Transboundary water challenges and potential collaboration in the Tigris-Euphrates river basin water management

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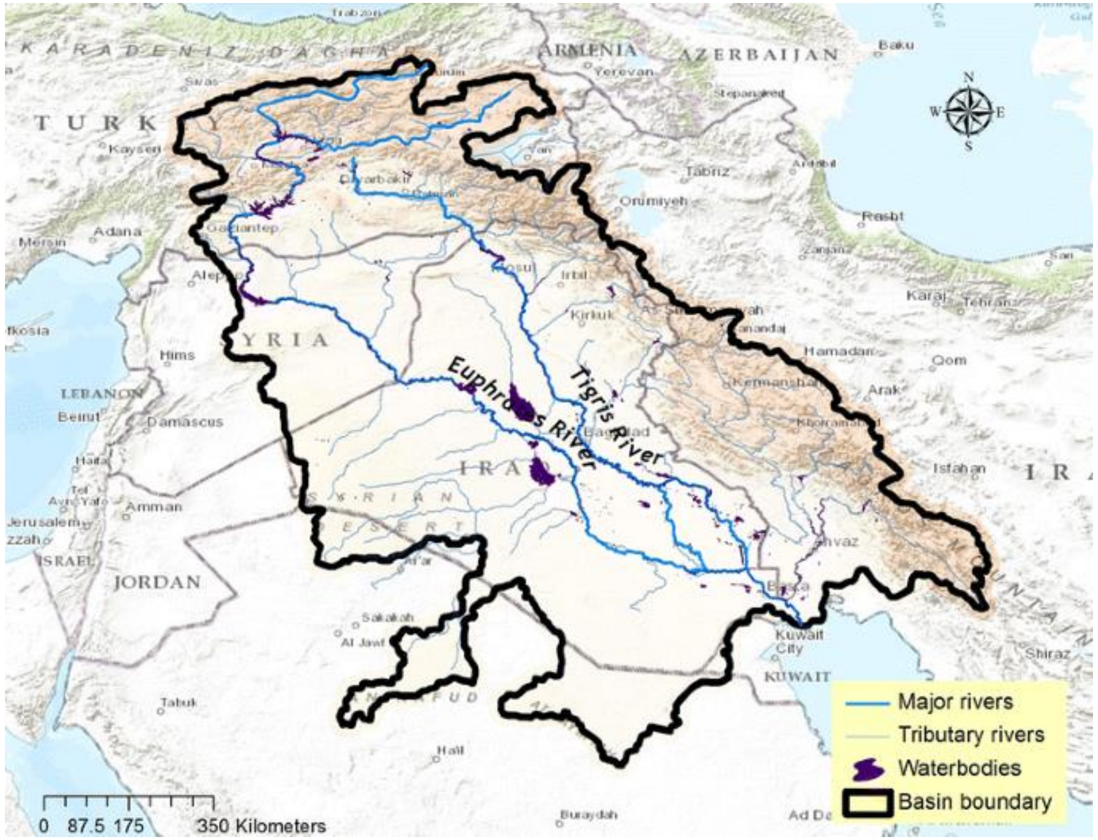
Introduction

- Today, 47% of global population experience water scarcity at least one month each year (UNESCO 2018)
- Globally, transboundary rivers carry 60% of fresh water (Economist Intelligence Unit 2020)
- These shared resources need to be managed in sustainable manner
- Tigris-Euphrates river basin is in crisis (Shamout and Lahn 2018)
  - Climate change
  - Weak cooperation among riparian countries
  - Intensive hydropower development
  - Inefficient agricultural practices
  - Political instability



Source: Daggupati et al. (2017)

Objectives

- Quantify the impacts of climate change on water scarcity by 2050 in the Tigris-Euphrates and other river basins within the Middle East region under alternative climate futures
- Assess economic outcomes of these changes in water supply
- Assess the economic outcomes of transboundary water allocation scenarios
- Evaluate cooperation plans that can be implemented to reduce controversies over water allocation in the Tigris-Euphrates river basin

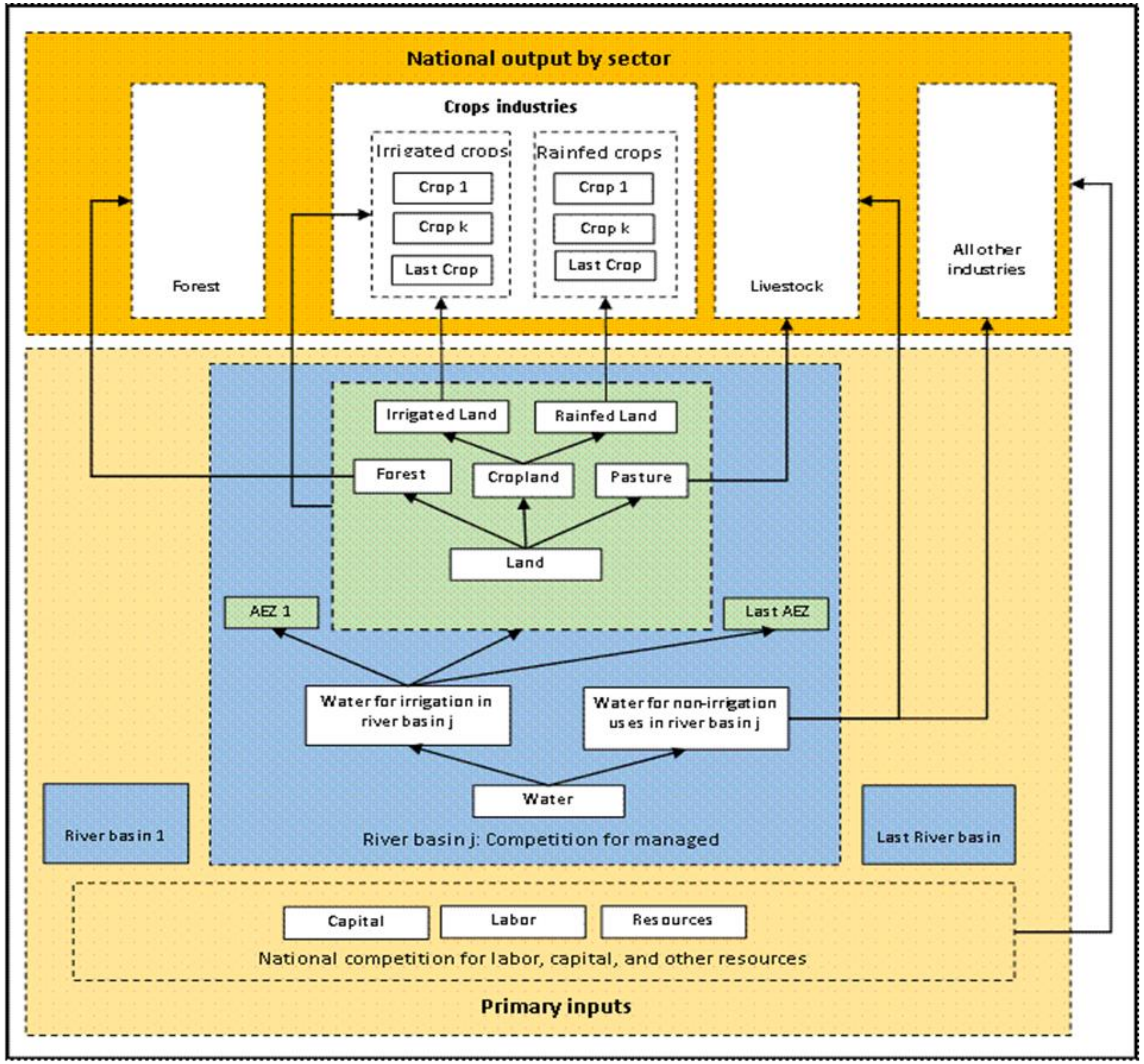
Methodology

- Global Circulation Models to project temperature and precipitation to 2050
- Hydrological model (Vörösmarty, Federer and Schloss 1998; Grogan 2016, Haqiqi 2019) to project water scarcity, given temperature and precipitation scenario
- Comparative static computable general equilibrium model GTAP-BIO-W (Taheripour et al. 2020) to quantify economic implications of the reduced water supply

GTAP-BIO-W

- Economic and biophysical information on land and water at River Basin–Agro-Ecological Zone (RB-AEZ) in each region
- Water is modeled as an explicit input in *irrigated crops, livestock, and water utility services*
- Irrigated crops are distinguished from rainfed
- Competition for water
    - The three activities compete at the RB level
    - Irrigated individual crops compete for water within RB-AEZ

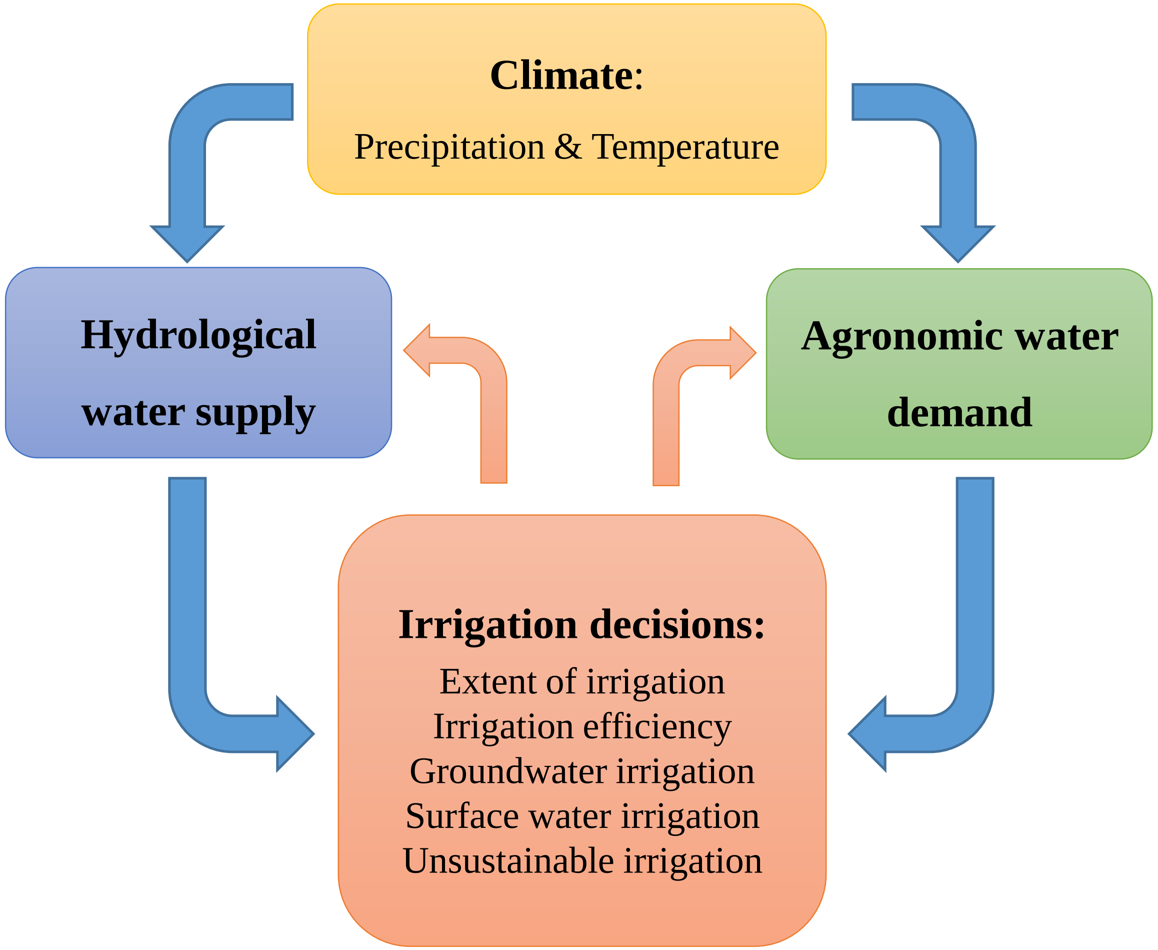
Structure of GTAP-BIO-W model



Source: Taheripour et al. (2020)

Hydrological model (Haqiqi 2019)

- Based on Water Balance Model (WBM) (Vörösmarty, Federer and Schloss 1998; Grogan 2016)
- Simulates the vertical exchange and horizontal transport of water at the grid cell level
- Distinguish between surface (SW), shallow groundwater (GW) and unsustainable groundwater (UGW)
- Inputs
  - Daily temperature and precipitation
  - Harvested area and non-agricultural use by country
- Produces irrigation requirements (split into SW, GW, UGW) to maintain agricultural yields in response to water stress in future climate



Data sources of climate projections

- Climate dataset by Boyko, Reggiani, and Todini (2022) constructed using Regianni et al. (2021) methodology (ensemble)
  - 19 CMIP5 GCMs and two scenarios RCP 4.5 and RCP 8.5 from 1979 to 2100
  - Weighted and bias-corrected using ERA5 reanalysis data (Hersbach et al. 2020) from 1979 to 2005

- NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6) (Thrasher, B. et al. 2021; 2022)

NEX-GDDP-CMIP6

- General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 6 (CMIP6)
  - 35 GCMs and four SSP scenarios from 2015 to 2100
- Bias-Correction Spatial Disaggregation (BCSD) downscaling algorithm

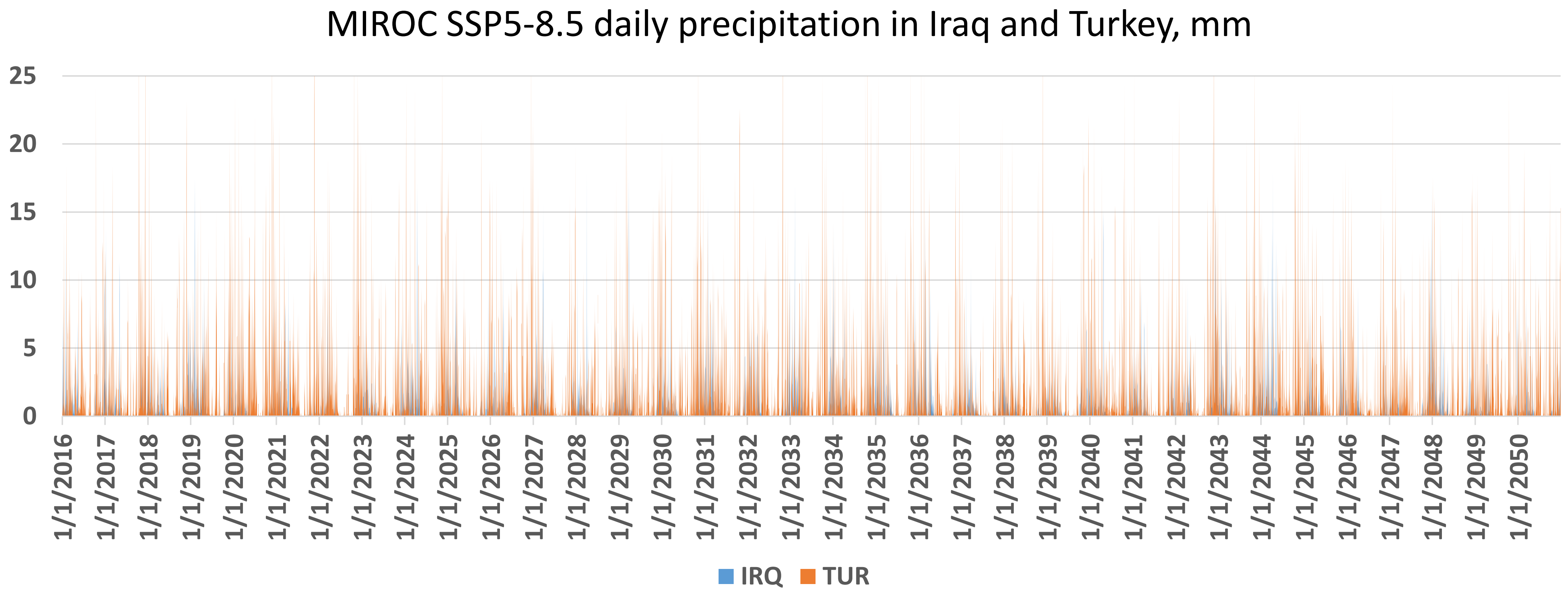
- Running the hydrological model with each GCM output would require very large computing resources

- Instead, systematically compare GCM retrospective runs with observational data to evaluate the performance on precipitation for the Middle East

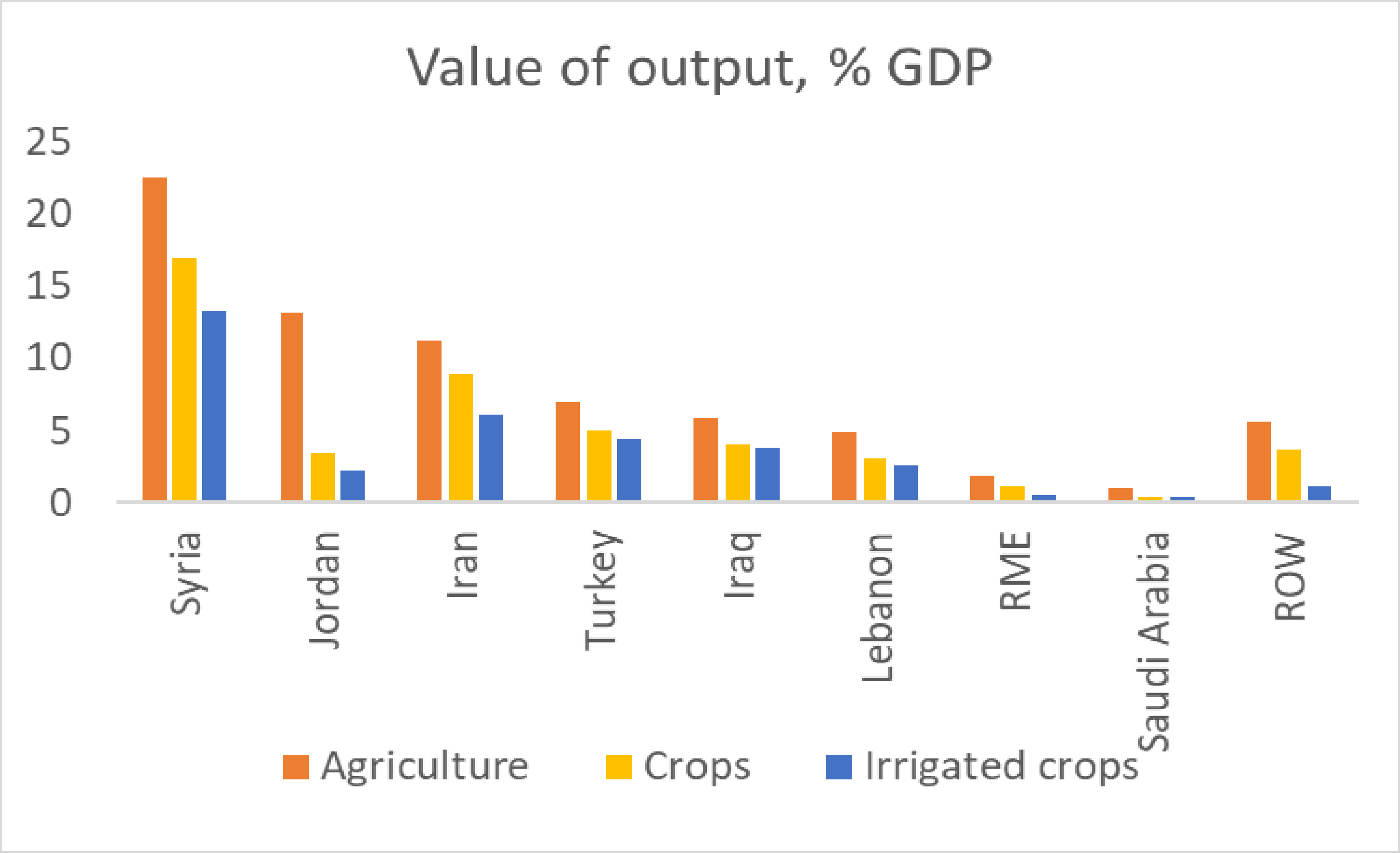
- We find MIROC performs somewhat better than other GCMs

Climate scenarios

- Two climate scenarios from each data source
  - MIROC SSP5-8.5 and SSP2-4.5
  - Ensemble RCP 8.5 and RCP 4.5

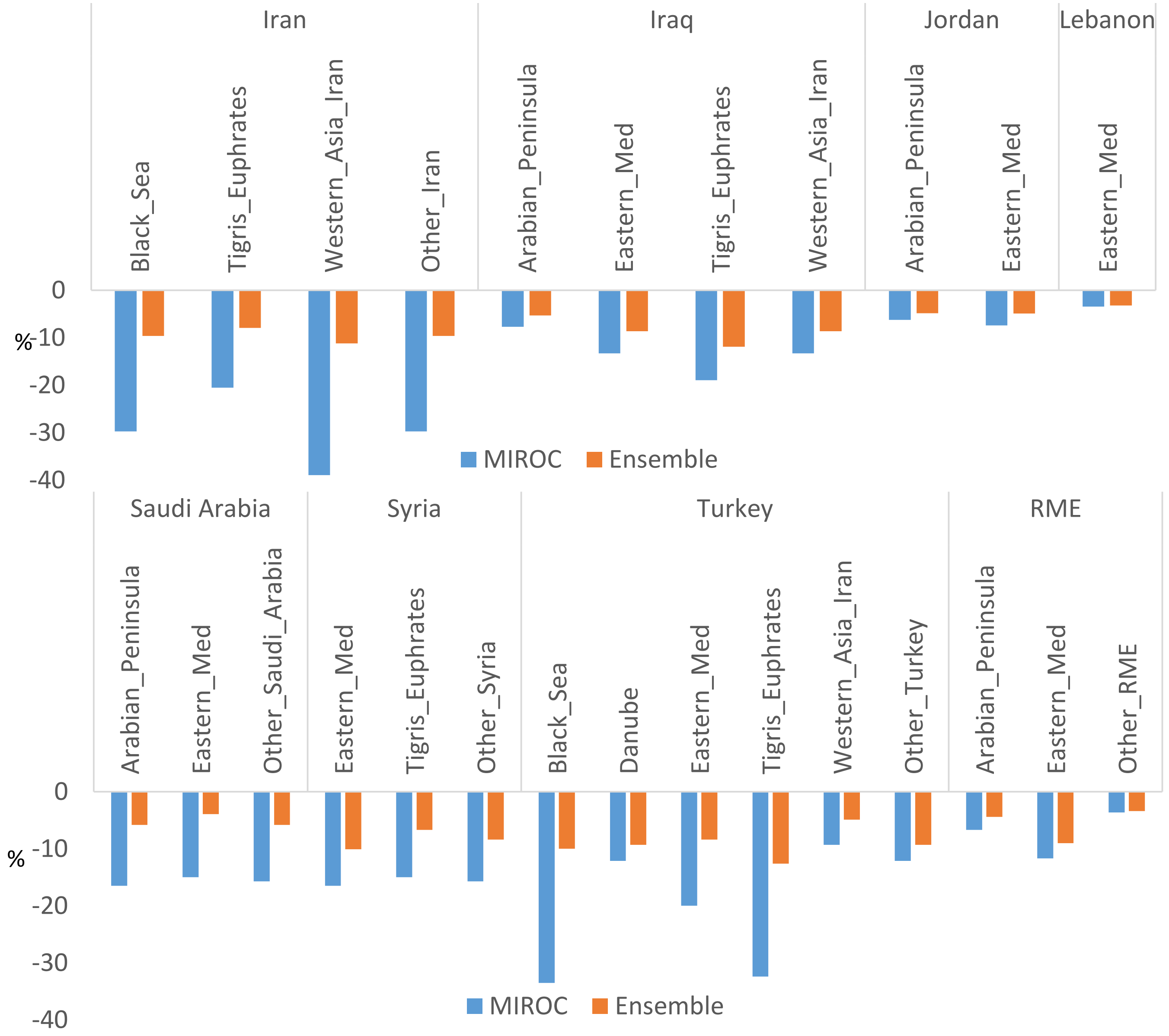


Agricultural sectors in the Middle East

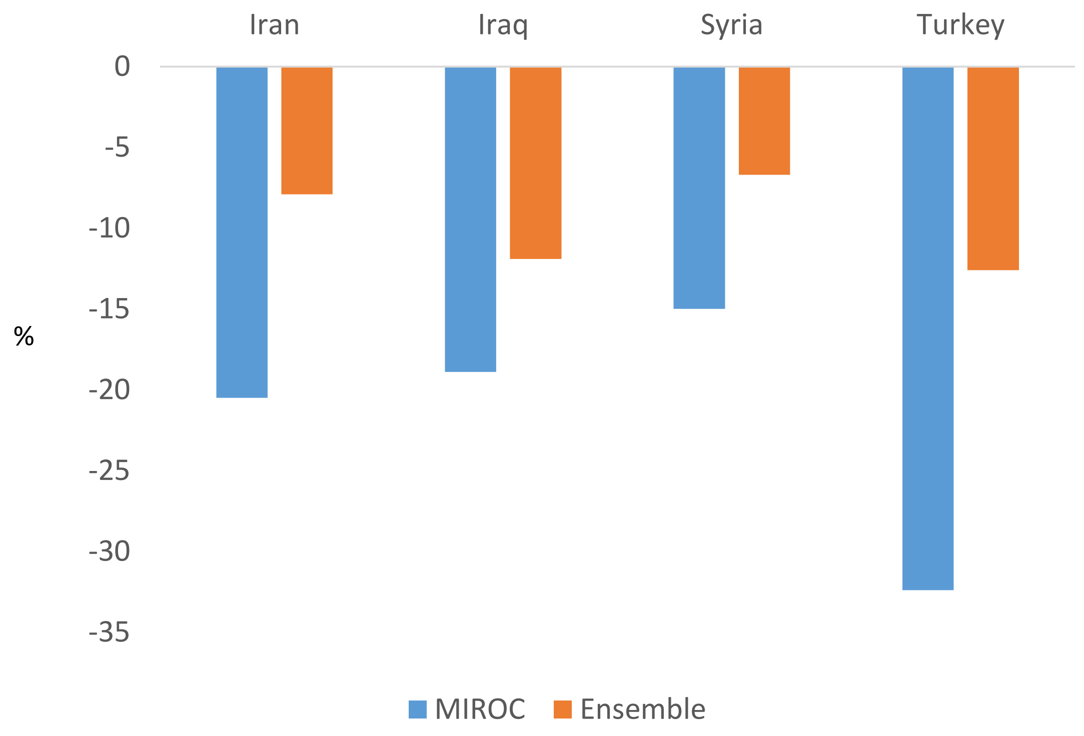


Source: GTAP-BIO-W data base

Hydrological model results: RCP 8.5 reduction in water supply in the Middle East by 2050



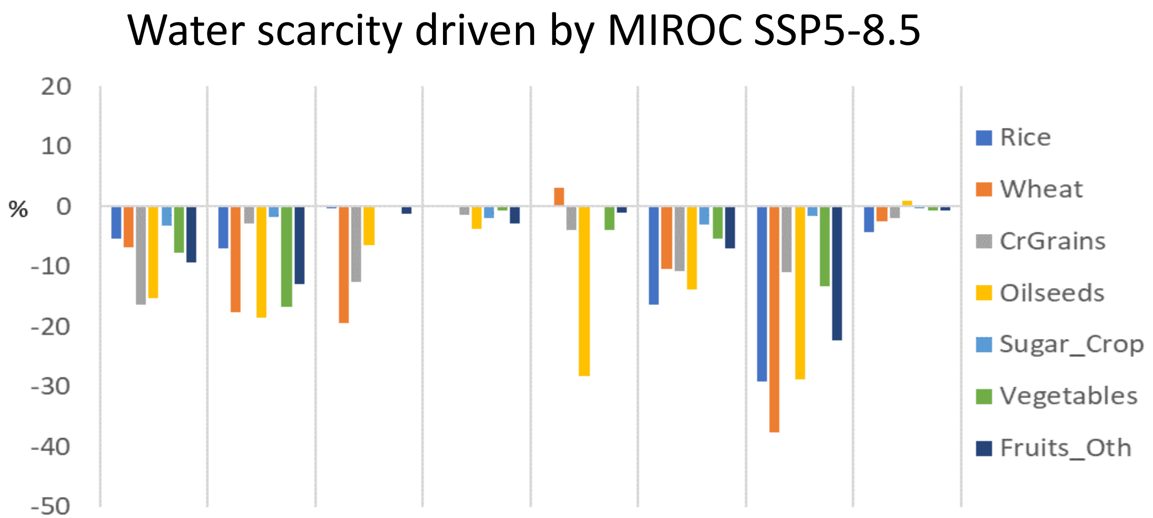
Hydrological model results: RCP 8.5 reduction in water supply in the Tigris-Euphrates RB by 2050

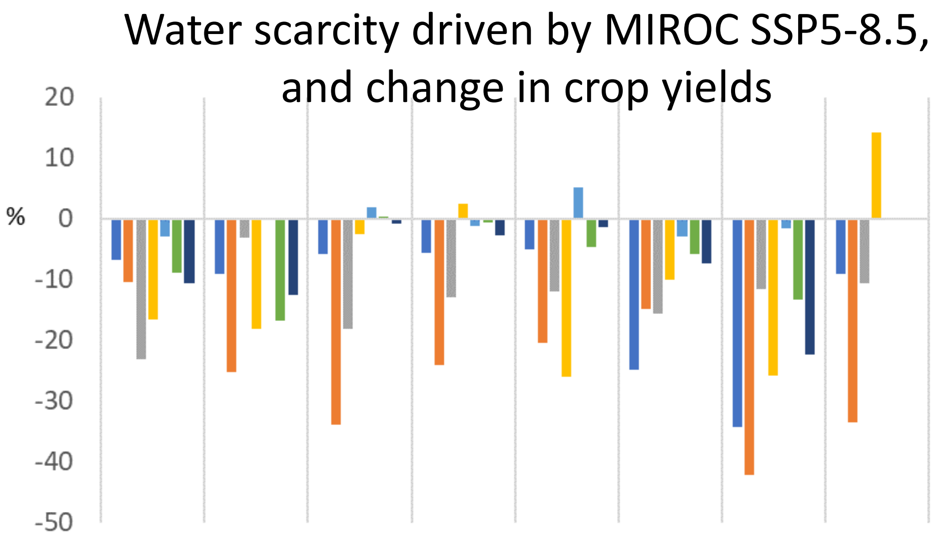


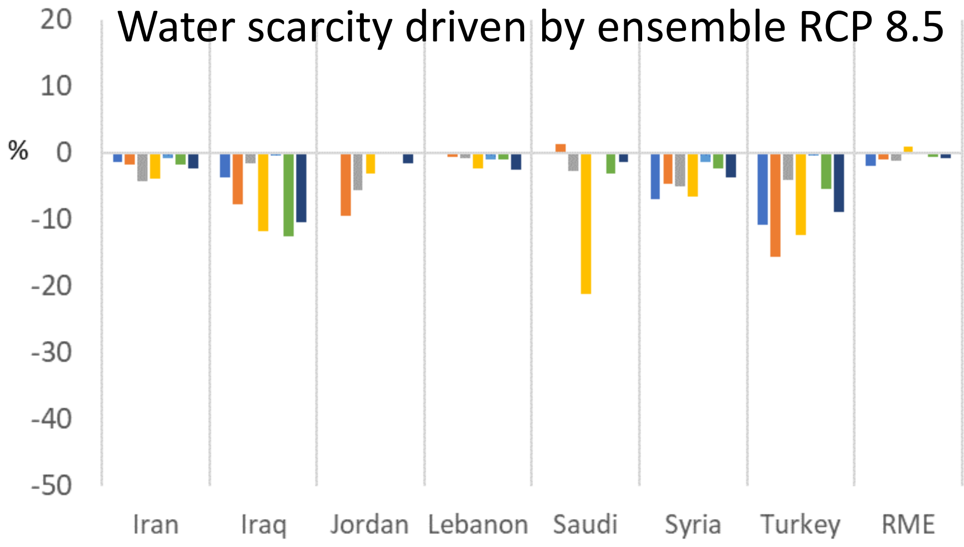
Scenarios analyzed with economic model

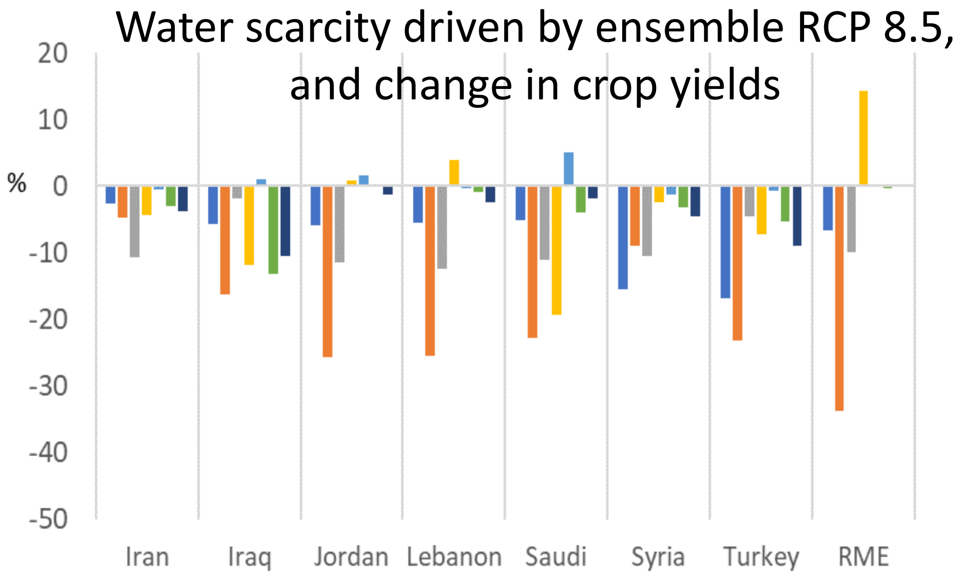
- Change in water supply by 2050 in the Middle East driven by MIROC SSP5-8.5 projections
  - Without changes in crop yields
  - With changes in crop yields
- Change in water supply by 2050 in the Middle East driven by Ensemble RCP 8.5 projections
  - Without changes in crop yields
  - With changes in crop yields

Scenario results: changes in crop output

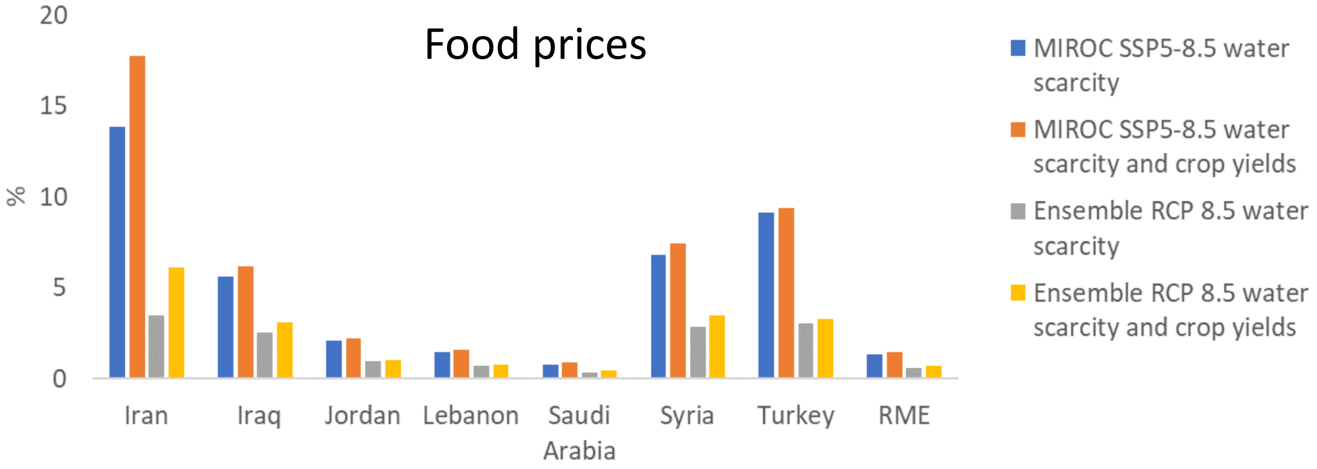


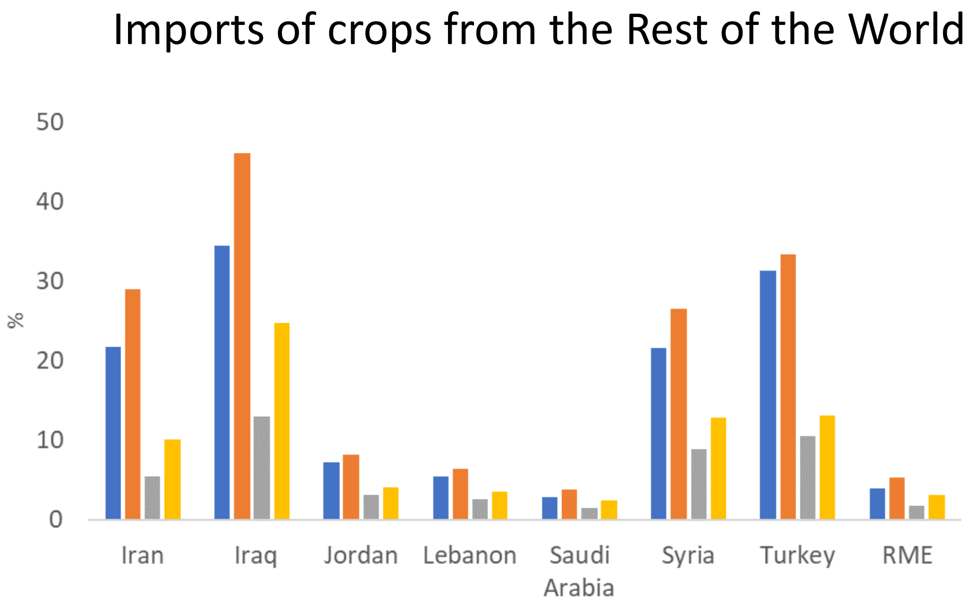


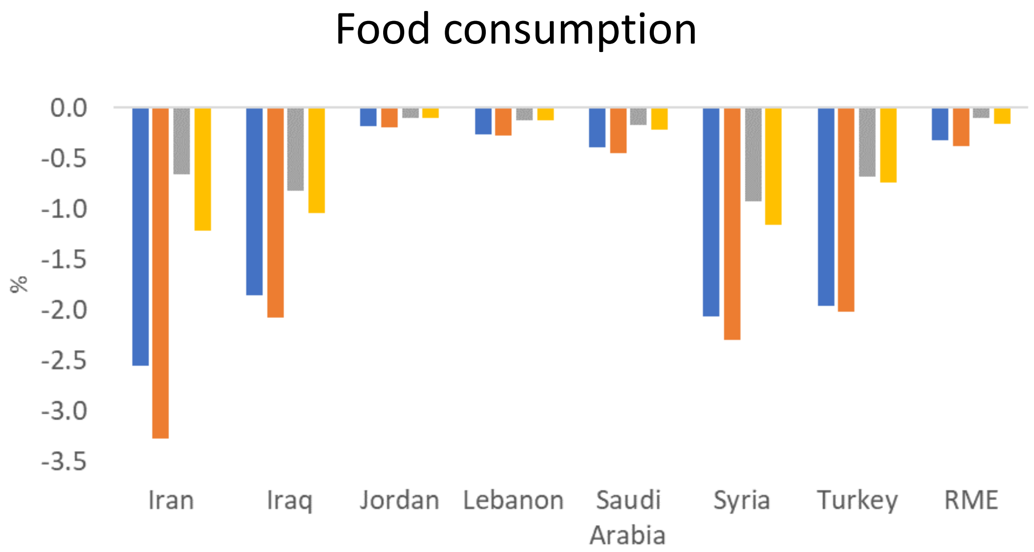




Scenario results: changes in consumption quantity and prices, and imports from the Rest of the World







Summary and next steps

- The goal of this study is to quantify economic implications of the impacts of climate change on water scarcity in the Tigris-Euphrates and other RBs within the Middle East region
  - Outcomes of cooperative vs. non-cooperative behavior of riparian countries
- Findings
  - A large range of reductions in water supply in the Middle East region, between 3 and 39% by 2050, depending on the river basin and country
  - Within Tigris-Euphrates RB, the largest relative reduction in the water supply is projected in Turkey
  - Among crop sectors, wheat output decreased the most
  - Crop imports by Middle East countries increase dramatically amid a reduction in domestic output
- Next steps
  - Evaluate economic implications of the impacts of climate change on water scarcity under the RCP 4.5 scenario
  - Combine climate impacts with increases in upstream countries’ water withdrawals within Tigris-Euphrates RB
  - Consider cooperation plans that can be implemented to reduce controversies over water allocation in the Tigris-Euphrates RB

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