4th International Forum on Sustainable Future in Asia - 4th NIES International Forum
23-24 January, 2019- Hanoi

Addressing Climate Change in the Water Sector: The Study of Run-of-river Hydro Power Potential in Vu Gia - Thu Bon River Basin of Vietnam

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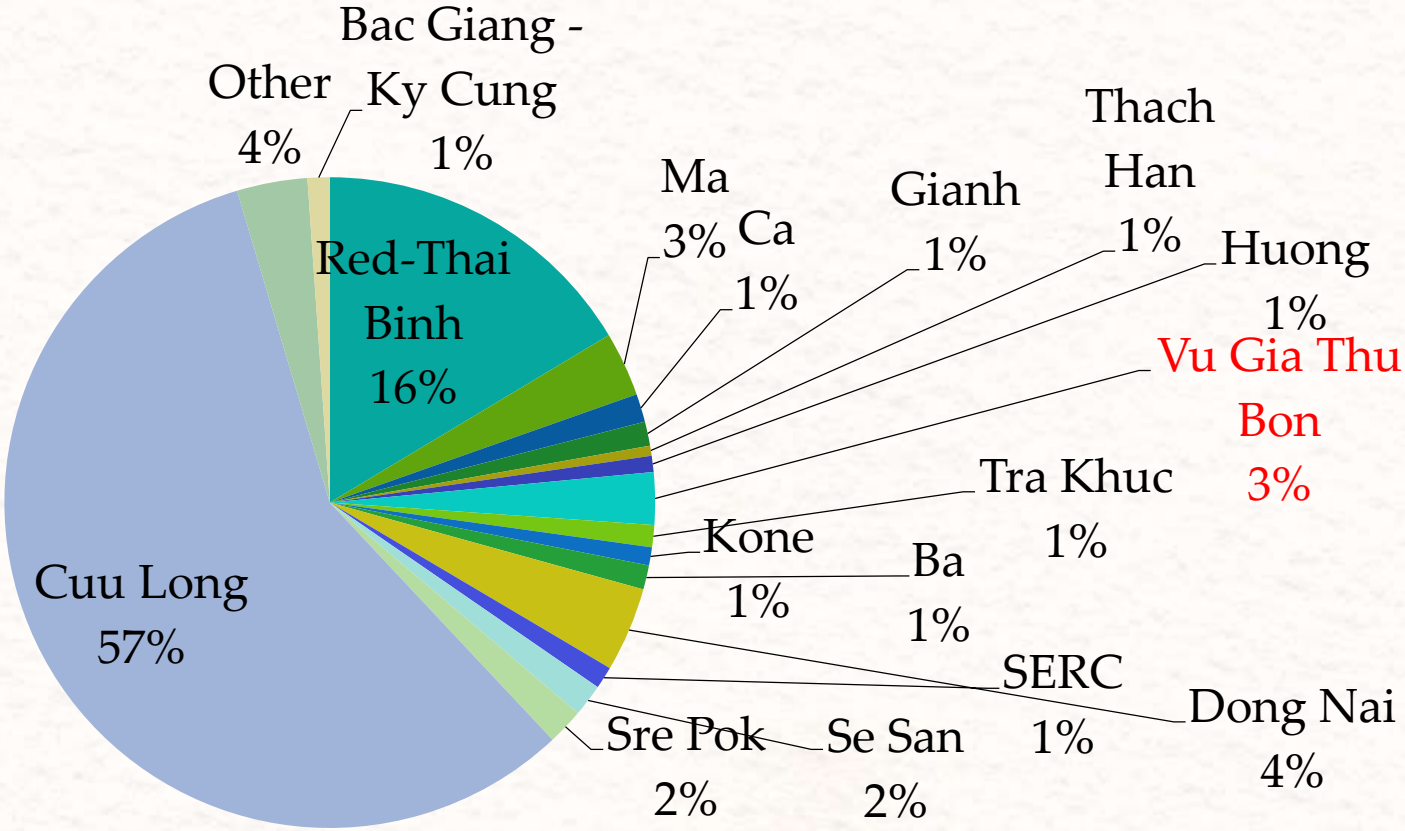
Water Climate Energy nexus

The Study of Run-of-river Hydro Power Potential in Vu Gia - Thu Bon River Basin of Vietnam

Vietnam water sector

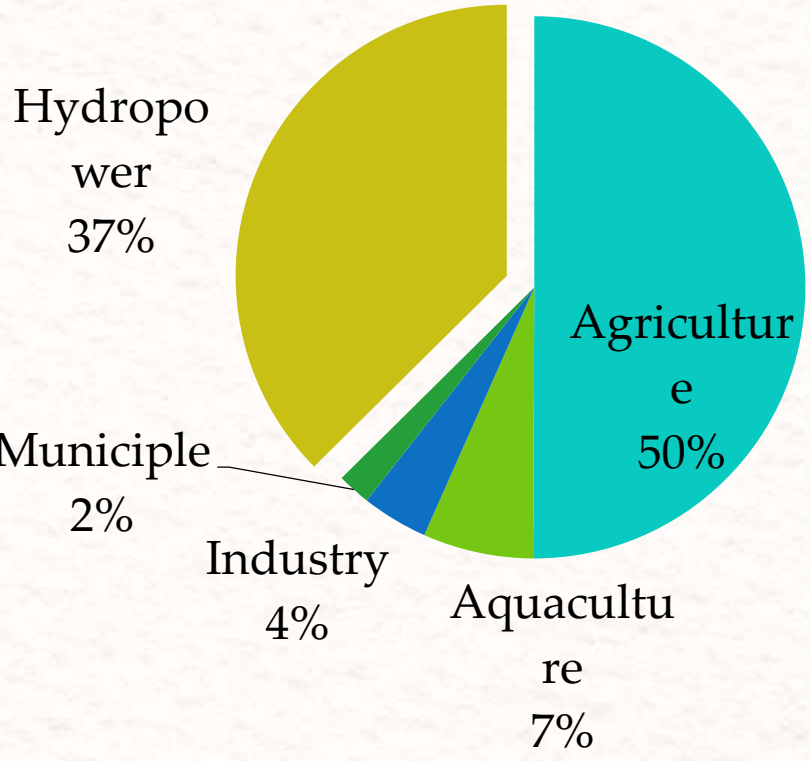


Source: MONRE, 2009

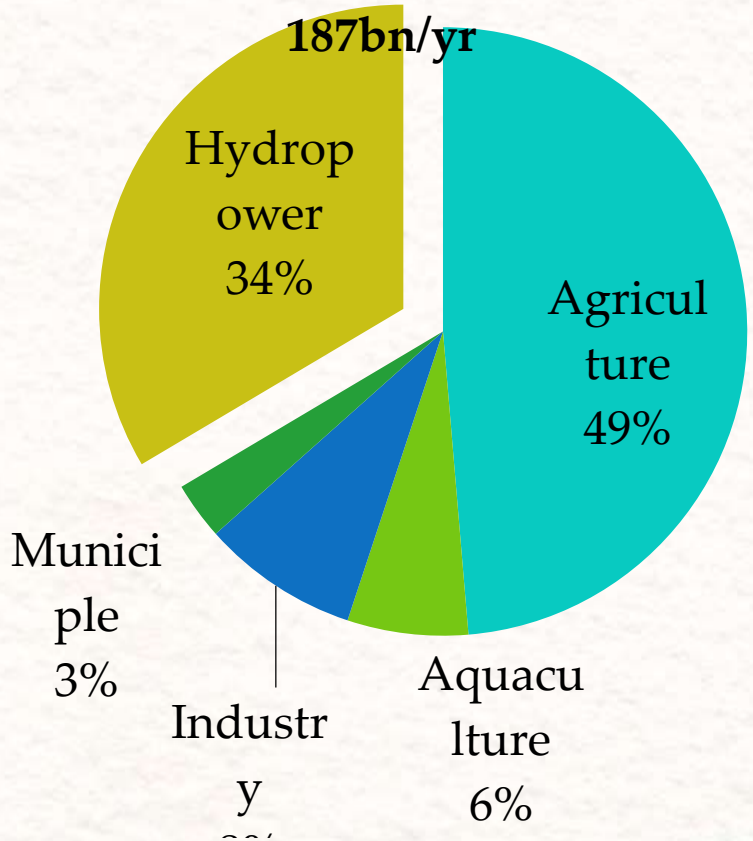
- Total renewable water resources amount to 884 bn m3/yr
- 63% of water resources originate outside of Viet Nam
- Urban water treatment plants only meet 55-70% of potable water demand
- Urban wastewater treatment plants only meet 12% of total domestic wastewater generated (source: MOC,2017)

Water demand by sector

Total water demand 2016: 151.8bn/yr



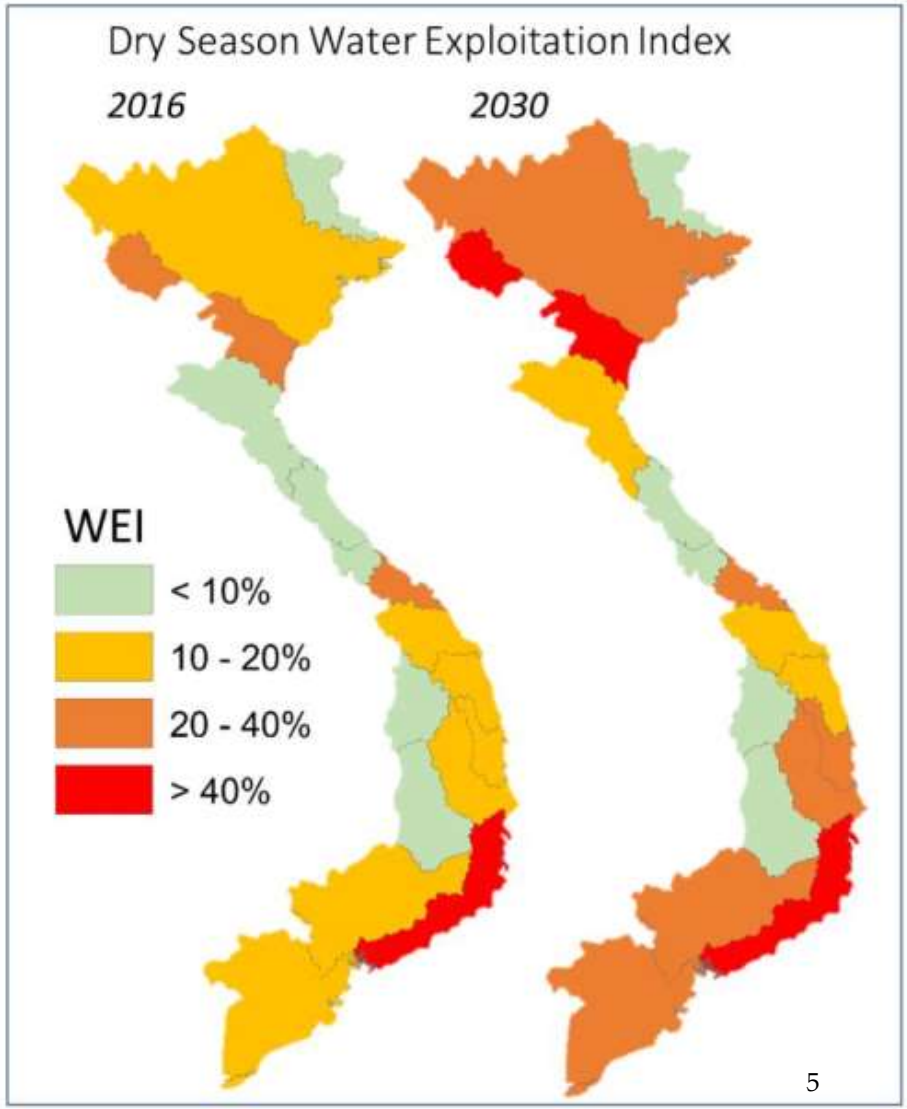
Total water demand 2030: 187bn/yr



Source: WRG,2017

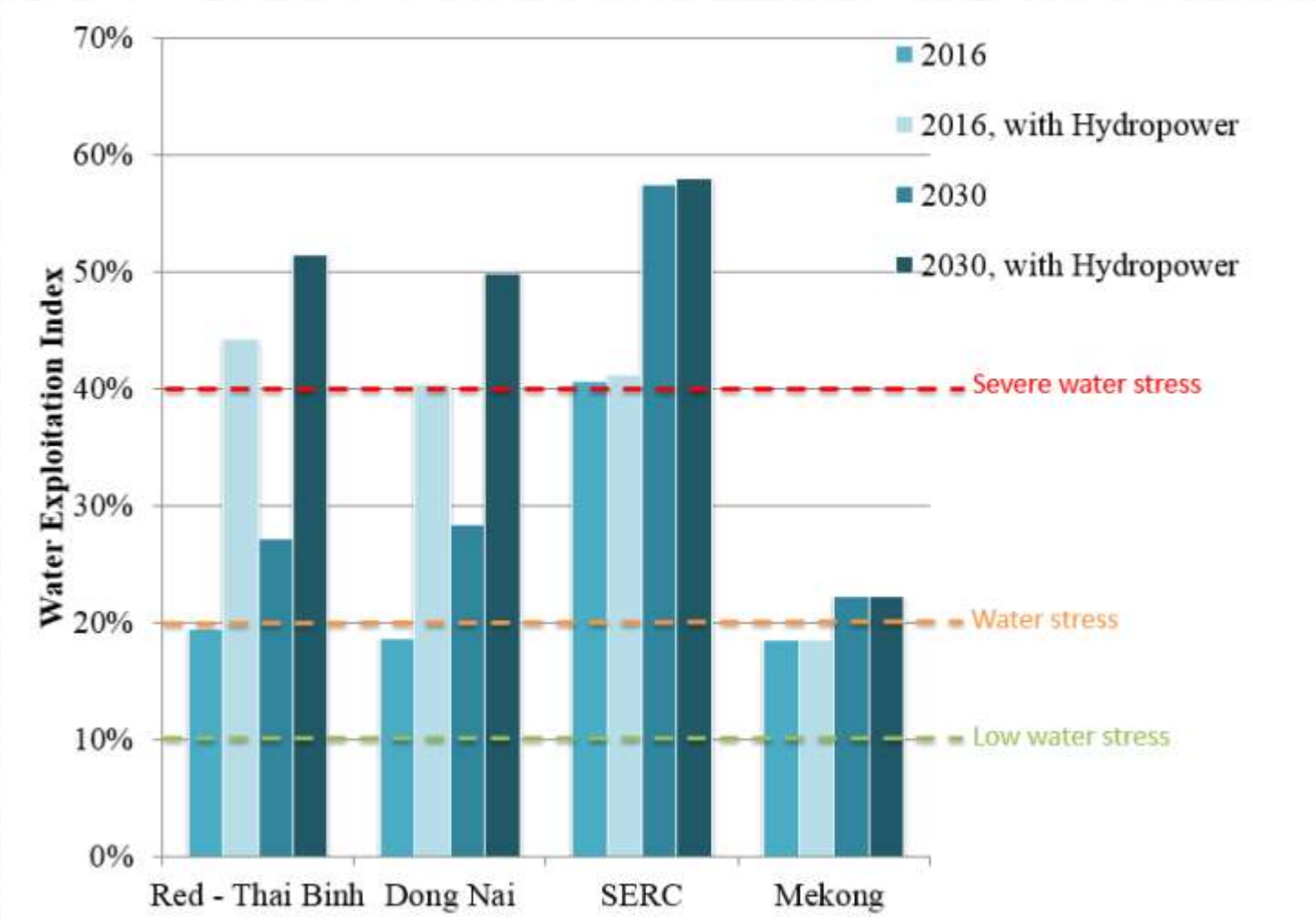
Water stress level = Water Exploitation Index (WEI)

Basin	2016	2030
Bang Giang - Ky Cung	1%	2%
Red - Thai Binh	19%	27%
Ma	35%	44%
Ca	9%	12%
Gianh	2%	3%
Thach Han	5%	6%
Huong	23%	28%
Thu Bon & Vu Gia	11%	15%
Tra Khuc	13%	16%
Kone	19%	23%
Ba	19%	24%
Dong Nai	19%	28%
SERC	41%	58%
Se San	<1%	1%
Sre Pok	5%	6%
Mekong	19%	22%



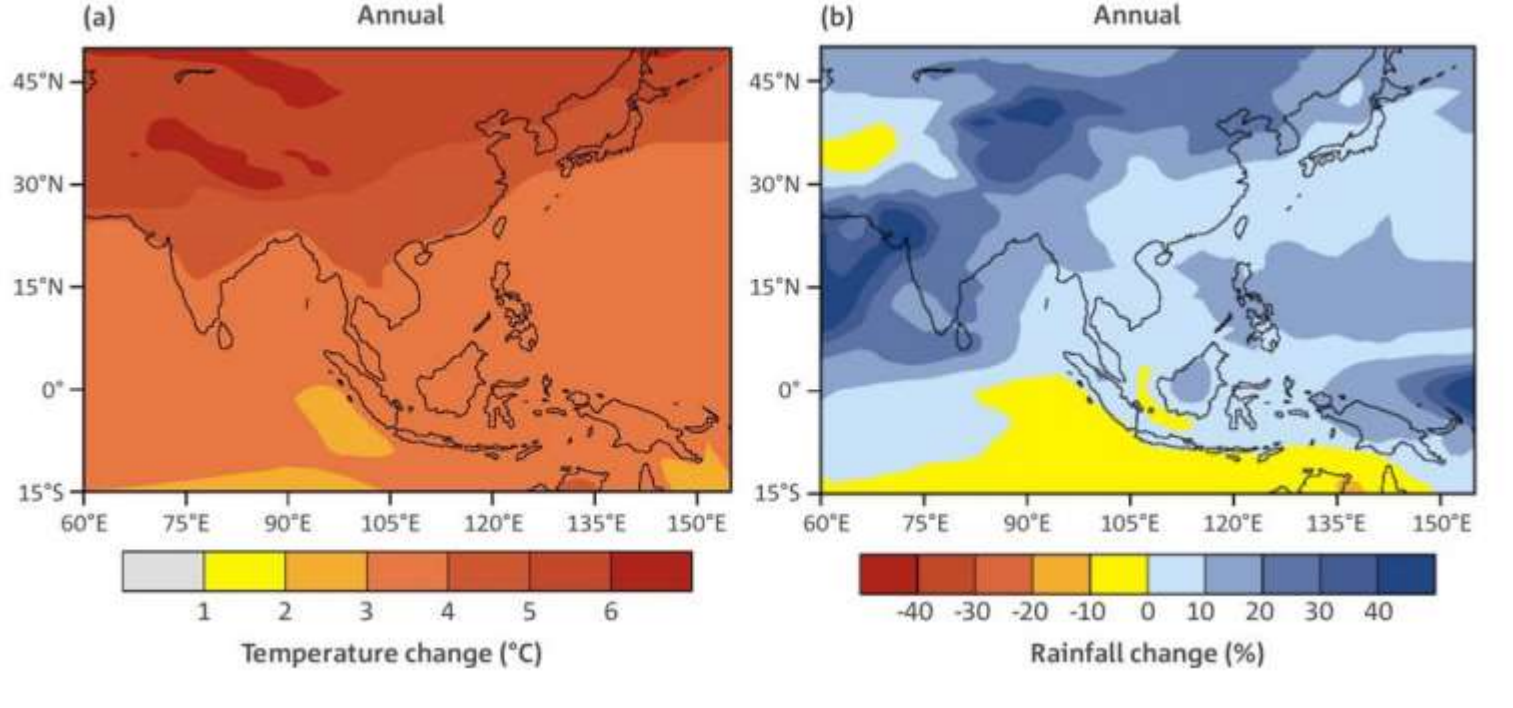
Source: WRG,2017

Water stress level



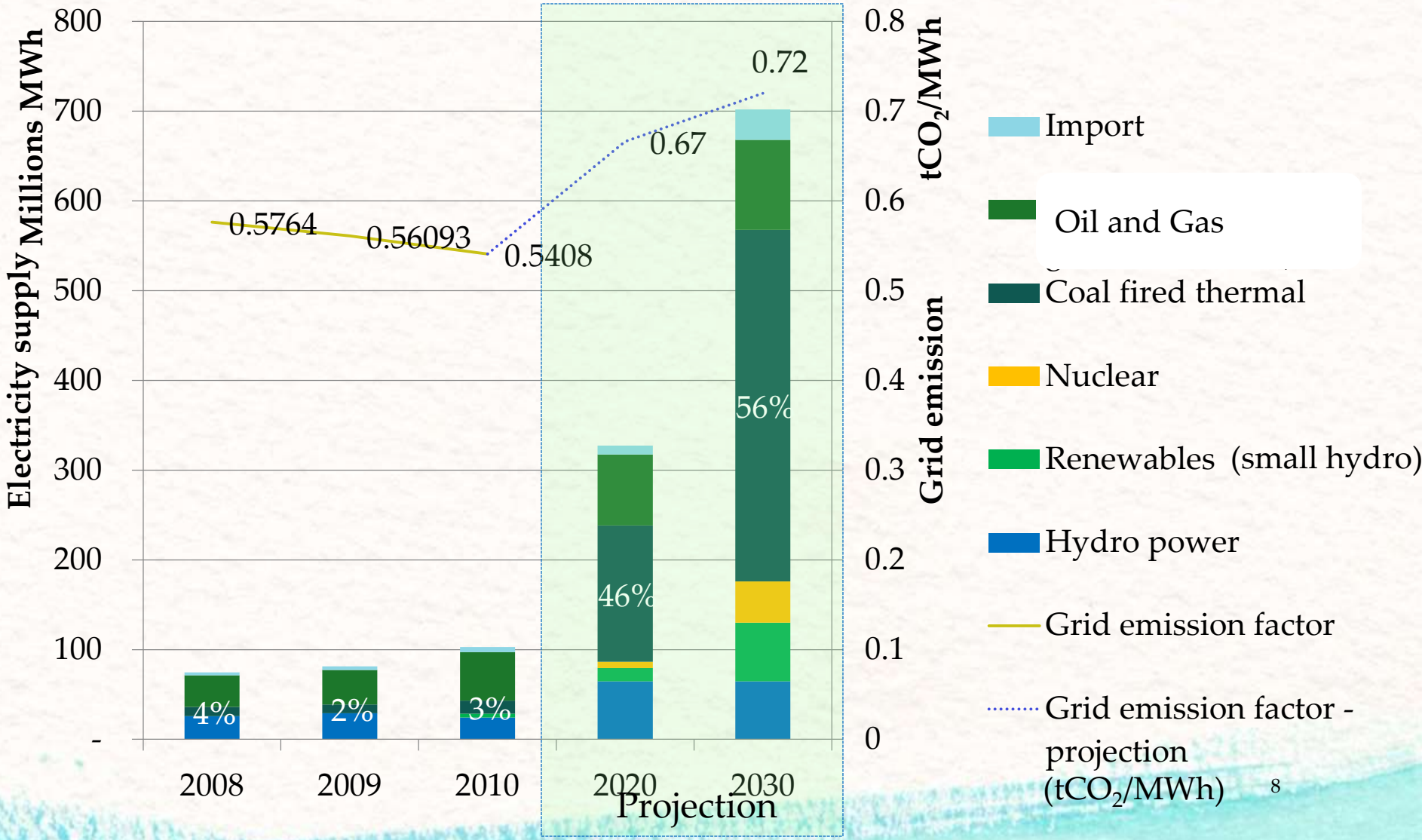
Climate change implication on water sector

Source: IMHEN,2014



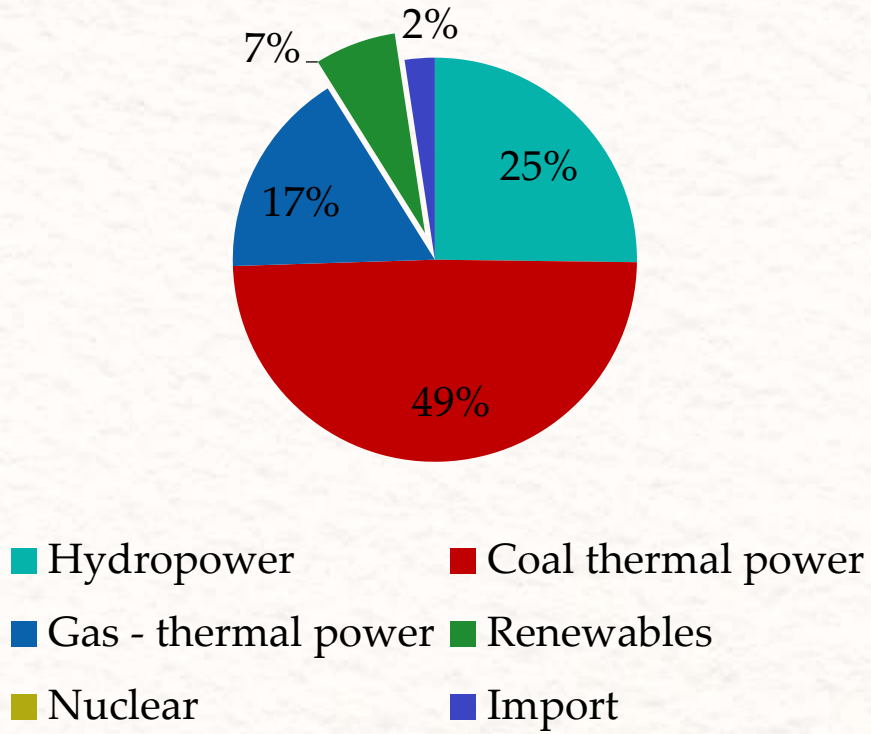
- Rainfall in the South Central region (Vu Gia- Thu Bon river basin): project increase in annual rainfall (RCP 4.5)
- Climate effects accounted for about 30% of total stream flow changes into the Hoa Binh reservoir - the largest (V=9.5 km3) and highest (120 m) dams in South-East Asia in the Red River basin.

Electricity generating capacity in Vietnam (2010-2030) - Source PDP 7 (2011)

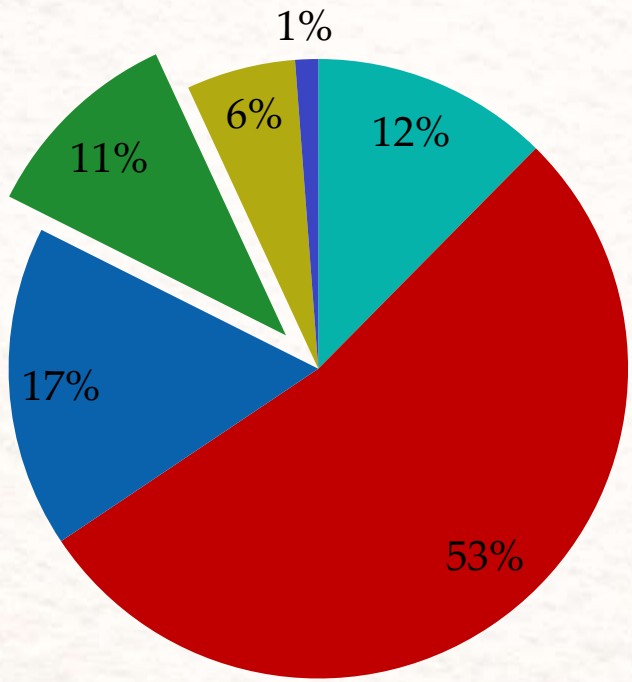


Electricity supply by sources (PDP7 revised)

Total electricity supply 265 mil.MWh (2020)



Total electricity supply 572,000 mil.MWh (2030)



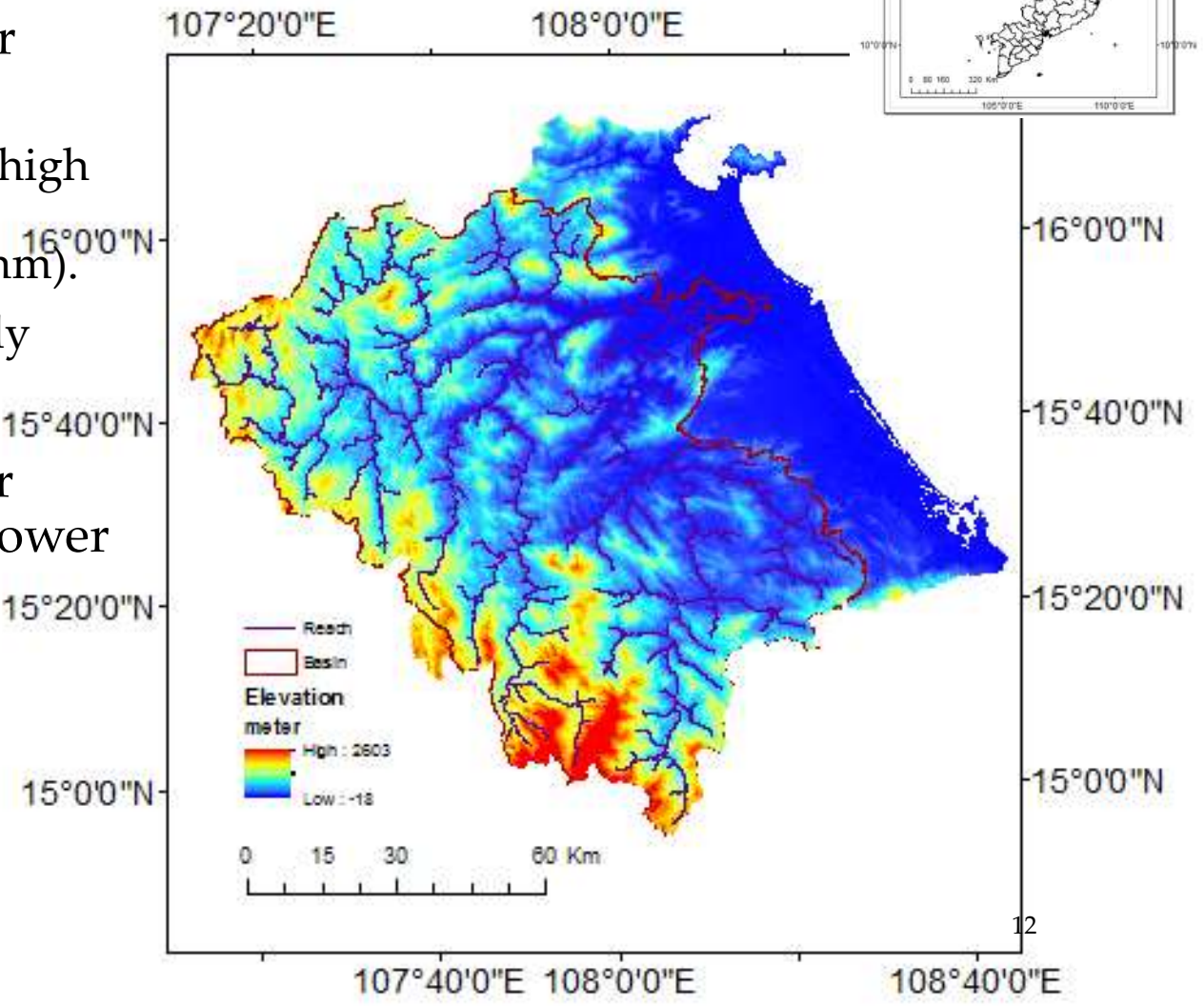
Source: TTCP, 2016

Small hydropower development

- Power Master Development Plan 7 and Revised PDP7 *(PDP7, 2011, 2016):* Increase the share of renewable source of electricity to 11% by 2030 (small hydropower plays important role).
- Vietnam National Green Growth Strategy *(VGGS, 2012)*: Restructure economy towards low carbon, commit to reduce emission from energy sector 10% in 2020 to 20% in 2030.
- National target program of new rural development *(NTP-NRD, 2010):*
  - Target 2.2: electricity accessibility
- Small hydropower has large potential (2925-4015MW) .

Vu Gia Thu Bon river basin

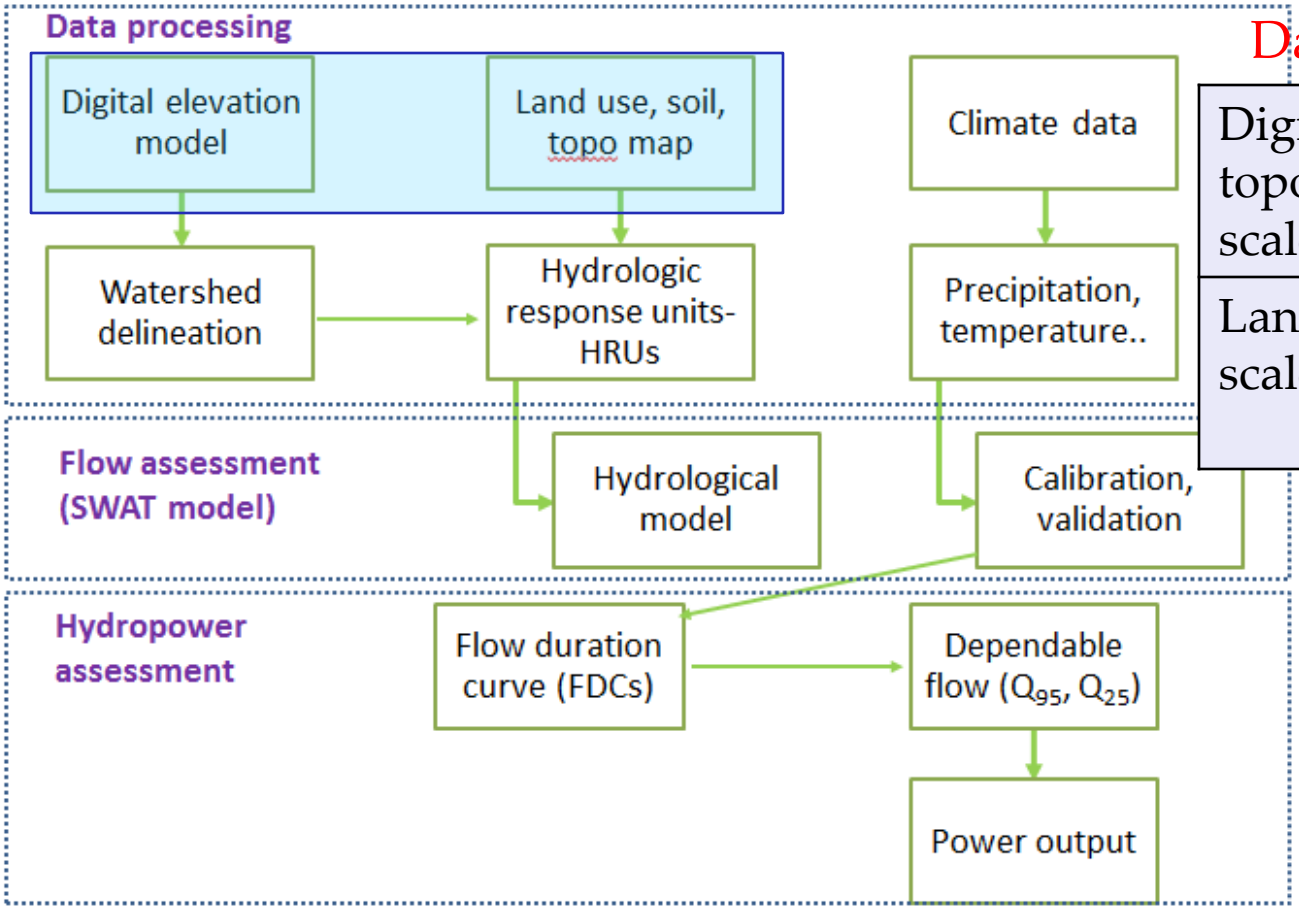
- Potential for hydropower development
  - Tropical monsoon zone, high precipitation (annual precipitation 2500-3000mm).
  - Dense river network, hilly terrain.
- One of nine priority river basins for future hydropower development (EVN).



Research Objectives and Methodologies

- **Objective**: Develop scheme for hydropower development to cope with climate change
  - ✓ Estimate the technical potential of small hydropower in the representative river basin of Vietnam.
- Methods:
  - Simulate rainfall-runoff using a distributed hydrologic model .
  - Estimate run-off-river hydropower potential using flow duration curves and energy duration curves

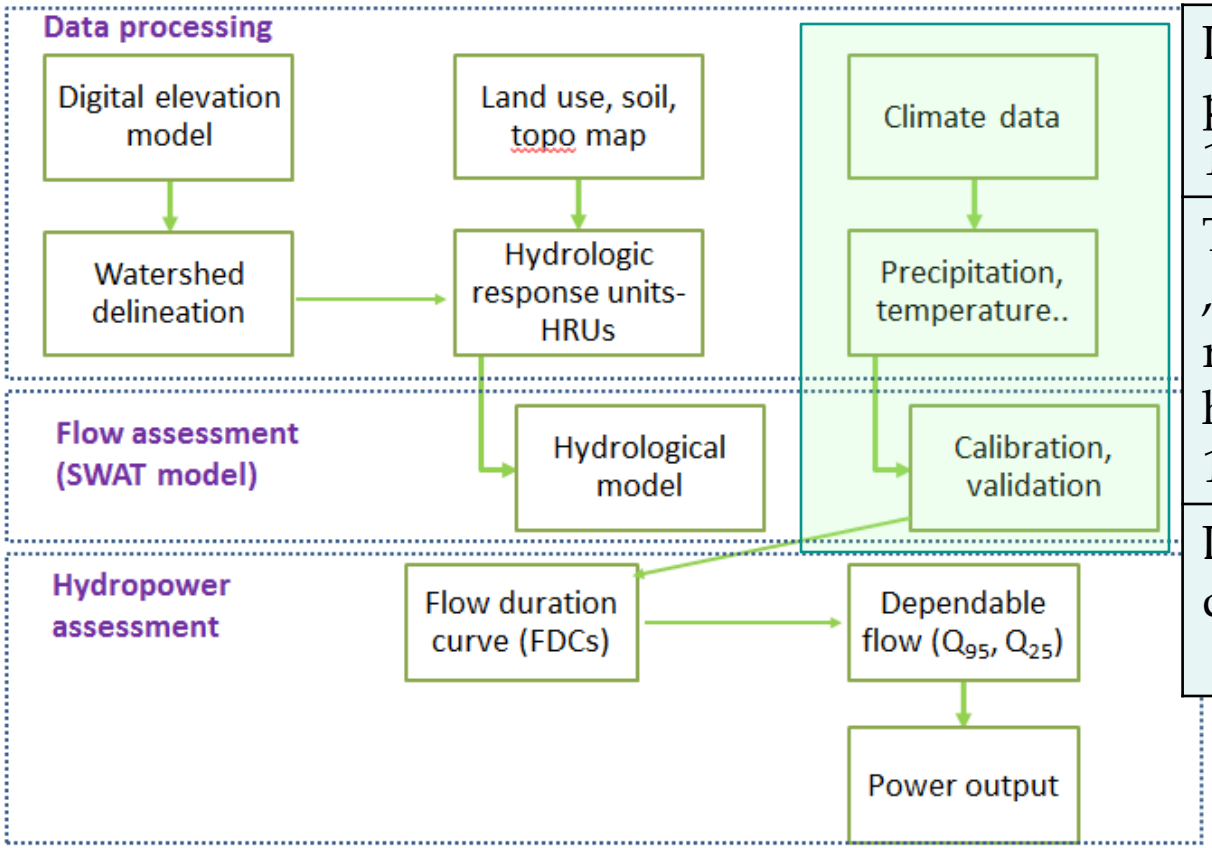
Methodology framework



Data sources

Digital topographic map, scale 1:50000	Quang Nam DoNRE
Landuse, soil map scale 1:50000	Quang Nam DoNRE

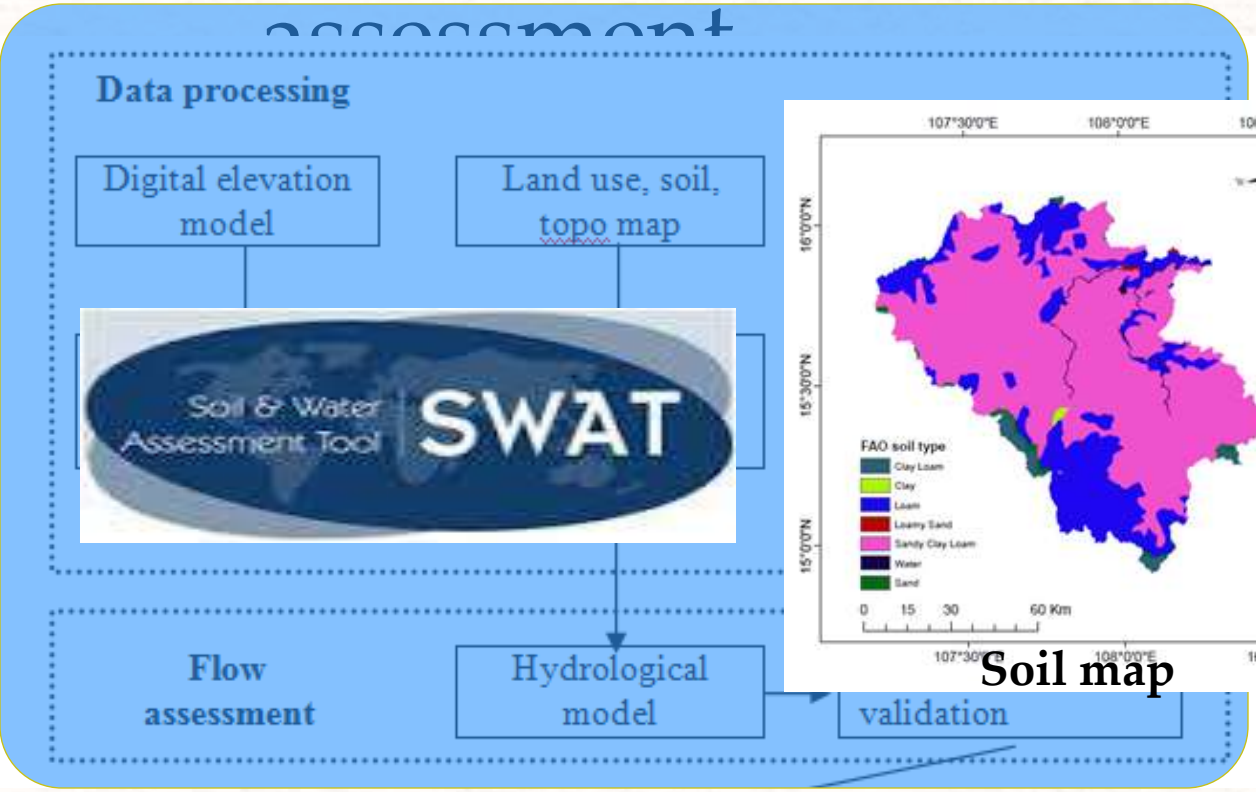
Methodology framework



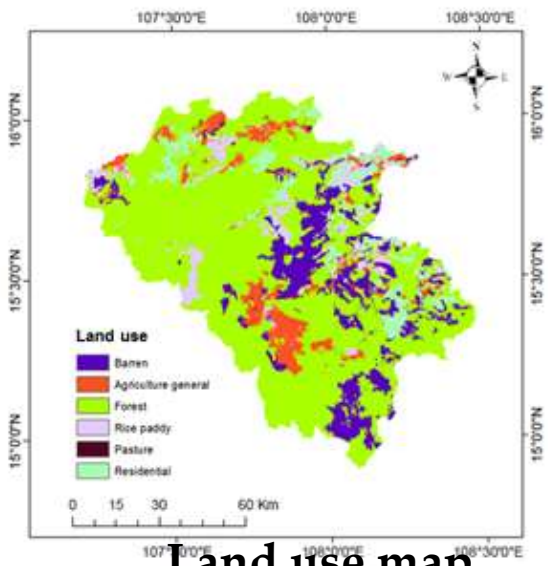
Data sources

Daily precipitation 1996-2007	16 meteorological stations
Temperature, wind, radiation, humidity 1996-2007	The National Centers for Environmental Prediction (NCEP)
Daily discharge	Thanh My meteorological station

Materials and Methods - Flow



Soil map

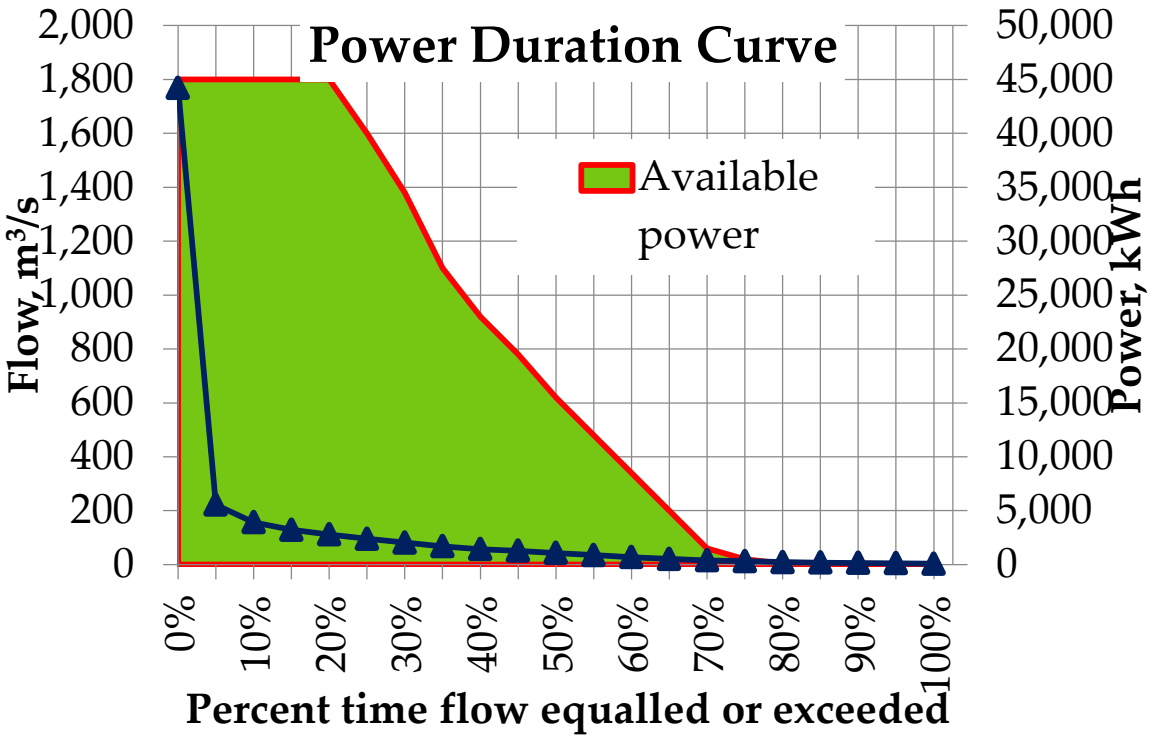


Land use map

$$Q_{surf} = \frac{(R_{day} - 0.2S)^2}{(R_{day} + 0.8S)}$$

Q_{surf} : accumulated runoff or rainfall excess, mmH_2O
R_{day}: rainfall depth of the day, mm H_2O
S: retention parameter, mm H_2O

Materials and Methods - Power



$$E_{avail} = \sum_{k=1}^{n} \left(\frac{P_{5(k-1)} + P_{5k}}{2} \right) \frac{5}{10} 8760(1 - l_{dt})$$

E_{avail} : the annual available energy

P_5 : the power at each flow with 5% interval of the curve

8760: the number of hour per year

ldt : the annual downtime losses

Theoretical power potential

$$P = \eta \rho Q g H$$

P: the mechanical power produced at the turbine shaft (Watts);

η: hydraulic efficiency of the turbine (85%);

ρ: the density of water (1000 kg/m^3);

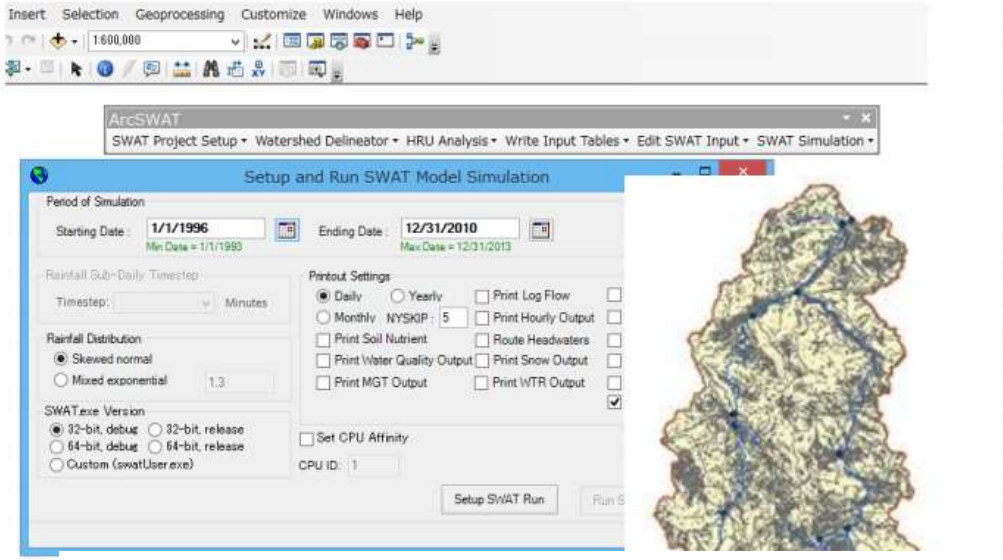
g: the acceleration due to gravity (9.81m/s^2);

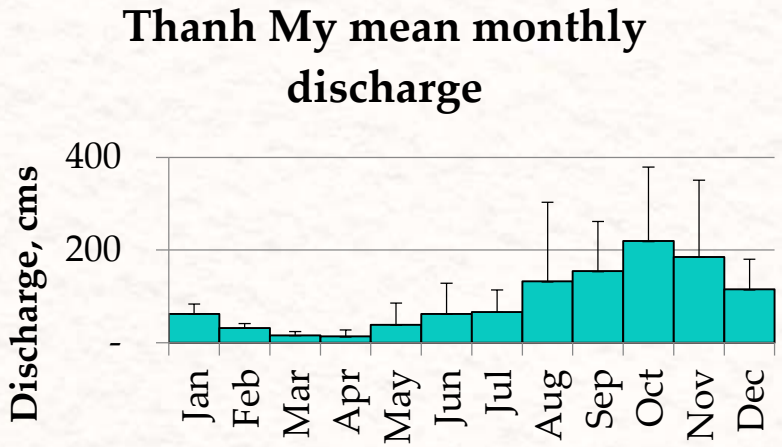
Q:the volume flow rate passing through the turbine (m^3/s);

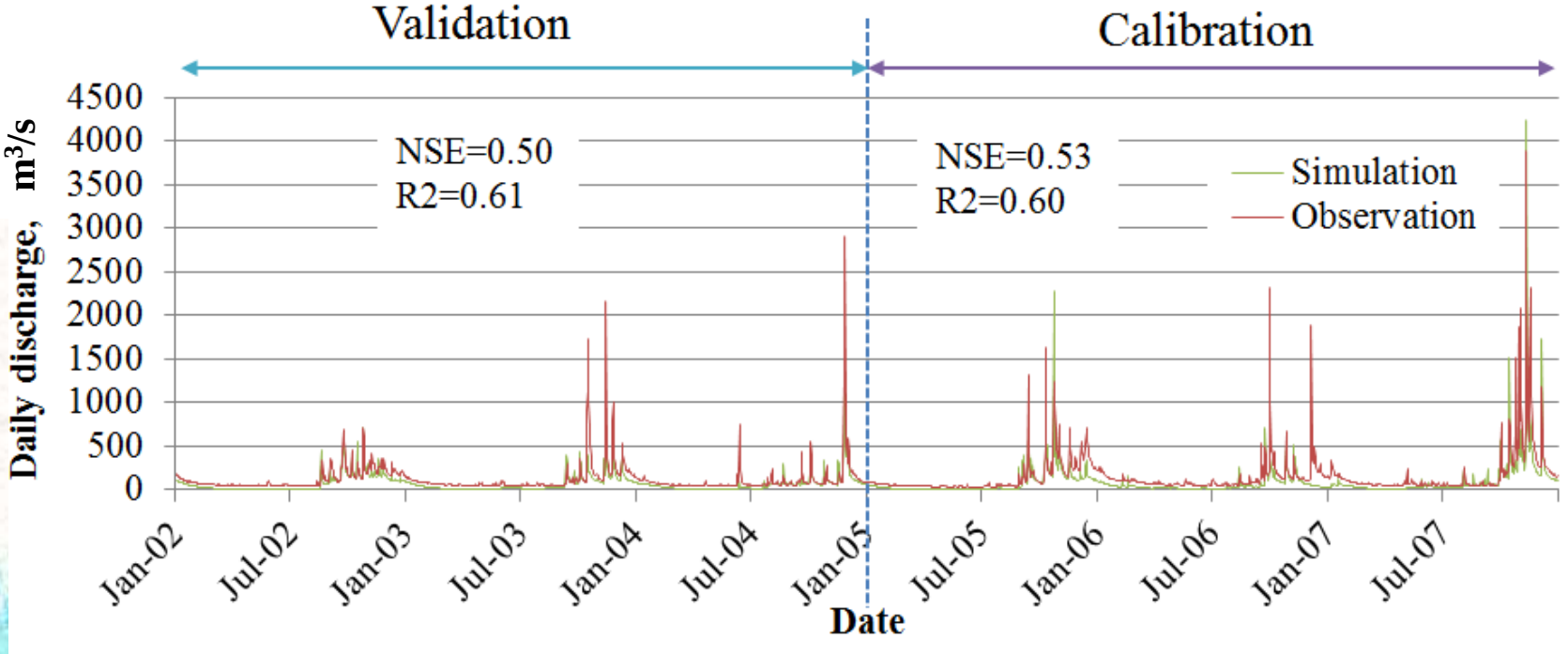
H: the head of water across the turbine (20m).

The downstream release of 10 % is considered for environmental release

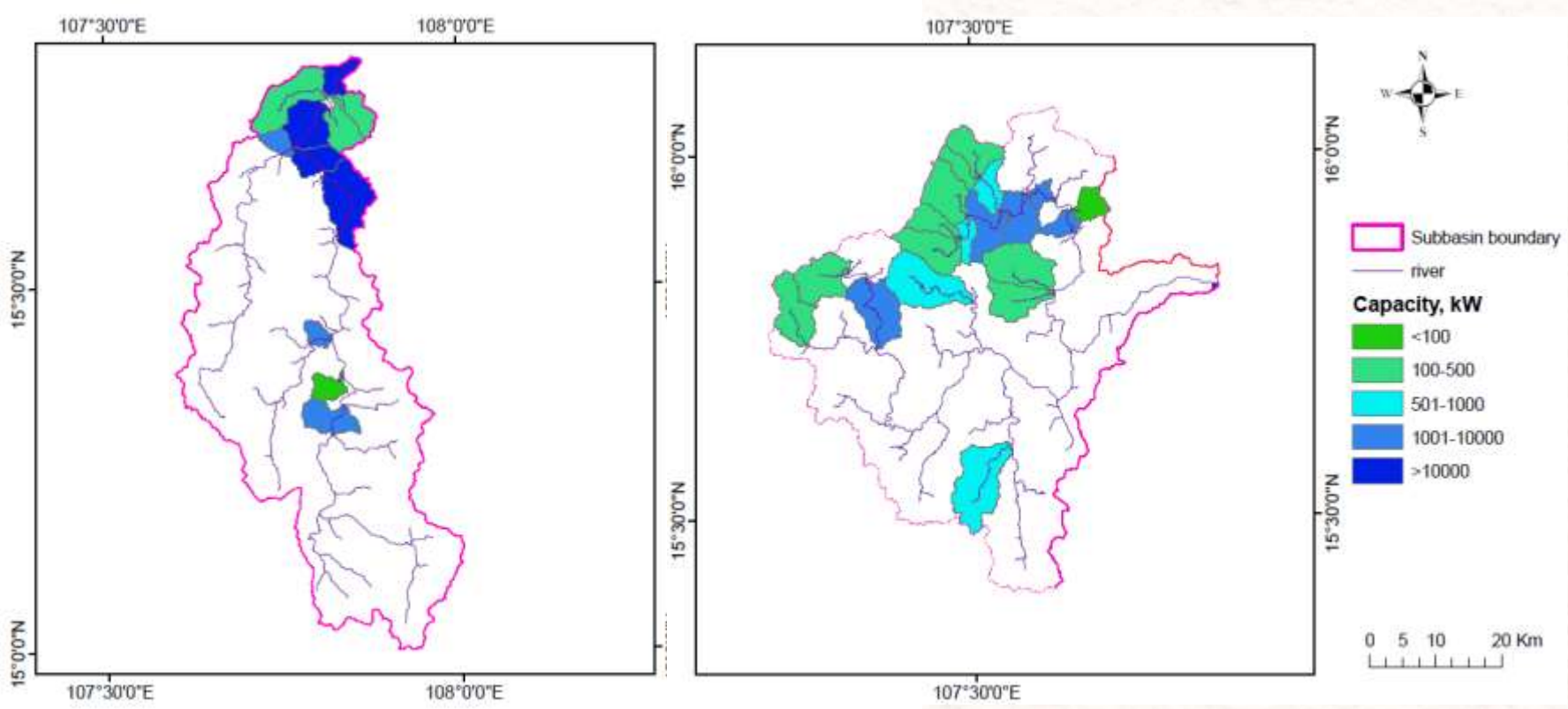
Results and Discussion - Flow assessment







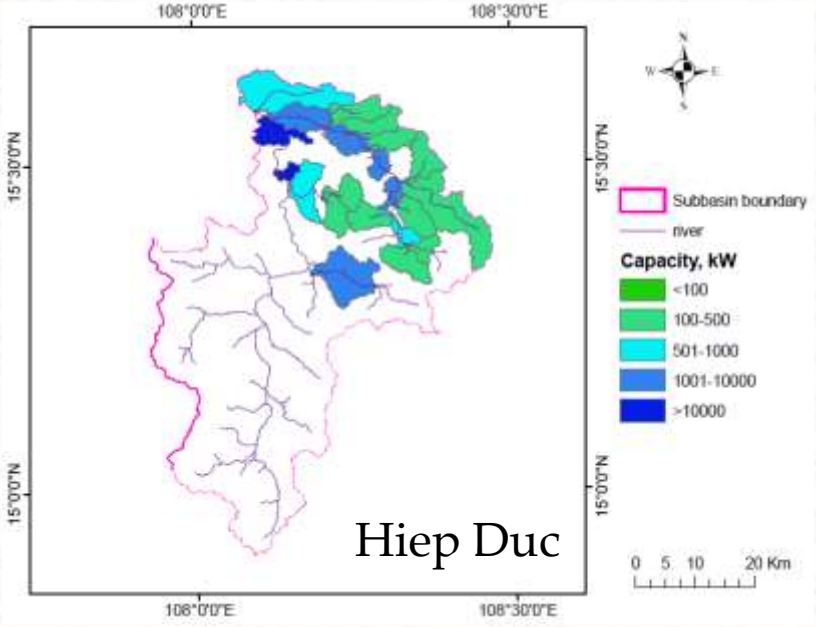
Results and Discussion - Power assessment

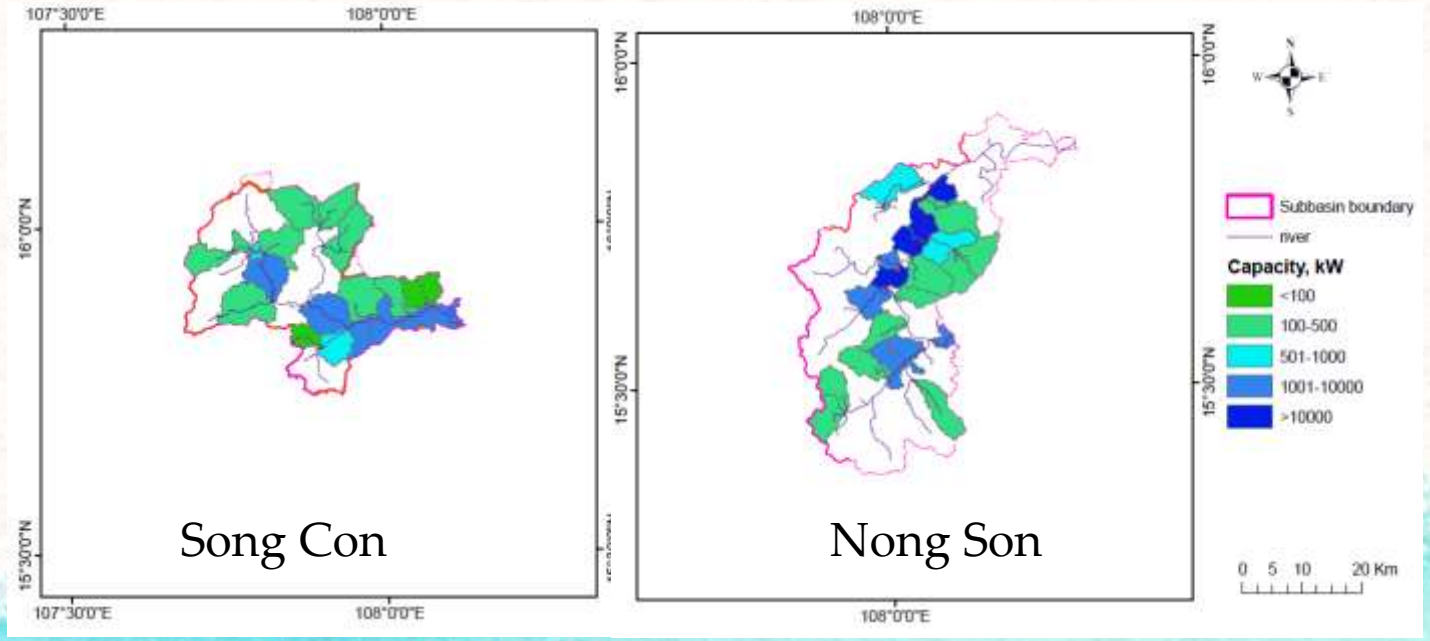


Thanh My

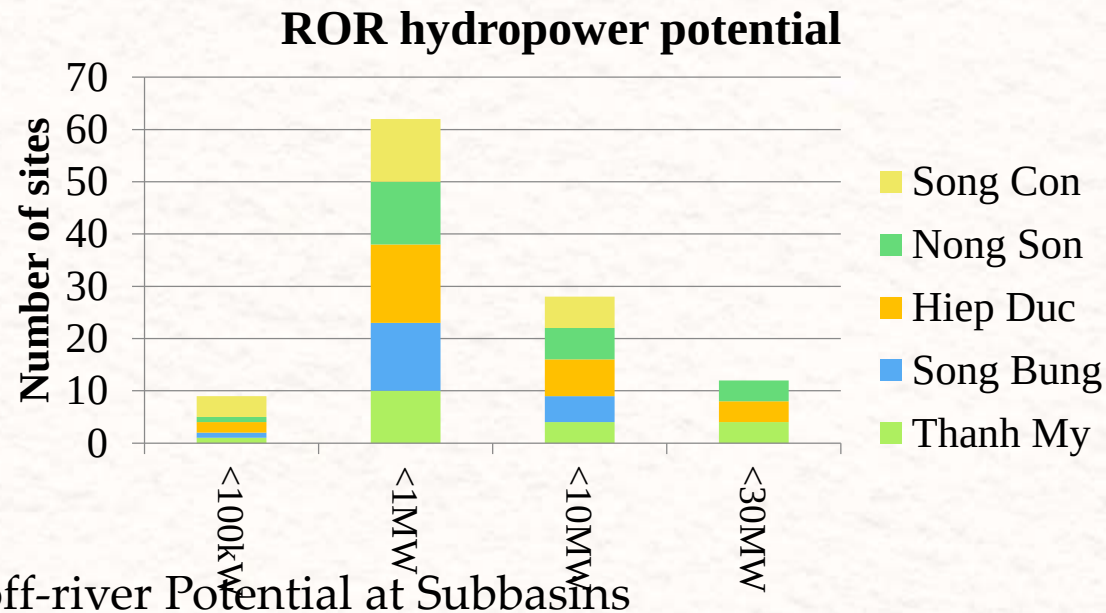
Song Bung

Results and Discussion - Power assessment





Results and Discussion - Power assessment



Run-off-river Potential at Subbasins

Subbasin	Capacity, kW	Capacity factor, %	Annual electricity generation, MWh
Thanh My (A)	62.099	41	237,845
Song Bung (B)	17.459	41	63,172
Hiep Duc (E)	78.226	39	277,811
Nong Son (D)	86.176	44	331,426
Song Con (C)	33.382	36	109,408
Total	277.342		1,019,661

Abatement Cost and Emission Reductions Potential of Small Hydropower

Compared to Conventional Diesel Generator and Grid Electricity Baseline (Source: Huong NL, 2016)

	Unit	Small hydropower	Diesel generator	Grid
Emission factor	tCO_2/MWh	0	0.89[1]	0.56[2]
Total electricity generated	TWh	19.68	19.68	19.68
Total emission reduction	$mil.tCO_2$	17.52	-	11.03
Abatement cost	USD/tCO_2	-195.51	-	-48.19

[1,2] Source: Ministry of Natural Resources and Environment (MONRE, 2012)

Conclusions

- The hydrological models for the five sub-basins of the Vu Gia-Thu Bon River basin were developed by SWAT.
- The model simulated quite good especially in the dry season, but slightly under-predicted the discharge during monsoon season.
- The small hydropower potential was estimated using hydrological distributed model, flow duration curves and energy duration curves.
- Total small hydropower potential is 277 MW with average capacity factor of 40.2 %.
  - Small hydropower system is capable to power 291,428 households with average electricity consumption of 3,500 kWh/year → Supply capacity 36.8% of total demand projection in 2050
  - Cost for CO_2 mitigation can be saved if small hydropower scheme will be developed in the region.
- International/local investment to develop the scheme in the basin.

Acknowledgment

- This study is partially supported by KAKENHI (26303012, P.I. Kensuke Fukushi) through JSPS and GLI fellowship at University of Tokyo funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of the Japanese Government

Thank you for your time.

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