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VALUING FOREST ECOSYSTEM SERVICES IN THE NORTHWEST REGION OF VIETNAM

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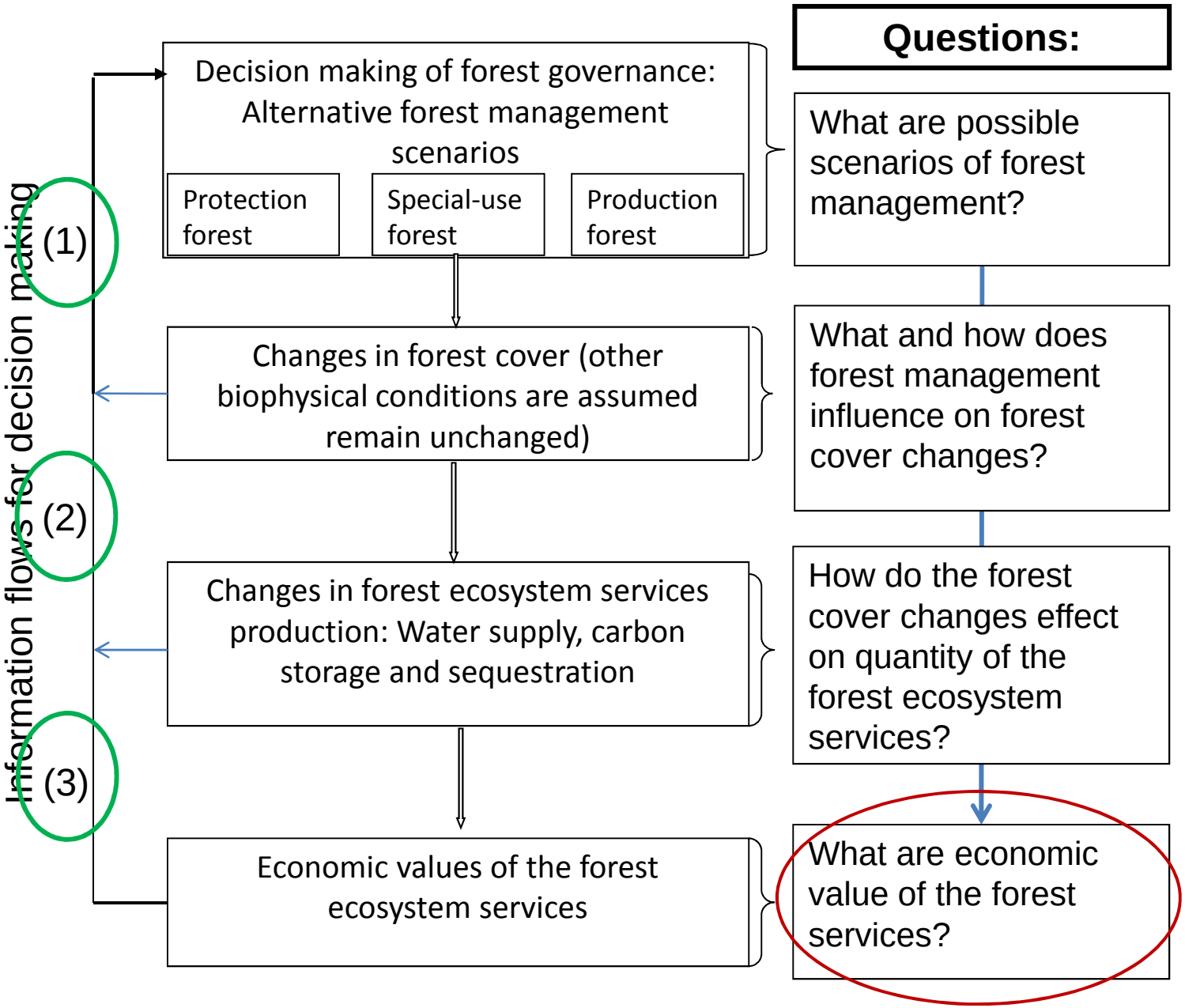
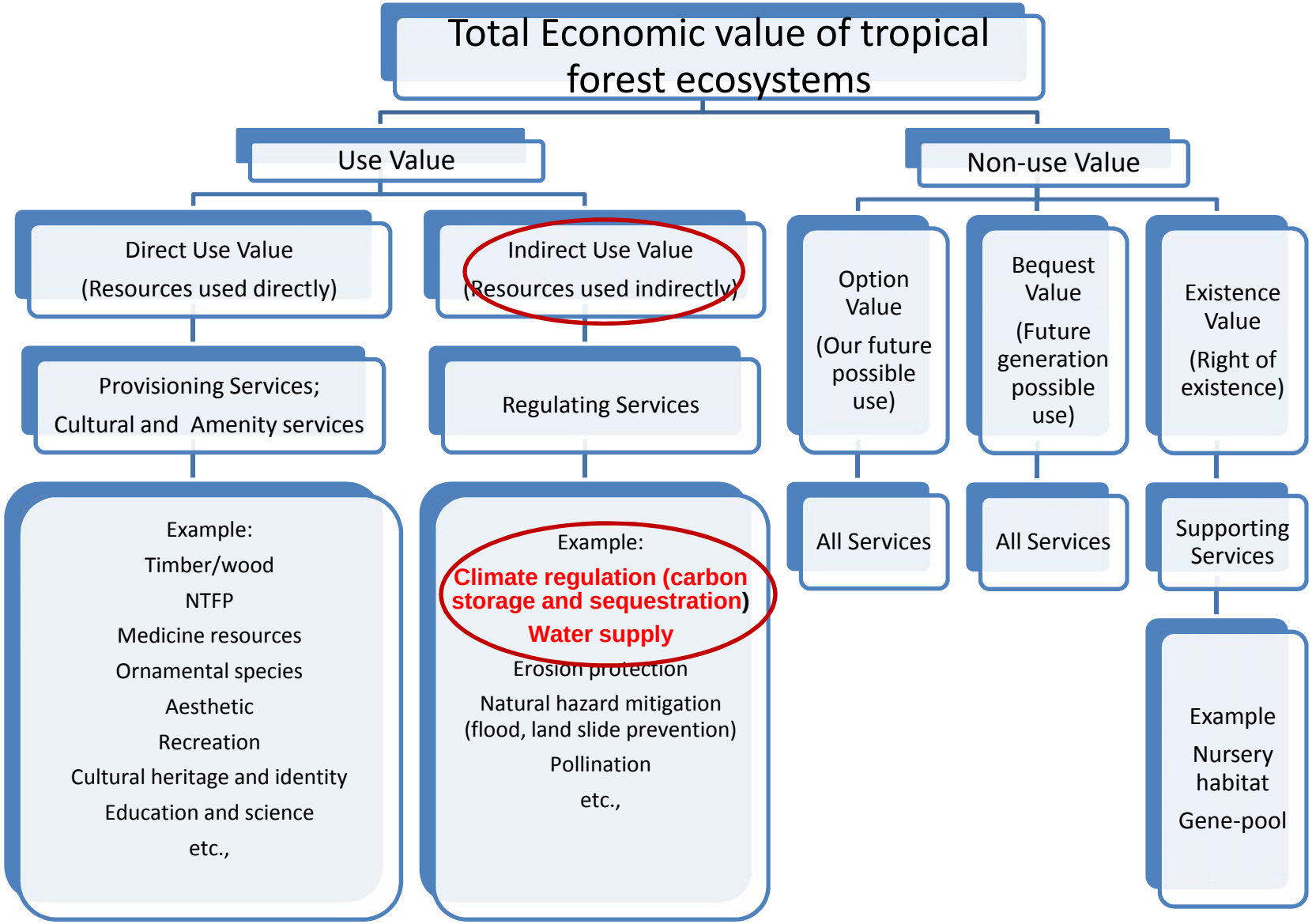
Background of the Study

- Despite essential services brought by ecosystems human societies have degraded the ecosystems. The reasons are:
  - Market failures lead to undervaluing ecosystem services;
  - The gap between scientific knowledge and decision making in environmental management;
  - The lack of/inadequate policy on environmental/natural resource management.
- Societies have concerns about the environmental problems.

Conceptual Framework



Economic Valuation Framework



Economic Valuation Framework

Valuing carbon storage and sequestration:

- The amount of carbon storage at the baseline stage and the volume of carbon sequestered in four carbon pools (aboveground biomass, belowground biomass, soil, and dead organic matter) over time is estimated.
- The social value of a sequestered ton of carbon is estimated using the data of social damage avoided by not releasing a ton of carbon into the atmosphere, and discount rate.

Social value of carbon sequestration = **Total volume of carbon sequestration in the carbon pools overtime** x **Discounted Social value/ton C**

- Valuation is applied to sequestration, not storage, because current market prices relate only to carbon sequestration.

Economic Valuation Framework

Valuing water supply

Water yield

The water yield model is based on the Budyko curve.
- First, the annual water yield ***Y(x)*** for each pixel on the landscape x is determined
- Then, the total and average water yield at the subwatershed level are generated.

Water supply for energy production

The water inflow to a reservoir is calculated based on water yield and water consumptive use in the watershed(s) of interest.

$$V_{in} = Y - U_d$$

Where: V_{in} is the realized supply (volume inflow to a reservoir),
$\boldsymbol{U}_a$ is the total volume of water consumed in the watershed upstream of dam d and
Y is the total water yield from the watershed upstream of dam d.

Economic Valuation Framework

Valuing water supply

Energy production

The hydropower model estimates the amount of energy produced given the estimated supply of water for hydropower production. It is assumed that the total annual inflow water volume is released equally and continuously over the course of each year. Total annual hydropower energy production is estimated by the below formula:

$$\varepsilon_d = 0.00272 \cdot \beta \cdot \gamma_d \cdot h_d \cdot V_{in}$$

Where:

- ε_d is total annual hydropower energy production (KWH),
- β is the turbine efficiency coefficient (%),
- γ_d is the percent of inflow water volume to the reservoir at dam d that will be used to generate energy.
- H_d is the water height behind the dam at the turbine (m)

Economic Valuation Framework

Valuing water supply

Energy production valuation

A net present value (NPV) of energy produced is calculated as followed:

$$\mathrm{NPVH}_d = (P_e \varepsilon_d - TC_d)\, x \sum_{t=0}^{T-1} \frac{1}{(1+r)^t}$$

Where:

- ***TCd*** is the total annual operating costs for dam *d*,
- ***pe*** is the market value of electricity at dam *d*
- ***T*** is the number of years present landscape conditions are expected to persist or the expected remaining lifetime of the station at dam d and
- ***r*** is the market discount rate.

The form of the equation above assumes that ***TCd, pe, and εd***, are constant over time.

Research Methodology

Research Design

- The combination of ecological and economic approaches will be used for this study. We use **InVEST** model (**Integrated Valuation of Ecosystem Services and Tradeoffs)** to quantify and valuate the ecosystem services.
- Scenario based approach:
  - For each hypothetical forest management scenario, one forest cover scenario will be mapped.
  - The quantity and values of water supply and carbon sequestration is estimated for each scenario.
- We use sensitive analysis to deal with the uncertainty.

Data analysis

- Level of analysis: watersheds and subwatersheds
- Quantity and value of ecosystem services are mapped/estimated and compared between the future scenarios and the baseline condition; and compared among the future scenarios.

The research site: North West Region

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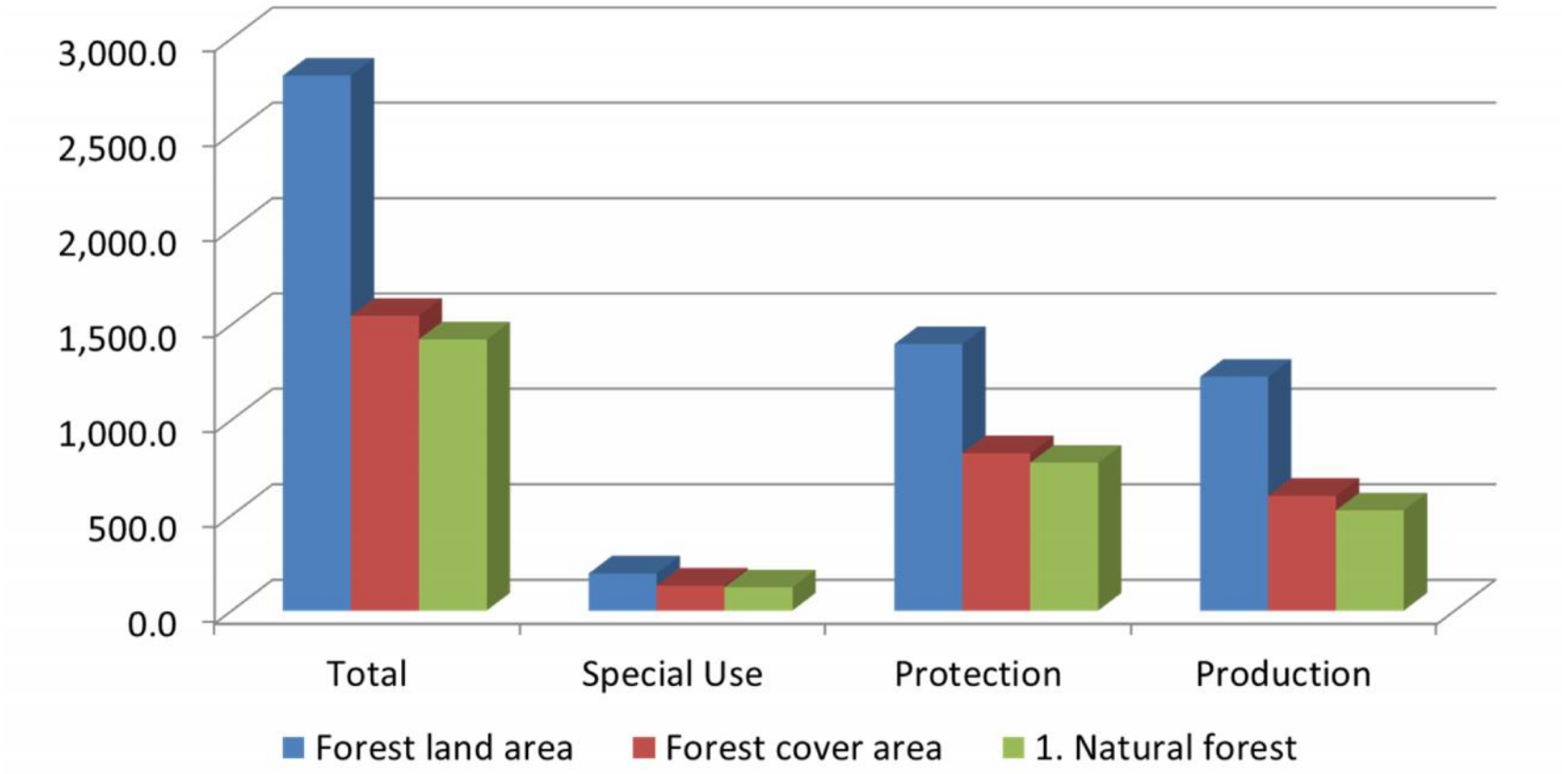
Forest land areas classified by types of forest management, 2010

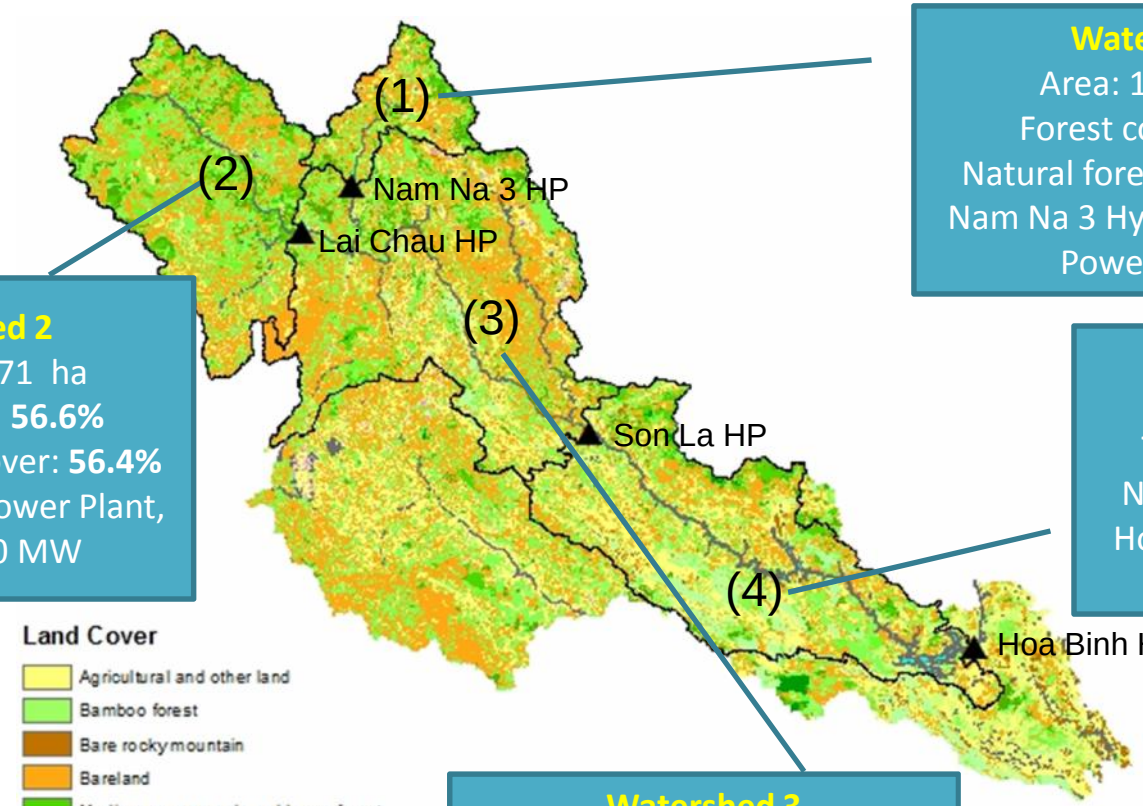
Unit: thousand ha



Source: VN-MARD

The Watersheds of interest

(Da River system)



Watershed 1
Area: 159 463 ha
Forest cover: **49.2%**
Natural forest cover: **47.1%**
Nam Na 3 Hydropower Plant,
Power 84 MW

Watershed 2
Area: 605 171 ha
Forest cover: **56.6%**
Natural forest cover: **56.4%**
Lai Chau Hydropower Plant,
Power 1200 MW

Watershed 4
Area: 784 673 ha
Total forest cover: **45.2%**
Natural forest cover: **37.3%**
Hoa Binh Hydropower Plant,
Power 1920 MW

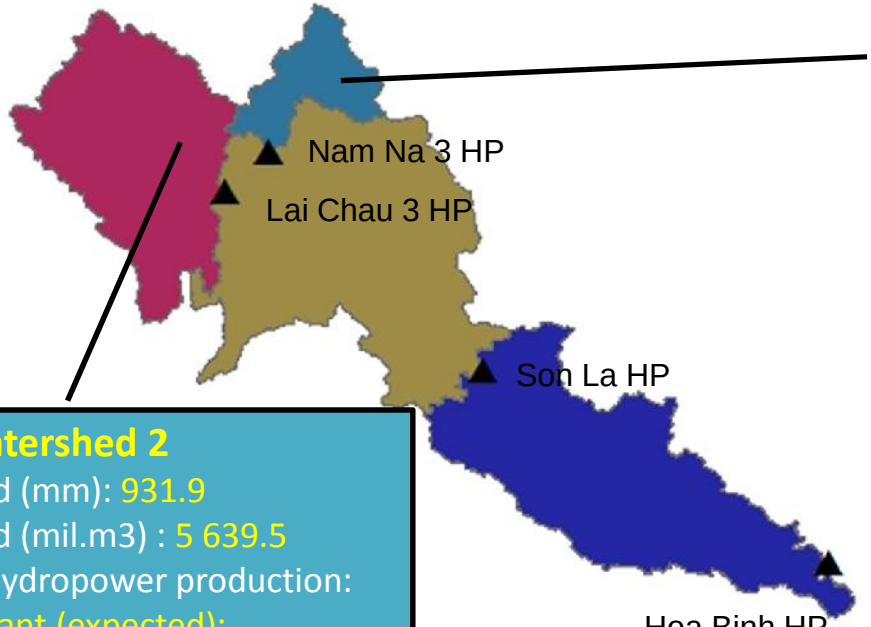
Watershed 3
Area: 935 953 ha
Forest cover: **40.2%**
Natural forest cover: **38.2%**
Son La Hydropower Plant,
Power 2400 MW

Land Cover

- Agricultural and other land
- Bamboo forest
- Bare rocky mountain
- Bareland
- Medium evergreen broad leave forest
- Plantation forest
- Poor evergreen broad leave forest
- Residential area
- Restored evergreen broad leave forest
- Rich evergreen broad leave forest
- Rocky mountain forest
- Timber and bamboo mixed forest
- Water surface

Initial results (Baseline 2010)

Water supply services



Watershed 1

Annual Water yield (mm): 957.4
Annual Water yield (mil.m3) : 1526.7
Water supply for hydropower production :

- Nam Na 3 Hydropower Plant:
  - ✓ Energy (mil. Kwh/year): **963.9**
  - ✓ HP_val (mil. PV_USD/life span): **811.4**
- Son La HP plant :
  - ✓ Energy (mil. Kwh/year): **736.9**
  - ✓ HP_val (mil. PV_USD/life span): **522.3**
- Hoa Binh HP plant
  - ✓ Energy (mil. Kwh/year): **305.9**
  - ✓ HP_val (mil. PV_USD/life span): **231.7**

- **Total Energy (mil. kwh/year): 2006.7**
- **Total HP_val (mil. PV_USD): 1565.4**

Watershed 2

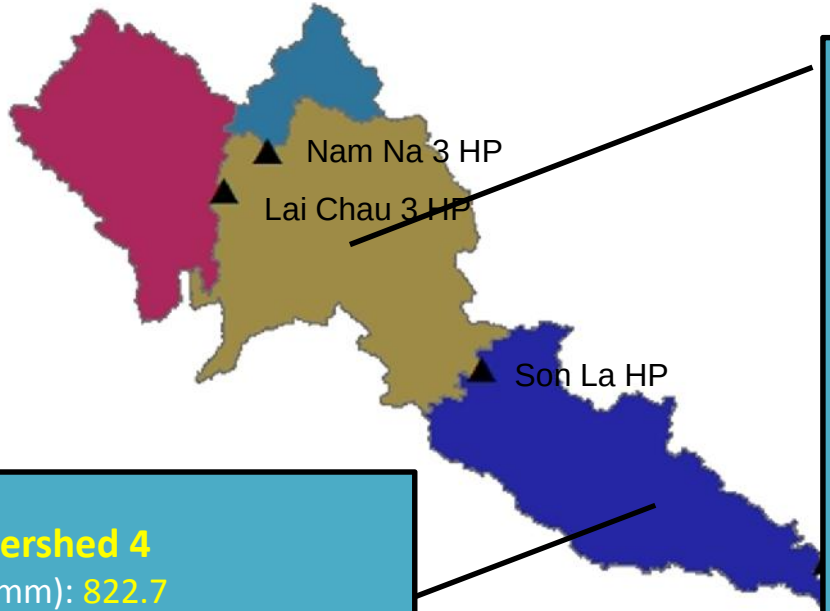
Annual Water yield (mm): 931.9
Annual Water yield (mil.m3) : 5 639.5
Water supply for hydropower production:

- Lai Chau HP plant (expected):
  - ✓ Energy (mil. kwh/year): **3502.6**
  - ✓ HP_val (mil. PV_USD/life span): **2896.5**
- Son La HP plant :
  - ✓ Energy (mil. kwh/year): **2722**
  - ✓ HP_val (mil. PV_USD/life span): **1929.3**
- Hoa Binh HP plant
  - ✓ Energy (mil. kwh/year): **1296.3**
  - ✓ HP_val (mil. PV_USD/life span): **855.9**

Total Energy (mil. kwh/year): 7520.9
Total HP_val (mil. PV_USD): 5681.7

Initial results (Baseline 2010)

Water supply services



Watershed 3

Annual Water yield (mm): 1105.7
Annual Water yield (mil.m3) : 10 349
Water supply for hydropower production :

- Son La HP plant :
  - ✓ Energy (mil. Kwh/year): **4 995.5**
  - ✓ HP_val (mil. PV_USD/life span): **3 540.8**
- Hoa Binh HP plant
  - ✓ Energy (mil. Kwh/year): **2378.8**
  - ✓ HP_val (mil. PV_USD/life span): **1570.6**

- **Total Energy (mil. kwh/year): 7374.3**
- **Total HP_val (mil. PV_USD): 5111.4**

Watershed 4

Annual Water yield (mm): 822.7
Annual Water yield (mil.m3) : 6455.6
Water supply for hydropower production:

- Hoa Binh HP plant
  - ✓ Energy (mil. kwh/year): **1 484.1**
  - ✓ HP_val (mil. PV_USD/life span): **979.8**

Total Energy (mil. kwh/year): 1484.1
Total HP_val (mil. PV_USD): 979.8

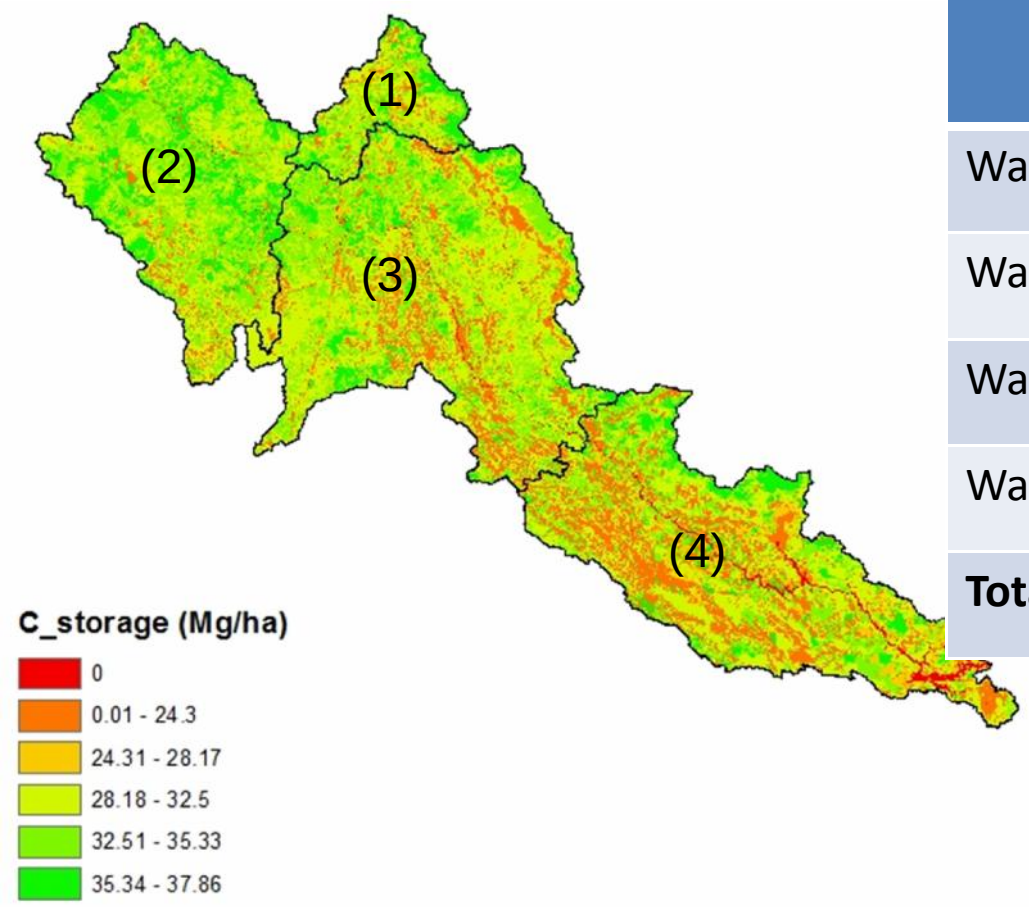
Water supply services

Summary of total value of water supply for hydropower production

HP station	Average annual HP energy production (mil. kwh)	HP production value (mil. PV_USD/life span)
Nam na 3	963.9	811.36
Lai Chau (expected)	3,502.6	2,896.49
Son La	8,454	5,992
Hoa Binh	5,510	3,638
Total	**18,430.5**	**13,337.85**

Initial results

(Baseline 2010)



Carbon storage

	Carbon storage (M Ton of C):	Density of C_storage (ton/ha)
Watershed 1	53,356	30.1
Watershed 2	208,740	31.0
Watershed 3	300,839	28.9
Watershed 4	239,971	27.5
Total	**802,906**	

Concluding remarks

- The value of water supply services for hydropower production is higher in watersheds 1 and 2 followed by that in watershed 3, and then watershed 4.
  - Value of the water supply services is depended on the spatial arrangement of the watersheds and hydropower plants.
- Watershed 1 and 2 also provide more carbon storage per ha., which is positively related to the higher percentage of natural forest cover.
- Future challenges:
  - Developing possible forest cover scenarios;
  - Mapping the changes of the ecosystem services and;
  - Find out the best forest management regime;
  - Add more types of values from water supply services (benefit transfer)

Thank you