European Commission

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

Modeling water regulation in support of ecosystem accounting

Stoyan Nedkov
NIGGG-BAS

MAIA webinar
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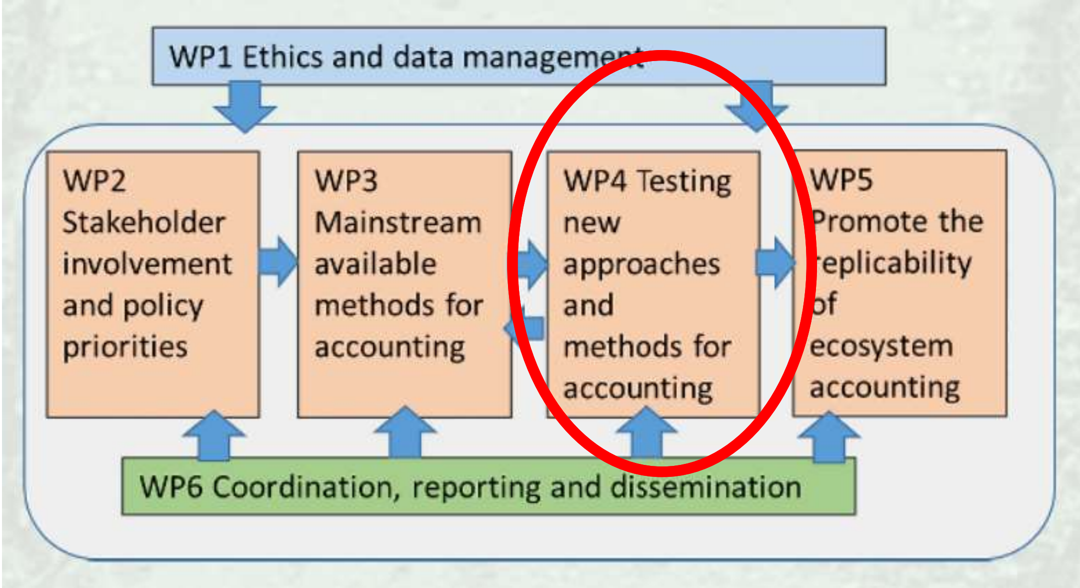
Outline

1. Background
2. Models of water regulation: a review
3. Modeling and ecosystem accounting
4. Flood control modeling
5. Key findings and research perspectives

1. Background

1. Developing new insights in order to fill selected key knowledge gaps in NCA

2. To ensure that the new insights will be shared among member states and applied in EU member state ecosystem accounting efforts.



Task 4.1 Modelling water regulation services in support of ecosystem accounting

Task 4.2 Exploring big data sources for quantifying cultural services

Task 4.3 Valuing Ecosystem Services and Ecosystem Assets

Task 4.4 Biodiversity accounting

Task 4.5 Piloting Marine accounts

Task 4.6 Coordination of research and development activities

1. Background

Water-related and water regulation ecosystem services

Water related Ecosystem Services

Type of service	Description	Examples
Provisioning services	Focused on directly supplying food and non-food products from water flows	Freshwater supply Crop and fruit production Livestock production Fish production Hydro-electric power
Regulating services	Related to regulating flows or reducing hazards	Buffering of runoff, soil water infiltration, groundwater, maintenance of base flows Flood prevention, peak flow reduction, landslide reduction Soil protection and control of erosion and sedimentation Control of surface and groundwater quality
Supporting services	Provided to support habitats and ecosys-tem functioning	Wildlife habitat Flow regime required to maintain downstream habitat and uses
Cultural services	Related to recreation and human inspira-tion	Aquatic recreation Landscape aesthetics Cultural heritage and identity

Hawkins et al. 2009

CISES version 5.1 (2018)

Control of erosion rates	2.2.1.1	*...that mitigates or prevents potential damage to human use of the environment or human health and safety*	*The capacity of vegetation to prevent or reduce the incidence of soil erosion Or Macroalgae, microphytobenthos, macrophytes and biogenic reef structures (epifauna and infauna) all contribute through sediment stabilisation*	*Reduction of damage (and associated costs) of sediment input to water courses*	
Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	2.2.1.3	*By depth/volumes*	*Hydrological cycle and water flow maintenance And Flood protection*	*2.2.2.1 & 2.2.2.2*	*Regulating the flows of water in our environment*
Regulation of the chemical condition of freshwaters by living processes	2.2.5.1	*By type of living system*	*Chemical condition of freshwaters*	2.3.4.1	*Controlling the chemical quality of freshwater*
Regulation of the chemical condition of salt waters by living processes	2.2.5.2	*By type of living system*	*Chemical condition of salt waters*	2.3.4.2	*Controlling the chemical quality of salt water*
Dilution by freshwater and marine ecosystems	5.1.1.1	*Amount by type*	*Dilution by atmosphere, freshwater and marine ecosystems*	*2.1.2.2*	*Diluting wastes*

SEEA-EA 2021

Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events
	Lifecycle maintenance, habitat and gene pool protection
	Water condition
Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes
Regulation of physical, chemical, biological condition	Regulation of baseline flows and extreme events

Abiotic_Surface water for drinking (4.2.1.1.)	Abiotic_Surface water used as a material (non-drinking purposes) (4.2.1.2.)	Abiotic_Freshwater surface water used as an energy source (4.2.1.3.)	Abiotic_Ground (and subsurface) water for drinking (4.2.2.1.)	Abiotic_Ground water (and subsurface) used as a material (non-drinking purposes) (4.2.2.2.)	Abiotic_Ground water (and subsurface) used as an energy source (4.2.2.3.)	Abiotic_Dilution by freshwater and marine ecosystems (5.1.1.1.)	Abiotic_Mediation by other chemical or physical means (5.1.1.3.)	Abiotic_Liquid flows (5.2.1.2.)	Biotic_Control of erosion rates (2.2.1.1.)	Biotic_Hydrological cycle and water flow regulation (Including flood control, and coastal protection), (2.2.1.3.)	Biotic_Maintaining nursery populations and habitats (Including gene pool protection), (2.2.2.3.)	Biotic_Regulation of the chemical condition of freshwaters by living processes (2.2.5.1.)

1. Background

Characterizing and assessing water regulation ES is challenging because:

- they can be regarded as both final and intermediate services i.e. it is usually difficult to distinguish between ES flow and ES potential;
- need various data which are usually not available through direct or indirect measurements
- It is often data-intensive and also analytically complex

….. therefore modeling approaches of water regulation are much needed!

2. Models of water regulation: a review

<u>Main objective</u>: to provide an overview of efforts in modeling water regulation ES in the current scientific literature to establish the background for the integration of such models into the NCA framework

1. to identify models for water regulation
2. to identify water regulation services which can be assessed by modeling
3. to define the main characteristics of the models in relation to ecosystem accounting

Main part

Publication_ID – Number (The ID that is indicated for the paper in the list of studies)	Type of Publication (Go through the options and mark the correct answer(s) by using '1' for "Yes" and '0' for "No") – Research paper	Type of Publication – Scientific project report	Year of Publication – Year	Authors – Name(s) (Indicate the authors' names OR only the first author in case of more than three co-authors)	Publication Title – Only the title	DOI – Insert publication's digital object identifier OR Web address link	Journal name / Publications office – Name	Case study country – Name *follow additions / guidelines	Purpose of the publication (Go through the options and mark the correct answer(s) by using '1' for "Yes" and '0' for "No". In case you choose 'Other', insert '1' in the b… textual explanation in the 'Other, please specify' box) – Methodological investigation	Tool - explanation / upgrading	Indicator development	Assessment	Valuation	Accounting	Mapping	Business investigation	Management options	Land use planning	Land use conflicts identification	Awareness raising	Decision making process and policy development	Paper review	Oth
1	1	0	2014	Roebeling et al	Gains from trans-boundary water quality management in linked catchment and coastal socio-ecological systems: A case study for the Minho region	https://doi.org/10.1016/j.wre.2014.10.002	Water Resources and Economics	Spain&Portugal	1	0						0	0	1	0				
2	1	0	2016	Francesconi et al	Using the Soil and Water Assessment Tool (SWAT) to model ecosystem services: A systematic review	https://doi.org/10.1016/j.jhydrol.2016.01.034	Journal of Hydrology		0	1						0	0	0	0				

Template structure

I. Main part

1. Publication info (7)
2. General characteristics of the publication (16)
3. Accounting issues (7)
4. Ecosystem services (40)
5. General modeling information (13)

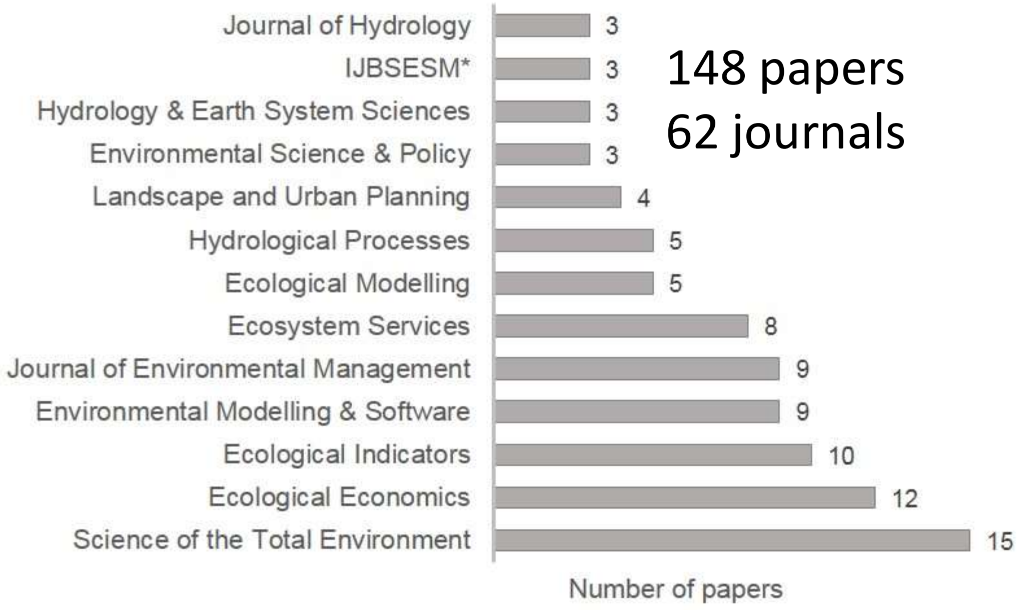
II. Modeling part

1. Publication info (3) – link to main part
2. Models specifics(46)

Modeling part

Publication_ID – Number (The ID that is indicated for the paper in the list of studies)	Model / Tool – Number (the number from section "models" in sheet "main")	Model / Tool – Name	Platform (Fill up only if the text provides explicit information) – GIS	Web-based	Windows	LINUX/UNIX	Other	Other, please specify	Additional aspects of the model/tool (Fill up only if the text provides explicit information) – Freely available	Publicly available/ Transparent	Actively supported	Compatible with another model	Compatible with another model, please specify	Not specified	Spatial scale of analysis (Go through the options and mark the correct answer(s) by using '1' for "Yes" and '0' for "No") – Basin	Subbasin	Field scale	Point scale	Grid sells	Grid sells, please specify	Time scale of … mark the correc… – Multiannual	Ann												
1		SWAT							1	1	1	1	Catchment to Reef Optimal Water Pollution Abatement		1	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	use, vegetation cover, soil types,
2		SWAT																																
113		WETTRANS												1	0	0	0	0	1	matrix model	0	1	0	0	0	1	0	1	1	1	0		1	peatland size, contributing area, transmisivity of
117	1	WSFS												1	1	1	0	0	0		0	1	1	1	0									
117	2	VEMALA	0	0	1	0	0		0	0	1	1	WSFS	0	0	0	1	0	0		0	1	0	0	0	0	0	0	1	0	0		1	Lake area, volume, depth, sources of
125		MIMES	1	0	0	0	0							1	0	0	0	0	1	raster model	1	0	0	0	0	1	0	0	0	0	0		1	land cover, hydrological soil
126		InVest	1	0	1	0	0		1	1	1	0			0	0	0	0	1	raster model	0	0	1	0	0	1	0	0	0	0	0		1	land cover, hydrological soil groups,

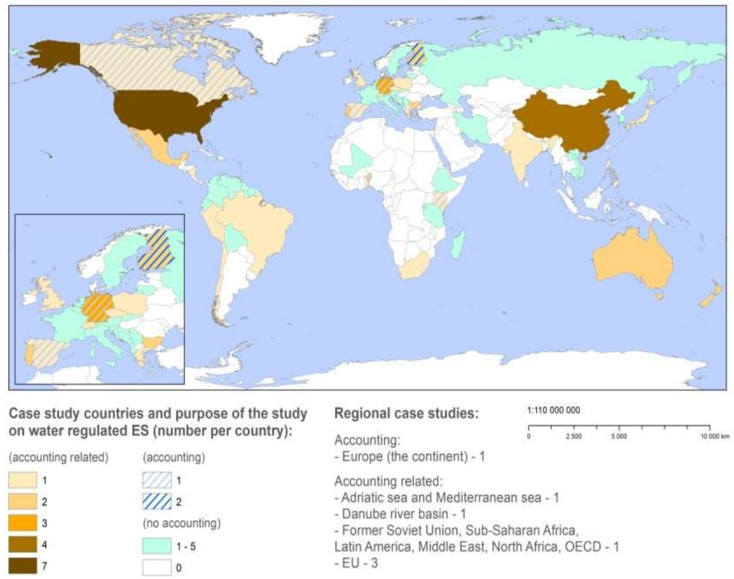
2. Models of water regulation: a review



148 papers
62 journals

Initial review:
139 different models and modeling approaches

Papers with:
Single model – 122
2 models – 13
3 models - 8
4 models - 2
5 models - 2



Main challenges

How to distinguish between the real models and modeling approaches and other methods defines as “models”?

The great variety of models and modeling approaches and the need for classification.

2. Models of water regulation: a review

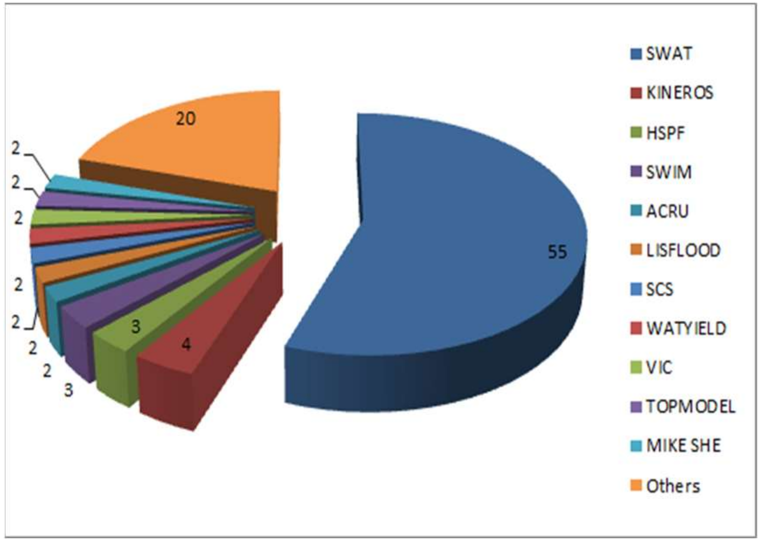
The analyses of the entries in the modeling part of the database enabled to distinguish eight categories, which covered all possible models and modeling approaches used for water-related ES assessment and mapping:

(1) **Hydrologic models**;
(2) **Hydraulic models**;
(3) **Integrated modeling frameworks**;
(4) **Other water-based models** (methods which better fit the classical model understanding but do not fit the above categories);
(5) **GIS tools** (use of tools which are an integral part of the commonly used GIS software such as ArcGIS, GRASS);
(6) **Water modeling approaches** (approaches or methods which use equations to calculate particular water parameters which do not fit the classical model understanding);
(7) **Conceptual or expert-based approaches**; and
(8) **Other models and modeling approaches** (non-water models used in combination with hydrologic or other water-based models to assess particular service or management practice).

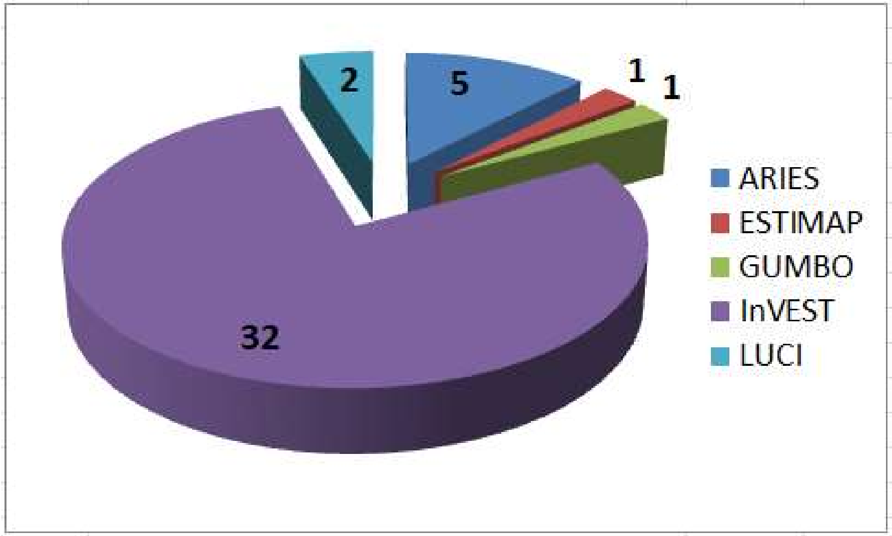
2. Models of water regulation: a review

Model category	All papers		n models
	n	%*	
1. Hydrologic models	99	67%	31
2. Hydraulic models	3	2%	3
3. Integrated modeling frameworks	42	28%	6
4. Other water-based models	13	9%	12
5. GIS tools	7	5%	7
6. Water modeling approaches	8	5%	8
7. Conceptual or expert-based approaches	10	7%	8
8. Other models and modeling approaches	18	12%	17

Hydrological models



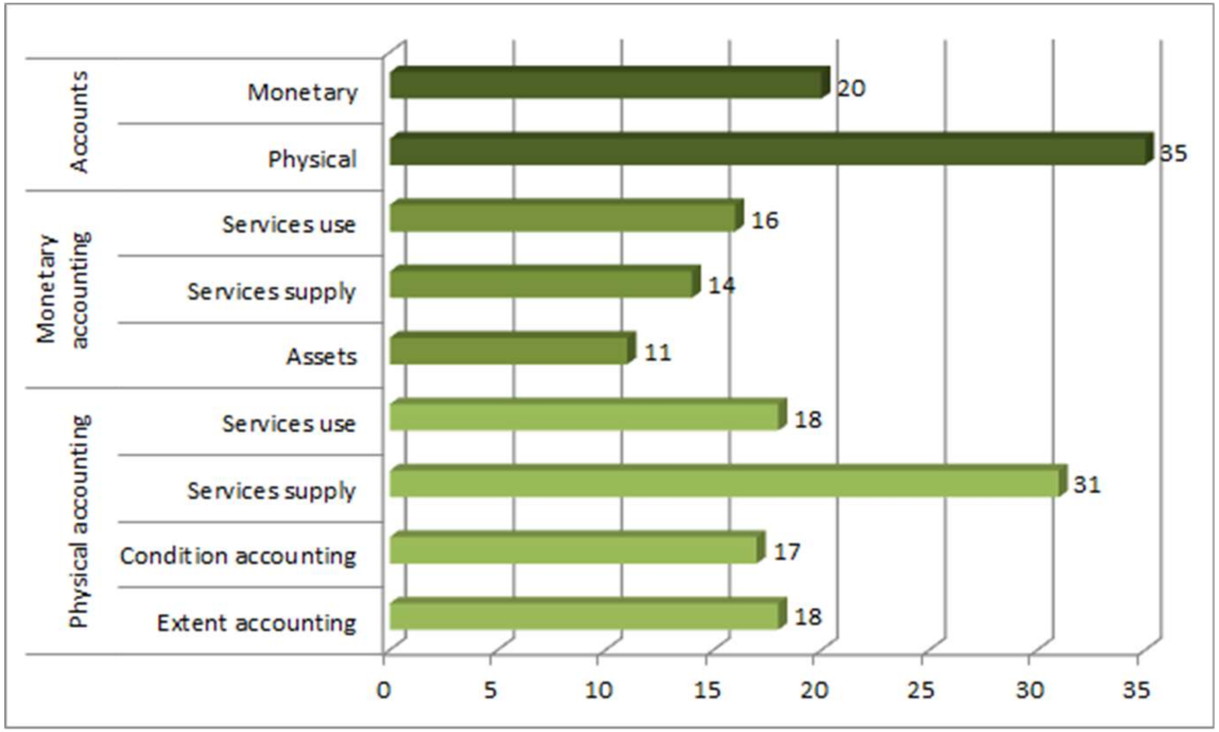
Integrated modeling frameworks



3. Modeling and ecosystem accounting

The papers were distributed into three groups according to their relation to the ecosystem accounting:

- papers that have accounting in their purpose - 10
- papers with relation to accounting (accounting has been mentioned in the paper in a particular context e.g. as a possible application, policy and decision making, relation to the methods, etc.)- 37
- other papers which do not have any relation to the ecosystem accounting - 101



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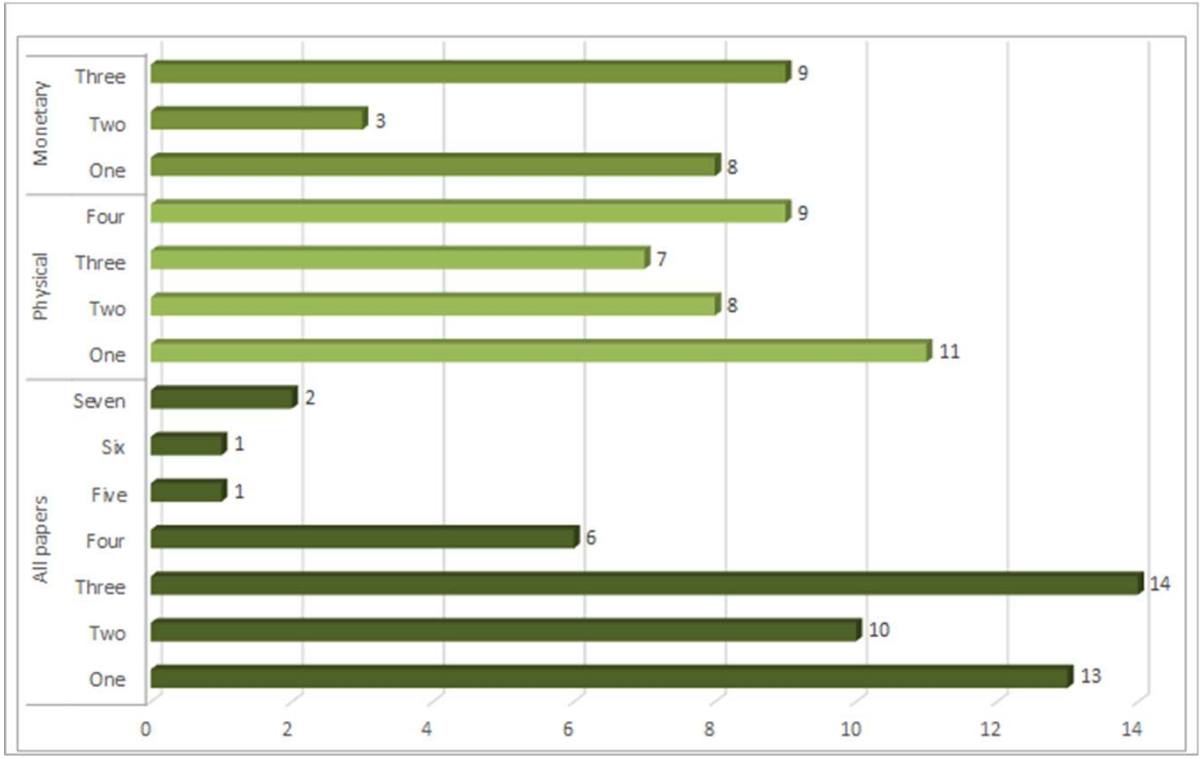
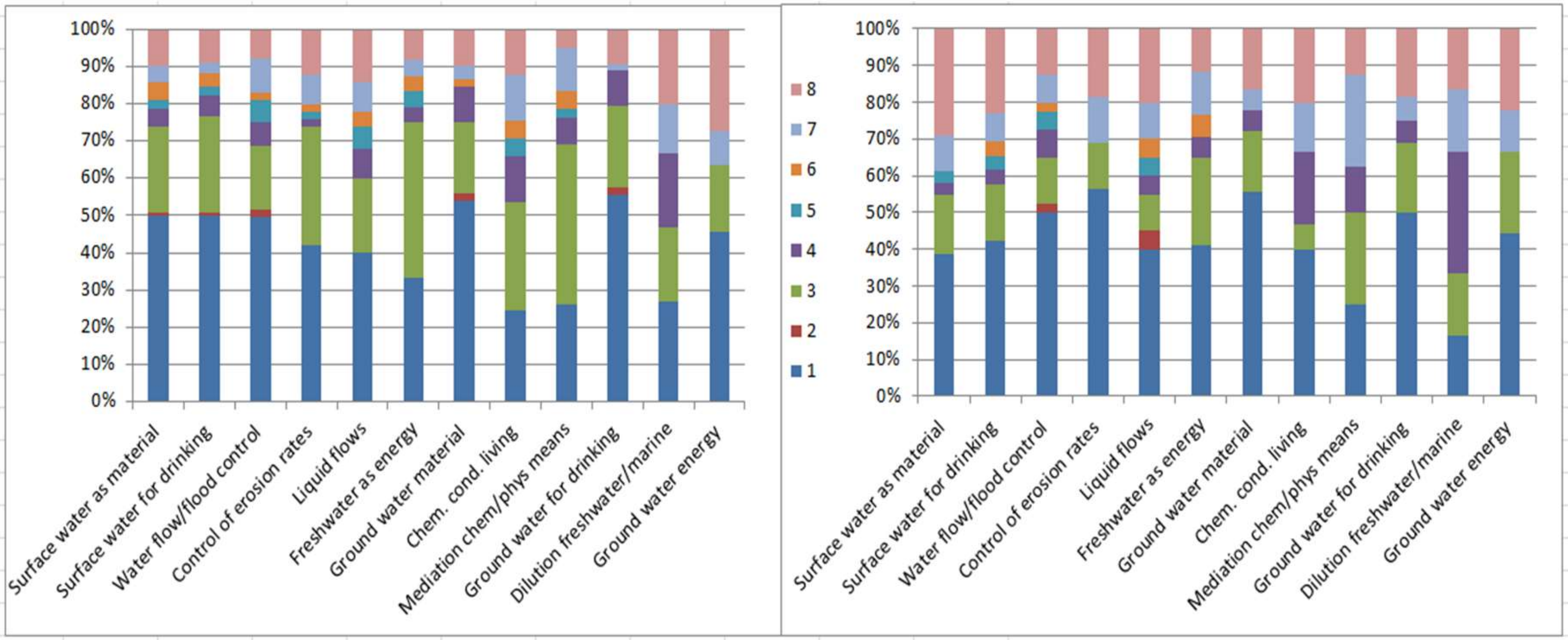
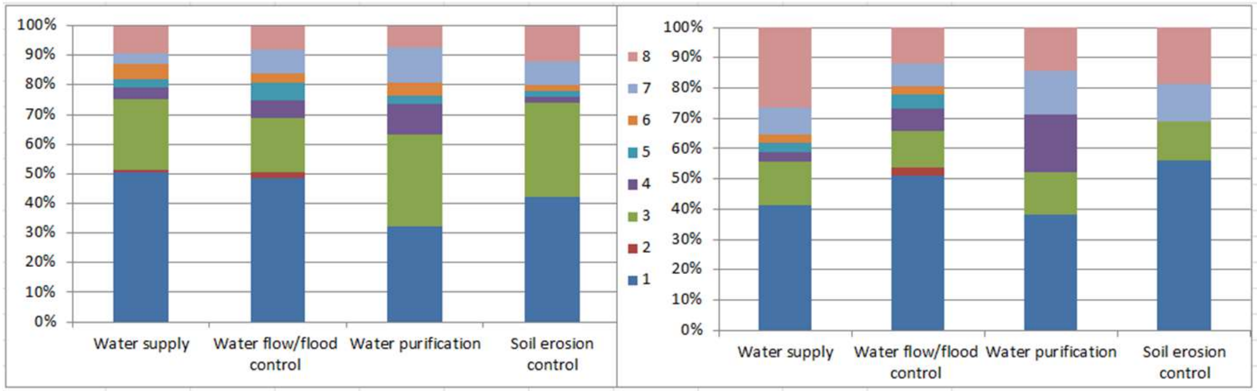


Distribution of papers related to ecosystem accounting to the number of accounting components covered by paper

3. Modeling and ecosystem accounting



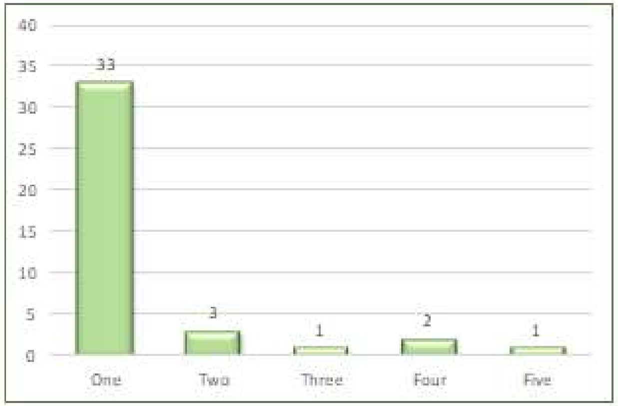
Relation between ecosystem services (CICES classes) and model categories for all papers (left) and accounting related papers (right)

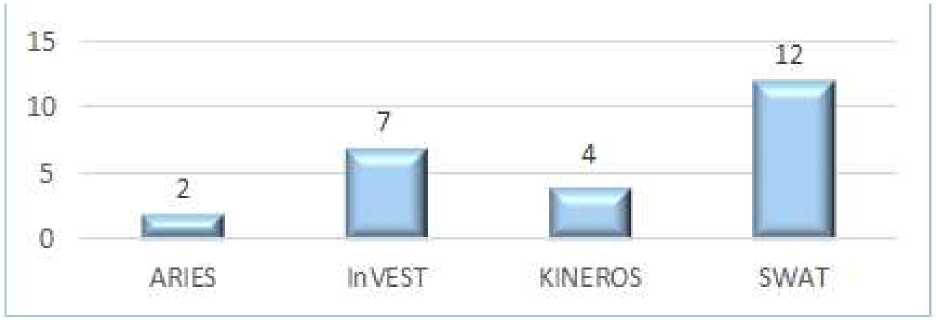


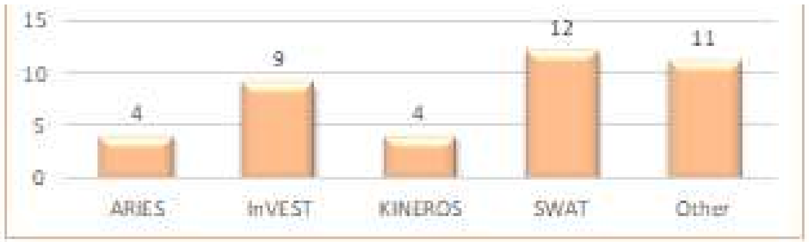
Relation between ES (SEEA-EEA reference list) and model categories (for all papers (left) and accounting related papers (right), the number of the models are given in table 1.

Extraction from the review

- The number of models used in each paper*
- Most commonly used models**
- Number of papers the four main models are used***
- The number single model papers the main models are used ****







- **River vs. Coastal flood regulation**

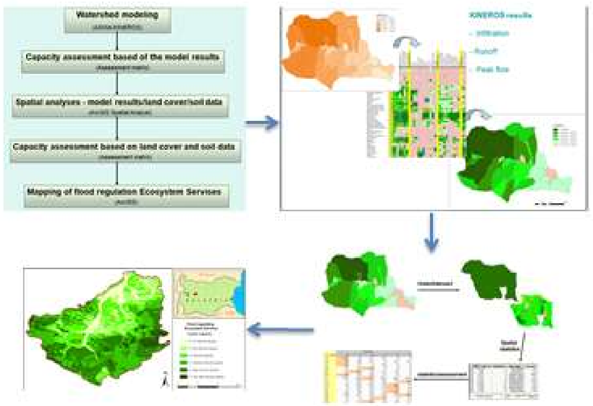
  From the perspective of quantifying the economic value the methods are broadly the same but in quantifying the biophysical nature of the service there are major differences in terms of biophysical processes, data, models and methods

- **Mitigation vs. Prevention function**

Floodplains and wetlands
Hydraulic modeling

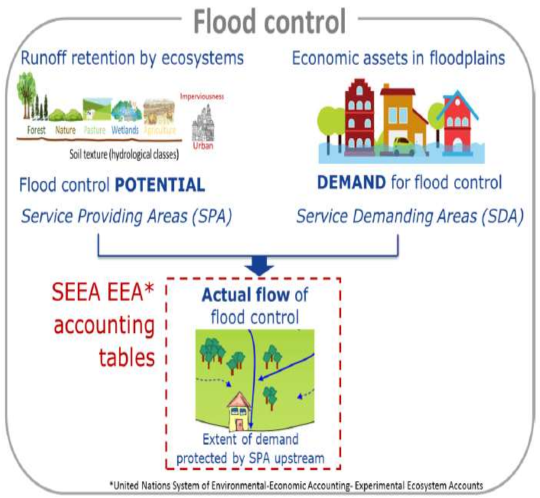
Ecosystems at watershed scale (forest)
Hydrologic modeling

Utilizing hydrologic modeling in ES assessment



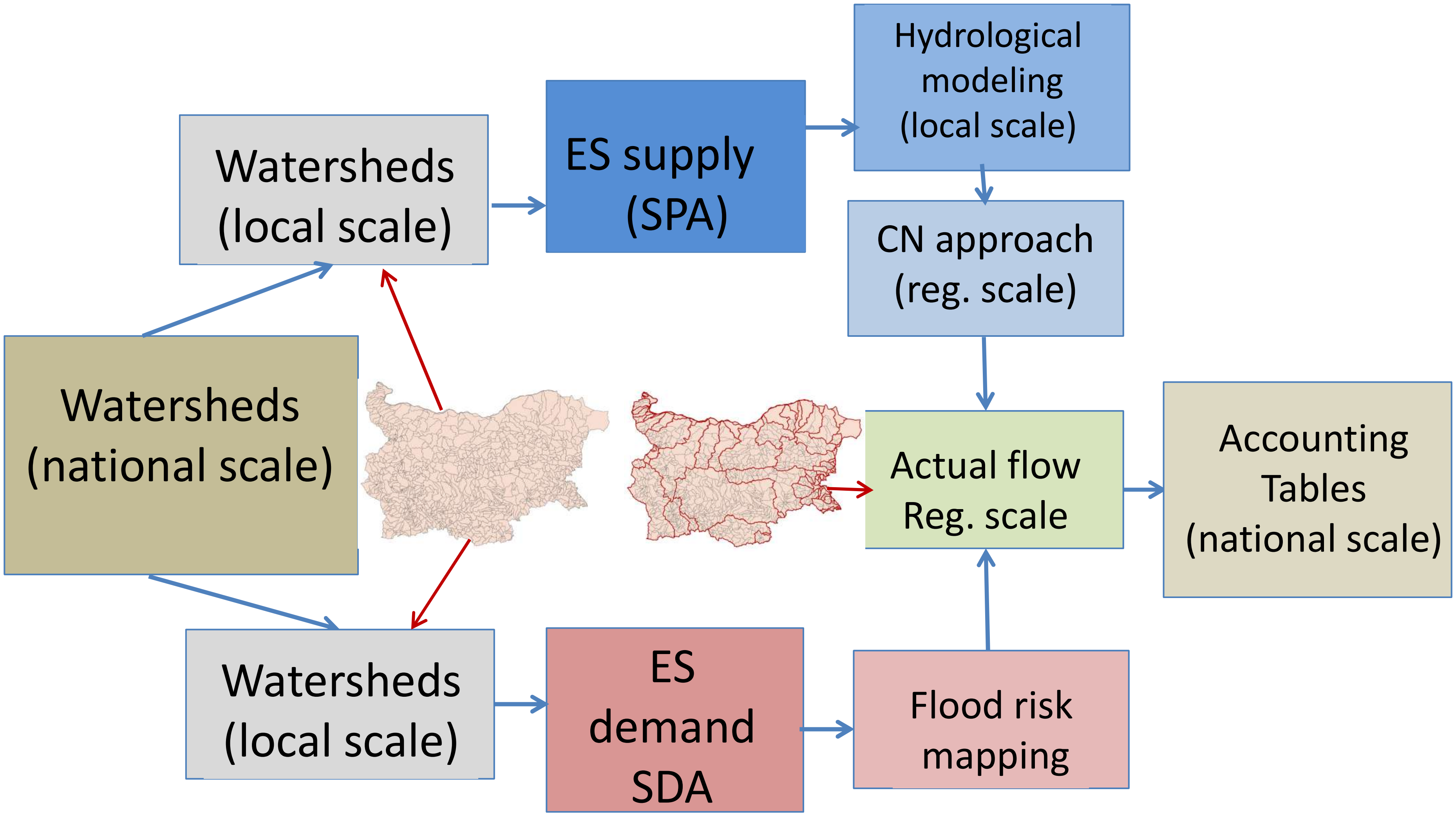
(Nedkov and Burkhard 2012

Flood ES accounting



Vallecillo et al. 2020

Conceptual scheme for Flood control accounting in Bulgaria

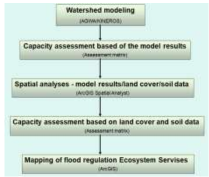


4. Flood control modeling

The main task is to delineate SPA as precisely as possible

1. Watersheds typology

2. Hydrological modeling (case studies)



Soil & Water Assessment Tool SWAT

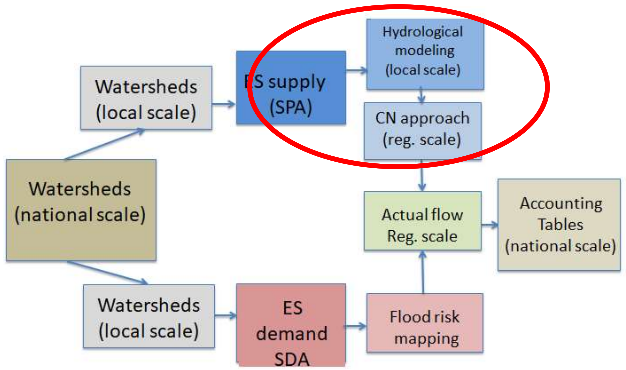
3. Calculation of LC indexes and CN parameters

4. Calculation of SPA threshold values

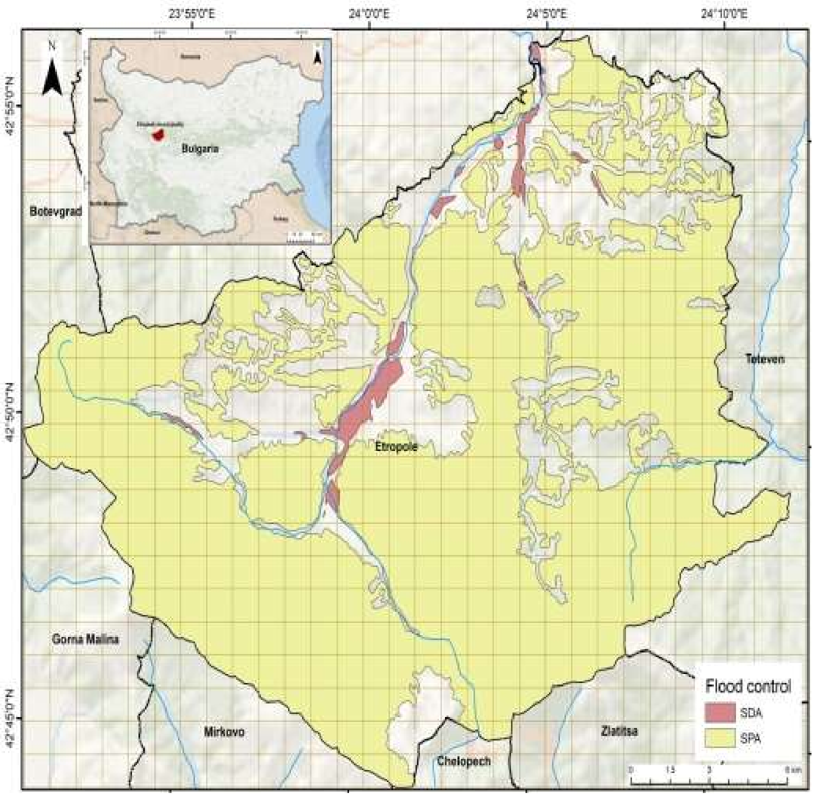
5. Application in watershed types

6. Floodplain and slope factors

7. Delineation of SPA for all watersheds



Results of the 1st stage testing at local scale



ES Flood regulation							
	Ecosystem types						
Components	Cropland	Grassland	Heathland and shrub	Urban	Woodland and forest	Total [ha]	Years assessed
ES Potential	76.35	1560.82	132.12	48.14	26316.60	28134.03	***2000***
	76.91	1560.71	132.15	74.10	26290.10	28133.97	***2006***
	190.40	1551.12	124.04	68.44	26200.00	28133.99	***2012***
	271.40	1812.11	0.00	146.97	25903.50	28133.98	***2018***
	153.76	**1621.19**	**97.08**	**84.41**	**26177.55**	**28133.99**	**average**
ES Demand	255.38	0.00	0.00	244.91	1.03		***2000***
	255.39	0.003	0.00	244.90	1.03		***2006***
	259.91	3.40	0.00	231.78	6.23		***2012***
	263.01	0.00	0.00	232.08	6.23		***2018***
	258.42	**0.85**	**0.00**	**238.42**	**3.63**	**501.32**	**average**
ES Actual flow	0.21	4.20	0.36	0.13	70.77		***2000***
	0.21	4.20	0.36	0.20	70.70		***2006***
	0.51	4.17	0.33	0.18	70.46		***2012***
	0.73	4.87	0.00	0.40	69.66		***2018***
	0.41	**4.36**	**0.26**	**0.23**	**70.40**	75.66	**average**

(Hristova et al. 2021)

5. Key findings and research perspectives

- The topic of modeling water-related ES is widely used in the scientific literature, which provides a good basis for both ecosystem assessment and accounting
- Specific accounting studies are scarce, which is a gap in ES research that needs to be filled
- A variety of approaches is available to model water-related ecosystem services
- The hydrologic model SWAT and the modeling tool InVEST are by far the most popular tools
- The hydrologic models are widely used while the hydraulic models are far less popular
- Further development of the model database and its planned integration into ESMERALDA MAES Explorer will enable to expand the online method database for mapping and assessing ES towards accounting

5. Key findings and research perspectives

Main research priorities on the integration of models in the accounting of water regulation ecosystem services:

1) analyses of models in respect to their application requirements and specific application potentials;
2) analyses of the spatial aspects of the model towards a clear distinction between ecosystem service supply and use;
3) development of guidelines for improved use of models in ecosystem accounting

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MAIA
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The team behind the literature review:

Sylvie Campagne, Bilyana Borisova, Petr Krpec, Hristina Prodanova, Ioannis P. Kokkoris, Desislava Hristova, Solen Le Clec'h, Fernando Santos-Martin, Benjamin Burkhard, Eleni S. Bekri, Vanya Stoycheva, Adrian Bruzon, Panayotis Dimopoulos

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Thank you for your attention

snedkov@abv.bg

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Questions