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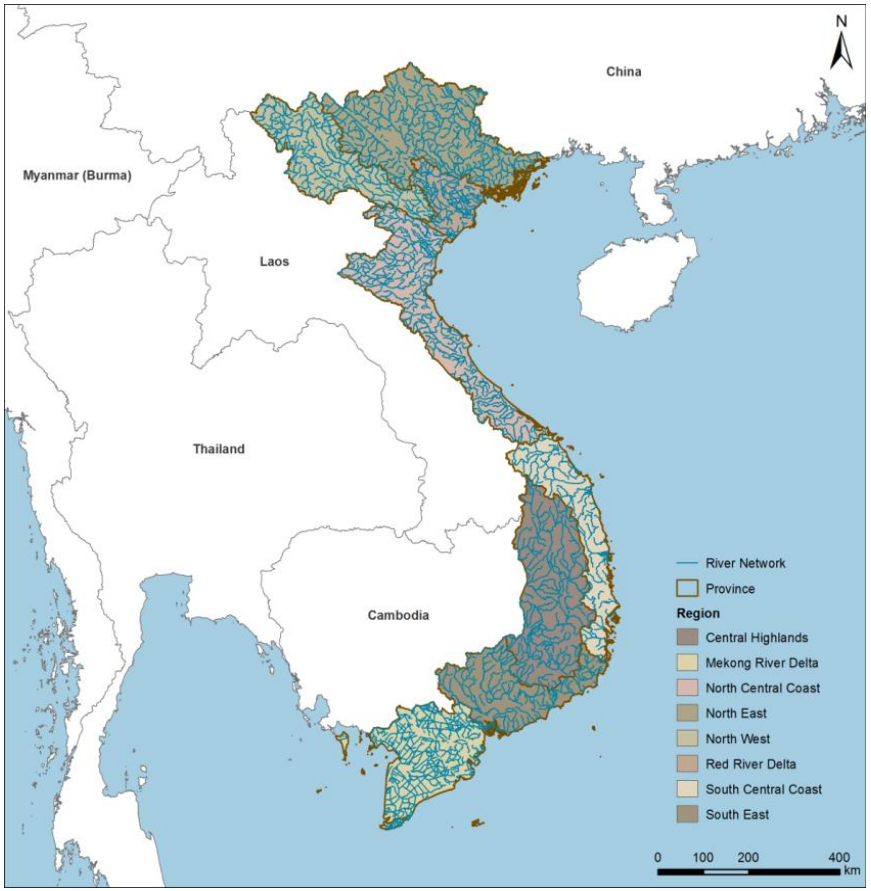
ESMAP
Energy Sector Management Assistance Program

Small Hydro Resource Mapping in Vietnam

Final Workshop

MARCH 2017



This report was prepared by Gesto Energy Consulting, under contract to The World Bank.

This is one of the several outputs from the small hydro resource mapping component of the activity "Renewable Energy Resource Mapping and Geospatial Planning – Vietnam" [Project ID: P145513]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the ESMAP website.

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Small Hydropower Mapping and Planning in Vietnam Technical Assistance

Workshop on Small Hydropower GIS Database and Guidelines for Review and Planning on Small Hydropower

VN.2017.A.001.0

Jorge ANDRÉ, jorge.andre@gestoenergy.com

Hanoi, February 2017

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INTRODUCTION

DATA COLLECTION

SMALL HYDROPOWER GIS DATABASE

GUIDELINES FOR REVIEW AND PLANNING OF SMALL HYDROPOWER

TESTING AND FINE-TUNING OF THE GUIDELINES

CLOSING REMARKS

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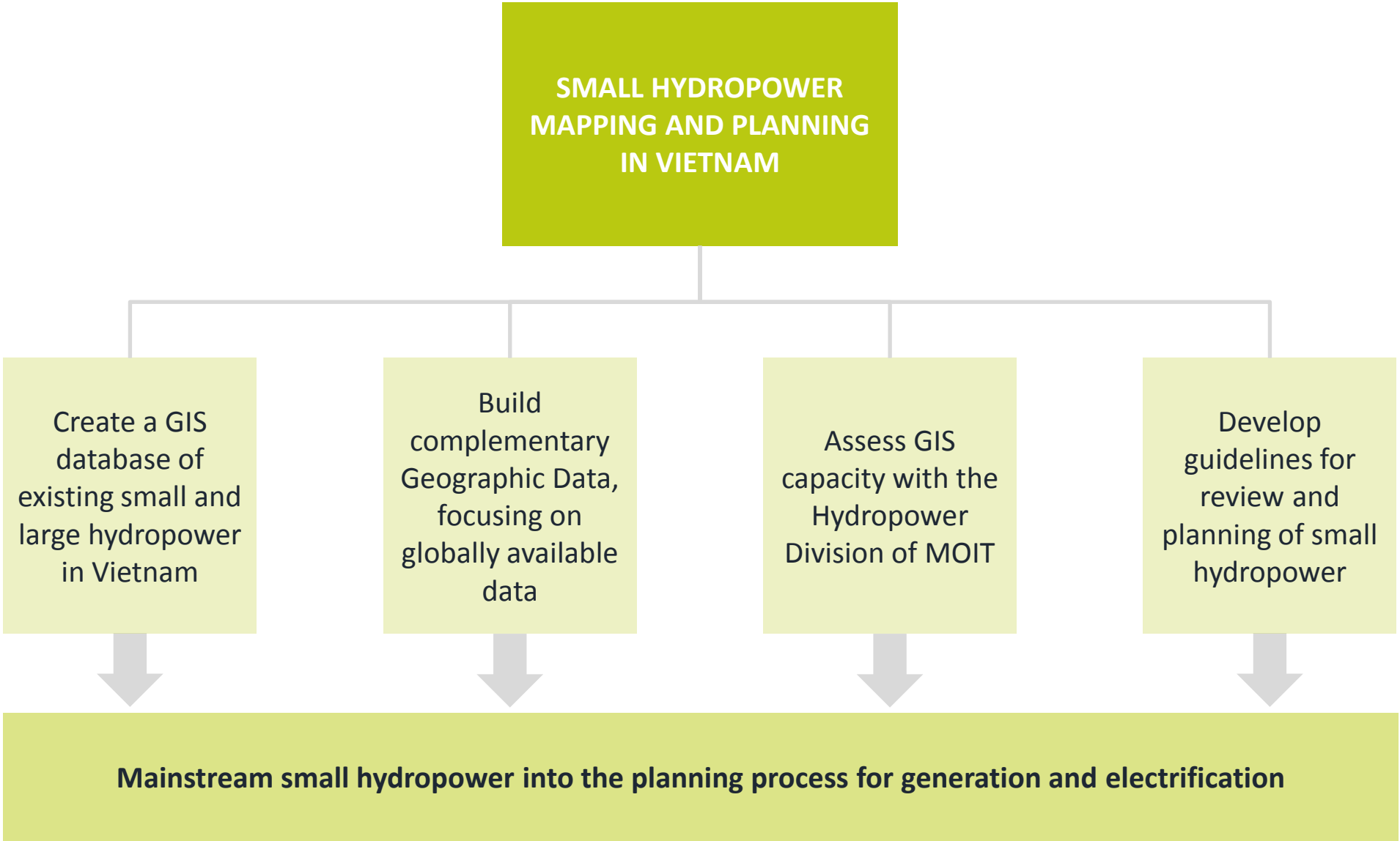
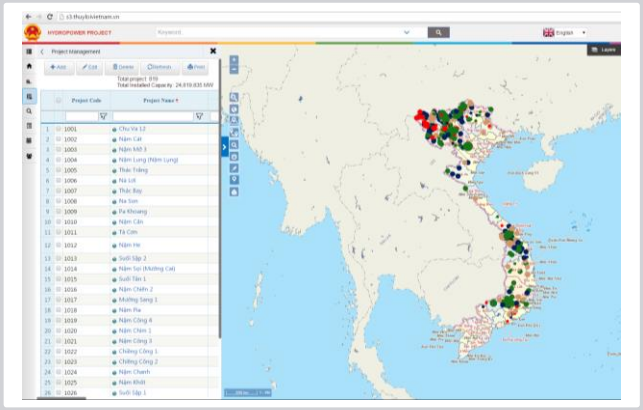
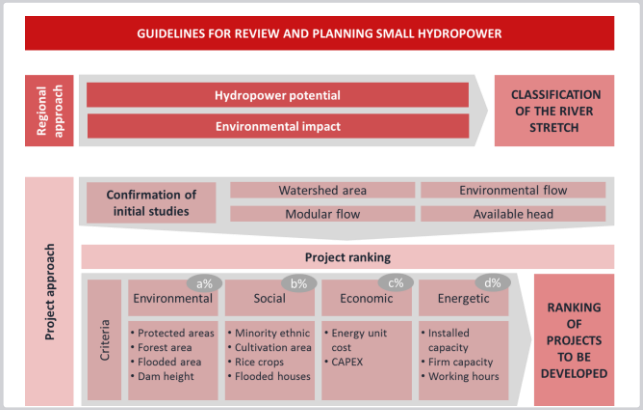
INTRODUCTION

WHAT IS THE MAIN OBJECTIVE OF THE TECHNICAL ASSISTANCE?



THE CURRENT TECHNICAL ASSISTANCE CONSISTED ON TWO MAIN ACTIVITIES





Activity 1

- Advisory services to a National Consultant for building up a national small hydropower GIS database

Activity 2

- Developing guidelines for improved planning of small hydropower

PROJECT IMPLEMENTATION PLAN

ACTIVITY 1: ADVISORY SERVICES FOR BUILDING UP A SMALL NATIONAL HYDRO GIS DATABASE

INCEPTION PHASE

1. INCEPTION MISSION
   - Evaluation of previous studies
   - Assessment of existing local and global data sources
   - Meetings
2. INITIAL COMPILATION OF EXISTING INFO AND DATA
   - Comprehensive list of existing small hydro projects
   - Brief characterization of the sector
   - Institutional assessment
3. DETAIL OF PRELIMINARY METHODOLOGY
4. INCEPTION REPORT
5. DECISION MEETING
6. FINAL METHODOLOGY

DESIGN OF A GIS DATABASE FOR NATIONAL INFORMATION ON SHP DEVELOPMENT

6. COMPLEMENTARY COMPILATION OF EXISTING INFO AND DATA
   - Existing SHP projects
   - Planned or potential SHP projects
7. DESIGNING A GIS DATABASE FOR INFO ON SHP DEVELOPMENT
   - Proposed software and hardware
   - Types, formats and attributes of data to include
   - Inclusion of readily available global geographic data
   - Assessment of the inclusion of data from other government bodies
8. RECCOMENDATIONS ON OPERATION AND MAINTENACE OF THE GIS DATABASE
9. WORKING REPORT ON THE DESIGN OF THE SHP GIS DATABASE

ADVISORY SERVICES FOR COMPILATION OF DATA, DIGITIZING AND POPULATION OF GIS DATABASE

10. COORDINATION WITH THE PARALELL CONTRACT
    - Discussion and update of proposed design
    - Plan for purchase of software and hardware, compilation of data, digitizing, population and documentation of the GIS database
11. TECHNICAL ASSISTANCE
    - Advisory services during implementation
    - One week mission in Vietnam for local support

ACTIVITY 2: DEVELOPING GUIDELINES FOR IMPROVED PLANNING OF SMALL HYDRO

DEVELOPMENT OF GUIDELINES FOR REVIEW AND PLANNING OF SMALL HYDRO

12. DETAILED REVIEW OF CURRENT PLANNING PROCEDURES FOR SHP IN VIETNAM
    - SWOT analysis
    - Legal framework
    - Assessment of expected info to be available for review and planning of SHP
13. DRAFT GUIDELINES FOR REVIEW AND PLANNING OF SHP
    - Implementation of a gradual process
    - Recommendations
    - Possible integration on an overall planning process for RE in Vietnam

TESTING AND FINE-TUNING OF GUIDELINES AND CAPACITY BUILDING OF MOIT

14. PRESENTATION AND APPLICATION OF THE PROPOSED GUIDELINES FOR REVIEW AND PLANNING OF SHP
    - Feedback
    - Simulation of a real case
15. UPDATED IMPROVED GUIDELINES FOR REVIEW AND PLANNING OF SHP AND RECOMMENDATIONS

REPORTING AND FINAL WORKSHOP

16. DRAFT REPORT
    - Description of used methodology
    - Detailed maps
    - Inputs to the Workshop
17. WORKSHOP
    - Results presentation
    - Next steps
18. FINAL REPORT
19. APPROVAL OF REPORT

SYMBOLS:
- Travel to/from Vietnam
- Deliverable
- Workshop/Capacity Building
- WB/GoV decisions

Coordination with National Consultant Vietnamese Academy of Water Resources

SEVERAL MISSIONS WERE CONDUCTED FOR THE DEVELOPMENT OF THE PROJECT

Mission	Date	Institutions involved	Objectives
Inception	October/ November 2014	MOIT, WB, MONRE, EVN, MARD, MRC, Suoi Tan Joint Stock Company, VAWR	Data collection, fine-tune of proposed methodology. Site visits
Interim I	November 2015	MOIT, WB, VAWR	Working mission
Workshop I	February 2016	MOIT, WB, VAWR	Small hydropower GIS demo version presentation
Interim II	May 2016	Lao Cai DOIT, MOIT, EVN, PECC-1, VAWR, WB	Visits to DOIT's and other stakeholders
Workshop II	February 2017	MOIT, WB, VAWR	Results presentation and validation

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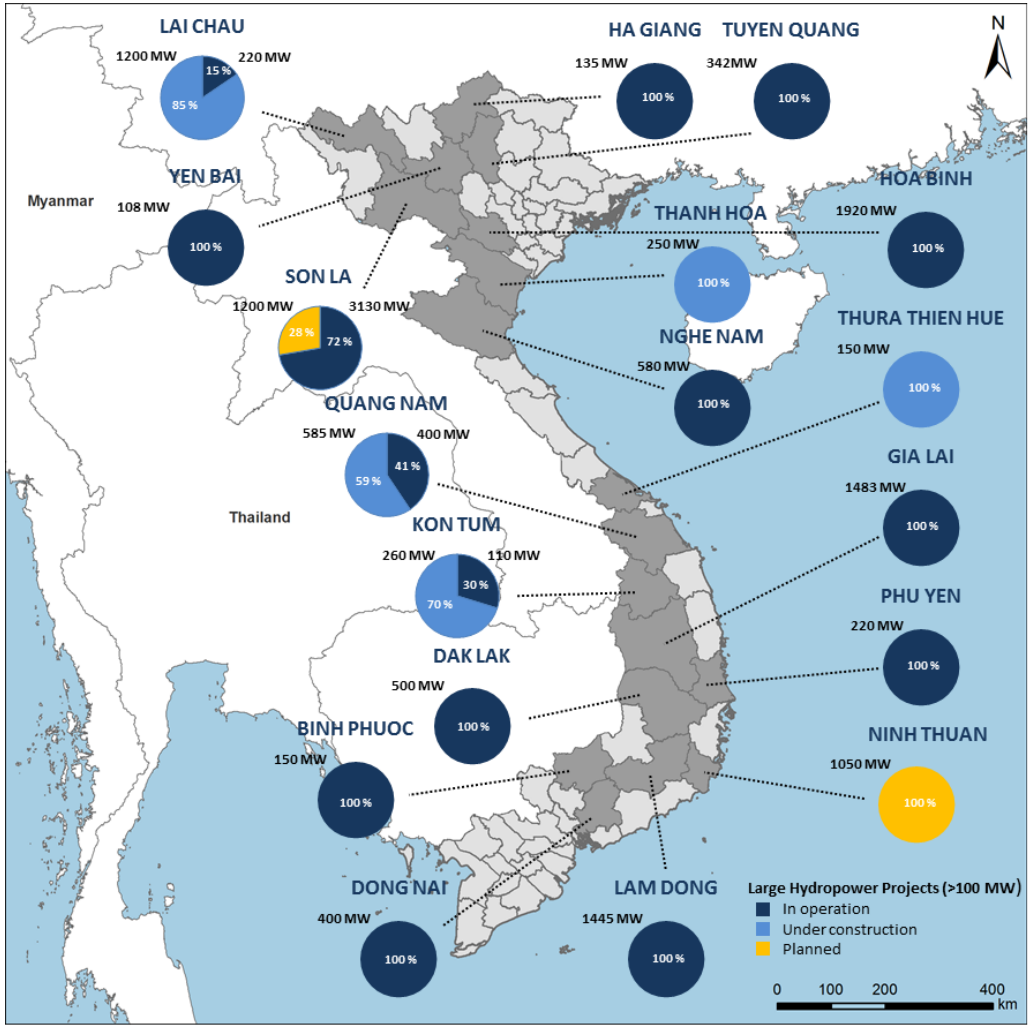
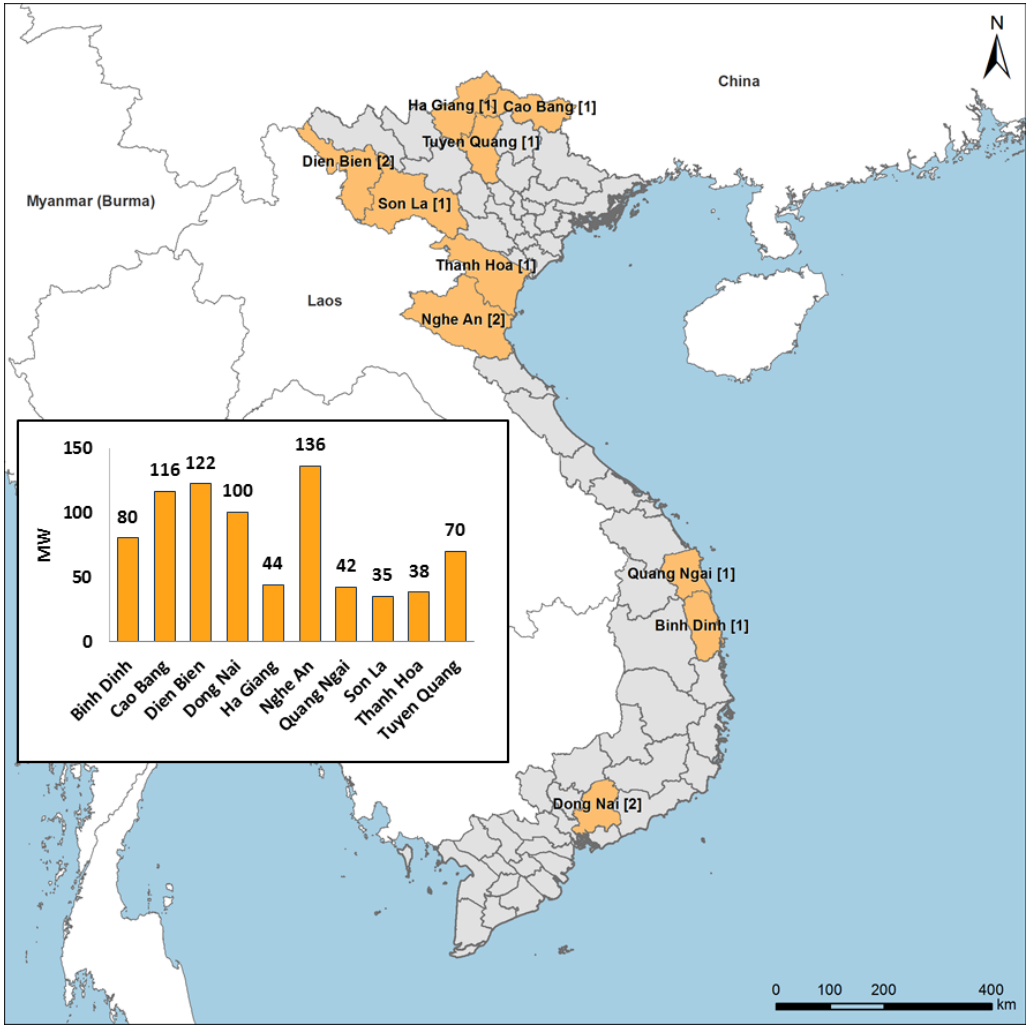
DATA COLLECTION

THE DATA COLLECTION STARTED WITH THE GATHERING OF RELEVANT LOCALLY AVAILABLE PROJECT DATASETS…



Current and future situation for LHP (Consultant's processing). Source: MOIT (2014).



MHP preparing for construction status (Consultant's processing). Source: MOIT (2014).

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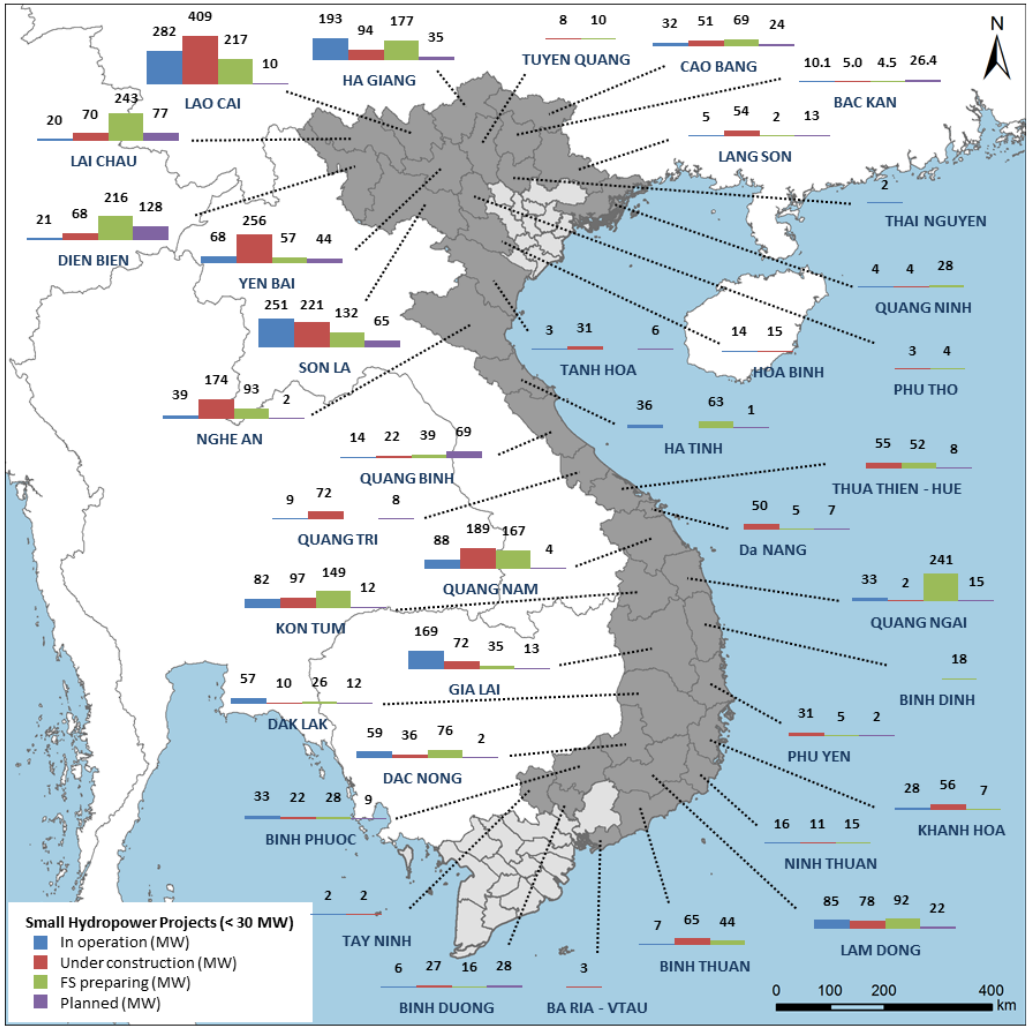
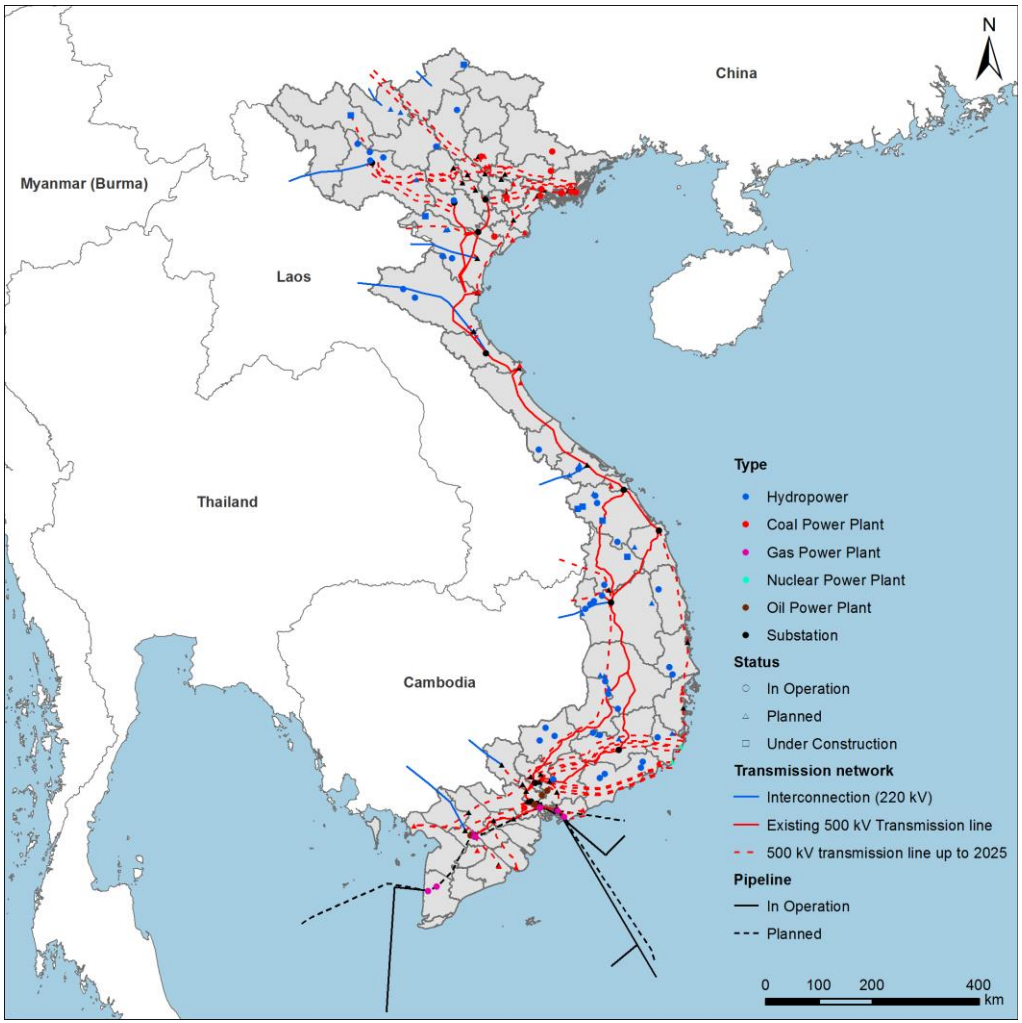
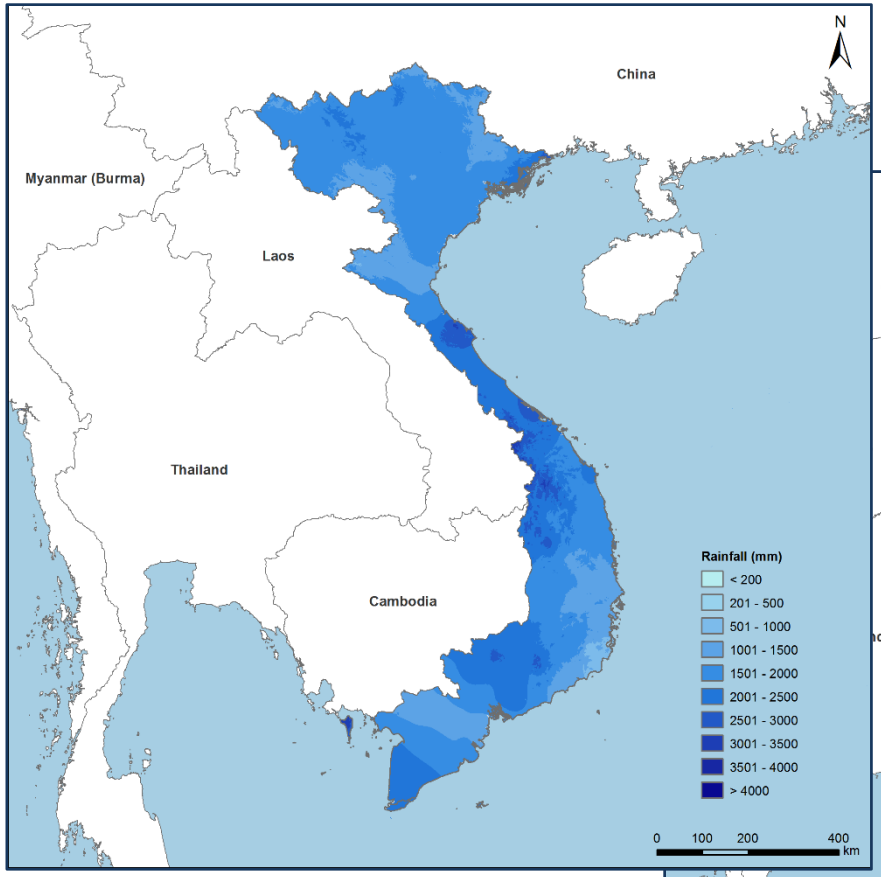


Current and future situation for SHP (Consultant's processing). Source: MOIT (2014).

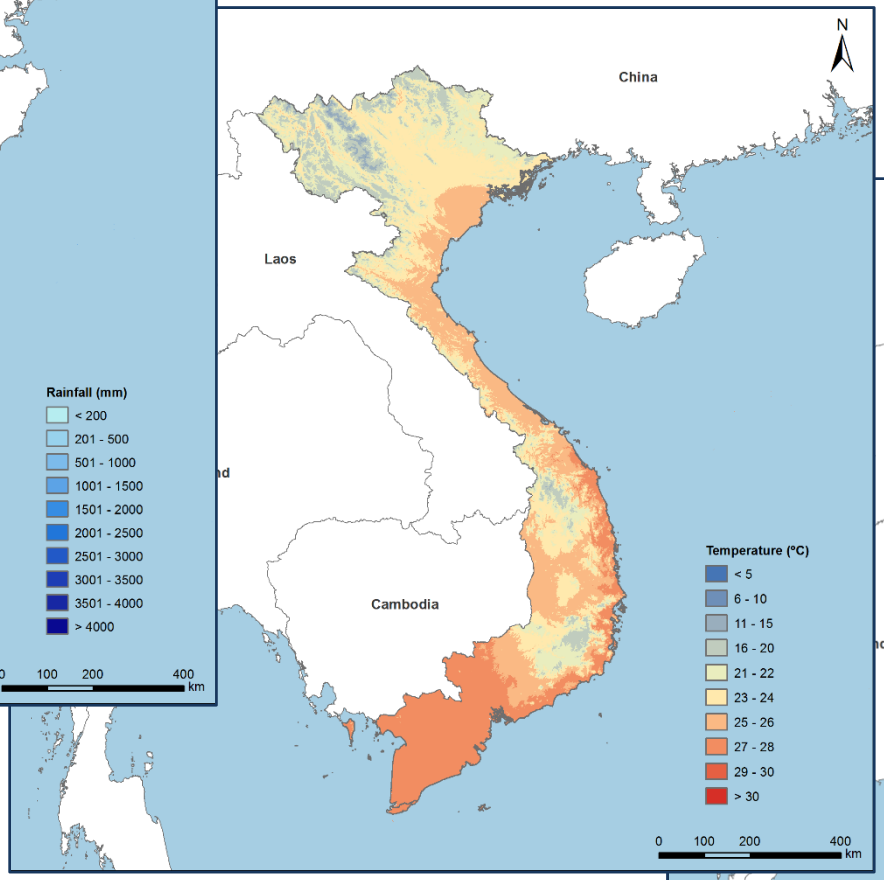


Vietnam Energy Map (Consultant's processing). Source: Japan External Trade Organization (JETRO)

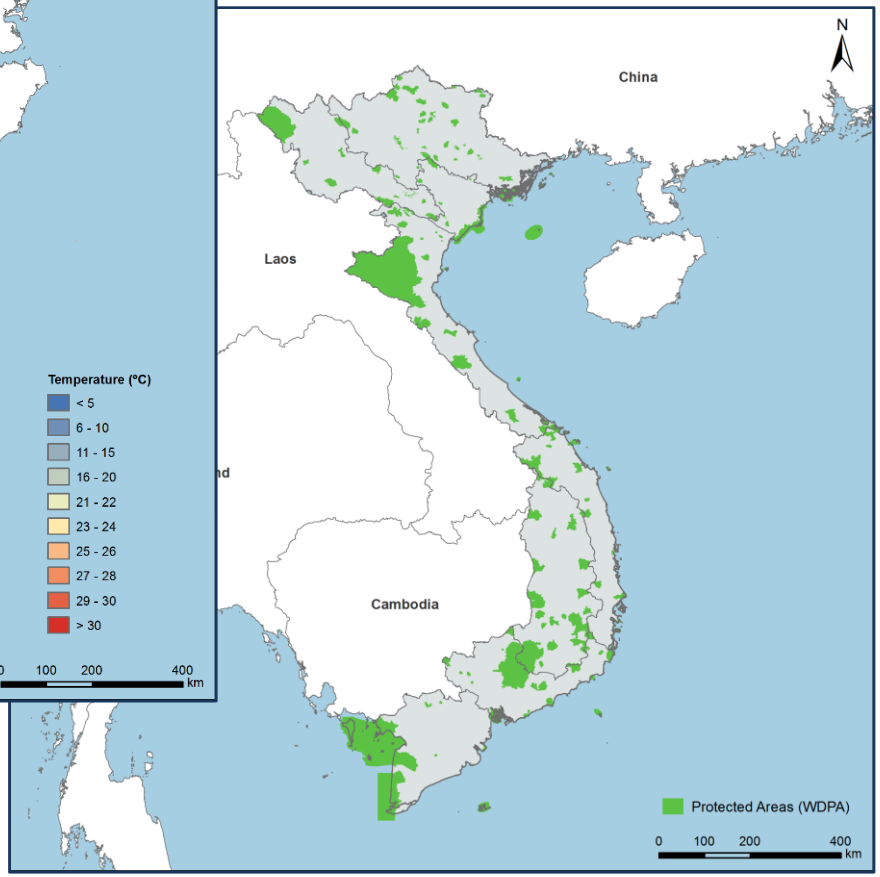
….AND PROCEEDED TO GLOBALLY AVAILABLE SPATIAL AND TEMPORAL DATASETS



Mean annual rainfall in Vietnam. (WorldClim, Consultant's processing)



Mean annual temperature in Vietnam. (WorldClim, Consultant's processing)



Protected areas. (WPDA, Consultant's processing)

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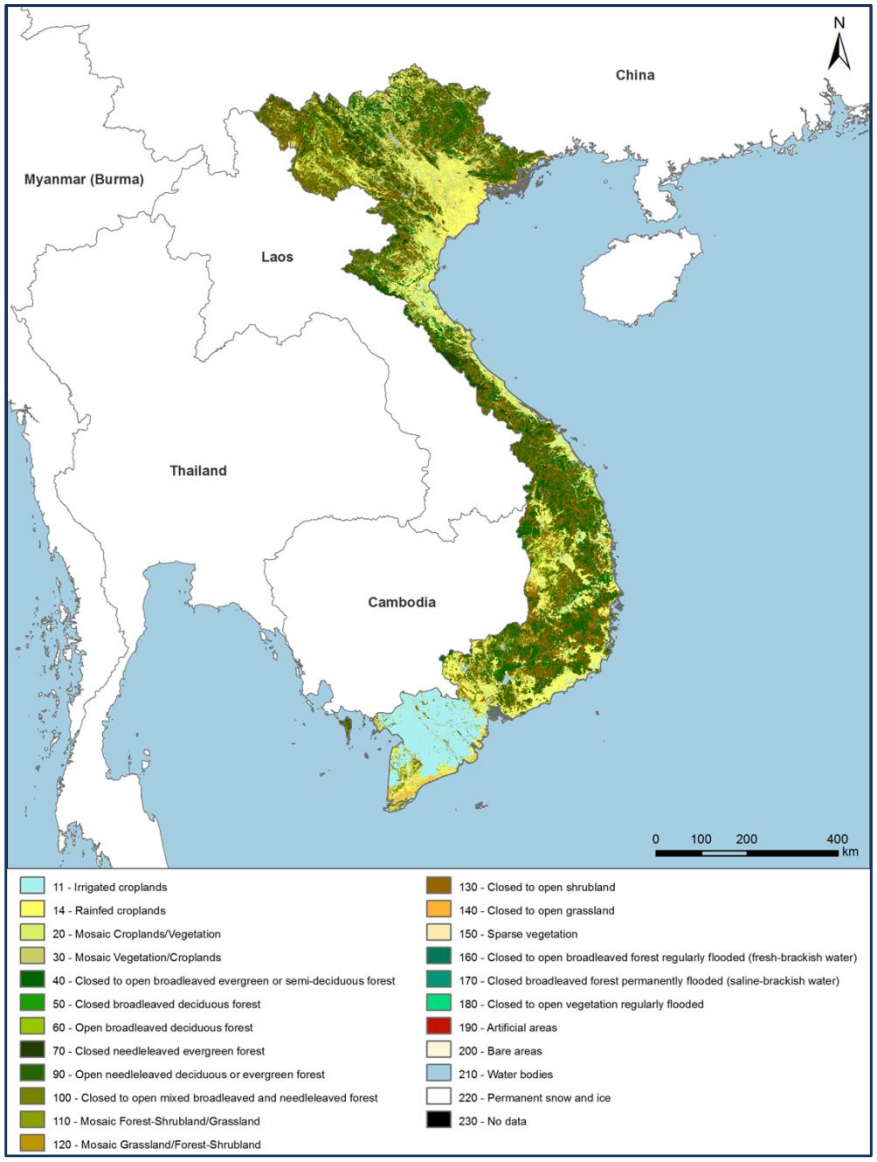
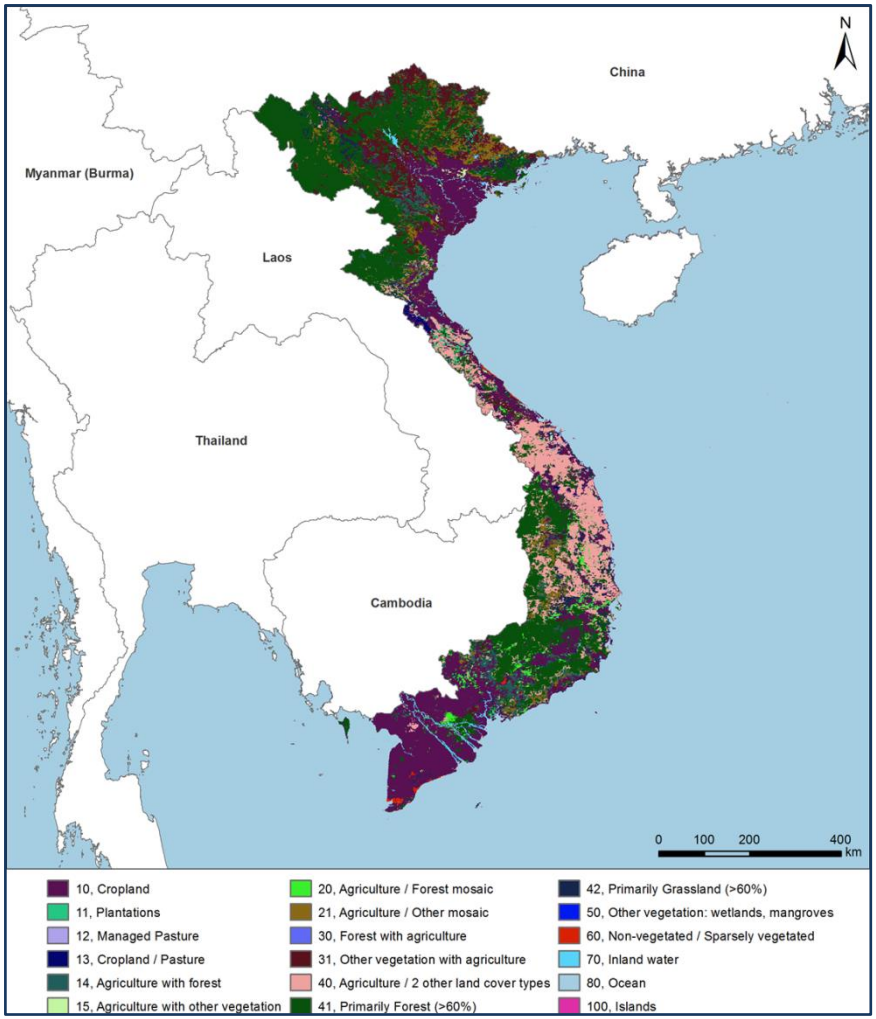


Land Cover
(GlobCover 2010, Consultant's processing)



Land Use
(GeoNetwork, Consultant's processing)

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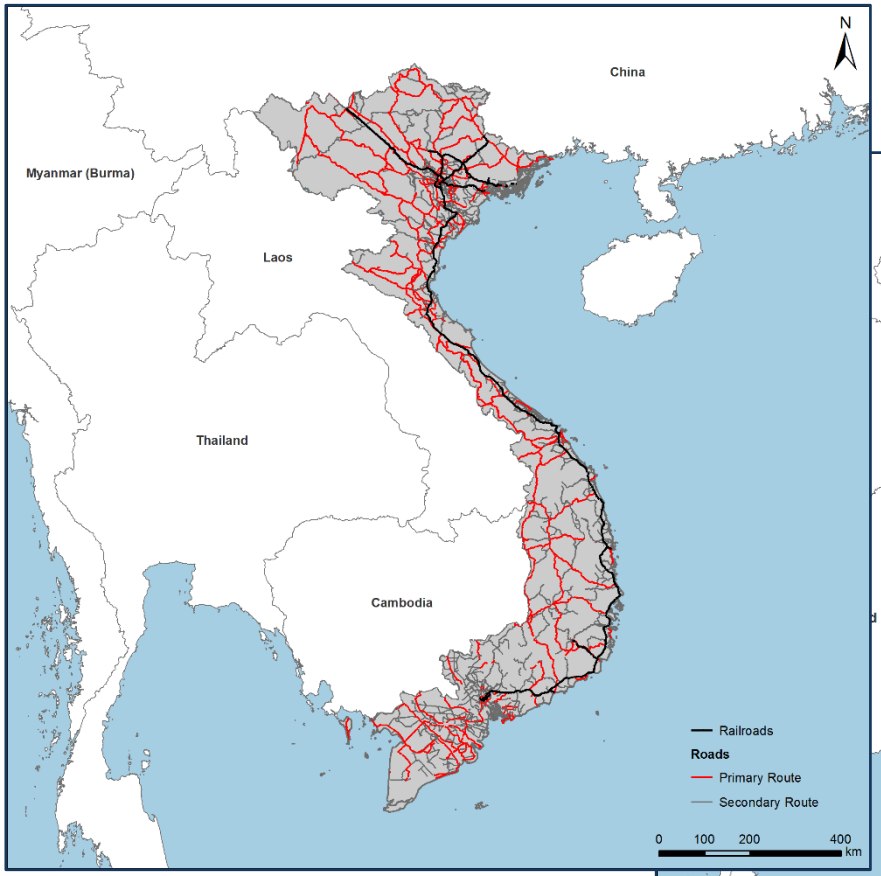
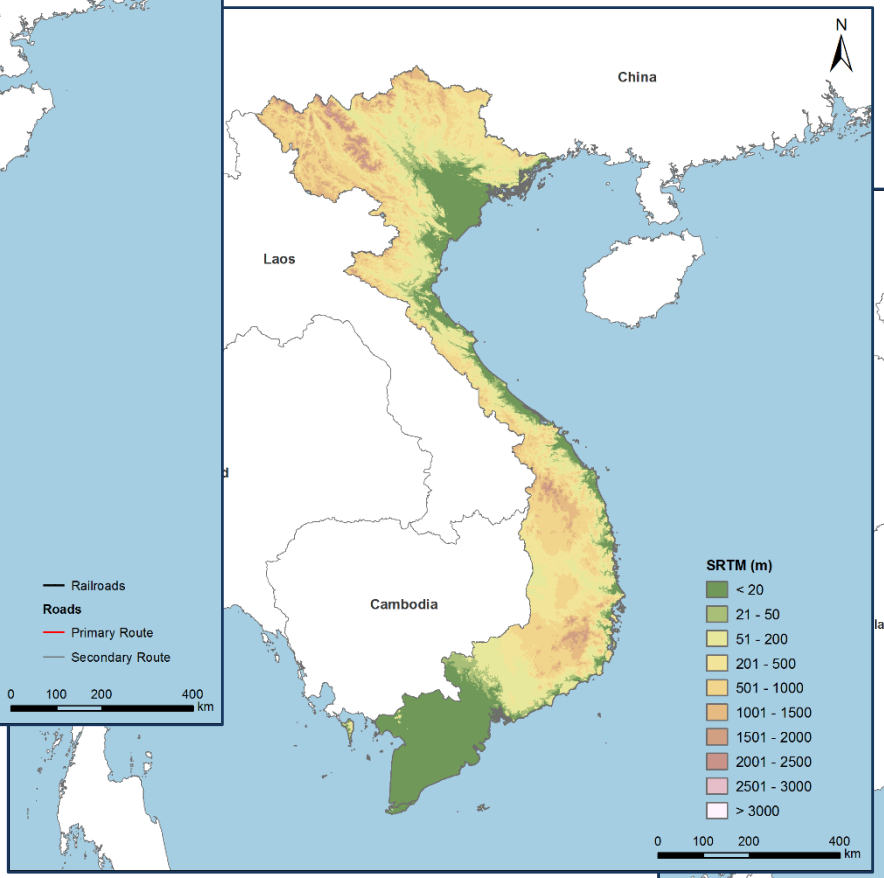
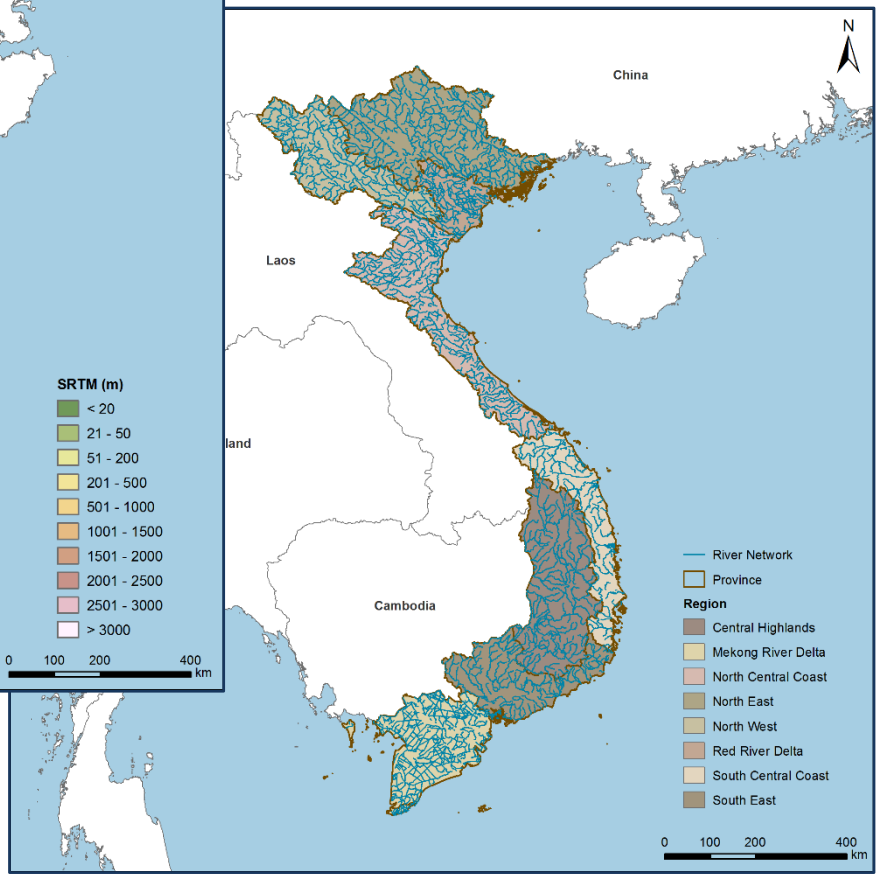


Road and railroad network (Open Street Map, Consultant's processing)



Digital global elevation data (SRTM –NASA, Consultant's processing)



River and Streams derived from a DEM (SRTM, Consultant's processing)

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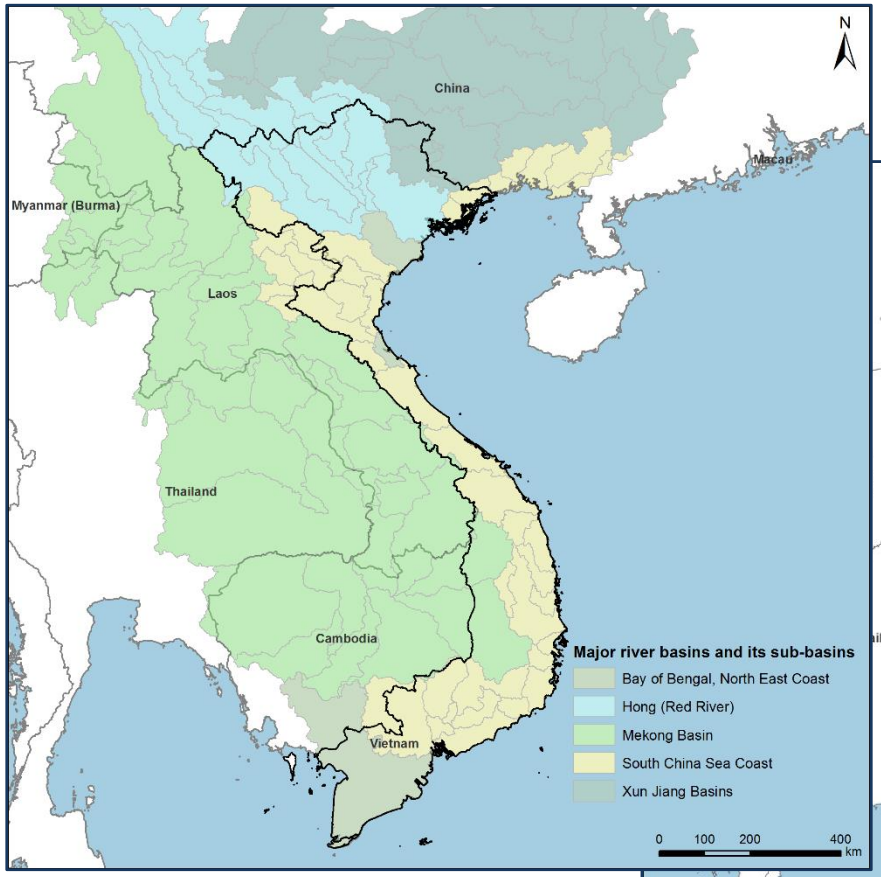
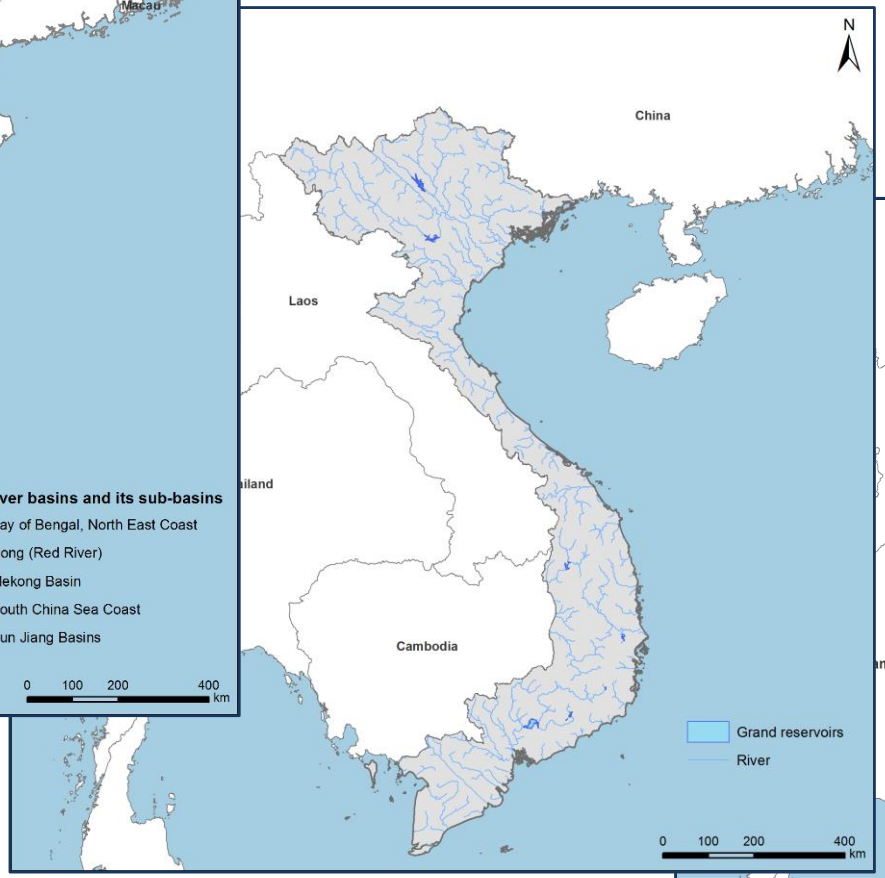
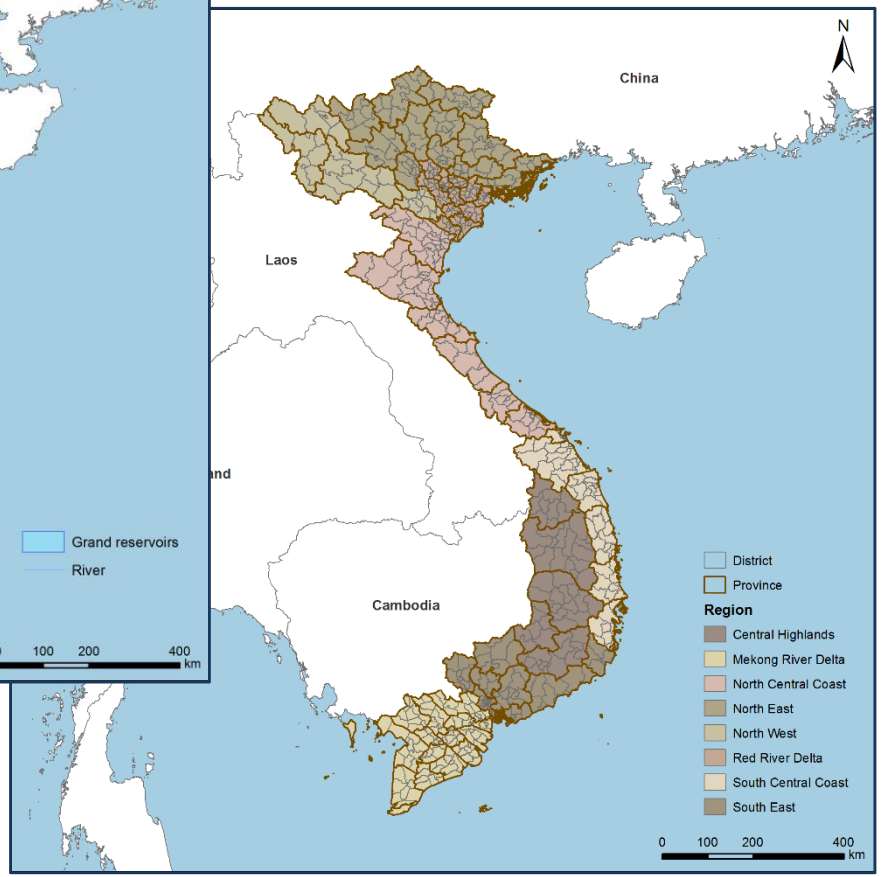


River basins and its sub-basins (Open Development Mekong, Consultant's processing).

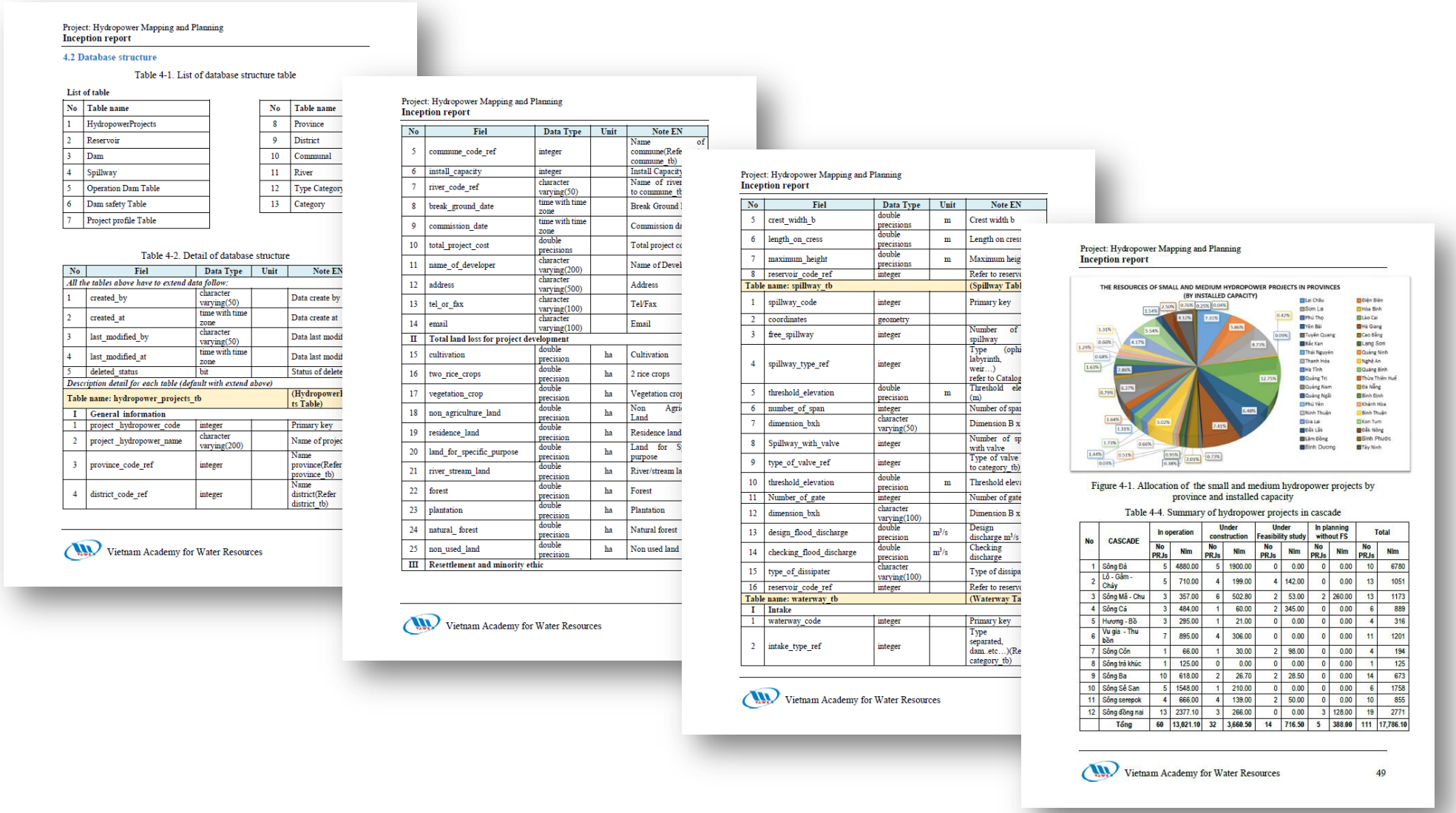


Large reservoirs and river network (Earthdata and Open Development Mekong, Consultant's processing).



Administrative divisions, district level (GADM data, Consultant's processing).

SPECIFIC SMALL HYDROPOWER DATA AND TECHNICAL FEATURES WAS COLLECTED BY THE NATIONAL CONSULTANT



Project: Hydropower Mapping and Planning
Inception report

4.2 Database structure

Table 4-1. List of database structure table

List of table

No	Table name
1	HydropowerProjects
2	Reservoir
3	Dam
4	Spillway
5	Operation Dam Table
6	Dam safety Table
7	Project profile Table

No	Table name
8	Province
9	District
10	Communal
11	River
12	Type Category
13	Category

Table 4-2. Detail of database structure

No	Fiel	Data Type	Unit	Note EN
All the tables above have to extend data follow:				
1	created_by	character varying(50)		Data create by
2	created_at	time with time zone		Data create at
3	last_modified_by	character varying(50)		Data last modi
4	last_modified_at	time with time zone		Data last modi
5	deleted_status	bit		Status of delete
Description detail for each table (default with extend above)				
Table name: hydropower_projects_tb				**(Hydropower ts Table)**
I	**General information**			
1	project _hydropower_code	integer		Primary key
2	project _hydropower_name	character varying(200)		Name of projec
3	province_code_ref	integer		Name province(Refer province_tb)
4	district_code_ref	integer		Name district(Refer district_tb)

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Inception report

No	Fiel	Data Type	Unit	Note EN
5	commune_code_ref	integer		Name of commune(Refe commune_tb)
6	install_capacity	integer		Install Capacity
7	river_code_ref	character varying(50)		Name of river to commune_tb
8	break_ground_date	time with time zone		Break Ground
9	commission_date	time with time zone		Commission da
10	total_project_cost	double precisions		Total project co
11	name_of_developer	character varying(200)		Name of Devel
12	address	character varying(500)		Address
13	tel_or_fax	character varying(100)		Tel/Fax
14	email	character varying(100)		Email
II	**Total land loss for project development**			
15	cultivation	double precision	ha	Cultivation
16	two_rice_crops	double precision	ha	2 rice crops
17	vegetation_crop	double precision	ha	Vegetation crop
18	non_agriculture_land	double precision	ha	Non Agri Land
19	residence_land	double precision	ha	Residence land
20	land_for_specific_purpose	double precision	ha	Land for S purpose
21	river_stream_land	double precision	ha	River/stream la
22	forest	double precision	ha	Forest
23	plantation	double precision	ha	Plantation
24	natural_ forest	double precision	ha	Natural forest
25	non_used_land	double precision	ha	Non used land
III	**Resettlement and minority ethic**			

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No	Fiel	Data Type	Unit	Note EN
5	crest_width_b	double precisions	m	Crest width b
6	length_on_cress	double precisions	m	Length on cres
7	maximum_height	double precisions	m	Maximum heig
8	reservoir_code_ref	integer		Refer to reserv
Table name: spillway_tb				**(Spillway Tabl**
1	spillway_code	integer		Primary key
2	coordinates	geometry		
3	free_spillway	integer		Number of spillway
4	spillway_type_ref	integer		Type (ophi labyrinth, weir…) refer to Catalog
5	threshold_elevation	double precision	m	Threshold ele (m)
6	number_of_span	integer		Number of spa
7	dimension_bxh	character varying(50)		Dimension B x
8	Spillway_with_valve	integer		Number of sp with valve
9	type_of_valve_ref	integer		Type of valve to category_tb)
10	threshold_elevation	double precision	m	Threshold elev
11	Number_of_gate	integer		Number of gate
12	dimension_bxh	character varying(100)		Dimension B x
13	design_flood_discharge	double precision	m^3/s	Design discharge m^3/s
14	checking_flood_discharge	double precision	m^3/s	Checking discharge
15	type_of_dissipater	character varying(100)		Type of dissipa
16	reservoir_code_ref	integer		Refer to reserv
Table name: waterway_tb				**(Waterway Ta**
I	**Intake**			
1	waterway_code	integer		Primary key
2	intake_type_ref	integer		Type separated, dam, etc…)(Re category_tb)

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Project: Hydropower Mapping and Planning
Inception report

Figure 4-1. Allocation of the small and medium hydropower projects by province and installed capacity

Table 4-4. Summary of hydropower projects in cascade

No	CASCADE	In operation		Under construction		Under Feasibility study		In planning without FS		Total	
		No PRJs	Nlm	No PRJs	Nlm	No PRJs	Nlm	No PRJs	Nlm	No PRJs	Nlm
1	Sông Đà	5	4880.00	5	1900.00	0	0.00	0	0.00	10	6780
2	Lô - Gâm - Chảy	5	710.00	4	199.00	4	142.00	0	0.00	13	1051
3	Sông Mã - Chu	3	357.00	6	502.80	2	53.00	2	260.00	13	1173
4	Sông Cả	3	484.00	1	60.00	2	345.00	0	0.00	6	889
5	Hương - Bồ	3	295.00	1	21.00	0	0.00	0	0.00	4	316
6	Vu gia - Thu Bồn	7	895.00	4	306.00	0	0.00	0	0.00	11	1201
7	Sông Côn	1	66.00	1	30.00	2	98.00	0	0.00	4	194
8	Sông trà khúc	1	125.00	0	0.00	0	0.00	0	0.00	1	125
9	Sông Ba	10	618.00	2	26.70	2	28.50	0	0.00	14	673
10	Sông Sê San	5	1548.00	1	210.00	0	0.00	0	0.00	6	1758
11	Sông serepok	4	666.00	4	139.00	2	50.00	0	0.00	10	855
12	Sông đồng nai	13	2377.10	3	266.00	0	0.00	3	128.00	19	2771
	Tổng	60	13,021.10	32	3,660.50	14	716.50	5	388.00	111	17,786.10

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Specific small hydropower data and technical features . Source: National Consultant's Inception Report.

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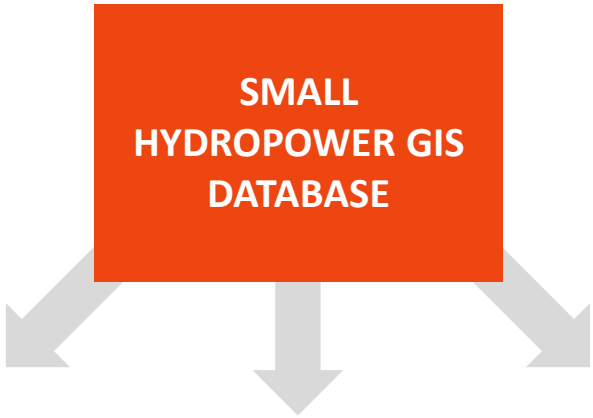
SMALL HYDROPOWER GIS DATABASE

WHAT ARE THE MAIN PURPOSES OF THE SMALL HYDROPOWER GIS DATABASE?



Outline national information on small hydropower with relevant data

Support electrification planning

Foster the integration of small hydropower in other Renewable Energy Sources planning and development

INITIAL DECISION BETWEEN PROPRIETARY AND OPEN-SOURCE OPTIONS

GIS software

Open-source (eg. WebGIS) ✓

vs.

Proprietary (eg. ArcGIS Online)

Main Advantages:

- Free and Open Source Software
- Free plugins
- Numerous updates available each year
- Huge community of users can easily support in technical issues
- Multi-plataform (Windows, Mac or Linux)

Database software

Open-source (eg.PostgreSQL) ✓

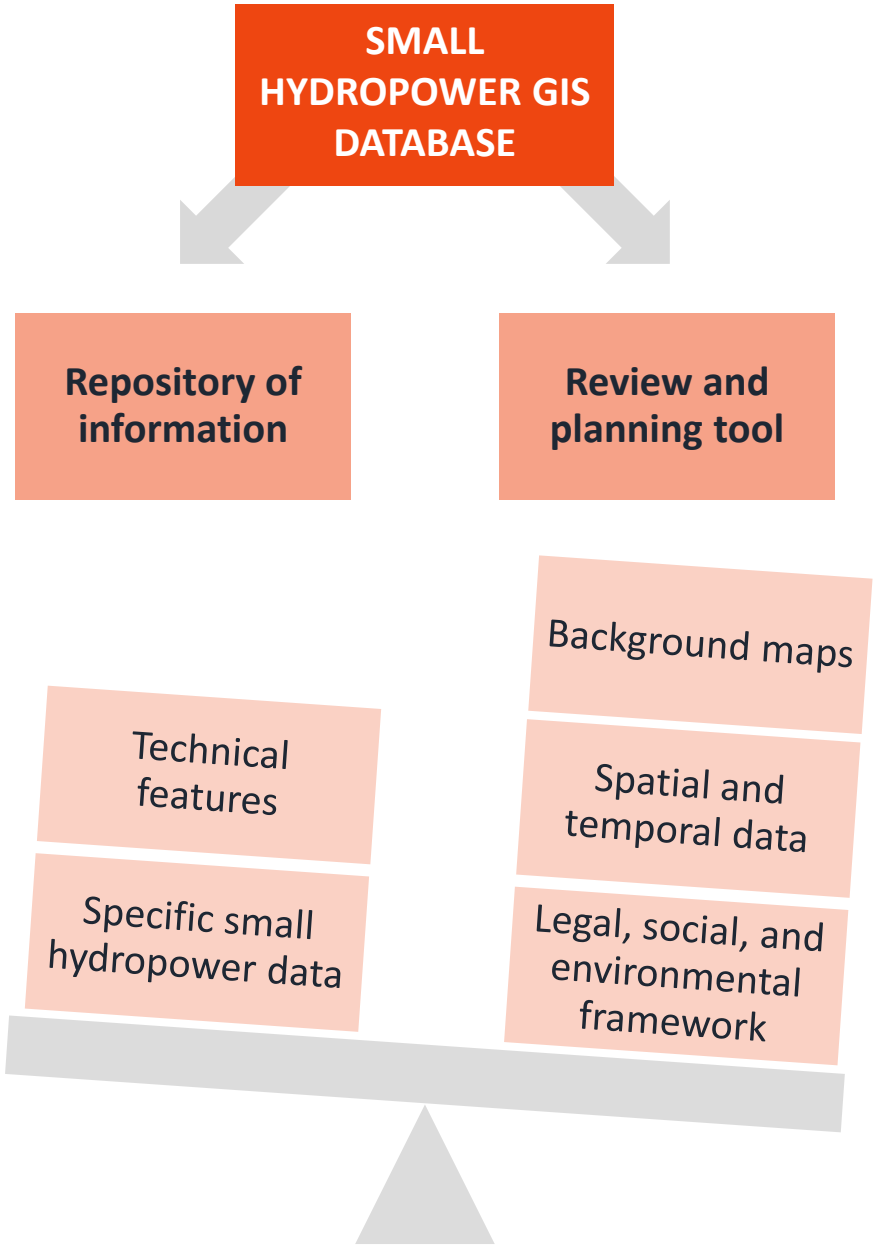
vs.

Proprietary (eg. MySQL)

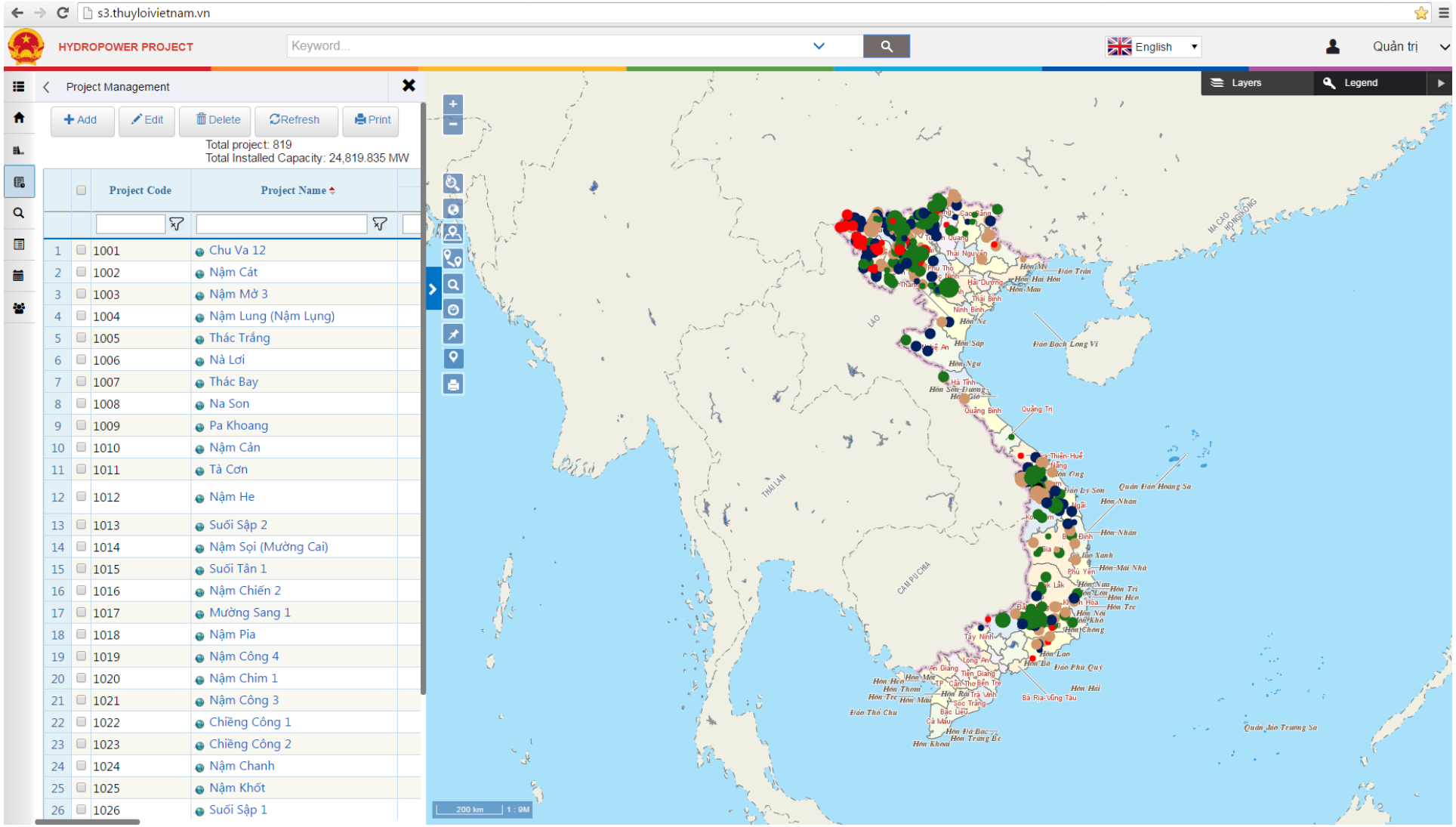
Main Advantages:

- Free and Open Source Software
- The most advanced, SQL-compliant and open-source ORDBMS
- Is supported by a devoted and experienced community which can be accessed for free;
- Strong third-party support: PostgreSQL is adorned with many great and open-source third-party tools for designing, managing and using the management system.

THE ADVISORY SERVICES FOR THE SMALL HYDROPOWER GIS DATABASE HAVE BEEN FOCUSING ON THE REVIEW AND PLANNING TOOL APPROACH



THE DATABASE HAS BEEN STEADILY PROGRESSING TOWARDS A USER-FRIENDLY AND VALUABLE TOOL WITH A SIGNIFICANT AMOUNT OF RELEVANT DATA…



…YET SOME IMPROVEMENTS CAN BE MADE

Recommendations

- Conclude data collection (fill data gaps)
- Review coordinates with aerial photos
- Streamline “Import” and “Export” base map options
- Customize the representation of the project (dam or powerhouse)
- Confirm the existence of a larger number of dams versus powerhouses or spillways
- Include a “powerhouse” tab on the main menu
- Organize the projects management main menus in the same fashion as the projects reports
- Include the “design head” and “flow features” in the tab menus
- Review the “Translate to English” option in all sections
- Review the “Export map background” option for other than the default base map
- Review the duration of filter option on map visualization
- Assess the workability of including global data on the database (meteo data, land cover, land use, …)
- Include legal framework links or documents for download

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GUIDELINES FOR REVIEW AND PLANNING OF SMALL HYDROPOWER

WHAT ARE THE MAIN PURPOSES OF THE GUIDELINES FOR REVIEW AND PLANNING OF SMALL HYDROPOWER?

Evaluate the current planning procedures

Develop recommendations for review and planning of small hydropower

Promote the use of the small hydropower GIS database as a planning tool

THE HYDROPOWER PLANNING PROCEDURES IN VIETNAM CAN BE CONSIDERED WELL ESTABLISHED AND REGULATED

Large hydropower

Studies are conducted by qualified and experienced companies

The process comprises a multi-criteria analysis based on technical, economic, environmental and social considerations

Development in line with the growth plans for the country

Small hydropower

The capacity for development is generally lower: developed at a provincial level, usually with limited capacity and resources

Often developed by private investors and many of them have little experience in hydropower

Difficult to predict the accuracy of the initial studies

TO ADDRESS THE ISSUES CONCERNING SMALL HYDROPOWER PLANNING, A SET OF GUIDELINES HAVE BEEN DRAFTED WITH TWO VARIED APPROACHES

GUIDELINES FOR REVIEW AND PLANNING SMALL HYDROPOWER

Regional approach

- Hydropower potential
- Environmental impact

→ **CLASSIFICATION OF THE RIVER STRETCH**

Project approach

Confirmation of initial studies

- Watershed area
- Environmental flow
- Modular flow
- Available head

Project ranking

Criteria

Environmental (a%)	Social (b%)	Economic (c%)	Energetic (d%)
• Protected areas • Forest area • Flooded area • Dam height	• Minority ethnic • Cultivation area • Rice crops • Flooded houses	• Energy unit cost • CAPEX	• Installed capacity • Firm capacity • Working hours

→ **RANKING OF PROJECTS TO BE DEVELOPED**

THE REGIONAL APPROACH

GUIDELINES FOR REVIEW AND PLANNING SMALL HYDROPOWER

Regional approach

- **Hydropower potential**
- **Environmental impact**

CLASSIFICATION OF THE RIVER STRETCH

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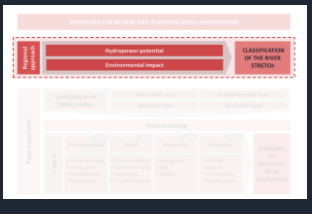
RANKING OF PROJECTS TO BE DEVELOPED

EVALUATION OF THE TWO INDICATORS



Hydropower potential

Direct methods:

- Specific potential energy generation
- Specific potential power output
- Specific head

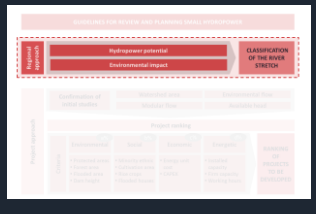
Ancillary method:

- Hydropower potential map

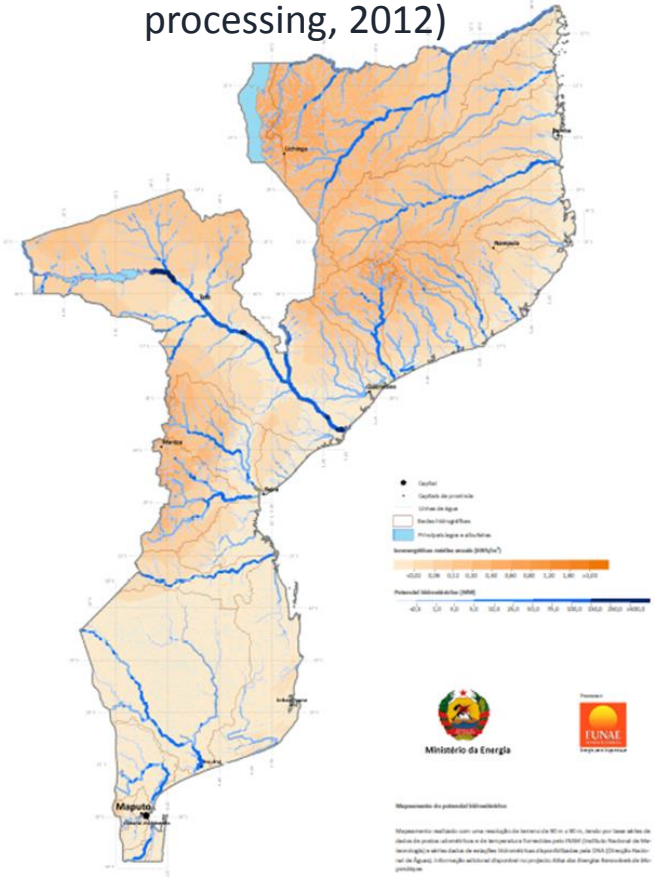
Environmental impact

- Protected areas
- Land use
- Plant operation type
- Morphology
- Biology
- Type of water body
- Importance as habitat
- …

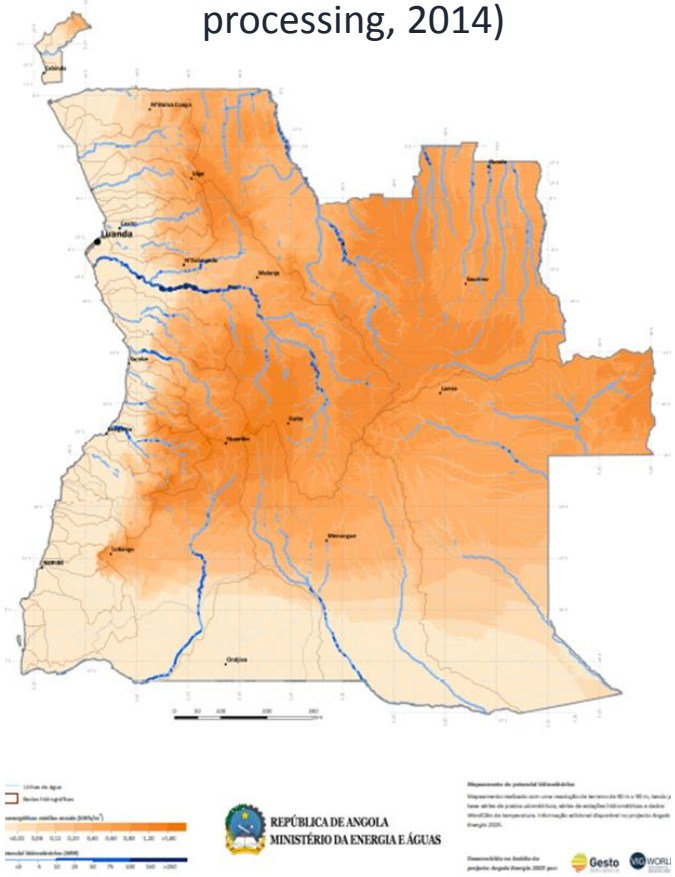
THE HYDROPOWER POTENTIAL MAPS CAN BE A MAJOR ENHANCEMENT ON HYDROPOWER PLANNING SINCE THE EARLY STAGES



Mozambique
(Consultant's processing, 2012)



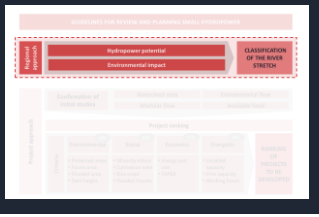
Angola
(Consultant's processing, 2014)

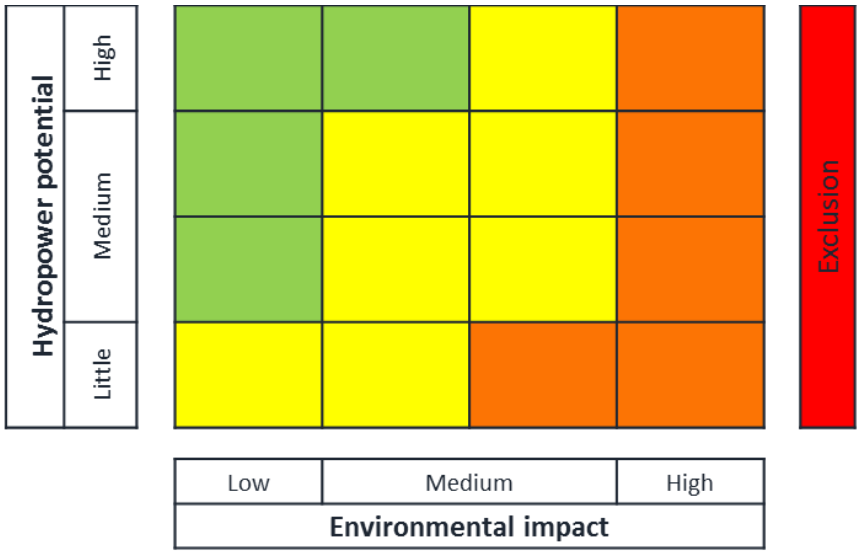


Liberia
(Consultant's processing, 2016)

Out of the scope of the Technical Assistance

THE REGIONAL APPROACH COMPRISES THE CLASSIFICATION OF THE RIVER STRETCH ON A MATRICIAL SCHEME UNDER TWO VECTORS

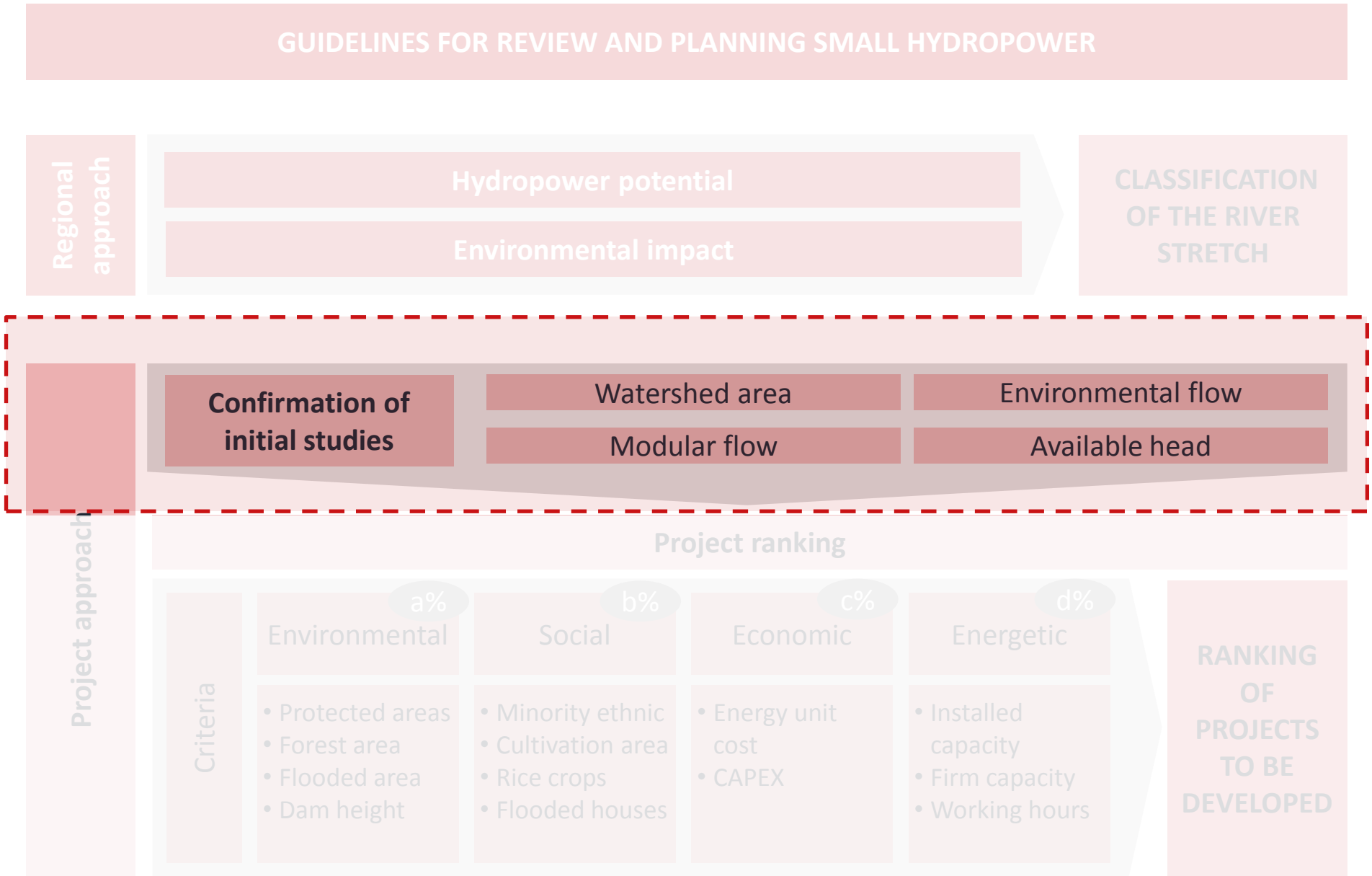




Favorable	Less-favorable	Non-favorable	Exclusion
For hydropower projects development	For hydropower projects development	For hydropower projects development	Hydropower projects forbidden by law
In accordance with environmental legal framework. Construction of SHP in general possible.	Environmental aspect needs to be assessed, weighing all relevant criteria. SHP can be developed under conditional criteria.	SHPs possible only in exceptional cases (e.g. auto-supply)	No hydropower exploitation possible. Protected areas where any interventions are forbidden by law.

Classification of the river stretch regarding environmental impact and hydropower potential.

THE PROJECT APPROACH, PROCESS 1: CONFIRMATION OF INITIAL STUDIES



THE OBJECTIVE: ENSURE THAT THE STUDIES SUBMITTED FOR APPROVAL ARE ACCURATE AND THAT NO SIGNIFICANT CHANGES SHALL OCCUR

Watershed area

- Evaluation of the correct location of the project
- Checking eventual conflicting water uses inside the basin
- Easily confirmed via a Digital Elevation Model

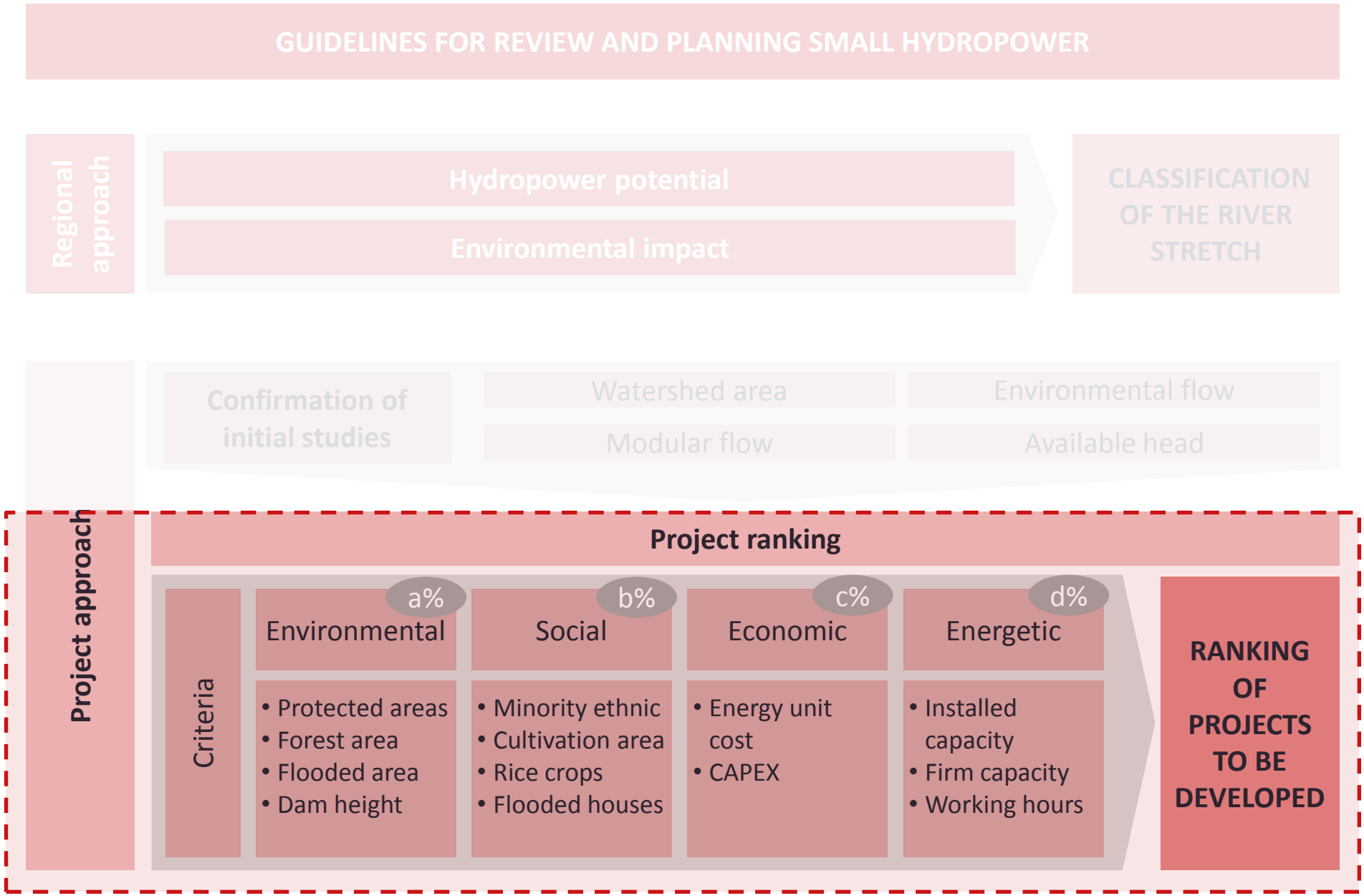
Modular and environmental flows

- Confirmation of the flow either by ground-based data, closeby verified projects or water-balance methods
- Checking for water availability and energy output.
- Environmental flow may be a fraction of the modular flow.

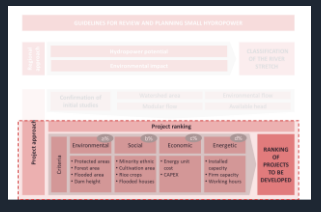
Available head

- Height confirmation between the full supply level and the tailrace.
- Easily confirmed via a Digital Elevation Model

THE PROJECT APPROACH, PROCESS 2: PROJECT RANKING



MULTI-CRITERIA ANALYSIS, EACH CRITERIA WITH A SPECIFIC WEIGHT TO OBTAIN THE PROJECT RANKING



Similar to the large hydropower process

Environmental criteria	Social criteria	Economic criteria	Energetic criteria
• Protected areas	• Flooded houses	• CAPEX	• Installed capacity
• Flooded area	• Resettled population	• Energy unit cost	• Firm capacity
• Dam height	• Ethnic minorities	• Levelized cost of electricity	• Working hours
• Ecological impacts	• Conflicts with other water users	• Regional economic effects	• Grid stability
• Integration in the landscape	• Necessity of further infrastructure	• Effect on tourism	• Use of hydroelectric potential
• Minimization of impacts	• Infrastructures affected	• …	• …
• …	• Archaeological heritage		
	• …		

a% b% c% d%

Weights (a+b+c+d=100%)

Gesto
ENERGY CONSULTING

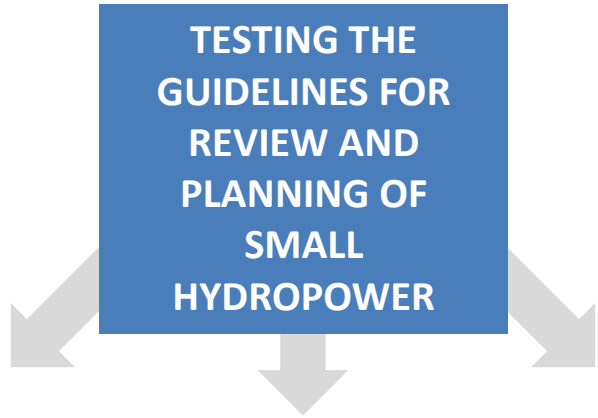
MINISTRY OF INDUSTRY AND TRADE
OF THE SOCIAL REPUBLIC OF VIETNAM

ESMAP
Energy Sector Management Assistance Program

WORLD BANK GROUP
Energy & Extractives

TESTING AND FINE-TUNING OF THE GUIDELINES

WHAT IS THE MAIN PURPOSE OF TESTING THE GUIDELINES FOR REVIEW AND PLANNING OF SMALL HYDROPOWER?



Put the guidelines into practice on real case studies

Fine-tune the approach

Check the ability of the small hydropower GIS database

IT WAS DECIDED THAT THE GUIDELINES OUGHT TO BE TESTED IN LAO CAI

LAO CAI PROVINCE

- Visited by the Consultant
- High hydropower potential and number of projects
- Significant amount of collected data

REMINDER OF THE REGIONAL APPROACH

GUIDELINES FOR REVIEW AND PLANNING SMALL HYDROPOWER

Regional approach

Hydropower potential

Environmental impact

CLASSIFICATION OF THE RIVER STRETCH

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Watershed area | Environmental flow

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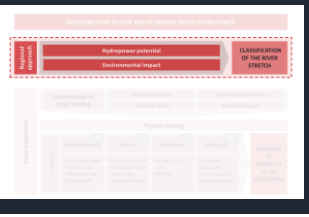
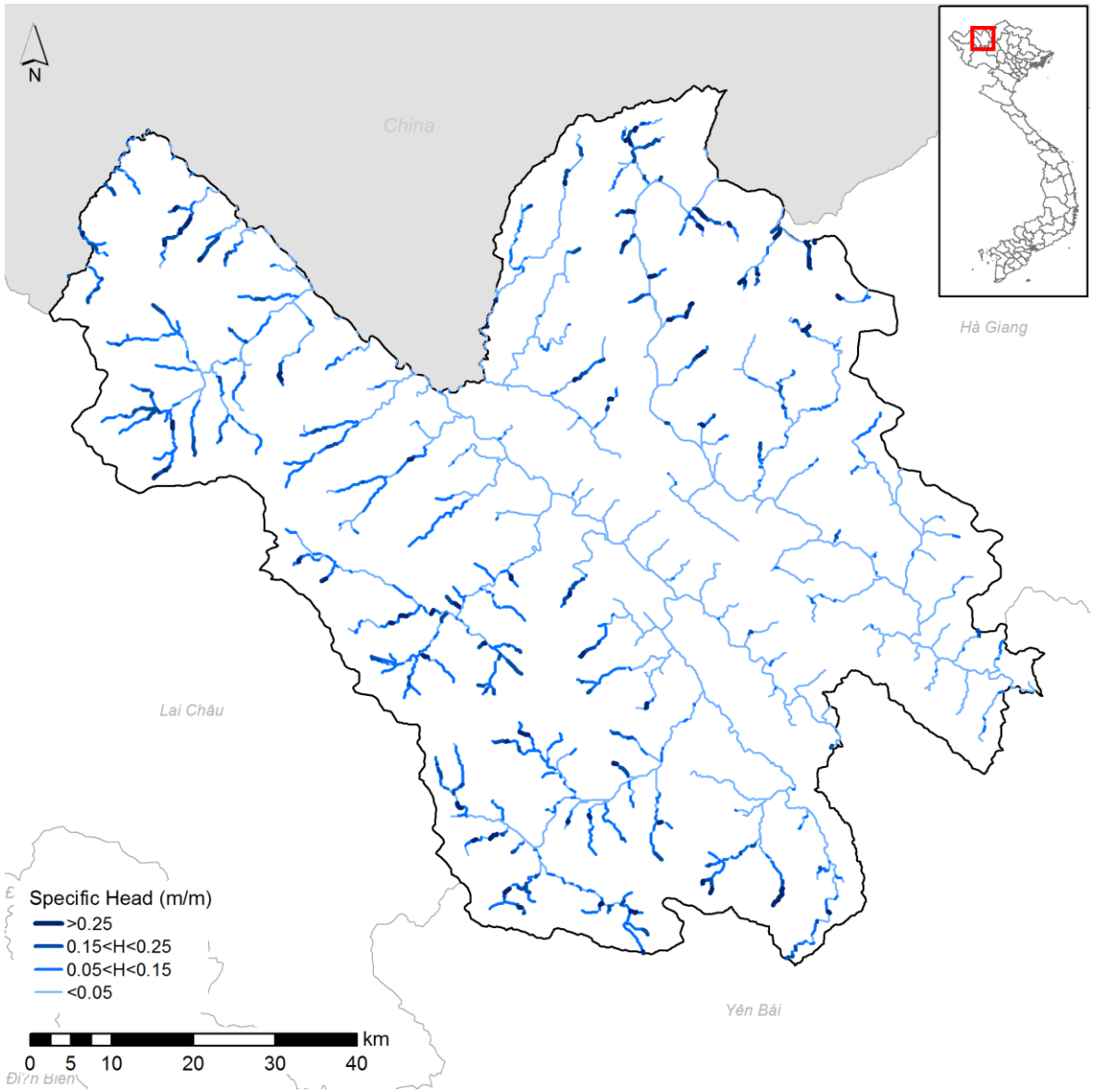
RANKING OF PROJECTS TO BE DEVELOPED

TO DETERMINE THE HYDROPOWER POTENTIAL TWO SEPARATE METHODS WERE APLLIED



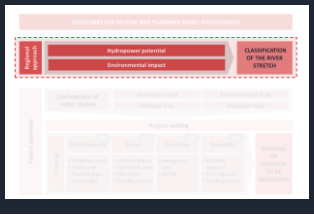
METHOD 1: SPECIFIC HEAD

- Ratio of the available head and the length of the river stretch
- Describes the slope of the river stretch
- Easily obtained via a Digital Elevation Model



Hydropower potential obtained from the specific head method

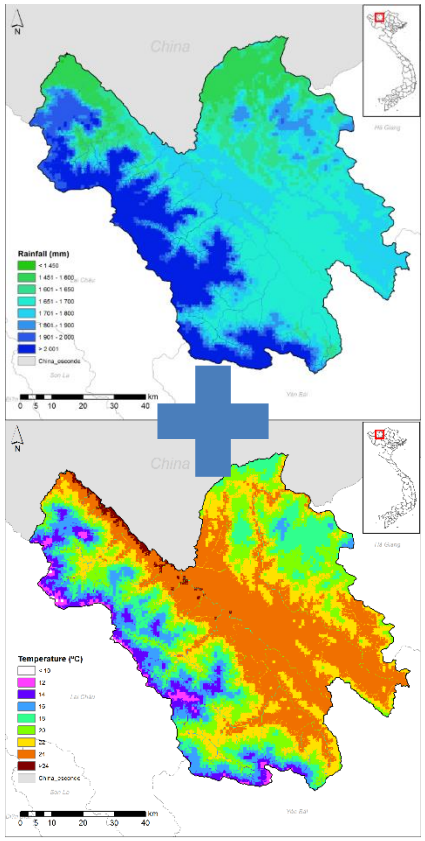
A MORE COMPLEX AND ANCILLIARY METHOD BASED ON A PROPRIETARY ALGORITHM WAS ALSO APPLIED



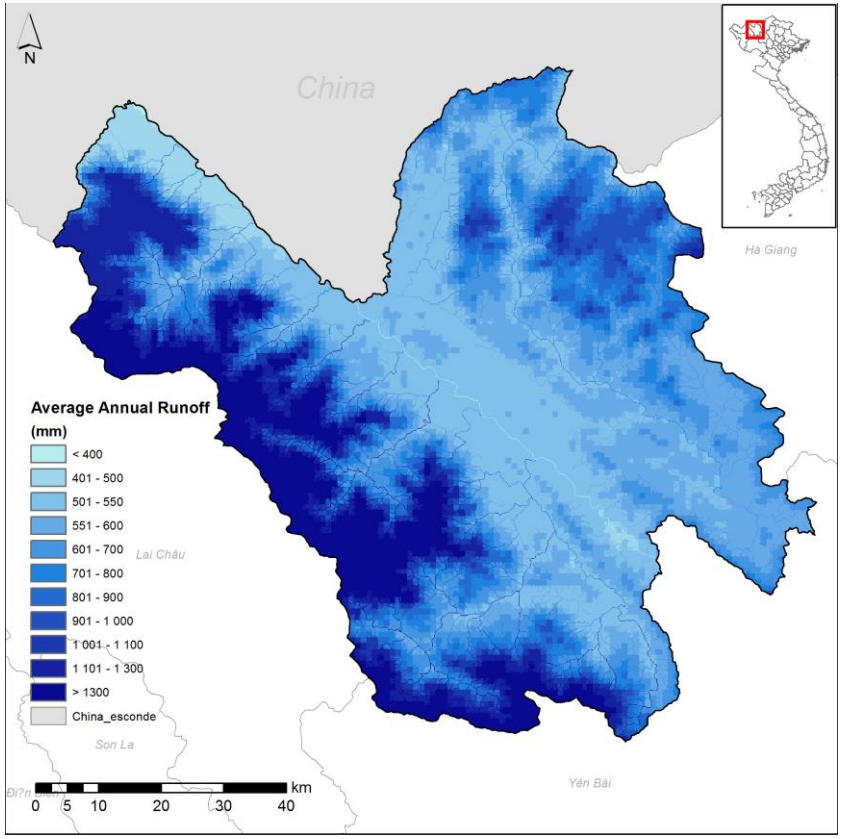
METHOD 2: HYDROPOWER POTENTIAL MAP

- Mapping of the possible capacities that can be installed
- Dependent on both hydrological and morphological features
- Calibrated with technical, economical and energetic parameters
- Complex processing and analysis requirements

Stage 1: Obtaining the average daily flow (eg. using Water-Balance System)

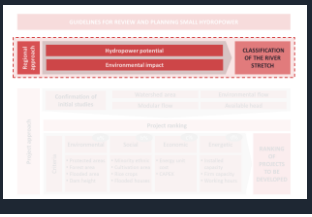


Rainfall
+
Temperature
(global satellite data)



Surface runoff map

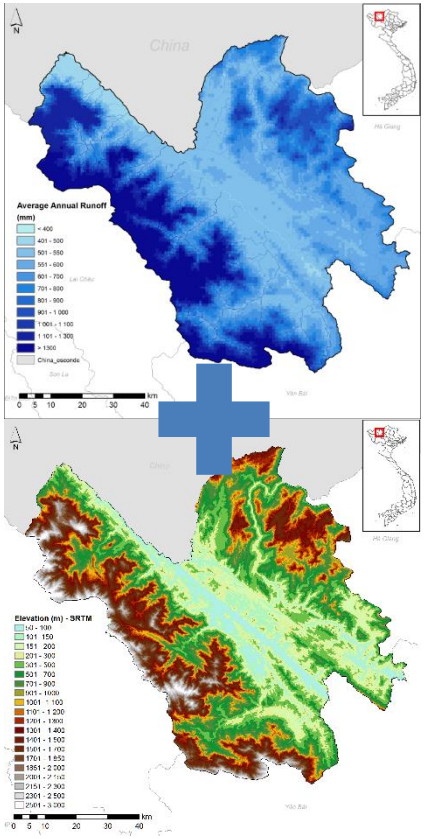
(CONTINUED)



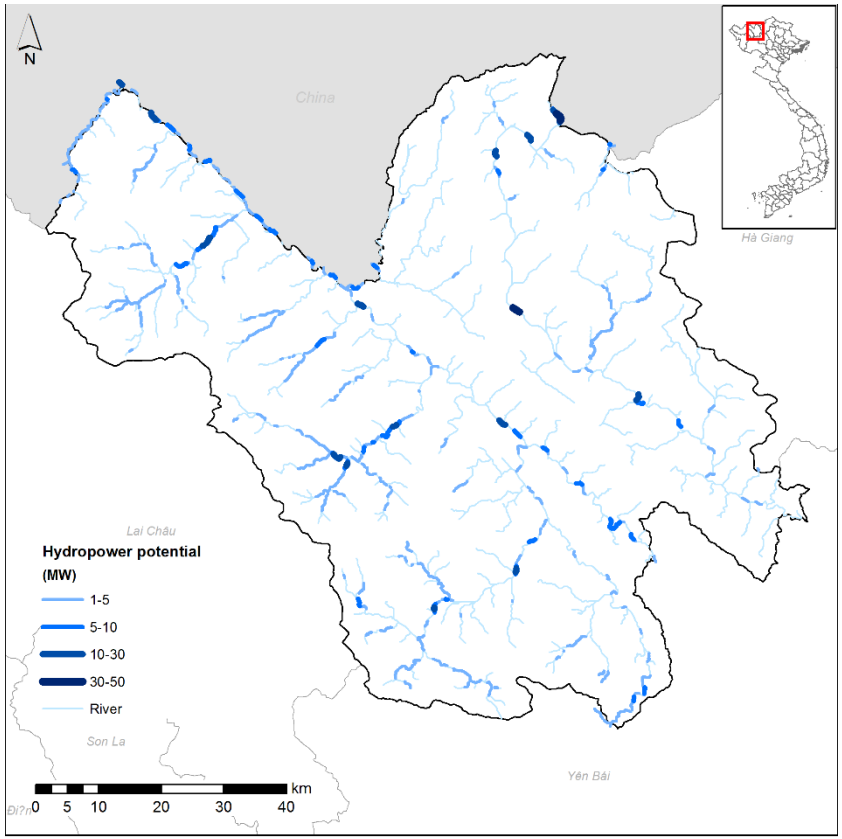
METHOD 2: HYDROPOWER POTENTIAL MAP

- Mapping of the possible capacities that can be installed
- Dependent on both hydrological and morphological features
- Calibrated with technical, economical and energetic parameters
- Complex processing and analysis requirements

Stage 2: Mapping the potential

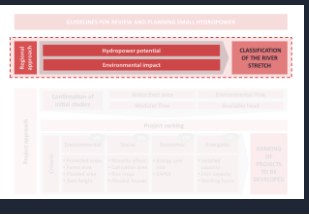


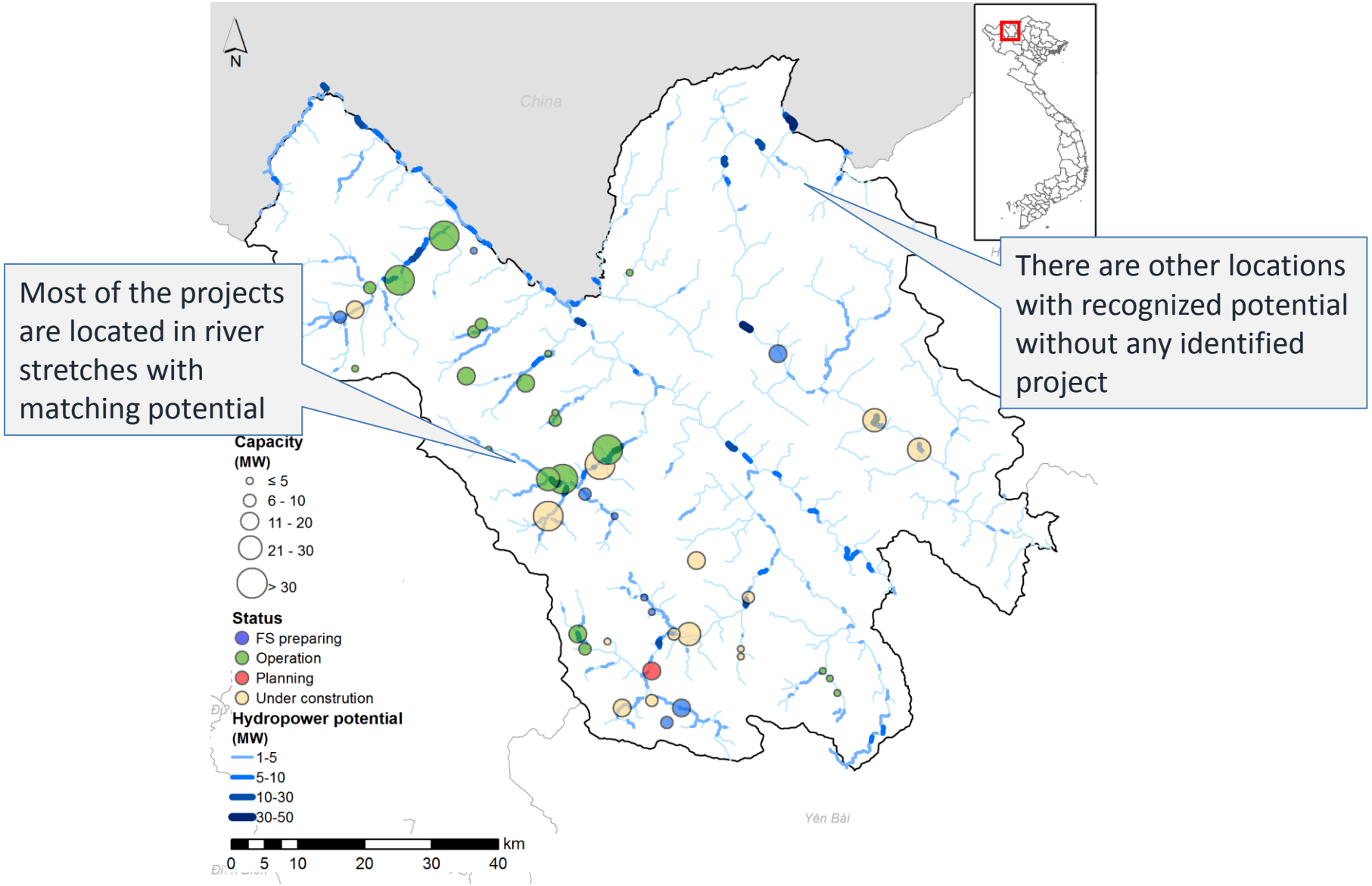
Surface runoff
+
Elevation
(global satellite data)



Theoretical hydropower potential map

THE HYDROPOWER POTENTIAL MAP WAS COMBINED WITH THE PROJECTS ALREADY ON THE SMALL HYDROPOWER GIS DATABASE



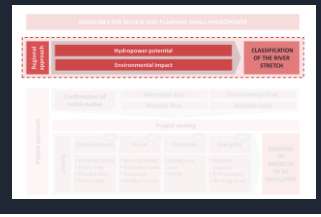


Most of the projects are located in river stretches with matching potential

There are other locations with recognized potential without any identified project

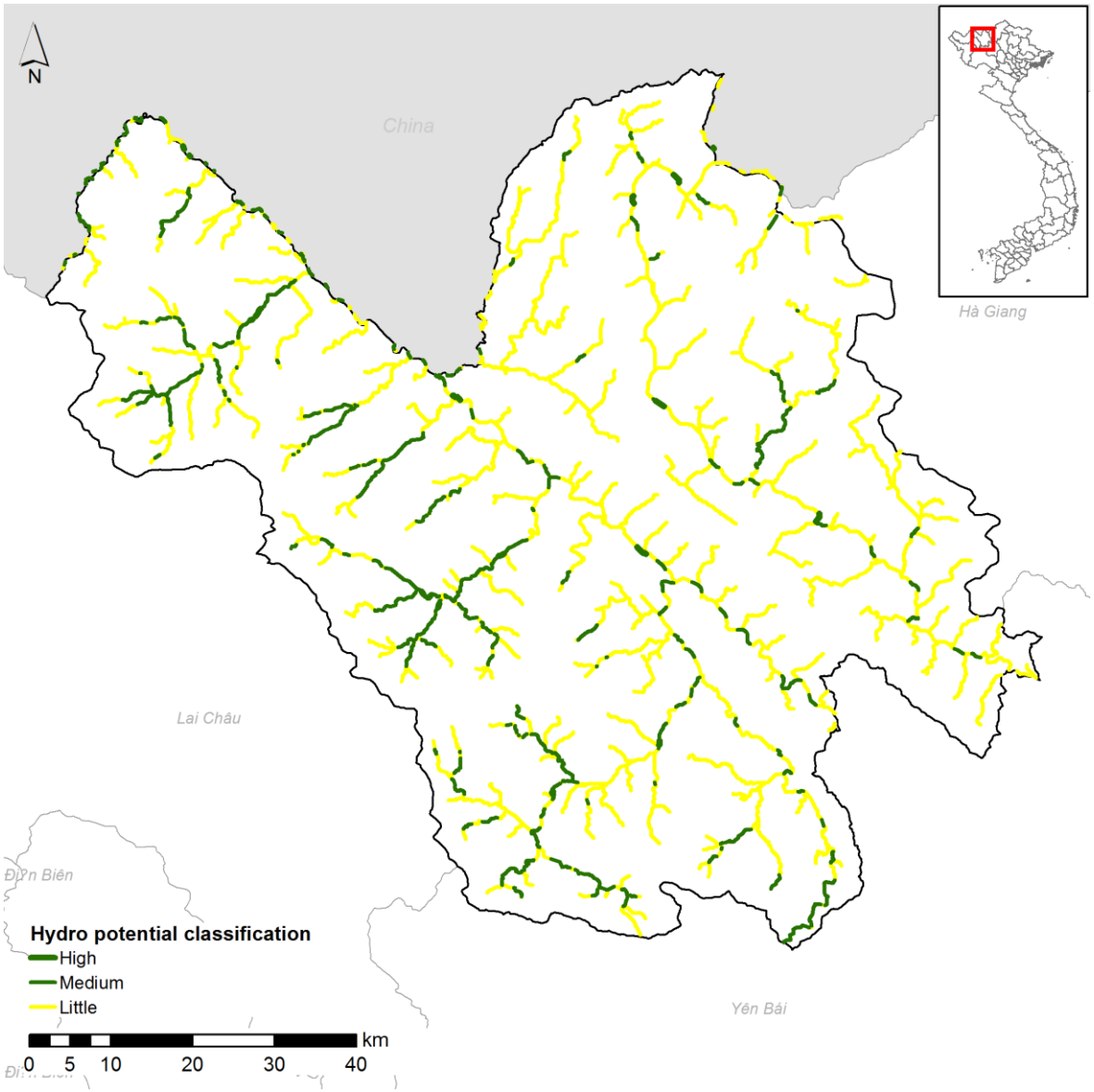
Hydropower potential map and matching identified projects

AFTER OBTAINING THE HYDROPOWER POTENTIAL, THE RIVER STRETCHES WERE CLASSIFIED IN “LITTLE”, “MEDIUM” OR “HIGH” POTENTIAL



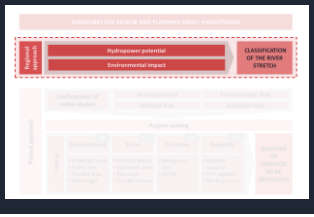
HYDROPOWER POTENTIAL CLASSIFICATION

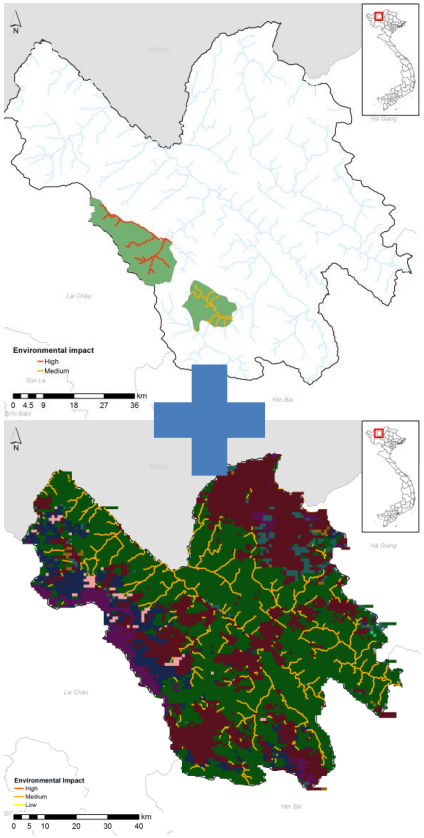
- Capacity below 1 MW: “**Little**”
- Capacity between 1 and 10 MW: “**Medium**”
- Capacity over 10 MW: “**High**”



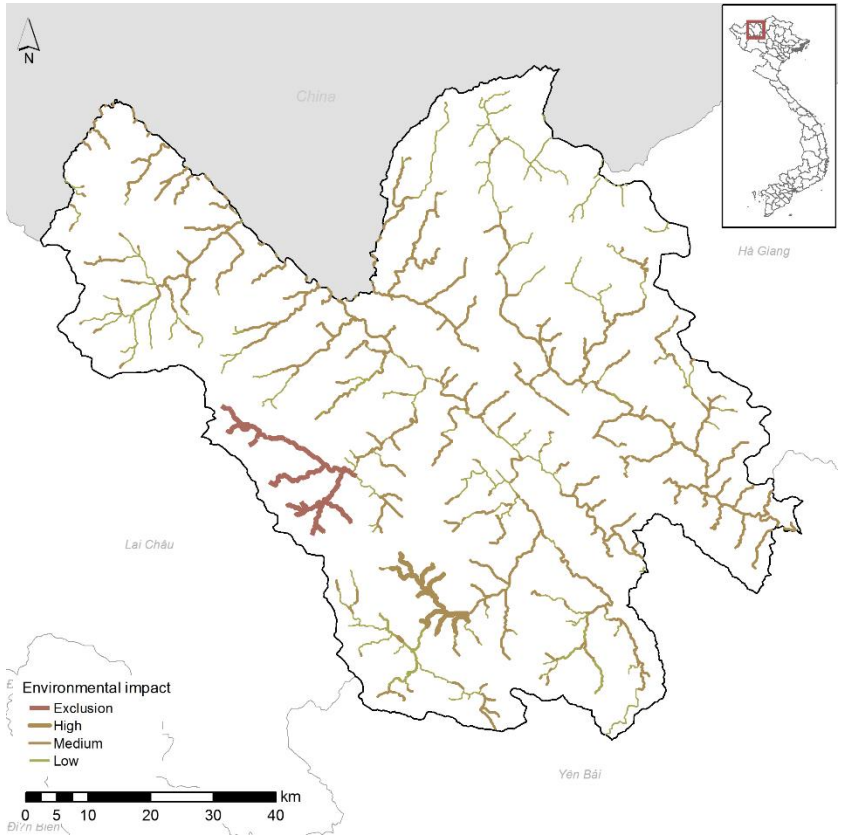
Regional approach: Hydropower potential classification

THE ENVIRONMENTAL IMPACT WAS DETERMINED COMBINING THE PROTECTED AREAS WITH THE LAND USE



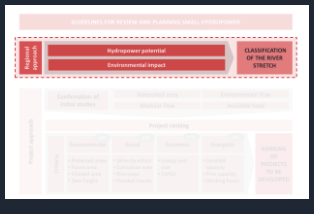


Protected areas
+
Land use
(global data)



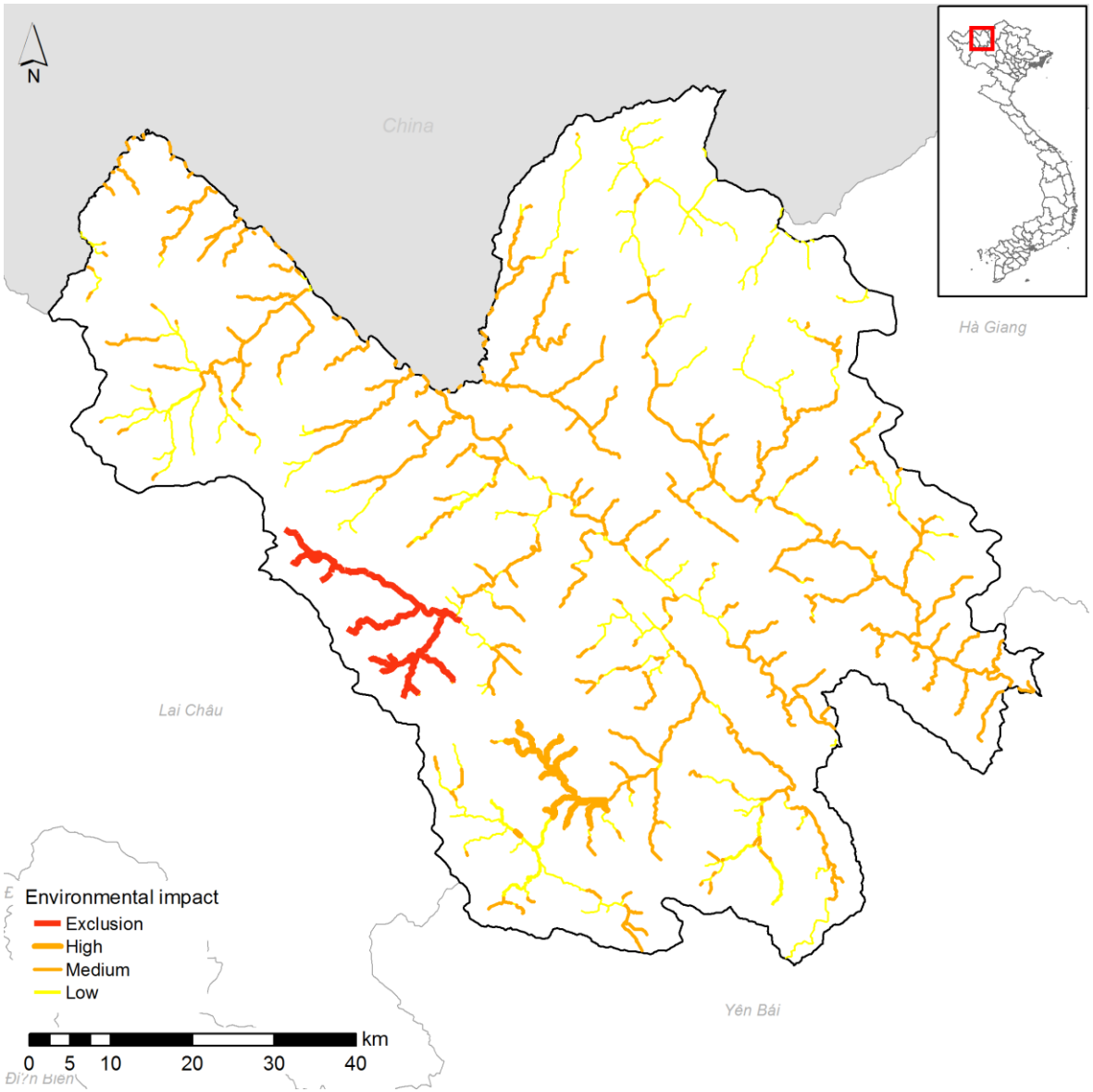
Combined environmental impact

AFTER OBTAINING THE ENVIRONMENTAL IMPACT, THE RIVER STRETCHES WERE CLASSIFIED IN “LOW”, “MEDIUM”, “HIGH” OR “EXCLUSION” IMPACT



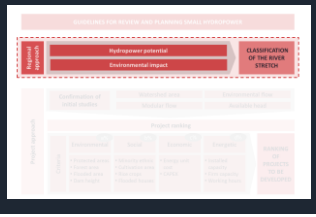
ENVIRONMENTAL IMPACT CLASSIFICATION

- National Parks: “**Exclusion**”
- Nature Reserves: “**High**”
- Forest Areas: “**Medium**”
- Remainder: “**Low**”



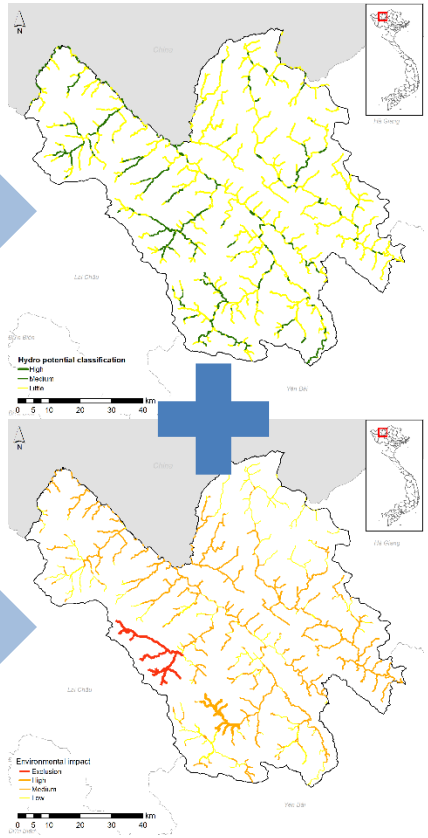
Regional approach: Environmental impact classification

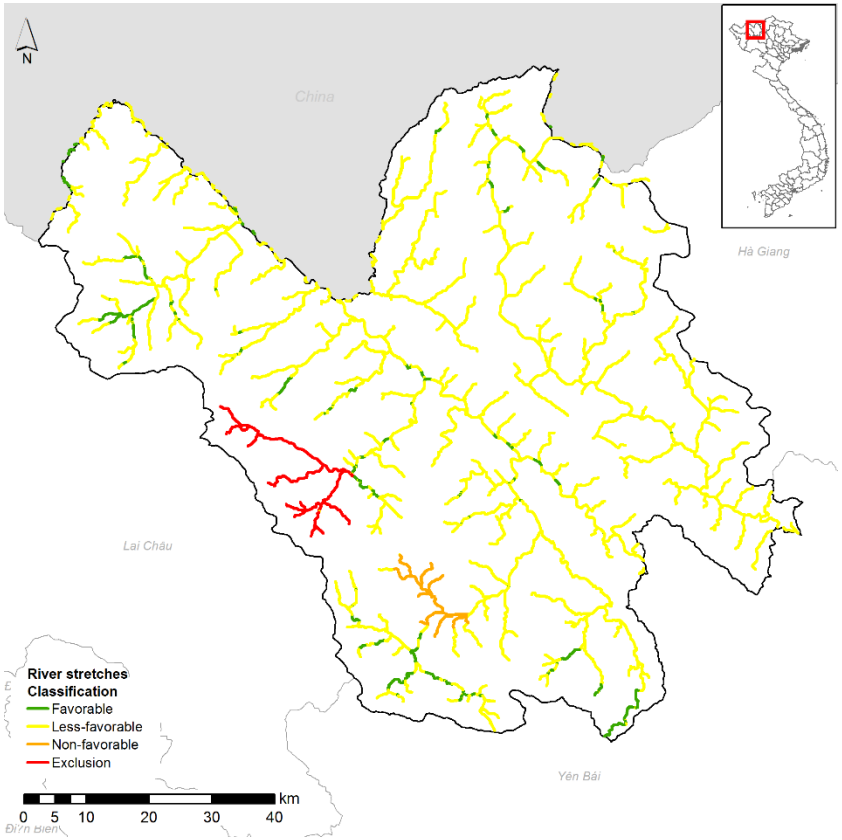
THE RIVER STRETCHES CLASSIFICATION WAS OBTAINED CROSSING THE HYDROPOWER POTENTIAL WITH THE ENVIRONMENTAL IMPACT



Hydropower potential

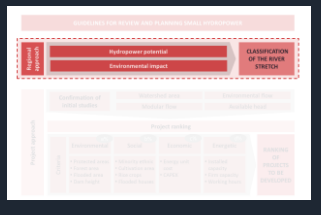
Environmental impact

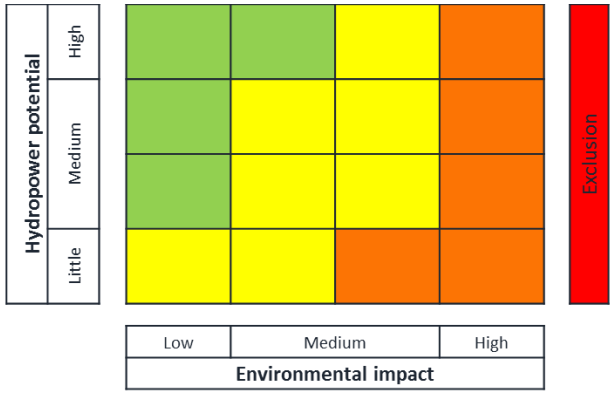




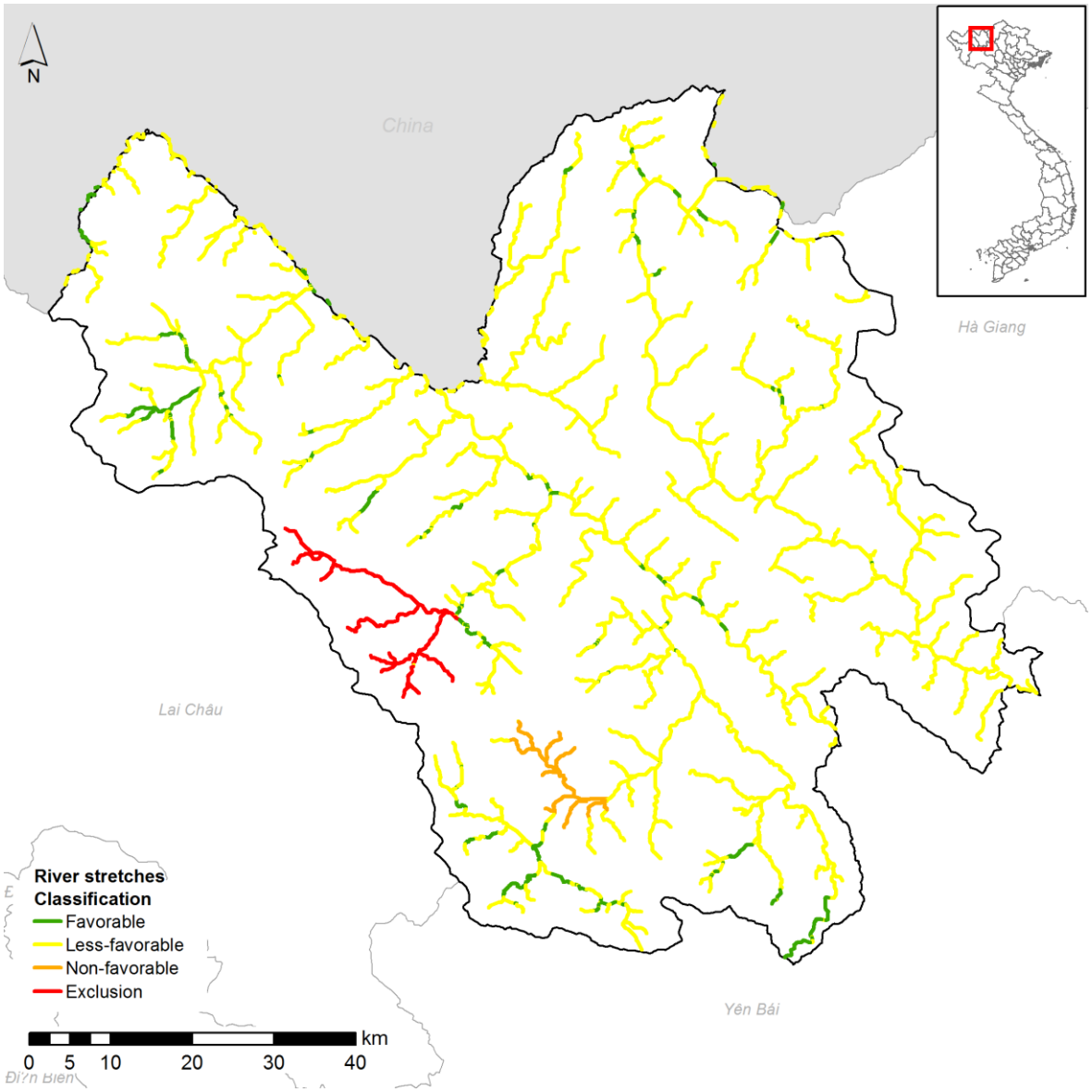
River stretches classification

FINAL RIVER STRETCHES CLASSIFICATION



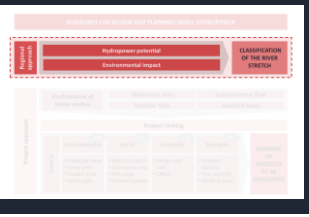


Favorable	Less-favorable	Non-favorable	Exclusion
For hydropower projects development	For hydropower projects development	For hydropower projects development	Hydropower projects forbidden by law
In accordance with environmental legal framework. Construction of SHP in general possible.	Environmental aspect needs to be assessed, weighing all relevant criteria. SHP can be developed under conditional criteria.	SHPs possible only in exceptional cases (e.g. auto-supply)	No hydropower exploitation possible. Protected areas where any interventions are forbidden by law.

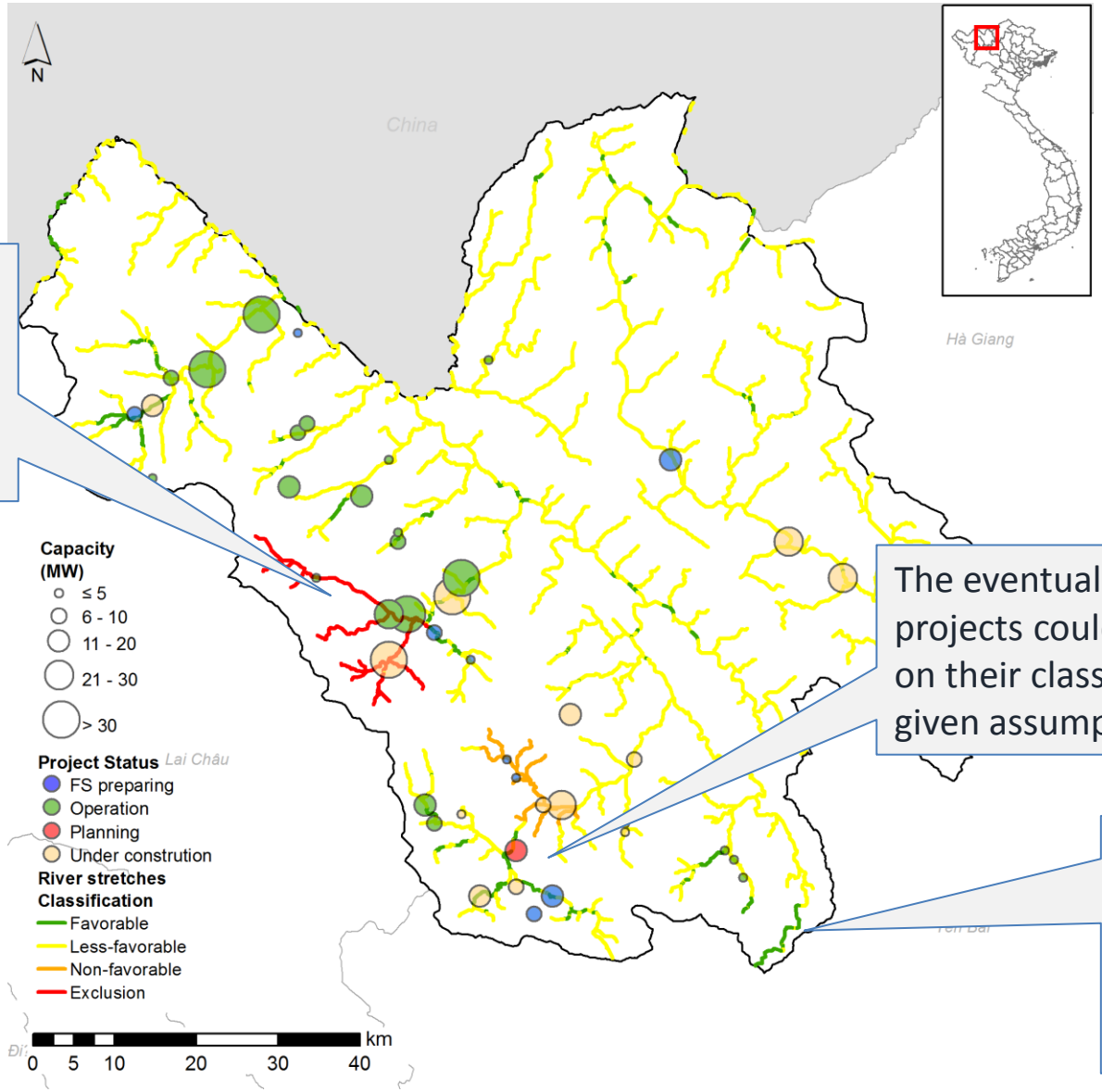


River stretches classification

THE RIVER STRETCH CLASSIFICATION MAY BE A VALID TOOL FOR PLANNING



Under the current assumptions, some projects would be given non-favorable appraisal

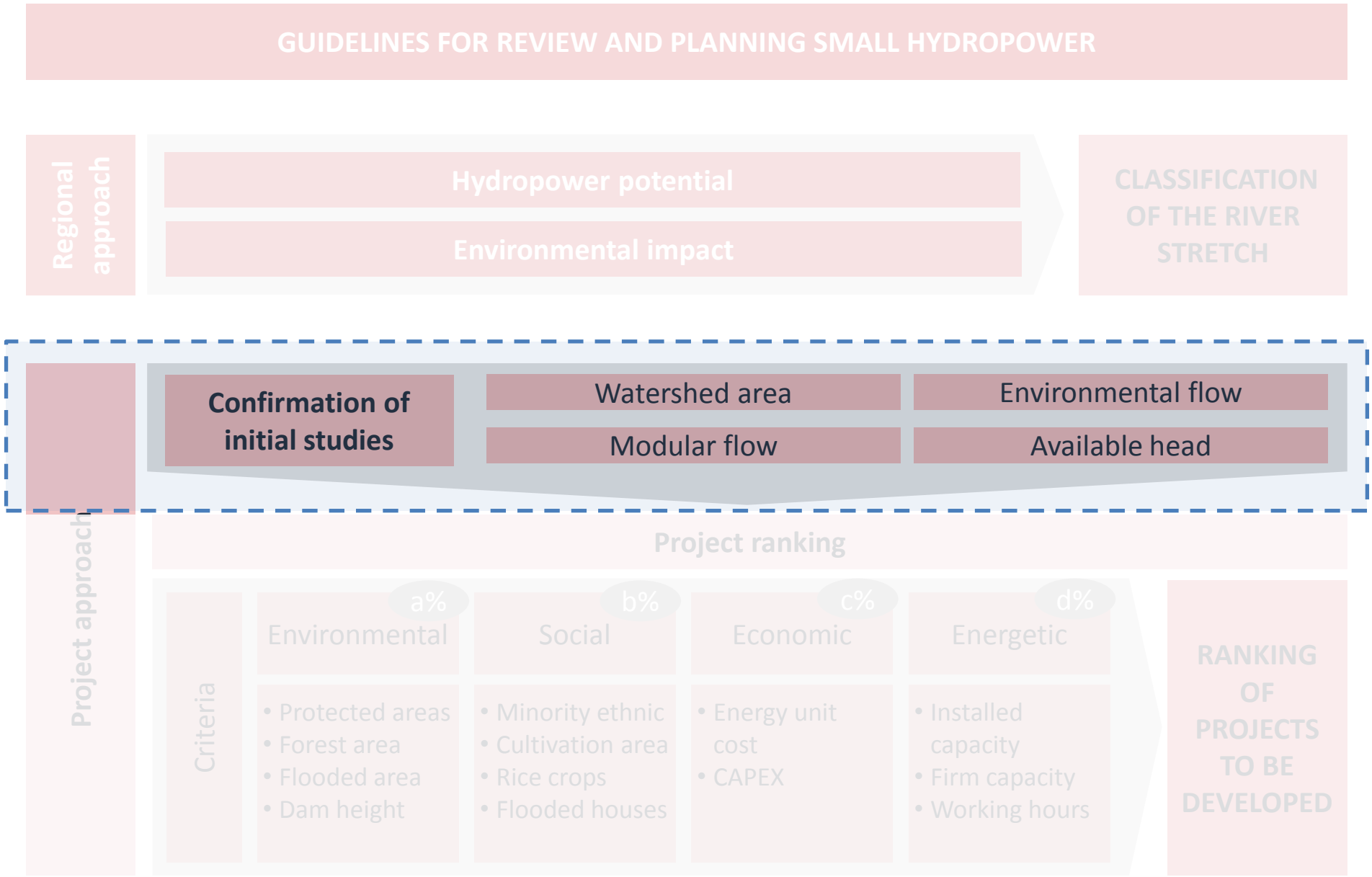


The eventual conflict between projects could be sorted based on their classification (and given assumptions)

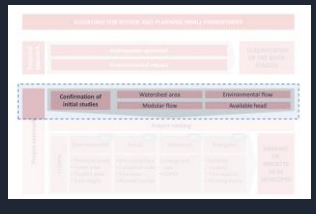
There are river stretches with good conditions for hydropower development where projects are not foreseen

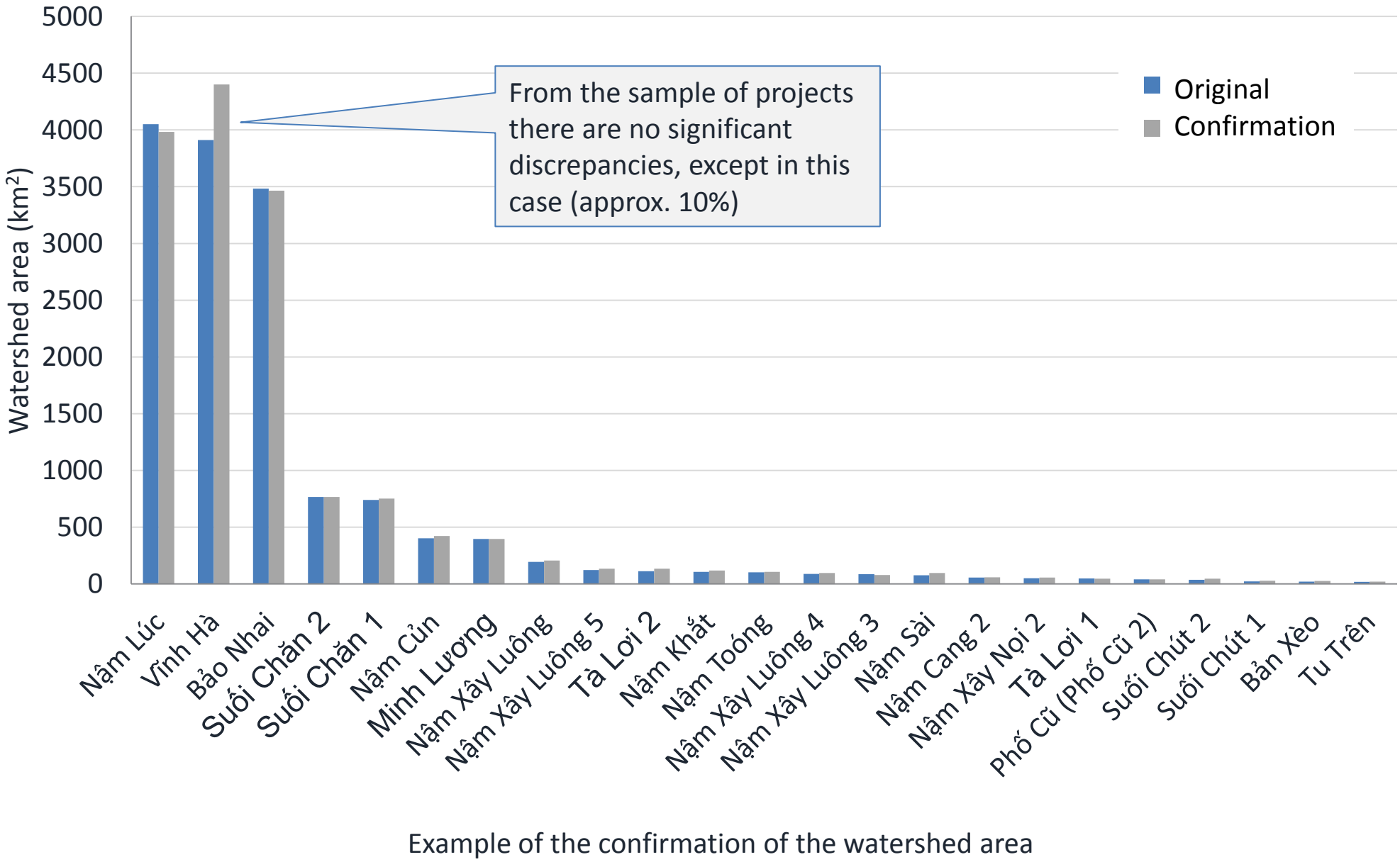
River stretches final classification and identified projects

REMINDER OF THE PROJECT APPROACH, PROCESS 1: CONFIRMATION OF INITIAL STUDIES



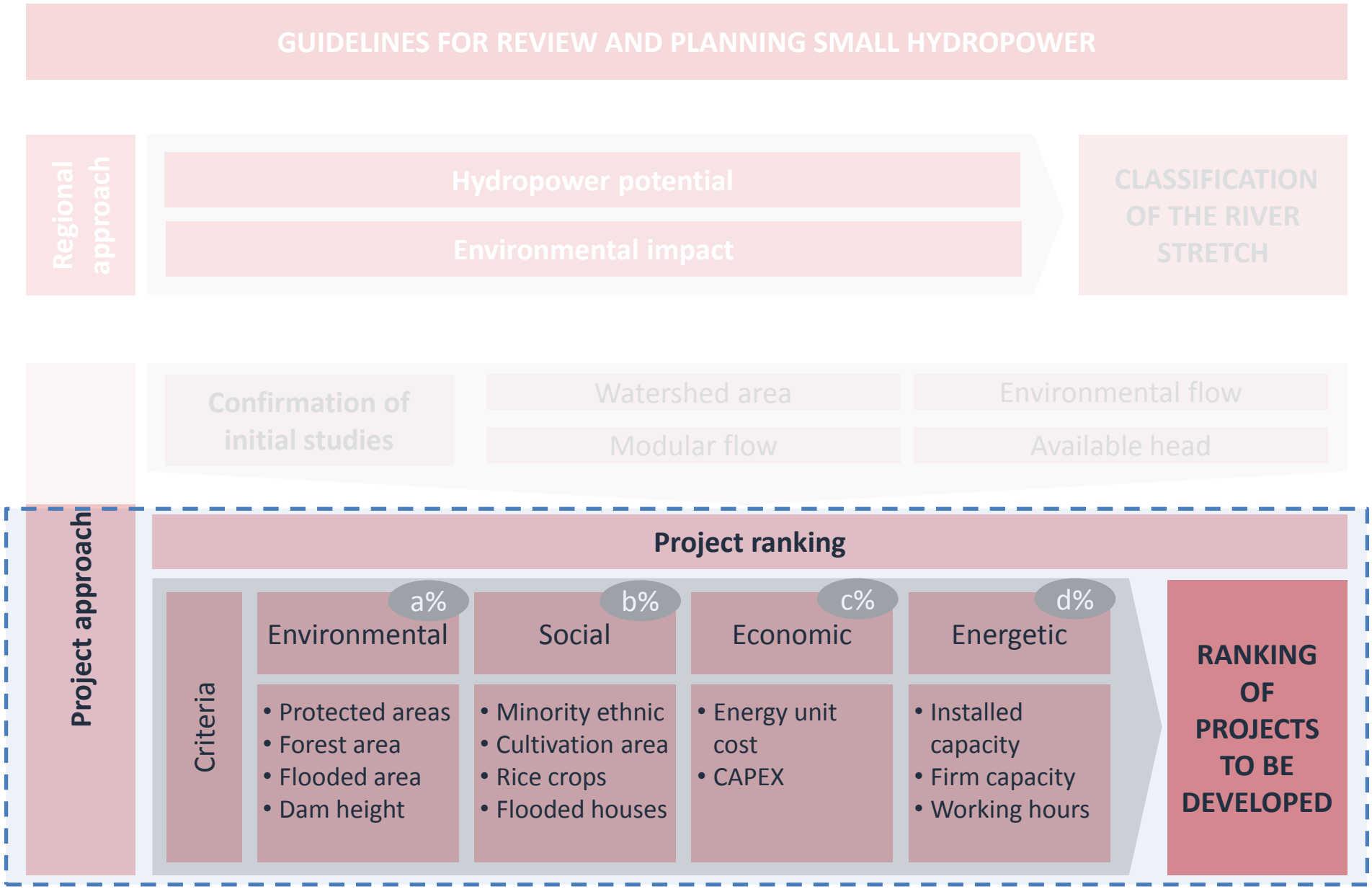
CHECKING THE INITIAL STUDIES' PARAMETERS MAY BE A GOOD INDICATOR OF THEIR QUALITY



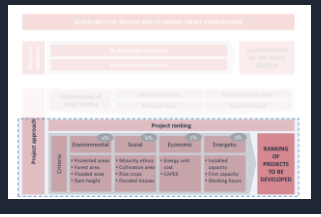


Example of the confirmation of the watershed area

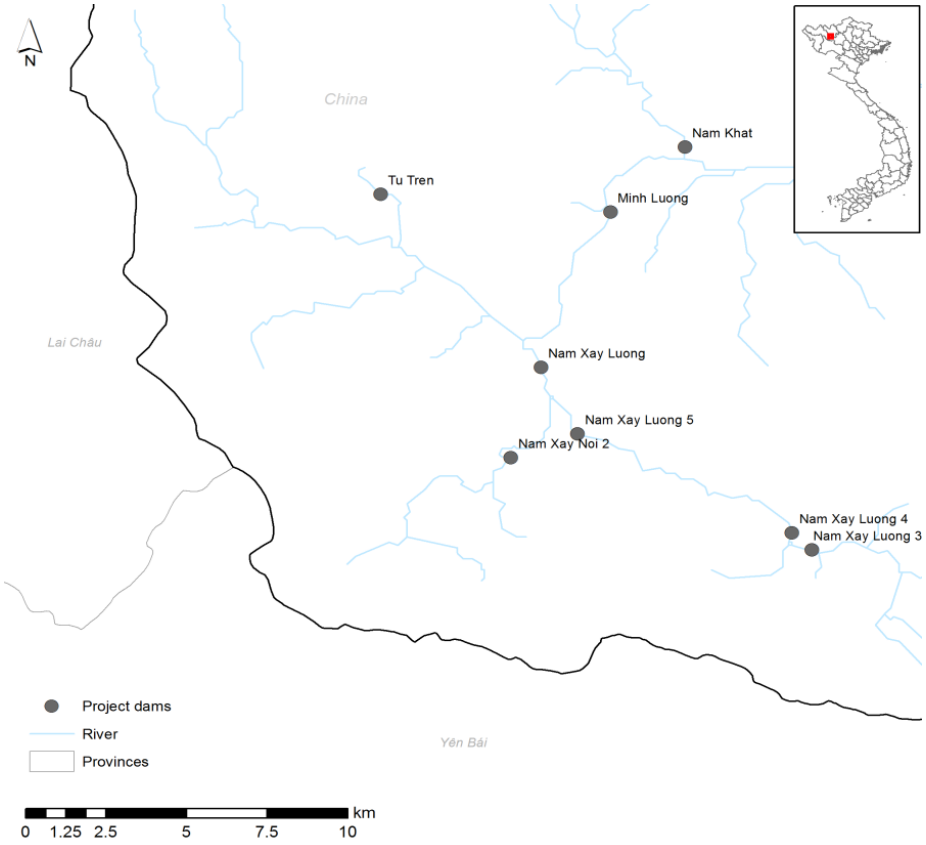
REMINDER OF THE PROJECT APPROACH, PROCESS 2: PROJECT RANKING



EIGHT PROJECTS LOCATED CLOSE BY IN VĂN BÀN DISTRICT WERE RANDOMLY SELECTED FOR EVALUATION

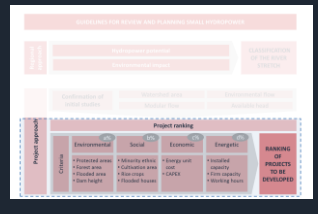


Data retrieved from the Small Hydropower GIS Database



Project name	Nậm Xây Luông 5	Nậm Khắt	Nậm Xây Nọi 2	Minh Lương	Tu Trên	Nậm Xây Luông 4	Nậm Xây Luông 3	Nậm Xây Luông
Project code	2035	2038	2041	2043	2046	3059	3064	4025
Status	Under construction	Under construction	Under construction	Under construction	Under construction	FS preparing	FS preparing	Planning
Watershed Area (km2)	121.6	105.7	50.5	396.6	19.0	89.2	87.0	195.0
Flooded area at FSWL (km2)					19.00		0.17	
Rainfall (mm)		2100		2010	2000	2110	2110	2110
Qmod (m3s)		4.12	1.85	15.37	0.95		4.18	9.57
Dam height (m)	36.5	8.0	19.5	36.5	14.9	22.0		17.4
Capacity (MW)	7.2	7.5	12.0	28.0	2.8	12.0	8.0	13.0
Firm capacity (MW)	7.2	0.9	2.0	5.0	0.4	2.7		1.4
Energy (GWh)	29.50	33.36	44.97	98.46	11.19	48.75		44.11
Working hours (h)	0	4448	3748	3516	3996	4063	0	3393
Energy Unitary Cost (MillVND_kWh)				8.217	6.613	13.880		7.533
CAPEX (MillVND/kW)				28.893	26.429	56.392		25.558
# household	0	0	0	0	0	0	0	0
# household								
Minority ethnic		Dân tộc Dao						
Cultivation (ha)	4.2	2.3	0.0	32.7	0.0	0.0	0.0	3.6
Forest (ha)	0	0	0	0	0	0	0	0
Rice crops (ha)	3.1	2.3		32.7		0.0		

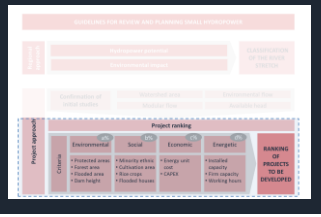
FOR THE PROJECT RANKING FOUR MAIN CRITERIA (AND SEVERAL SUB-CRITERIA) WERE CONSIDERED AND WEIGHTS GIVEN



Criteria	Environmental	Weight	Social	Weight	Economic	Weight	Energetic	Weight
Sub-criteria	Protected areas	12.50%	Ethnic minorities	12.50%	Energy Unitary Cost	12.50%	Capacity	6.25%
	Forest area	5.00%	Cultivation area	6.25%	CAPEX	12.50%	Firm capacity	12.50%
	Flooded area at FSWL	3.75%	Rice crops	6.25%			Working hours	6.25%
	Dam height	3.75%						
Total weight	**Environmental**	**25%**	**Social**	**25%**	**Economic**	**25%**	**Energetic**	**25%**

The scenario chosen was a balanced scenario with equal weights for every criteria

APPLICATION OF THE ENVIRONMENTAL CRITERIA

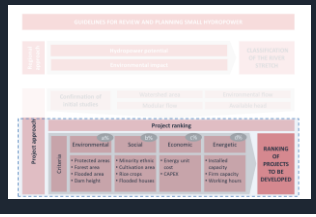


Name	Protected Area	Scoring 12.50%	Forest area (ha)	Scoring 5.00%	Dam height (m)	Scoring 3.75%	Flooded area (km2)	Scoring 3.75%	Global scoring (25%)
Minh Lương	Hoang Lien Son - Van Ban Nature Reserve	0	0.00	100	36.5	0		0	**20**
Nậm Khắt	Hoang Lien Son - Van Ban Nature Reserve	0	0.00	100	8.0	78		0	**32**
Nậm Xây Luông		100	0.00	100	17.4	52		0	**78**
Nậm Xây Luông 3		100	0.00	100		0	0.173	99	**85**
Nậm Xây Luông 4		100	0.00	100	22.0	40		0	**76**
Nậm Xây Luông 5		100	0.00	100	36.5	0		0	**70**
Nậm Xây Nọi 2		100	0.00	100	19.5	47		0	**77**
Tu Trên		100	0.00	100	14.9	59	19	0	**79**

The scoring is determined by comparing each project with the remaining: from 0 (lowest score) to 100 (highest score).

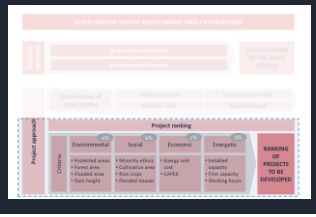
The project with highest global score is the first one of the ranking

APPLICATION OF THE SOCIAL CRITERIA



Name	Ethnic minorities	Scoring 12.50%	Cultivation (ha)	Scoring 6.25%	Rice crops (ha)	Scoring 6.25%	Global scoring (25%)
Minh Lương		100	32.75	0	32.75	0	**50**
Nậm Khắt	Dân tộc Dao	0	2.29	93	2.29	93	**47**
Nậm Xây Luông		100	3.55	89		0	**72**
Nậm Xây Luông 3		100	0.00	100		0	**75**
Nậm Xây Luông 4		100	0.00	100	0.00	100	**100**
Nậm Xây Luông 5		100	4.22	87	3.14	90	**94**
Nậm Xây Nọi 2		100	0.00	100	32.75	0	**75**
Tu Trên		100	0.00	100	2.29	0	**75**

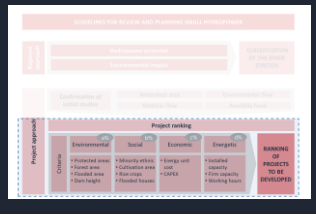
APPLICATION OF THE ECONOMIC CRITERIA



Name	Energy Unitary Cost (Mill VND/kWh)	Scoring 12.50%	CAPEX (Mill VND/kW)	Scoring 12.50%	Global scoring (25%)
Minh Lương	8.22	41	28.89	49	**45**
Nậm Khắt		0		0	**0**
Nậm Xây Luông	7.53	46	25.56	55	**50**
Nậm Xây Luông 3		0		0	**0**
Nậm Xây Luông 4	13.88	0	56.39	0	**0**
Nậm Xây Luông 5		0		0	**0**
Nậm Xây Nọi 2		0		0	**0**
Tu Trên	6.61	52	26.43	53	**53**

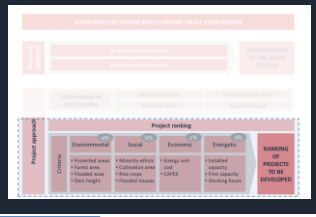
Important to fill data gaps

APPLICATION OF THE ENERGETIC CRITERIA



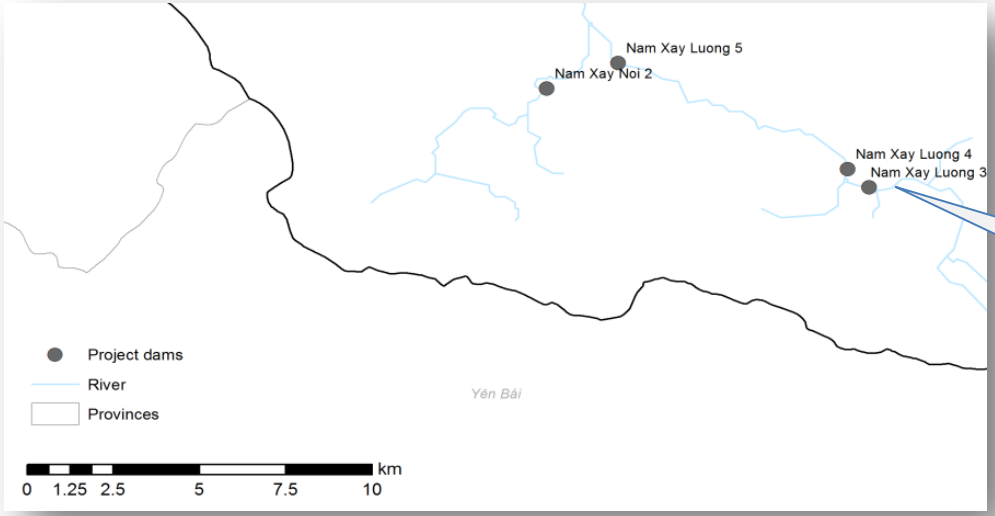
Name	Capacity (MW)	Scoring 6.25%	Firm capacity (MW)	Scoring 12.50%	Working hours (h)	Scoring 6.25%	Global scoring (25%)
Minh Lương	28.0	100	5.0	68	3516	79	**79**
Nậm Khắt	7.5	19	0.9	8	4448	100	**34**
Nậm Xây Luông	13.0	40	1.4	16	3393	76	**37**
Nậm Xây Luông 3	8.0	21		0		0	**5**
Nậm Xây Luông 4	12.0	37	2.7	34	4063	91	**49**
Nậm Xây Luông 5	7.2	17	7.2	100		0	**54**
Nậm Xây Nọi 2	12.0	37	2.0	23	3748	84	**42**
Tu Trên	2.8	0	0.4	0	3996	90	**22**

THE RANKING OF THE PROJECTS IS A HELPFULL PLANNING TOOL



Final ranking for a balanced scenario (25%-25%-25%-25%)

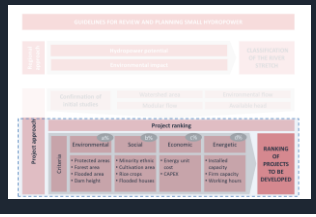
Name	Environmental (25%)	Social (25%)	Economic (25%)	Energetic (25%)	Score (100%)	Ranking
Nậm Xây Luông	78	72	50	37	59	**1**
Tu Trên	79	75	53	22	57	**2**
Nậm Xây Luông 4	*76*	*100*	*0*	*49*	*56*	***3***
Nậm Xây Luông 5	70	94	0	54	55	**4**
Nậm Xây Nọi 2	77	75	0	42	48	**5**
Minh Lương	20	50	45	79	48	**6**
Nậm Xây Luông 3	*85*	*75*	*0*	*5*	*41*	***7***
Nậm Khắt	32	47	0	34	28	**8**



The results may be eschewed from data gaps

Two potentially conflicting projects (both in FS stage) may be compared

AN ALTERNATIVE RANKING FOR A MORE AGGRESSIVE HYDROPOWER DEVELOPMENT SCENARIO



Name	Environmental (10%)	Social (10%)	Economic (40%)	Energetic (40%)	Score (100%)	Ranking
Minh Lương	20	50	45	79	56	**1 (was 6)**
Nậm Xây Luông	78	72	50	37	50	**2 (was 1)**
Tu Trên	79	75	53	22	45	**3 (was 2)**
Nậm Xây Luông 5	70	94	0	54	38	**4 (was 4)**
Nậm Xây Luông 4	*76*	*100*	*0*	*49*	*37*	***5 (was 3)***
Nậm Xây Nọi 2	77	75	0	42	32	**6 (was 5)**
Nậm Khắt	32	47	0	34	21	**7 (was 8)**
Nậm Xây Luông 3	*85*	*75*	*0*	*5*	*18*	***8 (was 7)***

Nậm Xây Luông 4 is still a better project than Nậm Xây Luông 3

Criteria and their weights can be adapted case-by-case according to local priorities and may be defined in cooperation with all stakeholders.

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CLOSING REMARKS

CLOSING REMARKS

Closing remarks
• The current version of the National Small Hydropower GIS Database should be appraised, even if there is still margin for improvement on workability and overall presentation • It is recommended to have an extended technical assistance period after the delivery of the National Small Hydropower GIS Database for revisions after a trial period • The vast majority of data required for the implementation of the guidelines is already part of the National Small Hydropower GIS Database • Attention should be given to data gaps, since they will affect project evaluation, and base maps, since they will help the planning decision process • The implementation of certain parts of the proposed guidelines requires the use of auxiliary GIS software performed by users with basic to intermediate levels of proficiency, depending on the complexity of the task • The guidelines include common principles and recommendations, and should be viewed as an outline for an assessment procedure as well as a pool of evaluation criteria • Sufficient flexibility for implementation of the guidelines is given, in order to pay attention to regional differences and development priorities

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