

# A multi-indicator framework for mapping the potential impacts of forest management activities on aquatic ecosystem services

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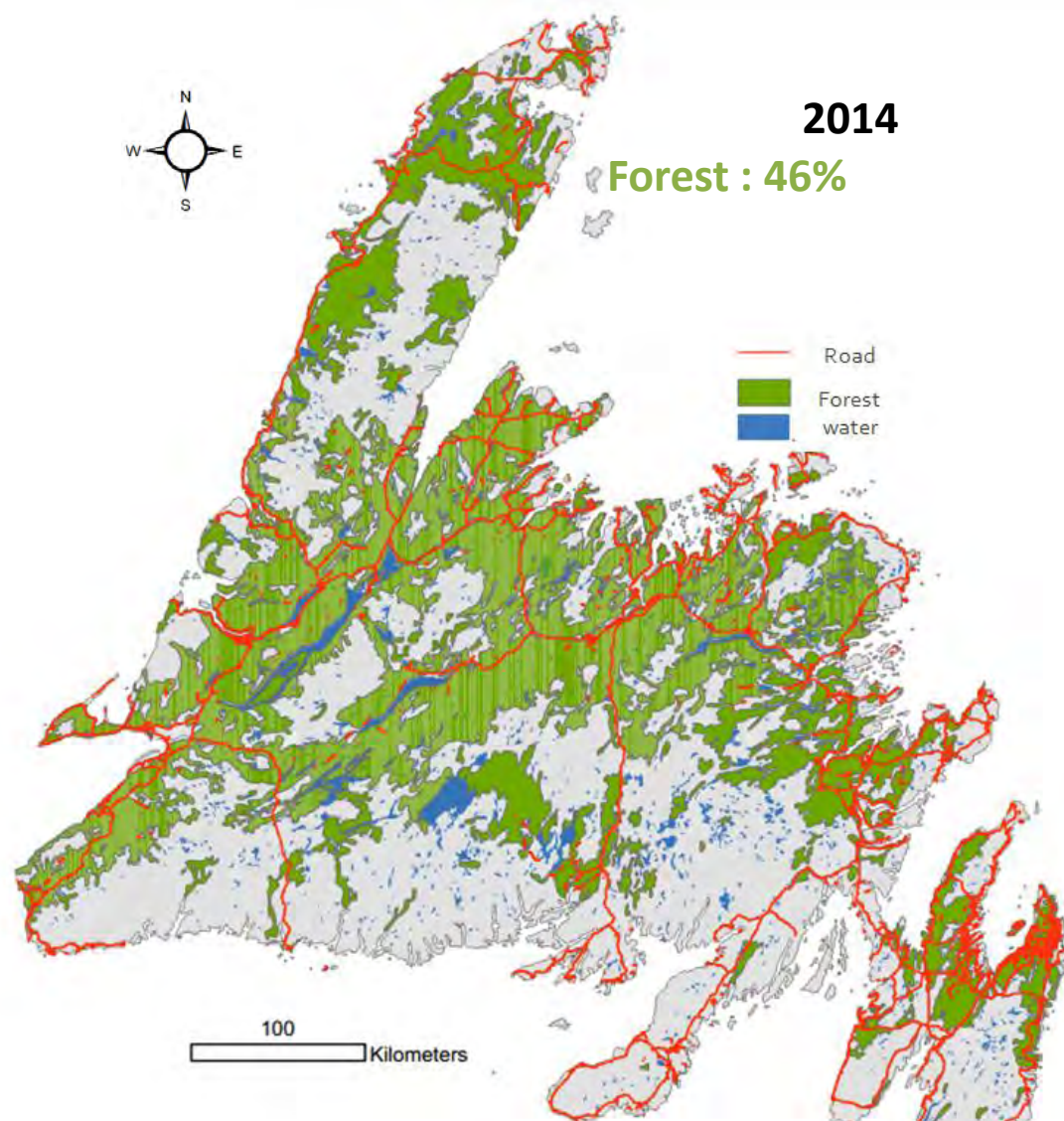
# Newfoundland Island Forest

Forest industry



an important component of  
the economy of  
Newfoundland

“1.3 million m<sup>3</sup> of local timber to  
produce wood products valued at  
\$259 million”  
(2012)



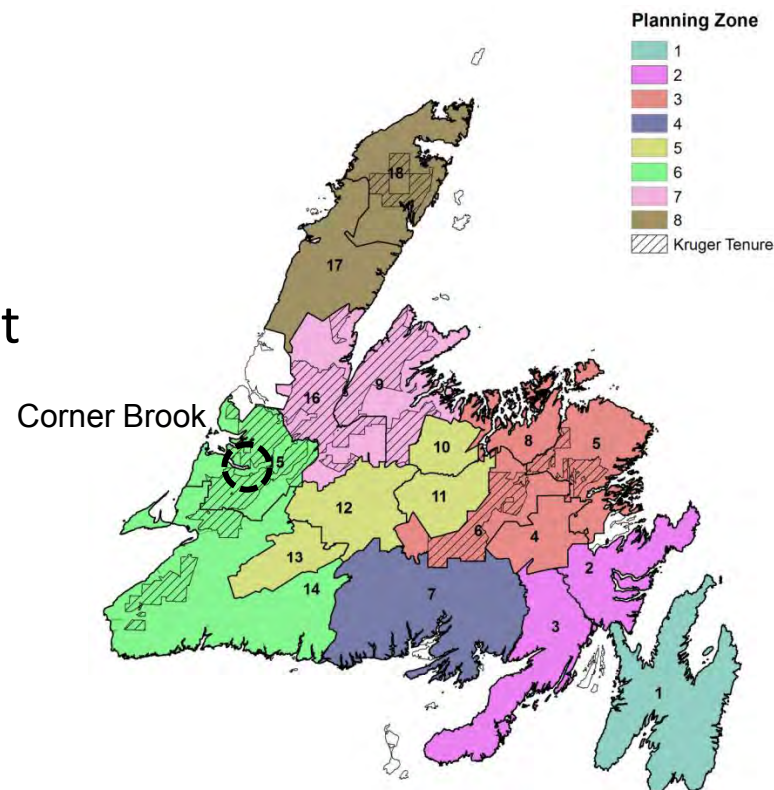
Source : Government of Newfoundland and Labrador



# Newfoundland Island

## Forest management

- Main contributors to forest management in Newfoundland:
  - Provincial Government
  - Corner Brook Pulp and Paper Ltd



Source : Government Newfoundland and Labrador

**Trend** : Since 2014, forest management emphasizes ecological sustainability and protection of the environment in order to limit impacts on forest ecosystem.

# Newfoundland Island

## Impacts on forest ecosystems

- **Forest industry** requires significant wood resources
- Resulting in **forest activities**



Harvest



Logging



Infrastructure

### Potential impacts on ecosystem services

- Forest loss cover
- Water cycle disturbance
- Soil disturbance
- Biodiversity loss
- Landscape fragmentation

# Ecosystem Services

## Definition

“ Benefits that humans obtain from ecosystems directly or indirectly ”  
 (Millennium Ecosystem Assessment report, 2005)

**Services = Benefits**





# Ecosystem Services

## Definition

- An ecosystem service is defined **only** if the potential **supply** and **demand** of the service exist.

(Villamagna *et al*, 2014; Cimon-Morin *et al*, 2014)

○ **Supply** : the capacity of a landscape to produce a service.

○ **Demand** : The human needs to use a particular service.

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# Newfoundland Island

## Water component

- **Water: an essential component of the forest ecosystem**

**Aquatic Ecosystem Services**





## Research Question

How can effects of forest management activities on aquatic ecosystem services be quantified using available geospatial data?

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**Hydrological  
physical model**

**Focus group of  
Experts**

**Index /  
indicators**

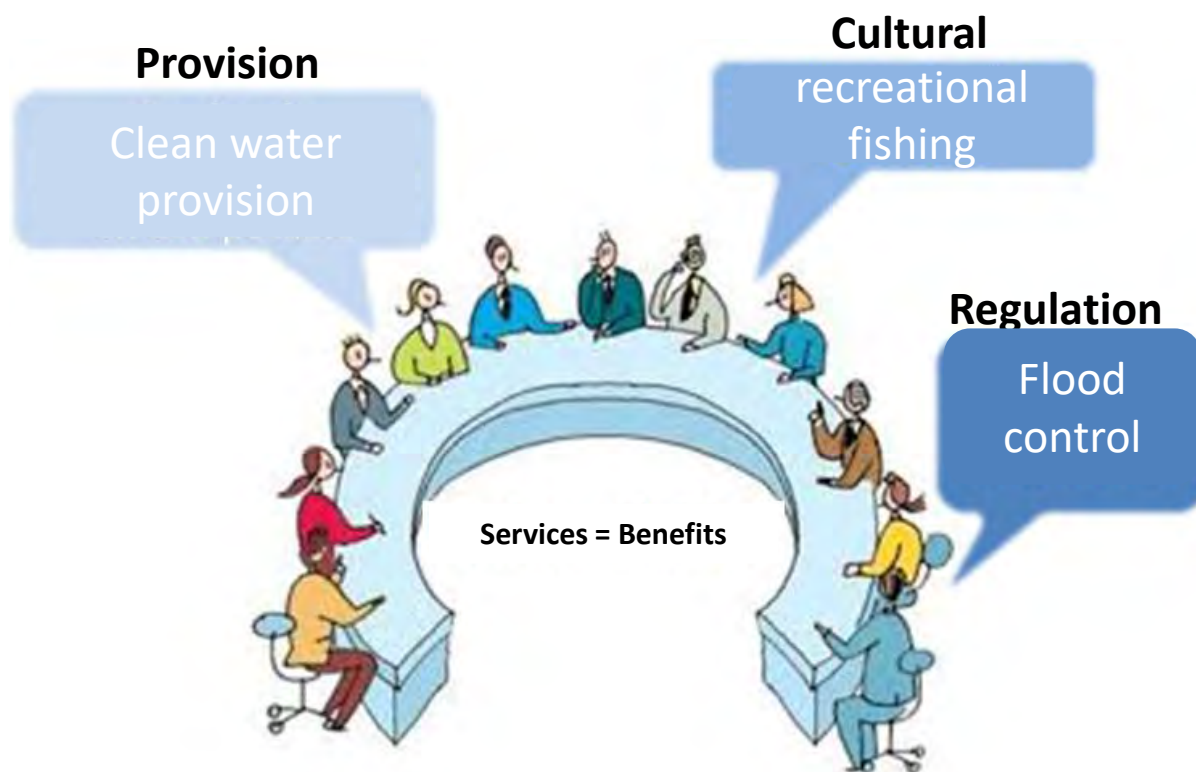
## Aim of the project

- Develop a **multi-indicator framework** for **mapping** and **assessing the potential impacts of planned forest activities** on selected **Aquatic Ecosystem Services (AES)** provided by boreal forests.



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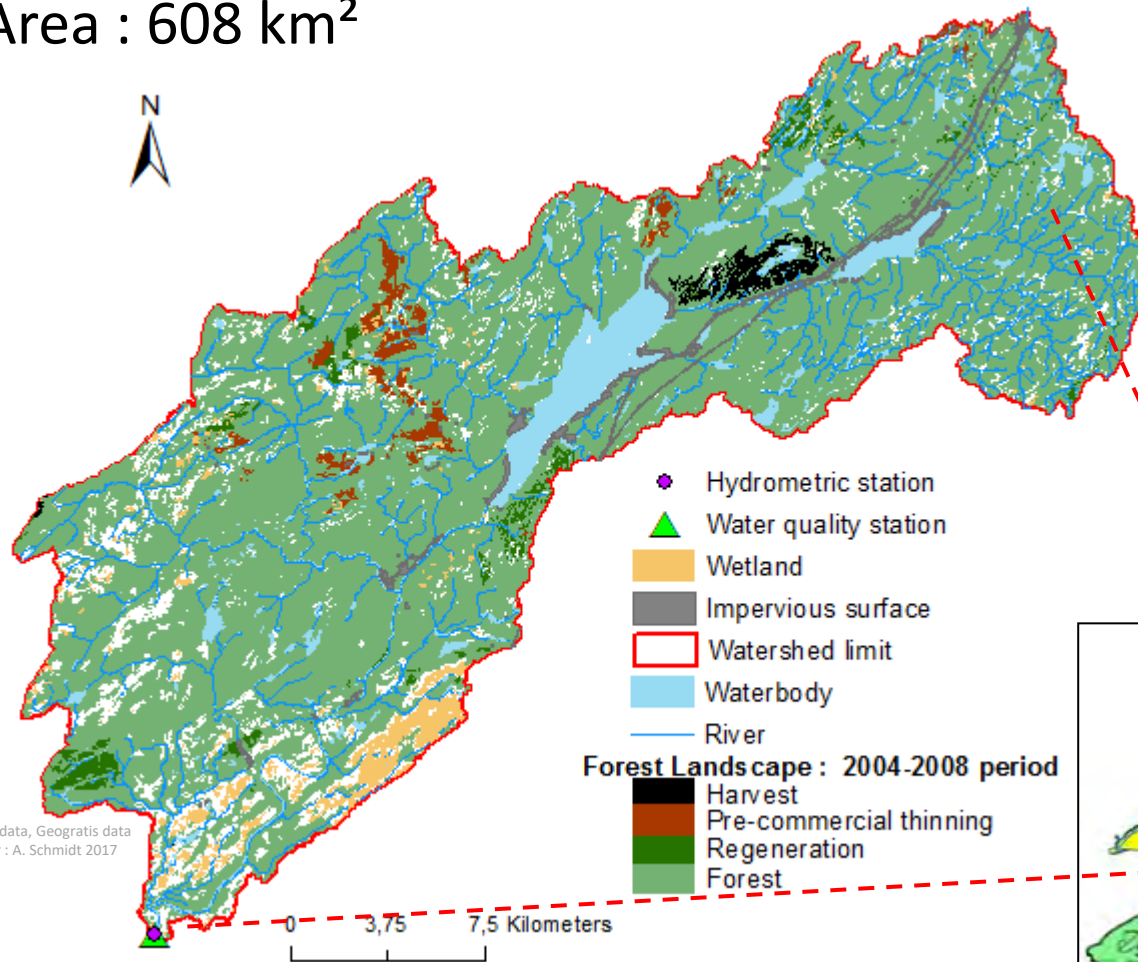
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- Develop a **multi-indicator framework** for **mapping** and **assessing the potential impacts of planned forest activities** on selected **Aquatic Ecosystem Services (AES)** provided by boreal forests.
  - Watershed scale
  - Maps period 5 years

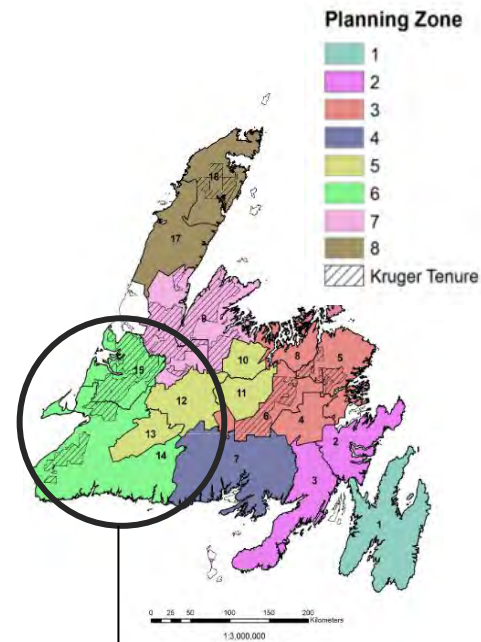
# Study area

## Harry's River Watershed (Newfoundland)

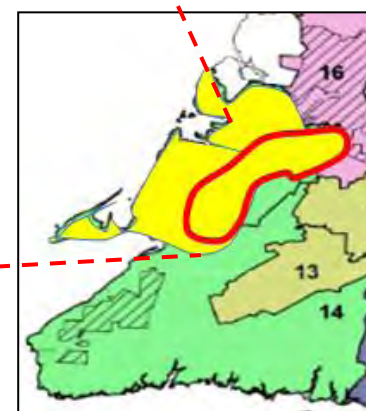
Area : 608 km<sup>2</sup>



- Hydrometric station
  - ▲ Water quality station
  - Wetland
  - Impervious surface
  - Watershed limit
  - Waterbody
  - River
- Forest Landscape : 2004-2008 period**
- Harvest
  - Pre-commercial thinning
  - Regeneration
  - Forest



Source : Government Newfoundland and Labrador, 2014

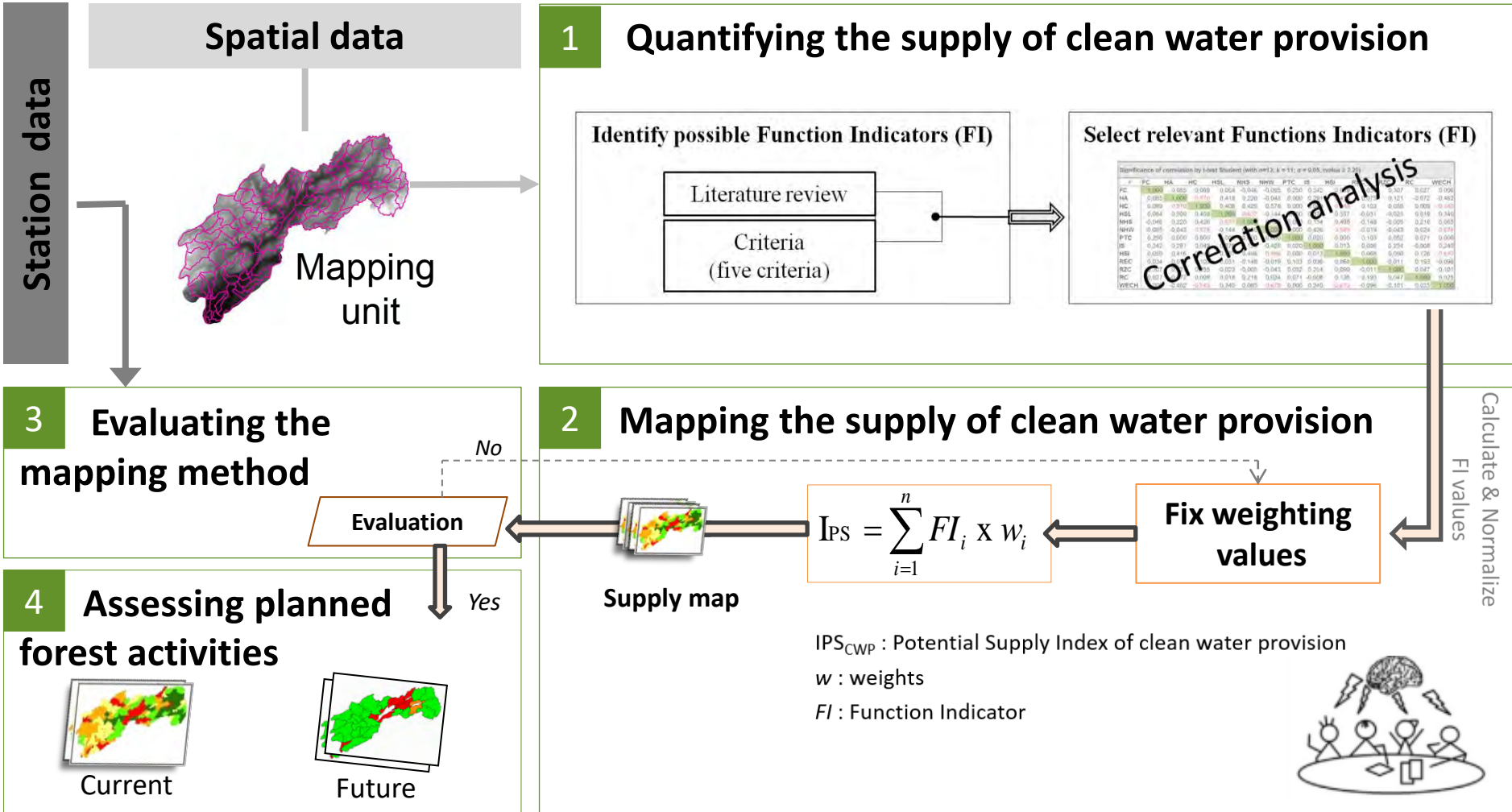


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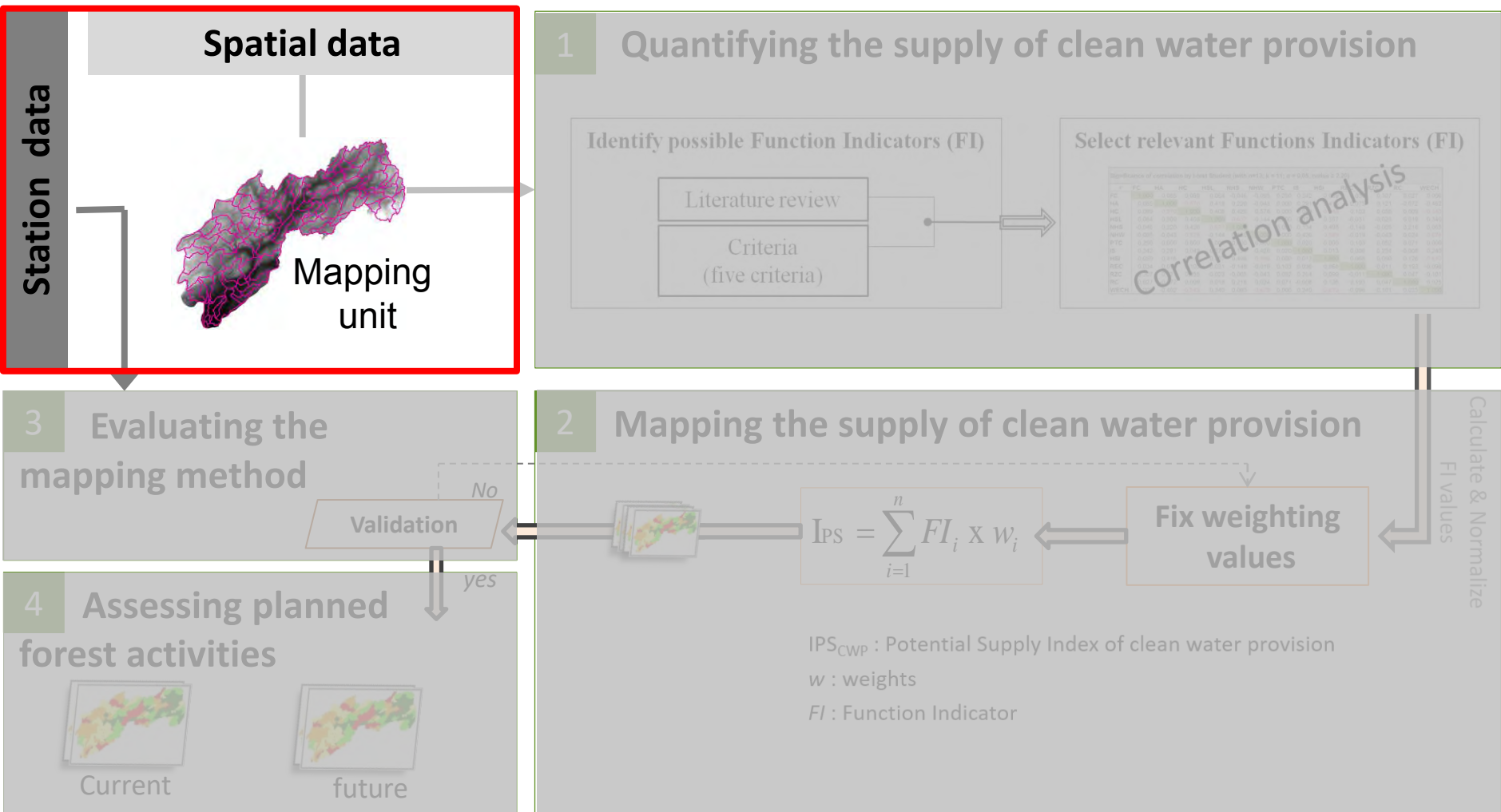
# Methodological framework

## The case of clean water provision service



# Methodological framework

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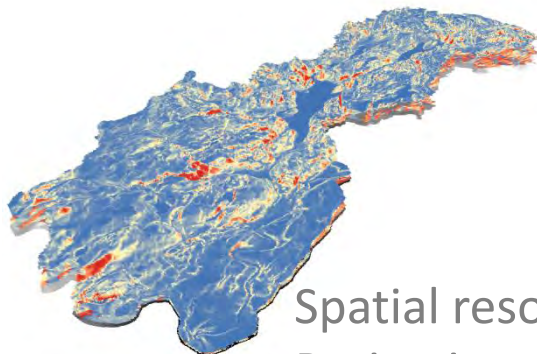
# Methodological framework

## The case of clean water provision service

### Spatial data

#### Raster format data

- Elevation
- Slope



Spatial resolution: 30 m  
Projection: NAD83 UTM 21N

#### Vector format data

- Hydrology network
- Land cover type
  - Roads
  - Forest
  - Wetlands
  - Infrastructures
- Silviculture treatment
- Harvest area



Between 1995 and 2018



# Methodological framework

## The case of clean water provision service

### Station data

#### Hydrometric

- Flow
- Level
- Sediment concentration

#### Water quality

- Chemistry parameters
- Water temperature
- pH

#### Climate

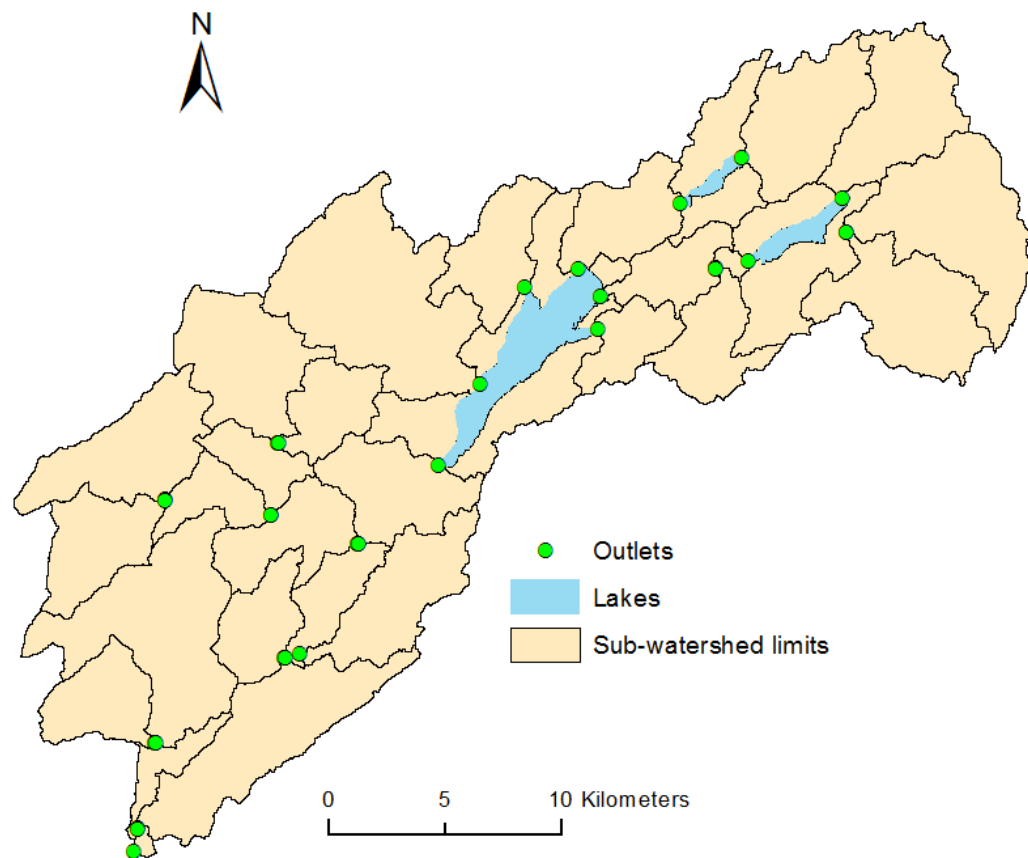
- Temperature
- Precipitation

# Methodological framework

## The case of clean water provision service

Mapping unit

Sub-watershed units

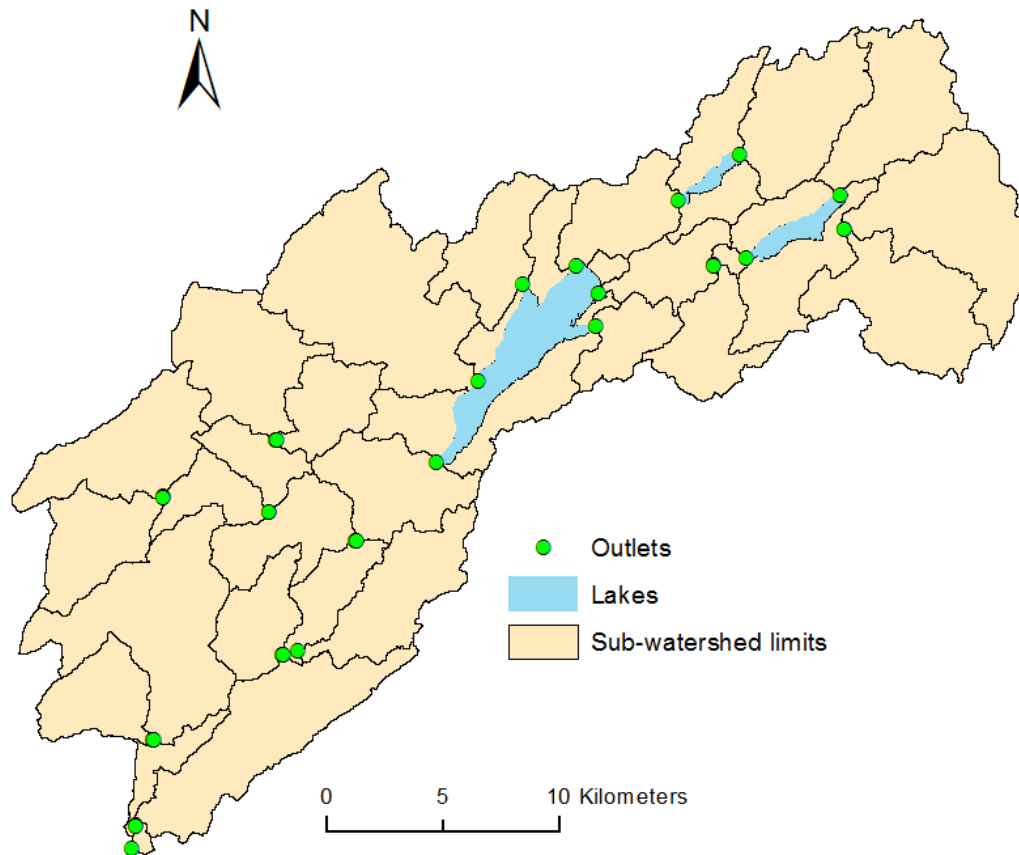


# Methodological framework

## The case of clean water provision service

Mapping unit

Sub-watershed units



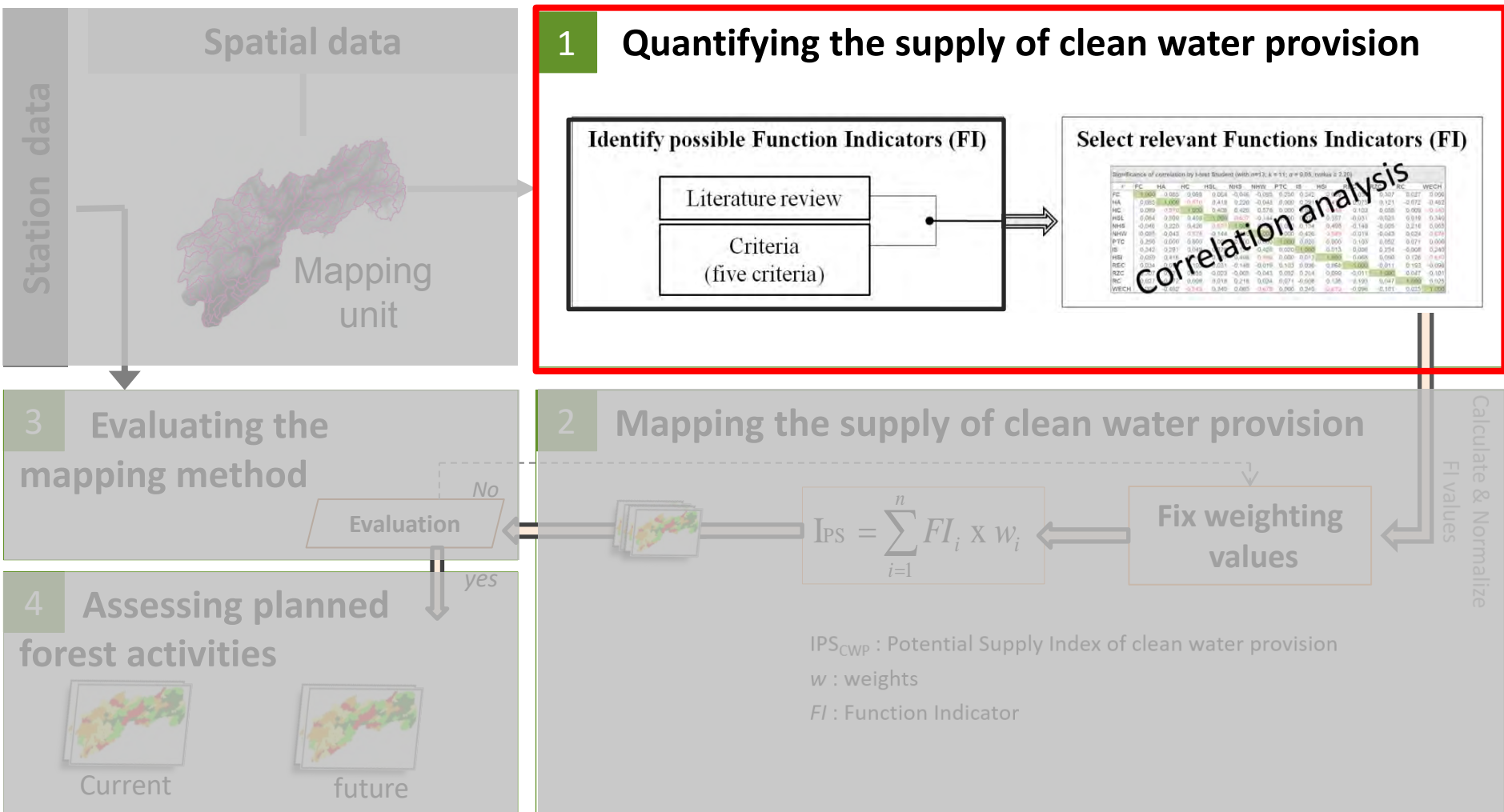
### Size?

- Count : 30 sub-watersheds
- Mean : 1961 ha

### Lakes?

# Methodological framework

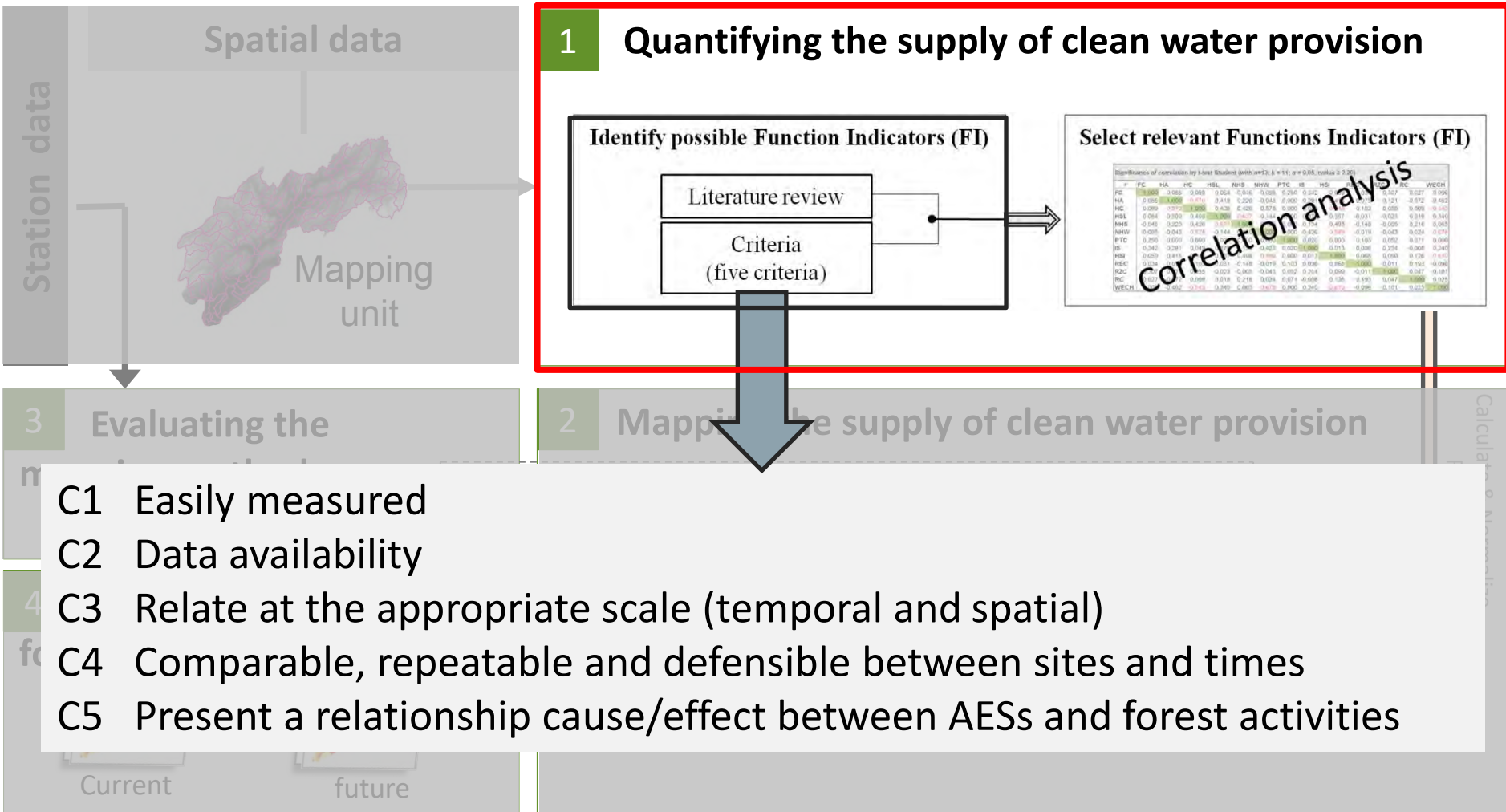
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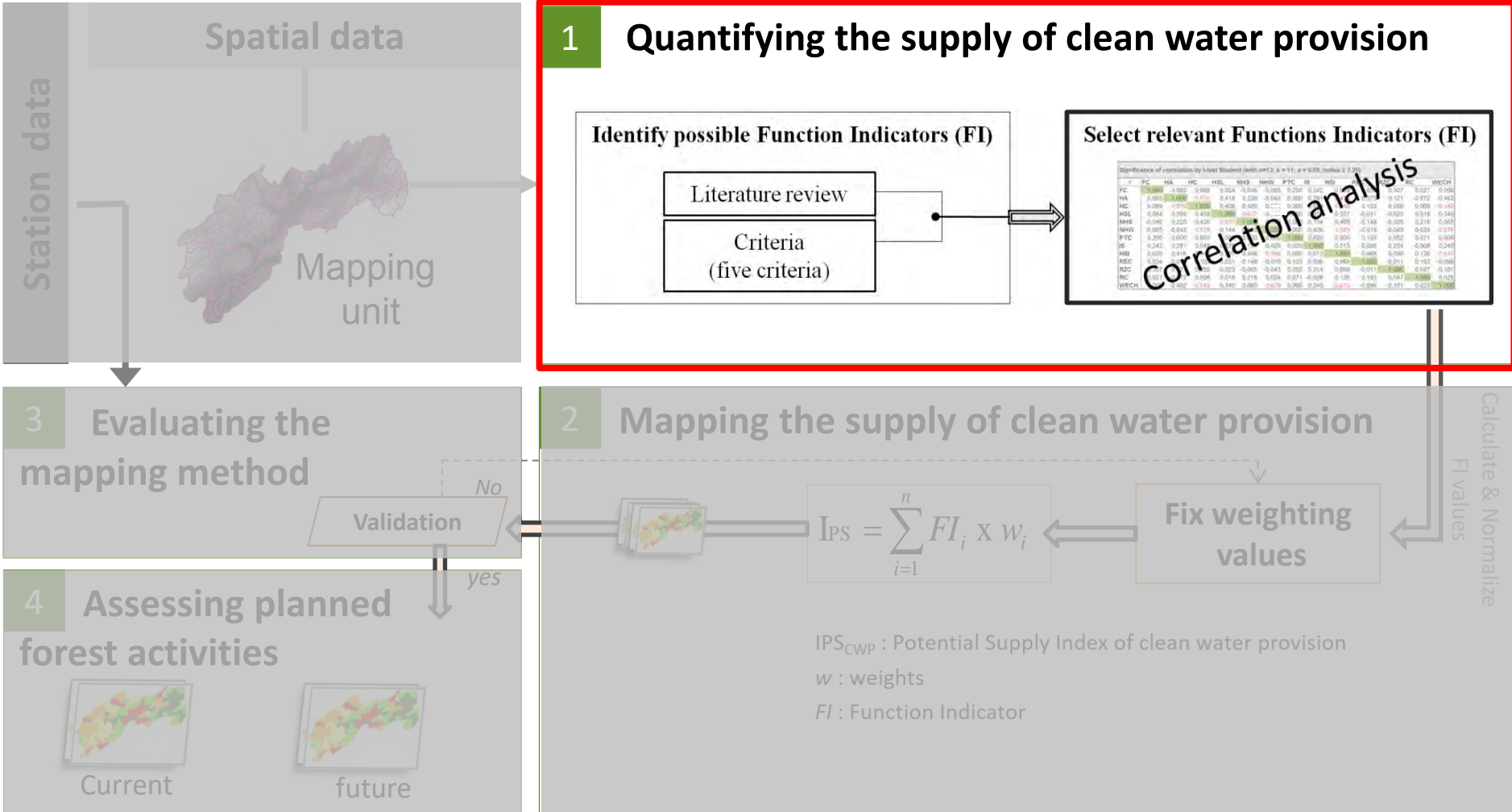
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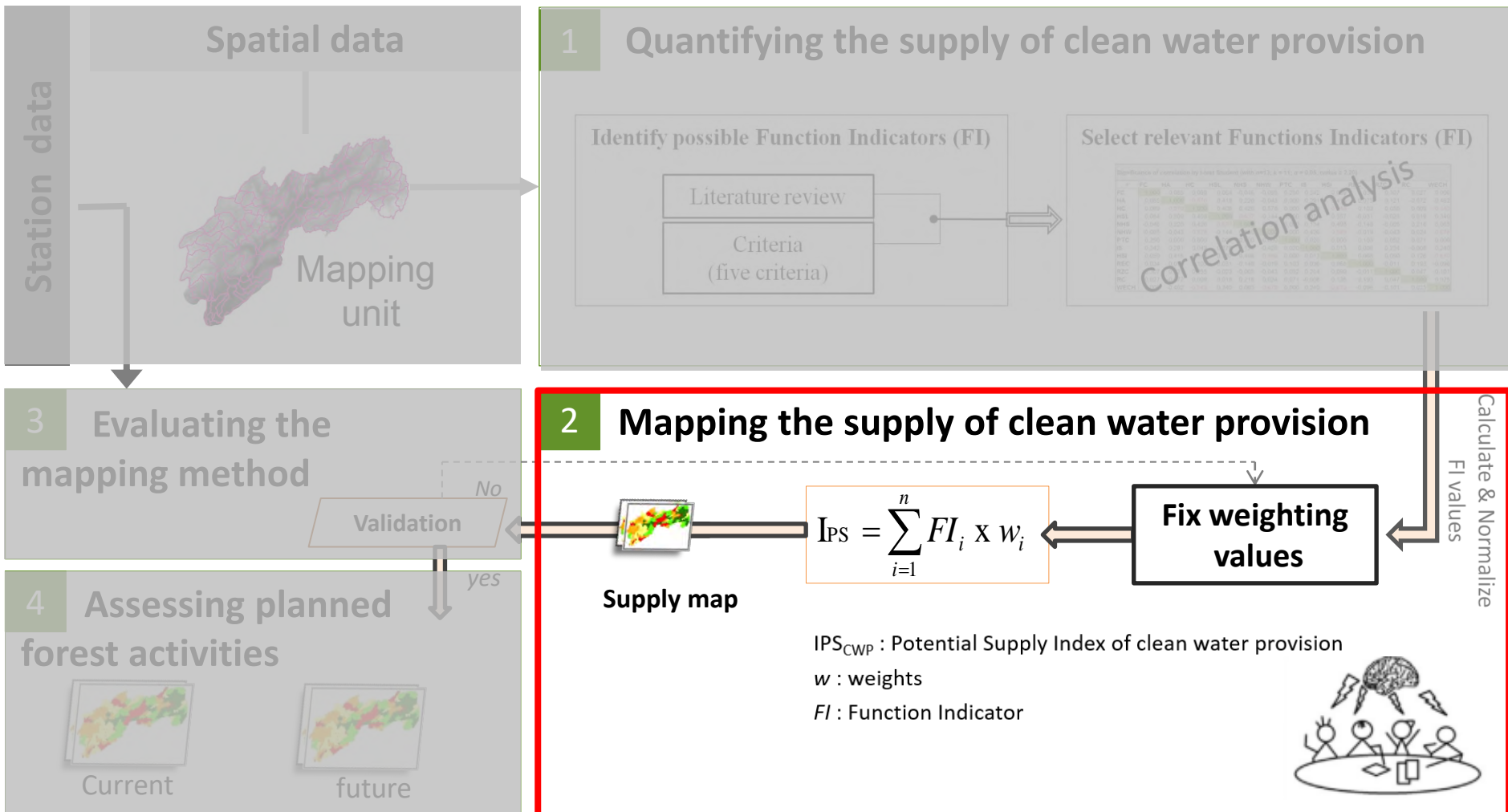
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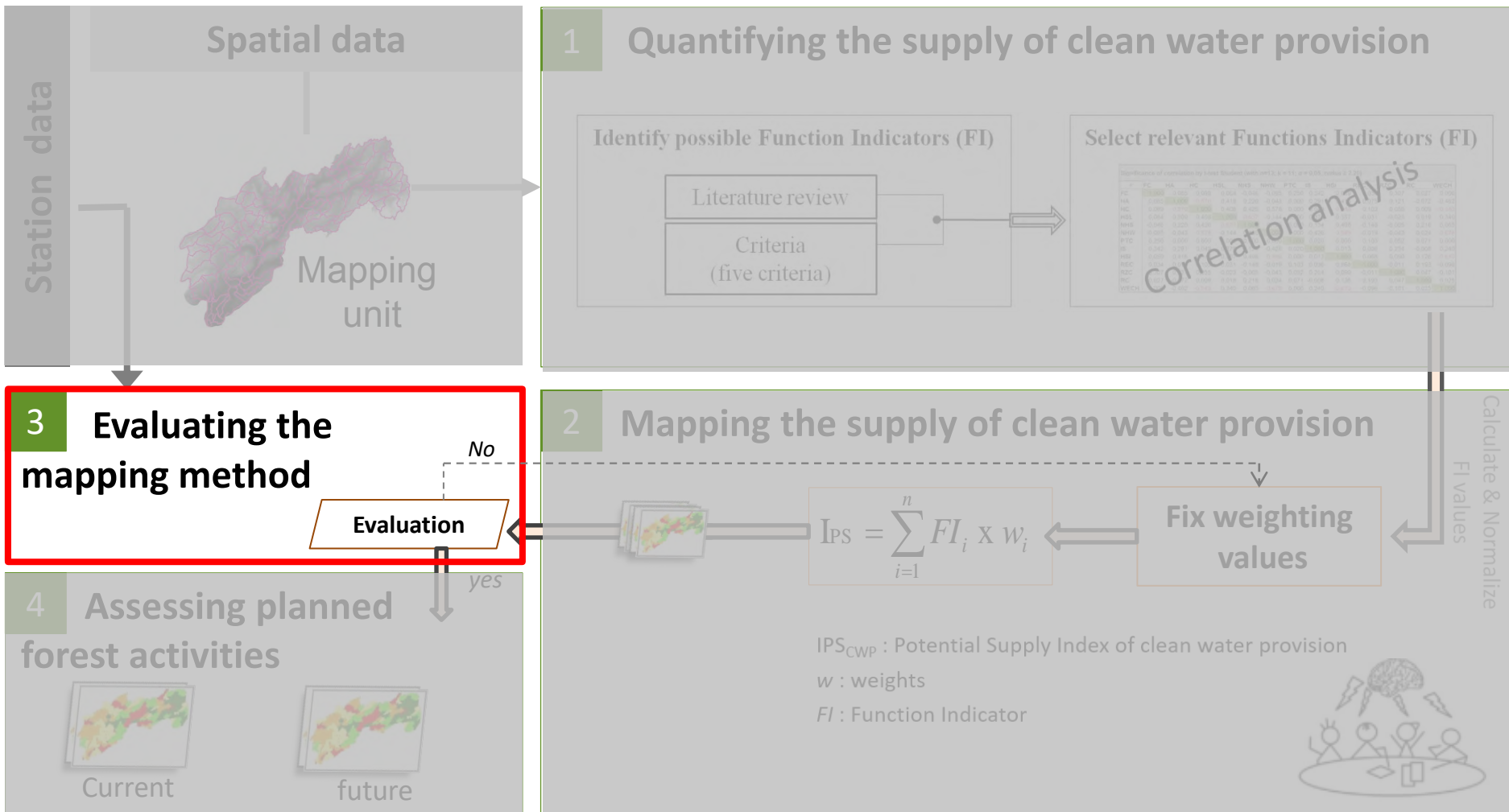
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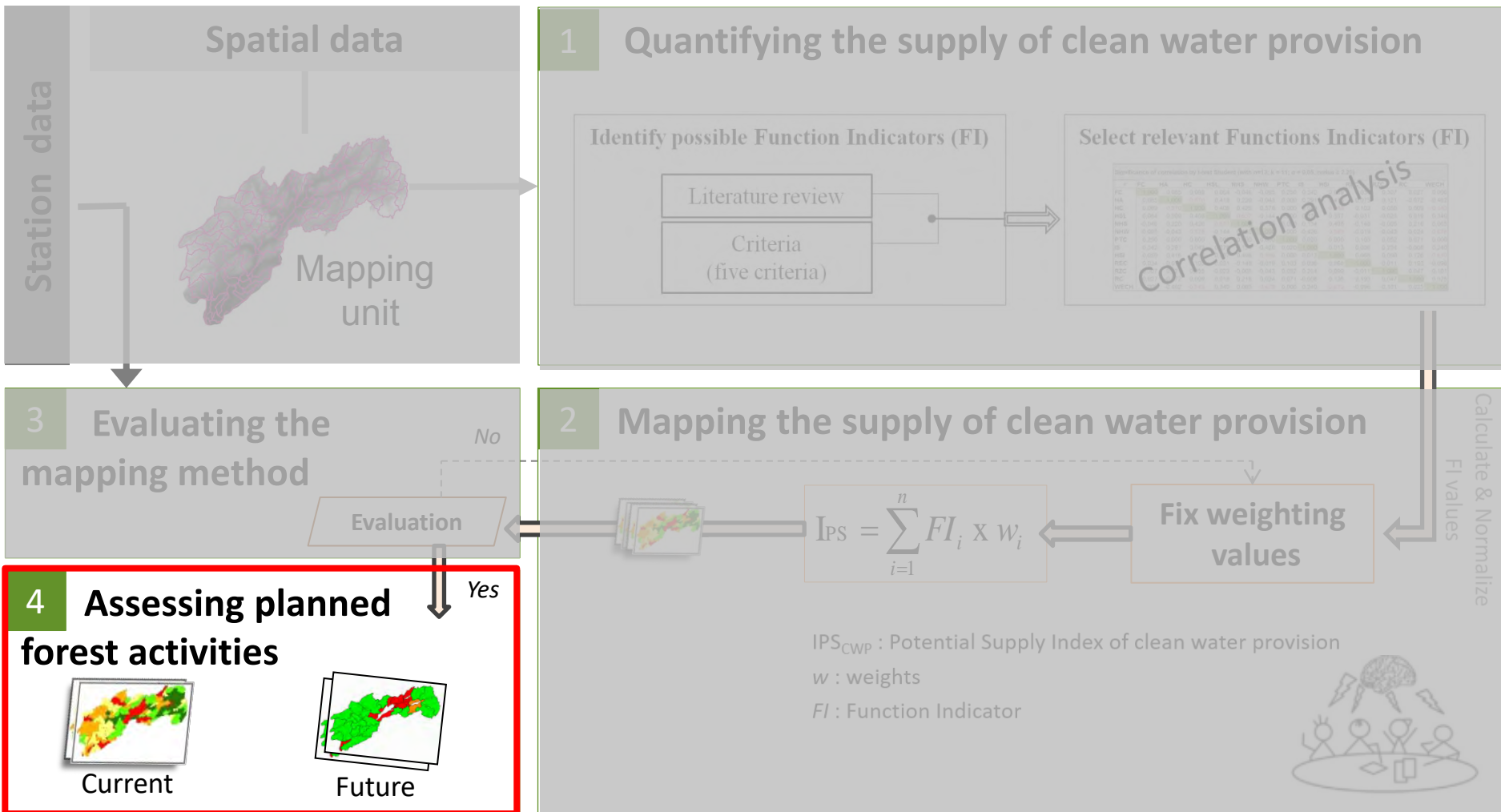
## The case of clean water provision service





# Methodological framework

## The case of clean water provision service



# The case of clean water provision service

Preliminary results: Potential supply index of clean water provision ( $IPS_{CWP}$ )

## ● Selection of Function Indicators : 8

Indicator	Name	Type
% Forest	<b>Forest</b>	State
% Wetland	<b>Wet</b>	State
% Riparian cover (20m)	<b>RC</b>	State
% Impervious Surface	<b>Imp</b>	Pressure
% Forest activities pressures	<b>FAP</b>	Pressure
- Flow connectivity (Stralher order)	<b>Flow</b>	Pressure
- Number of road-river crossing	<b>CrossN</b>	Pressure
% Average slope	<b>Slope</b>	Pressure

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$$\leftarrow FI_{FAP} = \sum_{i=1}^n Disturbances_i \times w_i$$

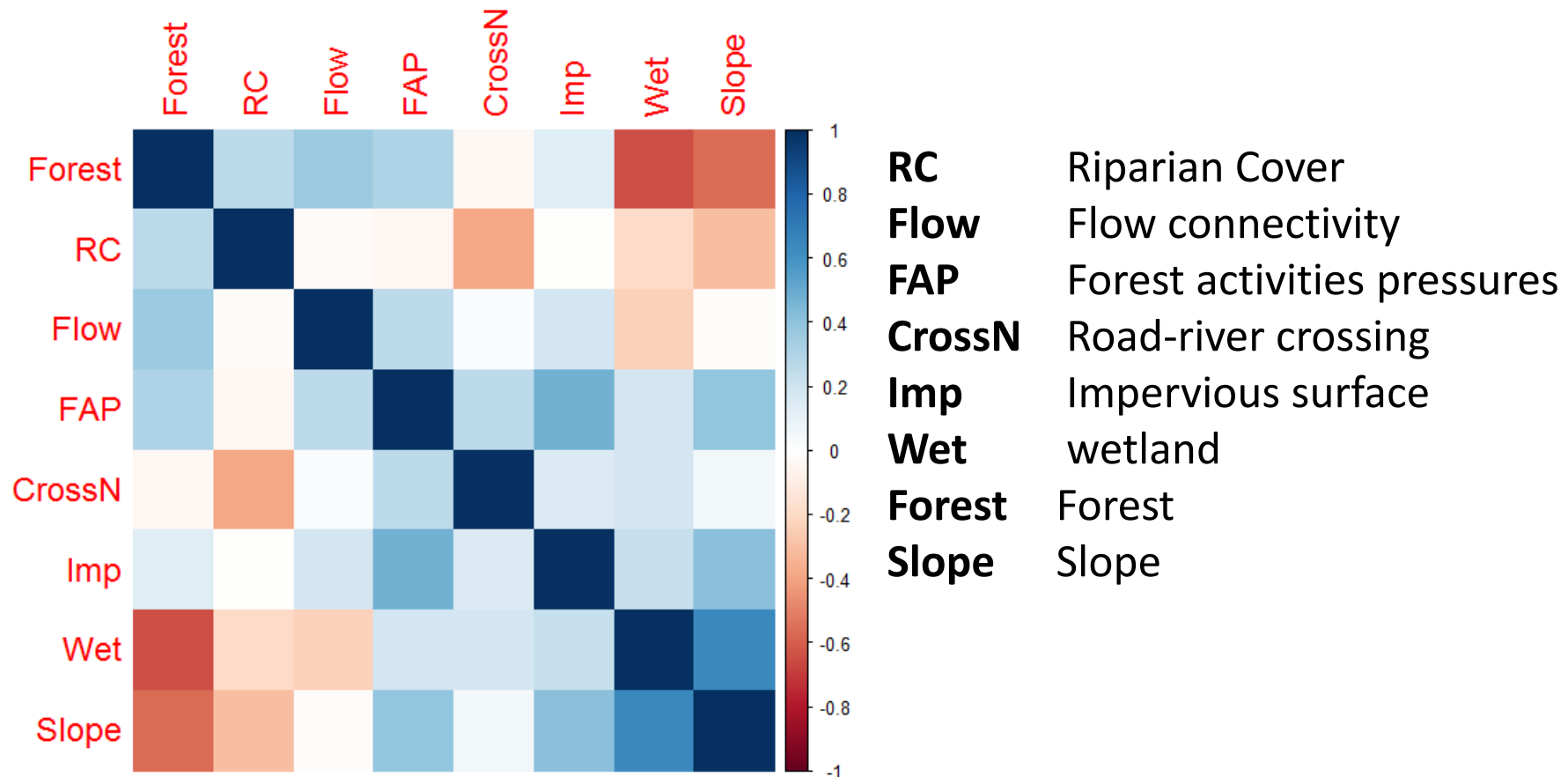
Cumulative pressures

- Harvest ( $w : 1$ )
- PCT ( $w : 0.6$ )
- Regeneration ( $w : 0.4$ )
- Insect breaks
- Fire

# The case of clean water provision service

Preliminary results: Potential supply index of clean water provision ( $IPS_{CWP}$ )

● Selection of relevant Function Indicators : correlation analysis

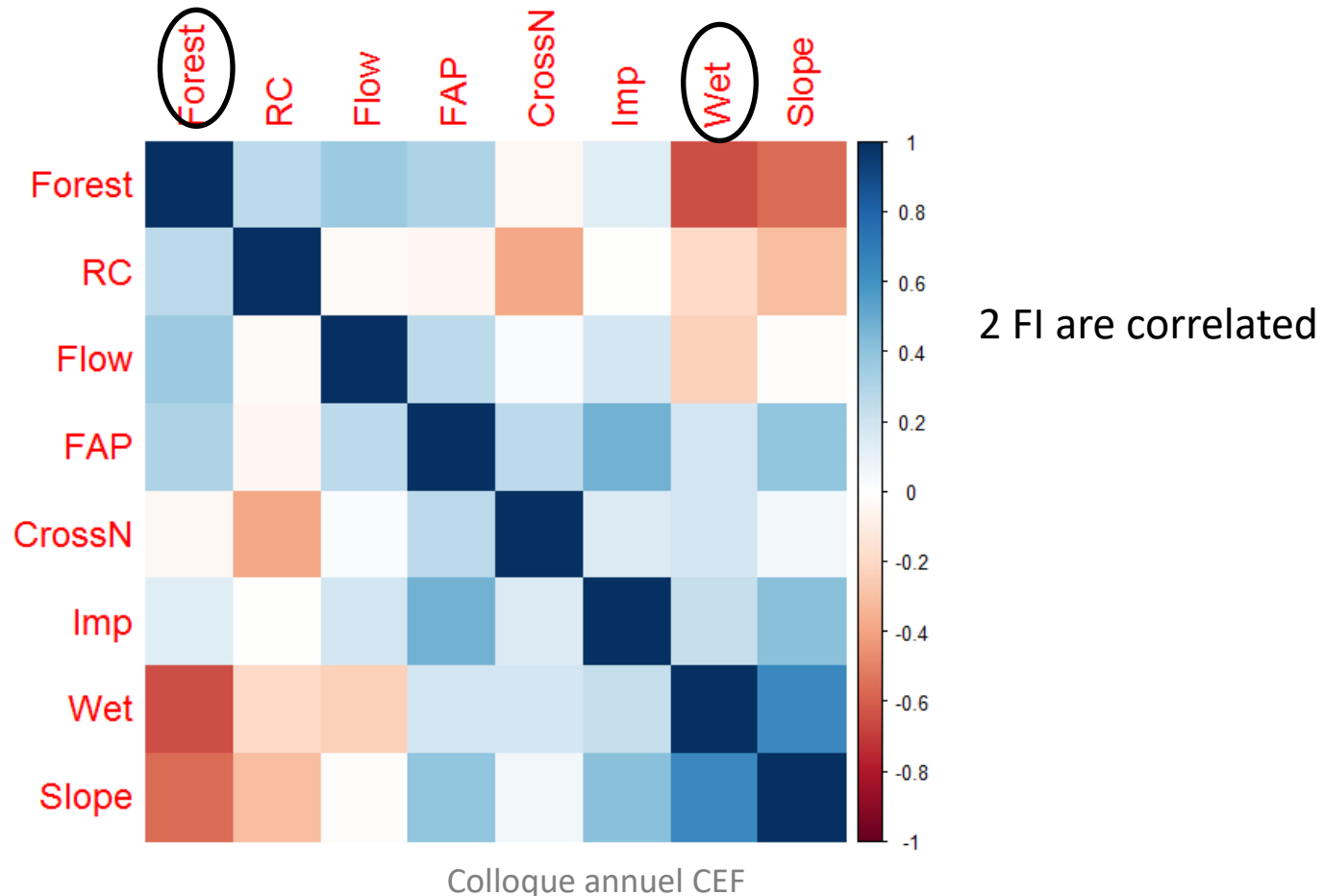




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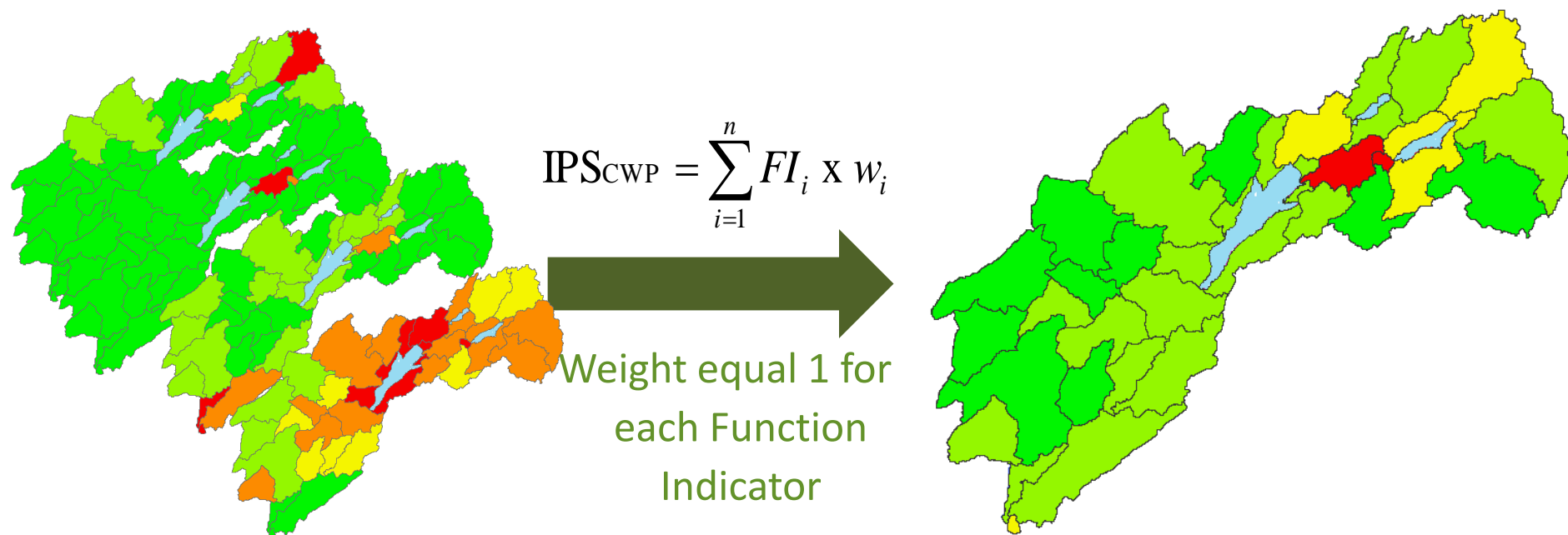
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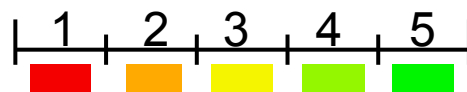
# The case of clean water provision service

Preliminary results: Potential supply index of clean water provision ( $IPS_{CWP}$ )

- $IPS_{CWP}$  map for year 2004-2008



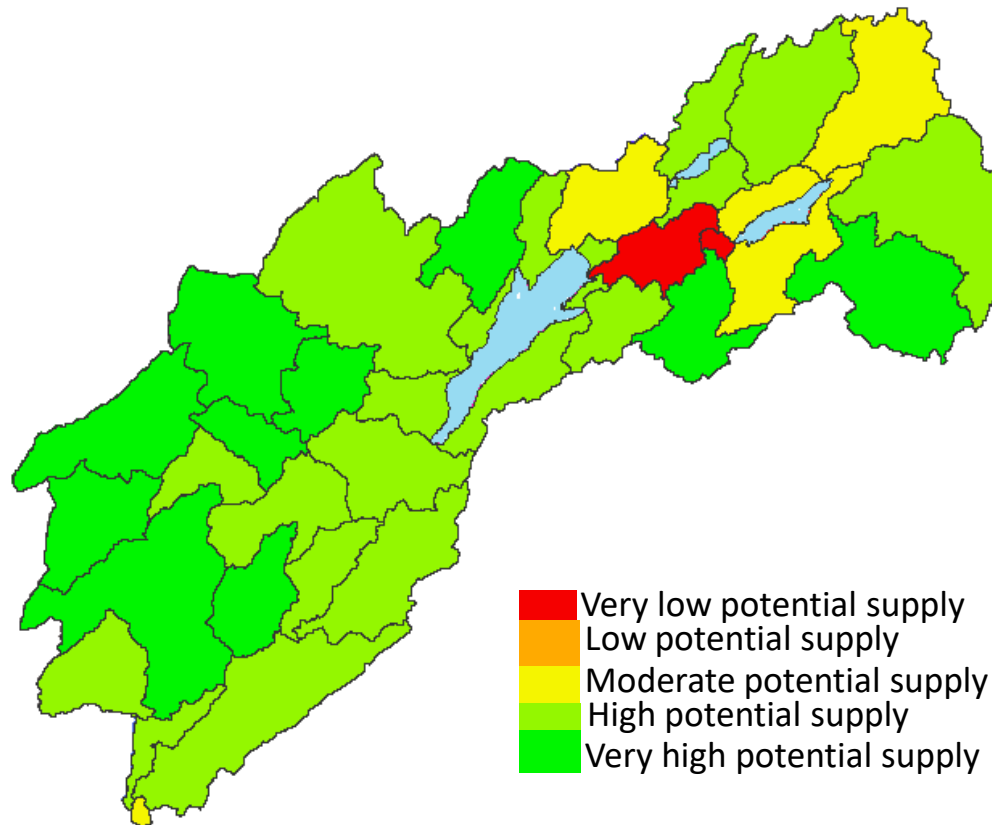
Relevant Function Indicators



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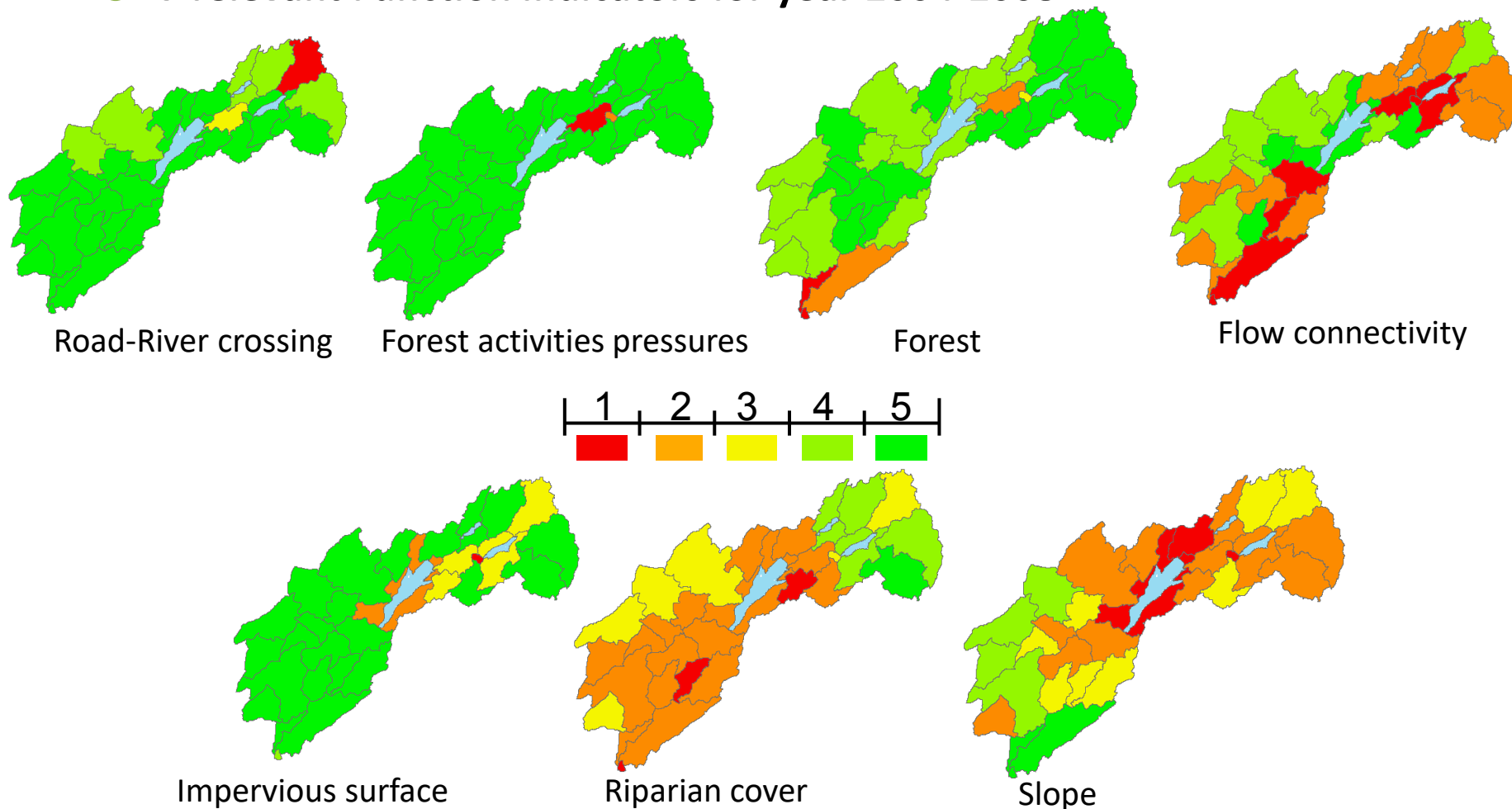
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# The case of clean water provision service

Preliminary results: Potential supply index of clean water provision ( $IPS_{CWP}$ )

● **7 relevant Function Indicators for year 2004-2008**





## Ongoing work

- A significant challenge : Evaluation process of the mapping method
- Weighting system
- Add new indicators :
  - Proximity Harvest to waterbody
  - Riparian connectivity index

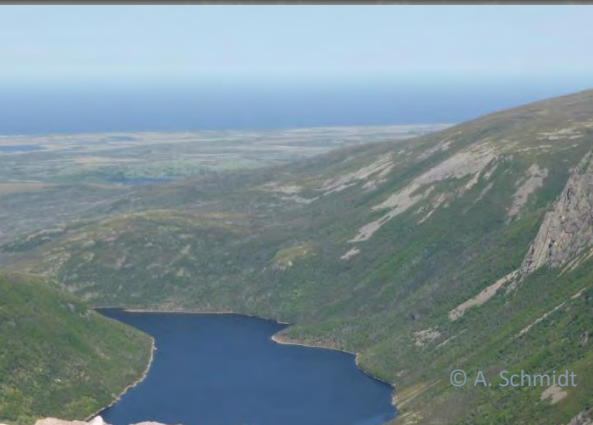
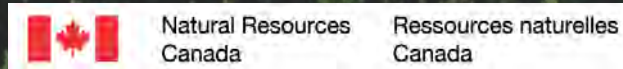
## Conclusion

- Map results help forest managers to better plan, manage and monitor forest resources and ensure the sustainable supply of AESs.
- Preliminary work in support of a PhD project

Thank you for your attention

And

my collaborator



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