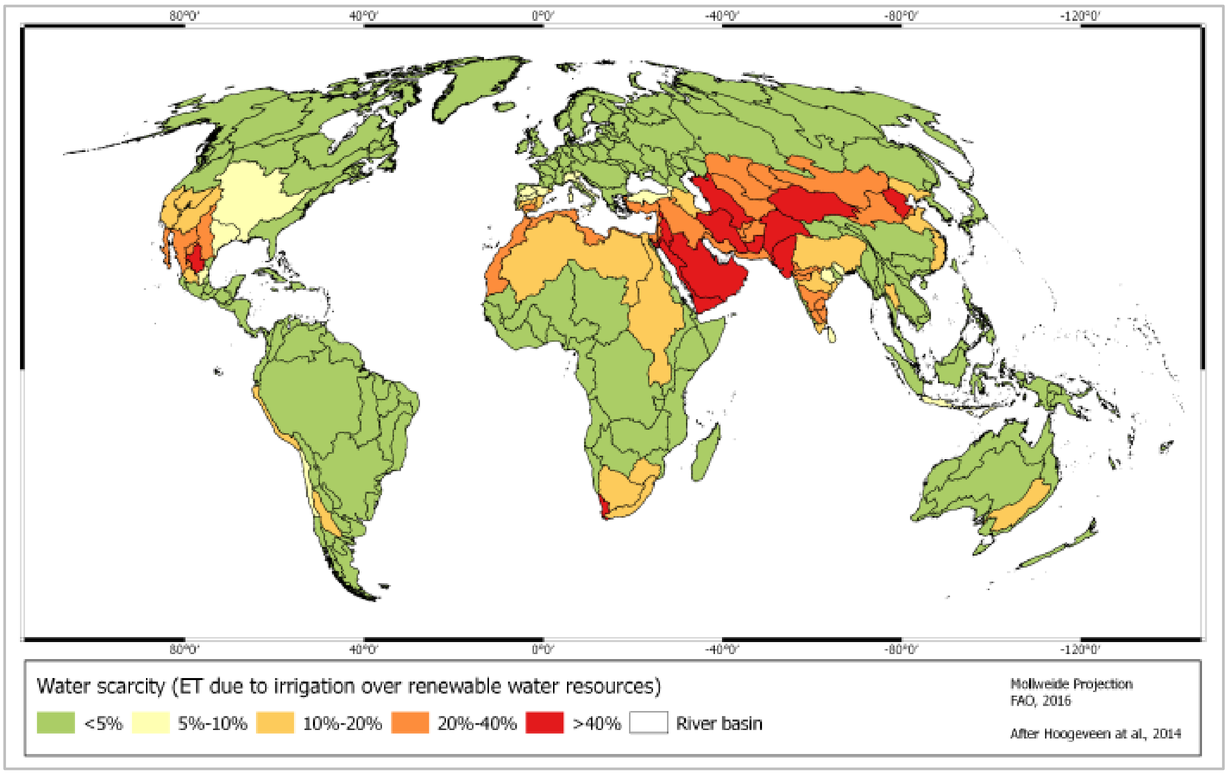
[12] Alexandratos, N. and J. Bruinsma. 2012. *World agriculture towards 2030/2050: the 2012 revision.* ESA Working paper No. 12-03. Rome, FAO. 154 pp.(also available at: http://www.fao.org/docrep/016/ap106e/ap106e.pdf).
[13] OECD. 2012. *Environmental Outlook to 2050: The consequences of inaction.* Paris. (also available at: http://www.oecd.org/document/31/0,3746,en_2649_37465_49742047_1_1_1_37465,00.html).

Water scarcity

16. Water scarcity occurs when water supply is insufficient to meet water demand.[14] This condition arises as consequence of a high rate of aggregate demand from all water-using sectors compared with available supply, under the prevailing institutional arrangements and infrastructural conditions. Globally, freshwater resources are sufficient for agriculture to meet demand requirements by 2050, given appropriate technologies and investments, but significant water availability discrepancy is expected between and within countries[15] and substantial water scarcity will persist in the Near East, North Africa, South Asia and other areas. Cities and industries compete with agriculture for the use of water and an increasing number of countries, or regions within countries, are reaching alarming levels of water stress and pollution. Map 1 illustrates current water scarcity levels around the globe. It shows that some of the river basins currently facing water scarcity coincide with some of the world's top cereal producing areas.

Map 1: Global water scarcity by major river basin[16]



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[14] FAO. 2012. *Coping with water scarcity: an action framework for agriculture and food security.* Food and Agriculture Organization of the United Nations, Rome. 100 pp.
[15] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).
[16] Hoogeveen, J.; Faurès, M; Peiser, L.; Burke, J. and van de Giesen, N. 2015, *GlobWat – a global water balance model to assess water use in irrigated agriculture.* In: Hydrology and Earth System Sciences (HESS).

17. Water overuse occurs when withdrawals exceed recharge rates, eventually leading to water scarcity. Groundwater use in agriculture and other sectors has increased substantially since the middle of the twentieth century and, in many areas, annual groundwater withdrawals exceed the rate of natural recharge.

18. Global withdrawal of groundwater is estimated to have grown from a base level of 100–150 km^3 in 1950 to 950–1 000 km^3 in 2000,[17] with the bulk of this growth being concentrated in agriculture. Latest available estimates based on comprehensive national and sub-national statistical data indicate that 40 percent of actually irrigated area in the world can be attributed to groundwater sources,[18] with an estimated annual abstraction level for agriculture of 454 km^3. In large areas of South and East Asia, in the Near East, North Africa, North and Central America, groundwater withdrawals exceed the rates of natural recharge and aquifers are in decline. [19]

19. Water scarcity will intensify in areas where water withdrawals are not sustainable, which can constrain agricultural production, threaten ecosystems, and affect the incomes and livelihood opportunities of many residents in rural and urban areas. [20] In addition to groundwater depletion, groundwater pollution and aquifers' salinization due to sea water intrusion are also growing concerns.

20. As an open access resource employed by individuals, groundwater is difficult to regulate and monitor and the legal basis for this is often absent.[21] When legislation exists, it faces serious enforcement challenges. This hinders measures for the conservation and efficient use of groundwater which constitutes a de facto incentive for farmers to overuse.

Climate Change

21. Climate change lays an additional layer of complexity upon the challenging scenario described above. Climate change is projected to have significant impact over the water cycle, altering rainfall patterns and affecting the availability and quality of both surface and groundwater, agricultural production and associated ecosystems. Increasing variability of rainfall can influence the flow of water in surface systems and the rates of recharge and discharge from aquifers.[22] Climate induced sea-level rise

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[17] Shah, T; Burke J.; and Villholth, K. 2007. *Groundwater: a global assessment of scale and significance.* In: Water for Food, Water for Life. Ed. David Molden. Earthscan, London; and International Water Management Institute, Colombo.

[18] S. Siebert, J. Burke, J-M. Faures, K. Frenken, J. Hoogeveen, P. Döll, and F. T. Portmann. 2010. *Groundwater use for irrigation – a global inventory.* In: Hydrology and Earth System Sciences (HESS).

[19] FAO. 2012. *Coping with water scarcity: an action framework for agriculture and food security.* FAO Water Reports, no. 38. Rome.

[20] FAO. 2012. *Coping with water scarcity: an action framework for agriculture and food security.* FAO Water Reports, no. 38. Rome.

[21] FAO. 2003. *Re-thinking the approach to groundwater and food security.* FAO Water Reports, no. 24.

[22] Kløve, B., Ala-Aho, P., Bertrand, G., Gurdak, J.J., Kupfersberger, H., Kværner, J., Muotka, T., Mykrä, H., Preda, E., Rossi, P., Uvo, C.B., Velasco, E., Pulido-Velazquez, M. 2014. *Climate change impacts on groundwater and dependent ecosystems.* Journal of Hydrology 518 (PB), 250-266.

will claim land dedicated to food production, either by inundation or saline intrusion into aquifers, requiring new food producing areas to be developed. Rainfed agricultural production, which accounts for 80 percent of global cropland and 60 percent of global food output, could be markedly affected by climate change, particularly in arid and semi-arid areas.[23]

22. Further research is needed to describe more fully the potential effects of climate change on groundwater dependent ecosystems, although the impacts are thought to be greater in arid regions, on shallow aquifers, and on ecosystems already stressed in advance of climate change.[24]

23. While some areas may experience beneficial changes in cropping patterns and increases in crop yields with warmer temperatures and longer growing seasons,[25] on average the negative impacts of climate change on agricultural production are expected to surpass positive ones.[26] In large countries, such as China and India, the impacts of climate change, and the appropriate policy responses and investments, could vary significantly across production regions.[27] Sustained high temperatures can directly impair livestock health and productivity. The impacts of climate change on smallholders could be particularly severe, given their limited resources and opportunities for adaptation.

Access to water

24. Access to safe water and sanitation is of essence to enable healthy and productive livelihoods and has important links to nutritional outcomes and gender equality. In many developing countries women are traditionally responsible for collecting water to meet the family needs. This draws women and girls

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Kurylyk, B.L., MacQuarrie, K.T.B., McKenzie, J.M. 2014. *Climate change impacts on groundwater and soil temperatures in cold and temperate regions: Implications, mathematical theory, and emerging simulation tools.* Earth-Science Reviews 138, 313-334.

[23] Turral, H., Burke, J., Faurès, J.M. 2011. *Climate change, water and food security*. FAO Water Reports 36. Rome, FAO.

[24] Kløve, B., Ala-Aho, P., Bertrand, G., Gurdak, J.J., Kupfersberger, H., Kværner, J., Muotka, T., Mykrä, H., Preda, E., Rossi, P., Uvo, C.B., Velasco, E., Pulido-Velazquez, M. 2014. *Climate change impacts on groundwater and dependent ecosystems.* Journal of Hydrology 518 (PB), 250-266.

[25] Kang, Y., Khan, S., Ma, X. 2009. *Climate change impacts on crop yield, crop water productivity and food security - A review.* Progress in Natural Science 19(12), 1665-1674.

[26] IPCC. 2014. *Summary for policymakers.* In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

[27] Chauhan, B.S., Prabhjyot K., Mahajan, G., Randhawa, R.K., Singh, H., Kang, M.S. 2014. *Global warming and its possible impact on agriculture in India.* Advances in Agronomy 123, 65-121.
Wei, T., Cherry, T.L., Glomrød, S., Zhang, T. 2014. *Climate change impacts on crop yield: Evidence from China*. Science of the Total Environment 499, 133-140.
Xiong, W., Holman, I., Lin, E., Conway, D., Jiang, J., Xu, Y., Li, Y. 2010. *Climate change, water availability and future cereal production in China.* Agriculture, Ecosystems and Environment 135(1-2), 58-69.
Zhou, L., Turvey, C.G. 2014. *Climate change, adaptation and China's grain production*. China Economic Review 28, 72-89.

behind, as they are put at risk and their access to education and income-generating activities is constrained. Increased access to irrigation by women can bring increased productivity and important nutritional improvements through enhanced food availability and dietary diversification.[28]

Water quality and pollution

25. Agriculture is both a cause and a victim of pollution. In many developed countries agricultural pollution from use of nitrogen and phosphorous, insecticides, herbicides, fungicides and bactericides has overtaken contamination caused by settlements and industries as the main cause of inland and coastal eutrophication. This results in toxic algal blooms, loss of habitat and biodiversity, and long term reduction or loss of fish catches. The run-off of farm and agro-processing chemicals into surface streams and their seepage into aquifers introduces risks for both human health and the environment. In most developing countries, agriculture's contribution to water pollution is less important, mainly because of the greater significance of pollution from urban and industrial sources.

26. Pollution reduces water available for beneficial use and increases the cost of water treatment. Polluted water has a high cost to human health: one-tenth of the global burden of disease can be attributed to water.[29] Other pollution costs include clean-up, additional treatment and damage to fisheries, ecosystems and recreation. Pollution also reduces opportunities for addressing water scarcity by the re-use of return flows in agriculture or any other water using sector, and although there are options for cleaning up, or diluting surface water pollution, polluted aquifers are very difficult to restore.

27. Water polluted by other sectors can potentially be of use in agriculture. The use of urban waste water for irrigation of nutritionally valuable fruits and vegetables in peri-urban agriculture can address water scarcity and food insecurity, if suitably treated.

28. While most countries have legislation to protect their water resources, compliance and enforcement is uneven, emanating from a multiplicity of reasons (e.g. dispersion of responsibilities across multiple institutions, high cost of control and monitoring, weakness in enforcement).

The water-food-energy nexus

29. In most irrigated areas, water and energy uses are directly linked through the use of energy for water pumping. Efforts to improve water management by upgrading irrigation systems often generate greater energy expenditure at the farm level. In rainfed areas, usually higher rainfall will generate higher yields that could be associated with larger amounts of fertilizer and machinery operations. Both of these inputs require notable amounts of energy, pairing water and energy in crop production. [30] In the past,

[28] Domenech, L.; Ringler, C. 2013.The Impact of Irrigation on Nutrition, Health, and Gender A Review Paper with Insights for Africa south of the Sahara. IFPRI Discussion Paper 01259.
[29] WHO 2004. Guidelines for drinking water quality. Geneva. 540 pp. (also available at: http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf?ua=1).
[30] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).

some countries subsidized energy prices to promote crop production and support smallholder households. However, such policies give farmers little incentive to minimize their use of groundwater and have contributed to the rapid decline of groundwater levels in some countries.

30. Water and energy – and land – also interact with the production of crops for biofuels. In areas where land and water are limited, the decision to produce crops for biofuel may reduce food production in the season. The impacts of such decisions depend on market prices for food and energy, and the returns earned in each activity.

31. Water, energy, and food also interact in the context of hydropower development in river basins.[31] Constructing a hydropower project can impact food production when farmers are removed from land that will be flooded by the reservoir. Hydropower projects often provide water storage for the generation of electricity and for delivery to downstream irrigation schemes, but operating a hydropower facility to optimize electricity generation can impose constraints on the release of water for irrigation.

32. Nexus interactions are found also in the large amounts of energy required for conveying irrigation and drinking water supplies in large-scale canal delivery systems, and the large energy requirements for desalination facilities in arid regions.

3. Recommendations for policy-makers

4. Even though population growth is expected to be largest in the urban areas of low income countries, a substantial share of the global population, and many of the poor, will continue to earn their living from agriculture in 2050. Agriculture, through its links to food security, nutrition and health, rural development and growth, and the environment, will continue to be a key driver of sustainable and inclusive growth.

5. Given the increasing demands for water in competing sectors, the notion that agriculture must "produce more food with less water" has taken hold. While compelling, this concept can lead to misconceptions since it does not distinguish between the water diverted and applied to farm fields, and the water transpired in the process of generating crop yields. Much of the water applied in irrigation runs off the ends of farm fields or percolates into shallow groundwater, where it is available for further use in irrigation or for other purposes. Only the portion of water consumed by the crop during transpiration, and the water that evaporates from plant and soil surfaces, is 'lost' from the system at this point in the hydrologic cycle. Opportunities for saving water through investments in technology will be limited by the extent to which water is lost in each setting. [32] In light of the above, the definitions presented in Box 2 aim to clarify the concepts referred to in the recommendations that follow.

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[31] FAO. *The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture.* Rome.

[32] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).

Box 2: Definitions

Water scarcity occurs when demand for freshwater exceeds supply. The unsatisfied demand can manifest itself in tensions between users, competition for water, over-extraction of groundwater and insufficient flows to the natural environment. Scarcity can occur or worsen if legal or institutional arrangements to regulate and improve access are weak or absent, or if the required infrastructure does not exist or is inadequate. Many of the causes of scarcity can be predicted, avoided and/or mitigated.

Irrigation efficiency is defined as the ratio of the volume of water required for irrigation (which includes water needed for crop transpiration, soil leaching to prevent salinization, weed control, etc.) over the volume of water diverted from the source of supply. This concept is useful to assess and monitor system losses.[33]

Water productivity is the ratio of the actual crop yield over the volume of water that is beneficially consumed[34] by the crop. This concept can also be applied in a wider sense, by placing monetary units (e.g. in dollars per cubic meter of water), social attributes (jobs, food security, etc.), or environmental attributes (carbon sequestration, biodiversity, etc.).[35] Economic valuation of water resources provides a method to compare economic water productivity values across scales, but also across production systems such as crops, energy, fisheries, and livestock.[36]

Water-use efficiency is often used in the agricultural sector to measure the efficiency of crops (irrigated or rainfed) to produce biomass and/or harvestable yield[37] while it is generally defined as the ratio between the water used and the water withdrawn for the water sector as a whole. The different attributes given by the water and agriculture sectors in the use of this term is often a cause for confusion.

FAO recommends that ***'water productivity'*** be the metric of choice given that it is not scale-dependent, unlike 'irrigation efficiency', and can be applied in a wider sense and multiple contexts due to the possibility of assigning monetary, economic, social and production terms to the numerator.

[33] Irrigation system losses may be non-recoverable (e.g. evaporation from a canal) or recoverable (e.g. seepage from unlined canals).

[34] It should be stressed that the concept refers to the volume of water that is *actually* consumed by crops – and therefore depleted from the hydrological domain – as opposed to the total water use or total water applied. Using total water values tends to hide rather than explain the potential trade-offs and reallocations of water uses and users in a water scarce basin when increases in agricultural production are propagated.

[35] Turner, K., Georgiu, S., Clark, R., Brouwer, R. & Burke, J. 2004. *Economic valuation of water resources in agriculture. from the sectoral to a functional perspective of water resources management.* FAO Water Reports 27, Rome, FAO.

Knox, J.W., Morris, J., Weatherhead, E.K. & Turner, A.P. 2000. Mapping the financial benefits of sprinkler irrigation and potential financial impacts of restrictions on abstractions: a case-study in Anglian Region. J. Environ. Manage. 58, 45–59.

Renault, D. & Wallander, W.W. 2000. Nutritional water productivity and diets. Agric. Water Manage. 45 (3), 275–296.

[36] van Halsema, G.E. & Vincent, L. 2012. *Efficiency and productivity terms for water management: A matter of contextual relativism versus general absolutism*. Agricultural Water Management, 108, 9– 15.

[37] Pereira, L.S., Cordery, I. & Iacovides, I. 2012. *Improved indicators of water use performance and productivity for sustainable water conservation and saving*. Agricultural Water Management, 108, 39– 51

(i). Recommendations under the agriculture domain

Enhancing irrigation infrastructure and management and increase irrigation efficiency and access

6. Irrigation infrastructure is expensive to construct, operate and maintain. Irrigation systems and the day-to-day management of the service itself often need to be adapted to changing circumstances over their useful life. Financial resources and technical support from public or international donors for upkeep and management are less available than those for the initial investment. This can result in poor maintenance and service delivery.[38]

7. National governments have built and operated many irrigation schemes worldwide, often with mixed results in terms of system performance and financial viability.[39] In some cases, the maintenance of infrastructures is delegated to local communities, while property of the infrastructure continues to belong to the State. Ambiguity about ownership and responsibilities often leads to neglect of the infrastructure.[40]

8. In some contexts, Public-Private Partnerships (PPPs) can facilitate the resource mobilization for investments in infrastructure and increase the pace at which new technologies are developed and implemented. The expertise and technology brought in by PPPs can increase agricultural output and benefit farmers and the overall economy. PPPs in the water and agriculture sector, however, are better suited in countries where certain preconditions are in place – such as clear land ownership and water rights/allocations, and public sector capacity to foster and align private investment goals with national priorities. Public-Private Community Partnership (PPCP), a special variant of PPPs, has been used in some water projects bringing the local community as a partner, establishing a local pillar to the investment.

9. Participatory approaches can lead to better management and maintenance of infrastructure, thus to more efficient use of water. Farmer-managed systems, often operated jointly with private sector contractors, or by water-user associations are such forms of collective action and management. However, large agency-managed systems often have been turned over partially or completely to various types of management bodies with mixed results, due to low management capacity and severe financial constraints. It is essential to accompany such turnover processes with well-thought capacity development programmes and irrigation modernization plans.

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[38] HLPE. 2015. *Water for food security and nutrition: a report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome.

[39] Borgia, C., García-Bolaños, M., Li, T., Gómez-Macpherson, H., Comas, J., Connor, D., Mateos, L. 2013. *Benchmarking for performance assessment of small and large irrigation schemes along the Senegal Valley in Mauritania.* Agricultural Water Management 121, 19-26.
Al Zayed, I.S., Elagib, N.A., Ribbe, L., Heinrich, J. 2015. *Spatio-temporal performance of large-scale Gezira Irrigation Scheme, Sudan*. Agricultural Systems 133, 131-142.

[40] Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for food, water for life: a comprehensive assessment of water management for agriculture.* London, Earthscan and Colombo, International Water Management Institute.

10. Farmer-led management systems are more effective when well-defined institutions exist that support the assignment of property rights to land and water and provide legal recourse for disputes regarding those rights.[41] Such participatory systems also are key to promote water productivity by ensuring timely and reliable availability of water for irrigation.

11. Shifting from on-farm surface irrigation to pressurized on-farm irrigation and from conveyance through canals to pipeline networks has helped improve conservation of water resources. However, such improvements have the drawback of raising energy demand at the farm and system levels (see section on water-food-energy nexus)[42], which should be factored in when the intervention is planned. Still, the adoption of pressurized irrigation often represents a step forward towards better control, flexibility and accountability of irrigation water delivery, and therefore allows for transformation from low-return to high-return agriculture. Such transformations can therefore be justified not only in terms of water saving but in terms of increasing the productivity of irrigation.

12. Increased irrigation access is linked to higher productivity and important nutritional outcomes through improvements in food availability and dietary diversification. Investments in irrigation designed to provide equal access by women and men are important to ensure women, children and disadvantaged groups benefit from increased food access and diets diversification.

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[41] Hanemann, M. 2014. *Property rights and sustainable irrigation-A developed world perspective.* Agricultural Water Management 145, 5-22.
[42] Hardy, L., Garrido, A. & Juana, L. 2012. *Evaluation of Spain's water-energy nexus.* International Journal of Water Resources Development, 28(1): 151–170).

Recommendation 1: Modernize irrigation schemes

G20 members can consider to:

- Promote the modernization of large scale surface irrigation systems to improve irrigation efficiency, water delivery services to all users, and enhance resource utilization (labour, water, environmental) including cost effectiveness of operation and management.

- Commit to reviewing irrigation management schemes that may generate perverse incentives for sustainability, encouraging inefficient and unsustainable use of water.

- Facilitate, where the conditions exist, public-private and community partnerships to address funding gaps on irrigation infrastructure development in line with the Outcome Document of the Third International Conference on Financing for Development.

- Promote participatory irrigation management, inclusive of farmers and their organizations, to enhance timely and reliable water supply and increase the productivity of water sustainably. In doing so, promote equity and women's rights, increase their participation in management structures and in decision-making, and their access to irrigation.

This recommendation directly supports SDG 6 and contributes to SDG 1, SDG 2, SDG 5, and SDG 10.

Improving water supply management

13. Globally, rainfed agriculture is the primary source of food production. In many regions gaps persist between actual and potential yields and opportunities exist to improve yields and water productivity without irrigation. Rainwater harvesting, as well as supplemental irrigation, can substantially improve rainfed agriculture. On-farm water conservation, particularly the adoption of agricultural practices that reduce runoff and increase the infiltration and storage of water in the soil in rainfed agriculture, is the most relevant local supply enhancement option that farmers have to increase production. On a slightly larger scale, small, decentralized water harvesting and storage systems contribute to increasing water availability and agricultural production at the household and community levels. These small-scale measures promote local economic development and increase the climate resilience of local communities.

14. For example, increased rainfall intensity due to climate change may increase the availability of surface water, but will result in more runoff, higher soil erosion and lower soil infiltration causing more

moisture stress on plants and reduced recharge of groundwater. More intense and longer droughts will expose crops to moisture stress, and reduce rainfed yields and quality.[43]

15. However, decentralized water measures, even if they are small, can have an impact on the catchment's water balance. Large programmes of small-scale water harvesting, like the local basin management programmes developed in Andhra Pradesh and other parts of India have had substantial impacts on the basin's overall hydrology and the availability of water downstream.[44]

16. Rainwater harvesting slows down or halts the increased runoff from increased rainfall intensity, allows for more infiltration, increased soil water storage and better groundwater recharge. Much can be done in dry environments where rainwater is lost through runoff to salt sinks and rapid evaporation from bare soil surfaces. In these cases water harvesting through storing water in surface areas, in the soil profile, or by facilitating recharge of aquifers can reduce vulnerability to dry spells, reduce yield losses and allow farmers invest in other inputs, such as fertilizers and high-yielding varieties. Water stored in surface ponds or aquifers is often used as a source of supplemental irrigation that can improve rainfed yields and help stabilize farmers' production and income. Supplemental irrigation also increases farmers' resilience and adaptation to climate change.[45]

17. Increasing urbanization will impact the volume and quality of water available for agriculture, particularly in peri-urban areas. Competing demand from other sectors and public demands for environmental amenities will limit the development of surface and groundwater for agriculture in many regions. This, in conjunction with the impact of climate change will necessitate investments in measures that enhance the adaptation of agriculture, and ensure availability of water for food security. Substantial public and private investments in wastewater capture, treatment, and reuse will be required to protect public health in urban areas and to utilize both the water and nutrients in effluent streams.

18. As cities expand and urban populations increase, it will become increasingly important to capture the nitrogen, phosphorus and other plant nutrients present in wastewater for use in agriculture. Efforts will be needed to ensure that farmers in peri-urban areas retain access to water for irrigation, particularly when there is collection and treatment of wastewater. [46] Globally, the volume of urban wastewater available for reuse in agriculture is small but can be potentially significant at the local level, particularly in arid and semi-arid areas. Urban wastewater, when treated for use in agriculture, provides

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[43] HLPE. 2015. *Water for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.* Rome.

[44] Rao, R.M., Batchelor, CH., James, A.J., Nagaraja, R., Seeley, J. & Butterworth, J.A. 2003. *Andhra Pradesh Rural Livelihoods Programme Water Audit Report*. APRLP, Rajendranagar, Hyderabad 500 030. India.

[45] IPCC. 2014. *Climate change 2014: impacts, adaptation, and vulnerability*. In V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, and New York, USA, Cambridge University Press

[46] FAO. 2015. *Towards a water and food secure future: critical perspectives for policy-makers.* Food and Agriculture Organization of the United Nations, Rome and World Water Council, Marseille. 61 pp. (also available at: http://www.fao.org/nr/water/docs/FAO_WWC_white_paper_web.pdf).

for stable and reliable supply and increases in volume during hot and dry periods as urban dwellers tend to increase water use.

Recommendation 2: Improve agricultural water supply systems

G20 members can consider to:

- Promote sustainable, decentralised water harvesting and storage systems to enhance reliable water supply for single or multi-purpose uses to increase agricultural productivity and climate resilience of local communities.

- Promote investments on the treatment of urban wastewater and its re-use for agriculture, in view of ensuring adequate water supplies to peri-urban agriculture in the context of increased urbanization.

This recommendation directly supports SDG 6 and SDG 13, and contributes to SDG 2 and SDG 15.

Improving productivity, including that of water, with an eye on the natural resource base

19. Raising yields (production per unit of land) is the single most important source of crop water productivity increase. Over the last 30 years, yield increases accounted for 75 percent of the growth in agricultural production. Currently, lower productivity and slow yield growth in some developing countries and in small family farms raise specific concerns. The gap between farmers' yields and technical potential yields reflects the largely suboptimal use of inputs and insufficient adoption of more productive technology.

20. There is great potential to improve productivity where yields are still low, as is the case in many regions of sub-Saharan Africa.[47] Productivity growth needs to increase to keep up with demand growth, but also to increase resilience of the sector to supply shocks, whether due to climate change or due to resource limits. Climate change will increasingly challenge conventional, resource-intensive agricultural systems.

21. Sustainable production intensification[48] provides for the needed shift from the past practices focusing on productivity gains as the primary concern and reducing environmental impacts as a

[47] Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for food, water for life: a comprehensive assessment of water management for agriculture.* London, Earthscan, and Colombo, International Water Management Institute).
[48] Rockstrom et al. 2016. *Sustainable intensification of agriculture for human prosperity and global sustainability.* Pp. 1-14, Ambio. doi:10.1007/s13280-016-0793-6

secondary issue, thus moving sustainability to the core of agricultural development. FAO[49] has developed policy guidelines for the implementation of sustainable intensification and a programme to benefit smallholders.

22. Good agricultural practices, based on soil management, water, fertility and pest control, combined with improved access to markets, can lead to significant improvements in agricultural productivity, adapting to climate change with little impact on water resources. For example, Conservation Agriculture (CA), based on minimal soil disturbance, permanent soil cover and crop rotations, holds tremendous potential for all sizes of farms and agro-ecological systems. Under CA, soils have higher water infiltration capacities, reducing surface runoff and thus soil erosion significantly. This improves the quality of surface water reducing pollution from soil erosion, and enhances groundwater resources.[50]

23. Climate Smart Agriculture (CSA) manages multiple objectives in agricultural growth and development strategies under the specific constraints of climate change. The approach involves identification of technologies to support sustainable increases in agricultural productivity and incomes, building resilience and adaptive capacity in agricultural systems, while reducing and removing greenhouse gases from the atmosphere to contribute to climate change mitigation.

24. Insurance services are a key determinant with respect to the adoption of sustainable production intensification approaches, especially in the context of climate change. Insurance builds resilience and unlocks opportunities that facilitate investment in new agricultural technologies or inputs. Innovative instruments, such as index-insurance differs from traditional indemnity insurance, where payouts are explicitly based on measured loss. Instead, in index-insurance farmers can purchase coverage based on an index that is correlated with those losses, such as wind speed, the amount of rain during a certain window of time (weather based indices) or average yield losses over a larger region (area yield indices).

25. Index-insurance does not claim to protect farmers against every peril, but is designed for situations where there is a well-defined climate risk that significantly influences a farmer's livelihood. As such insurance products indexed to weather station data, area and yield, or satellite rainfall estimations, have the potential to overcome high transaction costs associated with traditional multi-peril crop insurance.

26. Recent projects and analyses suggest many of the challenges that have previously hindered the uptake of index-based insurance, such as poor infrastructure and lack of financing, have been overcome with market-based index-insurance products reaching millions of smallholder farmers even in some of the poorest areas of the world, many of which were previously considered uninsurable.[51]

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[49] FAO. 2011. Save and grow. A policymaker's guide to the sustainable intensification of smallholder crop production. Rome: Food and Agriculture Organization of the United Nations.
[50] Ram A. Jat, Kanwar L. Sahrawat, and Amir Kassam 2014. *Conservation agriculture: global prospects and challenges.* CABI
[51] Greatrex H, Hansen JW, Garvin S, Diro R, Blakeley S, Le Guen M, Rao KN, Osgood, DE. 2015. *Scaling up index insurance for smallholder farmers: Recent evidence and insights.* CCAFS Report No. 14. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen.

27. Achievements in earth observation science have indicated that nowadays it is feasible to determine key data on sustainable agricultural production on the basis of spatial satellite measurements. Remote Sensing and Information and Communication Technologies (ICTs), combined with in-situ data can be used to assess the terrestrial soil water balance and related biomass production to monitor agricultural land and water productivity. This way, farmers can be assisted in obtaining more reliable yields, and irrigation authorities will have access to information to improve their water delivery services.

Recommendation 3: Improve productivity sustainably, including that of water

G20 members can consider to:

- Commit to integrate natural resource management into agricultural policy by reviewing current policies and measures that may provide perverse incentives for unsustainable use of natural resources and redress them.

- Support relevant International Organizations that promote sustainable agricultural production intensification technologies, and strengthen own efforts to increase awareness and adoption of such technologies and approaches, based on a comprehensive analysis of the relationships between food security, food production and natural resource use.

- Promote inter-departmental coordination and implementation of legislation that protects the natural resources and water base, and promote awareness regarding the high human, environmental and financial costs incurred to restore natural environments once pollution and degradation occurs (as opposed to prevention).

- Support innovative and effective market-based risk management options, including weather index insurance, promote the use of ICTs and satellite imagery in agriculture, and the exchange of weather information, including the recovery of historical meteorological information to further the development of weather index insurance and re-insurance markets in developing countries.

This recommendation directly supports SDG 2 and SDG 6, and contributes to SDG 13 and SDG 15.

Reducing food losses and waste to help reduce pressure on land and water

28. Substantial amounts of land, water, energy, and plant nutrients are used to produce the food that is lost or wasted along the supply chain from farms to households. In some settings, efforts to reduce these losses can contribute to improving resource use and enhancing food security. Globally, about one third of the volume of food produced for human consumption is lost or wasted each year. Rough

estimates suggest that the cost for producing food that is wasted amounts to US$750 billion each year. This amounts to 1.3 billion tonnes, enough to feed 2 billion people.[52]

29. Aside from reducing the quantity and quality of food available along the entire food chain, food loss and waste also has negative environmental impacts The amount of water that corresponds to food loss and waste is estimated to be around 250 km³, or three times the volume of Lake Geneva, each and every year. In addition, the production, processing and marketing of food that is eventually lost or wasted contribute to greenhouse gas emissions.[53] The economic, and environmental impacts of food loss and waste must be addressed concurrently due to their direct and significant impact on food security and nutrition, natural resources, and climate change.

Recommendation 4: Reduce food loss and waste

G20 members can consider to:

- Create synergies between activities that promote food loss and waste reduction with national priorities on managing natural resources and adapting to climate change, taking into consideration cross-cutting synergies between water, climate change mitigation and adaptation, food security and nutrition.
- Support the G20 Technical Platform on the Measurement and Reduction of Food Loss and Waste in facilitating local, national and regional level food loss and waste prevention, reduction and measurement.

This recommendation directly supports SDG 12 and contributes to SDG 2, SDG 6, SDG 13 and SDG 15.

Using agricultural trade as an option to address water scarcity

30. Many countries are already witnessing small but progressive changes in their seasonal rainfall patterns and temperatures due to climate change. These fluctuations are expected to become more pronounced, together with increasingly frequent, more severe and unpredictable extreme weather events. Higher temperatures, changing rainfall patterns, and more frequent drought and flooding will impact water availability and quality and hence yields and production.

31. With climate change harming some countries and benefiting others, its effects on water for food security will be uneven across regions, and the overall net effects on yields are expected to be negative. Risks to water and food security are generally greater in low-latitude areas, where the negative effects of climate change will be felt sooner, with countries facing multiple stresses and with low adaptive capacity expected to suffer the most.

[52] FAO (2011). *Global food losses and food waste – Extent, causes and prevention.* Rome.
[53] FAO (2013) *Food wastage footprint: Impacts on natural resources*. Rome.

32. Countries for which the negative effects of climate change will be more severe may have to increasingly resort to global markets as means of ensuring sufficient food for their people. Trade will be an essential tool to maintain global food security in the context of climate change and water scarcity. Projections show an increase in cereal exports from water-abundant to water-deficit areas from 23 percent in 1995 to 38 percent by 2025.[54] Facilitating food trade and improving the functioning of markets will contribute to price stability, and ensure that regions that may face shortages due to adverse effects of climate change can purchase sufficient food.

33. During the 2007-2009 period, export restrictions exacerbated the price spikes and, according to most experts, contributed to severe disruption and a collapse in confidence in international markets. Export prohibitions or restrictions relating to foodstuffs must also conform to the provisions of the WTO agreements. Article XI.2(a) of GATT provides for the temporary application of export prohibitions or restrictions to prevent or relieve critical shortage of foodstuffs. Article 12 of the Agreement on Agriculture requires World Trade Organization (WTO) Members to give due consideration to the effects of such prohibition or restriction on importing Members' food security, give notice in writing, as far in advance as practicable, and consult, upon request, with other WTO Members. These provisions are not applicable to developing countries unless they are a net exporter of the product concerned. These disciplines were considered to have been insufficient and weak during the 2007-2009 period.

Recommendation 5: Strengthen international disciplines on all forms of import and export restrictions, and reduce distorting domestic support

G20 members can consider to:

- Substantially improve market access, while maintaining appropriate safeguards for developing countries, especially the most vulnerable.
- Substantially reduce trade distorting domestic support.
- Widen, strengthen and enforce consultation and notification processes related to WTO rules for export restrictions.
- Promote Aid for Trade initiatives with a view to facilitate the integration of developing countries mostly affected by climate change, water scarcity and reduced productivity, to the international food trade system.

This recommendation contributes to SDG 1, SDG 2, SDG 5, SDG 6, SDG 10 and SDG 16.

[54] Rosegrant, M.W., S. A. Cline, and R.A. Valmonte-Santos. 2010. *Global Water and Food Security: Megatrends and Emerging Issues*. Chapter 2. *In* Ringler, C., A. Biswas and S.A. Cline (eds.), Global Change: Impact on Water and Food Security, Springer.

(ii) iRecommendations under the water domain

Ensuring inter-sectoral policy alignment between water, agriculture, food security, energy and environment

34. As demand grows, there is increasing competition for resources between water, energy, agriculture, fisheries, livestock, forestry, mining, transport and other sectors with unpredictable impacts for livelihoods and the environment. Large-scale water infrastructure projects, for instance, can simultaneously create multiple benefits (hydropower, jobs, water storage for irrigation and urban uses, and to cope with climate change) and negative impacts (on downstream agro-ecological systems, social implications such as resettlement).

35. The concept of Integrated Water Resources Management (IWRM), following the Dublin principles brings together social, environmental and economic objectives, in a cross-sectoral approach of water management, combining users, planners, scientists and policy-makers. IRWM has been widely used and promoted, but it is also the object of numerous criticisms. While it forms a comprehensive framework, it is often found too abstract when addressing implementation challenges. This makes it less operational and practical in recognizing conflicts and enabling proper prioritization of issues, especially those most important for people locally, including water for food security and nutrition.[55]

36. Addressing the challenge of water governance and water allocation between and within economic sectors requires significant efforts, especially in the context of constraints on water availability and climate change. There are significant benefits in the coordination of water policies with development, agriculture, industrial and energy policies. Different forms of coordination, including nexus approaches, can build on synergies between different government departments but also across local and regional actors, including consultation with private actors, civil society and water users.

37. Decisions outside the water domain, such as those determining energy prices, trade agreements, agricultural and other subsidies and poverty reduction strategies, can all have a major impact on water provisioning and demand. Alignment of the many policies, legislation and fiscal measures that influence water management, service delivery and level of demand, calls for an institutional and legal framework that can underpin well-define water rights, provide appropriate incentives for water use, and increase coherence in measures for supply enhancement and demand management.

38. A number of initiatives help advance knowledge and promote more effective governance in the field of water, The Water Governance Facility (WGF), a joint initiative of the United Nations Development Programme (UNDP) and the Stockholm International Water Institute (SIWI), provides assistance and technical support to countries in areas such as integrated water resources management, transboundary water, water supply and sanitation, adaptation to climate change, gender, and integrity, to promote progress on water governance.

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[55] HLPE. 2015. *Water for food security and nutrition*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

39. The Organisation for Economic Co-operation and Development (OECD) has launched the Initiative on Water Governance, a network of public, private and not-for-profit actors, to support better governance in the water sector through experience sharing, analytical work and peer-to-peer dialogue, gathering an inventory of water governance tools, practices and guidelines.

40. The World Bank, Global Water Partnership, and World Water Council have worked on and promoted good water governance and issued reports, recommendations and policy documents.

41. The Groundwater Governance Programme is a joint initiative of FAO, the United Nations Educational, Scientific and Cultural Organization International Hydrological Programme (UNESCO IHP), the International Association of Hydrogeologists (IAH), the World Bank and Global Environment Facility (GEF), coordinated by FAO. The Programme's overarching goal is to put on the agenda of decision-makers the governance required to sustain the socioeconomic benefits of groundwater and avert the impending water crisis.

Recommendation 6: Improve water governance, make institutions adaptive and capable of cross-sectoral coordination

G20 members can consider to:

- Improve the institutional setting for inter-sectoral coordination and decision-making among water users, taking into consideration the multiple societal needs for water and addressing possible inter-sectoral competition.
- Consider water as part of the broader tenure discussion and request FAO and other relevant organizations to gather evidence and engage in reviews, reflections and discussions with key stakeholders on the concept of water tenure in order to develop a common understanding of its use as a governance instrument.
- Support and promote coherence among the existing international initiatives that facilitate governance and knowledge-sharing, and encourage dialogue along the water-food-energy nexus.

- This recommendation supports SDG 6 and contributes to SDG 2, SDG 7 and SDG 16.

Improving knowledge and understanding of the water cycle

42. Governance mechanisms should also recognize the high level of uncertainty associated with future situations, placing emphasis on flexible planning that allows regular upgrading of plans and activities. Such a level of responsiveness is only possible if information and knowledge are updated, and if monitoring and information management systems continually provide decision-makers with reliable

information. There is always the risk that coping strategies be derailed by external factors (such as climate change, global financial and economic shocks, and shifting international cooperation agreements), but to be effective these need to be based on a clear understanding of the hydrological cycle and sound water accounting.

43. Existing data on water resources and use are uneven and inadequate to support many of the policy decisions, including the implementation of SDG 6. Monitoring systems for water, data base and information systems, and modelling capabilities aided by remote sensing technologies are to be more systematically supported and strengthened. FAO's global water data and information system, AQUASTAT[56], helps countries, institutions and individuals through the collection, analysis and dissemination of information related to water resources, water uses and agricultural water management, with an emphasis on countries in Africa, Asia, Latin America, and the Caribbean. AQUASTAT offers standardized data and information providing evidence to measure progress and to inform decision-making; tools to allow for specialized analyses; and capacity development for countries to help improve their understanding and monitoring of water resources, uses, and irrigation management. AQUASTAT is the most widely used and quoted source in water statistics, supports the relevant indicators of SDG 6 and has the potential to be the data, information and global monitoring support tool for water resources on a global scale.

44. Water accounting helps societies to understand their water endowment: how much water there is, where it is, how it is used, and whether current patterns of use are sustainable in future. While water accounting refers to a systematic study of the current status and future trends in both water supply and demand in a given spatial domain, water audit places this account into the broader framework of institutions, finance and the overall political economy. Water auditing presents a systematic review of resources, infrastructure, demand and access, combined with understanding of governance, finance and the overall political and social context.

45. For example, in the context of a village irrigation system, the problem can be either infrastructural (e.g. a pump breakdown), societal (e.g. social exclusion from using certain water points) or resource related (e.g. falling groundwater levels). As such, water auditing provides valuable information to identify problems and their underlying causes, and facilitates politically acceptable and practically possible solutions in the context of a district, a country or a large transboundary river basin.

[56] http://www.fao.org/nr/water/aquastat/main/index.stm

Recommendation 7: Support water data and information systems; develop effective water accounting and auditing systems

G20 members can consider to:

- Support acquisition and generation of water and related data and information at country level and help improve harmonization, analysis, and SDG 6 monitoring, including support to enhance AQUASTAT to better serve the increasing information needs at all levels (river basin, national, regional and global).
- Promote the development of water accounting and auditing systems to address the increasing importance of information and knowledge, as well as the significance of communicating scarcity conditions to relevant stakeholders.
- Commit to support developing countries, prioritizing those that will be negatively impacted by climate change, through capacity building, to establish and operate appropriate water accounting and auditing systems.

This recommendation directly supports SDG 6 and contributes to SDG 2.

Communicating scarcity

46. In many countries, increasing demand for water may result in intense competition within and across all economic sectors, especially in the context of countries that are characterized by limited water supply. Climate change can add significantly to such water scarcity. Water users should be made aware of scarcity conditions in ways that influence their water-use decisions.

47. Scarcity conditions can be communicated in the agricultural sector in a variety of ways, including farmer awareness campaigns, regulations, prices, incentives and allocations. Water pricing is an option to communicate scarcity - charging higher water prices to reflect scarcity conditions can encourage farmers to manage their water deliveries with greater care. A number of countries use water pricing to communicate water scarcity. For example, in Australia, price signals and effective water markets are seen as an essential part of improving the economic efficiency of water use and encouraging water users to adjust to changing climatic conditions.

48. Often, for political or cultural reasons, water pricing is difficult to implement. For many countries, agriculture has multiple roles, such as economic, social, cultural and environmental. In many cases, farmers are not averse to paying higher prices if water delivery service were to improve at the same time that prices increased. An effective public awareness campaign that explains the need for water prices due to scarcity conditions may help promote a positive response to increased water prices.

49. Nevertheless, the use of market or pricing mechanisms is not applicable in all situations. In irrigation, the excessive promotion of simplistic market-based approaches across the board in the 1990s has rarely been successful. In fact, there is much scepticism amongst irrigation professionals about the feasibility and even the desirability of using irrigation charges to encouraging the efficient use of water by farmers.[57]

50. In a few regions (Chile, parts of Australia and some states of the United States of America) water is allocated to agriculture and other sectors through markets. Through these markets, farmers can procure supplementary water for their crops during drought conditions, and municipalities can also address their growing water needs. The actual prices set in these markets signal the marginal values of water in these different uses. Nevertheless, these markets are local and pertain to water scarcity in a particular basin, and thus price observations from one context may have little relevance in another.[58] Water markets require strong institutions and well-defined water rights, in order to motivate water users to generate substantial value with the limited resources allocated. Farmers who can generate higher value to purchase water from farmers who generate lower value, thus increasing the value of output across a region or river basin.

51. In areas where water pricing is not yet politically feasible governments might consider implementing water allocations by assigning to each user a pro-rated portion of that volume. When farmers know their water supply is limited, they have an incentive to optimize the values they obtain with the amount of water they receive. Such a binding water constraint at the farm level can be as effective as water pricing in generating regional water use efficiency, if farmers were allowed to trade or sell portions of their water allocations.

52. Rationing is often viewed as a short-term response to temporary water shortage conditions. One challenge of implementing water rationing is to achieve the desired degree of equity and efficiency across water users and across competing sectors. An agricultural water agency may need to determine how to ration water for farmers producing grains, vegetables and perennial crops. For this reason, it is best to develop a water rationing policy in a collaborative process, ensuring inter-sectoral coordination and decision-making, well in advance of the need to implement water rationing.

53. Many semi-arid countries and provinces also engage in farmer awareness campaigns during periods of extraordinary water shortages. Such campaigns generally attempt to persuade farmers to use water wisely, while not requiring changes in water use practices or imposing fines for excessive water use. The effectiveness of farmer awareness campaigns can fall short of expectations in areas where farmers retain access to plentiful water supplies at affordable prices, despite increasing aggregate water scarcity.

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[57] Molle, F.; and Berkoff, J. (editors). 2007. *Irrigation water pricing: the gap between theory and practice.* Comprehensive Assessment of Water Management in Agriculture Series. Wallingford, United Kingdom, CABI.
[58] Aylward, B., Seely, H., Hartwell, R. and Dengel, J. 2010. *The Economic Value of Water for Agricultural, Domestic and Industrial uses: A Global Compilation of Economic Studies and Market Prices.* Rome, Italy, Food and Agriculture Organization.

Recommendation 8: Communicating scarcity conditions

G20 members can consider to:

- Undertake highly visible efforts to communicate scarcity conditions to farmers in regions where it is needed. These efforts should be an essential component of national water and food security strategies, based on monitoring and in line with institutional capacity and infrastructure, in ways that effectively influence decisions by farmers and increase efficient water use, without compromising productivity. Policies and their implementation should include provisions for the poor, disadvantaged, and women.

This recommendation directly supports SDG 6 and contributes to SDG 1, SDG2, SDG 5, SDG 13, and SDG 15.

Promoting and leading global coordination on water and agriculture

54. Adequate access to food and water are essential for life and socio-economic development, and as such are addressed by global fora in their efforts to end hunger and poverty worldwide.

55. Water is at the core of the 2030 Agenda, with a dedicated Goal (SDG 6) and many linkages to health, food security, climate change, resiliency to disasters and ecosystems, among many others. Reaching its ambitious objectives demands that we address access to water and sanitation along with issues of water quality and supply, in tandem with improved water management to protect ecosystems and build resilience.

56. The ministerial declaration adopted on 13 March 2012 during the World Water Forum in Marseille, France, recommends that water and food security policies meet the needs of the most vulnerable, in particular local communities, smallholder farmers, women and indigenous peoples. It also recommends that soil and water management practices need be promoted to minimize erosion, land degradation and water pollution. Furthermore, it welcomes specifically the commitment of the G20 and other relevant entities to address water and food security.

57. At the 21st Conference of Parties to the United Nations Framework Convention on Climate Change (COP21) in Paris, France, Parties reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris Agreement establishes binding commitments by all Parties to prepare, communicate and maintain Intended Nationally Determined Contribution for mitigation (INDCs). It also establishes a global goal to significantly strengthen national adaptation efforts – enhancing adaptive capacity, strengthening resilience and reduction of vulnerability to climate change – through support and international cooperation. COP21 identified water scarcity and water related issues as a major challenge to food security, ending hunger and reducing poverty in the twenty first century. Of all INDCs that have an adaptation section, 88 percent mention the water sector, and out of these, 86 percent specify water scarcity and water quality measures. This is in line with the 2030 Agenda as well SDG 6.

58. FAO will launch an initiative entitled “Coping with water scarcity in agriculture: a global framework for action in a changing climate” during COP22 in Marrakesh, Morocco. The Global Framework will support the development and implementation of policies and programmes for the sustainable use of water in agricultural sectors (including crop production, livestock, fisheries, aquaculture, and forestry), and along the value chain, using context-specific approaches and processes. It will provide countries with support to integrate climate change into agricultural policies by identifying priority actions and scaling up successful responses to the threats to agricultural production posed by increasing water scarcity. In so doing, the Global Framework will help countries, communities and businesses satisfy their needs for increased food production in the face of climate change, while conserving the ecosystems and the ecosystem services they provide.

Recommendation 9: Effectively engage in dialogue in, and support international fora and initiatives

G20 members can consider to:

- Continue dialogue based on the recommendations concerning food security and water made by Ministers in their Declaration at the World Water Forum, held in Marseille, France, on 13 March 2012.
- Support more effective dialogue between food and agriculture; water; and energy sectors and bring the food and agriculture dimension to the respective global and regional water and energy fora.
- Support the operationalization of the recommendations endorsed by the Committee on World Food Security (CFS), in its 42nd Session in 2015, on Water for Food Security and Nutrition (available at http://www.fao.org/3/a-av046e.pdf).
- Engage in the 22nd Session of the Conference of Parties (COP22) to the United Nations Framework Convention on Climate Change (UNFCCC) recognizing the importance of food security as part of the Paris Agreement and emphasizing the linkages between water, agriculture, food security and nutrition within the context of the international response to climate change.
- Support FAO’s initiative, entitled *‘Coping with water scarcity in agriculture: a global framework for action in a changing climate’*, which will be launched at COP22 to promote the sustainable use of water resources.

This recommendation directly supports SDG 6 and contributes to SDG 1, SDG2, SDG 5, SDG 7, SDG 10, SDG 13, SDG 15 and SDG 17.

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