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Global to Local Analysis of Systems Sustainability



# **MANAGING THE GLOBAL COMMONS: SUSTAINABLE AGRICULTURE AND USE OF THE WORLD'S LAND AND WATER RESOURCES IN THE 21ST CENTURY**

**PI: Thomas W. Hertel, Co-PIs: Uris L.C. Baldos, Laura Bowling, Keith Cherkauer,  
Matthew Huber, David R. Johnson, Carol X. Song, Dominique van der Mensbrugge**

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# NEED



## MEETING THE GLOBAL SUSTAINABLE DEVELOPMENT GOALS ON A CHANGING PLANET WITH LIMITED LAND AND WATER RESOURCES



  
TRANSFORMING OUR  
WORLD:  
THE 2030 AGENDA FOR  
SUSTAINABLE  
DEVELOPMENT

[development.un.org/bost2015/transformingourworld](http://development.un.org/bost2015/transformingourworld)



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**MANY GOALS RELATE TO LAND AND WATER RESOURCES, SUGGESTING WE NEED A SYSTEMS APPROACH TO SEE COMBINED IMPACTS**



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RESEARCH ON THE SUSTAINABLE DEVELOPMENT GOALS TYPICALLY FALLS INTO ONE OF THREE TRAPS

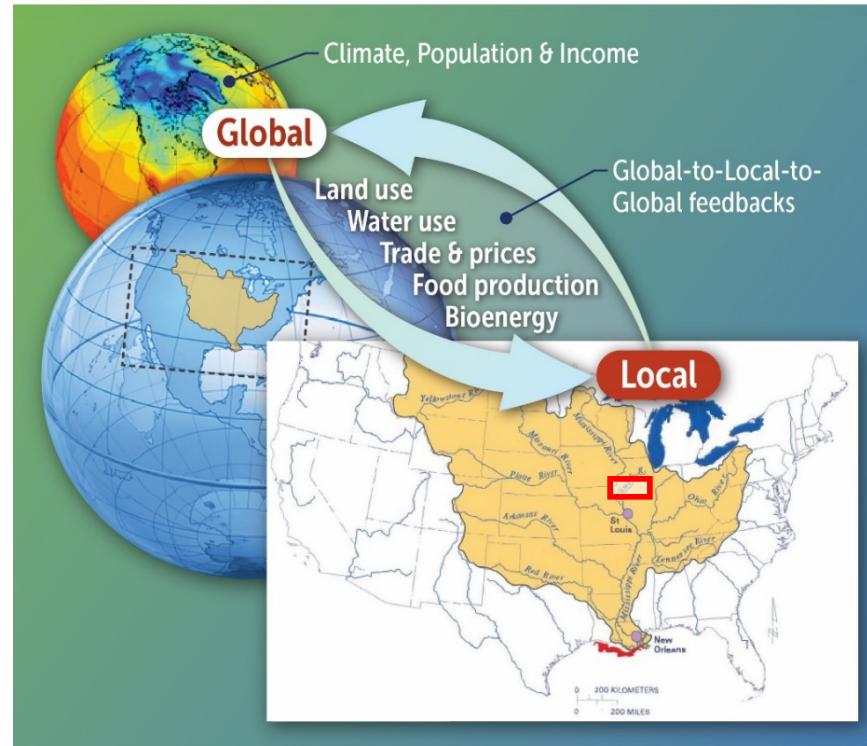
COMMONLY, SUSTAINABILITY RESEARCH IS TOO...

- 1) DISCIPLINARY, LIMITING THE VALIDITY OF FINDINGS
- 2) LOCAL, IGNORING GLOBAL CONTEXT & DYNAMIC FEEDBACKS
- 3) COMPLEX AND/OR PROPRIETARY, LIMITING THE REPLICABILITY AND TRANSPARENCY OF ANALYSES



# APPROACH

## GLASS: GLOBAL-TO-LOCAL ANALYSIS OF SYSTEMS SUSTAINABILITY



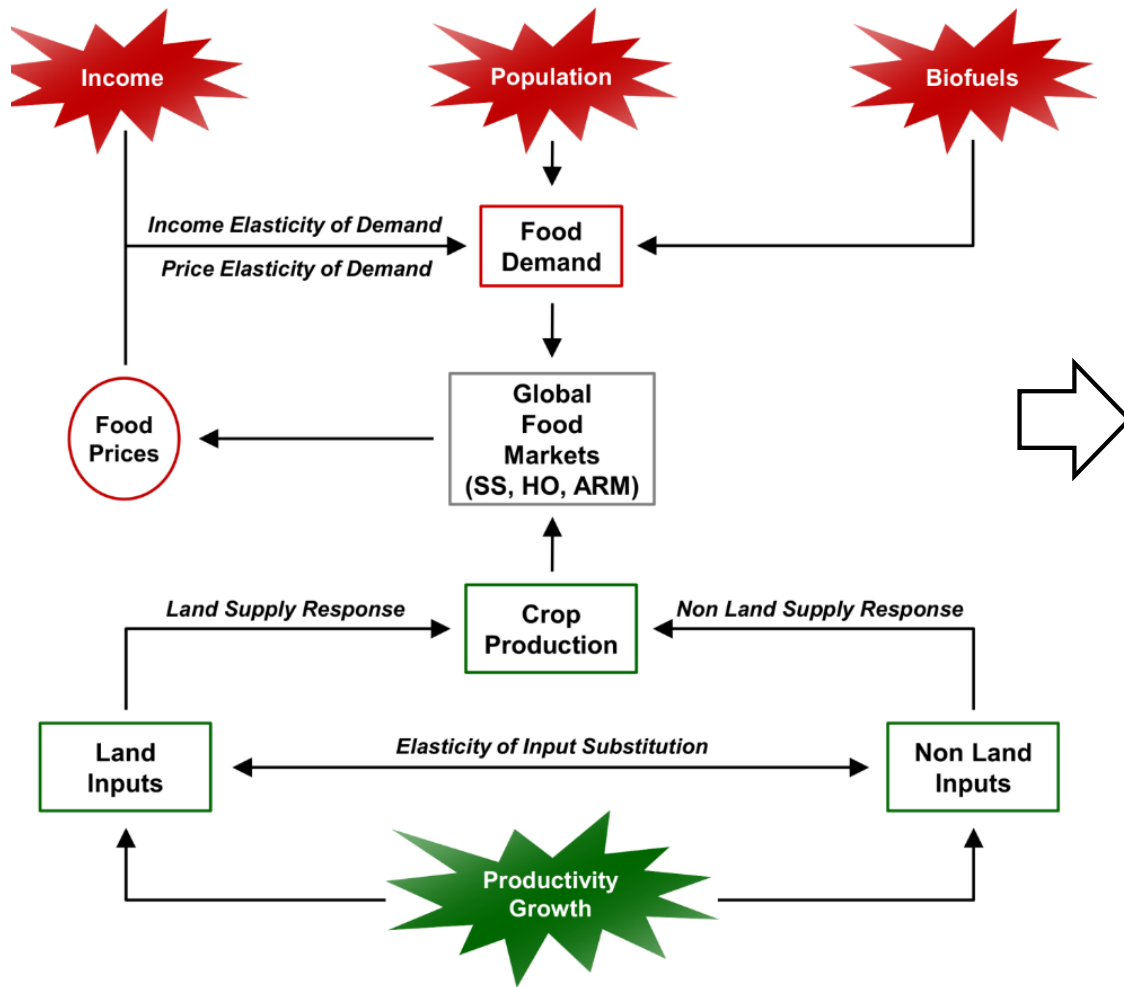
- **SUSTAINABILITY STRESSES ARE OFTEN HIGHLY LOCALIZED**
- **BUT GLOBAL FORCES DRIVE THESE LOCAL STRESSES**
- **LOCAL RESPONSES TO SYSTEM STRESSES CAN HAVE GLOBAL CONSEQUENCES**



# APPROACH

## SIMPLE: A SIMPLIFIED INTERNATIONAL MODEL OF AGRICULTURAL PRICES, LAND USE AND THE ENVIRONMENT

### LONG-RUN DEMAND DRIVERS



### LONG-RUN SUPPLY DRIVERS



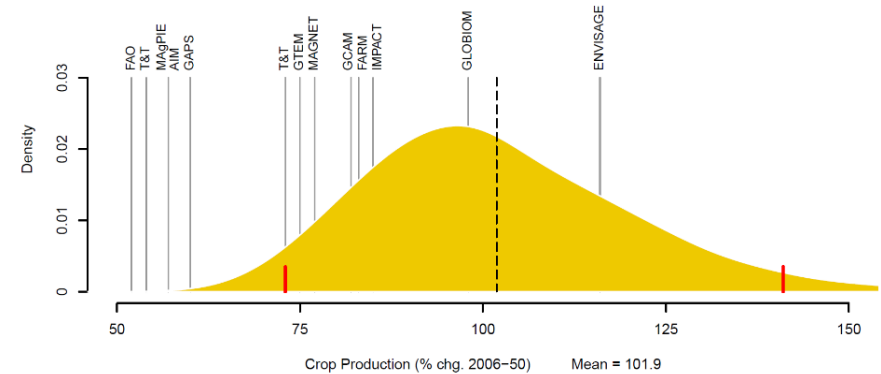
## MODEL OUTCOMES

### FOOD PRICES AND PRODUCTION PROJECTIONS

Predicting Long-Term Food Demand, Cropland Use, and Prices

Annual Review of Resource Economics  
Vol. 8:417-441 (Volume publication date October 2016)  
First published online as a Review in Advance on July 22, 2016  
<https://doi.org/10.1146/annurev-resource-100815-095333>

Thomas W. Hertel, Uris Lantz C. Baldos, and Dominique van der Mensbrugge  
Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana 47907-1145; email: hertel@purdue.edu



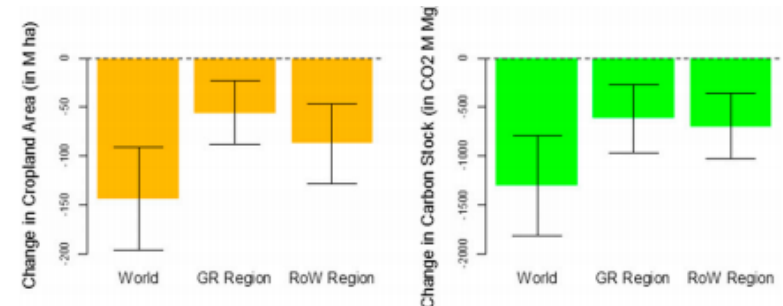
### LAND USE AND GHG EMISSIONS

Global market integration increases likelihood that a future African Green Revolution could increase crop land use and CO<sub>2</sub> emissions

Thomas W. Hertel<sup>1,\*</sup>, Navin Ramankutty<sup>2,\*</sup>, and Uris Lantz C. Baldos<sup>3</sup>

<sup>1</sup>Department of Agricultural Economics, Purdue University, West Lafayette, IN 47907; and <sup>2</sup>Department of Geography, McGill University, Montreal, QC, Canada H3A 0B9

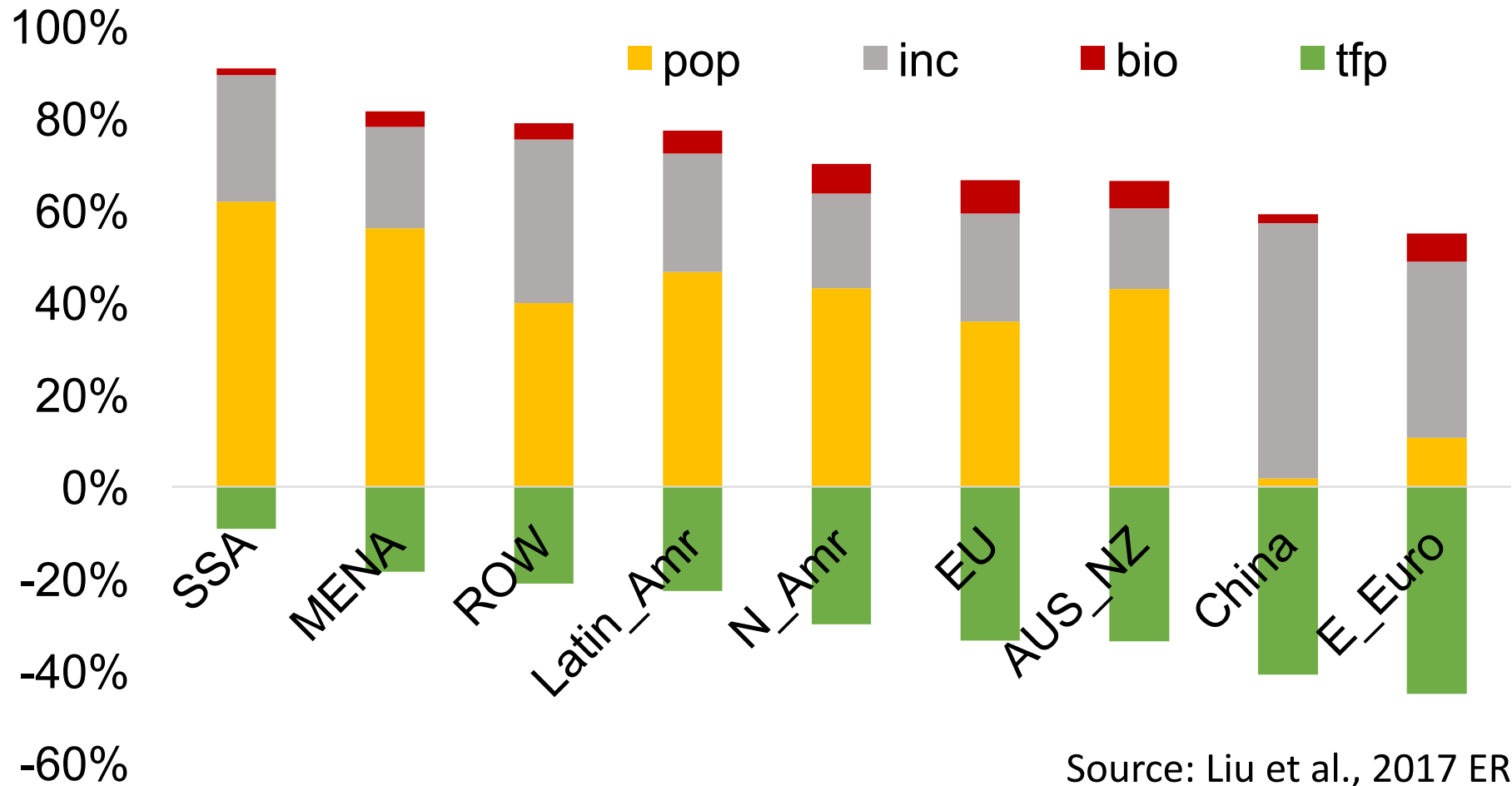
Edited by B. L. Turner, Arizona State University, Tempe, AZ, and approved August 8, 2014 (received for review February 25, 2014)



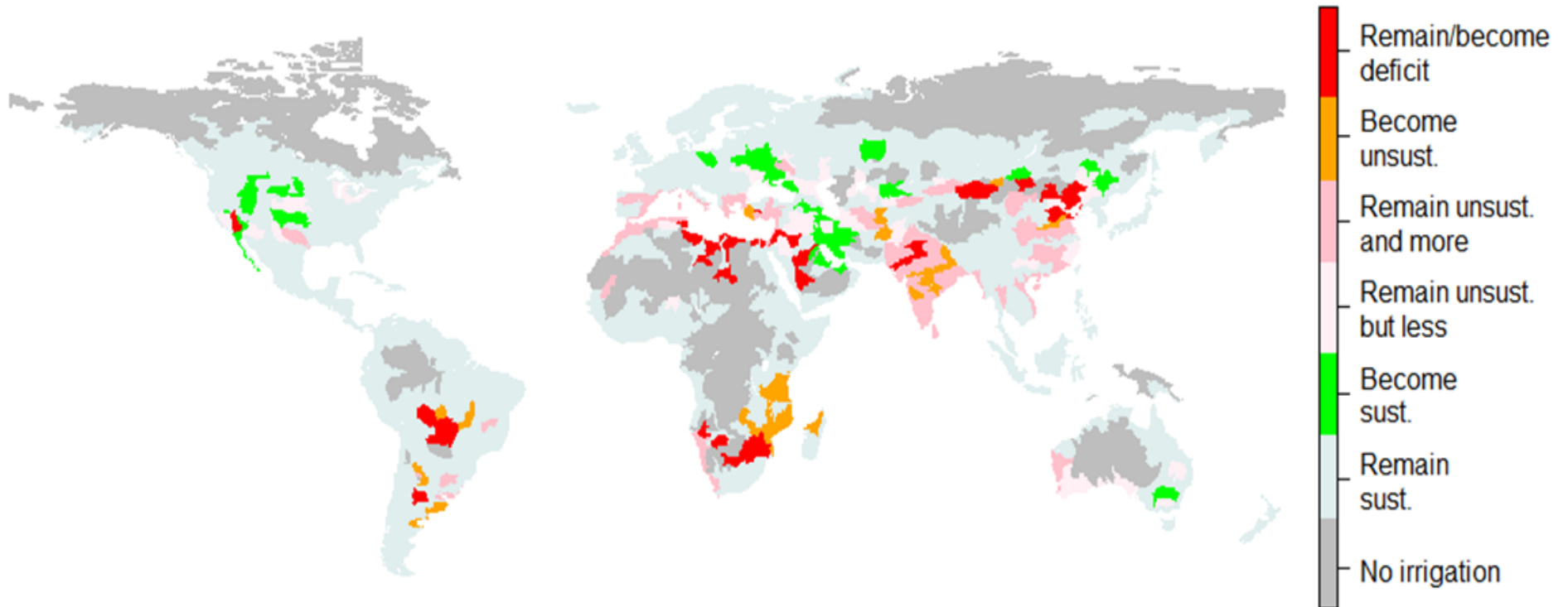
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# DRIVERS OF GLOBAL IRRIGATION DEMAND GROWTH: 2006-2050 using SIMPLE-G



# GLOBAL DRIVERS INCREASE LOCAL STRESSES: UNSUSTAINABLE IRRIGATION



Source: Liu et al., 2017 ERL

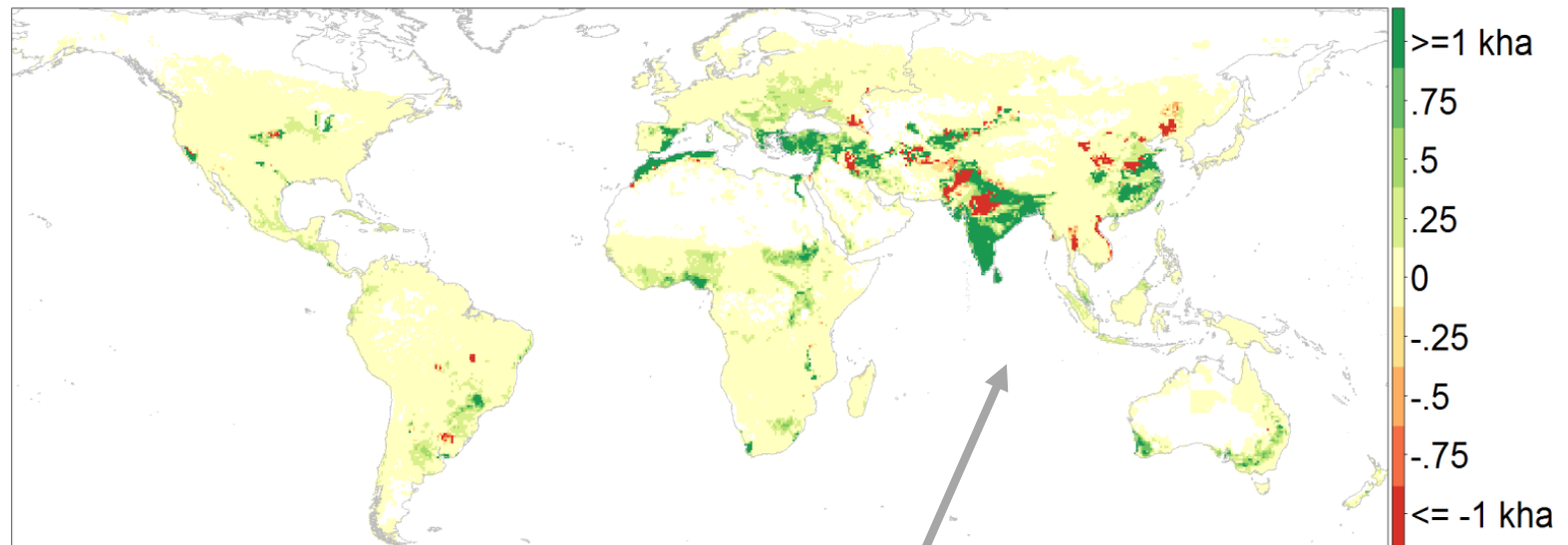


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# RESTRICTING UNSUSTAINABLE IRRIGATION AT SUBBASINS HAVE BROAD IMPACT ON GLOBAL MALNUTRITION AND LAND USE



Globally,

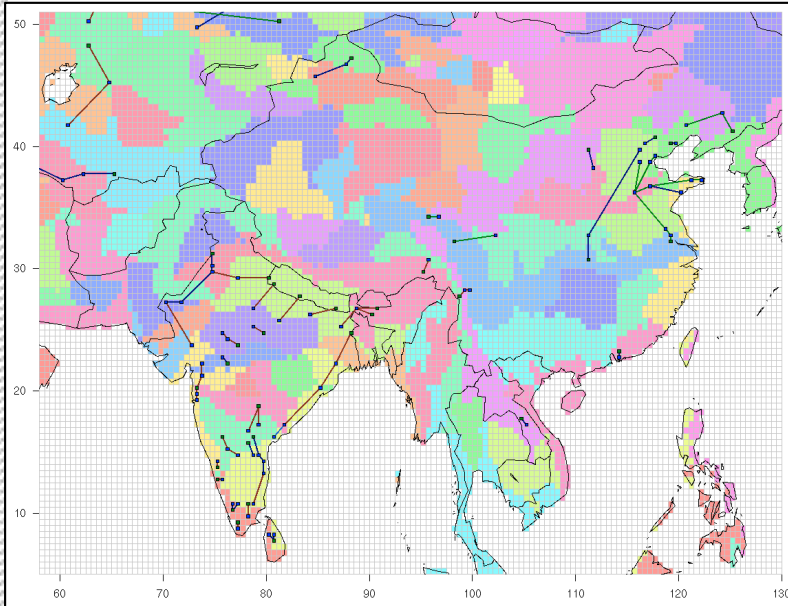
- Crop output **-16 MMT**
- Undernourished pop. **+800k**
- Cropland area **+12 Mha**
- CO<sub>2</sub> emissions **+0.87GtC**

Source: Liu et al., 2017 ERL

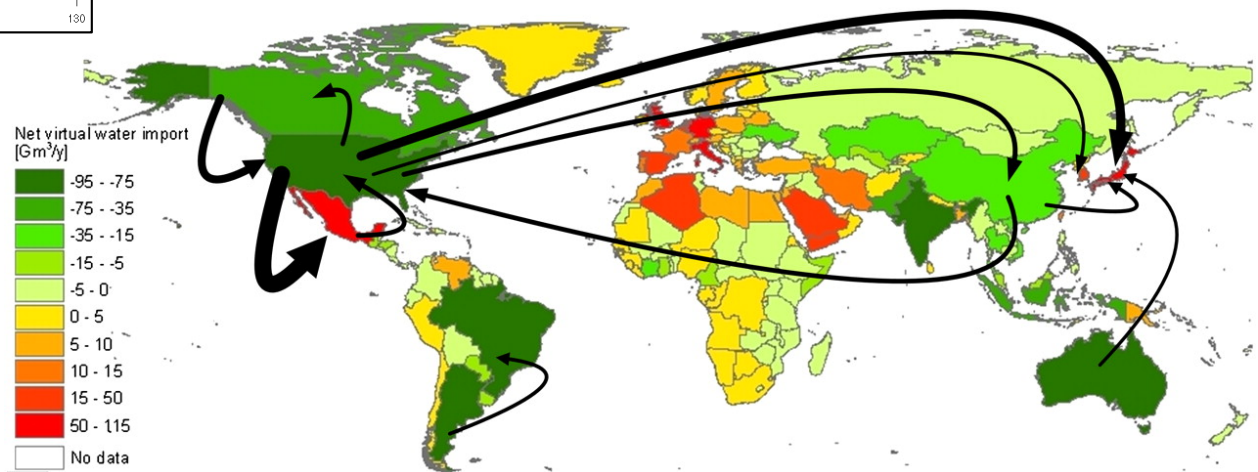


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# LOCAL WATER STRESSES CAN BE ALLEVIATED BY MOVING PHYSICAL OR VIRTUAL WATER



Inter-basin water transfers,  
(Water Balance Model, UNH)



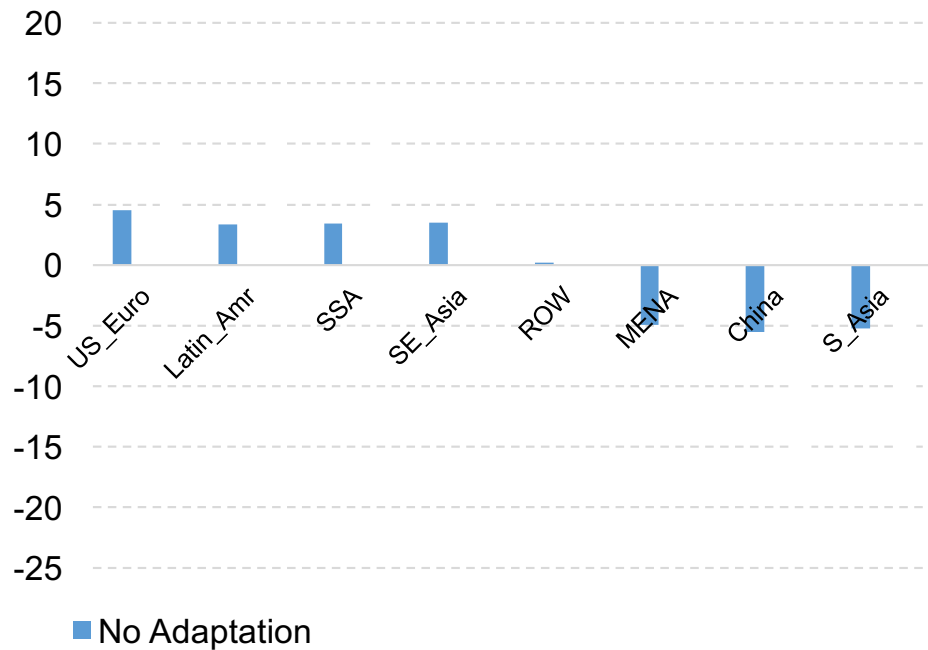
Virtual water balance 1996-2005 (Hoekstra and Mekonnen, 2011)



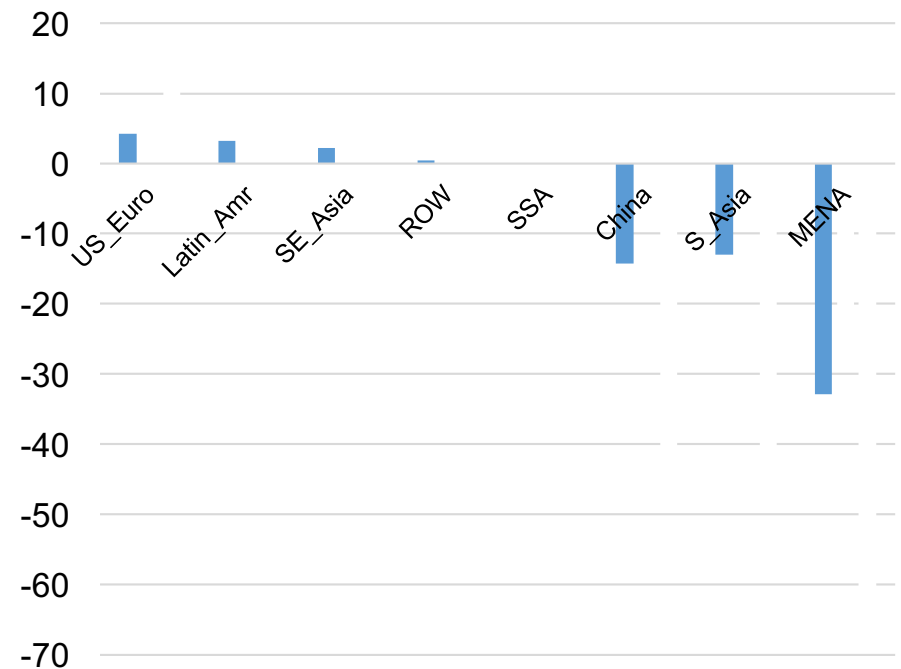
# IMPACT OF ELIMINATING UNSUSTAINABLE IRRIGATION IN 2050



Net export of crops, million tons



Net export of virtual water, million m3



Source: Liu et al., 2017 ERL

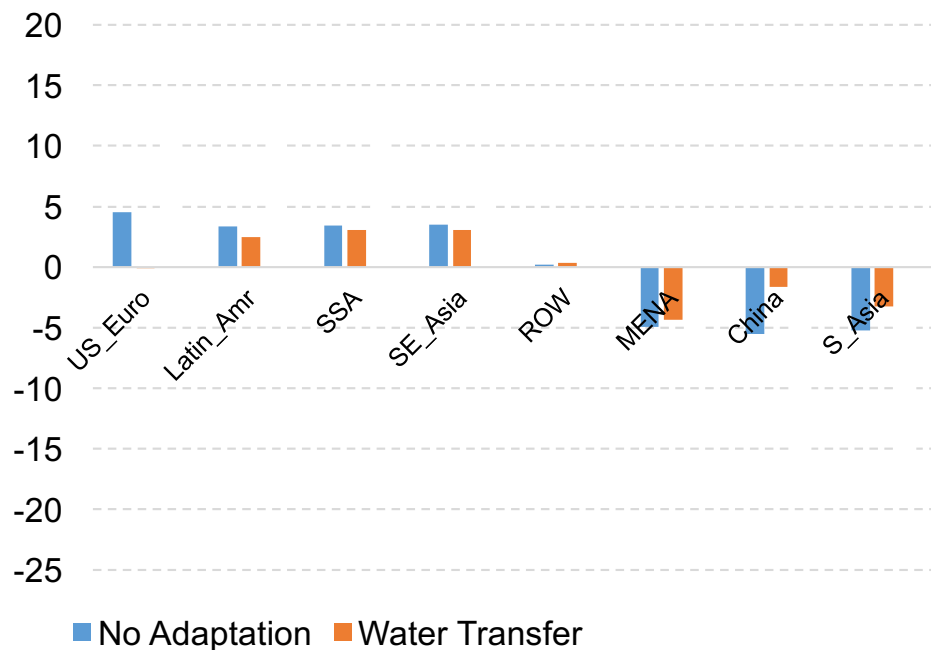


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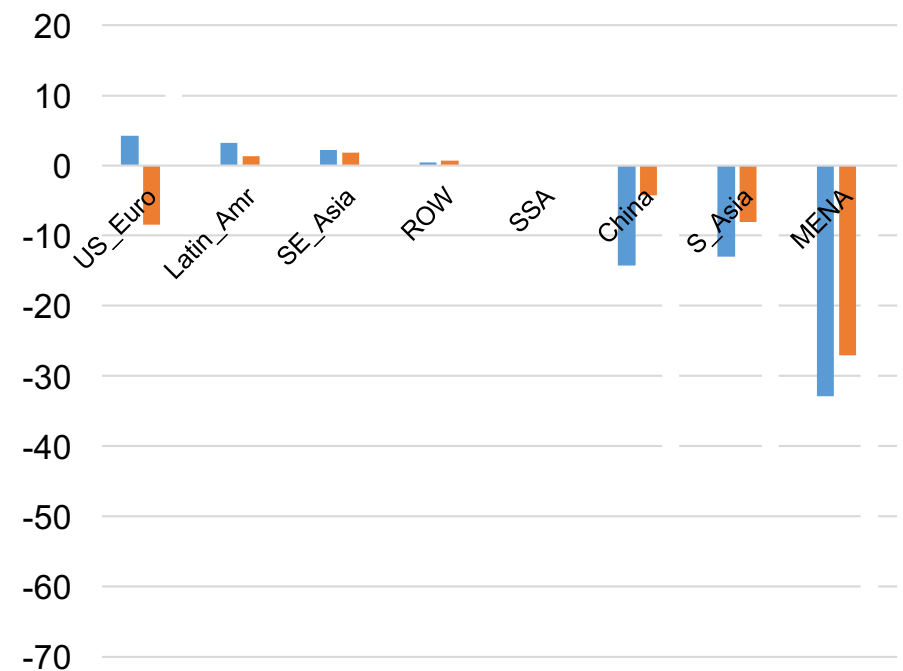
# IMPACT OF ELIMINATING UNSUSTAINABLE IRRIGATION IN 2050 IN THE PRESENCE OF IBTs



Net export of crops, million tons



Net export of virtual water, million m3



Source: Liu et al., 2017 ERL

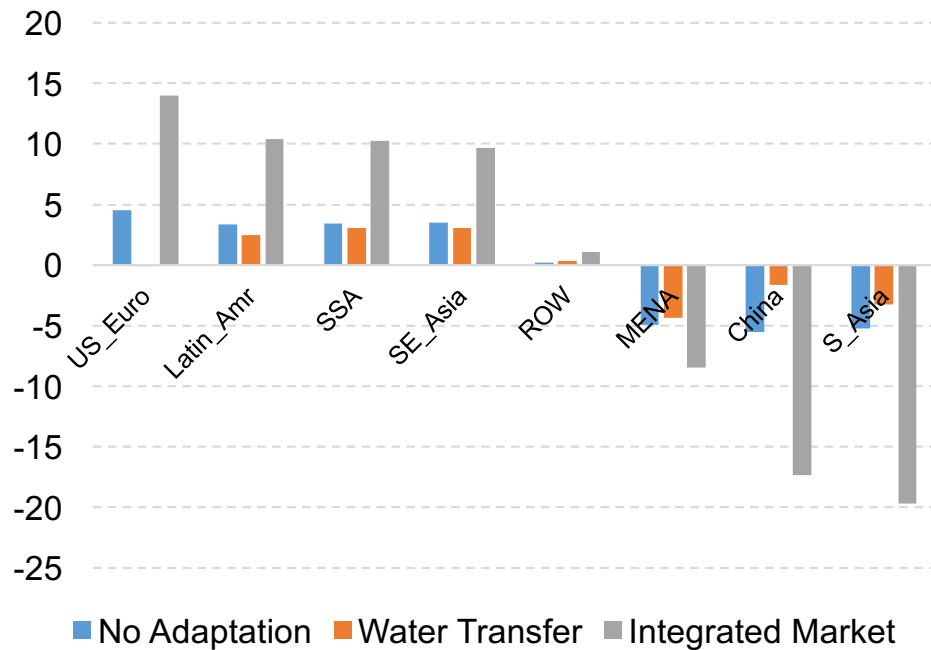


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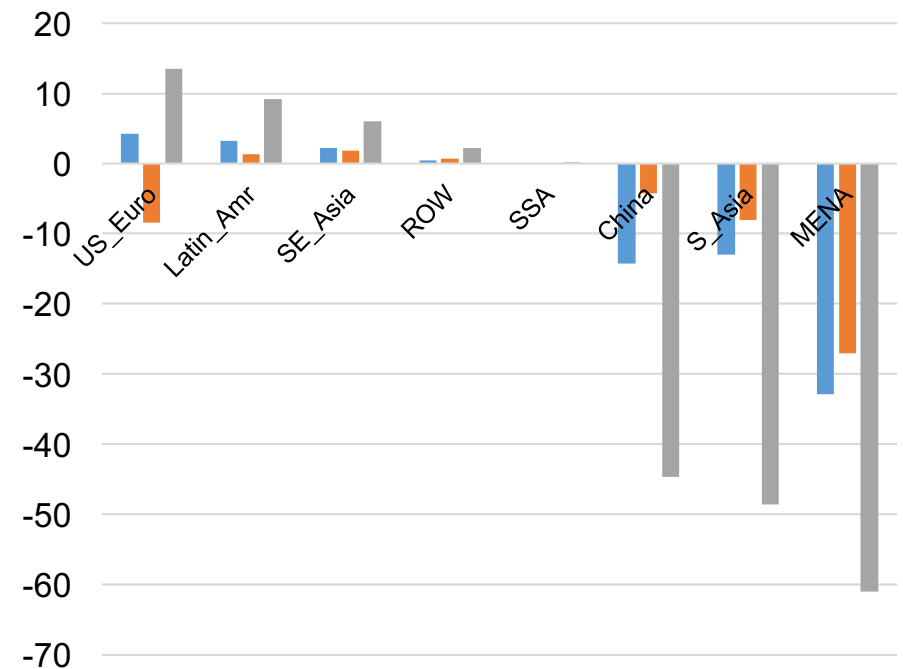
# IMPACT OF ELIMINATING UNSUSTAINABLE IRRIGATION IN 2050 IN THE PRESENCE OF ENHANCED COMMODITY TRADE



Net export of crops, million tons



Net export of virtual water, million m3



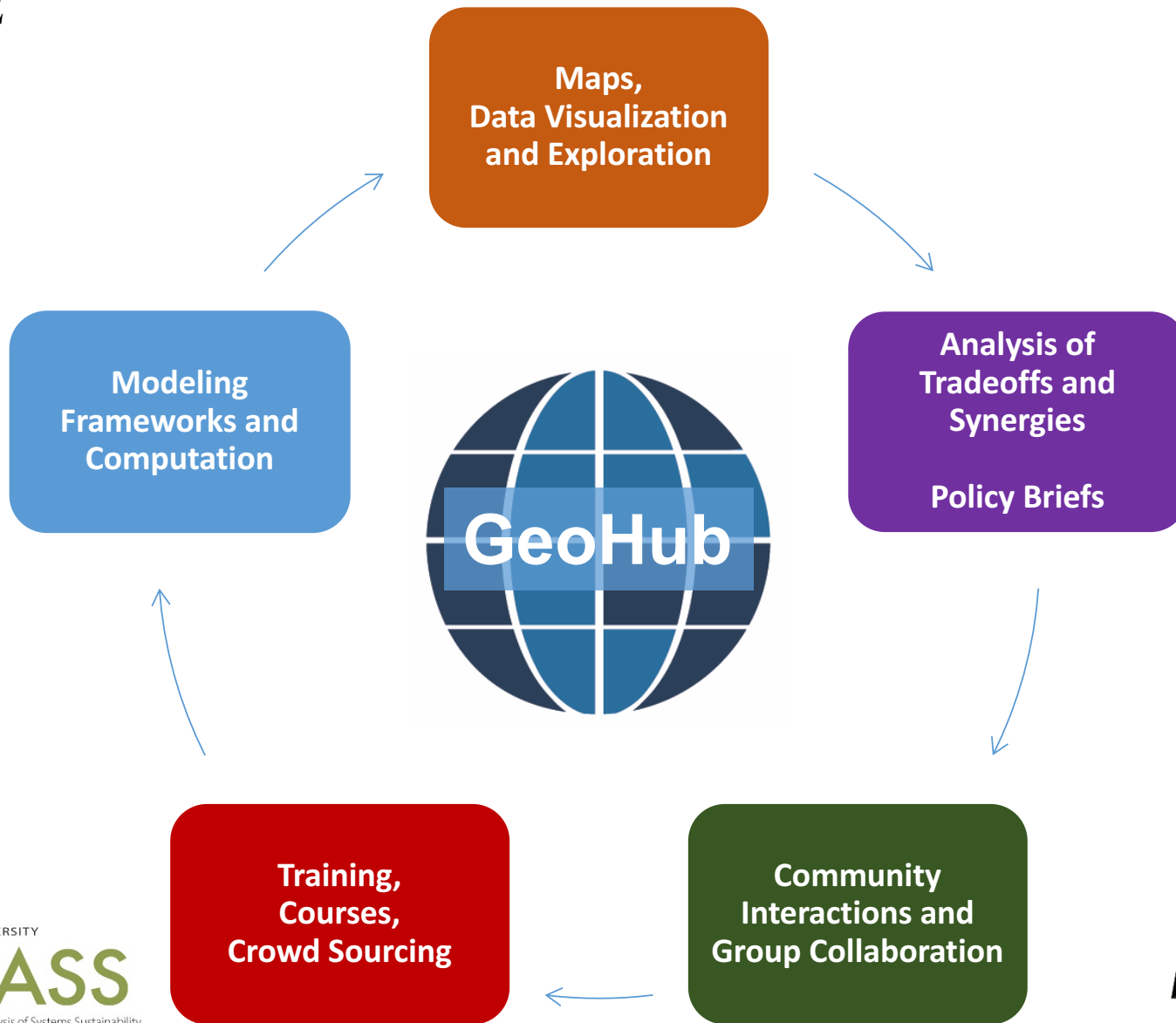
Source: Liu et al., 2017 ERL



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# APPROACH

CREATE THE INFRASTRUCTURE AND OPEN-SOURCE TOOLS NECESSARY TO DEVELOP A SELF-SUSTAINING COMMUNITY OF PRACTICE



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# BENEFITS

## AN APPLIED RESEARCH CONSORTIUM FOCUSED ON THE SUSTAINABLE DEVELOPMENT GOALS WILL BENEFIT A WIDE ARRAY OF STAKEHOLDERS



**INVESTORS SEEKING TO UNDERSTAND FUTURE INFRASTRUCTURE NEEDS**



**LOCAL COMMUNITIES DEVELOPING CLIMATE ADAPTATION PROJECTS AND ASSESSING RISK MANAGEMENT OPTIONS**



**NATIONAL POLICY MAKERS EVALUATING THE CONSEQUENCES OF LOCAL ACTIONS, INCLUDING TRADE-OFFS (E.G., USDA, DOE, EPA, FAO) AND ADAPTATION OPTIONS (E.G., TRADE, TECHNOLOGY INVESTMENTS, WATER GOVERNANCE)**



**SCIENTIFIC COMMUNITY OF PRACTICE COMPILING A SHARED REPOSITORY OF BOUNDARY CONDITIONS, DATA AND SCENARIOS TO MEDIATE BETWEEN GLOBAL AND LOCAL STUDIES**



# THE PURDUE TEAM IS A MICROCOSM OF THE LARGER COMMUNITY



**HYDROLOGY**



Laura Bowling

**CLIMATE SCIENCE**



Matt Huber

**CLIMATE IMPACTS ON  
CROPS**



Keith Cherkauer

**GLOBAL TRADE &  
SUSTAINABILITY**



Tom Hertel

**POLICY DESIGN,  
IMPLEMENTATION**



David Johnson

**CLIMATE MITIGATION**



Dominique van der  
Mensbrughe

**ECONOMIC MODELING**



Uris Baldos

**COMMUNITY  
INFRASTRUCTURE  
ENVIRONMENTAL**



Carol Song

**ECONOMICS**



Jing Liu



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