Macroeconomic tools and ecosystem accounts

A case on Sustainable Management of Water Resources in Turkey

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14 February 2020 / Geneva Switzerland

A Conceptual Framework for Integrated GIS-based Ecohydrology Modeling and Computable General Equilibrium Modeling for Buyuk Menderes Basin with the support of the System of Environmental Economic Accounting

A Conceptual Framework → How
for Integrated → How
GIS-based → How
Ecohydrology Modeling and → What
Computable General → What
Equilibrium Modeling
for Buyuk Menderes Basin → Where
with the support of
the System of Environmental → What
Economic Accounting

Outline

- Why this research? The problem and the motivation
- What? The objective of the research
- How? The methodology of the research
- Where? The research area
- The preliminary findings

Why this research? (1)

- **Water** is an important **natural capital** (for the **economy** of Aydin, Denizli and Mugla region).
- **Ecosystems**, through its ecological and evolutionary processes, and the species that make them up **sustain and fulfill human life**
- Different terrestrial ecosystems **have effect** on water **quality, quantity**, and the **timing** and **rate** of flow

Problem

- Land-use change, agricultural expansion, more resource-intensive consumption and production, and human based pollution have had the largest negative impact on terrestrial and freshwater ecosystems
- The drivers of pollution and the degradation of ecosystems are mainly economic activities
- Degradation and pollution reduce ecosystems' capacity to provide ecosystem services

Why this research? (2)

- There is a growing body of literature suggesting that **decoupling of economic growth** from **natural resource use and environmental impacts** is a requirement of sustainable development.
- Conventional non-integrated methodologies are not sufficient to demonstrate the interdependencies among economy and environment.

- It is widely recognized that environmental externalities are not considered in economic decisions
- This is partly due to a lack of knowledge of the costs of mismanagement of natural resources.

The Objective

- The overall expected impact is that the decision makers at all levels of governance consider ecosystems in their decisions, and scientific information provide guiding evidence in their decisions.

- The major objective of this research is to **develop an integrated economic and environmental model which combines a spatial model of hydrological ecosystem services and a computable general equilibrium model** to better inform policy and decision-making.

- Provide the information within a scientifically accepted framework.

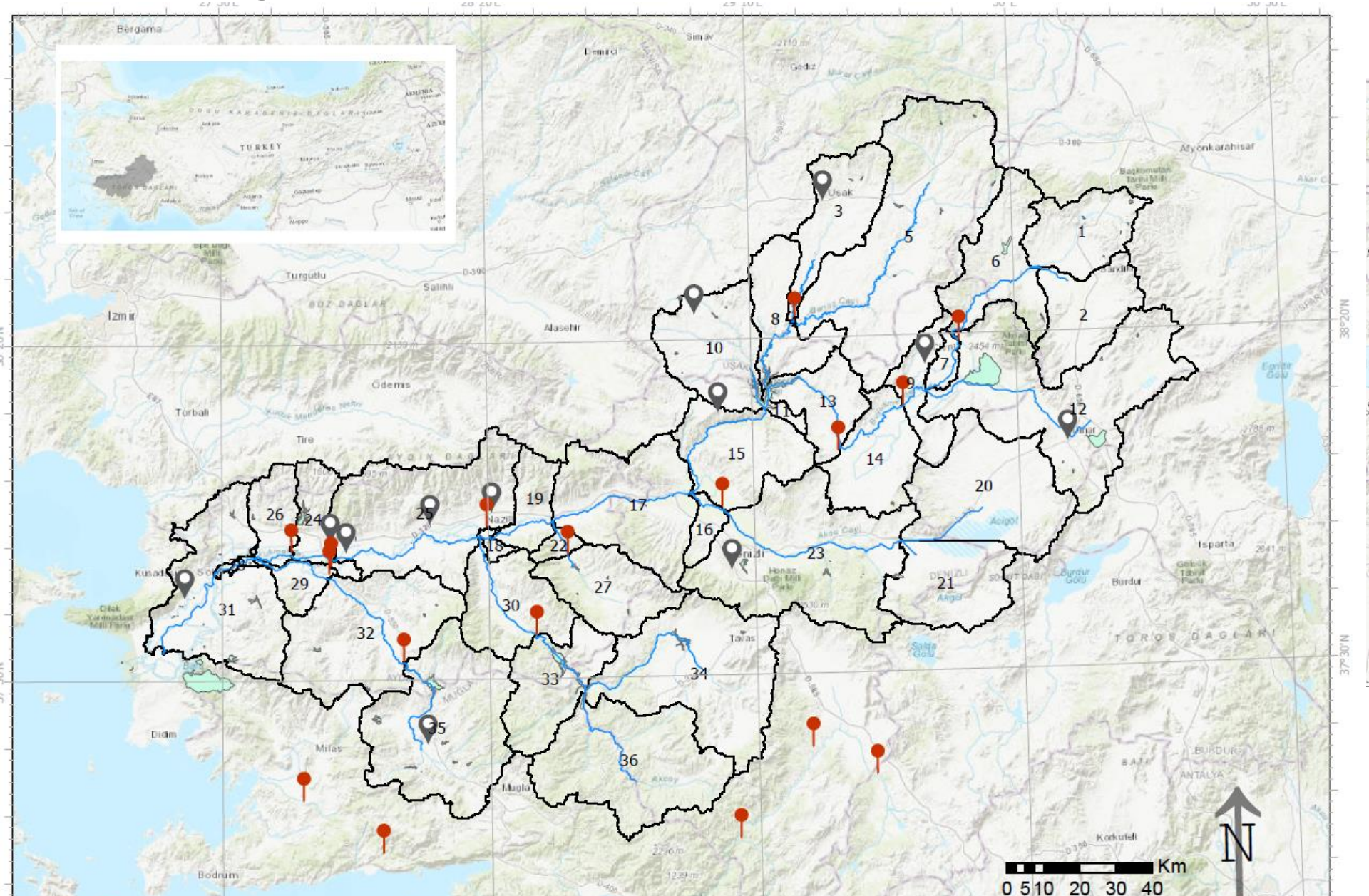
- Measure contribution of water (and relevant ecosystems) to regional GDP

and

- Illustrate how natural asset wealth measures can be used in policy analysis to maximizing the potential identify win-win opportunities for the nature and economy

Where?

Study Site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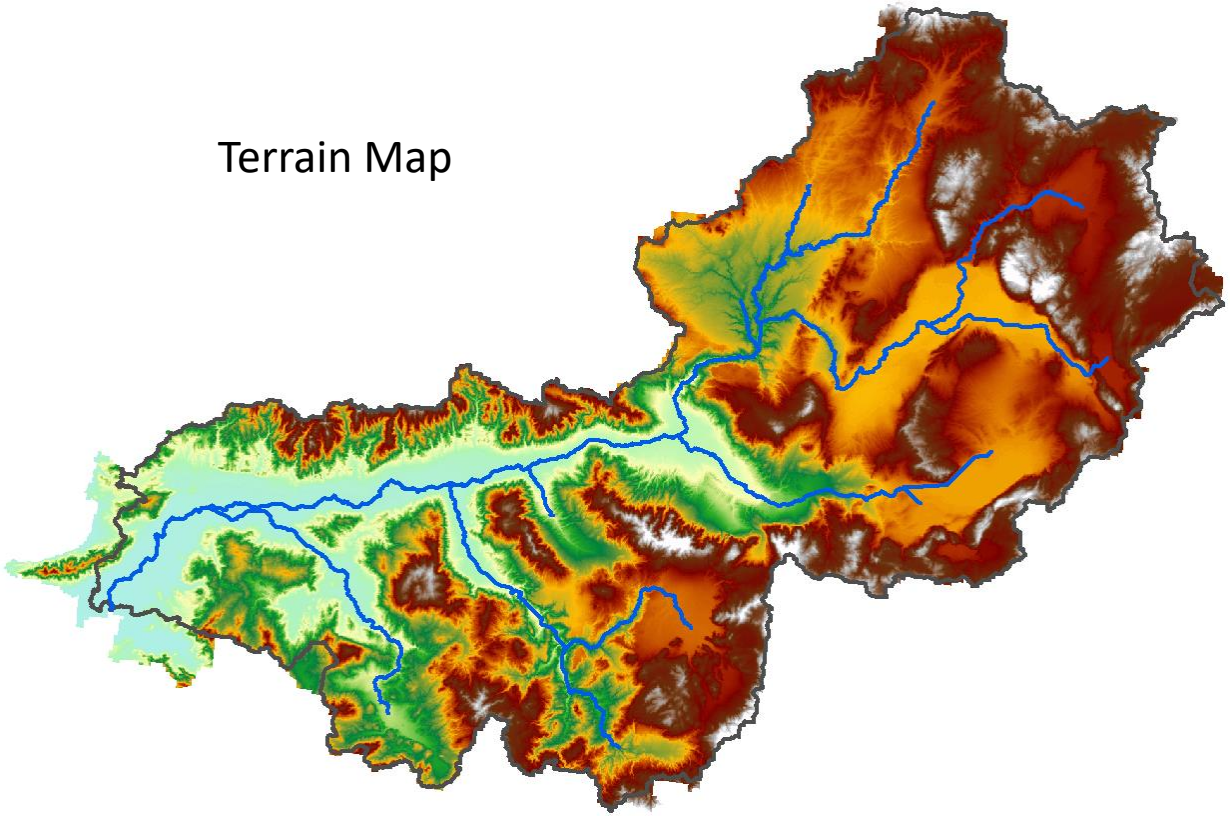
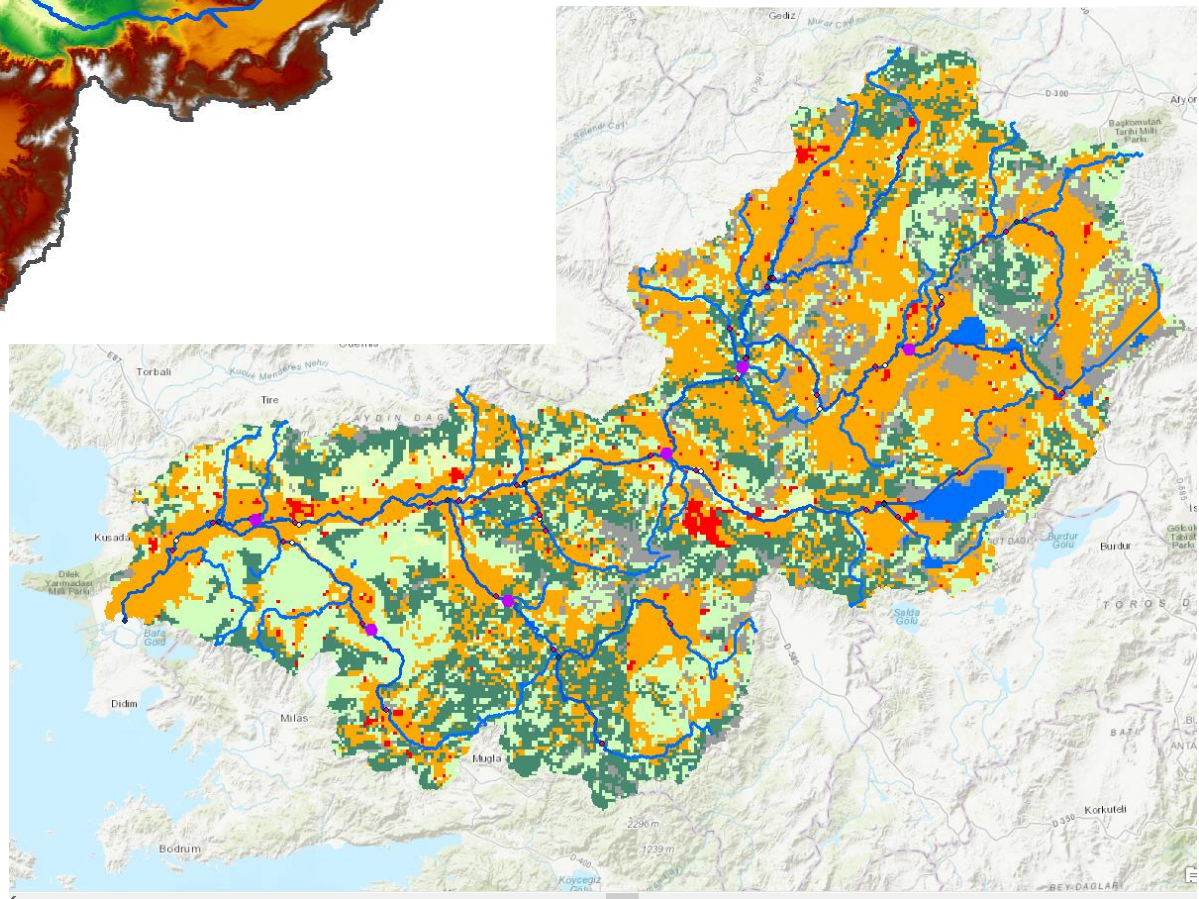
Terrain Map

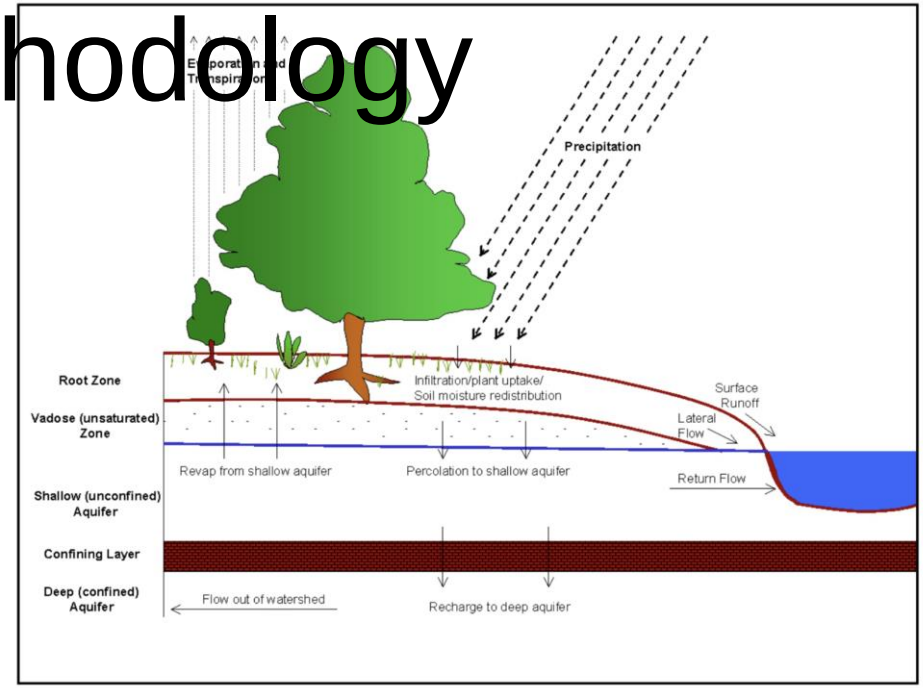


Land Cover Map

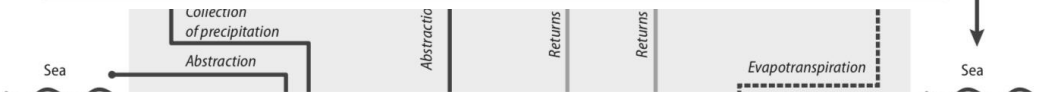


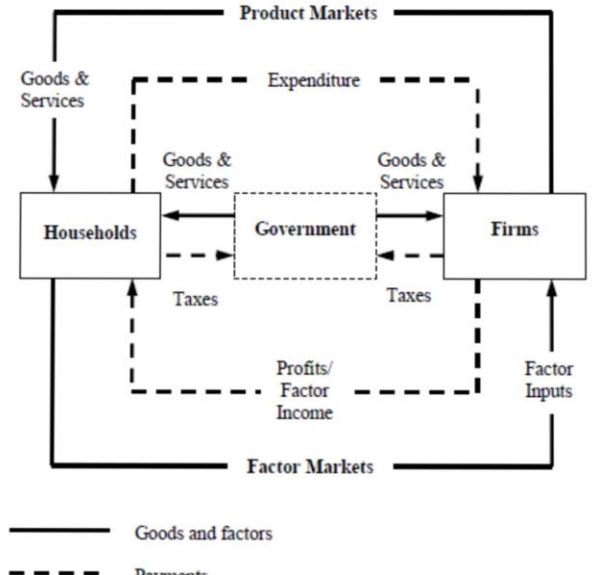
How?

The Methodology



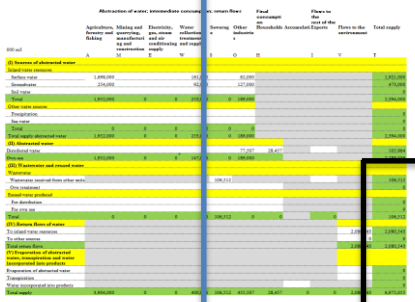
Hydrological Model





Macroeconomic Model

The Methodology



SEEA Accounts

* SEEA Water Accounts Supply &Use
* Ecosystem Accounts (Provision, Purification, Flood Control)

Spatially Explicit Economic Analysis

* Water (Demand, Use)
* Resource efficiency
* Spillover effects of land cover change

Hydrological Model

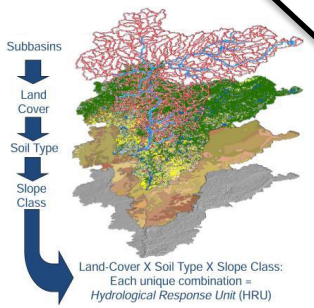
Water Yield (Stock)
Water Purification
Agricultural water supply
Other water supply

Spatial Database

* Biophysical Properties
* Landscape service supply change
* Land use change
* Spatially identified institutions (Cities, provinces, etc)

Regional CGE Model

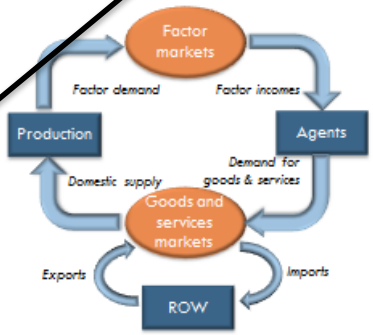
I/O Table
Social Accounting Matrix
Production and Consumption Shocks



Economic & Environmental Policy

Conservation vs Development balance (spatially identified)

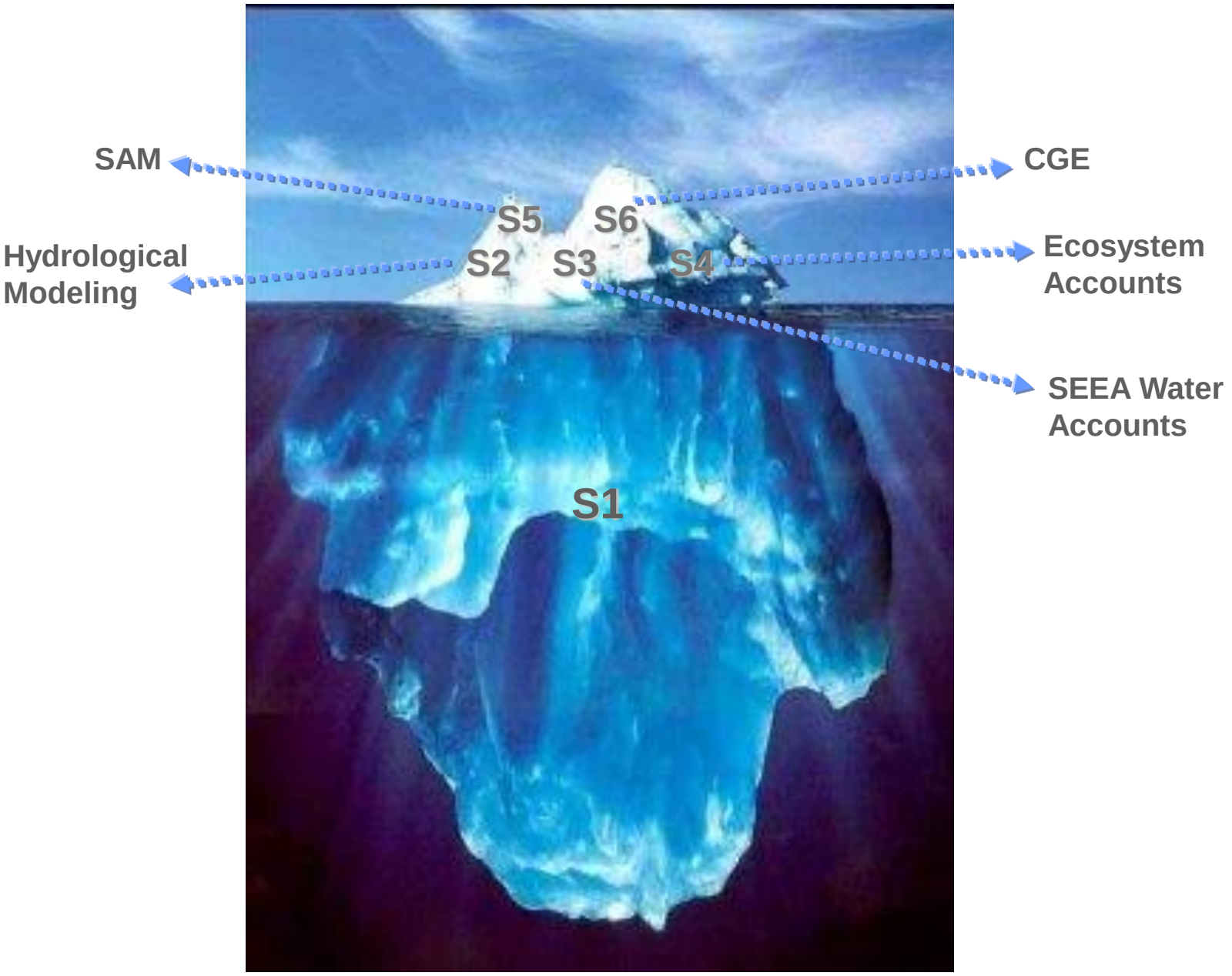
Resource allocation



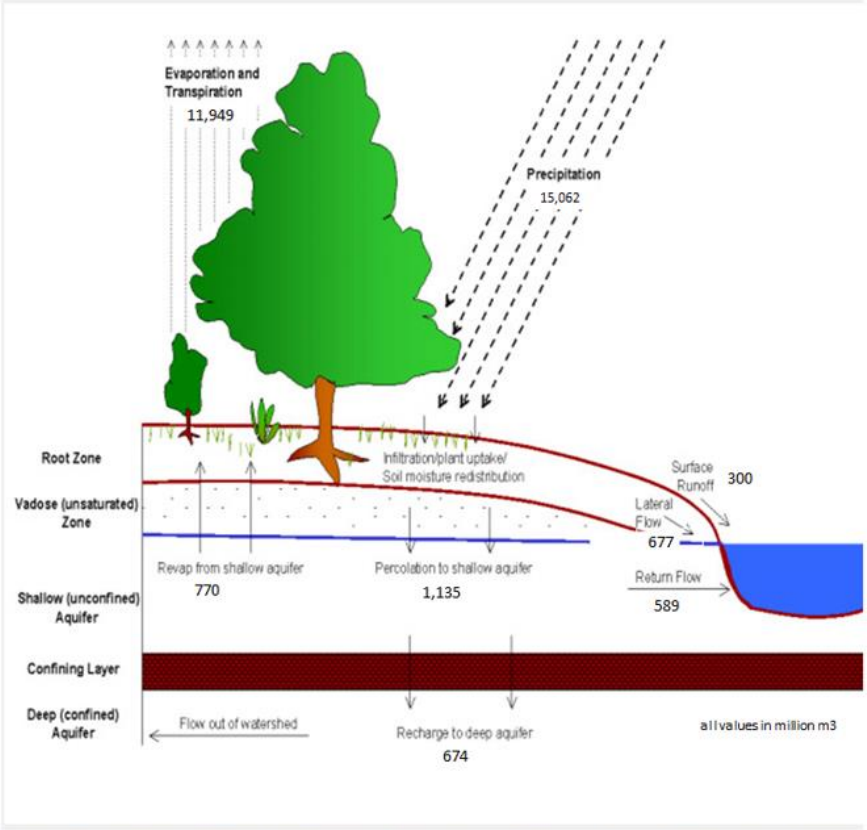
Steps in Linking Models

- Data Collection (S1)
- Hydrological Model (S2)
- SEEA Water Accounts (Physical Supply&Use Accounts, Asset Accounts) (S3)
- Ecosystem Accounts (S4)
- Construction of Social Accounting Matrix (S5)
- Incorporation of ecosystem services as factors of production in a regional CGE model (S6)

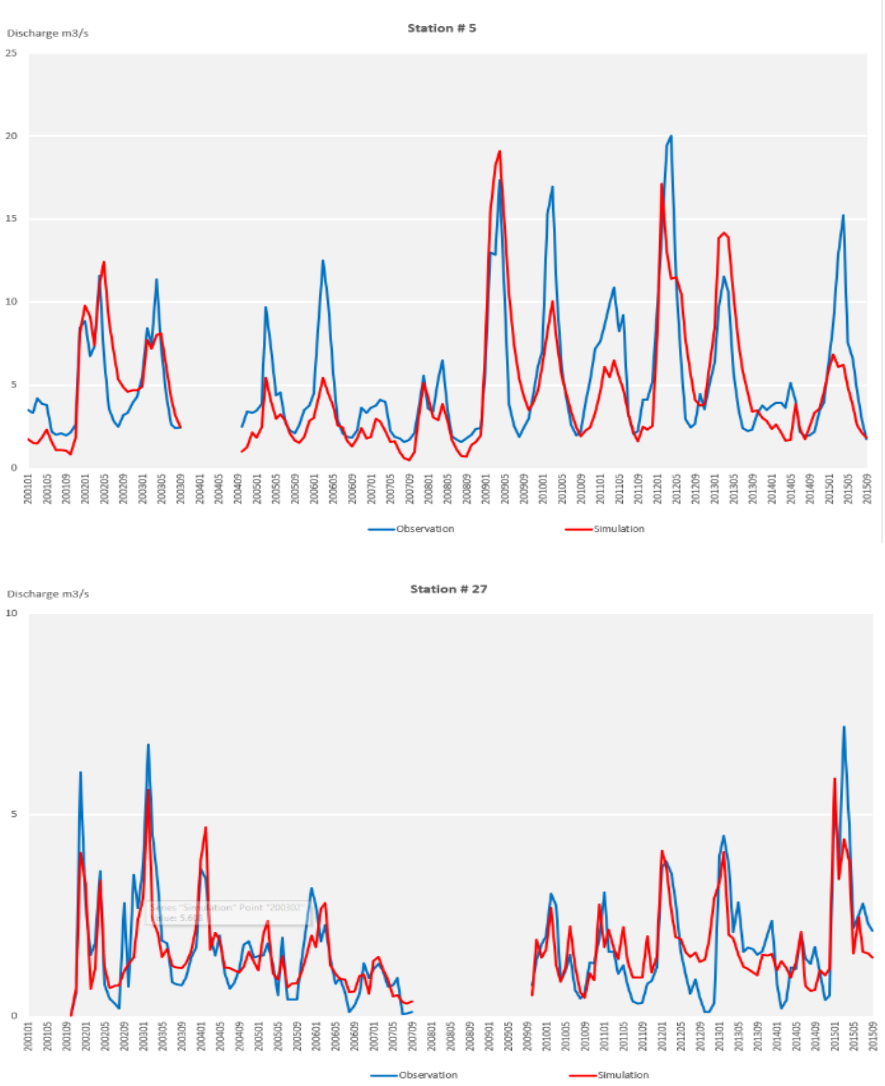
S1 Role and Importance of Data



SWAT Model



Schematic representation[4] of the hydrologic cycle of the Buyuk Menderes River (2014)



Observed Data and Model Results for Selected Stations

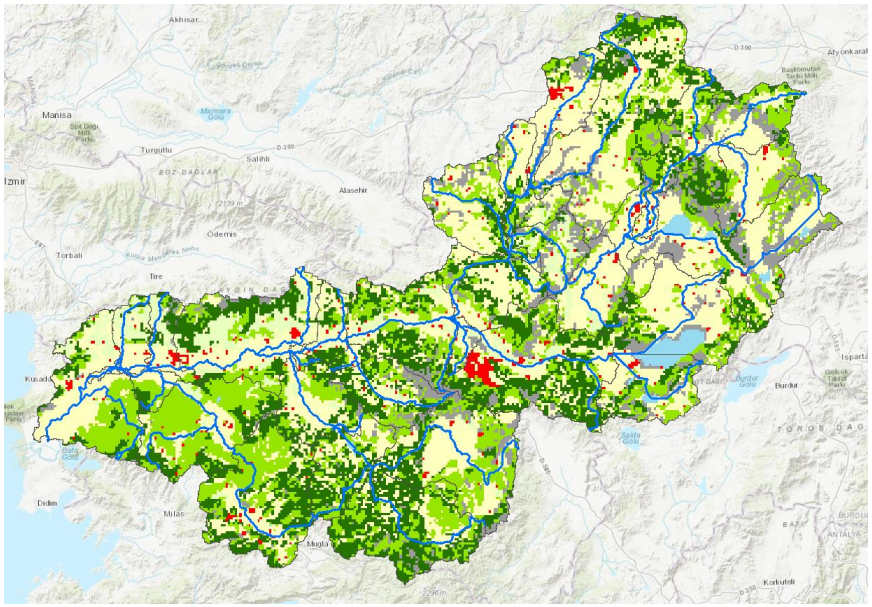
SEEA Water Accounts - Supply

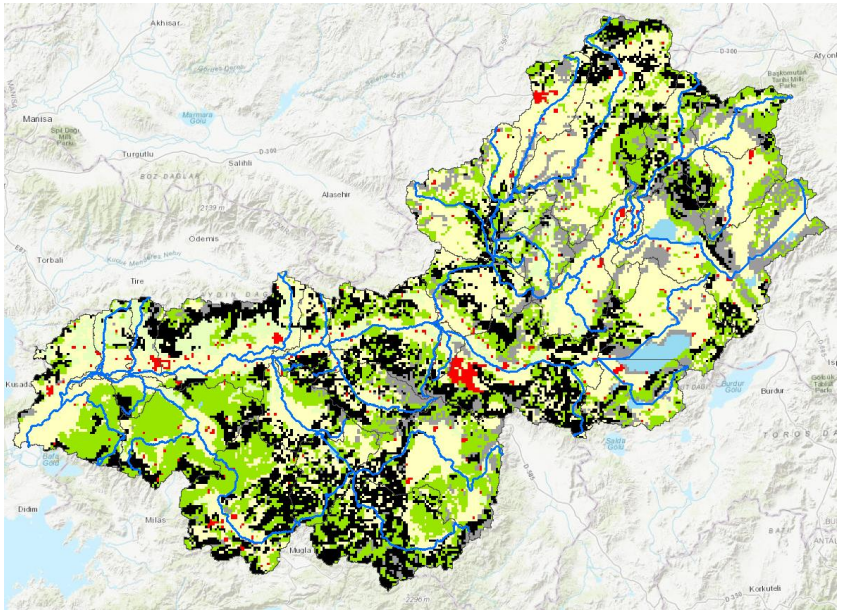
SUPPLY	YEAR: 2014									
	Abstraction of water; production of water; generation of return flows									000 m3
Physical supply table for water	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing and construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Households		Flows from the environment	Total supply
(I) Sources of abstracted water										
Inland water resources										
Surface water									3,359,006	3,359,006
Groundwater									170,971	170,971
Soil water									0	0
Total									**3,529,977**	**3,529,977**
Other water sources										
Precipitation									*15,061,641*	15,061,641
Sea water									3,594	3,594
Total									**15,065,235**	**15,065,235**
Total supply abstracted water									**18,595,212**	**18,595,212**
(II) Abstracted water										
For distribution					**127,184**					127,184
For own-use	16,095,143	14,298	15,606	2,293,554	49,428	0				18,468,028
(III) Wastewater and reused water										
Wastewater										
Wastewater to treatment	0	433	11,500				114,519			126,453
Own treatment	0	896	9,309			0				10,205
Reused water produced										
For distribution	0	2	642			0				644
For own use	0	5	16	0	0	0	0			21
Total	**0**	**1,337**	**21,467**	**0**	**0**	**0**	**114,519**			137,323
(IV) Return flows of water										
To inland water resources										
Surface water		6,235	6,916	2,293,554	0	122,578	0			2,429,284
Groundwater		1,033	450		0	1,091				2,574
Soil water	4,130,393	0	0			0				4,130,393
Total	**4,130,393**	**7,268**	**7,367**	**2,293,554**	**0**	**123,669**	**0**			6,562,251
To other sources		509	74			2,783				3,366
Total return flows	**4,130,393**	**7,776**	**7,441**	**2,293,554**	**0**	**126,453**	**0**			6,565,617
of which: Losses in distribu-tion					49,428		453			49,881
(V) Evaporation of abstracted water, transpiration and water incorporated into products										
Evaporation of abstracted water	*11,949,298*	6,846	7,473			0				11,963,618
Transpiration						0				0
Water incorporated into products	16,095	0	0			0				16,095
Total supply	**32,190,929**	**30,257**	**51,987**	**4,587,108**	**226,040**	**126,453**	**114,973**		**18,595,212**	**55,922,958**

SEEA Water Accounts - Use

	YEAR: 2014									
USE	Abstraction of water; intermediate consumption; return flows						Final consumption			000 m3
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing and construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Households	Accumulation	Flows to the environment	Total supply
	A	M	M2	E	W	S	H		V	T
(I) Sources of abstracted water										
Inland water resources										
Surface water	1,033,545	1,194	1	2,293,554	30,713	0				3,359,006
Groundwater	0	9,474	15,597	0	145,899					170,971
Soil water	0									0
Total	**1,033,545**	**10,668**	**15,598**	**2,293,554**	**176,612**	**0**				**3,529,977**
Other water sources										
Precipitation	*15,061,598*	35	8			0				15,061,641
Sea water	0	3,594	0	0	0					3,594
Total	**15,061,598**	**3,629**	**8**	**0**	**0**	**0**				**15,065,235**
Total supply abstracted water	**16,095,143**	**14,298**	**15,606**	**2,293,554**	**176,612**	**0**				**18,595,212**
(II) Abstracted water										
Distributed water	0	761	11,451	0		0	114,973			127,184
Own-use	**16,095,143**	**14,298**	**15,606**	**2,293,554**	**49,428**	**0**				**18,468,028**
(III) Wastewater and reused water										
Wastewater										
Wastewater received from other units						126,453				126,453
Own treatment	0	896	9,309	0	0	0	0			10,205
Reused water received										
From distribution	644									644
From own wastewater	0	5	16	0	0					21
Total	**644**	**901**	**9,325**	**0**	**0**	**126,453**	**0**			**137,323**
(IV) Return flows of water										
To inland water resources									*6,562,251*	**6,562,251**
To other sources									3,366	**3,366**
Total return flows									**6,565,617**	**6,565,617**
(V) Evaporation of abstracted water, transpiration and water incorporated into products										
Evaporation of abstracted water									11,963,618	**11,963,618**
Transpiration									0	**0**
Water incorporated into products								16,095		**16,095**
Total supply	32,190,929	30,257	51,987	4,587,108	226,040	126,453	114,973	16,095	18,529,235	**55,873,077**

Ecosystem Accounts



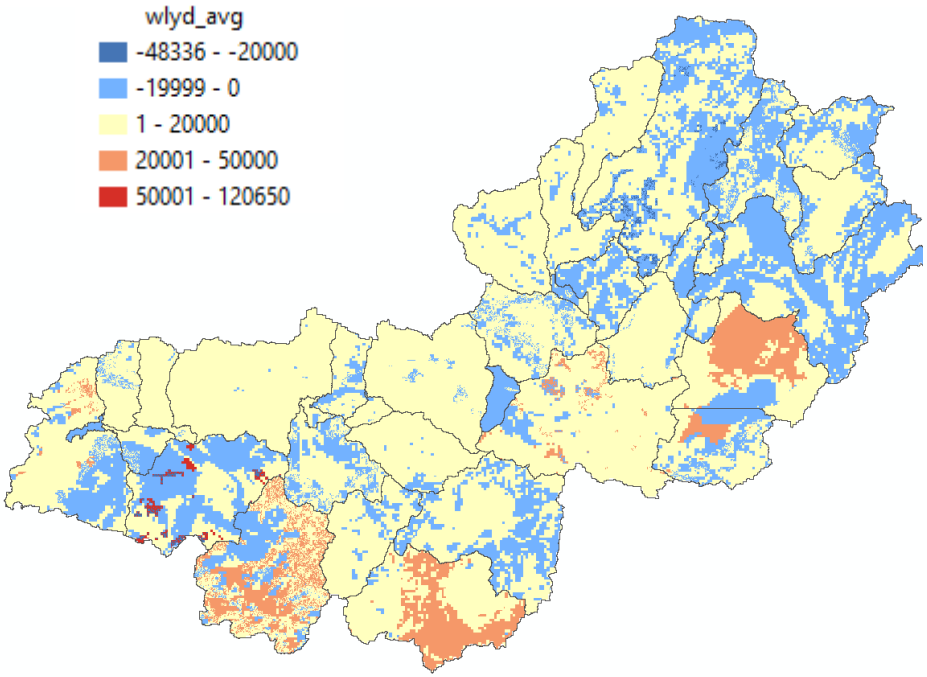


- Supply of Ecosystem Services with Forest
- Water Provision
  - Quantity
  - Timing
- Water Purification
  - Nitrogen
  - Sediment
- Flood Control

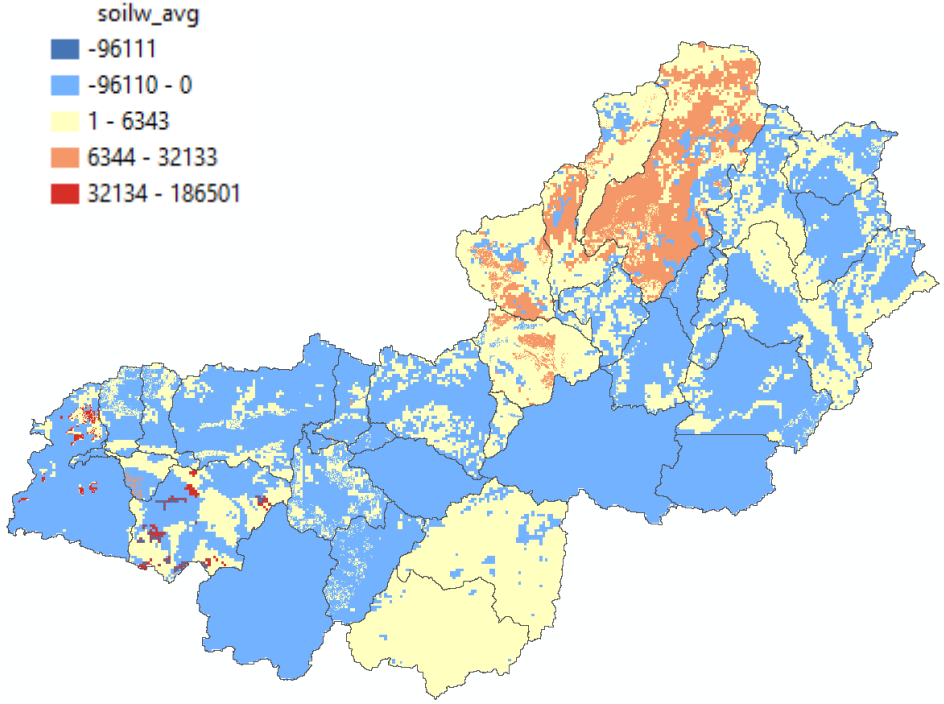
- Supply of Ecosystem Services without Forest
- Proxy Indicator
  - Water yield
  - Soil Water
  - Total Nitrogen
  - Sediment Yield
- Surface Flow

Ecosystem Accounts

Provision-Water Yield (000m3)

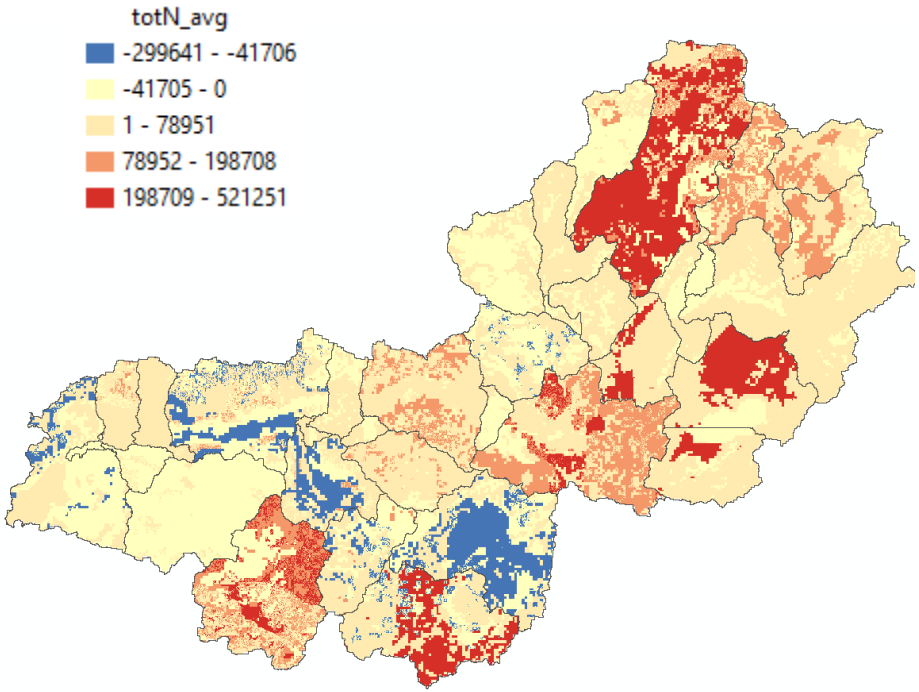


Timing-Soil Water (000m3)

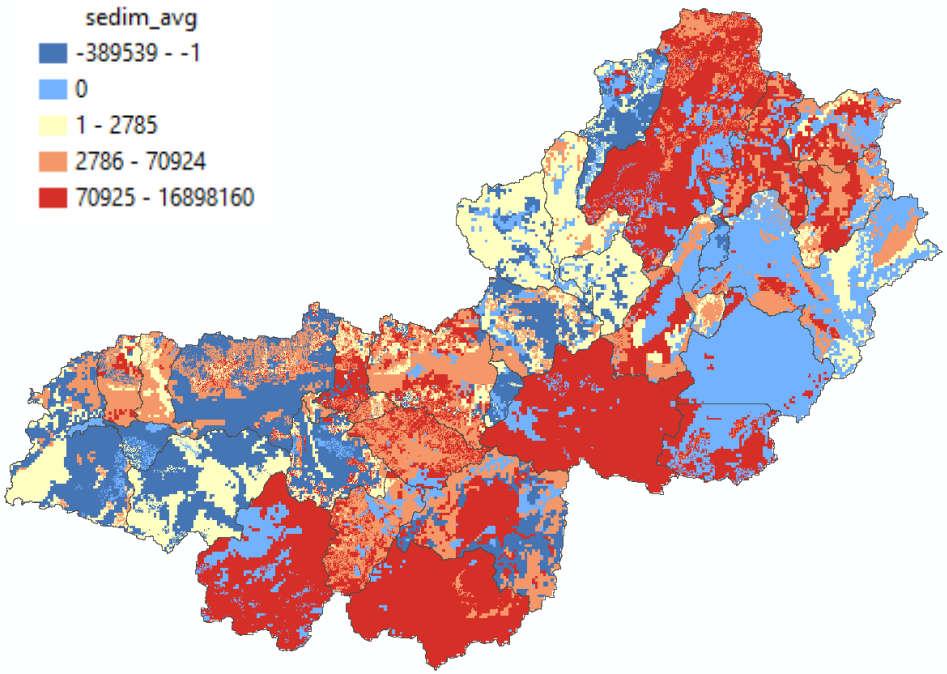


Ecosystem Accounts

Water Purification- Total N (kg)



Water Purification- Sediment Yield (tons)



Incorporation of Ecosystem Services into the regional SAM

	Activities	Commodities	Factors of Production	Agents	Capital Accumulation	Rest of Turkey	Rest of World	Ecosystems	Total
Activities		Sales				Sales to Turkey	Exports		Total Sales
Commodities	Intermediate Inputs			Consumption	Investment Inventories				Total Demand
Factors of Production	Value Added								Factor Income
Agents	Taxes Subsidies	Sale Taxes Subsidies	Salaries Profits		Interest Profits				Income of Agents
Capital Accumulation				Savings			FDI		Total Savings
Rest of Turkey		Purchases from Turkey							RoT Earnings
Rest of World		Imports							Foreign Earnings
Ecosystems	Ecosystem Services			Ecosystem Services to households					Use of Ecosystem Services
Total	Production Cost	Total Supply	Factor Income	Total Spending	Total Investment	RoT Expenses	Foreign Expenses	Supply of Ecosystem Serv	

Regional Social Accounting Matrix 1

			Activities							Commodities						
			AG	MI	MC	EL	WS	SW	OE	AG	MI	MC	EL	WS	SW	OE
Activities	Agriculture, forestry and fishing	AG								110,855,513						
	Mining and quarrying	MI									-2,879,782					
	Manufacturing and construction	MC										86,887,562				
	Electricity, gas, steam and air conditioning supply	EL											20,694,024			
	Water collection, treatment and supply, Sewerage	WS												6,198,137		
	Sewerage	SW													8,286,943	
	Other Economy	OE														786,817,286
Commodities	Agriculture, forestry and fishing	AG	1,135,073	3,479	2,650,661	9	6	571	273,866							
	Mining and quarrying	MI	189,545	955,125	1,565,203	1,174,684	3,829	26,226	2,308,236							
	Manufacturing and construction	MC	645,691	56,465	18,124,239	54,319	31,153	172,110	5,074,232							
	Electricity, gas, steam and air conditioning supply	EL	34,799	26,208	707,032	2,486,803	44,198	11,467	844,941							
	Water collection, treatment and supply, Sewerage	WS	21,168	338	37,256	571	4,228	4,550	126,190							
	Sewerage	SW	0	352	1,109,607	0	762	290,475	53,897							
	Other Economy	OE	360,478	209,264	6,442,931	216,960	29,715	210,366	16,996,256							
Factors of Production	Labor	LF	296,683	146,885	3,622,284	106,513	44,318	65,651	9,021,746							
	Capital	KP	7,941,591	376,873	7,543,085	513,900	139,372	206,461	15,866,914							
Agents	Households	HH														
	Enterprises	Lt														
	Soc Sec Inst	SS														
	Government	G	-3,824,885	40,952	3,092,650	236,979	14,505	21,488	6,521,965	17,574	49,138	214,367	39,469	915	4,019	268,143
Capital Acc	Investments	HHI														
		GI														
Rest	Rest of Turkey	RoT								0	0	0	0	0	0	0
	Rest of World	RoW								541,108	2,956,079	11,631,937	19,001	0	1,189,977	806,707
Ecosystems	Water Provision	ES_WP	X	X	X	X	X		X							
	Controlling soil loss	ES_SD				X	X									
	Controlling the chemical quality of the fresh water	ES_PUR					X	X								
	Regulating the flow of water	ES_FL	X		X											
	Total	Tot	6,800,143	1,815,940	44,894,948	4,790,738	312,086	1,009,364	57,088,243	111,414,195	125,435	98,733,867	20,752,494	6,199,052	9,480,938	787,892,137

Regional Social Accounting Matrix 2

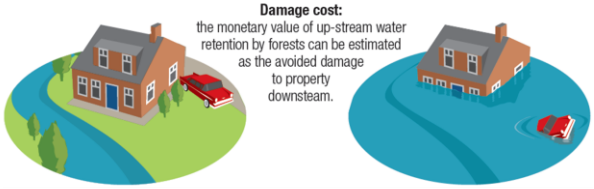
			Factors		Agents				AccumItn		Rest		Ecosystems			
			LF	KP	HH	Lt	SS	G	HHI	GI	RoT	RoW	ES_WP	ES_SD	ES_PUR	ES_FL
Activities	Agriculture, forestry and fishing	AG									0	275,914				
	Mining and quarrying	MI									0	509,120				
	Manufacturing and construction	MC									0	7,123,485				
	Electricity, gas, steam and air conditioning supply	EL									0	9,949				
	Water collection, treatment and supply, Sewerage	WS									0	0				
	Sewerage	SW									0	22,781				
	Other Economy	OE									0	1,441,936				
Commodities	Agriculture, forestry and fishing	AG			1,978,958			0	401,906	14,469						
	Mining and quarrying	MI			399,843			0	46,705	689						
	Manufacturing and construction	MC			7,222,085			140,736	11,506,599	475,873						
	Electricity, gas, steam and air conditioning supply	EL			686,335			0	0	0						
	Water collection, treatment and supply, Sewerage	WS			170,030			15,594	0	0						
	Sewerage	SW			26,728			89,570	190,539	8,429						
	Other Economy	OE			16,968,126			3,172,534	1,863,379	76,688						
Factors of Production	Labor	LF														
	Capital	KP														
Agents	Households	HH	13,304,079			32,588,195		275,276								
	Enterprises	Lt		32,588,195				39,458								
	Soc Sec Inst	SS				0		0								
	Government	G			3,608,932	1,407,193					0	58,469				
Capital Acc	Investments	HHI			13,853,145						1,287,876	0				
		GI						-643,485			0	0				
Rest	Rest of Turkey	RoT														
	Rest of World	RoW				0		0								
Ecosystems	Water Provision	ES_WP			X											
	Controlling soil loss	ES_SD														
	Controlling the chemical quality of the fresh water	ES_PUR														
	Regulating the flow of water	ES_FL			X											
	Total	Tot	13,304,079	32,588,195	44,914,180	33,995,388	0	3,089,684	14,009,129	576,148	1,287,876	9,441,654	0	0	0	0

Next Steps- Ecosystem Accounts Monetary Terms

Market prices

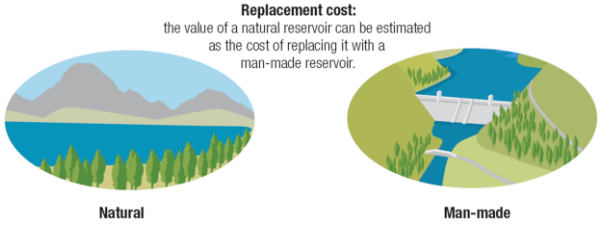
- Used for valuing provisioning services (e.g. timber, food, thatch)
- Straightforward and inexpensive data
- Ignores the costs of other inputs

Damage cost avoided



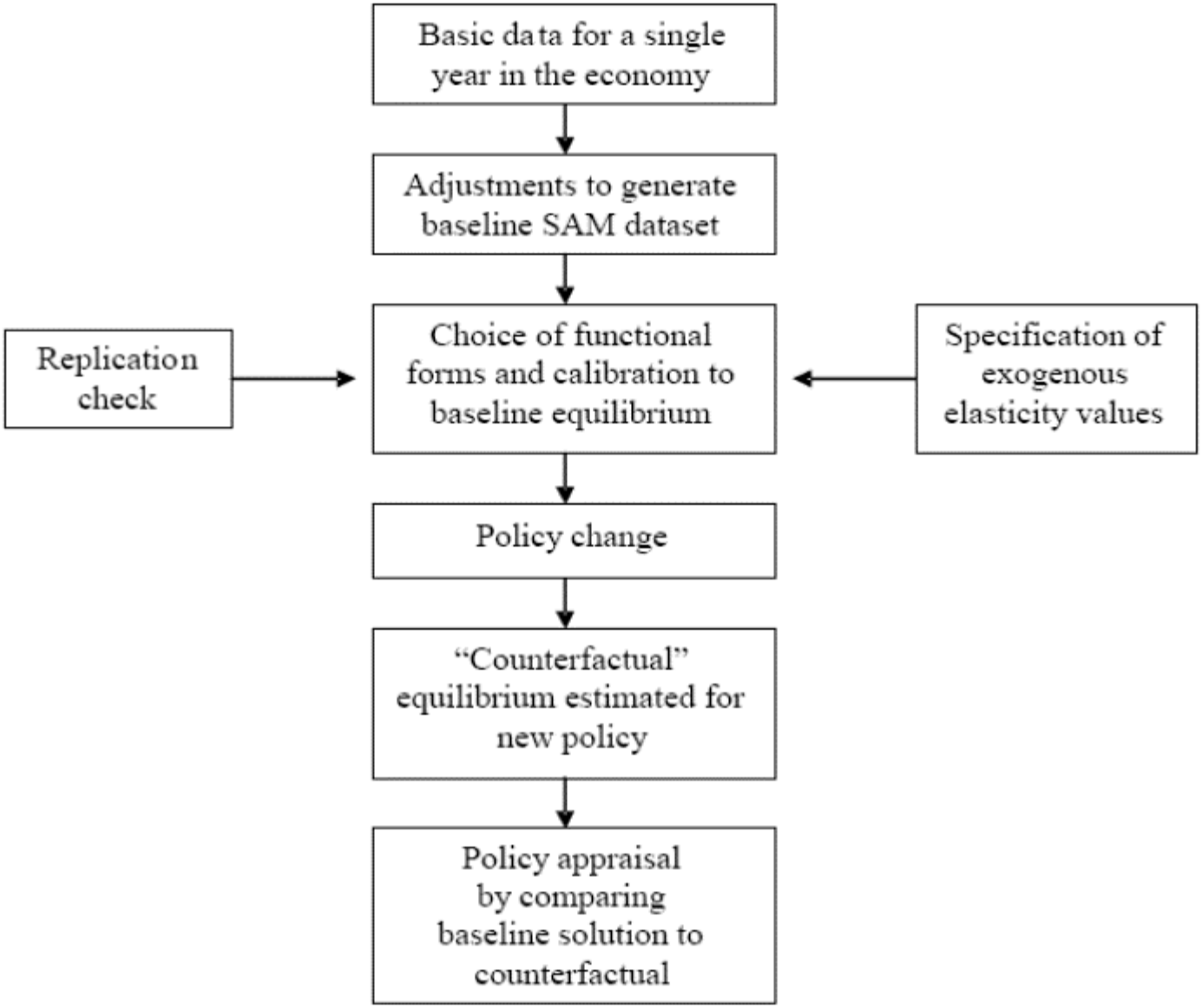
- Used for valuing ecosystems that provide some form of natural protection
- Estimate the value of assets that are protected by intact ecosystems
- Difficult to quantify the level of protection

Replacement cost



- Used for valuing provisioning and regulating services
- Cost is not necessarily a good measure of benefit
- Difficult to find "exact" equivalent replacements

Steps in developing and applying the CGE model



Conclusion

- The SEEA **Water accounts** provide a **standardised method** for water-related statistics
- The SWAT model fills some of the **data gaps** and contributes to data uniformity in accounting
- **SWAT outputs** can be used in developing ecosystem accounts to understand better the contribution of ecosystems to economic activities and trade-offs
- The aggregated use table shows a **relatively high variation** in water consumption per economic sector. Agriculture is by far the largest user at 86 % of the total use, followed by Electricity at 12 % along the study period
- the accounts reveal that **precipitation** is the key input of agriculture water use
- changes in precipitation due to climate change may have impact on the agriculture in the basin and this may not be compensated with more storage capacity
- The accounting results are expected to **influence the behaviour** of economic agents and thus have an impact on water use.
- **Aggregated accounts** have **limited impact** on decisions since they don’t provide much policy relevant information.
- When we zoom in **subbasin scale**, we can retrieve more information on dynamics between environment and economy
- **Next steps**: construction and calibration of the regional CGE model

Thank you

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