This background note compiles analytical work on agriculture, fisheries and water sectors and was prepared by Luz B. Diaz Rios and Joshua Gill (Agriculture and Food Global Practice), Berengere Prince (Environment and Blue Economy Global Practice) and Canan Yildiz, Sanyu Lutalo, Regassa Ensermu Namara, Verena Schaidreiter and Zhimin Mao (Water Global Practice), with inputs from Jun Han (Social Protection and Labor Global Practice).
INTRODUCTION

Making economic development more resilient and sustainable in Turkey largely depends on the possibility to consolidate significant gains in the agriculture, fisheries, and water sectors. Climate risks are a significant threat to livelihoods and economic opportunities generated by these sectors, yet the intensification of these sectors and unsustainable management are also contributing to the climate problem.

Climate change is expected to exacerbate land degradation through soil erosion, fertility loss, and nutrient depletion, with negative impacts on agriculture and livestock productivity. The short-term impacts of severe climate-related events in the sector can be dramatic and seriously compromise food security—droughts in 2007-08 affected 435,000 farmers with declines in wheat production of up to 90 percent in some regions. Climate change poses significant risks to Turkey’s water security and sustainability of Turkey’s fisheries and aquaculture systems. Over two-thirds of the country’s 25 river basins face severe water scarcity, with implications for urban and rural populations and the overall economy. A World Bank assessment on water scarcity estimates that a 10 percent reduction of water supply due to climate change would cost Turkey 6 percent of GDP. Similarly, ocean warming has contributed to an overall decrease in maximum catch potential and observed declines in many regions in the abundance of fish and shellfish stocks.

While these sectors are highly affected by climate change, they are also important contributors to its solution. Agriculture is relatively carbon-intensive, compared with the rest of the economy, representing 13.4 percent of total 2019 Greenhouse gas (GHG) emissions in Turkey. Emissions in the water sector are largely generated by electricity and fossil fuel used in pumping for water-related services. Achieving efficiencies in these sectors through adoption of improved management practices and technologies, offer considerable potential for emission reduction and enhanced carbon sequestration.

This Background Note discusses key elements of the nexus between climate and the agriculture, fisheries, and water sectors to inform Turkey’s Climate Change Development Report. Chapter 1 focuses on climate change and agriculture, especially how climate risks threaten different aspects of agriculture, how agriculture and related activities contribute to climate change pressures, and how to strengthen pathways for low-carbon agriculture development. Chapter 2 focuses on climate change and fisheries. It reviews Turkey’s coastal and marine ecosystems, and sheds light on the impact of climate change on Turkey’s fisheries. Chapter 3 focuses on climate change and the water sector. It highlights the countrywide significance of climate change in this sector and of its implications across productive subsectors, landscapes and on rural and urban populations. It identifies priorities for advancing climate adaptation and mitigation to strengthen Turkey’s path towards resilience and decarbonization in the water sector.
CHAPTER 1: CLIMATE CHANGE AND AGRICULTURE AND FOOD SYSTEMS

Turkish agriculture sector contributes importantly to exports, overall economic growth, and employment. Consistent with increasing urbanization and overall economic development, the contribution of the agricultural sector to total GDP in Turkey has declined over the years. However, this declining trend has been showing signs of slowing down, fluctuating between 5.8-6.7 percent for most part of the past decade, reaching a 6.6 percent in 2020 (this is well above the average of OECD countries). The sector has been expanding, at an average of 2.7 percent during the period 2010-19, and demonstrating promising signs of resilience in the context of the 2018 economic and COVID-19 crises, growing faster (3.7%) than overall GDP (2.9%) during the period 2016–20. The agri-food sector shares about 10-11 percent of total country exports. The sector’s primary activities provide employment for about 5 million people, approximately 18 percent of the country’s labor force, of which 40 percent are women. Overall, agricultural growth in Turkey has proven to be pro-poor and it has considerable unrealized potential to expand prosperity.

Climate risks represent a significant threat to sustain sectoral gains, rural incomes, and employment, and can increase food price pressures and overall food security concerns. Data from the Turkish State Meteorological Service confirms the increasing occurrence of extreme weather events, which are projected to occur more often as the climate changes.\(^1\) Climate change is also projected to reduce the availability of surface water, increase the frequency and severity of floods, and prolong dry seasons and droughts. The Global Food Security Index ranks Turkey 47\(^{th}\) among 113 countries with respect to the overall food security environment.\(^2\) A granular look at the index categories shows that the major risks for Turkey are exposure to droughts and severity of storms. The impacts of severe climate-related events in the agriculture sector can be dramatic. For example, droughts in 2007-08, affected 435,000 farmers, with estimated losses by the Ministry of Agriculture and Forestry (MoAF) of TRY 1.8 billion, crop production declined by 9 percent year-on-year, with a drop in total cereal production of 16 percent (reaching 90 percent for wheat and other grains in the south-eastern Anatolia Region and 60 percent for red lentils). A World Bank assessment on water scarcity estimates that a 10 percent reduction of water supply from climate change would cost Turkey 6 percent of GDP and about US$50 billion (see Chapter 3 for further details).\(^3\)

Climate risks are also a significant threat to the resilience of the sector’s natural capital (soil, water, biodiversity) and upsurge of pests and disease outbreaks. The combination of geographical, topographic, climatic, and soil characteristics, combined with unsustainable farming practices, makes Turkey prone to erosion, with a recent study estimating that 32 percent of the country’s territory is at high risk of land degradation and desertification.\(^4\) Climate change is expected to exacerbate land degradation through soil erosion, fertility loss, and nutrient depletion, with negative impacts on agriculture and livestock productivity and the soils’ capacity to serve as carbon sinks— About 55.14 percent of Turkey’s land area is used for agricultural purposes. The sector is the largest water user in the country accounting for more than 85 percent of total freshwater abstractions, compared with an OECD average of 42 percent. An analysis of water requirements for 35 crops in 81 regions suggests that the economic effects of climate

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2. The index is a function of affordability, availability, quality and safety, and natural resources and resilience. Among these categories, Turkey does particularly poorly on affordability and natural resources and resilience.
change will be mild until the mid-2030s and then become more severe. Changes in climate are already affecting which crops can be grown where and the productivity of farmlands and pasturelands. Declining biodiversity is reducing the numbers and variety of pollinators, loosening natural checks on pests, and risking eliminating species that could have benefited humans in the future. Extreme weather events and exposure to increased temperatures can adversely affect animal and plant health, resulting in an increased propensity for disease incidence (including of zoonosis diseases) and death. Turkey has borders with countries where many economically important infectious and vector borne diseases are endemic. Climate-related events can create even more favorable conditions for emergence/re-emergence of existing and introduction of plant diseases, new infectious and/or vector-borne animal diseases and zoonoses.

The expansion and intensification of agriculture and related manufacturing activities is also contributing to climate change pressures. Turkey’s agriculture sector is relatively carbon intensive compared with the rest of the economy, with the sector’s share of emissions doubling its share in GDP. Turkey’s total GHG emissions from agriculture were estimated at 68 million tons of carbon dioxide equivalent (tCO2e) in 2019 representing 13.4 percent of total country GHG emissions. The sector is the primary contributor of methane (CH4) and nitrous oxide (N2O), with 62.4 percent of CH4 emissions and 70 percent of N2O total emissions originating from agricultural activities, both gases with a higher warming potential than CO2. The largest sources of GHG emissions in agriculture are digestive processes in animals (enteric fermentation, 49 percent of sector emission), agriculture soils (35 percent), and livestock manure (13 percent).

Current food/feed demand and agricultural expansion trends suggest the sector’s fast GHG emission growth trajectory experienced during the past decade, may continue in the decades to come. Although agriculture GHG emissions have been growing slower in comparison with other sectors (47.7 percent growth in 2019 as compared to 1990 level), yet rapid emissions growth has indeed occurred since 2010, resulting from the expansion and intensification of agriculture and livestock activities. The livestock sector, in particular, has experienced a considerable expansion. Numbers of cattle were 58.5 percent higher in 2020 than in 2010, growing at an average of 3.6 percent during the period (versus 1.2 percent during 2000-2009), and growing even faster during the period 2015-2020, at a 5.7 percent average rate. During the past decade, approximately 6.4 million head were added to the national herd (equivalent to about 0.68 head for every new inhabitant added). The trend in numbers of poultry, sheep, and goats was similar; modest or negative growth in numbers before 2010 was succeeded by very dynamic growth in numbers from 2010 onward. Livestock production has also driven land degradation, given the high intensity of production in Turkey, contributing further to GHG emissions. Although consumption of red meat in Turkey remains much lower than global and regional averages, it is projected to continue increased, fueling the sectors expansion. In relation to crops, fertilizer consumption is growing fast and above the average for OECD countries. Misuse of fertilizers, when combined with the mismanagement of land, increases GHG emissions and cause water and soil pollution problems.

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8 Methane is a powerful greenhouse gas with a 100-year global warming potential 28-34 times that of CO2. Measured over a 20-year period, that ratio grows to 84-86 times. Nitrous Oxide (N2O) has a GWP 265–298 times that of CO2 for a 100-year timescale.
9 This category covers N2O emissions from synthetic fertilizers, organic fertilizers, and crop residues, as well as N2O emissions from pasture, range and paddock manure, cultivation of organic soils, and indirect emissions, which consist of atmospheric deposition and nitrogen leaching and run-off.
Building climate resilience in the agriculture sector against drought and other natural hazards is a key adaptation challenge for Turkey. Climate change impacts on Turkey’s agriculture sector are expected to exacerbate in the coming decades, requiring improved risk management, planning and adaptive innovation. A set of priority actions to reduce vulnerability to, transfer and cope with climate-related risks are at the core of effective adaptation strategies in the agriculture sector. Turkey has identified agriculture as a core priority in its National Climate Change Adaptation Strategy and Action Plan (2011-2023) and has been investing in building adaptation, largely around irrigation investments, but also through some targeted research and development efforts on drought-and-disease tolerant plant varieties; supporting the adoption of improved agricultural practices; and expanding protected agriculture; yet these efforts would need to be scale-up in the years ahead as climate-related challenges intensify. In the irrigation front, Turkey has ambitious goals to expand and modernize irrigated areas (see Chapter 3 for details), but expanding irrigation is only a piece of the puzzle, as strategies for enhancing the climate resilience of the agriculture sector need to be holistic, and improve both access and efficient water use, along with seizing opportunities for influencing crop patterns towards promoting water storage and conservation practices, as well as low-water demand crops in regions facing high water scarcity. In the risk transfer front, the Agricultural Insurance Pool (TARSIM) is a strategic risk-transfer instrument established in 2005 to compensate and minimize farmers’ financial losses due to climate and other natural risks, with more than US$6 billion insured in 2020. Still, there is potential to continue improving it to increase outreach and test innovations. Coping with climate change through social safety nets and food reserves, among others, are also complementary measures to help farmers and rural villagers overcome the impacts of a changing climate.

Strengthening development pathways for low carbon agriculture would contribute to national climate mitigation objectives and build the basis for the long-term sustainability of the sector. Expanding the use of climate-smart agriculture (CSA); supporting a strong agenda on soil health, effective land planning, bringing nature to agriculture land; and sizing opportunities for reducing food losses and waste, are clear pathways to support low-carbon agriculture in Turkey.

(i) Climate-smart agriculture (CSA) can facilitate a triple-win for sustainable agriculture development. CSA aims to simultaneously achieve three outcomes: enhanced resilience, increased productivity, and reduced GHG emissions. Examples of CSA range from traditional practices (e.g., organic farming), nature-based solutions (e.g., conservation agriculture and ecosystem-based approaches to production), to modern technologies such as alternate wetting and drying (AWD) and precision agriculture (PA). AWD can minimize energy and water use while improving crop yields. PA applies digital technologies for improved decision-making in crop and livestock production based on real-time data, thus can effectively respond to climate risks and emergencies, and contribute to enhanced crop production and efficient input use. Protected agriculture simultaneously increases adaptation and productivity, while generating important input-use efficiencies. Investments in expanding and modernizing irrigation systems and effective water use and storage are top priority, triple-win solutions to

10 2020 Annual Report. Available at: https://www.tarsim.gov.tr/pages/aboutUs/faaliyet-raporlar.jsp
11 CSA is an integrated approach to managing landscapes—cropland, livestock, forests, and fisheries that addresses the interlinked challenges of food security and accelerating climate change. World Bank Climate Change Action Plan 2021-2025.
scale-up adaptation in the Turkish agricultural sector. Recent IFC estimates suggest that investing in CSA in four emerging economies in Europe, including Turkey, could generate a market size of US$80 billion while reducing 15.1 million tons of GHG emissions and generating 2.5 million jobs.\textsuperscript{12}

(ii) **Preserve soils health and bring nature to agriculture landscapes.** Protecting soil health through the adoption of sustainable soil and land planning management practices is essential for strengthening adaptation, agricultural productivity, and food security. Conservation and better management of soils and land has emerged as a key priority for climate change adaptation and mitigation, both globally and in Turkey, with important regulatory actions taken by the government to address issues of soil and land degradation, as well as implementing grant schemes with farmers to encourage soil conservation and good agricultural practices such as organic agriculture, among others. Bringing nature to productive landscapes e.g., live fences; connectivity corridors, watershed protection, etc., to enhance provision of climate adaptation/mitigation services represent important opportunities for enhancing resilience and carbon sinks. Furthermore, interventions around improving grasslands/pastureland represent important opportunities for reducing GHG net emissions from the livestock sector, specifically in areas of Turkey with more extensive livestock systems. Yet, much needs to be done to expand the benefits of soil/land and pasture practices to larger number of farmers.

(iii) **Tackling food losses and waste.** A recent Life cycle assessment (LCA) of the carbon, water, and energy footprints throughout the food supply chain in Turkey, estimated food losses and waste in the amount of 16 million tons in 2016, representing a GHG emissions, water, and energy footprint of 23.7 Mt of CO2-eq; 6.2 × 10\textsuperscript{9} m\textsuperscript{3} of water and 13.5 ×10\textsuperscript{4} TJ of energy, respectively.\textsuperscript{13} The FAO (Food and Agriculture Organization) estimated food losses and waste in Turkey to reach 19 million tons every year. The Government has undertaken successful campaigns to create awareness among consumers and other supply chain actors on the opportunities to reduce food waste. Effective implementation of the recently prepared National Strategy on Prevention, Reduction and Monitoring of Food Loss and Waste will go a long way reducing GHG emissions in the sector, while achieving efficiencies and food security gains.

(iv) **Energy efficiency solutions for agriculture.** There are also opportunities to complement the above sectoral investments with cross-cutting investments, such as energy efficiency investments (e.g., biogas production; solar energy; geothermal generation; wind energy) to bring holistic low carbon solutions to the sector and increase its competitiveness.

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Smart climate policy in agriculture contribute to reducing emission and environmental and natural resources degradation, improving resilience, and generation of livelihood opportunities. Turkey has made important progress on prioritizing agriculture climate action as part of the national climate change plans and strategies and aligning national development plans and sectoral programs around such climate change objectives. However, there are opportunities to repurpose public investment support towards further advancing actions highlighted in such policies and global commitments. Agriculture support in Turkey is still highly focused on price support and variable input subsidies. These types of support are high in most OECD countries, but in Turkey its share of agriculture support has traditionally been particularly high. Turkey maintains production-linked payments for many products. Contrary to the United States and


the European Union, Turkey’s support for less-distorting non-commodity-type programs (i.e., green box)—conservation, rural development, agroforestry, nutrition, and bioenergy, etc.—has increased substantially and now accounts for a majority share of total farm support. Meanwhile public expenditure on agricultural research, development, and innovation (RD&I) averaged only 5 percent.¹⁴

Implementing a strong climate change agenda in the sector, will require analysis and capacity assessment, improved coordination across MoAF departments, and other relevant agencies to align policies at the national and subnational levels. A very important entry point is to work towards evidence-based policy making, starting with rigorous assessments of the current sectoral support impact on productivity, climate, and the environment. Furthermore, piloting new programs and investments and scaling-up past successful programs also represent opportunities. To support effective policy making, Turkey will need to invest on improving its agricultural and livestock data (the last agricultural census in Turkey was carried out twenty years ago), and enhance data collection, sharing and dissemination. For the management of agriculture risks (e.g., droughts; land), there are multiple policy frameworks and responsibilities among relevant agencies that remain to be further clarified and coordinated in an integrated manner. Recent institutional changes have attached directorates for water infrastructure (DSI), water management (SYGM), and meteorology (MGM) to the MoAF, and hence strengthened its capacity to integrate actions and improved coordination.

Public and private sector coordination and collaborative engagement is key for effective climate action. The largest investments in the future growth of the agri-food system will come from the private sector (including large, medium, and small-scale producers and processors), with public spending required as well. It is the coordination of private efforts with public investments, however, that will open the most important avenues for collaborative innovation focused on the objectives of a productive, climate resilient and low carbon sector. This collaboration should be institutionalized as the foundation for sustained growth that contributes to poverty and shared prosperity and to national and global environmental and climate objectives.

¹⁴ In high agricultural producing countries such as Brazil, 92 percent of its GSSE goes to innovation, and in Norway, Australia, the EU and Argentina, half of expenditures on general services support agriculture innovation. OECD (2020). Agricultural Policy Monitoring and Evaluation 2020. OECD (Agricultural Policy Monitoring and Evaluation). doi:10.1787/928181a8-en.)
CHAPTER 2: CLIMATE CHANGE AND THE BLUE ECONOMY

Climate change is expected to have significant negative impacts on Turkey’s ocean and coastal economy. Climate change and sea level rise (SLR) will negatively impact economic assets and activities in coastal areas that are nationally important to economic productivity. Turkish coastal cities cover less than 5% of the total surface, yet they are home to 51% of the population, 80% of industrial activities and 90% of tourism income.15 According to a study, potential losses resulting from SLR and storm surges could cost Istanbul US$ 200 million annually until 2030, and this will increase up to US$10 billion dollars annually by 2100.16 Moreover, the resulting changes to ocean processes and functioning are projected to have serious impacts on key economic sectors such as tourism and fisheries, which are highly reliant on climate-sensitive resources.

Turkey’s coastal and marine ecosystems are increasingly threatened by climate change stressors. According to a recent study, surface sea water temperatures (SST) values increased along the whole coastal areas of Turkey with expected impacts on marine life, fish population, precipitation regime, and drought feature.17 Moreover, warming temperatures and ocean acidification are weakening the ability of the ocean and coasts to provide critical ecosystem services such coastal protection, food, and carbon storage. Oceans by absorbing about one-third of carbon dioxide emissions play a vital role in mitigating climate change, for instance, the current value of carbon sequestration over the entire Mediterranean basin amounts to €337.3 million every year.18 Yet studies point out that climate change decreases the ocean’s biological role as a carbon sink, with estimates that the amount of carbon that has been removed and stored in the deep ocean has decreased by 1.5 percent over the past 30 years as a result of rising temperatures.19

Climate change poses new challenges to the sustainability of Turkey’s fisheries and aquaculture systems. Ocean warming has contributed to an overall decrease in maximum catch potential and observed declines in many regions in the abundance of fish and shellfish stocks due to direct and indirect effects of global warming and biogeochemical changes.20 This phenomenon is already being observed in Turkish waters, where anchovies population has diminished as a result of warming of sea water finding refuge in the much cooler northern regions of the Black Sea.21 Future projections, suggest that all fish stock will decrease in all the regions of the Black Sea except for sprat.22 Climate-driven changes are also expected to have both long and short-term impacts in the aquaculture sector at multiple scales. Aquaculture is one of the fastest growing industries in Turkey and its production is projected to reach

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15 Albayrakoğlu E. Climate change and security: the case for Turkey. Gazi University Akademik Bakış J. 2011; 5:59–76.
600,000 metric tons in 2023, with a value of around US$2 billion.\textsuperscript{23} Examples of potential climate impacts include loss of production or infrastructure due to extreme events, diseases, toxic algae and parasites; decreased productivity due to suboptimal farming conditions; limited access to freshwater for farming, limited access to feeds from marine and terrestrial sources; eutrophication and other perturbations.\textsuperscript{24}

**Turkish coasts and seas are also threatened by increasing levels of pollution and climate change may exacerbate these detrimental effects.** Turkey has seen an increase in coastal pollution in recent years. A recent WWF (World Wide Fund) Report estimated Turkey’s coastlines receive the highest plastic debris flux of any Mediterranean coast and its economy loses over US$95M annually due to plastic pollution, as it affects the tourism, shipping, and fishing economies.\textsuperscript{25} Nutrient overload caused by excess agricultural runoff is also causing serious harm to coastal marine ecosystems and represents the main cause of marine eutrophication. Climate change can further exacerbate these impacts, while for example extreme weather events may increase river runoff and, as a consequence, the level of nutrient or plastic pollution reaching the coast. According to several experts, the massive Mucilage outbreak event in the Marmara Sea (summer 2021) is linked to nutrient pollution combined with complex temperature and water exchange impacts from climate change.

**Realizing the potential of the Turkish ocean economy is a major challenge that is likely to become increasingly important in coming decades.** Climate change impacts are likely to increase dramatically toward the end of this century and risk to further compromise the already fragile health and resilience of marine ecosystems and the ability of the ocean economy to sustainably develop and prosper. Maintaining a robust ocean economy will depend on swift efforts to shift to a sustainable and climate-resilient Blue Economy. In this regard, nature-based solutions (NBS) represent particularly sustainable and cost-effective strategic approaches that incorporate ecosystems within climate efforts and can be rapidly implemented.


\textsuperscript{25} Dalberg Advisors, WWF Mediterranean Marine Initiative, 2019 “Stop the Flood of Plastic: How Mediterranean countries can save their sea”
Turkey is not water rich, and current levels of water stress and the risk of hydrological extremes and scarcity are likely to increase in the future, exacerbated by the effects of climate change, urbanization, and increased water demand induced by growth in economic activities such as tourism and agriculture. Water availability in Turkey varies significantly in space and season, leading to regional and local water scarcity. The country has an average annual precipitation of 593 mm. The Black Sea and Mediterranean regions have relatively more precipitation, while the Central Anatolia Region and Eastern Anatolia Region of the country are water scarce, with average amounts of 2500 mm and 230 mm in the northeast and middle of the country, respectively, as demonstrated in Figure 1 (Source: Turkey Water Sector Engagement Note, 2020).

Turkey’s available per capita freshwater amount is only half the global average, and 15 of its 25 river basins are water stressed. This includes some of the highest populated basins such as, the Marmara basin where Istanbul, the country’s largest city of about 16 million inhabitants is located, with just 225 m$^3$/capita/year; Sakarya, where Ankara, the second largest city of over 5 million inhabitants is located, having 517 m$^3$/capita/year, and similar trends in large cities such as Izmir and Antalya (Turkey Water Sector Engagement Note, 2020, p.62). As a result of the drought in the second half of 2020 and early 2021, several reservoirs around major cities had reached their lowest water storage levels in 15 years. For example, Istanbul’s reservoir levels fell to less than 20 percent of their capacity in early 2021, putting water supply services at high risk for the city’s 16 million customers and other users, including industry. Important agricultural areas, such as the Konya plains in the central part of the country, are also facing increasing water scarcity. Most of the renewable water resources of Turkey are internally generated, with the water Dependency Ratio at only about 1.5%.

Current and projected water stress levels are unevenly distributed across regions in Turkey. Figures 2-4 present the baseline and projected water stress for 2040 across Turkey, based on analysis from the World Resources Institute’s (WRI) Aqueduct risk mapping tool [1]. These maps measure the ratio of total annual water withdrawals to total available annual renewable supply, accounting for upstream consumptive use, based on current and 2040 projections under a business-as-usual approach.

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26 Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress may cause deterioration of freshwater resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.), environmental flows and accessibility to water. The threshold for countries regarded as water stressed is those having available water resources below 1,700 m$^3$ per capita per year. However, it shall be noted that global evidence from water poor countries such as Singapore and South Korea, which have achieved water security, has shown that water security is not just dependent on a country’s water endowment, but also on overall management of the resource.

27 “Water scarcity” refers to the volumetric abundance, or lack thereof, of water supply. Absolute water scarcity is defined as providing less than 500 m$^3$/capita/year; water scarcity is less than 1,000 m$^3$/capita/year, water stress is less than 1,700 m$^3$/year, and more than 1,700 m$^3$/capita/year is no water stress.


29 Water dependency ratio is an indicator expressing the percent of total renewable water resources originating outside the country.
Figure 1 – Average annual precipitation in Turkey 2019

Source: Turkey Water Sector Engagement Note, 2020, p.35

Figure 2 - Baseline Water Stress in 2015 with Population
Despite increasing water scarcity, water use, and withdrawals have steadily increased in recent decades in Turkey. In 2018, the total water withdrawals reached 61,094 million m³, almost doubled comparing with 28,073 million m³ in 1990. In 2017, 85 percent of annual freshwater withdrawals was used for agriculture, 10 percent for domestic purposes, and 5 percent for industry. According to the Ministry of Environment and Urbanization (2016), water demand is expected to increase even further to 112km³ in 2023 especially for irrigation purposes. Between 1990 and 2013, Turkey’s sectoral water consumption increased significantly: water demand for agricultural purposes more than doubled and the demand for

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[1] The WRI Aqueduct risk mapping tool provides data on countries’ projected exposure to baseline water stress under the business-as-usual, pessimistic, and optimistic scenarios for the years 2020, 2030, and 2040.

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30 Data Source: OECD (2022), Water withdrawals (indicator) in Turkey. doi: 10.1787/17729979-en (Accessed on 05 April 2022)
31 Data source: World Bank DataBank, applying filters including Turkey and Annual Freshwater withdrawals, https://databank.worldbank.org
public usage almost doubled. Water usage for energy increased by about 46 percent, and water for industrial use (excluding energy) increased by around 10%. In contrast, over the same period, most European countries were able to reduce their total annual water extraction rather than increase it, and even in southern Europe (where most irrigation undertaken by European countries occurs) agricultural water consumption was brought down by about 7 percent. Figure 5 demonstrates the water consumption by sectors for selected years (Turkey Water Sector Engagement Note, 2020, p.20-21).

The combined impacts of climate change and excessive groundwater pumping due to increasing water demand have caused a significant decline in groundwater levels. Simulation of aquifer behavior until 2050 using a numerical groundwater flow model predicted reductions in recharge of aquifers and groundwater availability in Turkey, particularly in the coastal plains along the Mediterranean Sea where groundwater is the main source of irrigation water. An estimated 95 percent of exploitable groundwater resources are already being used for irrigation, domestic, and industrial purposes, with irrigation consuming about two-thirds of the total amount of groundwater used. Drought severity has exacerbated groundwater depletion leading to unsustainable levels of groundwater in some basins. For example, in Konya basin groundwater levels have dropped by more than two meters, threatening the long-term sustainability of agriculture, and contributing to the occurrence of massive sinkholes. While some sinkholes are relatively shallow, others can be as deep as 150 meters.

Water quality and pollution are also serious concerns in Turkey. This is caused by widespread pollution from the discharge of untreated industrial and domestic wastewater into freshwater bodies and the sea, and pollution from agricultural practices such as use of fertilizers and pesticides (Turkey Water Sector Engagement Note, 2020, p.11). Approximately 16% of residential wastewater and 38% of industrial wastewater is not treated before being discharged into water bodies (OECD, 2019). A third of Turkey’s lakes and up to half of its rivers are considered either “contaminated” or “highly contaminated” by phosphorus and nitrogen (Turkey Water Sector Engagement Note, 2020, p.11). About 90% of municipal or urban populations and 50% of rural population have access to safely managed sanitation, with the rest using on-site sanitation (Turkey Water Sector Engagement Note, 2020, p.12). Wastewater treatment

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32 Avci et al. 2021. Assessing the effect of climate change on groundwater use in Demre coastal aquifer (Antalya, Turkey), coupled use of climate scenarios and numerical flow modeling

33 Sinkholes open up when underground caverns created by drought can no longer contain the weight of the layer of soil above
capacity has steadily increased as a result of sustained investments in the last decade, with the share of the population served by wastewater treatment plants growing from 36% to 79% between 2004 and 2018 (Turkstat 2019). Climate change induced warming of receiving water bodies exacerbated the impacts of excessive nutrient discharges (mainly nitrogen and phosphorous) from inadequate wastewater treatment on the Marmara Sea in 2021, resulting in the Marmara Sea mucilage crisis.

Impact of Climate Change on Water

Water Resources and Climate Change. The hydrological cycle is the main process through which the impacts of climate change are manifest. Climate change impacts water mainly through the following channels: (i) Water availability and stress; (ii) Water quality and quantity; and (iii) Intensification of storms and extreme water-related events, which may increase damages and losses to infrastructure and services due to floods. Climate change is raising concerns on both the quantity and quality of water and stream flow in Turkey’s river basins, since rivers are the main sources of water for Turkey, not only for safe drinking water, domestic and industrial use, but also for irrigation and power generation (OECD, 2013, p.209). Managing climate risks in Turkey should therefore focus on adapting with and managing the hydrologic cycle. This section highlights some of the impacts of climate change in Turkey in recent years.

Turkey’s rapid growth in the last two decades has caused its environmental footprint to increase rapidly. For example, country total GHG emissions rose from 219.6 million metric tons of carbon dioxide equivalent (MtCO2e) in 1990 to 488.144 million metric tons of CO2e in 2018 and 506.1 MtCO2e in 2019.34 Water is amongst the key resources that could become a binding constraint on growth. Due to its large population and already high levels of water resource use, Turkey faces a significant water security threat from climate change, which will manifest through potential drying associated with the rising temperatures, changes in precipitation patterns, and reduced seasonal snow storage. In general, shifting precipitation patterns from snowfall to rainfall and faster melting snow covers are expected to lead to water shortages in elevated areas where the snow storage plays a crucial role in regulating water supply throughout the year.

According to a 2016 Climate Change assessment (Ministry of Forestry and Water Affairs, 2016), exploitable water resources would decrease from the estimated 112.1 billion m³ to about 86 billion m³ by the 2050s, in an optimistic scenario. However, in a worst-case scenario, water demand may exceed Turkey’s exploitable water level as early as the 2030s. Irrigated agriculture would be the hardest hit, which would in turn affect the country’s economy. Since Turkey’s concrete steps to encourage performance improvements in water supply and wastewater reuse would only offset demand by 1-2 billion m³, a significant effort is needed to increase irrigation efficiency and agriculture productivity.

Climate change affects water availability, and different climate scenarios increase stress on surface and groundwater. Water resources needed for food production and rural development in Turkey are threatened by climate change impacts such as an increase in summer temperatures, a decrease in winter precipitation (in western provinces in particular), a loss of surface waters, an increase in the frequency of droughts, land degradation, coastal erosion, and floods.35

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Climate change can exacerbate negative impacts of pollution on water quality, for example, by harmful algae blooms impacting the quality of lakes and reservoirs as well as wetlands and ecosystems, with negative impacts on livelihoods of those depending on fishery and aquaculture and important aquatic ecosystem service. In 2021 Climate change-induced warming of the Marmara Sea, combined with widespread pollution from the discharge of untreated industrial and domestic wastewater and agricultural uses of fertilizers and pesticides resulting in excessive nutrients (mainly nitrogen and phosphorous), contributed to the mucilage crisis that has threatened aquatic life and economic activities such as tourism and fisheries. In June 2021, Turkish authorities announced a 22-point action plan to clear mucilage in the Sea of Marmara, including designating the entire Sea of Marmara as a protected area, reducing the amount of nitrogen by 40%, increasing the rate of treated and reused wastewater from currently 3.2% to 5% by 2023 and 15% by 2030, and discharge of domestic and industrial waste. This will require significant investment in the development and scale up of circularity in the management of water resources and related services in Turkey.

Climate change exacerbates the costs of extreme water related events, including floods and droughts and more drastic swings between wet and dry periods. Turkish shorelines, particularly in the Central and Eastern Black Sea, the Northern Aegean Sea, and Eastern Mediterranean, are negatively affected by flooding and coastal erosion. In the Mediterranean coastal zones, the demand for water is lowering the water table and leading to sea water intrusion in most coastal aquifers. Increased damage and losses to infrastructure and services due to floods, including interconnectivity of water infrastructure, operational and logistic interruptions relevant for the sector. In August 2021, the Black Sea Region in Turkey was affected by extreme flooding. At least 81 people died and about 228 more were injured in the floods, and more than 1800 people were evacuated as many people were rescued from rooftops. Reports have shown that at least 454 buildings have sustained significant damage. Bridges were also damaged or destroyed, and the infrastructure of multiple towns was significantly affected.

Climate change also causes increased damage and losses to water services and infrastructure, including interconnectivity of water infrastructure, operational and logistic interruptions relevant for the sector. Climate change related heatwaves contribute to soil moisture evaporating at increased levels, causing landslides that can damage water infrastructure and pollute water sources.

Climate and water risks may constrain the climate mitigation agenda. When water is less available for hydropower generation or for cooling-off energy generators or when floods disrupt energy logistics, the use of more carbon-intense energy sources may become more intense.

Water and the Economy

In Turkey, as in many other countries, water is a connector across sectors, such as agriculture, energy, environment, urban and disaster risk management, and industry. Water resources underpin key industries, including agriculture, energy/electricity, industry/manufacturing/mining, and tourism. In Turkey, agriculture contributed 6.6% to GDP, while industry and services accounted for 27.8% and 54.6% respectively, in 2020. 36 Water also plays an essential role in human capital accumulation and health and in achieving the SDGs37. In terms of the SDGs, water is vital for production of food and achieving (SDG2). Clean and safe drinking water and sanitation systems are necessary for achieving SDG3 and SDG6. Water is needed for powering industries and creating the new jobs identified in SDG7 and SDG8. It contributes

37 The list of SDGs is presented on the webpage https://sdgs.un.org/goals
to emissions reduction and adoption of renewables identified in SDG7, and to combatting the effects of climate change in line with SDG13. The availability of water is essential for making cities and human settlements sustainable and resilient in line with SDG11 and contributes to SDG12 on sustainable consumption. Adequate and safe water is also necessary to nourish the planet’s life-sustaining ecosystem services identified in SDG13, SDG14 and SDG15. As the US Environmental Protection Agency well described, Water is “used to extract energy and mineral resources from the earth, refine petroleum and chemicals, roll steel, mill paper, and produce uncounted other goods, from semiconductors to the foods and beverages that line supermarket shelves. Water cools the generators and drives the turbines that produce electricity and sustains the habitat and fish stocks that are vital to the commercial fishing industry. Rivers, lakes, and oceans also provide natural highways for commercial navigation”.  

**Water is critical for food security; and access to irrigation has been shown to improve agricultural productivity and food security.** About 2.5% of the population in Turkey is under severe food insecurity. Water is essential for energy security and green energy. Hydropower constituted 60% of Turkey’s total installed renewable capacity, which stood at 52,000 megawatts. Currently, more than 25.0% or 57.5 terawatt-hour (TWh) of the country’s electricity demand is supplied from hydropower. According to official projections this would increase to approximately 116.0 TWh in 2023. There are 706 dam/reservoirs in Turkey, with varying sizes. These dams have storage capacity of about 140 billion m³. The water collected in these dams' is essentially used for three purposes: irrigation, domestic and for electricity generation. It was estimated that Turkey has a gross annual hydroelectric potential of 433,000 GWh, which is 14.0% of the total hydropower capacity in Europe and approximately 1.0% of the world. Almost half of this gross potential is technically exploitable. Climate change effects, especially alterations in evaporation, river discharge, temporal precipitation patterns, frequency of extreme meteorological events, and glacial melt rate, have the potential to induce appreciable change in hydroelectric production in Turkey. Global experience shows that water is also needed for other forms of green energy - hydropower is the enabler of other energy renewables including hydrogen, solar, and wind. Some countries are using natural

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gas as a bridge fuel to transition away from coal production in its economic policies, and natural gas extraction can be water-intensive and pollute water resources that are then not available for use by other economic sectors (Guidance for the CCDR, 2021, p.2).

**Water is indispensable for industries and tourism.** By 2023, it is estimated that Turkey’s total water consumption will be 112 billion m³, comprising about 72 billion m³ for irrigation, 18 billion m³ for drinking and human consumption, and 22 billion m³ for industry. The clothing and metal sectors are the highest water consumers. The clothing sector contributes significantly to the country’s economy through 7.2% of recorded industrial employment and 18% of total export revenues, making it the second biggest export earner. The sector is expected to reach USD 52 billion export value in 2023. However, with its rather complex production system, the industry poses considerable environmental impacts through its intensive water resource use (350,000 m³/day) and waste discharges to the environment. The textile and garment industry are the second most water consumptive industry after basic metal industry, with a total annual water use of 191.5 million m³ or about 15% of the total water use of the manufacturing sector. The long-term viability of Turkey’s textile industry and its further growth are determined by the industry’s sustainability, especially in water management.

Tourism is one of the most dynamic and fastest developing sectors in Turkey, and it is highly dependent on water. In 2018, Turkey attracted around 46 million foreign tourists, ranking it as the 6th most popular tourist destination in the world (World Tourism Organization, 2019). Tourism makes seasonal demands on local resources, in particular, water supply and sewerage facilities, and the environment. During the tourist season from May to September, the resident population increases more than five-fold in coastal settlements located on the Aegean and Mediterranean coasts in particular. In these areas, water has been supplied mostly from groundwater and in excessive amounts to satisfy the demand of the newly developed settlements, lowering the water table and resulting in sea-water intrusion in most of the coastal aquifers. The sewage generated by congested population has caused pollution of bathing waters to exceed the standards relating to human health and environmental protection.

**Water dependent sectors such as construction, agriculture, energy, and tourism are supporting economic recovery and contributing to job creation and employment.** The 2015 World Water Development Report noted that three out of four jobs constituting the global workforce are dependent on water. As stated in Chapter 1, agriculture employs about 18 percent of Turkey labor force, about 5 million people, many of them women. Travel and Tourism contributed TRY 461.3 billion (USD95.6 billion) or 12.1 percent of Turkey’s total economy and supported 2.2 million jobs, or 7.7 percent of total employment (Turkey Water Sector Engagement Note, 2020, p.26). The water intensive textile and garment sector alone constitutes 7.2% of Turkey’s total industrial employment.

**Cities depend on water, and 76.11% of Turkey’s total population in 2020 lived in cities.** About 99% of the population were connected to a piped water network, and the remaining underserved were mostly located in rural areas (Turkey Water Sector Engagement Note, 2020, p.11). Although access rates are high in terms of water supply, water quality remains a concern in many cities. In 2018 only about 60 percent

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47 Phillia Restiani, Sila Temizel, Nilgün Cili, WATER GOVERNANCE MAPPING REPORT: TEXTILE INDUSTRY WATER USE IN TURKEY
of the total population was served by water treatment plants, which increases vulnerability to risks from pollution and other contaminants if raw water sources are contaminated. About 9 percent of existing water treatment plants are inactive.

**Role of water and human capital accumulation.** There are numerous pathways through which the water sector can impact human capital accumulation: access to improved water supplies, water quality, sanitation, and hygiene; water for irrigation; and better management of water resources to protect against rainfall deficiency and variability, including extreme water-related climate events like floods and droughts (Figure 6). These sub-sectors are all critical for determining the total human capital an individual accumulates throughout their lives. While water plays an essential role in the economy and human capital development, it can also be a source of destruction to human capital, from floods and droughts. The quality and availability of water and the damage caused by floods and droughts have direct impacts on illness, missed school, mortality, labor productivity, accessibility to services, movement of goods and commerce, among others. The proportion of population using safely managed sanitation services in Turkey is 78% while the proportion of the population using basic sanitation services is 21%. The relatively high sanitation coverage has contributed to declining mortality rates. The under-five mortality rate has significantly declined from 75% in 1990 to 9.5% in 2020 (see Fig. below)

**Figure 6: Trends in under-five mortality rate in Turkey**

Source: https://data.unicef.org/country/tur/

Besides its contribution to economic production, water, and its related ecosystems, including lakes, wetlands, and coastal zones, provide a wide range of benefits, such as natural water storage, flood protection, and biodiversity conservation. Yet, Turkey’s water-related environmental resources and ecosystems are under increasing stress from factors such as, widespread water pollution due to the discharge of untreated or insufficiently treated industrial and municipal wastewater effluents, high levels of groundwater withdrawals, and agricultural activities. These pressures are further exacerbated by strong economic growth and associated activities. The combination of drought and excessive abstraction of water has already led to the drying up of a number of lakes and wetlands. The Lake Tuz in the Konya basin was the country’s second largest lake, and it was visited by thousands of flamingos each summer in the past. Almost half of the famous salt lakes have dried out and have begun the process of transforming into
salt basins due to drought and continuous water withdrawal for irrigation. The same conditions affect Eregli Marshes and Bafa Lake. Beysehir Lake, which is the largest freshwater lake in Turkey, was 24m deep 25 years ago and it is now less than 9m deep (FAO, 2017).

Other social outcomes related to water security in Turkey are linked to the impacts of the heavy influx of refugees, putting significant pressure on existing municipal infrastructure, especially in the Southeastern part of the country. Turkey is currently hosting over 3.5 million refugees mostly from Syria, as well as other countries. While Turkey’s refugee response has been progressive and provides a model to other countries hosting refugees, the refugee and migrant influx poses development challenges for host and refugees. The population in the most affected municipalities has increased between 20 and 95 percent. Yet municipal budgets continue to be determined according to the number of host populations. In some of the impacted municipalities, the most vulnerable refugees are dwelling in informal urban and peri-urban settlements, some of which have inadequate access to water supply and sanitation services. It will be important to find appropriate solutions that will address the needs in these settlements.

A World Bank assessment on water scarcity in 2020 estimated the economic costs of a 10% reduction in water supply from climate change to be 6% of GDP and about US$50 billion in monetary losses.\(^{50}\) Devastating floods in Turkey in 2006 and 2009, totaled almost 1 trillion USD in damage. Potentially damaging and life-threatening river, urban and/or coastal floods are expected to occur at least once in the next 10 years (GFDRR 2019). In the event of a 100-year flood, more than 3 percent of GDP (or US$20 billion) and 3 million people (or 3 percent of the population) could be affected.

Figure 7: The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Changes on GDP, by country

![Graph showing the impact of climate change on GDP](image)

Source: World Bank based on Purdue University analysis.

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Impact of Water on Emissions Reduction

Water services are energy intensive and contribute significantly to climate change, both directly through water related GHG emissions, and indirectly through the water-energy-GHG nexus. In 2019, agriculture contributed 13.4% of total CO2 emissions, and power sector contributed 61% of total CO2 emissions.\(^{51}\) CO2 emissions are generated by electricity and fossil fuel used in pumping for water-related services, including water supply and wastewater treatment, and for irrigation services. Turkey’s energy mix is dominated by fossil fuels, which are water dependent (Turkey Water Sector Engagement Note, 2020, p.24). The coal capacity target of the Government has been recently updated to 14.7 GW, this will require increased amount of water for cooling but also for coal extraction and processing (Turkey Water Sector Engagement Note, 2020, p.24). Currently, gas supplies around a third of the country’s total primary energy demand, while coal and oil products provide 27% and 29%, respectively (Turkey Water Sector Engagement Note, 2020, p.24).

Water services related to sanitation and irrigation of certain crops such as rice can contribute to methane (CH\(_4\)) emissions. Figure 8 shows the CH\(_4\) emissions in Turkey from 1990 to 2050. In 2020, the wastewater and rice took 4.4% and 0.4% of CH\(_4\) emissions respectively, while in 2050, their proportions will decrease to 4.1% and 0.3% respectively.

**Figure 8: Methane emissions 1990-2050 for Turkey**

Source: Water and Climate GSG, 2021, Power BI

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N₂O emissions are emissions from agricultural biomass burning, industrial activities, and livestock management, as well as from sanitation and fertilizer use for irrigated crops and drainage. In 2020, the share of wastewater contributing to nitrous oxide emissions in Turkey was 6.3%. In 2050, it is estimated that the share of wastewater will reduce to 5.7% of all nitrous oxide emissions. Figure 9 demonstrates this trend.

Figure 9: Nitrous Oxide emissions 1990-2050 for Turkey

The water-energy-GHG nexus. The more dependent a country’s national or regional electricity grids are on fossil fuels, the more GHG emissions are associated with energy usage in the energy sector. Turkey’s energy is largely dependent on fossil fuel. For example, most of the Turkey’s electricity generation comes from fossil fuel-fired power plants (78% of total generation in 2014), with natural gas accounting for almost half of all electricity generation. Electricity from hydroelectric facilities accounts for 17% of Turkey’s total electricity generation.

In 2019, the total CO2 emissions of power sector in Turkey was 3.8 kg CO2/USD, among which coal constituted 26%, oil constituted 31%, and hydro constituted 24%. By sector, agriculture took 13.4% of total CO2 emissions, power took 61%, buildings took 21%, transport took 16%, and manufacturing took 11%.

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Policy and Strategic Context for Climate Change in Turkey

On August 8, 2021, the United Nations Intergovernmental Panel on Climate Change (IPCC) published the Sixth Assessment Report - *Climate Change 2021: The Physical Science Basis*. The report provides the most up-to-date physical understanding of the climate system and climate change. According to the Regional Fact Sheet of the Sixth Assessment Report, in the region of Mediterranean where Turkey locates, there are observed increase in hydrological and agricultural and ecological droughts (medium confidence), projected increase in aridity and fire weather conditions at global warming of 2°C and above (high confidence). Also, there is a projected combination of climatic impact-driver changes (warming, temperature extremes, increase in droughts and aridity, precipitation decrease, increase in fire weather, mean and extreme sea levels, snow cover decrease, and wind speed decrease) by mid-century and at global warming of at least 2°C and above (high confidence). These are big challenges for Turkey, and climate financing is in great demand.

The World Bank Group Country Program for FY22 and FY23 aims to address Turkey Government’s increasing demand for climate financing. The climate response-related lending pipeline in FY22 and FY23 is rich and focused on climate change adaptation or mitigation projects that are directly linked to the implementation of Turkey’s Intended Nationally Determined Contribution (INDC). These include engagements in, inter-alia, the water, agriculture, and urban sectors involving various adaptation and mitigation measures.

Strategic engagements on water and climate change with the Government of Turkey are critical. The CCDR proposes adopting a phased approach to provide specific recommendations for supporting key sectoral transformations, economy-wide transitions and adapting to the impacts of climate change in the immediate, medium- (e.g., 2030) and long- (e.g., 2050) term.

Proposed actions are recommended to be in alignment with Turkey’s own development goals presented in the 11th National Development Plan, the March 2021 Economic Reform Program, the New Economy Program 2021-2023, and other policy documents (including the climate change action plan and the draft climate change law). The CCDR will be followed by a Country Private Sector Diagnostic (CPSD) which will identify constraints and opportunities for private sector investments including sectors contributing to climate change mitigation, adaptation, and resilience.

To address water shortage and increased water demand, Turkey has significantly invested in water storage. For example, the dams and reservoirs built have enabled Turkey to save water from its brief seasons of rainfall to use throughout the year for various purposes. The main cities of Ankara, Istanbul, and Izmir are all dependent on freshwater storage in reservoirs. In 2017, Turkey’s dam capacity per capita was at the level of 1,945.67 m$^3$. Turkey has also been implementing an integrated water basin management program for management of its natural water resources, with planning at the basin levels.

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58 Project Concept Note for Proposed Turkey Integrated Water Conservation Project (P174915), page 2.
59 Project Concept Note for Proposed Turkey Integrated Water Conservation Project (P174915), page 2.
due to be completed by 2023. There is, however, still the need for further investment in storage, including both grey and green infrastructure to adapt to the increasing impacts of climate change as part of the implementation phase of the basin level plans.

Pathways Towards Resilience and Decarbonization - Opportunities for Mitigation and Adaptation

To strengthen resilience to growing water related risks, as well as contribute to achieving its long-term net-zero vision, Turkey needs to continue to invest in the following priority areas:

(I) Strengthening institutional capacity and regulations for water resources management.

1. **Integrated water resources management and investment planning should be pursued at the basin level as the most appropriate scale for effective water management** to both mitigate the adverse impacts of climate change and facilitate the adaptation of sustainable integrated water management policies to strengthen resilience.

2. **Policy and regulatory instruments that encourage demand-side management, circularity, and efficiency** (both in water supply and irrigation) and establishing effective institutional coordination mechanisms based on incentives with key stakeholders.

3. Adaptation to climate change will also largely depend on extending the knowledge of global warming and water scarcity, rising public awareness on water resources, and selecting suitable production and water consumption techniques for all sectors under the different development scenarios.

(II) Investing in Adaptation and Mitigation

1. **Investments in increasing and optimizing multi-purpose water storage**, including retrofitting, re-operating, rehabilitating, or raising new storage conventional surface water storage infrastructure, and coupling with other renewable energy sources, such as floating solar, and nature-based solutions (NBS), such as conjunctive use of aquifers (e.g. artificial recharge), which in addition to building resilience, manage variable water supplies over time, and provide protection during floods and droughts.

2. **Investment in enhanced water-energy use efficiency in water systems** (reducing water losses in water supply systems (non-revenue water), reducing water losses in irrigation, switching from pumped to gravity-based systems, pursuing more efficient treatment technologies, and replacing older treatment equipment, promoting demand management, and switching to more energy efficient forms of irrigation solutions, etc.).

3. **Modernization of irrigation and drainage systems** through more efficient conveyance and operation and management systems complemented by water-saving agriculture interventions (e.g., high efficiency drip, remote sensing approaches, automation).

4. **Diversification of freshwater resources through promotion of circular economy approaches in the delivery of water services.** This includes reducing water losses; recovering and capturing valuable resources such as biogas, nutrients, and heavy metals from wastewater treatment; and adapting reuse of treated effluents and resource recovery. Investments in circular economy through resource recovery will also contribute to reduced GHG emissions (e.g., reduced energy use, methane capture).

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(III) Promotion of policies that encourage decarbonization

Incorporate greening energy sources in the delivery of services by investing in renewable energy through solar pumping, hydroelectricity, and floating solar.

1. Protect watersheds and other landscapes to sequester carbon in soil and biomass and increase resilience to a more variable streamflow.

2. Promote climate-smart agricultural practices including more efficient use of fertilizer and other inputs for irrigated crops.

3. Harness water-energy innovations and digital technologies.