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WATER GLOBAL PRACTICE

Water in the Balance

The Economic Impacts of Climate Change and Water Scarcity in the Middle East

Summary for Policy Makers

WORLD BANK GROUP

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Foreword

Water is a vital element for production and underpins all economic activity, from agriculture, to manufacturing, to human capital, and natural capital. A lack of water can, therefore, put a brake on economic progress. Innovations in water management and irrigated agriculture powered water-scarce Middle Eastern economies for millennia. These innovations, ranging from ancient water harvesting techniques to modern-day wastewater reuse, sustained health, wellbeing and livelihoods and enabled increases in food production. However, as water becomes scarcer because of population growth and economic development, and even more erratic, because of climate change, the region's water security is coming under increasing threat. At the same time, the COVID-19 pandemic is bringing yet another shock to the economies and livelihoods already strained by decades of armed conflict in some countries in the region. This pandemic will further exacerbate the impact of water-related shocks, such as droughts, adding to the challenge of managing water in the face of increasing water use and climate change.

In this new context, understanding the role of water in sustaining economic development becomes more important than ever. This report applies an extended version of the Global Trade Analysis Project (GTAP) computable general equilibrium model to assess the economic impacts of water scarcity for six Middle Eastern countries and also to examine how water-use efficiency improvements and trade can mitigate these impacts. In doing so, it provides water planners and managers key arguments to guide water policies choices and priorities in the region.

Unsustainable water management has significant economic, social and environmental impacts. The report estimates that a 20 percent reduction in water supply could decrease GDP by up to 10 percent, compared to 2016 levels. Furthermore, increased water scarcity could reduce labor demand by up to 12 percent and lead to significant land-use changes, including loss of beneficial hydrological services.

The economic model described in this report suggests that trade of agricultural products could alleviate some of the impacts of water scarcity on food production and prices. *Water in the Balance* also demonstrates that improvements in water-use efficiency can reduce the pressure on water resources only with an enforced regulation of water withdrawals, including through water accounting and measurement. Finally, *Water in the Balance* emphasizes how the growing dependence on shared water resources reinforces the need to manage water across boundaries. The message for governments, investors, the private sector and development agencies is clear: unless new and transformative policies for sustainable, efficient and cooperative water management are promoted, water scarcity will negatively impact the region's economic prospects and undermine its human and natural capital. The World Bank Group stands ready to work with countries in the Middle East to work towards more water secure and climate resilient economies.

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Acknowledgments

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The Six Middle Eastern Countries Examined in this Summary

This summary focuses on six countries: Islamic Republic of Iran, Iraq, Jordan, Lebanon, Syrian Arab Republic, and Turkey

Note: Boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of the World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Key Messages

The Sweeping Impacts of Water Scarcity and Climate Change

- **While information about water scarcity at present and in the future is available, there is little knowledge of what this increasing scarcity means for Middle Eastern economies, for employment, and for food security.** The policy debate is still largely dominated by concerns over water volumes and per capita availability. This report aims to shift the debate regarding water scarcity away from a narrow focus on water stress and availability and toward a focus on economic, social, and environmental outcomes related to water resources. All results in this report are structured in an "if-then" framework: *if* water scarcity increases based on climate projections, socioeconomic factors, and economic structures, *then* these many jobs would be lost or this much decline in crop yield would be observed. This summary focuses on six countries: Islamic Republic of Iran, Iraq, Jordan, Lebanon, Syrian Arab Republic, and Turkey. The accompanying technical report (Taheripour et al. 2020) also shows results for two other two regions: the Rest of the Middle East, and the Rest of the World.
- **If water availability decreases by 20 percent, then the six countries could face an annual drop in GDP of between 5 percent to 10 percent compared to 2016 levels.** As these economies shrink because of water scarcity, demand for labor could drop by more than 10 percent in some countries, posing additional challenges on an already stagnant labor market.
- **Water scarcity could lead to land-use change and deforestation.** Reductions in water supply are expected to lead to conversion of irrigated areas back to rainfed agriculture, thus reducing crop yields and crop production. To recoup these losses, farmers might convert natural pasture and forest to rainfed cropland in areas that are less water stressed within each country. This could lead to a reduction in baseline natural resilience, weakening the country's ability to adapt and transform in the face of climate and other changes in environmental conditions. In addition to the monetary losses due to water scarcity, the six countries will experience environmental damages that will indirectly generate welfare losses due to environmental degradation, and loss of the environmental and hydrological services linked with the natural environment.
- **Agriculture will suffer because of climate change and water scarcity, and crop prices are expected to increase for both crop producers and consumers.** However, crop prices are expected to increase at a lower rate for consumers, mostly because Middle Eastern economies are expected to import more and export less of crop products.
- **Trade buffers impacts of water scarcity on food production.** The six countries are likely to rely more on food imports to buffer for the losses in their food outputs due to water scarcity and reductions in crop yields. This means that trade has the potential to buffer the negative impacts of water scarcity and climate change on food production in the region.

Five Insights for Policy

1. **How the countries respond to the impacts of water scarcity will be pivotal in determining its future economic prospects, and whether they can achieve the Sustainable Development Goals.** Given the

potentially very large economic impacts of water scarcity, water needs to be managed more prudently to prevent the crises of today becoming the catastrophes of tomorrow. Responding to water scarcity will require multiple policy actions, including moving away from policies advocating for food self-sufficiency and allowing unsustainable use of water.

2. **Improvements in the efficiency of water use can be counterproductive without proper regulation, water accounting, and water measurement.** As water is used more efficiently, this might lead farmers to use the "saved" water to irrigate more area or switch toward more thirsty crops. Thus, water-use efficiency measures need to be centered on water measurement and accounting, and policy interventions that regulate and control direct water withdrawals. Countries will have to take advantage of the digital economy, such as adopting new satellite-based technologies that have unleashed new opportunities to collect data and monitor outcomes in real-time.
3. **The consequences of water scarcity cascade, from declining irrigated agriculture to shrinking forests and natural habitats.** Without policy action, there is a likelihood of a vicious cycle where water scarcity leads to conversion of irrigated areas to low-productivity rainfed agriculture, in turn leading to expansion of cropland into forests and natural habitats to compensate for the loss of crop yields, removing important hydrological services (such as regulation and purification of water), and thus worsening water scarcity. On a larger scale, cropland expansion and land-use change also alter the global carbon balance, exacerbating climate change, and inducing further scarcity. To avoid this cycle, comprehensive policies are needed, such as restricting conversion of natural land to agricultural uses in watersheds or using market-based approaches—including payments for hydrological services and conservation practices—to protect forests and natural ecosystems.
4. **Policy levers outside of water are key to addressing scarcity, emphasizing the need for complementary actions and investments.** Countries should focus on sustainable land and water management policies to leverage remaining potential and measures to foster a trade-oriented agricultural sector, including through digital agriculture and improvements in the business climate. In addition, trade measures accompanied with targeted social protection systems could help manage expected higher dependence on food imports. Managing increasing food import dependence and the growing urbanization in the region will also require investments in value chains and related infrastructure such as roads, storage, and cooling chains. In turn, this will help move water use in agricultural systems away from low-value crops toward higher-value irrigation, which yield higher returns, and is typically more labor intensive than irrigated agriculture of low-value crops.
5. **Joint regional efforts to address water scarcity are a promising avenue to adapt to climate change, reap economic gains, and advance regional cooperation.** In an era of fragmentation and conflict, joint efforts and economic cooperation might seem like a daunting challenge and distant goal. Nonetheless, efforts continue. This report demonstrates that they can yield significant economic gains and shared prosperity. Benefits can accrue with cross-border integration of infrastructure and cooperative management of shared water resources. Moving forward, there is a need to build on ongoing efforts to further the debate on how the regional water scarcity challenge can be turned into an opportunity for greater cooperation over transboundary water resources and beyond.

Chapter 1
Tackling an Age-Old Problem in an Uncertain World

Water has always been scarce and variable in the Middle East. For thousands of years, societies have adapted to arid landscapes through innovations and investments in water management and irrigated agriculture. All countries in the region have invested heavily to store and divert water supplies and to expand water access to households, industries and farms. Most of the scarce surface freshwater resources available have been stored in reservoirs, giving the Middle East the largest volume of water stored as a share of its total freshwater resource endowment in the world (World Bank 2018). Some countries have also heavily invested in desalination and, increasingly, reuse of wastewater, whose potential, however, remains largely untapped. In some limited cases, countries have also developed the institutions and capacity required to manage these assets and ensure that they deliver water services. While the region has historically adapted to water scarcity, growing populations, rapid urbanization, economic development, and—last but not least—climate change mean that sustainable water management is becoming a defining challenge for the Middle East in the twenty-first century, further compounded by water allocation decisions driven by short-term priorities and concerns.

In an age of protracted conflicts, rising inequality, and systemic risks such as pandemics and trade wars, addressing the impacts of water scarcity may seem like a secondary issue for the Middle East. In addition, because water scarcity has been a central feature of the region through its history, there is a potential for complacency in accepting the limitations that it implies, or for dependence on incremental or traditional responses to water challenges (World Bank 2018). However, as this report shows, the sweeping impacts of water scarcity can significantly undermine economic development and bring about broader instabilities. This requires unprecedented transformation in the water sector that go beyond simple supply-side augmentation, and includes strategic and cooperative water planning, water governance, and improved water measurement and accounting. More importantly, the mix of policies required to address these impacts extends well beyond the water sector, highlighting the linkages between water and some of the systemic risks facing the region, such as conflict and inequality.

A New Look at an Old Problem

The dynamic interplay of population growth, economic development, and climate change is already increasing water scarcity. Weather station data confirms that climate change is already leading to higher temperatures and influencing rainfall patterns, with annual rainfall levels decreasing in many countries across the region (Verner 2012). This drying trend is set to continue, with climate models suggesting more frequent and severe droughts and increasing temperature (Waha et al. 2017). Water use already exceeds renewable freshwater resources availability in all Middle Eastern countries apart from Turkey, a trend expected to continue as populations and economies grow (Wada and Bierkens 2014). This is extremely concerning given that more than 60 percent of the population of the Middle East already lives in areas where water use exceeds sustainable limits, compared to some 35 percent for the rest of the world (World Bank 2018).

While information on water scarcity at present and in the future is available, there is little knowledge about what this increasing scarcity means for Middle Eastern economies, for employment, and for food security. The policy debate is still largely dominated by concerns over water volumes and per capita availability. Information on water availability provides very little insight to guide investments and economic policy. Water underpins a range of economic activities, social and cultural practices, and environmental services. Water is central to agriculture, which gives employment to at least 26 million people in the region (about 17 percent of the region's working age population; see table 1.1). These are the aspects of water that matter to society, and that are often not captured in current policy debates focused on water scarcity and supply-side fixes.

This report attempts to address this blind spot. In doing so, it aims to shift the debate regarding water scarcity away from a narrow focus on water stress and availability and toward a focus on economic, social, and environmental outcomes related to water resources. It contributes to this agenda by offering a systematic approach to track the impacts of water scarcity on a range of outcomes that matter to society, such as employment and food security, and moving away from single estimates of water stress by country, which often dominate water policy debates in the region. The objective is to highlight the sensitivity of economic development to water scarcity and policies to address it, such as enhancements

TABLE 1.1. Employment in Agriculture, Six Middle Eastern Countries, 2018

	Employment in agriculture (percent of total employment)[a]	Total working-age population, (million)	Working-age population employed in agriculture (million)
Iran, Islamic Rep.	17.9	56.7	10.2
Iraq	18.1	22.4	4.1
Jordan	3.1	6.2	0.2
Lebanon	13.6	4.6	0.6
Syrian Arab Republic	10.7	10.8	1.2
Turkey	18.4	55.0	10.1
Total		155.7	26.3

Source: World Bank Open Data.
Note: Ages between 15 and 64 are considered working age. Employment is defined as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job or to a working-time arrangement. The agriculture sector consists of activities in agriculture, hunting, forestry, and fishing, in accordance with division 1 (ISIC 2) or categories A-B (ISIC 3) or category A (ISIC 4).
a. Modeled International Labour Organization (ILO) estimate.

in water-use efficiency and trade, in ways that can help inform policy and investment choices. In turn, this will equip water planners in the region with key information to advocate for prioritizing water issues in regional economic policy.

To achieve this objective, the report applies an extended version of the Global Trade Analysis Project (GTAP) economic model to turn projections of water scarcity into meaningful metrics for policy making. GTAP is one of the most widely used models in economic policy, and has been undergoing constant refinement and improvements since its launch in 1992 (see accompanying technical report [Taheripour et al. 2020] for more information). For the purpose of this study, a major data collection and model refinement effort took place to prepare a benchmark database to represent the structure of the economies of the region and link them to the rest of the world according to the best and most reliable available data. To concentrate on the Middle Eastern economies, the model and its database are geographically aggregated into eight regions: the Islamic Republic of Iran, Iraq, Jordan, Lebanon, the Syrian Arab Republic, Turkey; the Rest of Middle East; and the Rest of the World. This summary highlights the result for the first six countries, while the accompanying technical report also shows results for the other two regions.

The economic model provides snapshots of the impacts of water scarcity on economies in their current state: this is a key assumption of this study. The model provides projections—the consequences of hypothesized scenarios—not predictions or forecasts of what might happen. Such modelling exercises are helpful to improve understanding of the direction and magnitude of changes and how alternative policies accentuate or mitigate adverse consequences. Since these models capture interlinkages across factor and product markets in an economy, they are useful in tracing effects that might cascade through the economy. Such models are not designed to forecast the future. As with all modeling exercises, the analysis is based on a litany of assumptions, driven by data availability and computational constraints (World Bank 2016). In other words, the study does not model change in socioeconomic structures and variables in response to, for example, population growth, rate of technological progress, and saving-investment behavior. In economics, this approach is known as static computable general equilibrium modelling. It allows analysts to quantify the impact of an exogenous shock, such as climate-change induced water scarcity, on the existing economy. This helps isolate the role of water on the economy, without having to make too many assumptions around complex changes in social and economic conditions.

All results in this report are structured in an "if-then" framework: *if* water scarcity increases based on climate change projections, socioeconomic factors, and economic structures, *then* these many jobs would be lost or this much decline in crop yields would be observed. Box 1.1 describes the main scenario analyzed in this study. The accompanying technical report (Taheripour et al. 2020) provides additional information on assumptions, models, and scenarios. As demonstrated by decades of World Bank experience on sustainable development policies, "if-then" approaches underpinned by economic models are key instruments to help policy makers navigate uncertainties and trade-offs in sustainable development policy (World Bank 2016; Hallegatte, Rentschler, and Rozenberg 2019; Rozenberg and Fay 2019).

BOX 1.1. Climate Change, Crop Yields, and Water Scarcity

Climate change will have impacts that encompass all areas of development—ecosystems, human health, agricultural yields, among others. The focus of this study is on the economic impacts of climate change through two channels: changes in crop yields and changes in water availability. The first channel accounts for the potential impacts of future changes in temperature, precipitation, and CO_2 concentration on crop yields. While this channel takes into account future changes in precipitation and their impacts on crop yields, it does not take into account the impact of climate change on the availability of water for irrigation and other uses: that is, it does not take into account the impacts of freshwater scarcity on economic activities. The second channel, on the other hand, accounts for the potential impacts of climate change on water supplies. For example, climate change can lead to permanent reductions in rainfall and thus water available for use in irrigation.

While there is agreement that climate change will alter crop yields and water availability in the Middle East (Waha et al. 2017), the question of how much change it will induce remains open. To answer this question, the study examined a number of published analyses and also carried out exploratory simulations. This allowed a set of scenarios of plausible changes in crop yields and water scarcity to be developed. These scenarios underpin the model results shown in this report. They do not provide predictions of what the future might look like due to all possible change in future, but they do isolate and capture a plausible estimate of future water scarcity and crop yields, thus providing a foundation to examine their impact on the economy and, in the process, to reframe understanding of water's role in the region's economies.

Based on a comprehensive analysis of the literature and simulations, the report adopts the following plausible scenarios. For crop yields, the scenario models a 5 percent reduction in yields of irrigated wheat and corn; 10 percent reductions for their rainfed counterpart; 5 percent improvements in yields for oil crops (rainfed and irrigated); and no change in yields for vegetables. For water scarcity, the scenario models a 20 percent reduction in water supplies across the region, except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined.

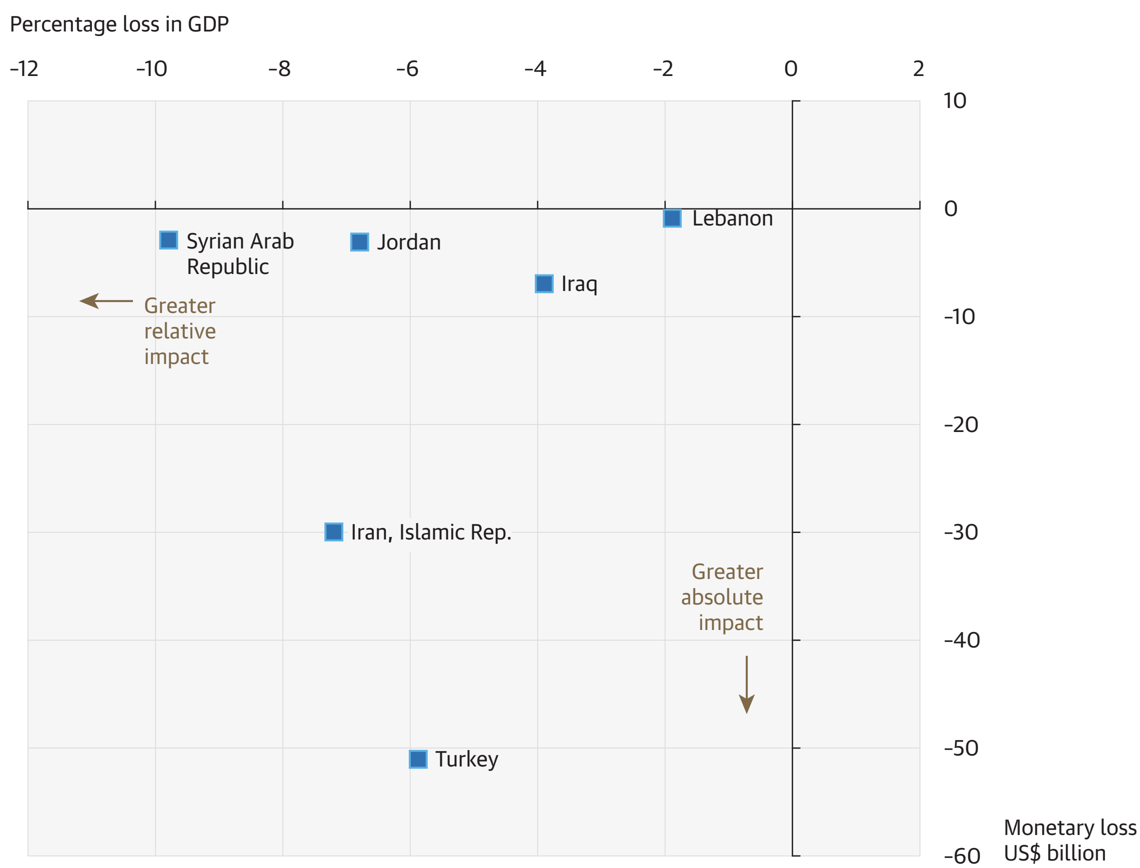
It is important to note that the economic impacts of climate change could go beyond the implications of water scarcity and changes in crop yields. This report focuses on the economy-wide impacts through these two channels, but ignores other impacts that climate change might generate, such as impacts of heat stress on labor productivity or increased energy consumption because of higher temperatures.

Chapter 2
The Sweeping Impacts of Water Scarcity in the Middle East

Water Scarcity is a Drag on Economies

Reductions in water supply curtail economic production across all countries, with larger increases in water scarcity leading to greater reductions in GDP. While all countries suffer losses under increasing scarcity, economic consequences are larger in the region's agricultural powerhouses, Turkey and the Islamic Republic of Iran. The Syrian Arab Republic also experiences very large reductions in GDP—a drop in annual GDP of 8 percent compared to 2016—if water scarcity increases by 20 percent (figure 2.1). On the other hand, Lebanon is projected to experience the lowest GDP reduction in the region, at about 2 percent. These results do not provide a forecast of GDP growth decades in the future. Instead, they

FIGURE 2.1. The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Changes on GDP, by Country



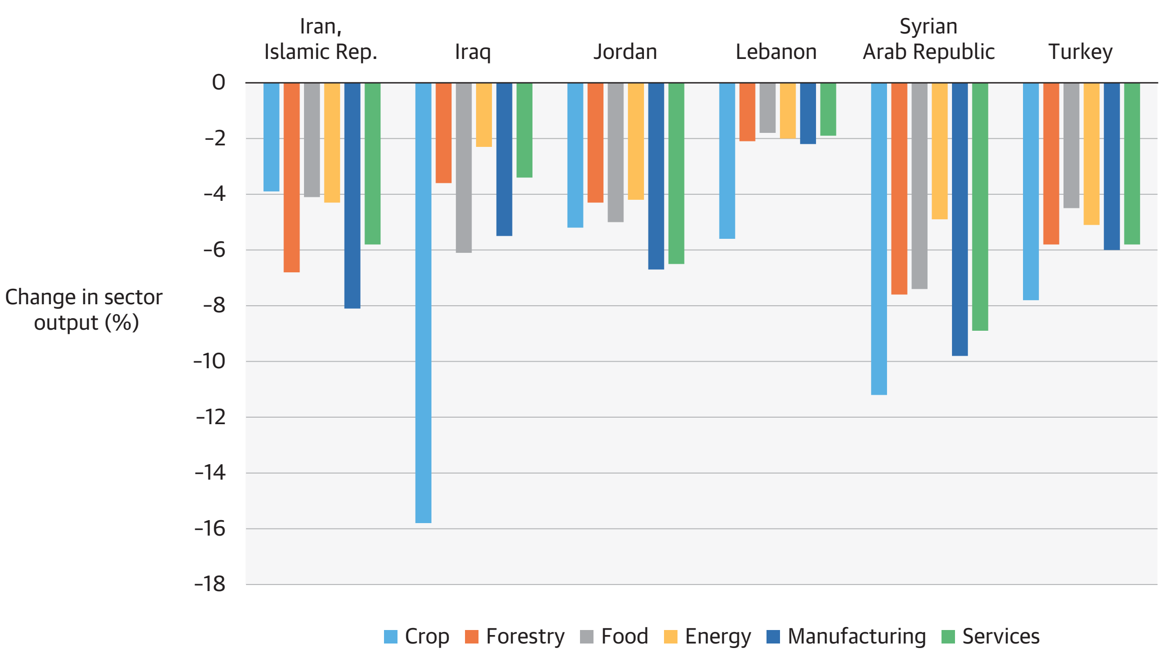
Source: World Bank based on Purdue University analysis.
Note: Relative changes shown compared to 2016 baseline for a business-as-usual scenario. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

improve understanding of the role of water shortages on economic production and highlight possible projections. In particular, the analysis considers impacts of climate change-induced water scarcity and crop yield changes on a business-as-usual scenario, where the efficiency with which water is used and allocated in the economy does not change.

Water scarcity directly reduces agricultural output, but its impacts on economies extend well beyond agriculture. As shown in figure 2.2, water scarcity reduces sectoral outputs differently across the Middle East. Agriculture is the hardest hit because of the importance of water as a key input factor. Reductions in water supply for irrigation and drops in crop yields due to climate change directly harm agricultural activities. This leads to reductions in agricultural outputs. However, agriculture is not the only sector negatively impacted by water scarcity, as shown in figure 2.2. Even in countries with small agricultural sectors, such as Jordan, the impact of water scarcity on the economy is high because water is a productive input to many sectors, including mining, manufacturing, energy, and services.

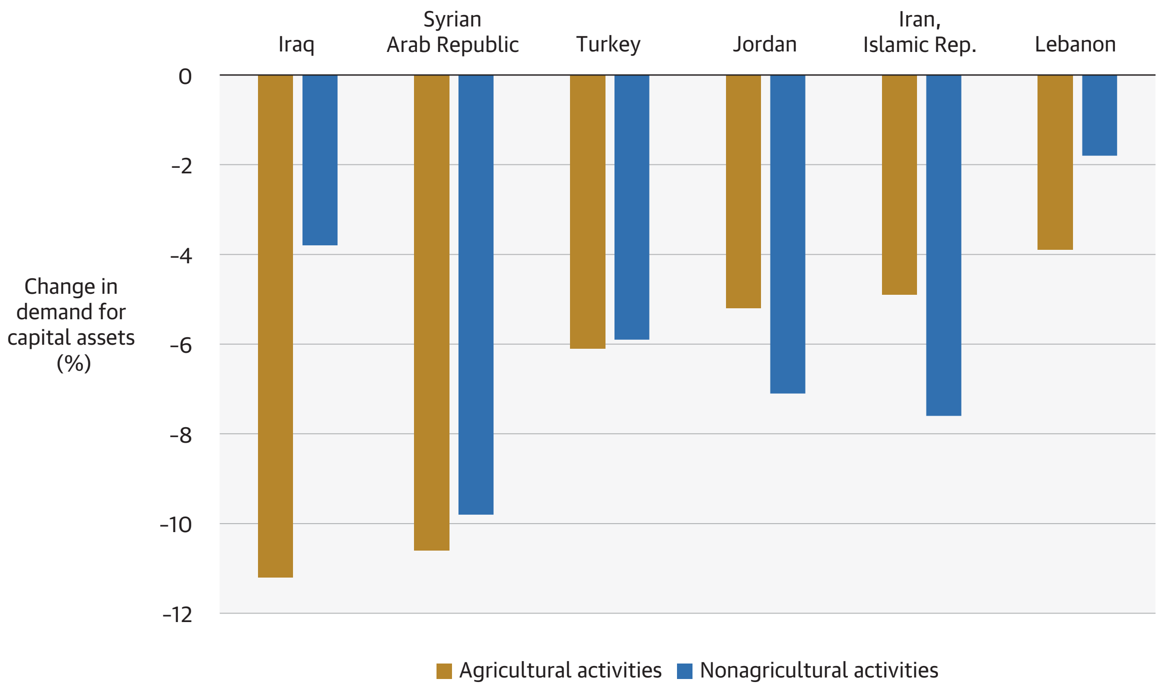
In addition, there are spillover effects from agriculture to the rest of the economy. Many producers—such as electricity producers, petrochemical facilities, and even services such as hotels and restaurants—will not be able to operate at full capacity with less access to water. Furthermore, the interlinkages between sectors mean that disruptions in agricultural production caused by water scarcity ripple through supply chains, affecting manufacturing and services sectors. This generates negative feedbacks in other activities that either provide inputs for agricultural activities or process

FIGURE 2.2. The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Change on Sectoral Outputs, by Country



Source: World Bank based on Purdue University analysis.
Note: Relative changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yield scenario, see box 1.1.

FIGURE 2.3. The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Change on Capital Assets, by Country



Source: World Bank based on Purdue University analysis.
Note: Relative changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

agricultural products. This explains the projected reductions in the industry, energy, and food manufacturing sectors.

Across the region, there is a high risk that assets in agriculture and other sectors will not be used productively as a consequence of increasing water scarcity. Permanent reductions in water supply could make a portion of the existing capital (representing private and public infrastructure, machinery, and durable equipment) idle in both agricultural and nonagricultural activities. As capital becomes idle, investment might also shift away from agriculture to nonagricultural activities. When water supply and crop yields drop, the existing capital in agricultural activities will not operate at full capacity. Then, with lower production of agricultural products, nonagricultural activities that have forward and backward linkages with agricultural activities will also not operate at full capacity. This could create idled capacity across the economy, at least in a medium-term time horizon. The impacts of water scarcity on the region's capital assets are shown in figure 2.3.

Drained Employment: Water Scarcity Reduces Labor Demand

A brake on economic growth will also mean a brake on employment creation. While the relationship between economic growth and employment is complex and depends on economic structures and productivity, employment creation is typically greater in economies that are growing and productive.

As economies slow down because of water scarcity, demand for labor is expected to drop, increasing unemployment rates across the region.

In Middle Eastern economies, the share of agriculture in employment is usually larger than the share of agriculture in the GDP. Thus, any major permanent reduction in agricultural activities due to water shortages could lead to a significant drop in demand for labor across the economy and a spike in unemployment. The simulation results confirm this effect, showing how water shortages lead to lower demand for labor in agriculture. And not only in agriculture: water scarcity drops the demand for skilled and unskilled labor in nonagricultural sectors as well. The labor demand reduction is proportional to the increase in water scarcity, so that the greater the water shortage, the greater the projected labor demand reduction.

The impacts of water scarcity on employment vary across countries and skill levels, as shown in figure 2.4. The greatest reductions in demand are expected to be for unskilled labor in agricultural activities.[1] In the case of nonagricultural activities, however, demand for unskilled and skilled labor will decrease at the same rate. Agricultural employment is projected to suffer more in Iraq and Lebanon, while the largest declines in nonagricultural employment as a consequence of water scarcity are projected for the Islamic Republic of Iran and Jordan. In Syria, demand for both agricultural and nonagricultural labor drops by more than 10 percent under a 20 percent increase in water scarcity.

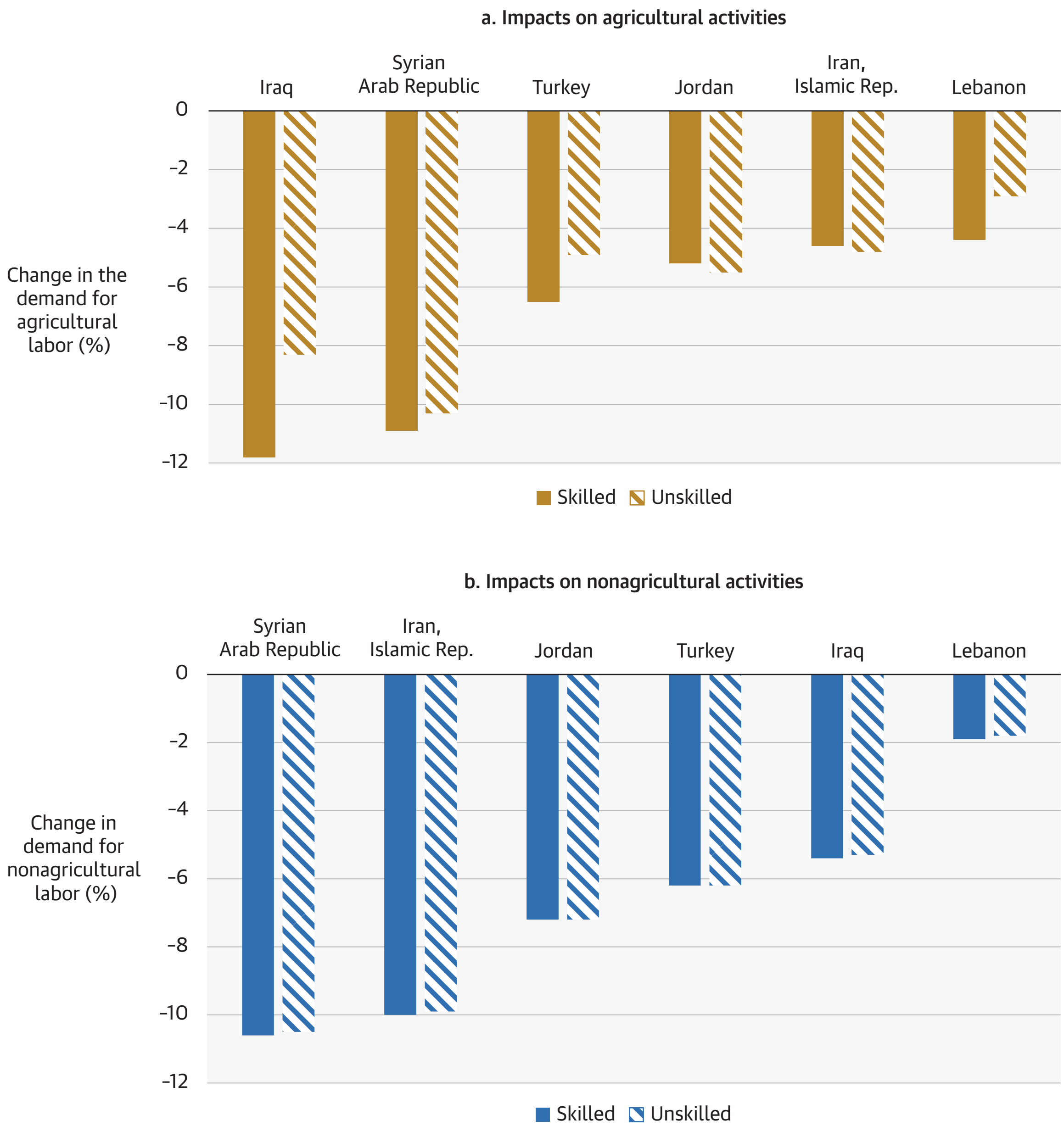
These impacts are set to compound existing unemployment challenges in the region, especially among women and youth. Youth unemployment rates in the region have been some of the highest in the world for the past 25 years and continue to rise.[2] The situation is even worse for female labor participation, with women three times less likely than men to seek work and two times less likely to get a job compared to men, on average, across the region (IMF 2018). Conflict and forced displacement compound the struggle of young people and women to find employment.

Water Scarcity Disruptions Translate into Higher Food Prices and Lower Wages

Crop prices increase on par with water scarcity. This increase is more or less linear, with higher levels of water scarcity leading to proportionally higher crop prices. Price changes from the perspective of domestic producers, measured with the producer price index of crops, increase across all countries: by 22.6 percent in Iraq, 10.4 percent in Syria, 9.4 percent in the Islamic Republic of Iran, 8.3 percent in Turkey, 5.9 percent in Jordan, and 4.6 percent in Lebanon (figure 2.5). Hence Iraq and Syria will likely experience the highest increases in the producer price index of crops. Price changes from the household purchaser's perspective, measured with the consumer price index, also increase, but at a lower rate, according to the model. For example, under a 20 percent increase in water scarcity, the consumer price index of crops could increase by as much as 13 percent in Iraq and 9 percent in Syria. Hence, from both the perspective of consumers and producers, water scarcity is expected to lead to price increases.

Higher food prices could raise poverty levels and reduce food security, at least in the short term. In the Middle East, where many households are net buyers of grains and food products, any increases in crop consumer prices could increase poverty. Low-income households are particularly vulnerable because

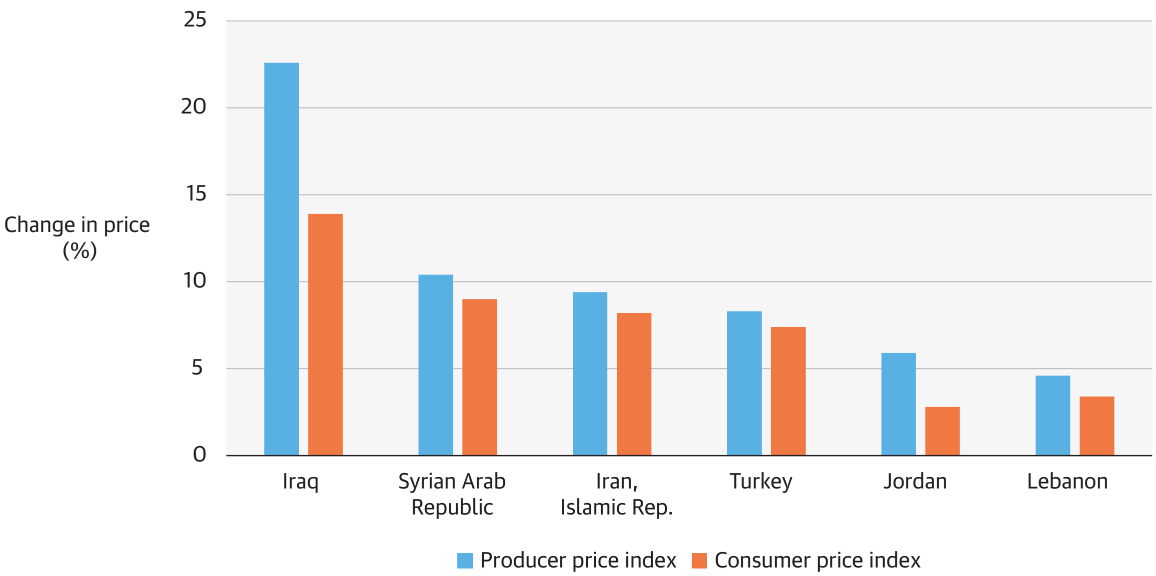
FIGURE 2.4. The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Change on the Demand for Unskilled and Skilled Labor in Agricultural and Nonagricultural Activities



Source: World Bank based on Purdue University analysis.
Note: Relative changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

they tend to spend a high share of their incomes on staple foods (Martin and Ivanic 2016). Impacts of high food prices also have high political and social costs beyond food security and poverty. Food riots have already occurred in response to higher food prices in the region, especially in the absence of measures to protect low-income consumers from price spikes (Maystadt, Tan, and Breisinger 2014).

FIGURE 2.5. The Impacts of Climate Change–Induced Water Scarcity and Crop Yields Change on Crop Prices for Producers and Consumers



Source: World Bank based on Purdue University analysis.

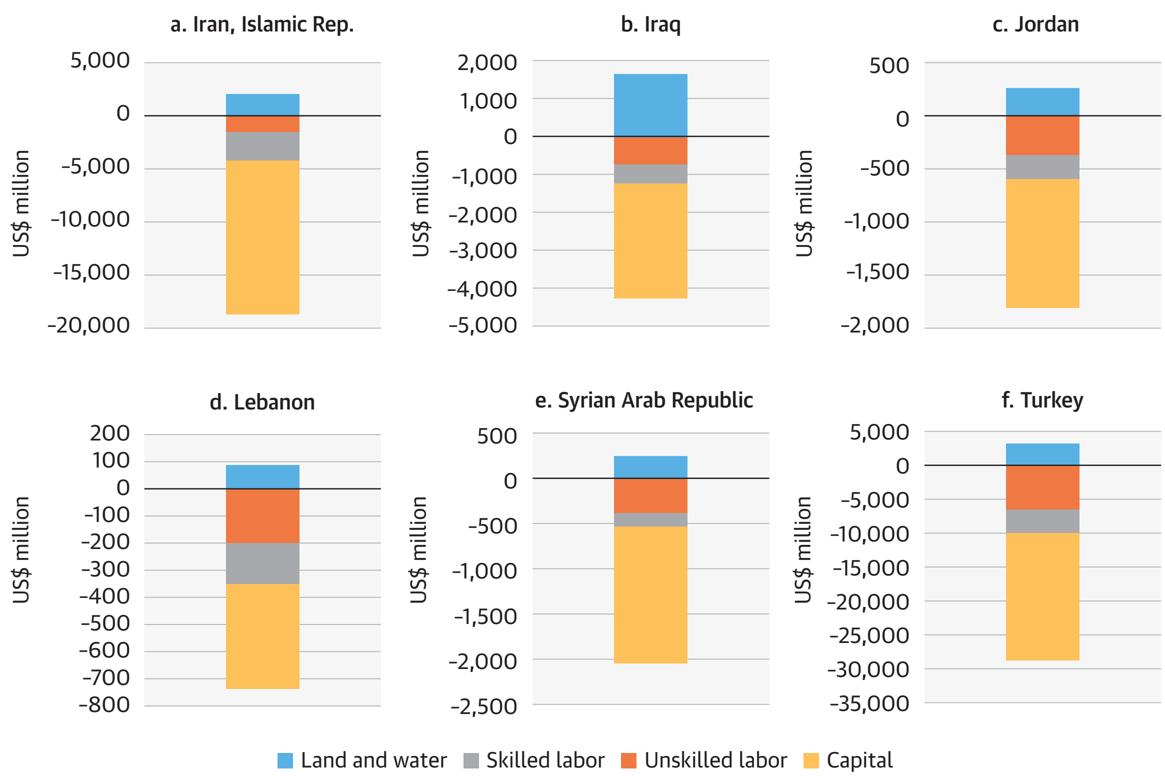
Note: Relative changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

Beyond food prices, water scarcity disruptions also translate into negative impacts on wages. Reductions in water supply and changes in crop yields jointly reduce demand for skilled labor, unskilled labor, and also capital, as discussed. These reductions drive changes in factor income: that is, the income that is generated from land, labor, or capital (such as infrastructure and machinery). Landowners are set to experience increased rents from their land because as land remaining under irrigation becomes scarcer because of lower water availability, it also becomes more valuable. Thus, the model projects a modest increase in the rents from irrigated land under increasing water scarcity. Skilled and unskilled laborers, on the other hand, will see a decline in their wages (that is, a decline in income generated from labor). Given that a large portion of these losses are projected to occur in rural areas where agricultural production takes place, rural workers are expected to experience the largest reduction in wages. As capital assets become idle, income from these sources is also set to decline quite significantly, as shown in figure 2.6.

Lowering Crop Yields and Increasing Land-Use Change under Water Scarcity

The cascading impacts of water scarcity threaten the region's irrigated agriculture. Water scarcity, arising from climate change and competition from other uses, reduces water available for irrigation. In turn, this leads to a reduction in agricultural area under irrigation and related declines in crop yields because rainfed agriculture is not as productive as irrigated agriculture. This can be observed in figure 2.7, which

FIGURE 2.6. **The Impacts of Climate Change-Induced Water Scarcity and Crop Yields Change on Factor Income, by Country**



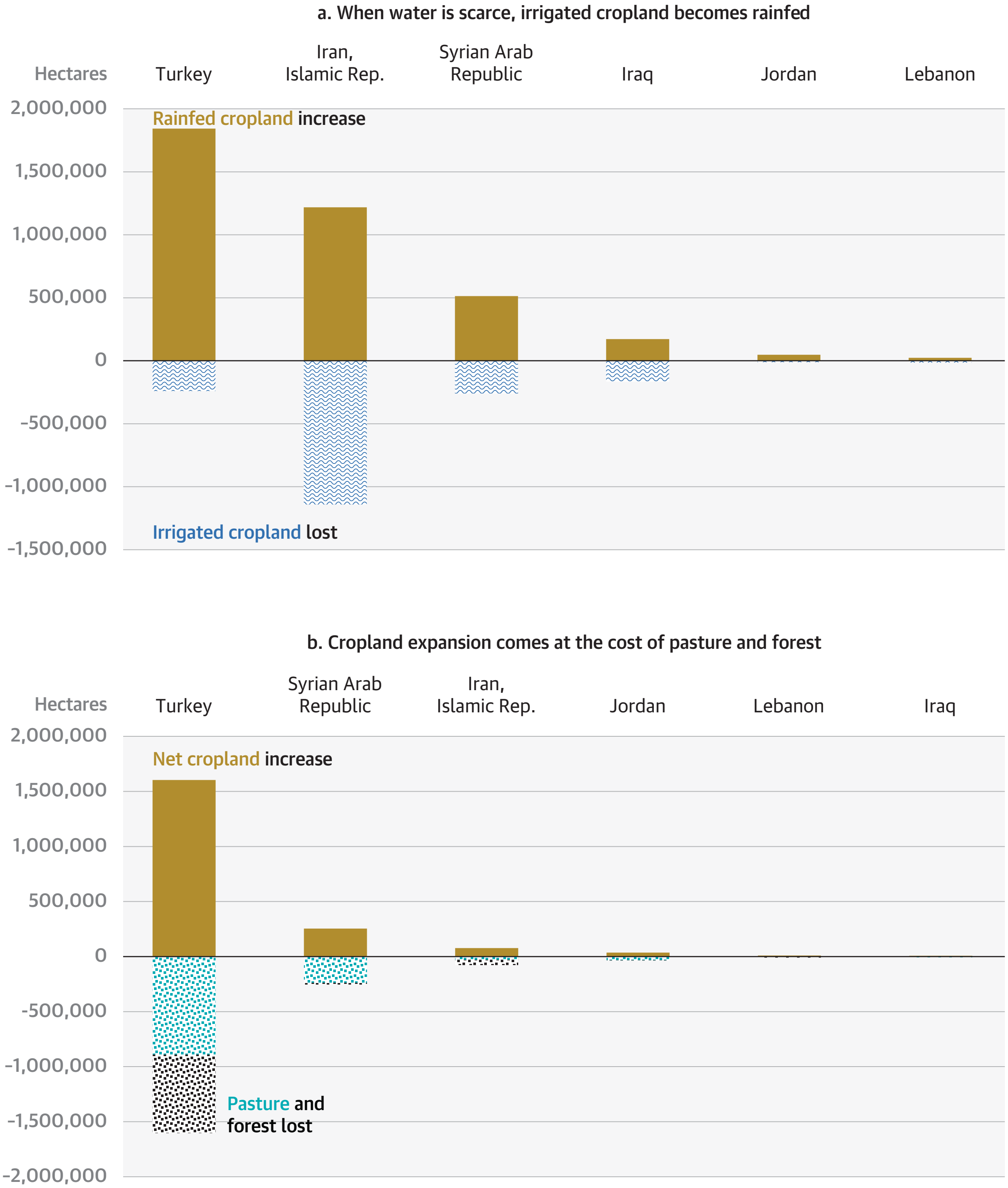
Source: World Bank based on Purdue University analysis.
Note: Relative changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

shows that if water scarcity increases by 20 percent, then cropland under irrigation is expected to decrease across the region, leading to a return to low-productivity rainfed agriculture.

Faced with declining crop yields due to water scarcity, farmers might seek to make up for these losses by expanding cropland, at the expense of remaining forests and natural habitats. Thus, the switch from irrigated to rainfed agriculture could result in a net expansion of cropland. As shown in figure 2.7, nearly one million hectares of natural forest cover could be lost in Turkey, the Islamic Republic of Iran, and Syria as farmers seek to recoup their losses by extending the area under cultivation.

This coping strategy poses a major threat to the region's ecosystems, as it can lead to the loss and fragmentation of natural habitats. Land-use change is also a major source of anthropogenic carbon emissions, so any cropland expansion activities in response to water scarcity could result in higher carbon emissions (Zaveri, Russ, and Damania 2020). Finally, any land-use changes and deforestation induced by water scarcity could reduce the hydrological services provided by forests and natural ecosystems, in turn exacerbating water scarcity in a harmful cycle of resource scarcity and degradation (Damania et al. 2017).

FIGURE 2.7. The Impacts of Climate Change–Induced Water Scarcity and Crop Yields Change on Cropland and Land Use, by Country



Source: World Bank based on Purdue University analysis.
Note: All values in hectares. Changes in land use with respect to the 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

These projections suggest a high risk of further land degradation in the Middle East, which already suffers from greater land degradation than other regions in the world.[3] Across the region, more than half of all land and one-quarter of arable land is degraded (World Bank 2019). The situation is particularly concerning in Iraq and Syria, where over 60 percent of the land is severely degraded, and Jordan, where the share of severely degraded land is as high as 80 percent (World Bank 2019). As water scarcity increases, more land is set to degrade, jeopardizing development gains and heightening vulnerability to climate change and food security shocks, especially for rural populations (Barbier and Hochard 2018).

Notes

1. Labor is divided into six categories in GTAP: Technician and associate professional (skilled); Clerks (unskilled); Service/shop workers (unskilled); Officials and managers (skilled); Agriculture and other workers (unskilled).

2. World Bank Data Unemployment, total (% of total labor force) (modeled International Labour Organization estimate). https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS. Data retrieved June 21, 2020.

3. Land degradation is defined as a negative trend in land condition caused by direct or indirect human-induced processes, including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or value to humans (Olsson et al. 2019).

Chapter 3
Water-Use Efficiency and Trade Levers to Address Water Scarcity

The Promise and Pitfalls of Water-Use Efficiency

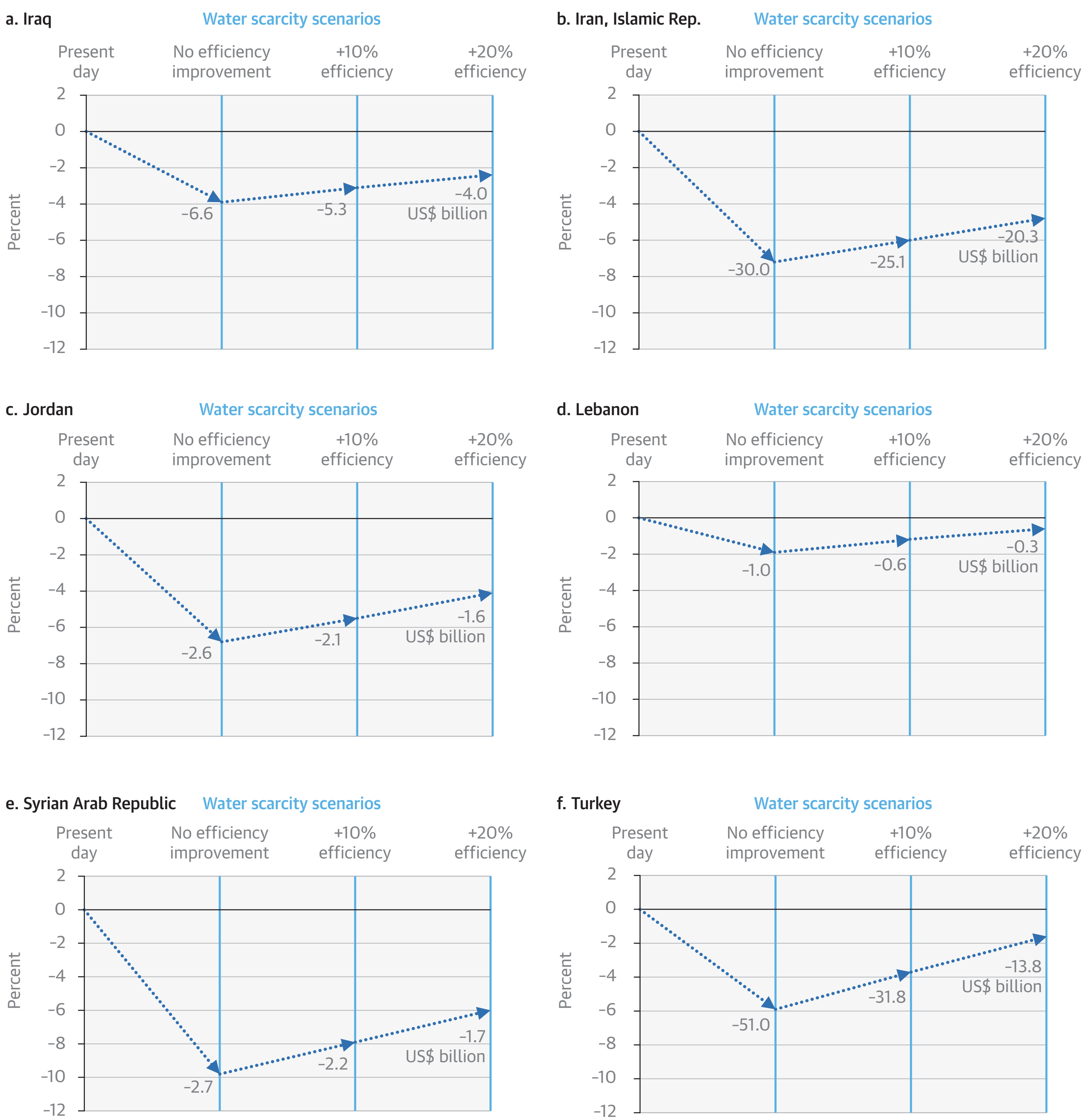
Increasing water-use efficiency is one key option to deal with water scarcity. As defined in Sustainable Development Goal (SDG) 6.4 on water use and scarcity, increasing water-use efficiency over time means decoupling a country's economic growth from its water use, such as by producing the same level of agricultural output with less water (UN Water 2017). While there are many other definitions of water-use efficiency, the SDG definition is adopted here to interpret water-use efficiency in the broadest possible sense as economic output per unit of water consumed (in US dollars at constant prices per unit of water). Building on this understanding of water-use efficiency, the model simulates the economic impacts of 10 percent and 20 percent increases in water-use efficiency across all economic sectors. As done in chapter 2, the model quantifies the impacts of climate change–induced water scarcity and crop yield changes, with the only difference being that now economic sectors need 10 percent or 20 percent less water to generate the same level of output.

Water-use efficiency can, in principle, help reduce the impacts of water scarcity on Middle Eastern economies. More efficient use of water in the economy decreases the economy-wide costs of water scarcity across the region (figure 3.1). As a representative case, consider the Islamic Republic of Iran, where 10 percent and 20 percent improvements in water-use efficiency save the economy about 1.2 percent and 2.4 percent of GDP in the face of increasing scarcity compared to a no policy scenario, respectively. A similar pattern, at different magnitude, can be observed for other countries, particularly Turkey, where water-use efficiency could potentially go a long way in shielding the economy from the far-reaching impacts of water scarcity.

Improvements in water-use efficiency could also slow down land conversion in response to water scarcity. The model results show that improvements in water-use efficiency lower the pressure to expand cropland and convert irrigated areas to rainfed areas. Overall, this confirms the expectation that improvements in water-use efficiency help sustain the productivity of irrigated agriculture in the face of scarcity. In turn, this could lower the risk of cropland expansion and prevent further land degradation and loss of forests and natural habitats. This effect is larger in Turkey and the Islamic Republic of Iran, while it is not so significant in Iraq and Jordan, as shown in figure 3.2. However, even a 20 percent improvement in water-use efficiency does not completely eliminate the gradual conversion of irrigated areas to rainfed areas and subsequent cropland expansion, suggesting that water-use efficiency on its own will not be enough to reduce pressure on the region's already degraded land and forest resources.

Increasing water-use efficiency can also help to avoid sharp declines in labor demand. As shown in figure 3.3, a 20 percent improvement in water-use efficiency stabilizes the demand for unskilled labor in both agricultural and nonagricultural activities. This positive impact is greater for unskilled labor in the agricultural sector, whose vulnerability to water scarcity highlighted in chapter 3 could be reduced by water-use efficiency. This effect is more pronounced in Turkey, Iraq, and Lebanon, where

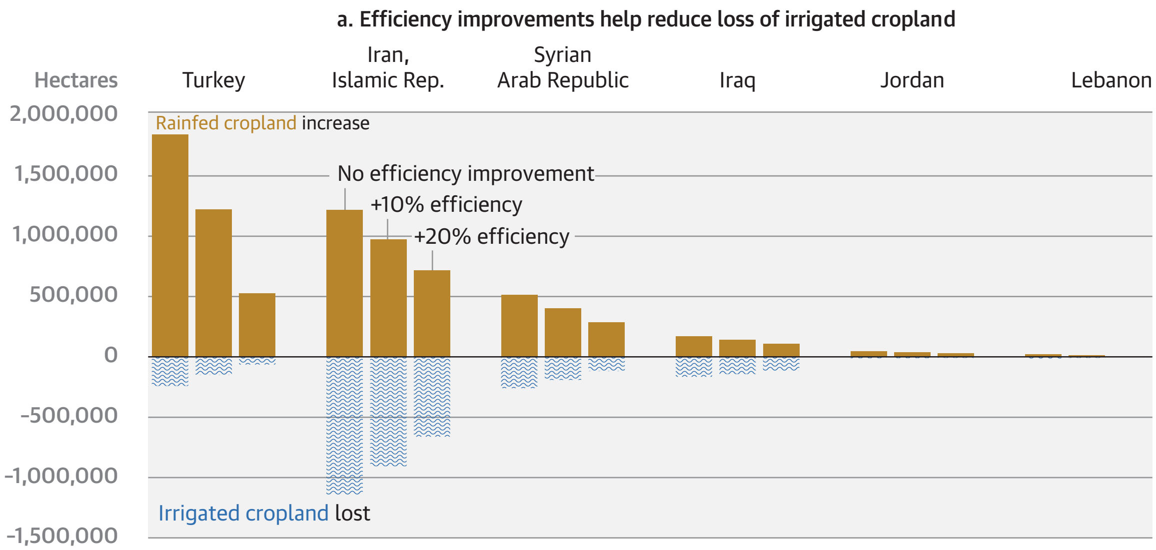
FIGURE 3.1. GDP Change in the Presence of Climate Change Induced Water Security and Crop Yield Changes Under a No-Policy Scenario, and Two Water-Use Efficiency Scenarios

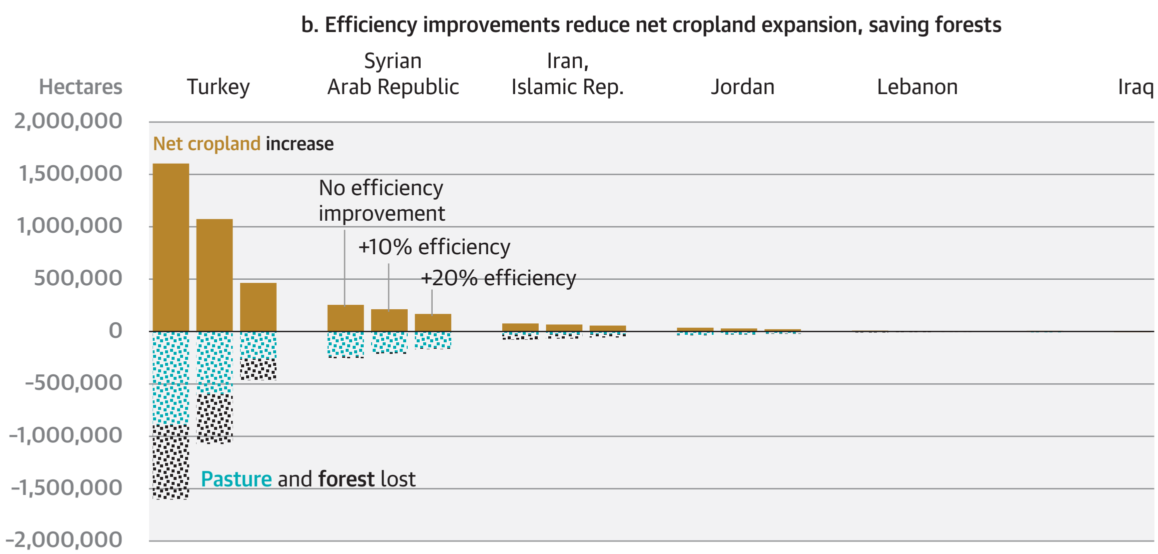


Source: World Bank based on Purdue University analysis.

Note: Changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

FIGURE 3.2. Land-Use Change in the Presence of Climate Change Induced Water Security and Crop Yield Changes Under a No-Policy Scenario, and Two Water-Use Efficiency Scenarios





Source: World Bank based on Purdue University analysis.
Note: All values in hectares. Changes in land use with respect to the 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario, see box 1.1.

improvements in water-use efficiency could help protect agricultural jobs from the impacts of water scarcity. While water-use efficiency also reduces the impact on skilled labor, the effects are not as strong as for unskilled labor.

Water savings across Middle Eastern economies can also reduce impacts on capital (including private and public infrastructure, machinery, and durable equipment) and crop prices. However, these reductions are lower than the effects on GDP, land conversion, and employment. The results for capital are

FIGURE 3.3. Change in Labor Demand in the Presence of Climate Change Induced Water Security and Crop Yield Changes Under a No-Policy Scenario, and Two Water-Use Efficiency Scenarios

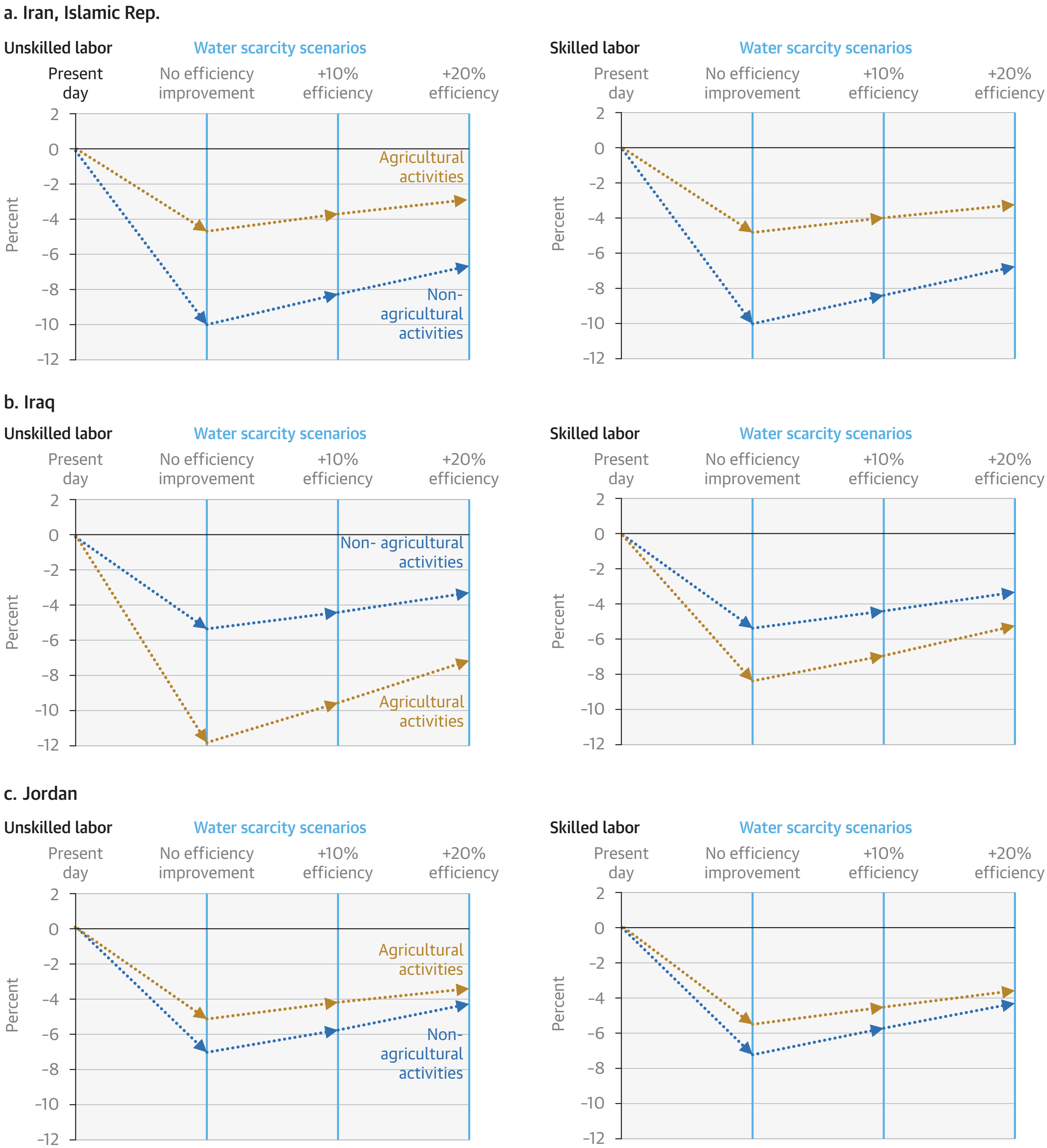
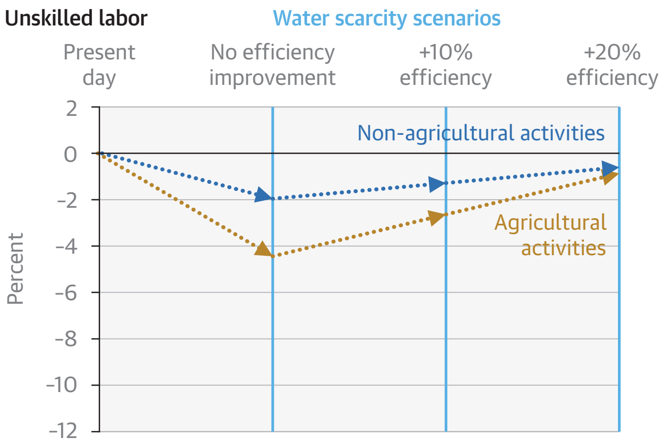
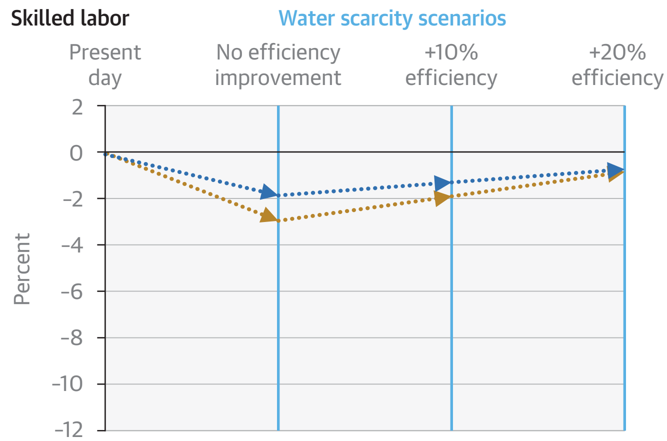


figure continues on the next page

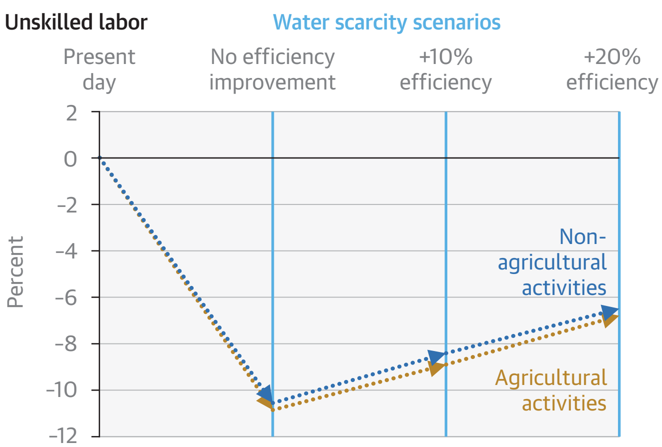
FIGURE 3.3. continued

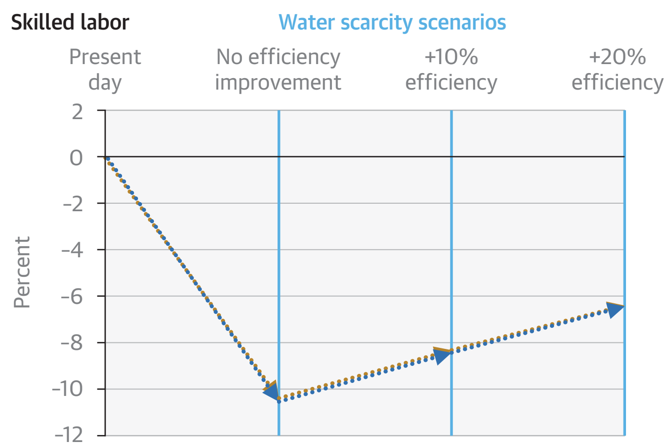
d. Lebanon



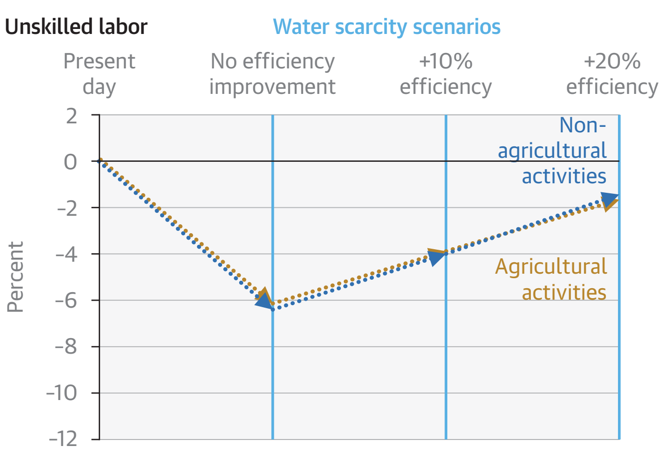


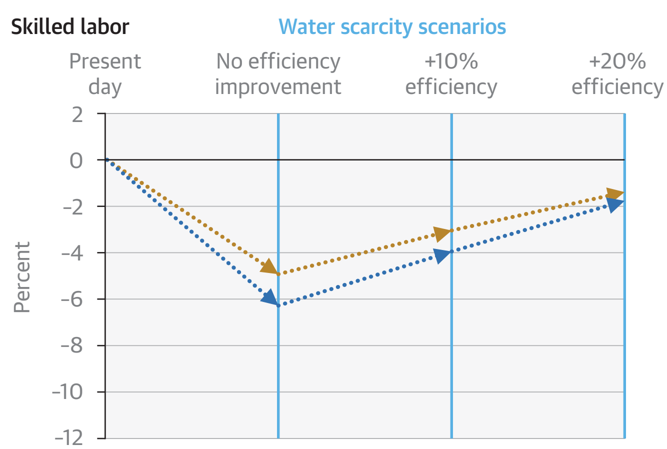
e. Syrian Arab Republic





f. Turkey





Source: World Bank based on Purdue University analysis.
Note: Changes shown compared to 2016 baseline. The figure shows the impact of a 20 percent reduction in water supplies for all countries except for Turkey and Lebanon, where a 10 percent reduction in the water supply is examined. For details on the crop yields scenario see box 1.1. Default orange is nonagricultural; default blue is agricultural.

shown in the technical report (Taheripour et al. 2020). In the case of crop prices and net imports of food items, simulation results suggest that water-use efficiency eliminates only a portion of the price impacts, for both producer and consumer price indexes. While this confirms the importance of water-use efficiency, it also demonstrates that water-use efficiency improvements will not be enough to mitigate the impacts of water scarcity on food prices, given the region's land and water constraints.

Given that crop irrigation accounts for more than 70 percent of regional water use, investments in water-use efficiency mostly target irrigation. These investments typically involve subsidizing advanced irrigation technologies such as sprinklers and drip systems. The stated promise of these investments is to "save" water and allow for its reallocation to cities or to the environment. However, global evidence shows that irrigation efficiency improvements rarely yield the level of expected savings in water consumption and that consumption of irrigation water often increases in response to efficiency improvements as farmers expand the area under irrigation (Ward and Pulido-Velazquez 2008; Giordano et al. 2017). This could occur, for example, when irrigation infrastructure subsidies encourage farmers to adopt more efficient irrigation methods (Grafton et al. 2018). Since water is now used more productively, it may incentivize the farmer to withdraw more water or to expand the irrigated area leading to an increase in water withdrawals. Hence, pursuing water-use efficiency improvements requires regulatory policies and caps on water consumption to prevent greater water consumption from taking place, as well as consideration of the technical aspects related to crop water use and irrigation technology (that is, under drip irrigation, more water is absorbed by crops, leading to less downstream flow and less non-beneficial evapotranspiration) .

To understand this potential rebound effect of investments in water-use efficiency, the model develops a separate set of simulations to examine how water consumption in agriculture changes following improvements in water-use efficiency and assuming there are no constraints on water withdrawals. The analysis focuses on the Islamic Republic of Iran and Turkey, the two largest agricultural producers, and attempts to quantify by how much water consumption would increase following efficiency improvements (figure 3.4). Results are sobering. In the Islamic Republic of Iran, a 10 percent increase in water-use efficiency across the economy would cause total water consumption to increase by the same amount, thus canceling out any "saved" water. A rebound effect is observed for Turkey, where a 5 percent increase in water consumption occurs after a 10 percent increase in water-use efficiency.

These results confirm the known pitfalls of water-use efficiency improvements: unless the right water measurement and management policies are in place, higher efficiency may not reduce consumption. To avoid these pitfalls and ensure that the gains are sustained, increases in water-use efficiency must be accompanied by water accounting and measurements, a cap on water withdrawals in basins, and a better understanding of the incentives and behavior of irrigators (Grafton et al. 2018).

International Trade Buffers Impact of Water Scarcity

Trade has been and will continue to be a significant instrument for the region to cope with water scarcity and meet growing demands for agricultural and food products and other goods. Trade in agricultural and food products is regarded as "virtual water trade" as it avoids agricultural water use in the importing country while increasing it in the exporting country (Allan 2002). In the Middle East, as in

FIGURE 3.4. The Rebound Effect of Water-Use Efficiency, Showing Countries Increasing Overall Water Consumption with Investments in Efficient Water Use

Source: World Bank based on Purdue University analysis.
Note: The simulation assumes that there are no constraints on water withdrawals.

many other parts of the world with little land and limited water endowments, virtual water trade in the form of imports of food products is key to buffer the impacts of water scarcity on food production (Liu et al. 2014).

In a scenario of increasing water scarcity and potential reductions in crop yields, countries in the Middle East are projected to import more food products, with trade buffering the effects of climate change on regional economies and food security (box 3.1). Production of key food products (crops; livestock and livestock products; and processed food and feed) is expected to decline under water scarcity. As a result, Middle Eastern countries will make up for this lost production by procuring foods on international markets. This increasing reliance on food imports will be particularly pronounced in

BOX 3.1. Impact on Trade Balance of Food Products

In general, a reduction in water supply increases the net imports of food items across the region. The larger the reduction in water supply, the higher the increase in net imports. The increase in net imports is particularly pronounced in Turkey, Iraq, the Islamic Republic of Iran, and the Syrian Arab Republic (table B3.1.1). The exception is Jordan, which experiences fewer net imports (or more net exports) as the level of water scarcity increases. This is because the model suggests that Jordan might export more valuable food products to neighboring countries as the severity of water scarcity grows in the entire region and imports fewer valuable products from the world market. Improvements in water use efficiency can partially eliminate a small portion of the increases in net imports of food items.

TABLE B3.1.1. Changes in Net Imports of Food Items under Alternative Scenarios

$US million

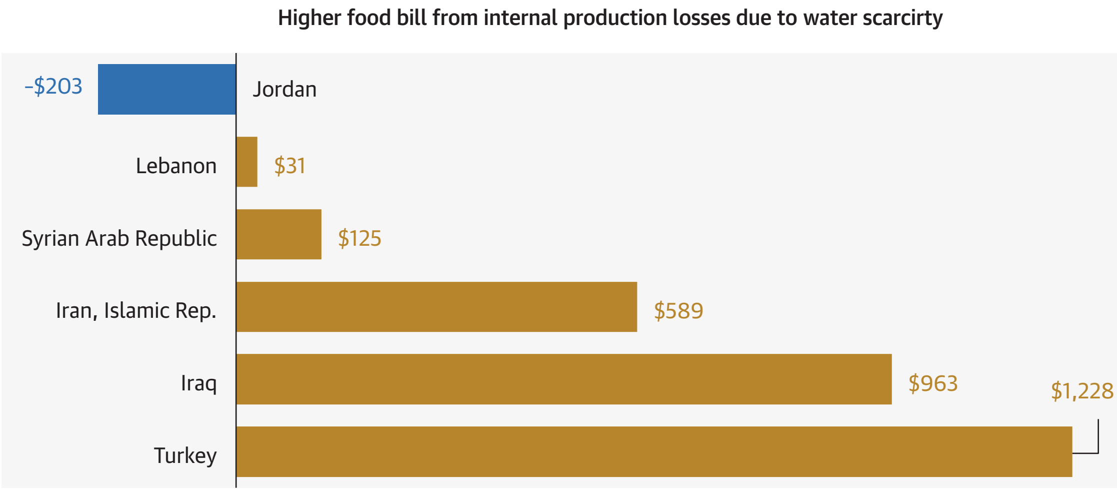
	Increase in water scarcity	Increase in water-use efficiency	
Country	20 percent	10 percent	20 percent
Iran, Islamic Rep.	589	533	481
Iraq	963	801	623
Jordan	−203	−155	−105
Lebanon	31	14	−2
Syrian Arab Republic	125	107	89
Turkey	1,228	728	245

Source: World Bank based on Purdue University analysis.
Note: Food items consist of crops; livestock; and processed food and feed.

Turkey, Iraq, the Islamic Republic of Iran, and the Syrian Arab Republic, as shown in figure 3.5. In Jordan, water scarcity might lead to a negative net change in imports: that is, an increase in the net export of crops, livestock, and processed food in monetary terms. Under this scenario, Jordan might end up exporting more valuable food products (such as horticultural products) to its neighbors and importing fewer valuable products (such as grains) from the world market as water scarcity grows in the entire region.

Apart from its ability to buffer water scarcity impacts, international trade in food products is closely intertwined with food security concerns and the debate on food self-sufficiency. Policies focused on food self-sufficiency have always been politically appealing in the region (Richards and Waterbury 1990), partly because of the political isolation and sanctions implemented against certain countries, and partly because of volatile world food prices and risks related to over-reliance on global supply chains. However, the model results show that food production is expected to drop under conditions of water scarcity. This means that food self-sufficiency is not a target within reach because of the water scarcity constraints faced by all countries in the region, with the exception of Turkey.

FIGURE 3.5. Change in Net Imports of Food Items ($US million)



Source: World Bank based on Purdue University analysis.
Note: Food items consist of crops; livestock; and processed food and feed.

This finding confirms existing analyses showing that countries in the region will increasingly rely on imports to meet their food needs (UN and FAO 2017). Hence, to improve food security in the short-term, countries should focus on a set of policy options to build strategic reserves and improve the efficiency of supply chains to safeguard against excessive global food price volatility (Larson et al. 2012). They should also expand and better target food subsidies and social protection programs to protect the poorest and more vulnerable from food price shocks (Lampietti et al. 2011). Over time, coping with scarcity while maintaining food security will likely entail moving away from policies targeting self-sufficiency of low-value staple crops for which the region has no competitive advantage (such as wheat) toward more balanced policies promoting production of high-value crops and export-led growth (Borgomeo and Santos 2019). The accompanying technical report provides (Taheripour et al. 2020) a more detailed analysis of the impacts of water scarcity on other key dimensions of trade, including terms of trade.

Chapter 4
Five Insights for Policy

Decisive action is required to manage the impacts of water scarcity. Identifying these actions requires consideration of country-specific contexts and priorities. This research identifies five key insights that can help guide country-level action on water scarcity.

Policy Insight 1. Climate-driven water scarcity could reduce economic growth by more than 6 percent compared to 2016 levels and lead to food price spikes in some countries. Water scarcity has sweeping impacts that ripple through the economy, hampering growth and constraining economic opportunities for farms, firms, and people. How the region responds to these impacts will be pivotal in determining its future economic prospects and stability, and whether it can achieve the Sustainable Development Goals. To accelerate growth and create jobs for millions of unemployed youths, countries should move away from policies advocating food self-sufficiency and allowing unsustainable use of water.

Policy Insight 2. Improvements in the efficiency of water use can be counterproductive without proper regulation, water accounting, and water measurement. Water use efficiency measures need to be centered on water measurement and accounting, and reductions in direct water withdrawals. While saving water through efficiency improvements offers the prospect of providing water for additional users, it could be counterproductive and lead to a rebound effect in water consumption: as water is used more efficiently, this might lead farmers to use the "saved" water to irrigate more area or switch toward more thirsty crops. This well-known paradox can be addressed through increased awareness and better water accounting, along with constraints and enforcement on land expansion and water withdrawals. Advances in remote sensing offer the possibility of developing water accounts at a much lower cost and a greater scale than previously available (Grafton et al. 2018). Countries will have to take advantage of the digital economy by adopting new technologies for water measurement and management in agriculture as part of broader efforts to move toward a digital future (Arezki, Belhaj, and Shah 2019).

Policy Insight 3. The consequences of water scarcity cascade, from declining irrigated agriculture to shrinking forests and natural habitats. Water scarcity is a driver of land use change and cropland expansion, highlighting the need for policies to address the synchronous challenges facing agriculture and the environment. As water available for irrigation declines, farmers might seek to recoup these losses by further expanding crop production on less productive rainfed cropland. Such expansion can contribute to land degradation, deforestation, and loss of related hydrological services (such as regulation and purification of water). Thus, without policy action, there is a likelihood of a vicious cycle where water scarcity leads to conversion of irrigated areas to low productivity rainfed agriculture, which in turn leads to expansion of cropland into forests to compensate for the loss of crop yields, removing important hydrological services and thus worsening water scarcity. On a larger scale, cropland expansion and land-use change also alter the global carbon balance, exacerbating climate change, and inducing further scarcity. To avoid this cycle, policies could take the form of restrictions on land-use in watersheds or the use of market-based approaches to protect forests, such as payments for hydrological services.

Policy Insight 4. Policy levers outside the realm of water are key to address scarcity, emphasizing the need for complementary actions and investments. Agricultural and energy subsidies, social protection, and trade policy all have fundamental impacts in mitigating or magnifying the impacts of water scarcity on regional economies. Hence, complementary actions and investments are needed to overcome water scarcity issues in agriculture, such as new and more robust trade agreements accompanied with targeted social protection systems. Managing increasing food import dependence and the growing urbanization in the region will require investments in value chains and related infrastructure such as roads, storage, and cooling chains. The strategic vulnerabilities that come with a higher dependence on imports can also be managed by diversifying trading partners and developing storage solutions. In turn, this will help move water use in agricultural systems away from low-value crops toward higher-value irrigation that yields higher returns, and is typically also more labor intensive than irrigated agriculture of low-value crops (Christiaensen 2020). Research shows that water allocation reform coupled with trade reforms can also lead to significant economic benefits (to Diao, Roe, and Dooukkali 2005) and foster an export-led agricultural sector.

Policy Insight 5. Joint regional efforts to address water scarcity are a promising avenue to adapt to climate change, reap economic gains, and advance regional cooperation. In an era of fragmentation and conflict, joint efforts and economic collaboration might seem like a daunting challenge and distant goal. Nonetheless, efforts continue. This report demonstrates that they can yield significant economic gains and shared prosperity. In fact, benefits can accrue with cross-country integration of infrastructure and cooperative management of shared water resources (box 4.1). Moving forward, there is a need to build on ongoing efforts to further the debate on how the regional water scarcity challenge can be turned into an opportunity for greater integration and prosperity.

BOX 4.1. Can Economic Models Help Navigate Transboundary Water Management?

This study examines the economic impacts of a decrease in water supplies in six Middle Eastern countries for the existing water withdrawals by river basin and political boundaries as of 2016, as explained in more detail in the accompanying technical report (Taheripour et al. 2020). But the impacts of changes in water supplies ignore political boundaries. Accordingly, the effects can be magnified or moderated through potential collective responses. However, water withdrawal is likely to change in the future, particularly from those basins that serve several nations. For example, one country may choose to increase water withdrawals from a basin that serves several nations, which could amplify negative impacts in a neighboring country. Conversely, collaborative responses across nations could promote greater efficiencies to mitigate anticipated impacts.

Beyond the economic impacts to countries reported here, the study also modeled some cross-border implications on the Tigris-Euphrates basin, which primarily includes Turkey, Syria, and Iraq. The modelers first simulated a 5 percent increase in water withdrawal in Turkey, resulting in 10 percent reductions in water supplies in Syria and Iraq. Naturally, such changes would generate

box continues on the next page

BOX 4.1. continued

economic gains for Turkey, and losses for both Syria and Iraq, increasing the real GDP of Turkey by about 0.9 percent (or US$7.5 billion) and decreasing the real GDP of Iraq by 1.2 percent (or US$2 billion) and Syria by 2.9 percent (or 0.8 billion). Impacts on the demand for unskilled and skilled labor, capital (private and public infrastructure, machinery, and durable equipment), irrigated area, the producer price index of crop products, and net trade of food products would all be positive for Turkey, and negative for Iraq and Syria.

Given the significant impact an increase in water withdrawal in Turkey would have on the economies downstream, concerned countries could get together to identify options for sharing benefits and costs to mitigate and avoid negative downstream impacts. In this study, only a subset of impacts and options to address these identified impacts have been studied. Additional work is required to identify the wider set of potential effects, including environmental impacts and additional social and economic impacts arising from collaborative responses on transboundary waters issues.

The point of the exercise was not to be prescriptive, but rather to suggest the dangers of thinking only within country boundaries for policy responses to change. The study indicates how cooperation might help mitigate these cross-border impacts. There is a need to study this mitigation process in more detail to explore cooperative options to address water scarcity. Further research could analyze the economic impact of fully noncooperative and cooperative scenarios in terms of transboundary waters cooperation.

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