

# The Green Sudoku and Nature-based Solutions

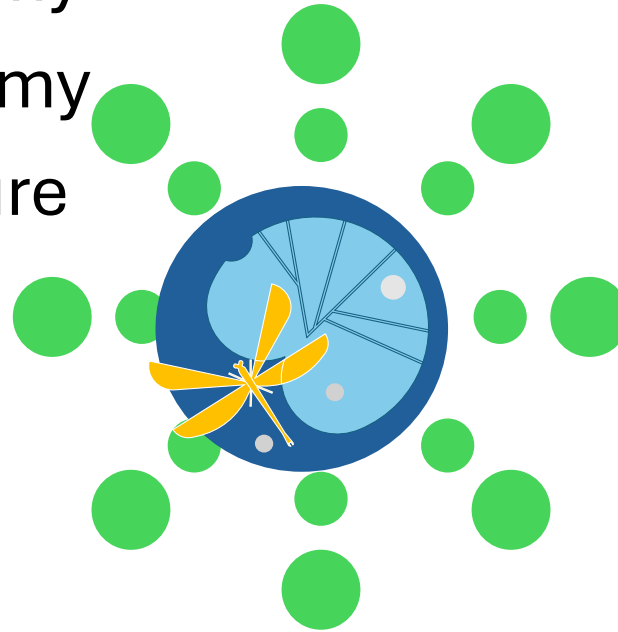
Alessandra La Notte

**31<sup>st</sup> London Group Meeting, Tallinn (EE)**

**25 September 2025**

# What is the problem?

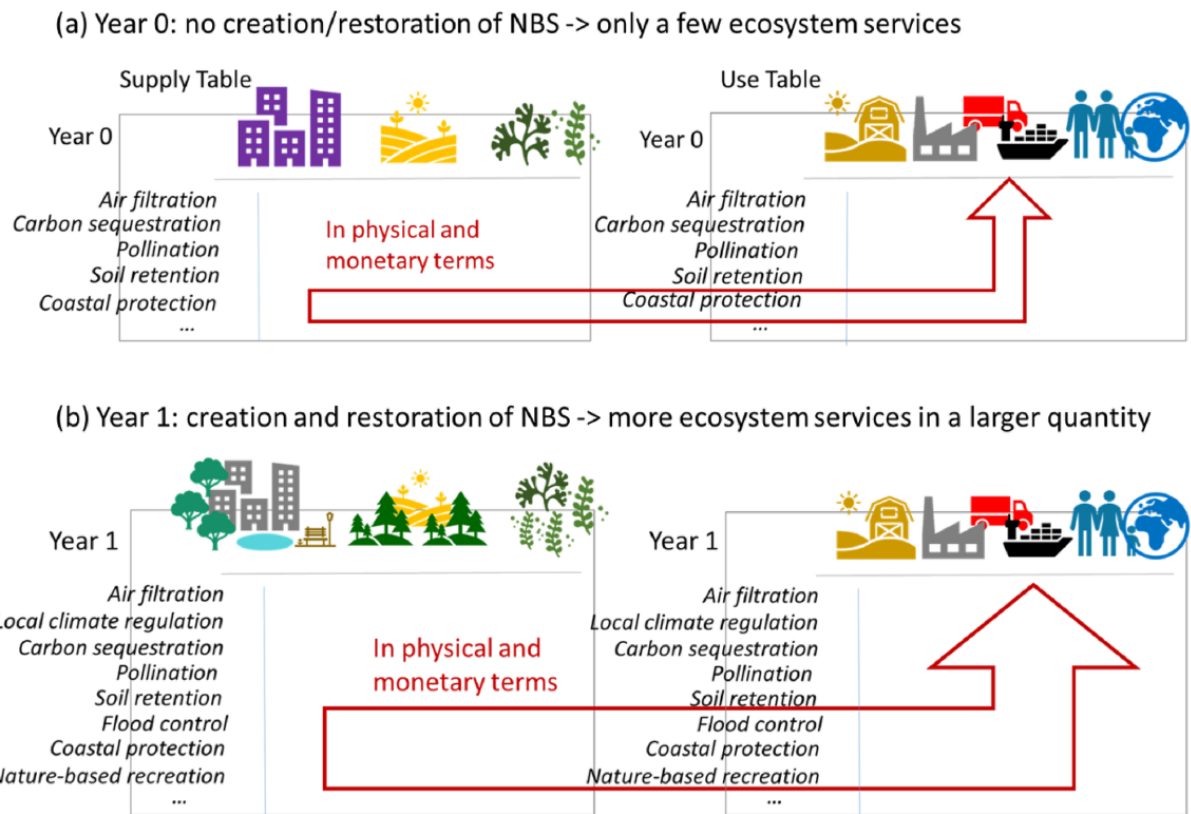
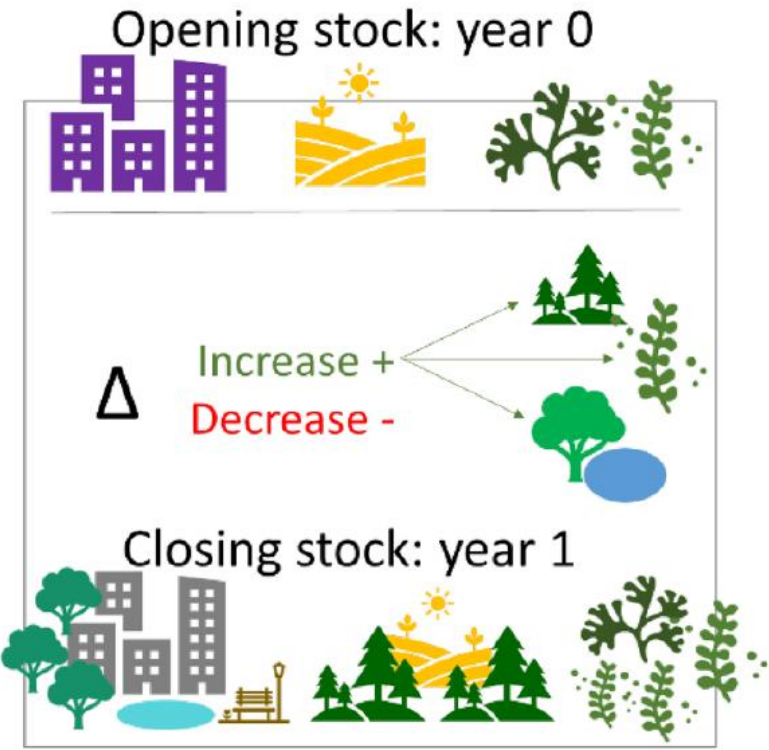
- Transformative economy
- Nature Positive economy
- Regenerative agriculture
- ...



## Nature-based Solutions

How to (i) connect, (ii) measure and (iii) monitor that the investments in Nature-based Solutions generate advantages for the economy and for the society?

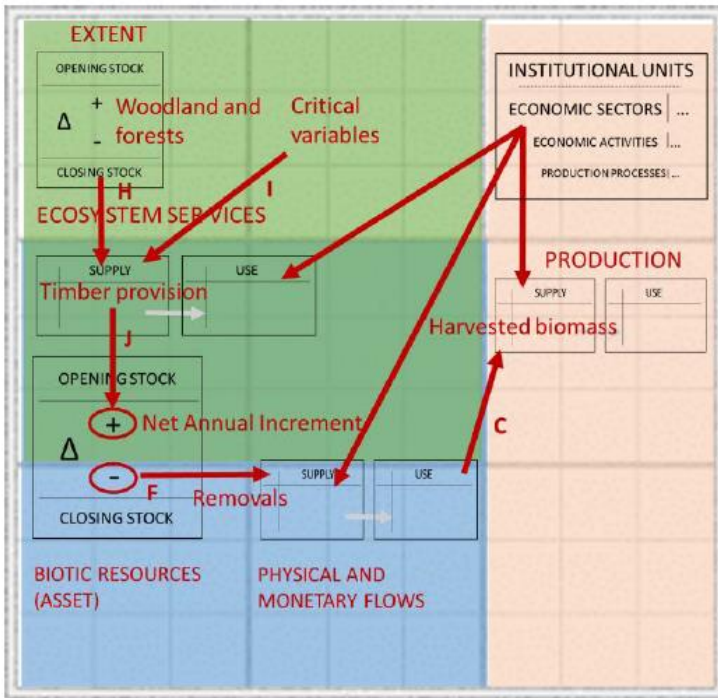
# We are aware that NbS enhance ecosystem condition & services



<https://www.sciencedirect.com/science/article/pii/S2772411524000557>

...but we don't know how to connect this directly with "investments in NbS"

# The Green Sudoku approach



## Legend

- Direct linkages
- Indirect linkages
- C** Economic products
- F** Extraction of biotic resources
- H** Ecosystem extent input
- I** Other input variables
- J** Ecosystem service (physical)

**SEEA EA**

Woodland and forests		EXTENT	
Km2			
Opening stock	1,572,705		

SUPPLY				USE				
Ecosystem Services	Economic Units		Ecosystem Types	Total supply by Ecosystem Service	Ecosystem Services	Economic Units		Total (final) use by Economic Unit
	Industries	Households	Terrestrial			Industries	Households	
Provisioning services					Provisioning services			
timber provision			891,220	891,220	timber provision	891,220		891,220

Opening stock	19,641,808	1,808,290
<b>Addition to stock</b>		
Growth in stock	891,220	21,072
<b>Reductions in stock</b>		
Removals	464,345	-
Losses	202,421	-
Closing stock	19,866,262	1,829,362

**BIOTIC RESOURCES (ASSET)**

**SEEA CF**

SUPPLY					USE						
	Production		Rest of the world	Environment	Total supply		Production		Rest of the world	Environment	Total use
	Industries	Households					Industries	Households			
Natural inputs				464,345		Natural inputs	464,345				464,345
Residuals						Residuals					
<b>Total supply</b>				464,345	464,345	<b>Total use</b>	464,345				464,345

**SNA**

SUPPLY				USE					
	Production		Rest of the world	TOTAL		Production		Rest of the world	TOTAL
	Industries	Households				Industries	Households		
Products	408,929		57,222	466,151	Products	359,363	71,576	35,212	466,151
industrial RW	332,917		55,810	388,727	industrial RW			33,493	33,493
fuelwood	76,012		1,412	77,424	fuelwood			1,719	1,719
<b>Total Supply</b>	<b>408,929</b>		<b>57,222</b>	<b>466,151</b>	<b>Total Supply</b>	<b>359,363</b>	<b>71,576</b>	<b>35,212</b>	<b>466,151</b>

1st numerical example:  
timber provision

# The Green Sudoku approach

**SNA**

**EMISSIONS**

tonne	Production	
	Industries	Households
Products	606,500,480	

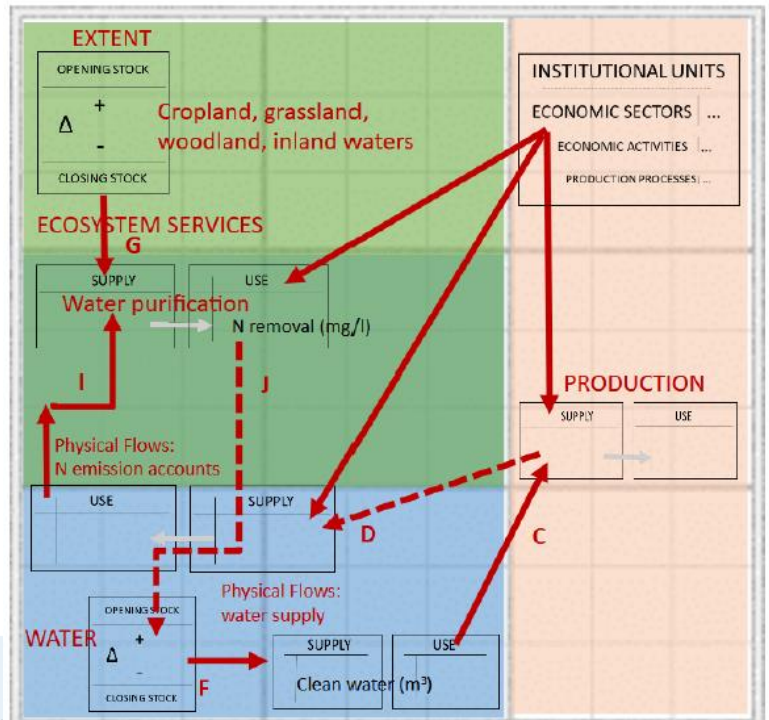
**SEEA CF**

**SUPPLY**

tonne	Production		Rest of the world	Environment	Total supply
	Industries	Households			
Natural inputs					
Residuals	4,102,132	1,002,015			5,104,147
<b>Total supply</b>	<b>4,102,132</b>	<b>1,002,015</b>			<b>5,104,147</b>

**USE**

tonne	Production		Rest of the world	Environment	Total supply
	Industries	Households			
Natural inputs					
Residuals				5,104,147	5,104,147
<b>Total use</b>				<b>5,104,147</b>	<b>5,104,147</b>



- Legend**
- Direct linkages
  - - - Indirect linkages
  - C Economic products
  - D Emissions & wastes
  - F Extraction of abiotic resources
  - G Ecosystem extent input
  - I Other input variables
  - J Ecosystem service (physical)

**SEEA EA**

**SUPPLY**

tonne	Economic Units		Ecosystem Types	Total supply by Ecosystem Service
	Industries	Households		
Regulating services			actual flow	
water purification			1,512,236	1,512,236
			overuse (1mg/l)	
			1,300,895	1,300,895

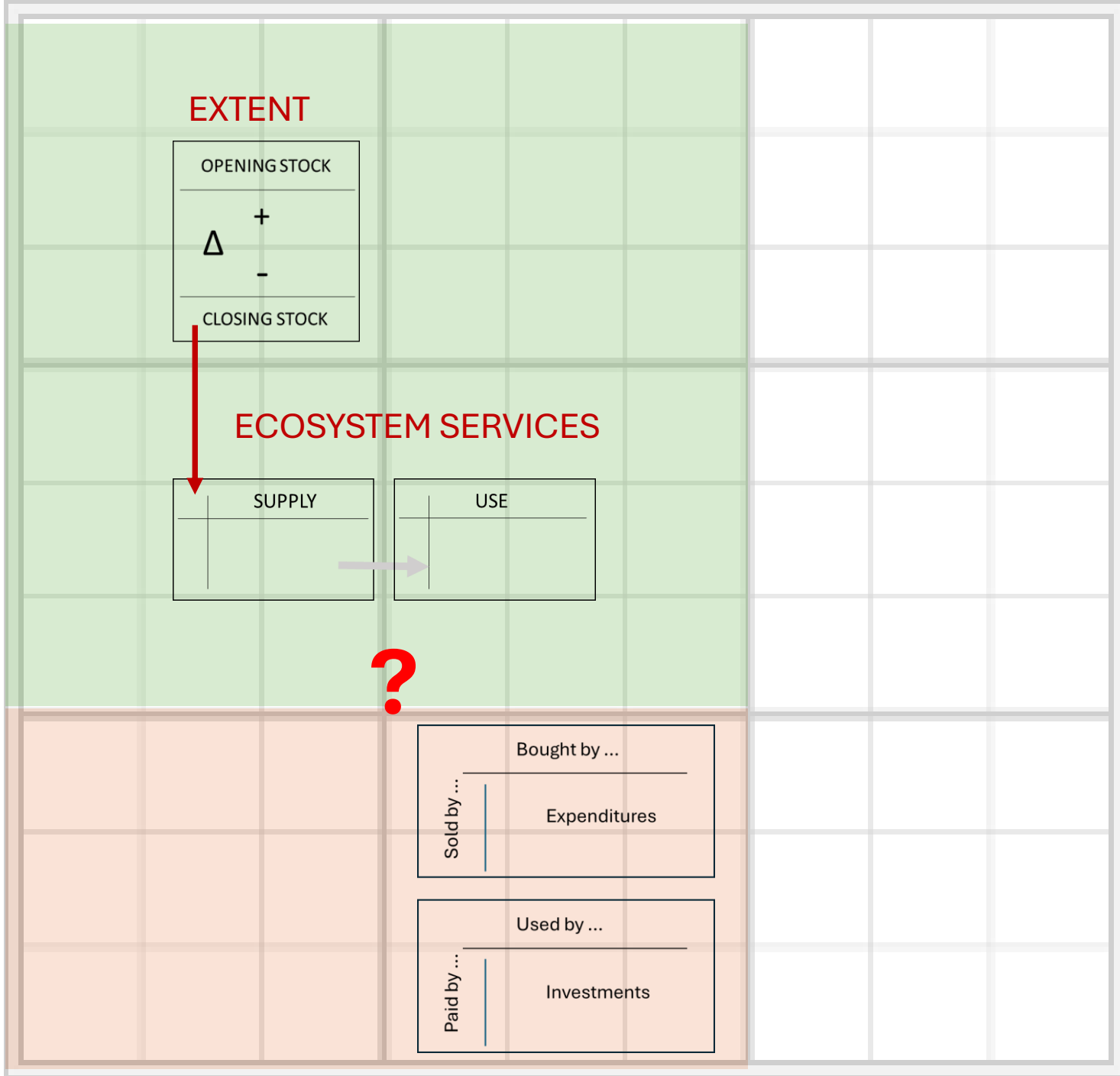
**USE**

tonne	Economic Units		Total (final) use by Economic Unit
	Industries	Households	
Regulating services			actual flow
water purification	1,285,401	226,835	1,512,236
			overuse (1mg/l)
	1,105,761	195,134	1,300,895

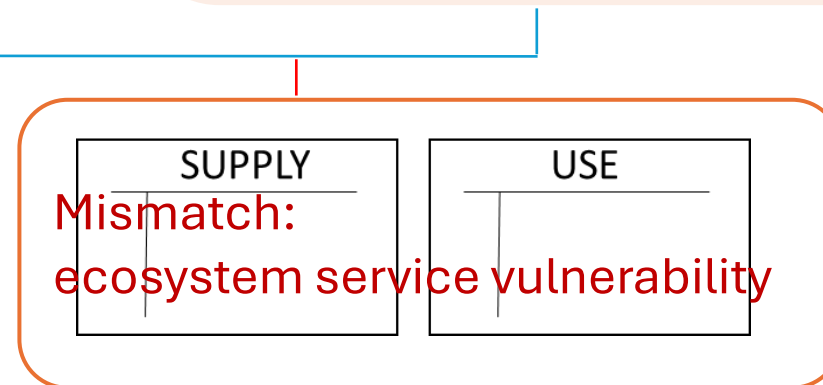
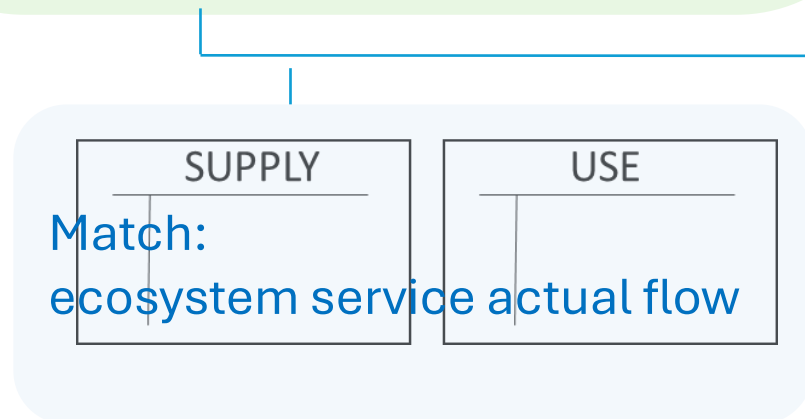
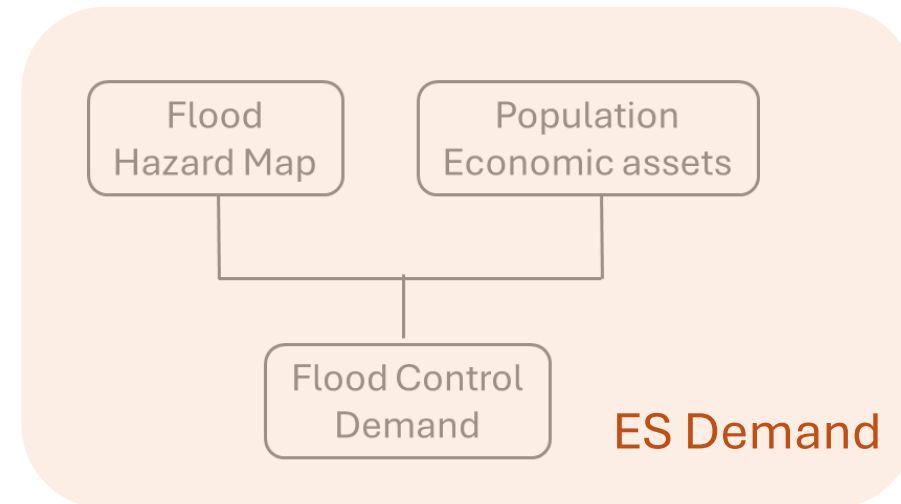
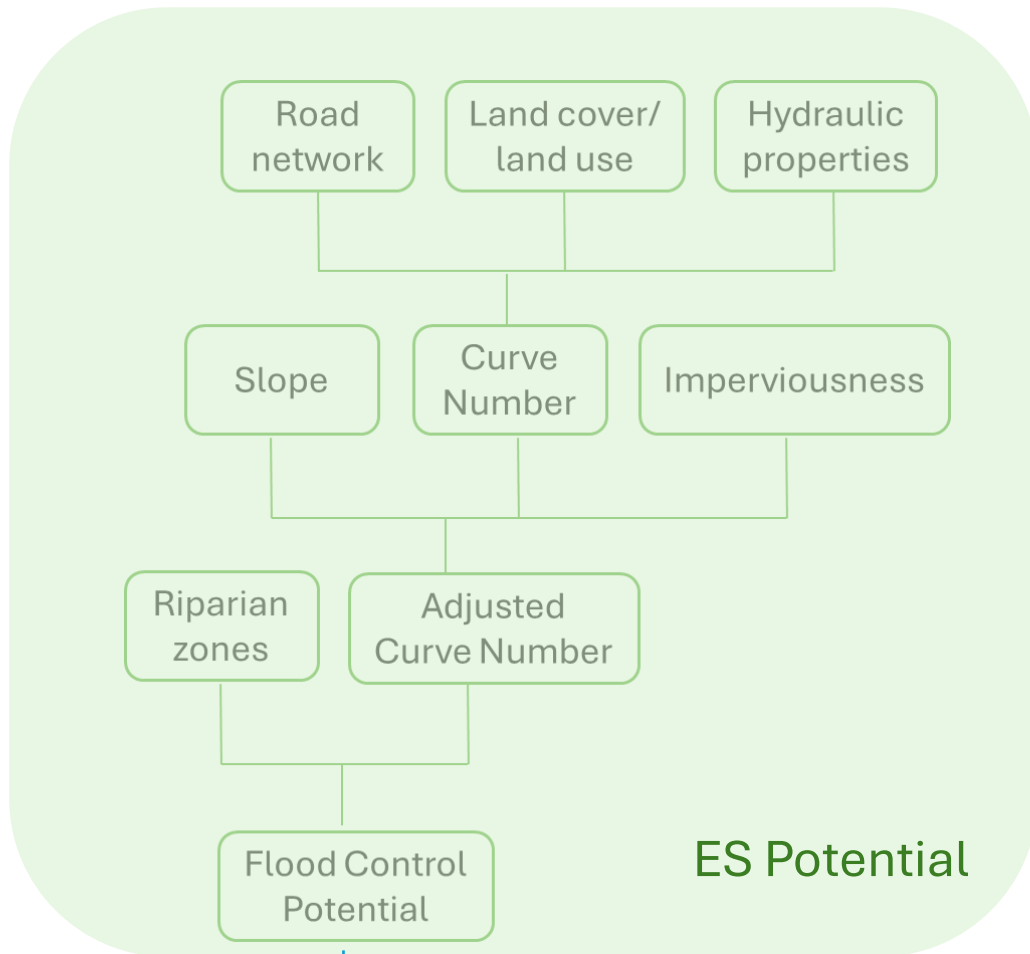
2nd numerical example:  
water purification

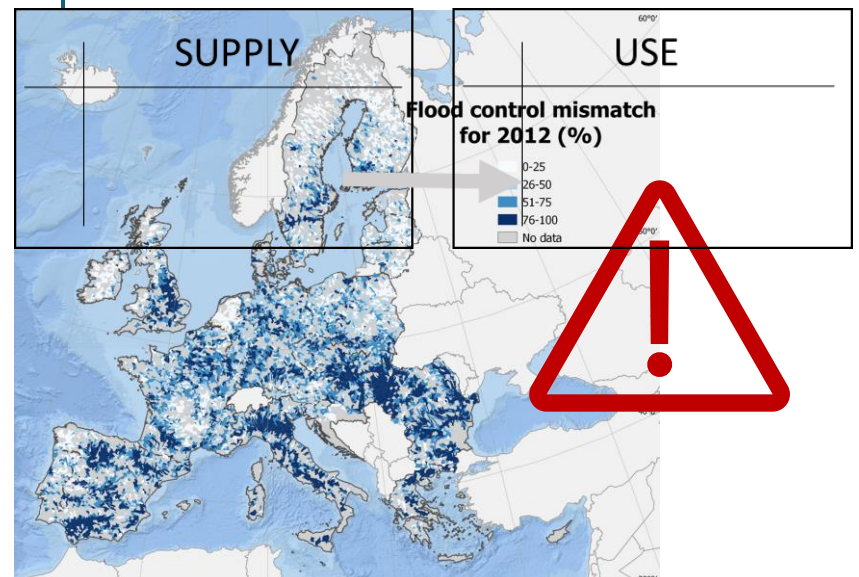
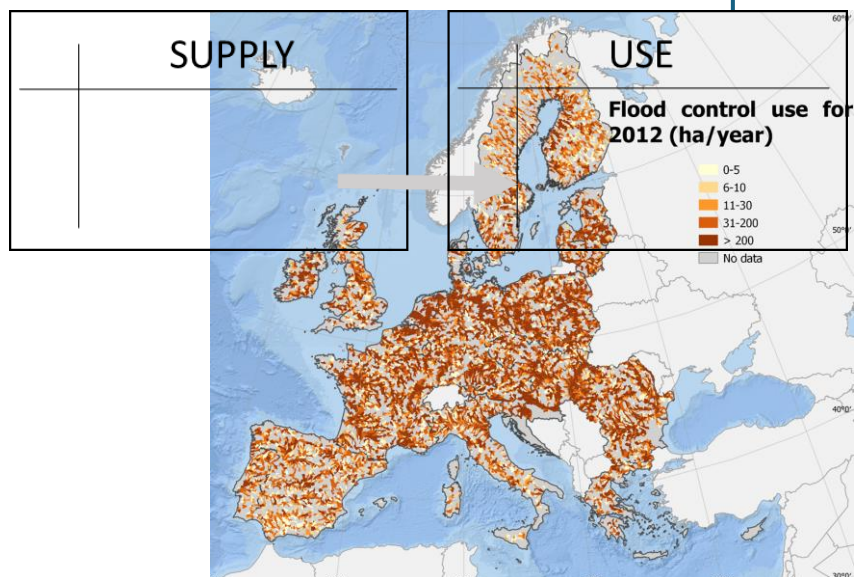
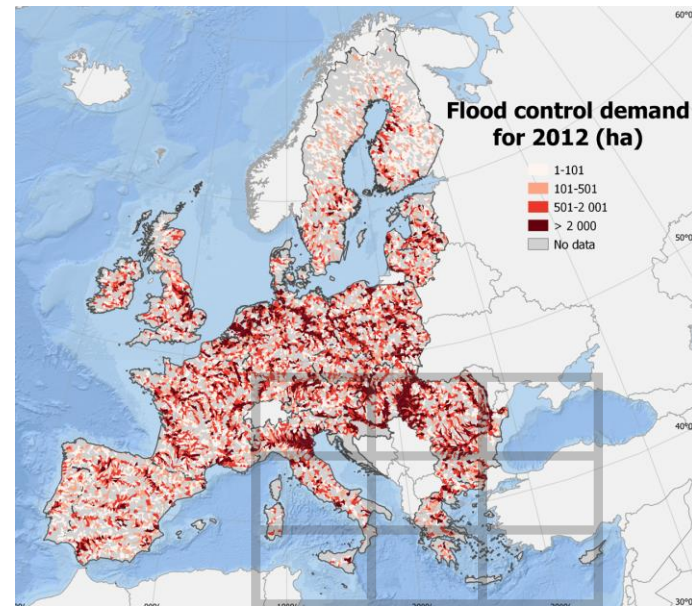
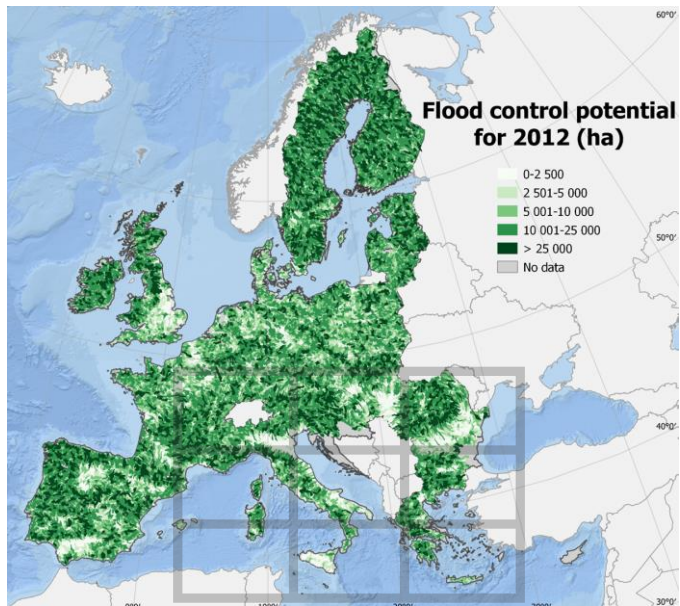
SEEA EA

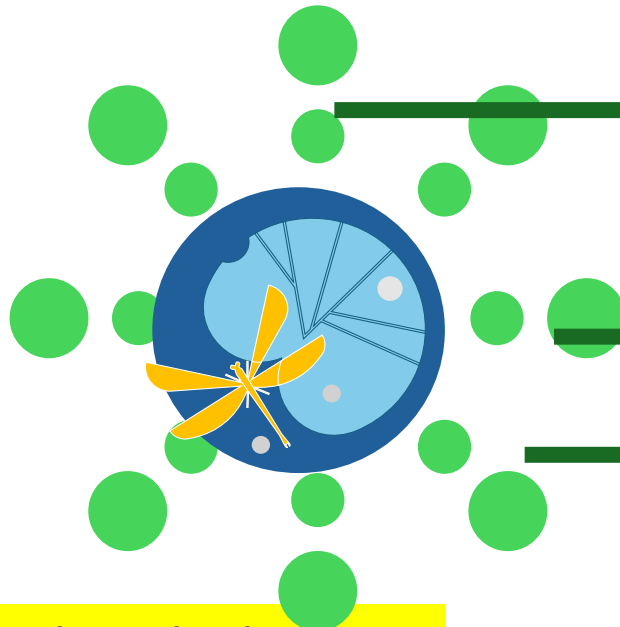
SNA



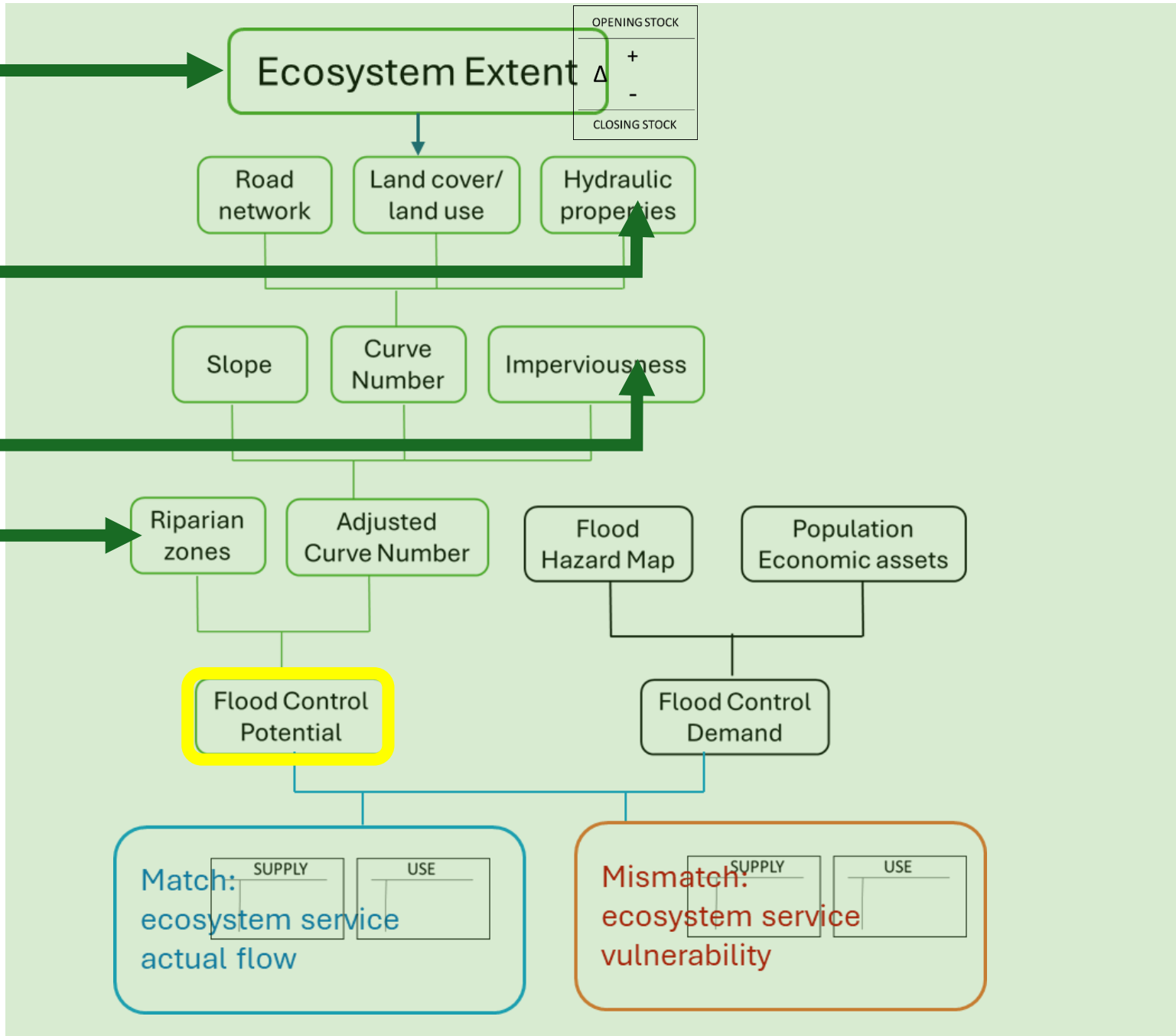
# Let's brainstorm with an example: flood control







Nature-based solutions  
Biophysical information



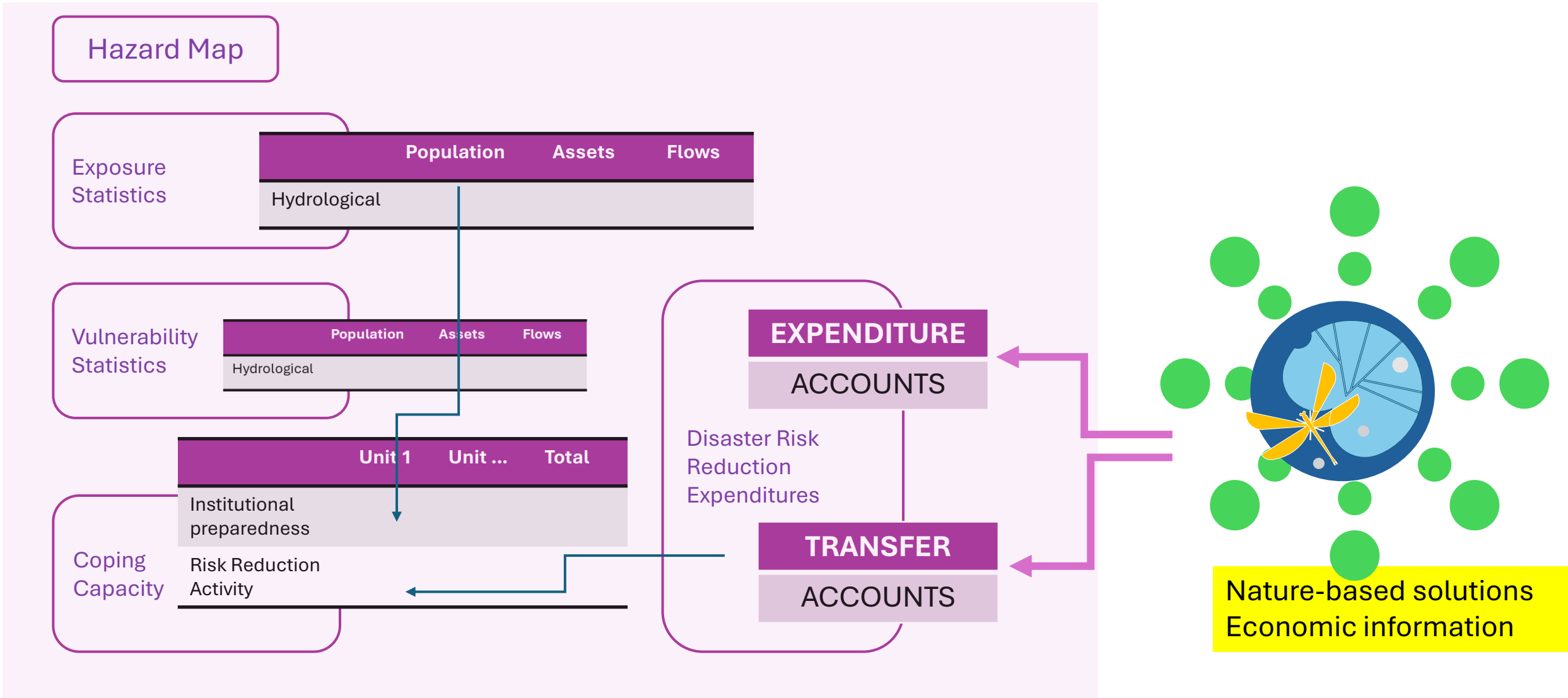
Match: 

SUPPLY	USE
ecosystem service	actual flow

Mismatch: 

SUPPLY	USE
ecosystem service	vulnerability

# Let's add one component to the Green Sudoku: the Global Disaster-Related Statistic Framework



# The classification of disaster risk activities

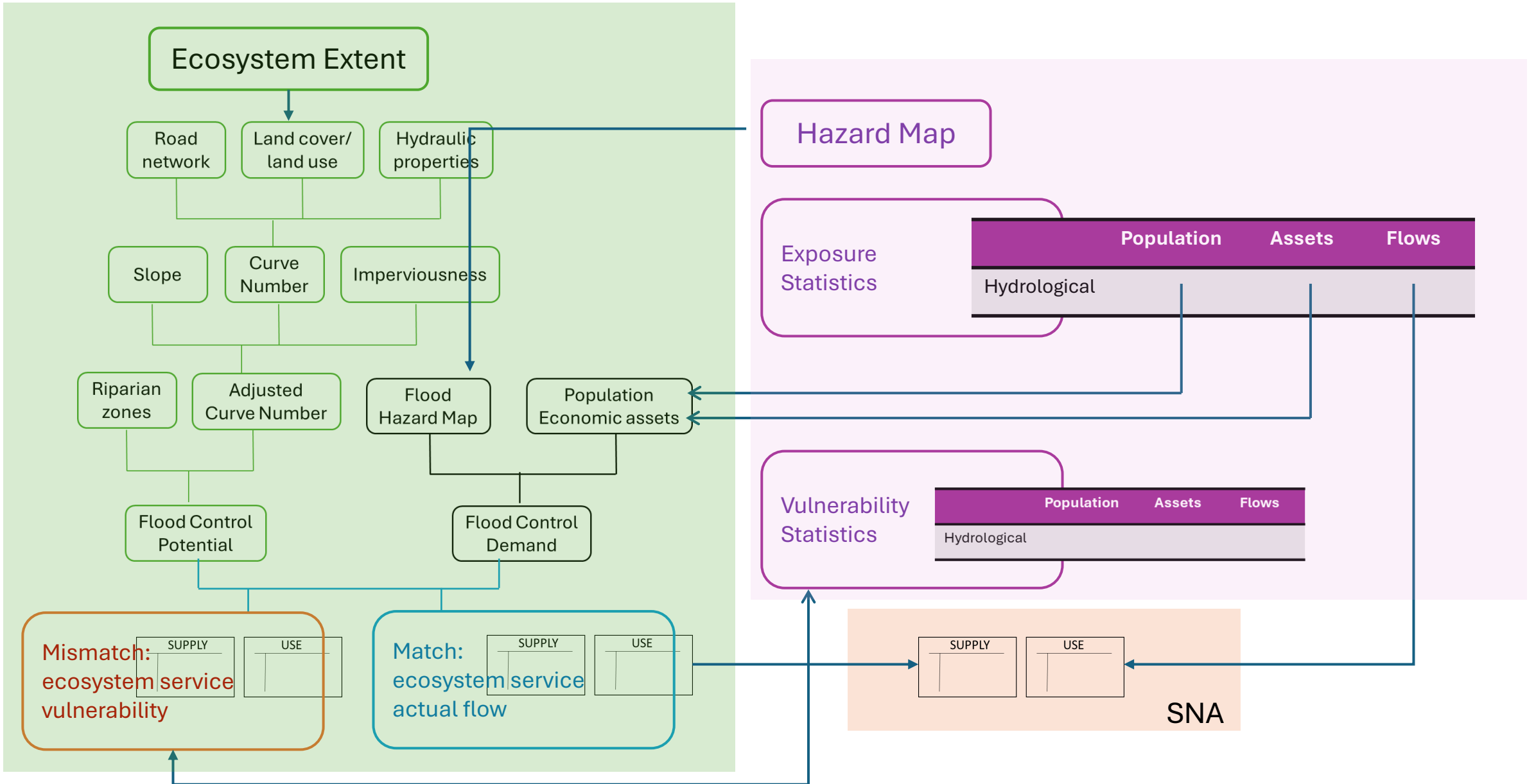
1. Disaster risk prevention: activities and measures to avoid existing and new disaster risks. The objective of risk prevention activities is to avoid potential adverse impacts of disasters before, during and after their occurrence
  1. Risk prevention before disaster activities aim at reducing vulnerability and exposure to hazards...
2. Disaster risk mitigation: activities to reduce or lessen existing disaster risks or to limit their adverse impacts
  1. Structural measures: any physical construction activity to reduce or avoid possible impacts of hazards...
3. Land use planning



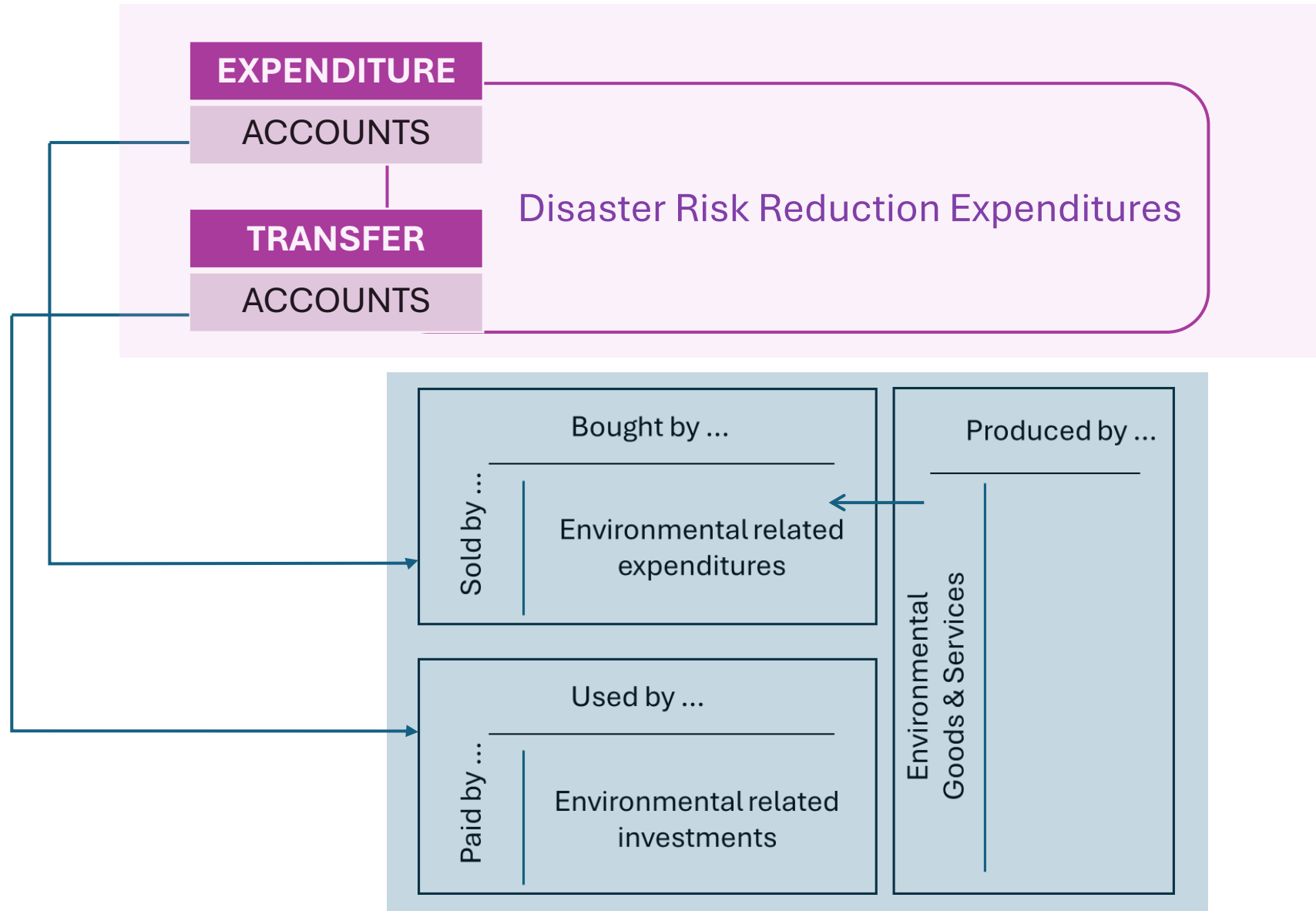


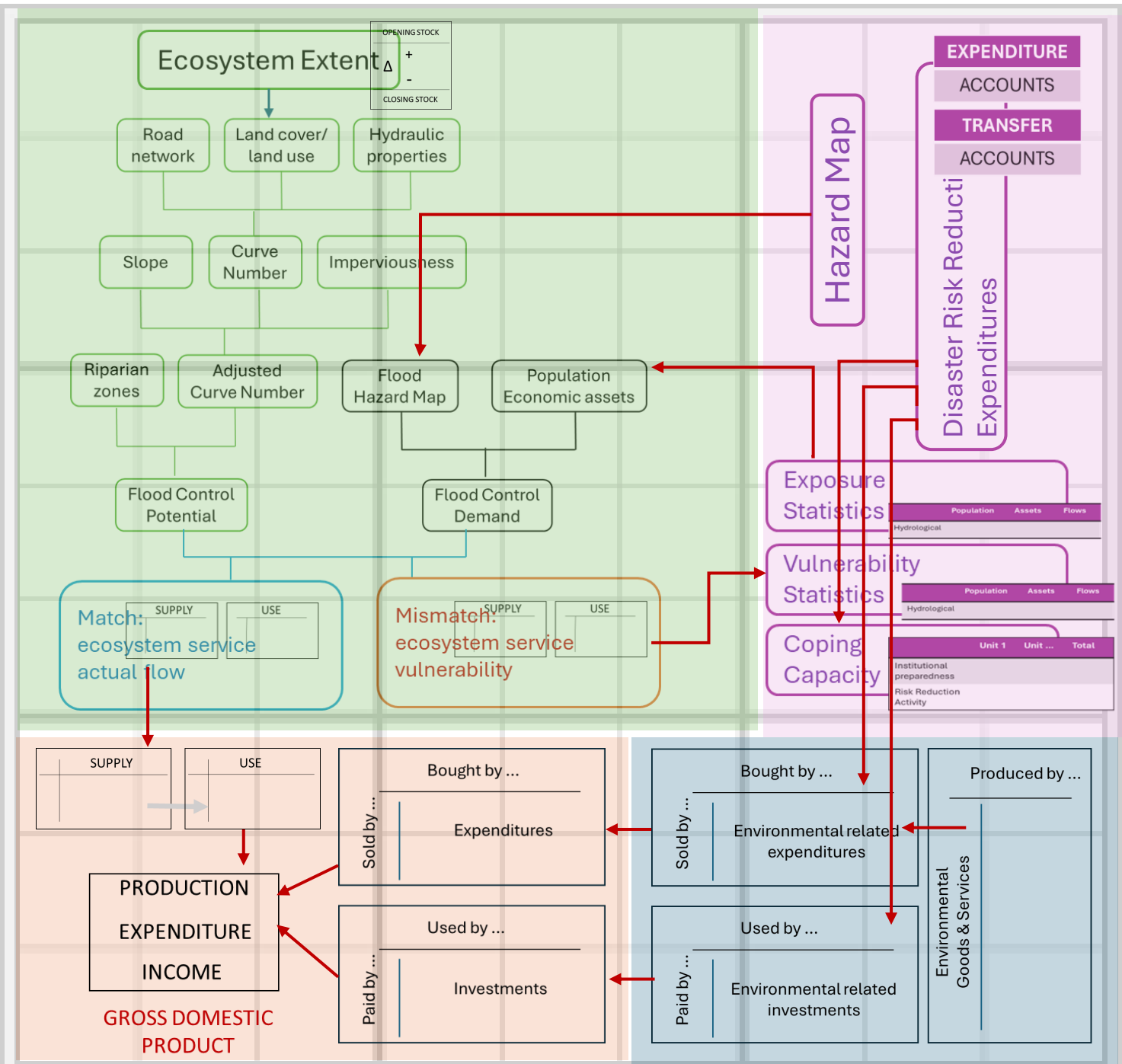


# The connection between G-DRSF and SEEA EA



# The connection between G-DRSF and SEEA CF





Ecosystem Extent  $\Delta$  +  
-  
CLOSING STOCK

Road network Land cover/land use Hydraulic properties

Slope Curve Number Imperviousness

Riparian zones Adjusted Curve Number Flood Hazard Map Population Economic assets

Flood Control Potential Flood Control Demand

Match: ecosystem service actual flow  
SUPPLY USE

Mismatch: ecosystem service vulnerability  
SUPPLY USE

Hazard Map

EXPENDITURE ACCOUNTS  
TRANSFER ACCOUNTS

Disaster Risk Reduction Expenditures

Exposure Statistics  
Hydrological Population Assets Flows

Vulnerability Statistics  
Hydrological Population Assets Flows

Coping Capacity  
Institutional preparedness Risk Reduction Activity  
Unit 1 Unit ... Total

SUPPLY USE

PRODUCTION EXPENDITURE INCOME

GROSS DOMESTIC PRODUCT

Bought by ...  
Sold by ...  
Expenditures

Used by ...  
Paid by ...  
Investments

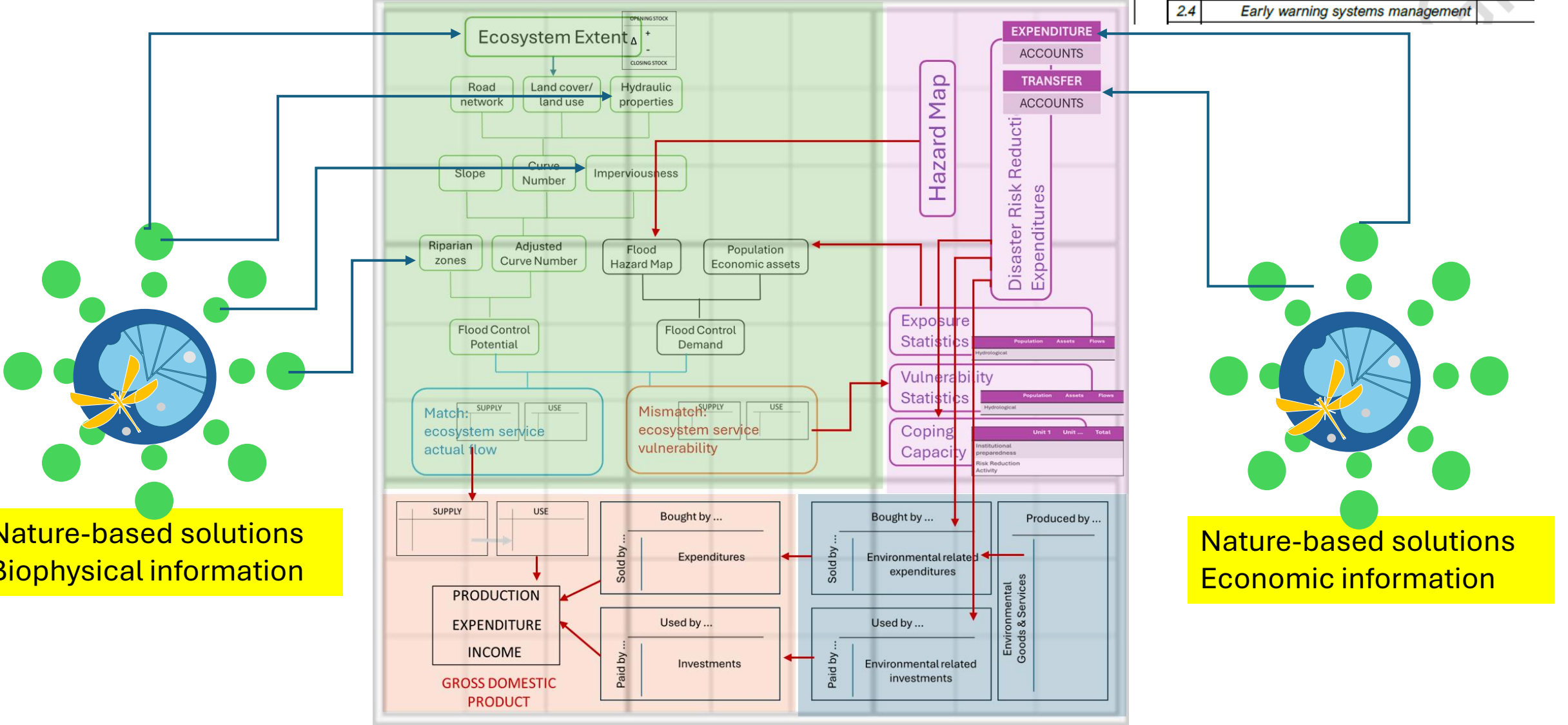
Bought by ...  
Sold by ...  
Environmental related expenditures

Used by ...  
Paid by ...  
Environmental related investments

Produced by ...  
Environmental Goods & Services

# Time 0: when the investment in NbS is undertaken

B Investment expenditure (gross fixed capital formation)	
1	Disaster risk prevention
1.1	Risk prevention before disasters
1.2	Risk prevention in or after disasters
2	Disaster risk mitigation
2.1	Structural measures
2.2	Non-structural measures
2.3	Land-use planning
2.4	Early warning systems management



Nature-based solutions  
Biophysical information

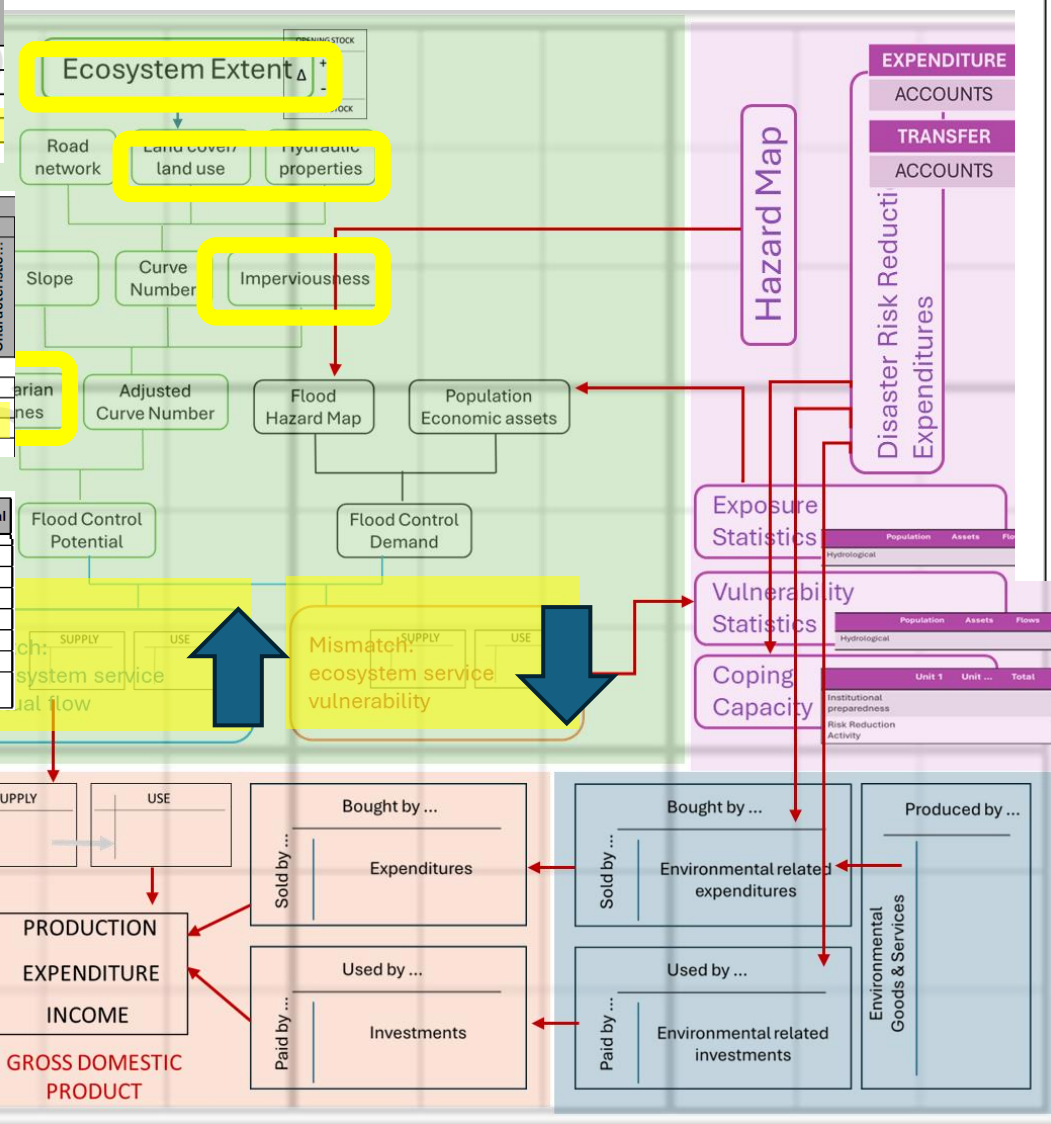
Nature-based solutions  
Economic information

# Time 1: after 2, 5, 10 years (depending on the NbS)

Hazard type	Exposure elements									
	Population	Assets				...	Flows			
		Asset i	Asset ii	Asset iii	Asset iiiii		Flow i	Flow ii	Flow iii	Flow iiiii
Hydrological and meteorological										
High exposure										
Medium exposure										
Low exposure										
<b>Total</b>										

Hazard type	Population	Assets						Flows	
		Asset i		Asset ii		Asset...		Flow i	Flow ii
		Characteristic i	Characteristic ii	Characteristic i	Characteristic ii	Characteristic i	Characteristic ii	Characteristic i	Characteristic ii
Hydrological and meteorological									
High exposure									
Medium exposure									
Low exposure									
<b>Total</b>									

Coping capacity type	Geographic unit 1	Geographic unit 2	Geographic unit ...	National total
<b>Risk Reduction Activity (sub-national DRRE)</b>				
Disaster risk reduction characteristic transfers received				
Disaster Risk Prevention				
Disaster Risk Mitigation				
Disaster Management				
Disaster Recovery				
General Government, Research & Development, Education Expenditure				



<b>1</b>	<b>Disaster risk prevention</b>	
1.1	Risk prevention before disasters	
1.2	Risk prevention in or after disasters	
<b>2</b>	<b>Disaster risk mitigation</b>	
2.1	Structural measures	
2.2	Non-structural measures	
2.3	Land-use planning	
2.4	Early warning systems management	
<b>3</b>	<b>Disaster preparedness and response</b>	
3.1	Preparedness	
3.2	Emergency management	
3.3	Emergency supply of commodities	
3.4	Other disaster response activities	
<b>4</b>	<b>Disaster recovery</b>	
4.1	Relocation	
4.2	Rehabilitation	
4.3	Reconstruction	
<b>5</b>	<b>General government, research &amp; development, education, activities</b>	
5.1	General government activities for disaster risk reduction	
5.2	Research and development, risk assessment, and information activities	
5.3	Education activities for disaster risk reduction	

**Nature-based solutions**  
Biophysical information

**Nature-based solutions**  
Economic information

# Some reflections...

- There are cases when we **don't need new accounts, but rather clear connections**
- Statisticians cannot **measure real-world effect**, but ecological modelers can estimate them
- The sudoku works not only at the **accounts** level, but also at **classifications** and **statistics** levels
- An effective connection may need to be worked on **over different time periods**.

## ...and some questions

- What do you think about the proposed **connections** and suggested **connectors**?
- Which are the weakness that you see? (Any idea how to address them?)
- Do you agree with the above reflections?
- Are you willing to work with a concrete numerical example?