



# Virtual Water Values (ViWA)

Multiscale Monitoring of Global Water Resources and Options for their Efficient and Sustainable Use

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# The water cycle

*Water moves from upstream to downstream and is stored across the land surface at varying rates.*



## *Economic relevance*

*Agriculture: Largest water user for crop production.  
Blue water (irrigation); Green water (rainfed agriculture).*

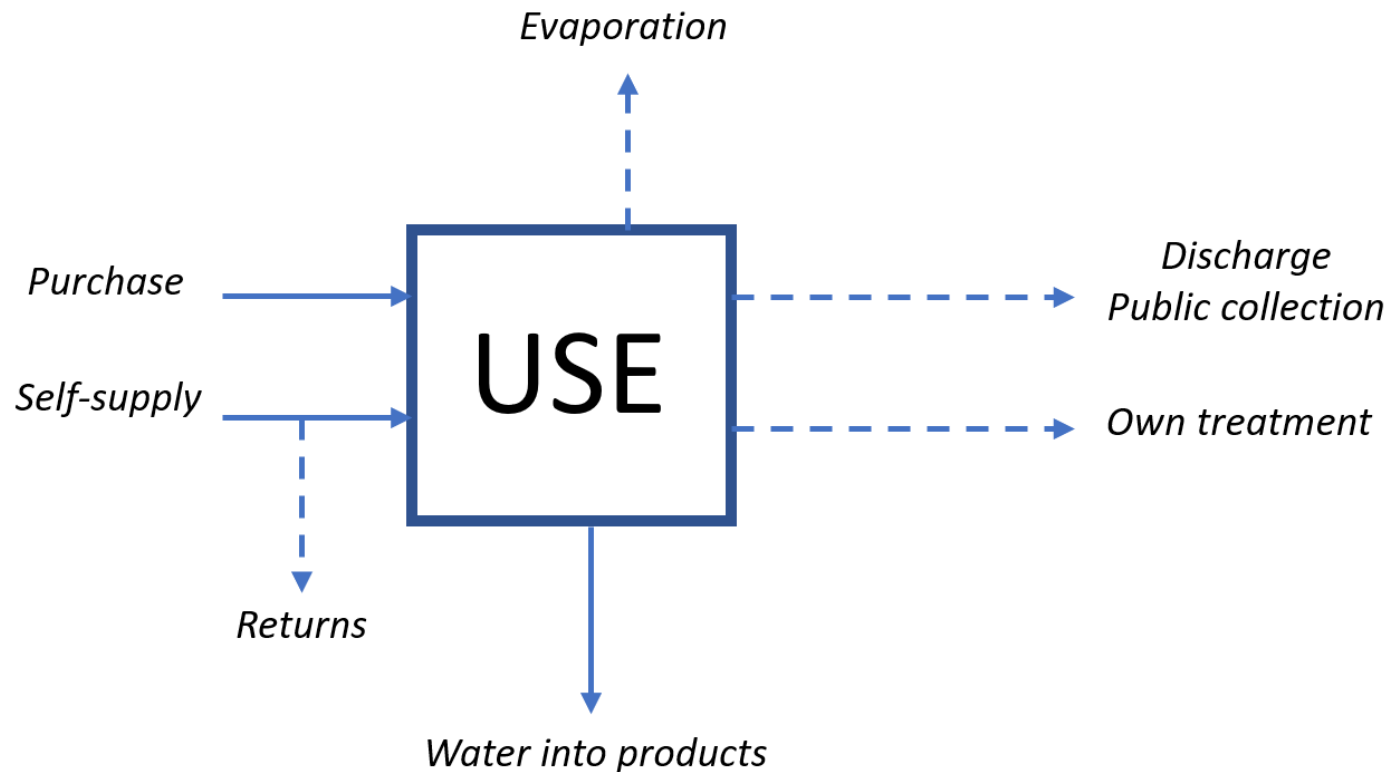
*Ecosystems: Rainfall for natural growth, ecosystem services, sustain water levels of rivers and lakes.*

*Industry: Energy production, cooling, water from rivers to support industrial production.*

Reference figure: <https://thechartroom.co/2019/05/20/are-we-travelling-upstream-or-downstream/>



# Water flows in Industries



## Definitions

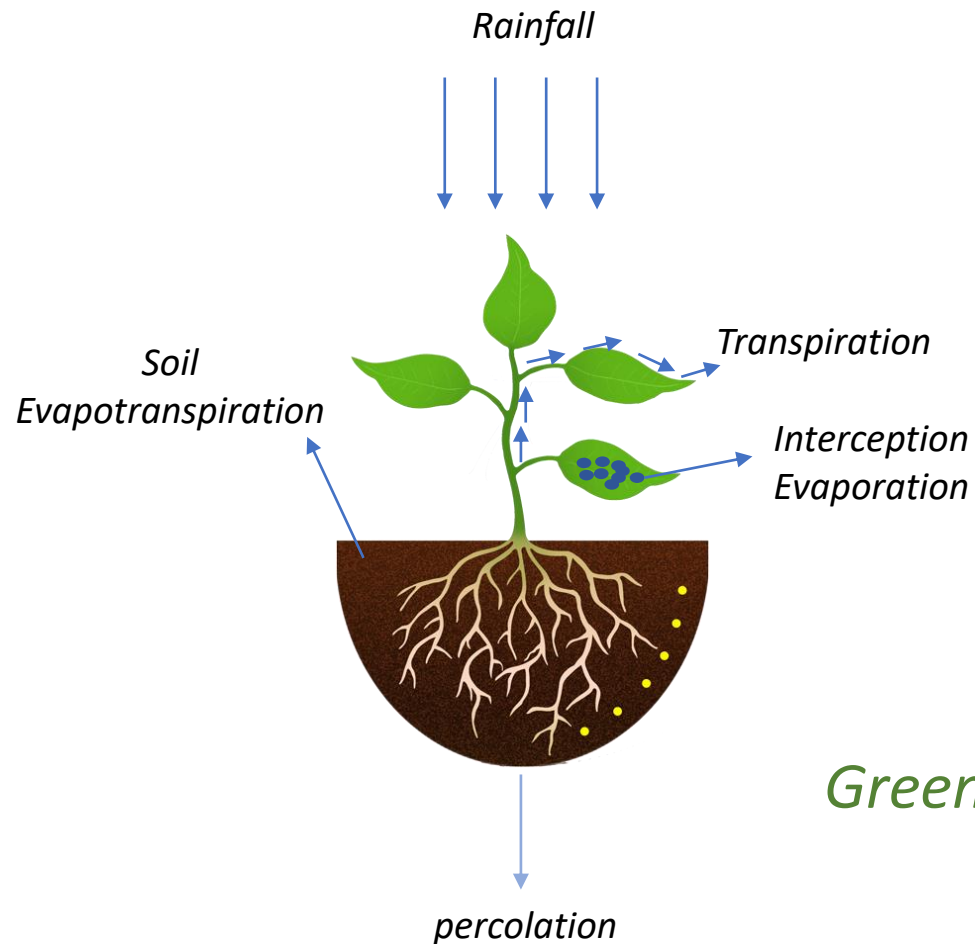
*Withdrawal: Water abstraction from nature + external procurement of water.*

*Use: Water withdrawal – unused returned water.*

*Consumption: Water use – discharges – evaporation.*

# Water in Agriculture

## *Evapotranspiration of natural land cover*



**Evaporation:** Physical water phase-change from solid or liquid to gas.

**Transpiration:** Physical water phase-change from liquid to water vapor.

*In living plant cells*

**Green water:** Rainfall water subjected to evapotranspiration.



# Green and Blue water

## *Why differentiate between blue and green water?*

- Evaporation of green water is key to agricultural production worldwide
- Blue water is the the main consumptive water use in industries.
- Irrigation (blue water) is to support food production in areas where green water is scarce.

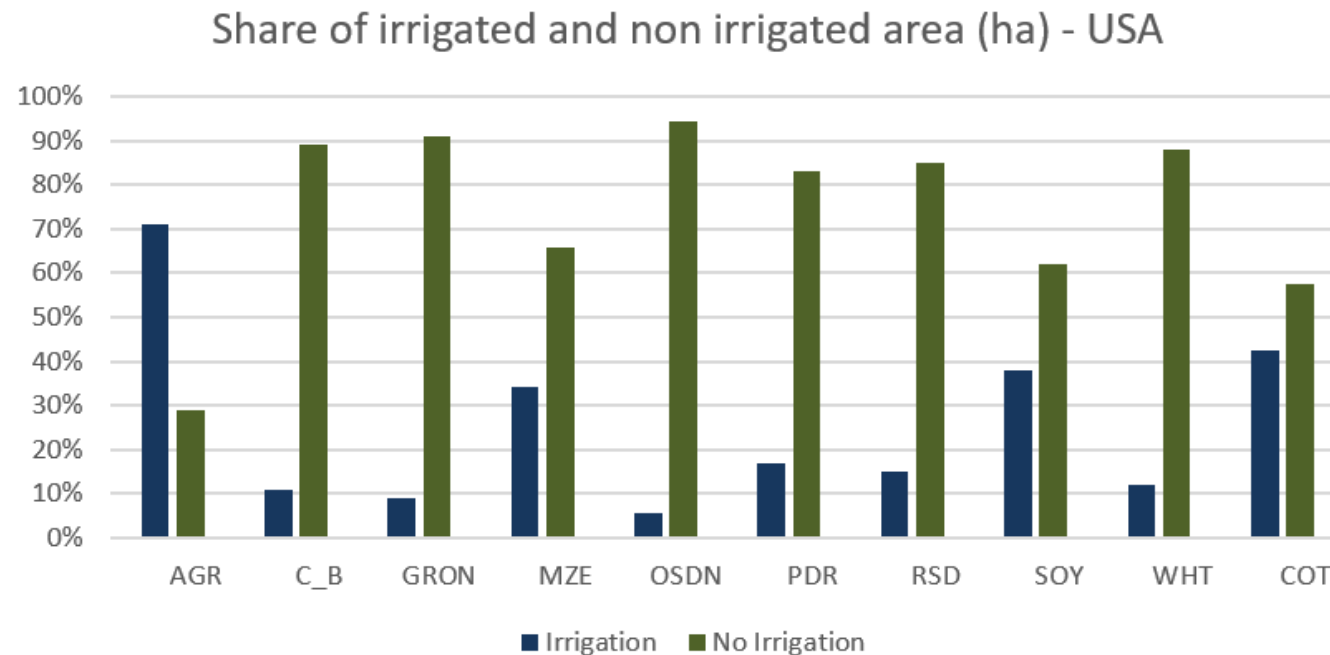
## *Competition between blue and green water*

- Evapotranspiration of blue water in irrigation may compete with industrial evaporation.
- Evapotranspiration of green water in agriculture may reduce levels of blue water in rivers and ground water.
- Evapotranspiration of green water may compete with downstream evapotranspiration of blue water in irrigation due to river flow reduction

# The Applied Regional Trade (ART)- Water

## Agriculture

- Explicitly model irrigated and non-irrigated agriculture  
Model green water → Link PROMET – LMU





# The Applied Regional Trade (ART)- Water

## Model Features

- Static multiregional Computable General Equilibrium (CGE) model  
*Comparison of the economy equilibrium before and after a shock*
- Data Global Trade Analysis Project (GTAP)  
*Version: GTAP 9; Extension: GTAP Power*
- Water is explicitly modelled as an input factor
- Irrigated and non-irrigated agriculture is distinguished  
*Green and Blue water in agriculture*
- Disaggregated electricity sector
- Model captures land heterogeneity  
*Land in 18 Agro-ecological Zones (AEZ)*



# The Applied Regional Trade (ART)- Water

## Model Features

- Reference year 2011
- Global coverage  
*22 regions*

**Table 1 List of regions in the static water CGE model (ART-Water)**

Europe		Middle East and Northern Africa	
GEU	Germany, Austria	MEA	Middle East, Northern Africa, Turkey
NWE	Denmark, Finland, Sweden, Ireland, United Kingdom, Rest of North Europe	AFR	Sub-Saharan Africa
WEU	Belgium, Netherlands, Luxemburg, France	MAI	Indonesia, Brunei, Darussalam, Malaysia, Rest of Southeast Asia (Myanmar, Timor)
MED	Spain, Portugal, Italy, Malta, Cyprus, Greece	Africa	
RNE	Norway, Switzerland, Rest of EFTA (Iceland, Liechtenstein)	SAF	South Africa, Namibia, Botswana
REU	Czech Republik, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria Croatia, Romania	Asia	
FSU	Rest of Former Soviet Union and Rest of Europe	CHN	China, Hong kong
North America		IND	India
USA	United States of America	EAS	Japan, South Korea, Singapore, Taiwan
CAN	Canada	RUS	Russian Federation
Central and South America		ROA	Pacific Asia
BRA	Brazil	Oceania	
PAC	Argentina, Chile, Paraguay, Uruguay	ANZ	Australia, New Zealand
LAM	Latin America		

# The Applied Regional Trade (ART)- Water

## Model Features

- 21 Agricultural Sectors
- 5 Meat and dairy Sectors
- 4 Industrial Sectors
- 2 Public Sectors
- 13 Energy Sectors

**Table 2 List of sectors in the static water CGE model (ART-Water)**

<i>Agricultural Sectors</i>		<i>Industrial Sectors</i>	
PDRir	Paddy rice irrigated	TEX	Textiles
PDRni	Paddy rice non-irrigated	PPP	Paper products publishing
WHTir	Wheat irrigated	CRP	Chemicals (include fertilizer)
WHTni	Wheat non-irrigated	OMF	Mineral products nec
MZEir	Maize irrigated	<i>Public Sectors</i>	
MZENi	Maize non-irrigated	PUB	Public services
GRONir	Rest of Cereals irrigated	WTR	Water
GRONni	Rest of Cereals non-irrigated	<i>Energy Sectors</i>	
PLMir	Palm oil irrigated	MIN	Mining
PLMni	Palm oil non-irrigated	CRU	Crude Oil
RSDir	Rapeseed irrigated	GAS	Natural gas
RSDni	Rapeseed non-irrigated	OIL	Refined petroleum and coal products
SOYir	Soybean irrigated	EGas	Gas based electricity
SOYni	Soybean non-irrigated	ECoal	Coal based electricity
OSDNir	Rest of oil seeds irrigated	EHydro	Hydro based electricity
OSDNni	Rest of oil seeds non-irrigated	ENuclear	Nuclear based electricity
C_Bir	Sugar cane sugar beet irrigated	Eoil	Oil based electricity
C_Bni	Sugar cane sugar beet non-irrigated	EOther	Other based electricity
COTir	Cotton irrigated	ESolar	Solar based electricity
COTni	Cotton non-irrigated	EWind	Wind based electricity
AGR	Other crops	TnD	Electricity transmission and distribution
<i>Meat and dairy Sectors</i>			
OLVS	Bovine byproducts		
ILVS	Indoor lvs		
FRS	Forestry		
FOD	Food products		
PCM	Meat cattle sheep goats horse		

# The Applied Regional Trade (ART)- Water

## Industry

- Water data sources:  
EUROSTAT and National Statistics
- Sectoral data assumption due to data issues.

Table 3: Sectoral mapping the ART-Water industrial sectors and Eurostat database.

ART-Water Industrial Sectors		Eurostat-Database
TEX	<i>Textiles</i>	Manufacturing
PPP	<i>Paper products publishing</i>	Manufacturing
CRP	<i>Chemical rubber plastic prods</i>	Manufacturing
OMF	<i>Mineral products nec</i>	Manufacturing
MIN	<i>Mining</i>	Electricity
CRU	<i>Crude Oil</i>	Electricity
GAS	<i>Natural Gas</i>	Services
OIL	<i>Refined petroleum and coal products</i>	Services
EGas	<i>Gas based electricity</i>	Services
ECoal	<i>Coal based electricity</i>	Electricity
EHydro	<i>Hydro based electricity</i>	Electricity
ENuclear	<i>Nuclear based electricity</i>	Electricity
EOil	<i>Oil based electricity</i>	Electricity
EOther	<i>Other based electricity</i>	Electricity
ESolar	<i>Solar based electricity</i>	Electricity
EWind	<i>Wind based electricity</i>	Electricity
TnD	<i>Electricity transmission and distribution</i>	Services

# The Applied Regional Trade (ART)- Water

## Industry

- Regional data assumption due to data issues

**Table 4 Regional assumption reference countries**

ART-Water	Reference	ART-Water	Reference
<i>Europe</i>		<i>Middle East and Northern Africa</i>	
GEU	Germany	MEA	Turkey
NWE	Denmark	AFR	Default
WEU	Belgium	MAI	Default
MED	Spain	<i>Africa</i>	
RNE	Switzerland	SAF	Default
REU	Czech Republic	<i>Asia</i>	
FSU	Lithuania	CHN	Default
<i>North America</i>		IND	Default
USA	Default	EAS	Default
CAN	Canada	RUS	Default
<i>Central and South America</i>		ROA	Default
BRA	Default	<i>Oceania</i>	
PAC	Default	ANZ	Australia
LAM	Default		

*Default: 0.7 manufacture; 0.3 services; 0.9 electricity.*

*Overall approximated average of the data available*

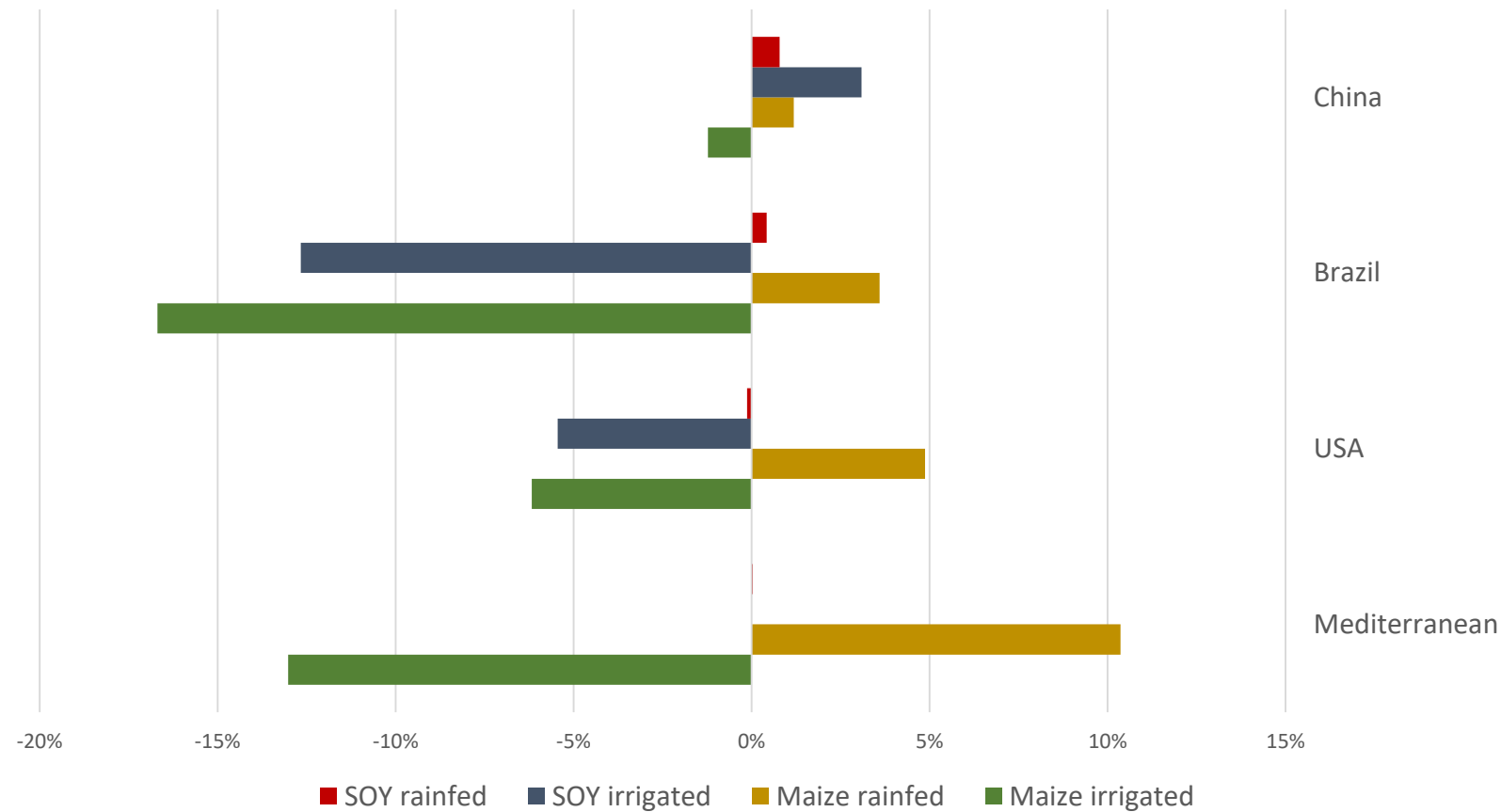


# The Applied Regional Trade (ART)- Water

***Model simulation example***

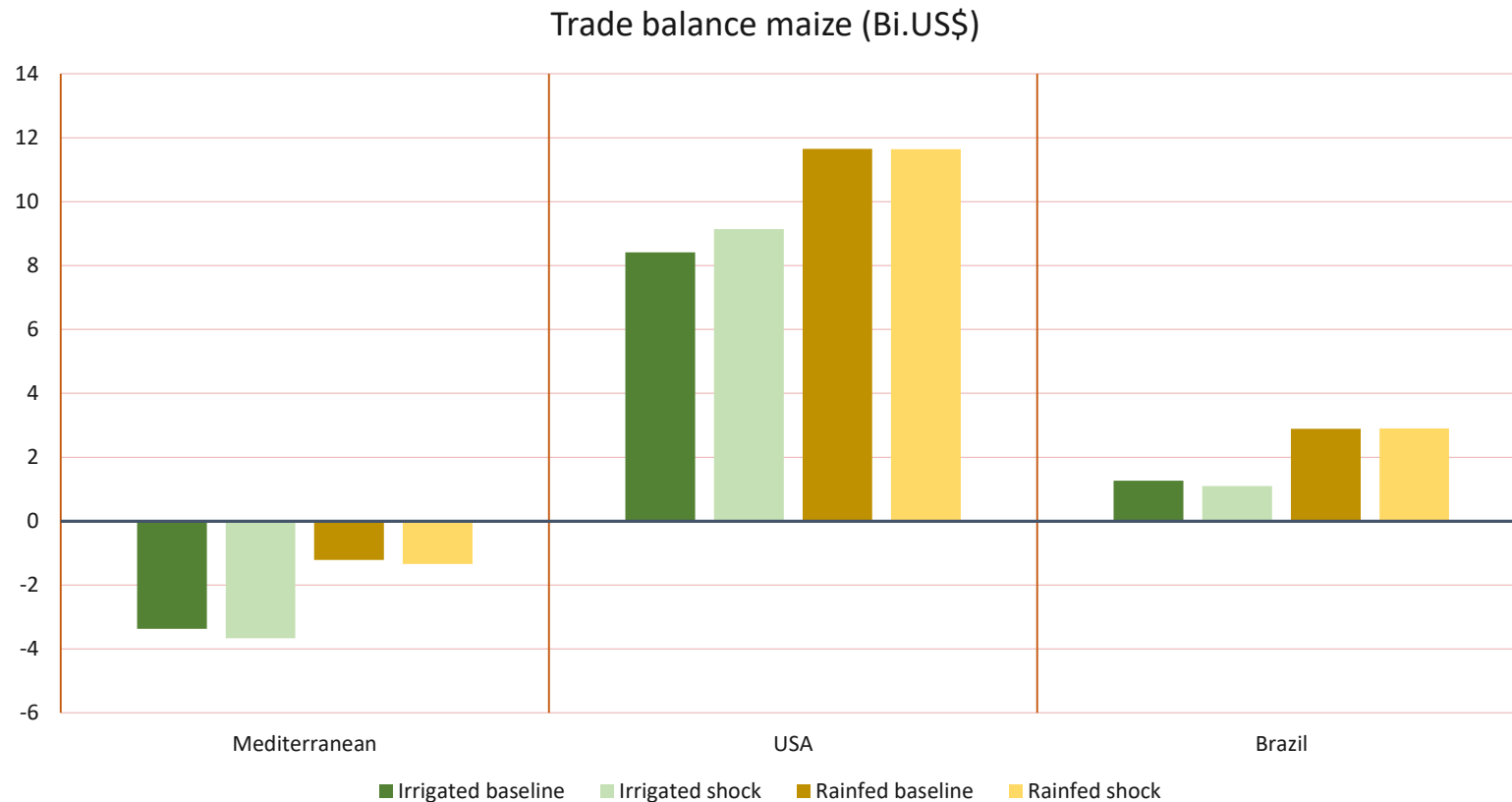
*Irrigation water pricing*

Supply of agricultural products



# The Applied Regional Trade (ART)- Water

*Model simulation example      Irrigation water pricing*





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