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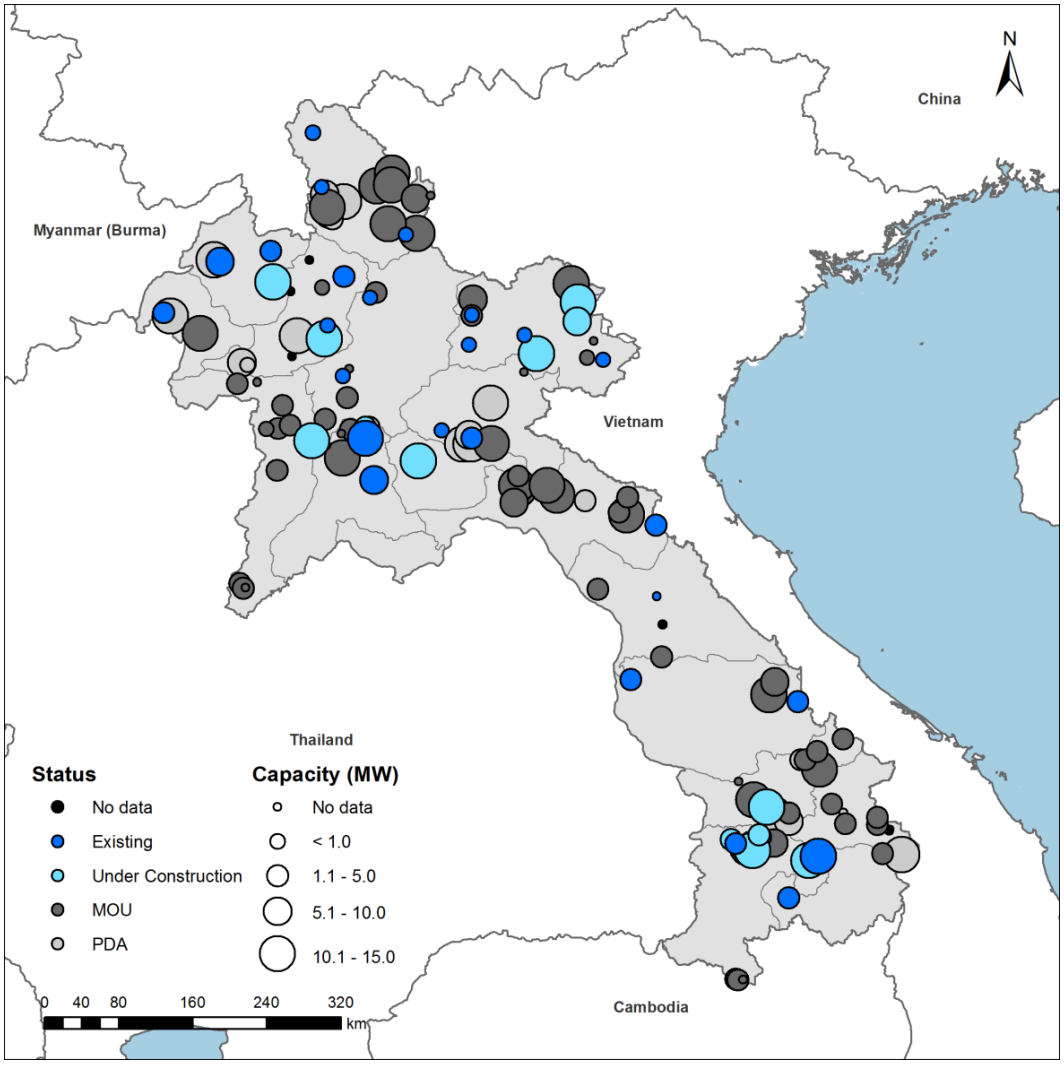
ESMAP
Energy Sector Management Assistance Program

Small Hydro Resource Mapping in LAO PDR

INCEPTION REPORT

JULY 2017



This report was prepared by GESTO, under contract to The World Bank.

It is one of several outputs from the small hydro resource mapping component of the activity "Renewable Energy Resource Mapping and Geospatial Planning – LAO PDR" [Project ID: P163979]. 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.

This document is an **interim output** from the above-mentioned project. Users are strongly advised to exercise caution when utilizing the information and data contained, as this has not been subject to full peer review. The final, validated, peer reviewed output from this project will be the LAO PDR Small Hydro Atlas, which will be published once the project is completed.

HYDROPOWER MAPPING IN LAO PDR

PROJECT ID: 1239196

INCEPTION REPORT

July 2017

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1 PROJECT SYNOPSIS

Project title: Hydropower Mapping in Lao PDR

Project Number: Selection No. 1239196

Country: Lao PDR

Project objectives: To provide the Government of Lao PDR and other key stakeholders with an assessment of small and medium hydropower potential within the context of hydropower resources more generally, to support the identification of potentially viable sites, and to provide the data and knowledge needed to assess whether further work is needed and, if so, what it may involve.

Expected results: A comprehensive hydropower resource assessment exercise using both in-country and earth observation datasets, followed by a site prioritization analysis to rank identified small-medium hydropower sites in terms of technical and economic potential, reporting of the results in a way that supports further use and analysis by the government and, finally, capacity building and training.

Contract signing date: May 22, 2017

Project duration after final methodology approval: 12 months

2 INTRODUCTION

2.1 ESMAP

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by The World Bank Group (WBG) and supported by 11 bilateral donors. ESMAP's effort focuses on energy security, energy access, and climate change, and it takes into account three core services: i) analytical work, ii) knowledge clearinghouse, and iii) operational support to The World Bank regions for technical assistance work at country level.

Carrying out RES mapping and geospatial analysis at country level helps to scale up the deployment of biomass, hydropower, solar and wind electricity generation, particularly in countries where one or more of these sources of power are underdeveloped. This is because such mapping is a crucial step to developing a policy framework to guide investment in RES electricity generation which, along with publicly-available data, helps reduce transaction costs and speeds up deployment, by providing commercial developers with:

- Increased certainty that projects are likely to be approved or permitted with minimal bureaucracy and delay.
- Data transparency and an even playing field, thereby reducing entry barriers and limiting corruption.
- A baseline of reliable data that can help to guide prospecting activities and that can be used for data verification purposes
- A better informed off taker or purchasing authority, thereby improving the price negotiation process

In response, ESMAP has launched a new initiative to support country-driven efforts to improve RES awareness, to put in place appropriate policy frameworks for RES development and to provide "open access" to resource and geospatial mapping data. One of the key elements of this ESMAP initiative was to select consulting firms and to establish framework agreements for the procurement of resource data and mapping services.

The tender for *Hydropower Mapping in Lao PDR* was released in April 2017. For this particular tender, an International Consultant's Association (Consultant) led by Gesto Energy Consulting (GESTO) and including TPF Planege Cenor (TPF) was formed. Additionally, Lao Global Engineering (LGE) was subcontracted as local partner.

After the tenders' evaluation early May 2017, the World Bank informed the Consultant that it was chosen to carry out the Project. The Contract was signed May 22 and, on the same day, the Consultant started the Inception Mission in Vientiane.

2.2 THE CONSULTANT

GESTO, the leading partner, is an international company focused on energy consulting and renewable energy project development, with emphasis in developing countries. With an overall experience of more than 50,000 MW of energy projects consulting in Africa, America, Asia and Europe, GESTO has know-how and experience in hydropower mapping (small, medium and large), mini-grids, hydropower generation plans, energy policies, tariff definition, energy master plans (including Least Cost Power Development Plans), and supports all phases of energy project development and energy planning. GESTO is a certified ISO-9001 and ISO-4457 international company, founded in 2008 and headquartered in Lisbon (Portugal) and with offices in Mozambique, Angola, Kenya and Italy.

Currently, GESTO presents a worldwide portfolio of projects ranging from resource evaluation to project development, from rural energy master plans to rural electrification preliminary engineering design, from energy sector strategy and institutional reform to RE legislation and tariffs, among others.

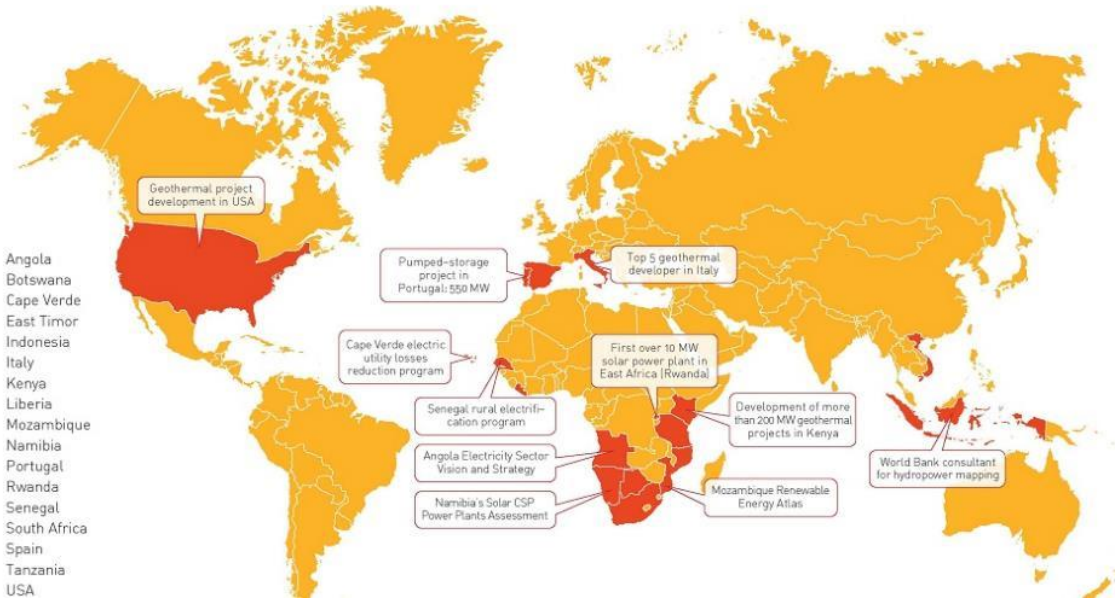

Figure 2.1 – GESTO worldwide

The map above illustrates the geographical presence of GESTO and some of its most relevant past projects. GESTO has been working in Southeast Asia since 2010 (Renewable Energy Based Electrification Master Plan for East-Timor) and is a renowned hydropower consultant and developer.

GESTO has significant experience with ESMAP, precisely in hydropower mapping. In 2013 GESTO was awarded a four-year Framework Contract with the World Bank itself for the ESMAP initiative "Small Hydropower Resource Data and Mapping Services" (Selection No. 1092748), establishing it as an eligible vendor for the World Bank and one of the only three worldwide companies able to do so. Following this, Gesto has been granted the initiatives "Small Hydropower Mapping and Improved Geospatial

Electrification Planning in Vietnam" and "Small Hydropower Mapping and Improved Geospatial Electrification Planning in Indonesia", that were successfully concluded early this year.

TPF Planege Cenor is one of the major Portuguese engineering companies, havingh an accumulated experience of over 37 years that ensures the fully integrated provision of engineering services, from design to management, for complex undertakings.

The company is part of the TPF GROUP, which has about 4.250 co-workers all over the world. TPF Planege Cenor itself is a global supplier of technical and management services in a wide range of market sectors, including transport, health, industry, tourism, environment, energy, water and sanitation, taking advantage of the synergies and experiences of the different group companies, in all the major markets were it is active.

The TPF GROUP has 4 Centers of expertise, with headquarters in the following countries:

- Water (in Portugal)
- Buildings (in France).
- Energy (in Brazil).
- Transportation (in Spain).

Figure 2.2 - TPF GROUP in the world

Therefore, TPF Planege Cenor is able to provide design and technical advice, from feasibility studies to construction supervison management, in the Environment, Water Resources, Hydraulic and Hydrology sector, namely in what concerns:

- Dams, Reservoirs, Water Intakes and Pumping Stations.
- Hydropower.
- Dam Break Studies and Dam Monitoring Plans.
- Hydrological Studies.
- Flood Protection and River Training.
- Irrigation.
- Water Supply and Sanitation.
- Geological and Geotechnical Studies
- Environmental Impact Studies.
- Environmental Rehabilitation and Landscaping.
- Environmental audits.
- Strategic Environmental Plans
- Environmental Monitoring Plans
- Water Resources Management Plans.

2.3 OBJECTIVES

The objectives of the assistance are to provide the Government of Lao PDR (Client), represented by the Ministry of Energy and Mines (MEM), and other key stakeholders with an assessment of small and medium hydropower potential within the context of hydropower resources more generally, to support the identification of potentially viable sites and to provide the data and knowledge needed to assess whether further work is needed and, if so, what it may involve.

Therefore, the assignment shall include a comprehensive hydropower resource assessment exercise, using both in-country and earth observation datasets, followed by a site prioritization analysis to rank identified small-medium hydropower sites in terms of technical and economic potential, reporting of the results in a way that supports further use and analysis by the government and, finally, capacity building and training.

The Institute of Renewable Energy Promotion (IREP), under the MEM, is the key implementation partner for this activity.

The following steps and tasks are envisaged as part of the assignment:

- Inception Mission, including initial engagement with Government officials, needs assessment and data gathering.
- Resource assessment.
- Site visits to validate high priority sites and to gain field intelligence.
- Site prioritization and data gaps identification.
- Training on software tools to carry out further analysis.
- Final report, outlining key results and options for further analysis.
- Presentation of the final results to the government and to the key stakeholders.

For the development of these activities, the Consultant proposed, during the selection period, a methodological approach and a schedule for the development of the tasks, which are reviewed in this report, based on the results of the inception mission.

2.4 CONTENT OF THE REPORT

After carrying an Inception Mission, the Consultant reviewed the compiled information, including feedback from meetings, and refined the focus of the study to finalize the detailed methodology.

The findings of this pre-diagnostic exercise are summarized in this Inception Report, which will require approval by the Client and by the WBG team, for the continuation of the services.

Chapters 1 and 2 are the introduction to the project.

Chapter 3 describes the Inception Mission.

In Chapter 4, a preliminary compilation of globally available data is presented.

Chapter 5 contains the revision of the implementation plan and the final methodology proposal. In this chapter, key challenges in the project implementation are acknowledged, which lead to some modifications in the preliminary methodology. Finally, the proposal for the final methodology, milestones and work plan are presented.

In Chapter 6, the main conclusions of the Inception Report are presented.

3 INCEPTION MISSION

3.1 OBJECTIVES

The Inception Mission occurred between May 22 and May 26 in Vientiane, Lao PDR, with the general purpose of presenting the Consultant and Client teams to each other, getting the Consultant acquainted with local conditions and fine-tuning the proposed implementation plan. The specific objectives of the Inception Mission were to:

- To promote meetings with the Client.
- To identify and to promote meetings with relevant stakeholders.
- To make a first assessment of available information.
- To compile relevant information and data.
- To make an institutional assessment of MEM's capacity on GIS use.
- To identify the major challenges in this project.

Apart from the work-in-progress task of compiling relevant information and data, all objectives were fulfilled during the Inception Mission.

3.2 MEETINGS AND WORK SESSIONS

The Consultant had several meetings with the WBG and the Client, as well as with other relevant stakeholders. The performed work schedule for the Inception Mission is presented in Table 3.1.

Table 3.1 – Meetings and work sessions during the Inception Mission.

Location	Date	Participants	Description
World Bank Office	May 22, 2017	WBG Consultant	First Internal Team Meeting
Ministry of Energy and Mines (MEM)	May 22, 2017	WBG Consultant MEM Stakeholders	Kick-off Meeting
Ministry of Energy and Mines (MEM)	May 23, 2017	WBG Consultant IREP DEPP	Work meeting with IREP and the Dept. of Energy Policy and Planning (DEPP)
Ministry of Energy and Mines (MEM)	May 23, 2017	Consultant IREP	Consultation meeting with the Deputy Director General of IREP, Dr. Seumkham Thoummavongsa
Ministry of Home Affairs (MHA)	May 23, 2017	Consultant IREP MHA	Data collection at the National Geographic Department with the Director of the Topographic Survey Division, Mr. Sisombath Chanthaphim and staff
Ministry of Energy and Mines (MEM)	May 24, 2017	Consultant IREP	Consultation meeting with the Acting Director General of IREP, Mr. Chantho Milattanapheng
Ministry of Energy and	May 24, 2017	Consultant	Consultation meeting with the Deputy

Location	Date	Participants	Description
Mines (MEM)		IREP	Director General of IREP, Mr. Anousak Phogsavath
Electricité du Laos (EDL)	May 24, 2017	Consultant IREP EDL	Consultation meeting at the Technical Dept. of EDL with the Deputy Director of the Power Plan Development Dept., Mr. Viraphanh Nandavong
Ministry of Natural Resources and Environment (MONRE)	May 25, 2017	Consultant IREP MONRE	Data collection at the Department of Water Resources, with the Director of Training and Awareness Centre, Mr. Bounsanong Fongnaly and staff
Ministry of Home Affairs (MHA)	May 25, 2017	Consultant IREP MHA	Data collection at the National Geographic Department, with the Director of the Topographic Survey Division, Mr. Sisombath Chanthaphim and staff
Ministry of Natural Resources and Environment (MONRE)	May 25, 2017	Consultant IREP MONRE	Data collection at the Department of Meteorology and Hydrology with the Deputy Director General, Mr. Nikhom Keosavang and staff
Dept. of Geology and Mines (DGM) of the Ministry of Energy and Mines (MEM)	May 26, 2017	Consultant IREP DGM	Data collection at the Dept. of Geology and Mines
Ministry of Energy and Mines (MEM)	May 26, 2017	Consultant IREP	Consultation meeting with the Acting Director General of DEPP, Dr. Chansaveng Boungnong
Ministry of Energy and Mines (MEM)	May 26, 2017	Consultant IREP	Debriefing with the Acting Director General of IREP, Mr. Chantho Milattanapheng and staff

3.3 DATA COLLECTION

During the Inception Mission, the Consultant focused on getting an overview of the existing data that could later be helpful, when evaluating the hydropower potential and when identifying the most promising new sites in Lao PDR.

At this stage, the Consultant collected some basic information, such as:

- Hydropower Development Plan for the Lao PDR (1998).
- List of existing, under construction and under study small hydropower schemes in Lao PDR, as of 2015.
- Project Portfolio Reports from the Power System Planning Study, Lao PDR.
- Feasibility Studies and Detailed Designs of Micro Hydropower Projects in Lao PDR (2006).
- Topographic data, including topographic maps at scale 1:50 000, as well as contour lines and point elevations in shapefile at scale 1:100 000.
- Geological map.
- Gauging station locations and measured data.

During the Inception Mission, and in accordance with the Client, it was decided that the focus of this project will be the evaluation of promising locations to implement hydropower plants with 15 MW of maximum capacity, since Lao PDR already has many studies for larger hydropower plants locations.

At the current stage, it was possible to collect the data on existing and planned hydropower plants under 15 MW which are presented in **Figure 3.1** and in **Annex I**. This is an ongoing task.

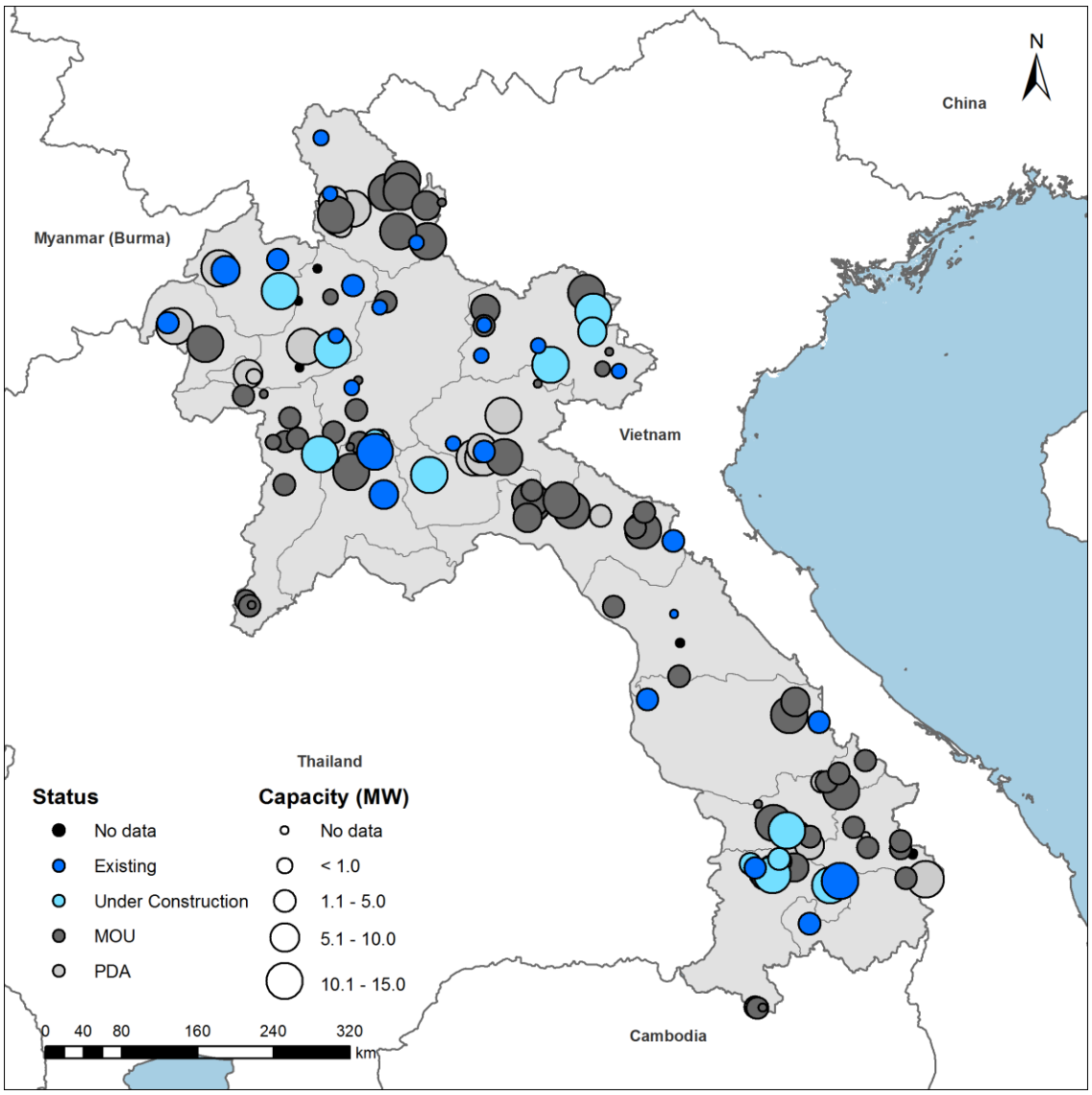

Figure 3.1 – Hydropower plants collected data. (Consultant's processing).

The project's evaluation will require an accurate hydrological study. To do so, the locations of the meteorological and hydrological gauging stations in Lao PDR (and their records) were collected (**Figure 3.2**).

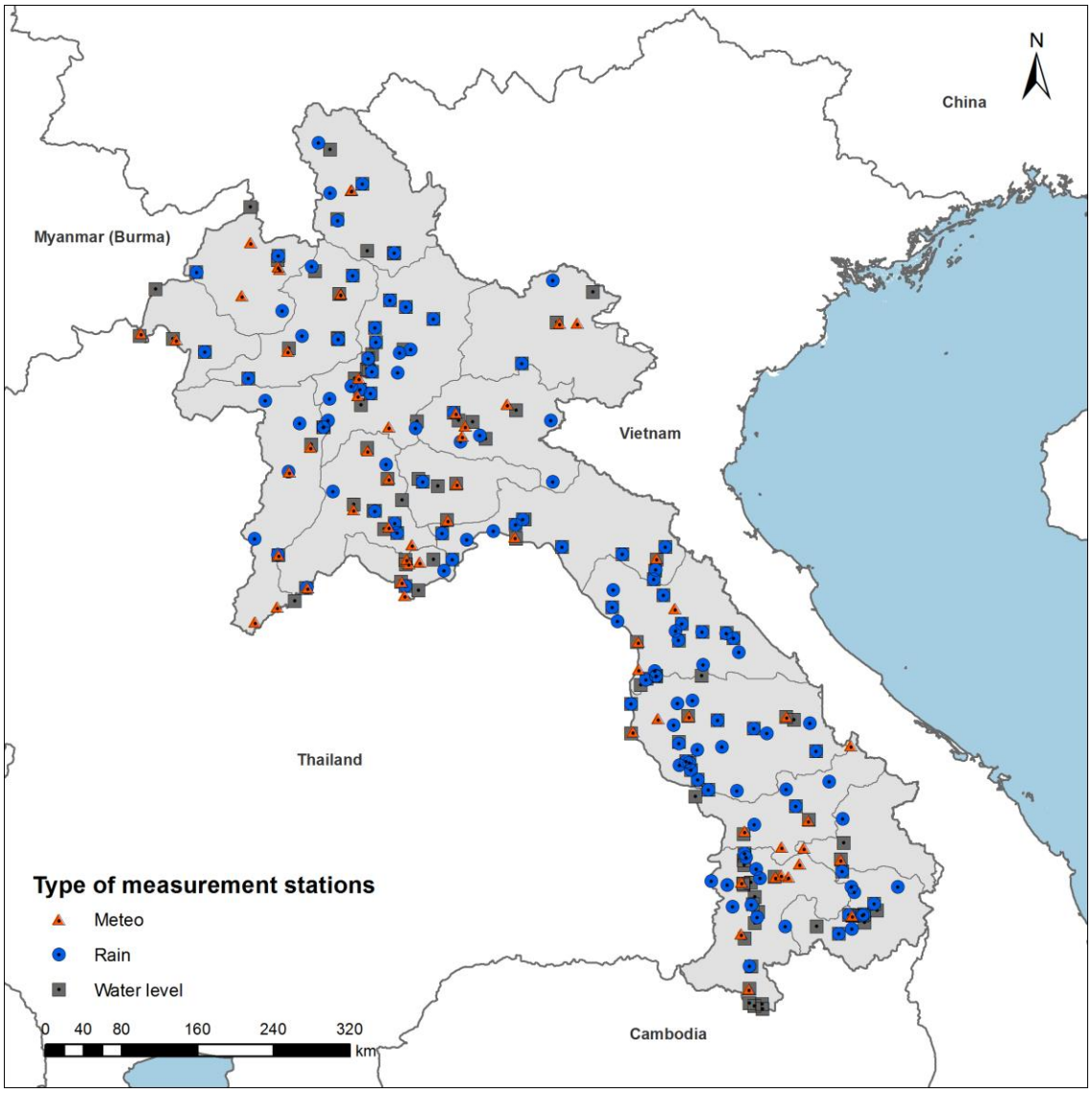

Figure 3.2 – Location of the gauging stations (Consultant's processing).

Concerning the data of the gauging stations, it was possible to collect monthly data from 58 stations. However, 9 of the 58 do not have coordinates. So it was not possible to identify their locations so far. In Figure 3.3, the gauging stations are presented together with the identification of the number of years with complete records they possess.

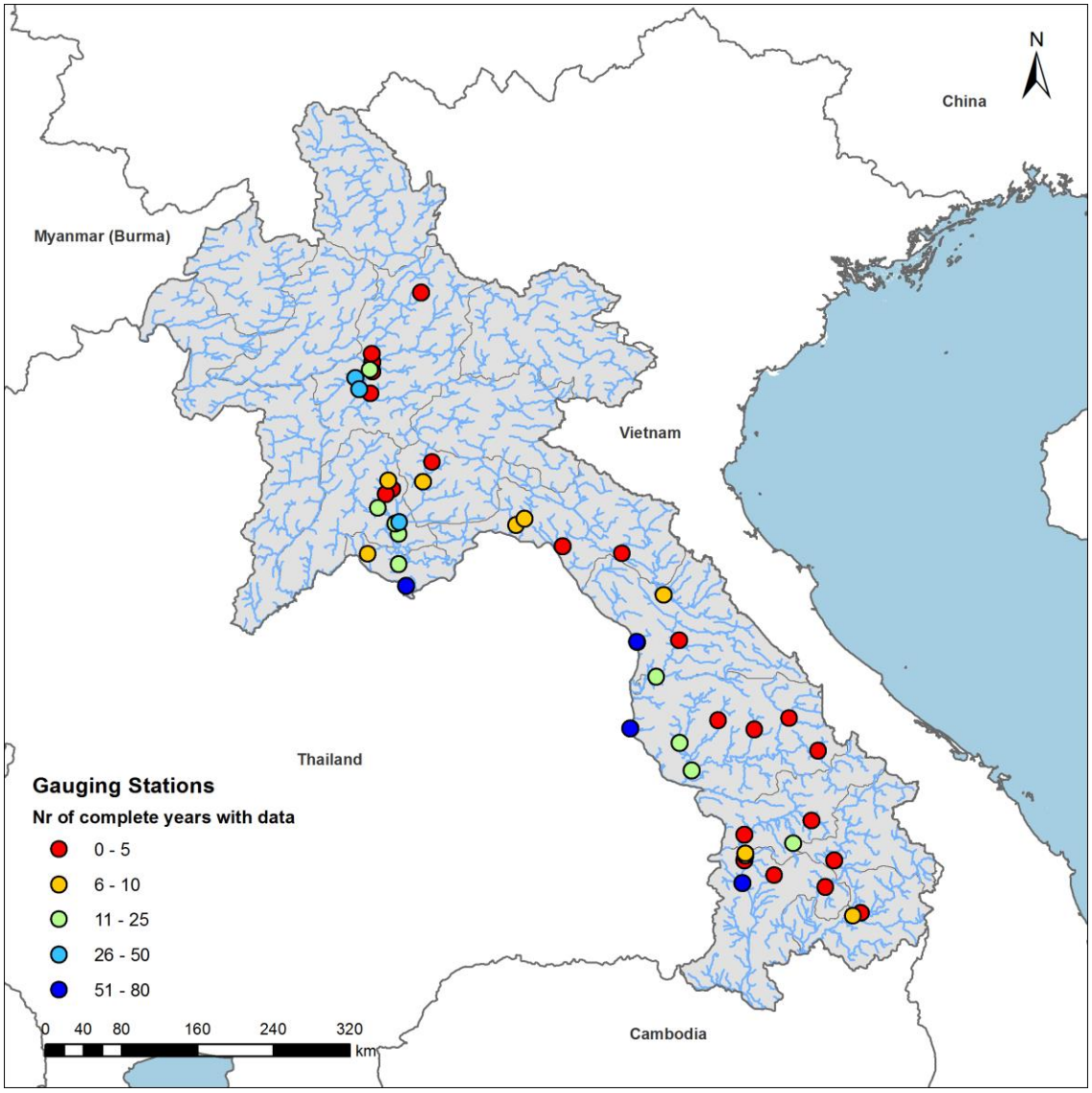

Figure 3.3 – Gauging stations classified by number of complete years with records (Consultant's processing).

Another important set of data sources are the industry standards and main features of recently developed projects, namely economical features like OPEX[1] and CAPEX[2] that will allow to calibrate the forthcoming analysis and prioritization of sites. This information will be accessed through the

[1] OPEX - Operational Expenditure

[2] CAPEX - Capital Expenditure

documentation collected during the Inception Mission (eg. *Feasibility Studies and Detailed Designs of Micro Hydropower Projects in Lao PDR* [2006]) and updated with the help of the Consultant's local staff.

3.4 INSTITUTIONAL ASSESSMENT OF THE CLIENT'S CAPACITY ON GIS

The Inception Mission included an institutional assessment, to identify factors that will be essential for the project's implementation and for sustainability of its results, with emphasis given to IREP's capacity for GIS operation.

After discussion with IREP on the best way to assess current capacity and future needs of its staff on this field, it was decided to prepare a straightforward GIS proficiency questionnaire to be circulated among IREP's internal divisions (Annex II). This would serve as the reference point for the training to be delivered.

The conclusion of the questionnaire is that the majority of users have limited GIS skills. This represents a need for a stepwise training program, focusing initially on first users/basic level sessions and, later, on basic to intermediate level users. Given the time and budget constraints of the current phase of the Technical Assistance, it is considered that building capacity for advanced users will only be possible in the forthcoming phases.

The proposed training program is presented in Annex III.

3.5 CHALLENGES IN THE PROJECT

Quality and completeness of the data to be gathered

The success or, better said, the accuracy of this project will depend strongly on the quality and on the completeness of the data to be gathered on the following fields:

- Topography.
- Geology.
- Hydrology.

So, obtaining enough of these data and treating them correctly constitutes a challenge, which will be coped with in the way explained in section 5.1 of this report.

Prioritization of hydropower sites

The vastness of the territory to be scanned is overwhelming, vis-à-vis of the objective of choosing just a limited number of sites to be visited and studied in more detail by the Consultant, under limited time and budget.

In section 5.1, it is explained how this challenge can be overcome.

Safety and interaction with people and nature on the sites

During the site visits, special attention will have to be given to social and environmental difficulties, as it is also explained in section 5.1.

4 COMPILATION OF GLOBALLY AVAILABLE DATA

4.1 CONTEXT

Data coming from local (usually official) sources should always be preferred, when compared with data coming from other sources, such as globally available databases. Nonetheless, the Consultant conducted a complementary compilation of readily available (global) geographic data for Lao PDR, to be used in the event of those data not being locally available[3].

Given the Consultant's experience, the types and sources of globally available datasets with relevance to the project might be:

- Meteorological Data - Rainfall, Temperature, Evaporation (e.g. from WorldClim).
- Digital Terrain Models, River Network, Catchment areas (e.g. from NASA's Shuttle Radar Topography Mission - SRTM).
- List of large dams (e.g. from ICOLD).
- Rails, roads, water bodies, rivers (e.g. from Digital Chart of the World).
- Administrative boundaries (e.g. from GADM).
- Administrative layers (city points, districts, localities, civil divisions, neighborhoods), geographic features (parks, forests, lakes, islands), points of interest (schools, markets, hospitals, temples, etc.), and roads and rails (e.g. from Google Map Maker).
- Highways, key locations, natural areas, points of interest, water bodies (e.g. from Open Street Map - crowd-sourced and updated frequently).
- Settlements and population (e.g. from Open Street Map).
- Protected lands (e.g. from Protected Planet).
- Land cover map (e.g. from ESA GlobCover).

The preliminary results of the globally available data collection, ready to be used in this project, are presented in the next sections.

4.2 HYDROLOGICAL AND METEOROLOGICAL DATA

Hydrological and meteorological info are amongst the most important type of data for hydropower and they should preferably be collected locally. However, in the event that no sufficient detailed hydro or meteo data are available for the development of the study, an alternative might be the use of global data sources such as the WorldClim project, the Tropical Rainfall Measuring Mission or the NCEP/NCAR reanalysis [1].

[3] During the meetings held at the National Geographic Department from the Ministry of Home Affairs, the Consultant was informed that, due to the absence of official information, that department itself uses globally available information for their maps (eg. the road network)

These global data sources allow an estimation of the rainfall and temperature, even though it is advisable to have at least some good quality ground stations to assess the global data sources level of accuracy. As an example, Figure 4.1 and Figure 4.2, respectively, present the mean annual rainfall and temperature for Lao PDR, obtained from data from the WorldClim project.

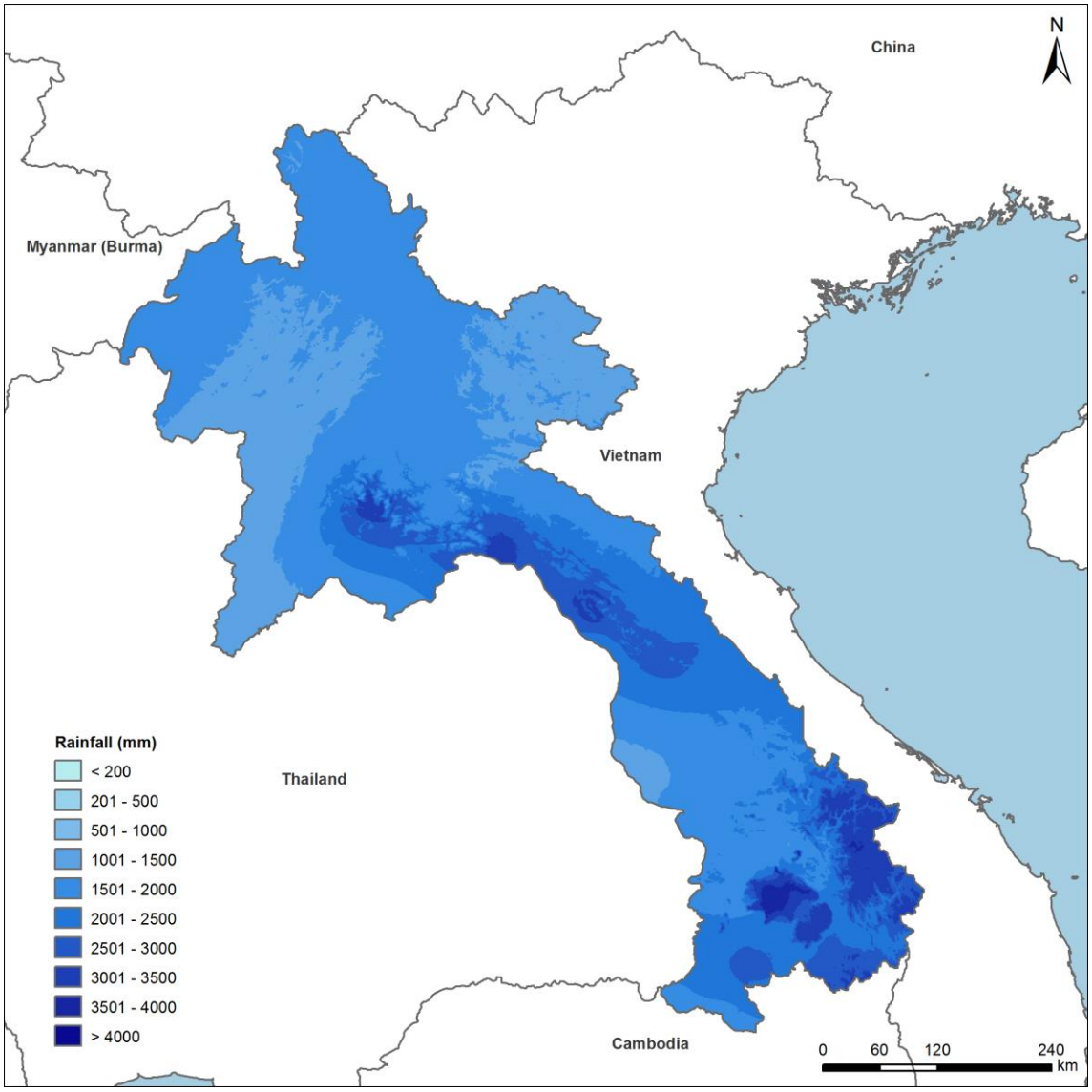

Figure 4.1 – Mean annual rainfall in Lao PDR (WorldClim data, Consultant's processing).

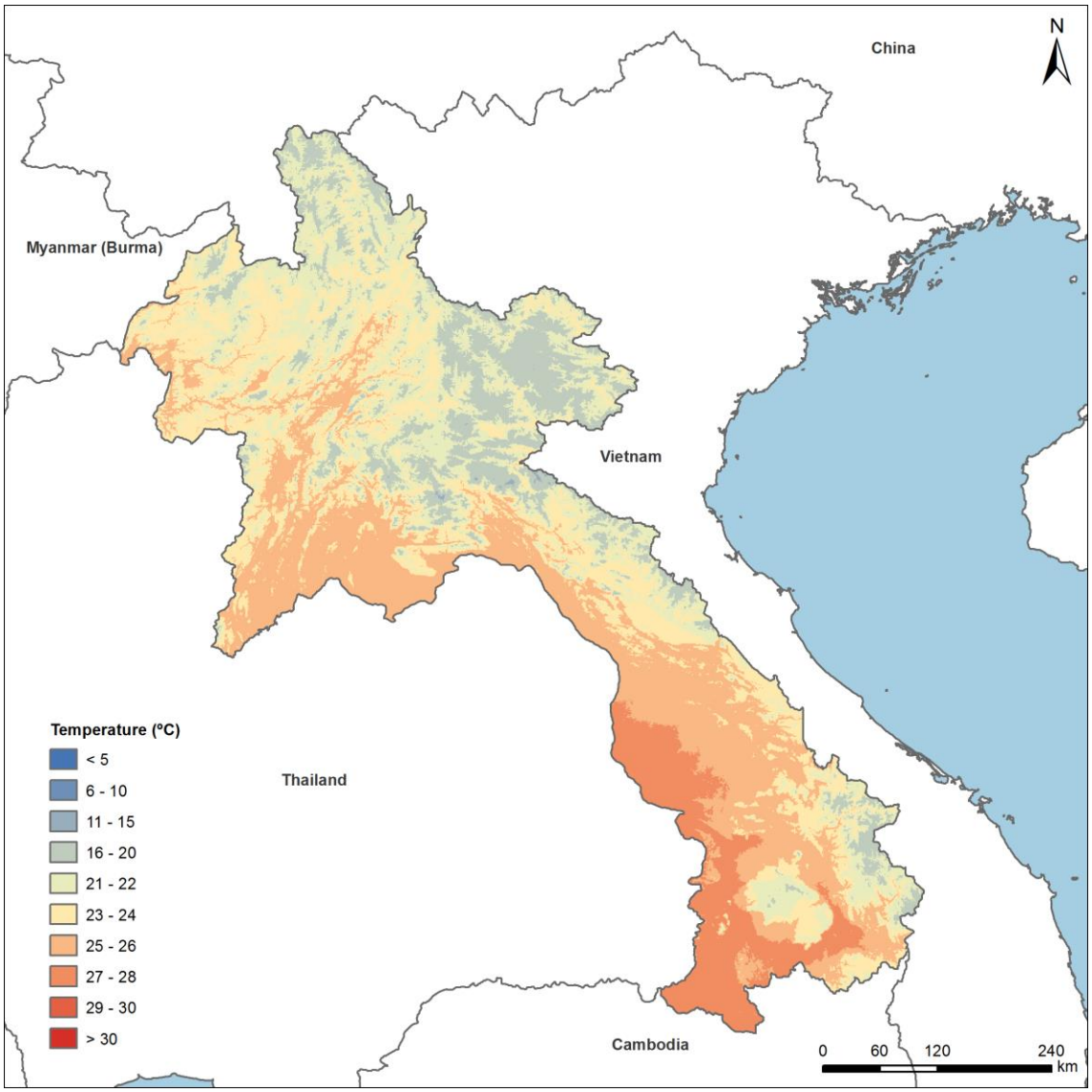

Figure 4.2 – Mean annual temperature in Lao PDR (WorldClim data, Consultant's processing).

4.3 PROTECTED AREAS

Protected areas are also one of the most important factors in the assessment of a potential site for a hydropower plant and for energy planning in general. The environmental impact can be a decisive factor and should be initially evaluated on a desktop level to avoid any possible conflicts. This information should be from official source, to guarantee its authenticity.

Alternative information is available in the World Database of Protected Areas (WDPA), such as the one presented in **Figure 4.3** [2]. The WDPA is a joint venture between the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP – WCMC) and the International Union for Conservation of Nature's World Commission on Protected Areas (IUCN – WCPA). It is the largest database, both on terrestrial and on marine protected areas, collected from the international convention secretariats, governments and NGO's.

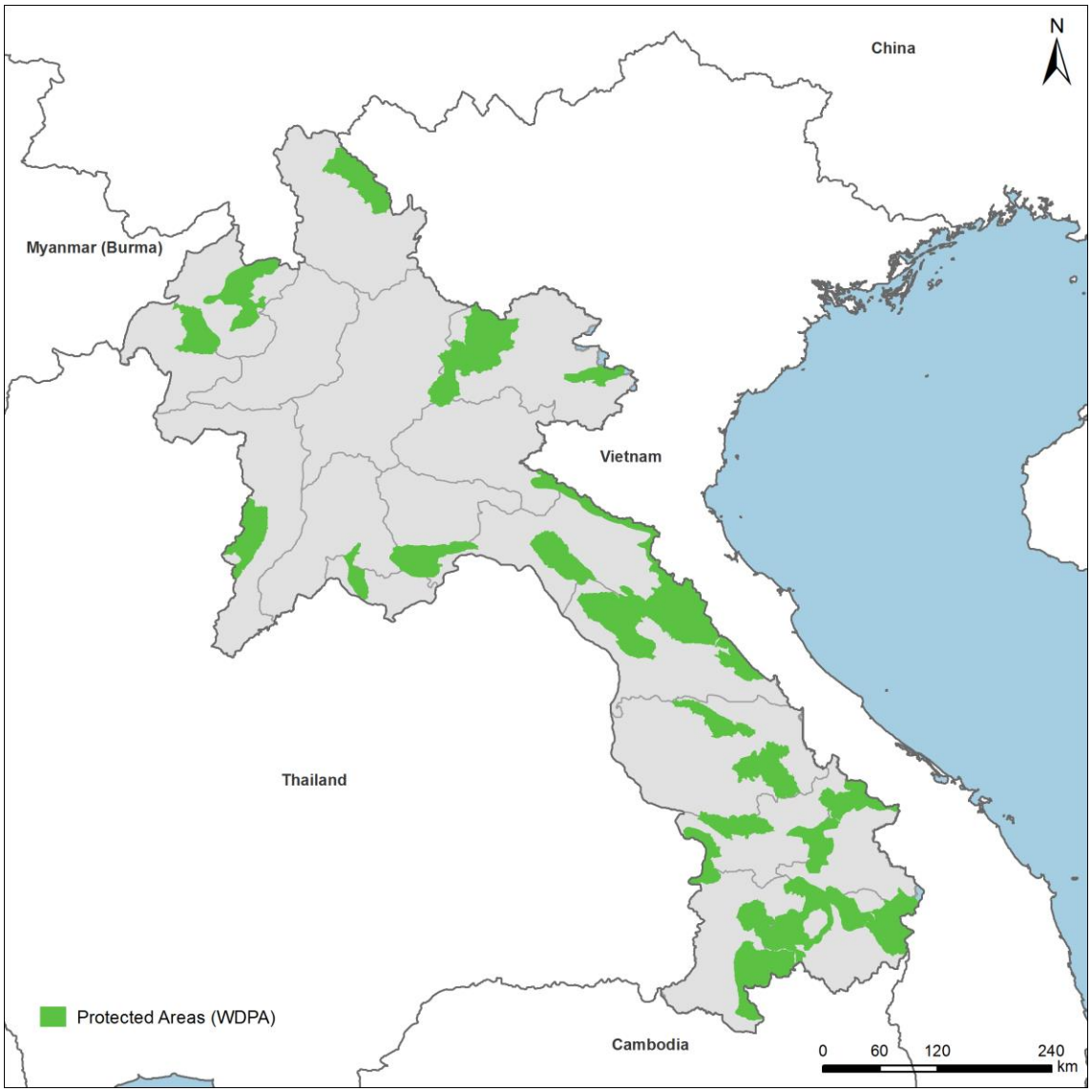

Figure 4.3 – Protected areas (WPDA data, Consultant's processing).

4.4 LAND COVER

Land cover may be a decisive factor when assessing a hydropower site, and if it is not possible to obtain this data locally, it is possible to obtain it from global datasets, such as *GlobCover* from the European Space Agency (ESA). The most recent version of the *GlobCover* land cover is from 2010 and it is presented in Figure 4.4 [3].

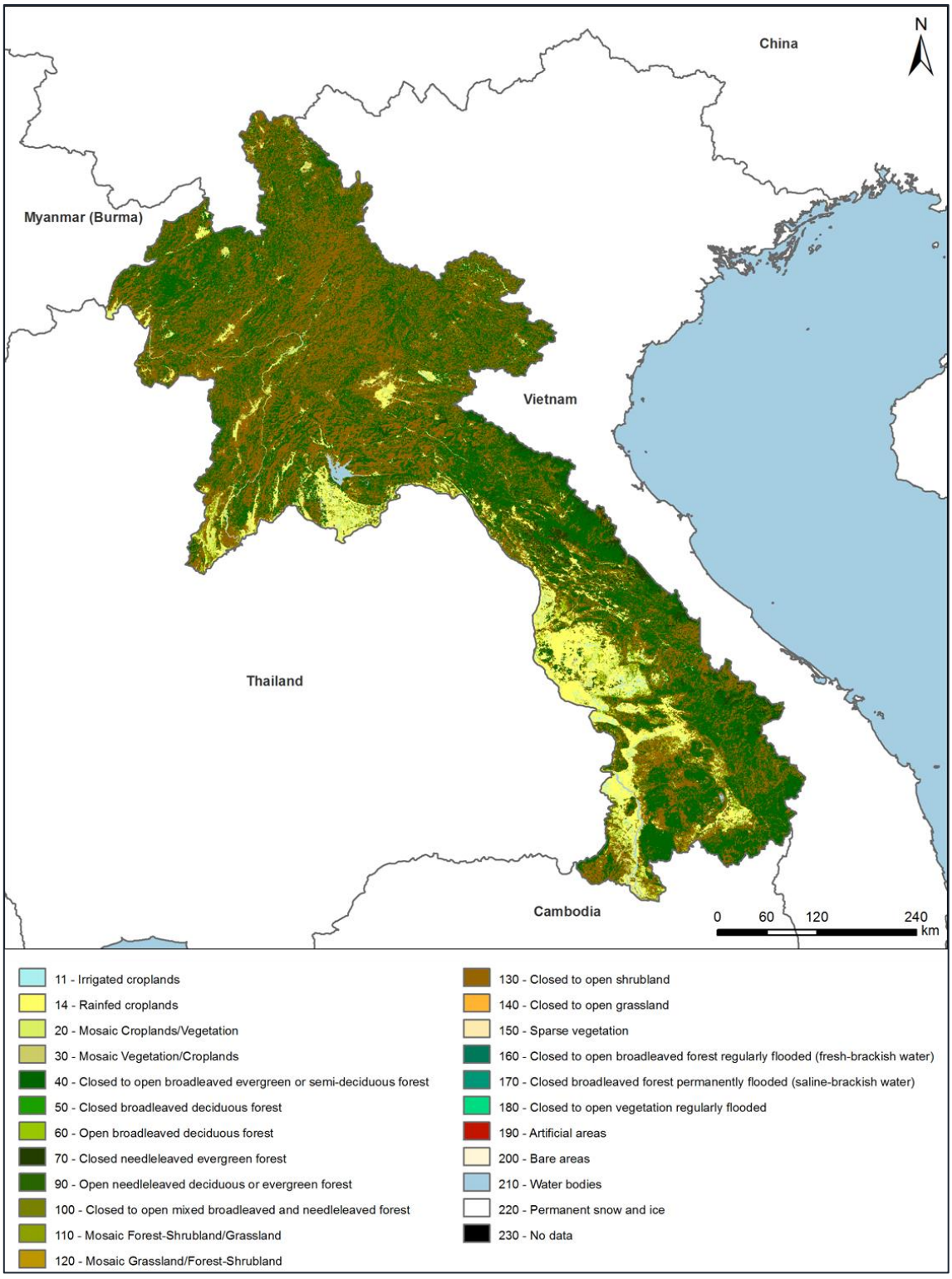

Figure 4.4 – Land Cover (*GlobCover* 2010 data, Consultant's processing).

4.5 LAND USE

As protected areas and land cover, land use is also very important for the environmental impact assessment, especially when specific areas may prevent the development of hydropower projects. Once

again, if it's not possible to obtain this data locally, it is possible to obtain it from global datasets, such as *GeoNetwork*, as presented in Figure 4.5 [4]. This open-source global database belongs to Food and Agriculture Organization of the United Nations (FAO) and it allows easy sharing of geographically referenced thematic information between different organizations.

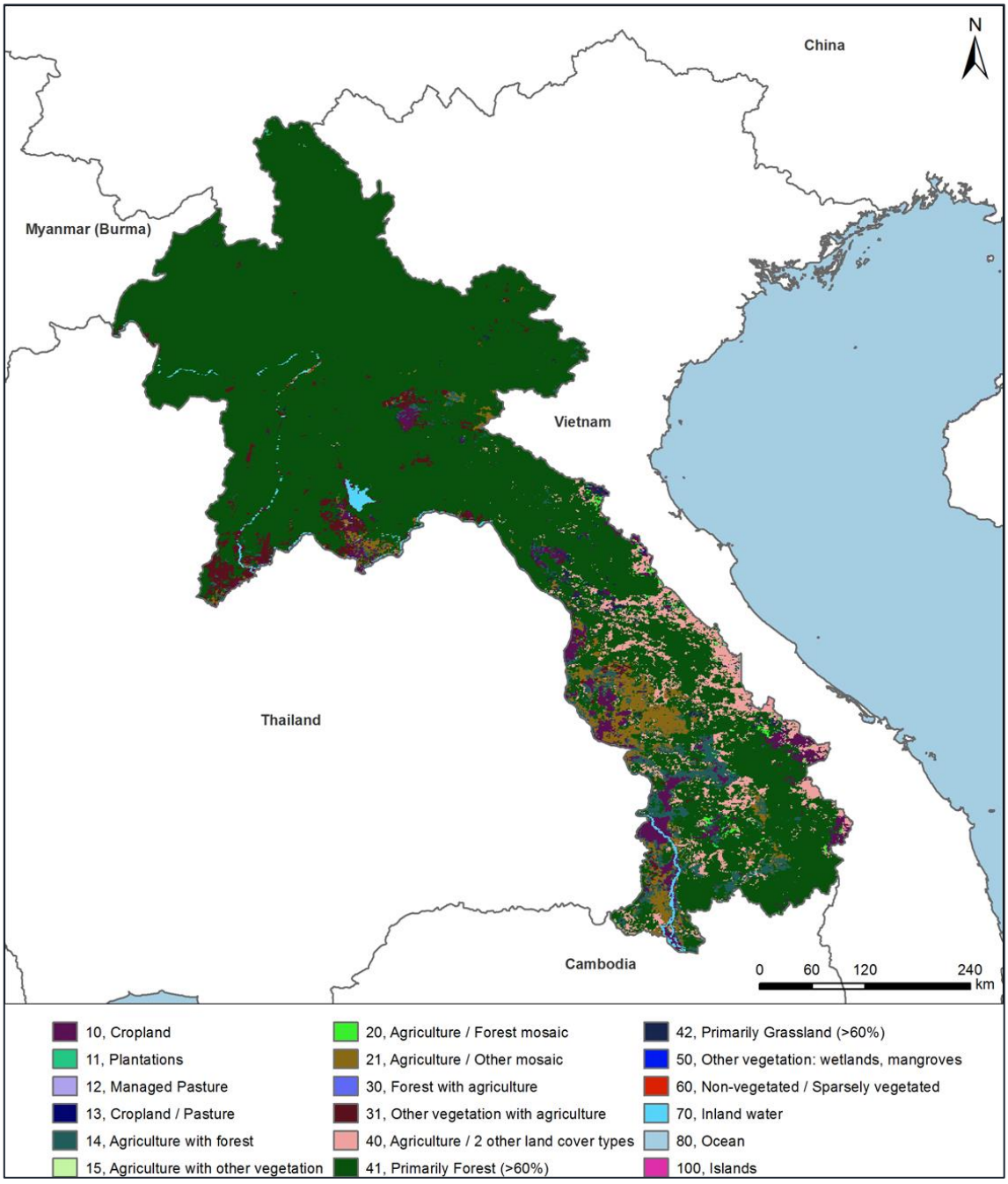

Figure 4.5 – Land Use (*GeoNetwork*, Consultant's processing).

4.6 ROAD NETWORK

The road network presented below, in **Figure 4.6**, was obtained from *Open Street Map*, a vector-based collection worldwide GIS data, with global coverage at public domains. This data may be used, if no other local data can be obtained [5].

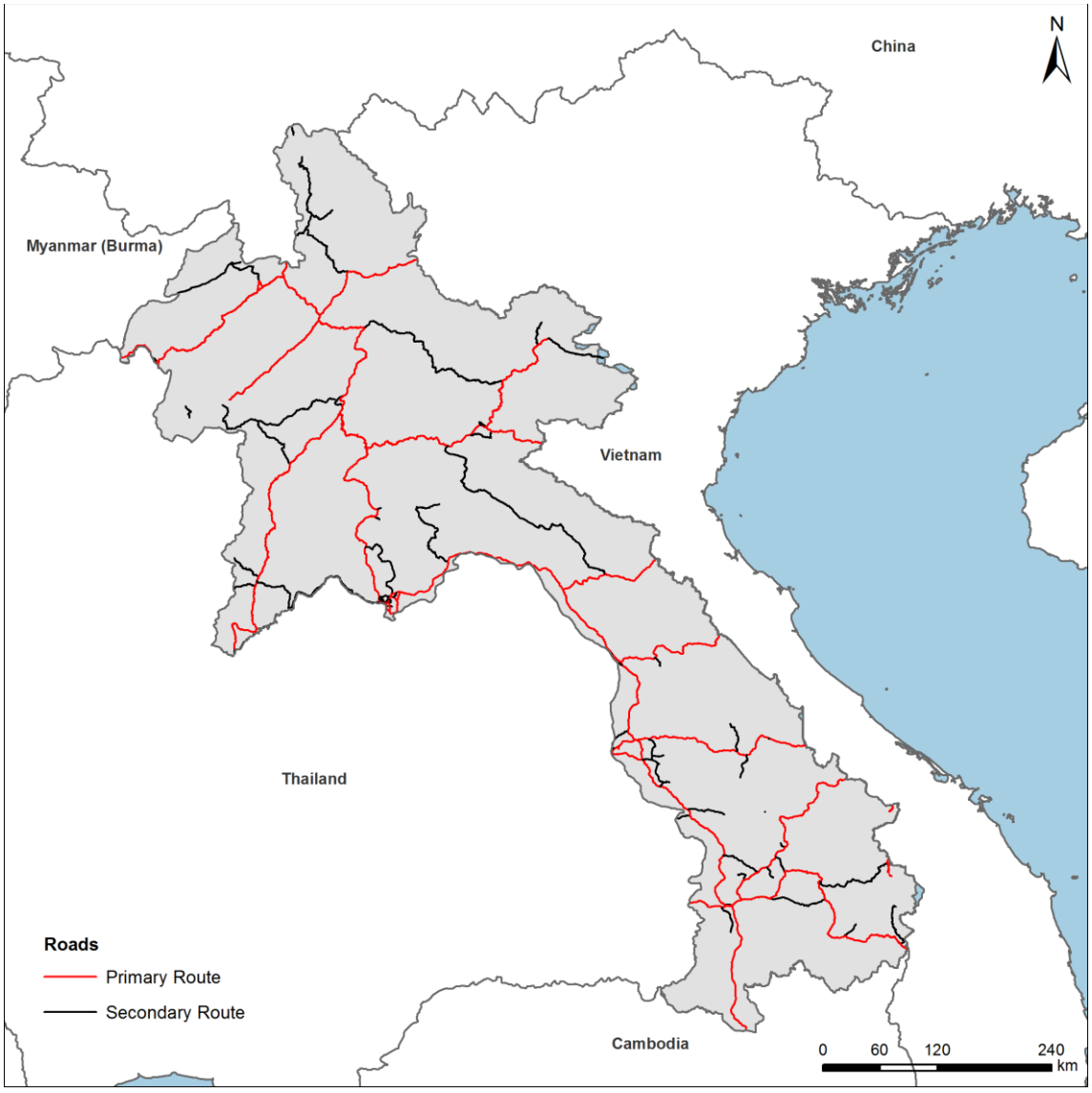

Figure 4.6 – Road network (*Open Street Map* data, Consultant's processing).

4.7 MORPHOLOGICAL DATA

Contour lines, as well as river and streams, may be derived from a Digital Elevation Model (DEM). Since the scope of work is hydropower, the DEM resolution should be as refined as possible, and, so, if a more detailed DEM exists locally, it should be obtained. During the Inception Mission presented in **section 3.3**, detailed topographic data has been obtained locally, including raster topographic maps at 1:50 000 scale and shapefiles at 1:100 000 scale, with contour lines and point elevations. Distances between contour lines range from 10 to 60 m. Nevertheless, an alternative dataset for this purpose is the larger scale

universally used digital elevation dataset provided by the Shuttle Radar Topography Mission (SRTM), presented in **Figure 4.7** [6].

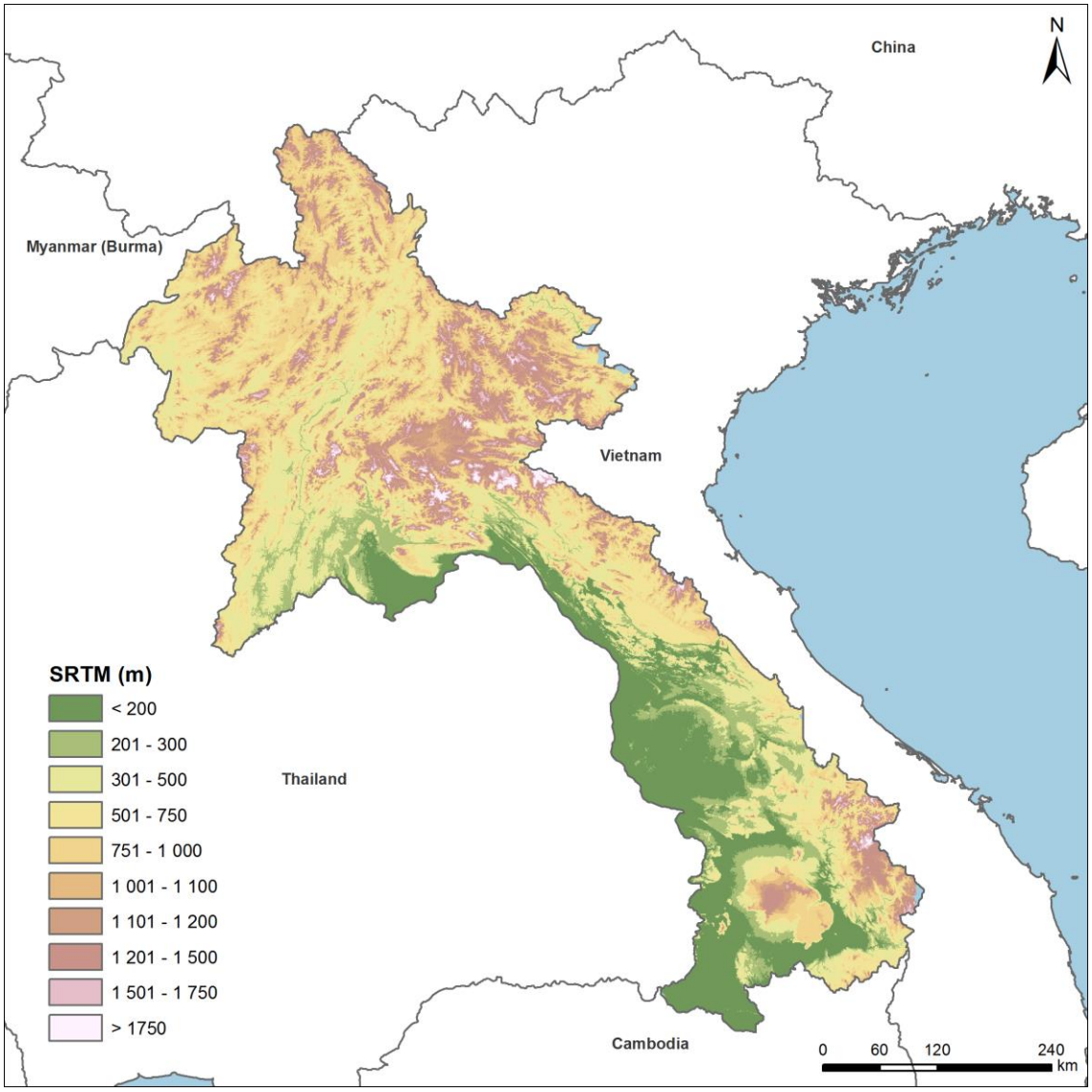

Figure 4.7 – Digital global elevation data (SRTM data, Consultant's processing).

As mentioned, river and streams may be derived from a DEM. An example of this approach, using the SRTM, is presented in **Figure 4.8**.

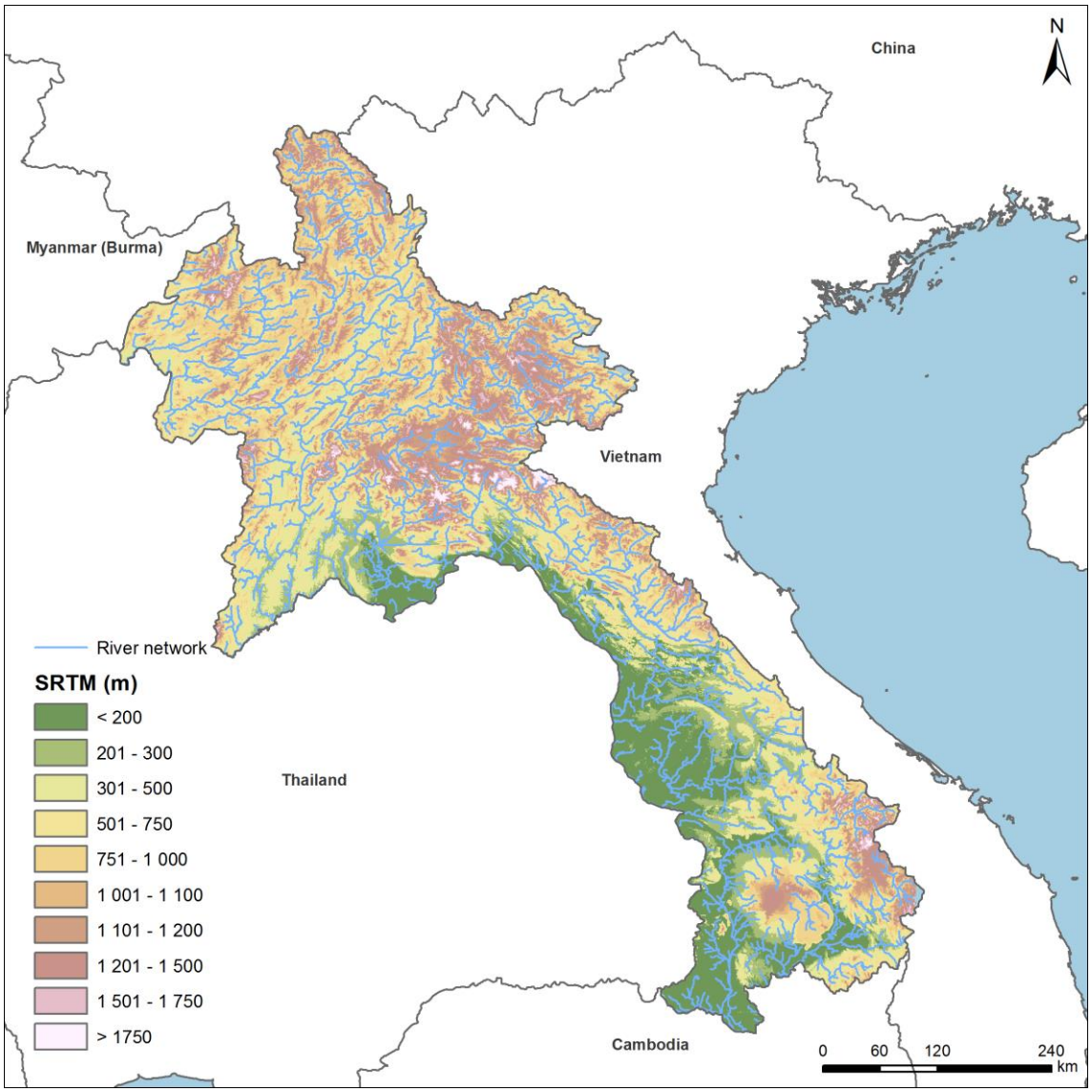

Figure 4.8 – River and Streams derived from a DEM (SRTM data, Consultant's processing).

A better resolution, but less widespread alternative to the SRTM, is the Advanced Spaceborne Thermal Emission and Reflection Radiometer[4] (ASTER). The comparison between these two alternative datasets is presented in Table 4.1.

[4] ASTER GDEM is a product of METI and NASA.

Table 4.1 – Comparison between alternative DEM datasets.

	ASTERGDEM	SRTM
Data source	ASTER	Space shuttle radar
Generation and distribution	METI/NASA	NASA/USGS
Release year	V1 ~2011 V2	~2003 V1 ~2007 V4.1
Data acquisition period	2000 ~ ongoing	11 days (in 2000)
DEM resolution	30m	90m
DEM accuracy (stdev.)	7~14m	10m
DEM coverage	83 degrees north ~ 83 degrees south	60 degrees north ~ 56 degrees south
Area of missing data	Areas with no ASTER data due to constant cloud cover (supplied by other DEM)	Topographically steep area (due to radar characteristics)

The main problems with the use of large scale DEMs, like SRTM or ASTER, for hydropower assessment may be summarized in two issues:

- The lower the resolution, the worst the hydraulic head and overall costs estimations.
- The stream network derived from flow accumulation procedures will present some deviations, sometimes getting the wrong path. This is more prone to happen in larger scales.

4.8 ADMINISTRATIVE BOUNDARIES

Administrative boundaries are crucial to extract location information for the projects and to correctly identify the local entities to be consulted. This information should be officially provided, as it is likely to change periodically. If this is not the case, the Global Administrative Areas databases[5] (GADM) may be used, as the ones presented nationwide in **Figure 4.9** [7]. The available administrative divisions available for Lao PDR are: country, provinces and districts.

[5] Version 2.0, January 2012

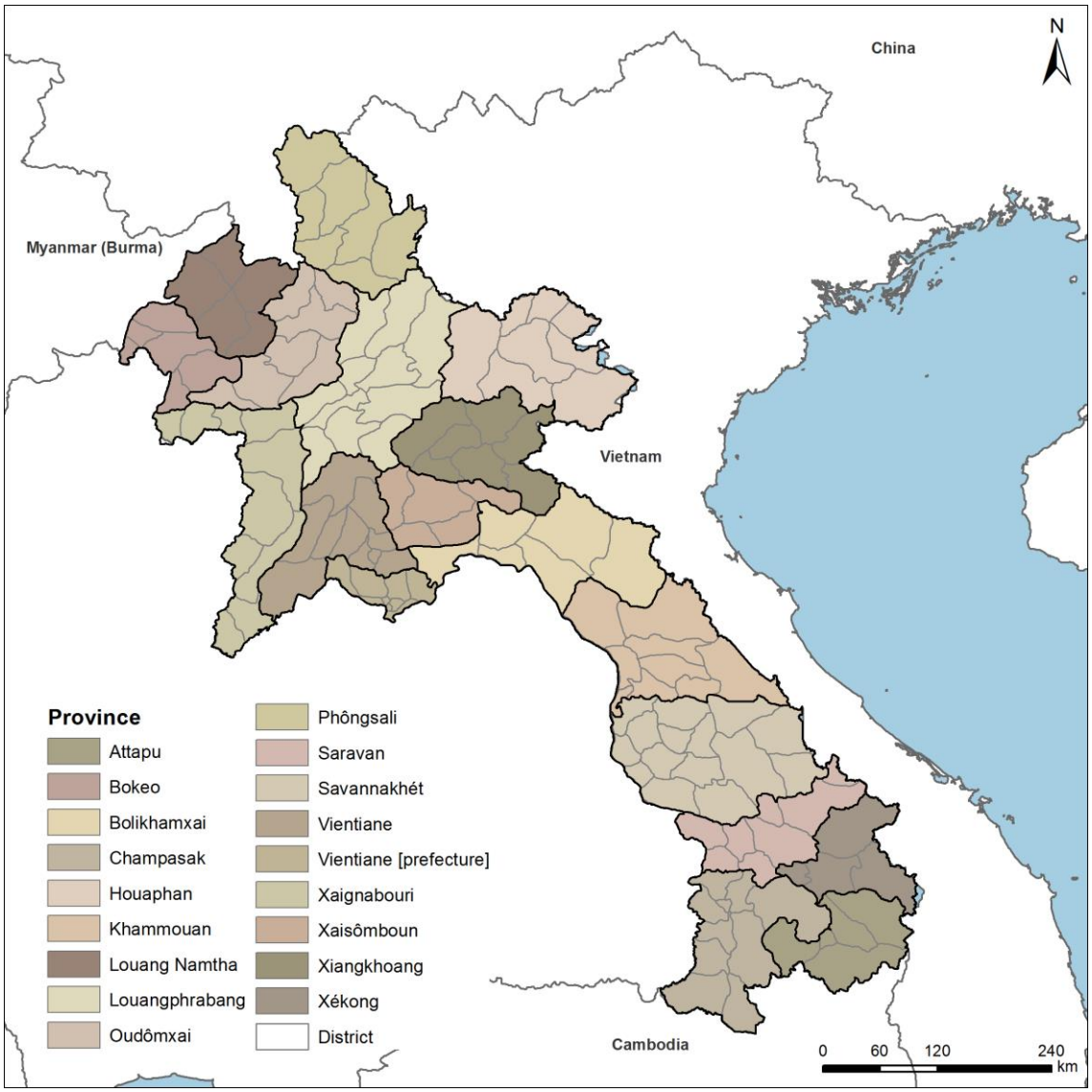

Figure 4.9 – Administrative divisions, district level (GADM data, Consultant's processing).

4.9 SETTLEMENTS AND POPULATION

The information on settlements and population, respective power demands, grid and mini-grids aggregation is crucial for the first design approach of the hydropower projects.

The hydropower project leveled cost of energy is strongly dependent on its energy production and consequently, on its installed capacity. For the same site, all the capacities below the optimum balance between capacity and resource will result in higher generation costs. Nevertheless, the capacity is sometimes limited, not by the resource, but by the power demand. For this reason, the population, expected loads and the aggregated load are essential information for the adaptation of the hydropower potential to grid and population needs.

At this stage, available data was collected from these global data sources:

- Open Street Map;
- Geonet Names Server (GNS).

An example of information obtained from the GNS is displayed in **Figure 4.10**, where major settlements in each district are geo-referenced [8].

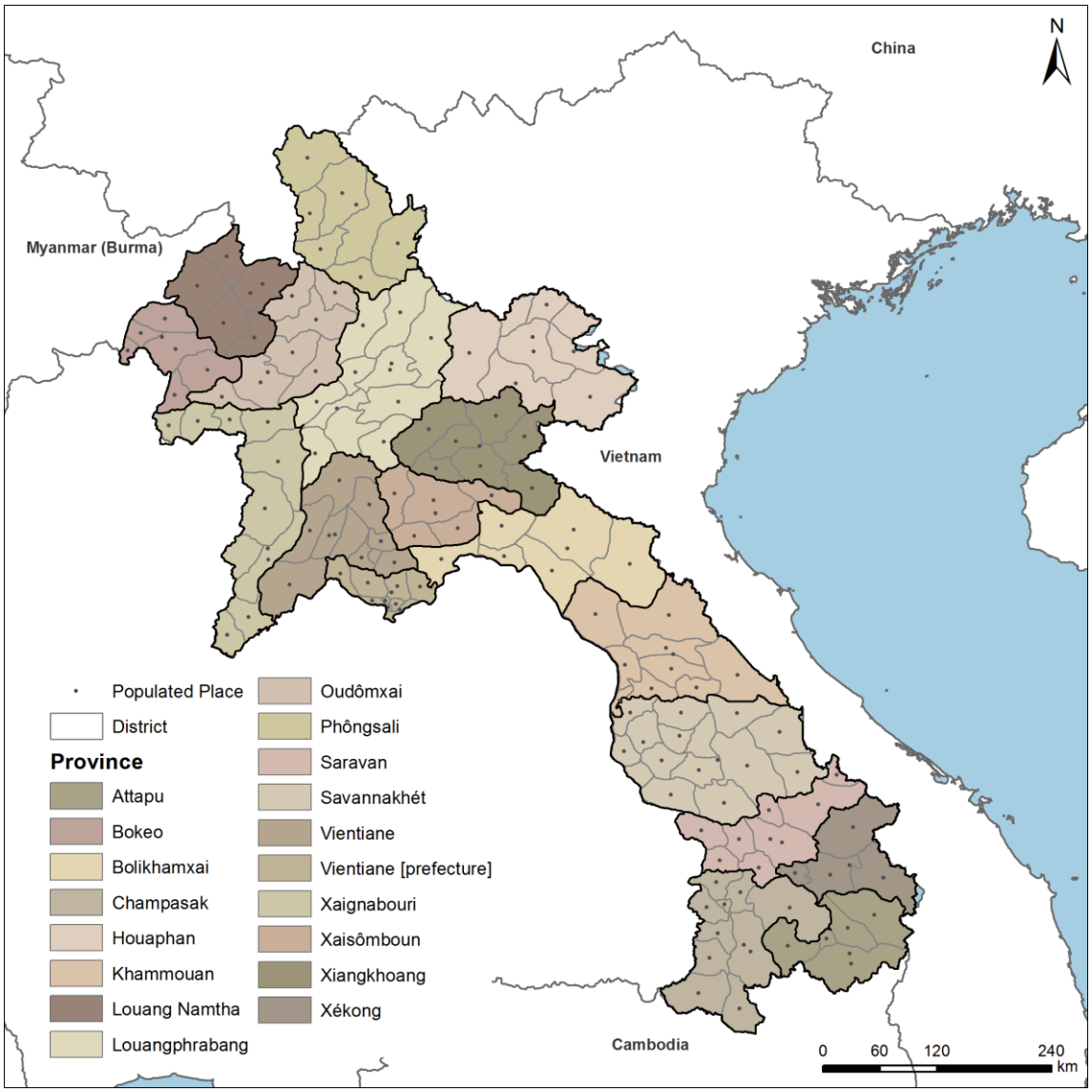

Figure 4.10 – Major settlements in each district (GNS data, Consultant analysis).

It should be noted that this information is not official and that population numbers are not available. Should this data be considered relevant for the project, it should be gathered locally.

5 REVIEW OF THE IMPLEMENTATION PLAN

5.1 MAJOR CHALLENGES AND HOW TO TACKLE THEM

Quality and completeness of the data to be gathered

As stated in section 3.5, the success or, better said, the accuracy of this project will depend strongly on the quality and on the completeness of the data to be gathered on the following fields:

- Topography.
- Geology.
- Hydrology.

The topographical information that has been acquired so far seems complete and detailed enough for a masterplan level project such as this one (see section 4.7).

In what concerns, geology, a global map of Lao PDR was also obtained, containing the basic information that is needed at masterplan level. Most important of all, such map allows for the identification of karstic limestone areas, which pose special problems to the installation of hydropower schemes, both in what concerns the water tightness of the reservoirs, and in what concerns the distribution of surface and underground runoff.

Therefore, it all comes down to knowing if the already gathered hydrological data will be enough.

The fact that this project focuses on small hydropower schemes, which are, usually, run-of-river, means that monthly flow data cannot, by any means, be considered enough, the availability of complete daily flow series being indispensable.

The objective will be to obtain the typical shapes of daily flow duration curves for the different parts of the country.

Since the referred shapes normally depend, mainly, on the average annual runoff magnitude and on the geology of each area, the Consultant should have daily flow data available for all combinations of climatic and geological zones occurring in Lao PDR.

So, if the already gathered daily flow data will prove insufficient, the Consultant will have to strive to obtain more.

Prioritization of hydropower sites:

The vastness of a territory can be overwhelming when dealing with greenfield surveys of any type of renewable energy sources projects, and hydropower ones are no exception. Much to the opposite, hydropower projects tend to be associated with such a wide range of alternatives within the same setting, let alone on its surroundings, that a swift identification of the best placements and options can contribute massively for the success of a project. In other words: it is a complex task to decide if a

site/project is more promising than other, which requires both a systematic approach on a first stage and a case by case analysis on a later stage.

Taking this into account, GESTO developed a cutting-edge GIS based Hydropower Potential survey model that, through certain input data (topographic, hydrologic, economic, land-use, etc.), performs a technical, hydrological and economic preliminary analysis and, as a consequence, maps the locations with the best hydropower potential from an integrated technical and economic perspective. This advanced methodology goes one step forward from the conventional approaches, integrating the usual combination of flow (resource) and available head (elevation), with other major parameters that influence the hydropower potential, like the type of storage (run-of-the-river or storage scheme), the height of the dam, the location of the power plant, the type of penstock/canal, the steepness of the stream and the cross-sectional slopes of the margins.

This process is highly innovative, since the main trend in the field of hydropower resource assessments dismisses an intermediate step between the mapping of the hydropower potential and the specific projects development. The immediate advantages of the process are evident: the development of site specific studies, investigations or ground-based data collection will be done only for the best available sites.

Safety and interaction with people and nature

This project comprises an important local component, through data collection and field surveys. Setting up such campaigns can prove to be a hard task in many regions, but the Consultant has the necessary know-how to deal with the related issues that surpass all technical expertise. Furthermore, the Consultant's local staff is extremely well experienced in local conditions and their support to the already experienced international consultants during the site visits will be instrumental.

From the Consultant's own experience, many unexpected issues have been dealt with in the past, such as: cultural, tribal and religious sensibilities of local communities, shortage of lodging facilities, inexistence of roads, lack of detailed maps, existence of scattered land-mines and minefields, contacting wild and environmentally sensitive areas, dealing with big game predators or the existence of armed conflicts.

With great awareness towards safety and respect to nature and people the Consultant has been able to accomplish its goals and intends to do the same in this project.

5.2 FINAL METHODOLOGY PROPOSAL

5.2.1 CONTEXT

The Consultant does not foresee substantive changes to the preliminary methodology proposed during the tender phase, other than a clearer adaptation to the Client's actual needs and requests gathered from the Inception Mission.

The final proposed methodology is depicted in a workflow of interconnected sub-activities and tasks in Figure 5.1, and a brief description of the tasks is presented in the following sections.

In section 5.2.6 the work plan and schedule is presented.

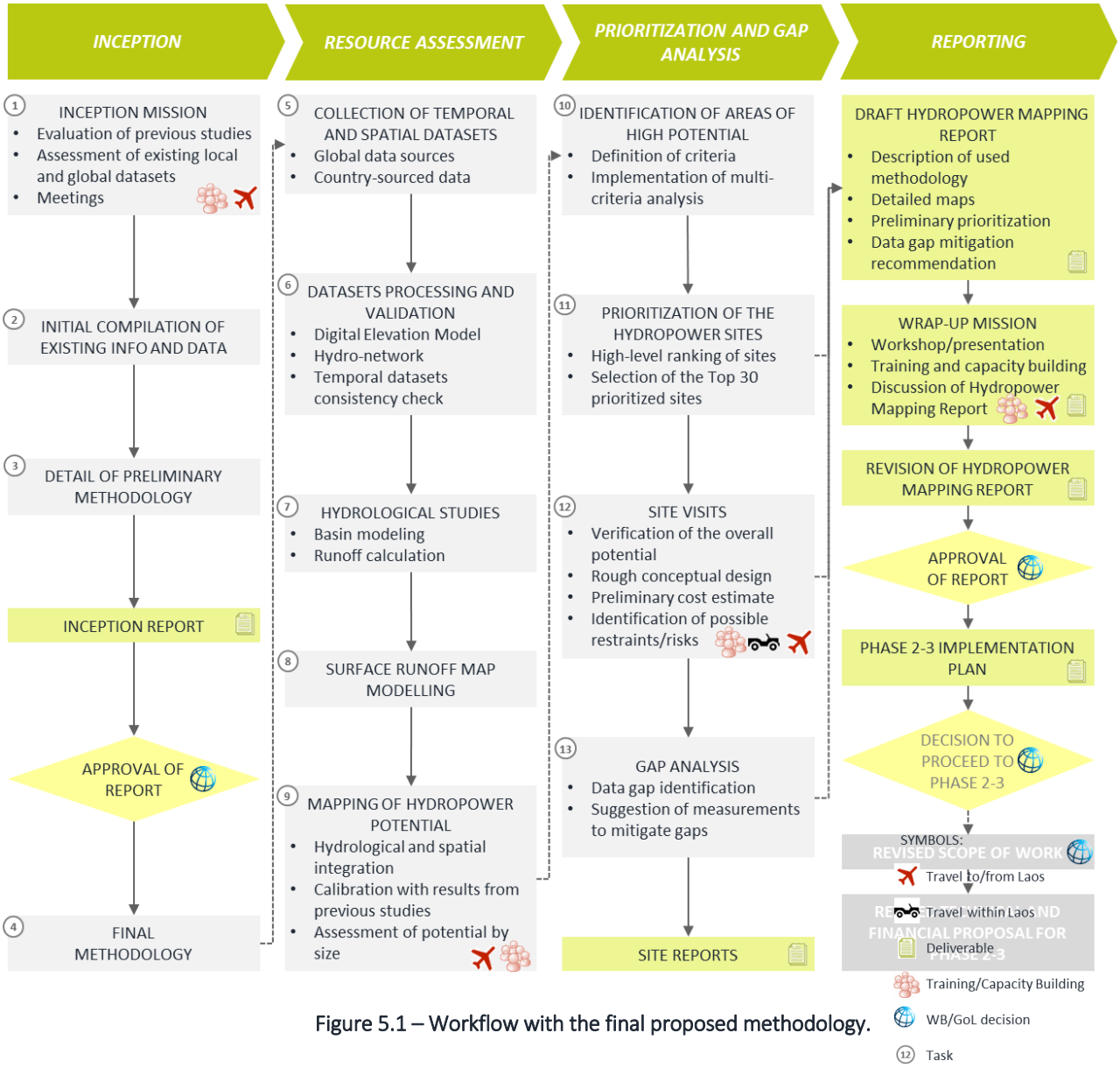

Figure 5.1 – Workflow with the final proposed methodology.

5.2.2 INCEPTION PHASE

- *Task 1: Inception Mission*
- *Task 2: Initial Compilation of Existing Info and Data*
- *Task 3: Detail of Preliminary Methodology*
- *Deliverable I: Inception Report*
- *Task 4: Final Methodology*

The Inception Phase is currently in Deliverable I. The Inception Phase shall be concluded with the approval of the Inception Report and accordance to the final methodology.

Start: May 22, 2017.

Duration of the tasks: 8 weeks (+2 weeks approval and revision).

Consultant's role: conduct the Inception Mission; perform data collection; deliver the Inception Report.

IREP's role: assist the Consultant on the Inception Mission and data collection; review and approve the Inception Report.

5.2.3 RESOURCE ASSESSMENT

- *Task 5: Collection of Temporal and Spatial Datasets*

  The data to be collected is divided between global and local data. The local data was requested to IREP. In section 4, the existing global datasets where already assessed.

  Start: Following the Inception Mission.

  Duration of the task: 8 weeks.

  Consultant's role: present list of data requirements; collect globally available data.

  IREP's role: collect the data requested by the Consultant available at IREP.

- *Task 6: Datasets Processing and Validation*

  Temporal datasets, typically hydrological and meteorological series of records, will be checked for consistency in this task.

  Spatial datasets will be processed, especially the digital elevation model (DEM) in order to obtain the hydro-network watersheds for the hydrological studies.

  Start: After the approval of the Inception Report.

  Duration of the task: 4 weeks.

  Consultant's role: perform the task.

  IREP's role: -

- *Task 7: Hydrological Studies*
- *Task 8: Surface Runoff Map Modelling*

  Hydrological studies will be developed considering, preferably, the available country-sourced data (such as rainfall, runoff, temperature, etc.). In the event that the country-sourced temporal data is not possible to collect or not adequate to use (eg. due to gaps in the data series or lack of consistency), global data can be used. The Consultant is aware

that during the 1998 *Hydropower Development Plan* the hydrological studies were comprehensive and that rainfall-runoff relations for many watersheds were deducted from ground-based data. The Consultant considers these rainfall-runoff relations may be used to transform rainfall data into runoff. In the unlikely event that these rainfall-runoff relations are not available or not valid, runoff can be obtained applying empirical water balance processes, such as the Turc method. The results obtained by this method should be calibrated with existing ground-based data in order to determine its accuracy.

The surface runoff map will be obtained using an algorithm developed by GESTO based in Geographic Information Systems (GIS). The procedure shall be computed in matrix format (*raster*), and the average annual runoff at each unit of processing (*pixel*) will be obtained. The flow value that will be calculated for each *pixel* will correspond to the annual average runoff in the catchment area defined by that *pixel*.

Start: After the approval of the Inception Report.

Duration of the tasks: 4 weeks.

Consultant's role: perform the tasks.

IREP's role: -

- *Task 9: Mapping of Hydropower Potential*

The hydropower potential map is the mapping of the theoretical capacity that can be installed on a given location, considering the estimated average daily flow and the available head at each point. The average daily flow can be obtained based on the surface runoff map determined on the previous task and the available head at each point can be calculated from the DEM.

The actual hydropower potential map will be obtained using a model developed by GESTO based in Geographic Information Systems (GIS) extensively used in similar country-wide assignments. The hydropower potential map is an extremely helpful tool for electrification planning at country and regional level since it allows for the rapid pinpointing of the areas within vast territories with the highest likelihood of gathering the conditions for implementing hydropower projects.

It is expected that, between this Task 9 – Mapping of Hydropower Potential and the forthcoming Task 10 – Identification of Areas of High Potential, an Interim Mission occurs to discuss results and build capacity in the topics addressed on said tasks.

Start: After the end of Task 8: Surface Runoff Map Modelling.

Duration of the task: 4 weeks.

Consultant's role: perform the task.

IREP's role: review the output.

5.2.4 PRIORITIZATION AND GAP ANALYSIS

- *Task 10: Identification of Areas of High Potential*
- *Task 11: Prioritization of the Hydropower Sites*

Following the elaboration of the hydropower potential map, the areas with higher potential to develop the intended size-range of hydropower schemes will be identified. The identification of these areas will be an important tool to quickly detect the river stretches that should be analyzed first, therefore focusing on the best projects and saving time and resources.

This identification will be focused on a series of pre-defined criteria agreed with the Client during the Inception Mission, namely:

→ installed capacities below 15 MW;
→ run-of-river operation (maybe with daily regulation);
→ on-grid connection;
→ ease of access;
→ include already planned projects with MOU[6] in the analysis;
→ exclude already planned projects with PDA[7] in the analysis (and include them as "under construction" or "existing" status in order to capture considerations such as cascade effects or cumulative impacts).

The prioritization of the hydropower sites is a crucial activity in any hydropower mapping. From the experience gathered by the Consultant in similar projects, this is indeed the most time-consuming of all desk assignments, only surpassed by field campaigns. To undertake this task, a number of preliminary steps must be accomplished after the previous tasks of mapping of the hydropower potential (Task 9) and the identification of areas of high potential (Task 10).

The most promising sites prioritization will be made by gradual screening, as the information is gathered and the analysis undertaken becomes more thorough and

[6] MOU – Memorandum of Understanding

[7] PDA – Power Development Agreement

complete. All possible information compiled could be taken into account, such as hydrological, geological, sediment, environmental, and social risks and road access on a primary level. Should reliable data on land ownership, protected and environmentally sensitive areas, military and other exclusion zones and security issues be obtained, it could also be taken into account on a secondary level. Existing and planned projects shall also be an important input.

Start: After the end of Task 9: Mapping of Hydropower Potential.

Duration of the task: 4 weeks.

Consultant's role: perform the task.

IREP's role: advise the Consultant on the criteria for the identification and prioritization.

- *Task 12: Site Visits*

  The proposed site visits will be achieved through careful identification of the areas with the highest potential and, resulting from the multi-criteria analysis, the regional selection of different scattered zones throughout the territory with higher concentration of sites, accounting for vicinity between those sites and/or possibility of sites in the same cascade, adequate itineraries and ease of transportation.

  The Consultant considers achievable to accomplish 30 site visits in a two-month timeframe, from November 2017 onwards. This starting date is dependent of the start of the dry season around October, since the feasibility of the task would be seriously compromised due to the unforeseen and harsh weather conditions expected earlier in the wet season. If, by any constraint, the 30 site visits goal is not accomplished, the Consultant will justify the reasons before the Client and seek its approval.

  Previous to the visits, however, a rough conceptual design of the sites will be developed, as a result of the analysis conducted earlier in Task 11: Prioritization of the Hydropower Sites. The overall scheme technical layout will be more thoroughly analyzed, with the inclusion of different alternatives regarding intake level and type, storage, conveyance type, waterway path, turbine flow, turbine type, among others. The added-value of this assessment will be the more detailed characterization of each of the selected sites, the basic scheme definition and operation, the assessment of the projects viability and sustainability, the evaluation of main CAPEX and OPEX costs and, finally, the better perception of the data gaps.

  The site visits will occur in order to verify *in situ* the overall potential of each prioritized site. Its characteristics will be assessed to verify the possible concept and implementation of the project, as well as the possible restrains/risks of project construction, such as geological, hydrological, social, etc. The task will begin with the preparation and planning

of all the associated logistics. The main goal of this task will be to validate previous assumptions and to collect as much information as possible related with each site. Visits will allow adjusting the pre-selection list of small hydro projects and will also allow a better evaluation of the potential for inclusion into electrification planning in Lao PDR.

Ideally, the visits should be jointly organized with IREP's team. It will also be a good opportunity to promote knowledge transfer and team acquaintance.

Start: After the end of Task 11: Prioritization of the Hydropower Sites (ideally early November 2017 – start of the dry season).

Duration of the task: 8 weeks.

Consultant's role: provide a team of experts and equipment; define the itinerary; support travel logistics (accommodation, transportation, meals) to the Consultant's team; conduct the site visits.

IREP's role: facilitate communication and eventual authorizations with local authorities; provide a team to accompany the Consultant (not compulsory); support travel logistics (accommodation, transportation, meals) to IREP's team.

- *Task 13: Gap Analysis*

  Following the site visits and rough conceptual designs (Task 12: Site Visits), suggestions of measurements to mitigate identified gaps will be made. These may include, for instance, low spatial resolution of topographical data, limited or uncertain hydrological data, uncertainty in geological characteristics crucial for the suggested design, or unclear settlement or land ownership data. The Consultant will suggest measurements to mitigate those gaps which will demonstrate the potential for the follow-up under a Phase 2-3 extension of the assignment.

  Start: After the end of Task 12: Site Visits.

  Duration of the tasks: 4 weeks.

  Consultant's role: perform the tasks.

  IREP's role: -

- *Deliverable II: Site Reports*

  The deliverables of the *Prioritization and Gap Analysis* stage will be the *Site Reports* that will be composed by the individual analysis, datasheets and photo reports of each site, thus assimilating the results of the desk analysis and also the outcome of the subsequent field campaign.

The *Site Reports* will incorporate site details, location, basic layout and cost estimate, with comprehensive info on each site for parameters such as: photographical survey, cross section, stream slope, mean annual flow, nearest gauging stations, distance to transmission line, distance to roads, population within a defined range, costs, among others. This database shall include the key drivers and variables for the design of a hydro scheme, facilitating the study at pre-feasibility level of different locations.

Start: After the end of Task 12: Site Visits.

Duration of the task: 4 weeks.

Consultant's role: perform the tasks.

IREP's role: -

5.2.5 REPORTING

- *Deliverable III: Draft Hydropower Mapping Report*

  The previous activities will be reported and a draft will be presented for Client's approval. Maps created from GIS layers will be included, as well as a clear methodology description, detailed maps, site visit reports, preliminary economic appraisal and prioritization, data gap mitigation recommendations and further analysis.

  The draft Hydropower Mapping Report will be ready and distributed at least two weeks ahead of the wrap-up mission to Lao PDR, including a workshop to present and discuss the results to the Client and key stakeholders.

  Start: After the end of Task 12: Site Visits.

  Duration of the task: 6 weeks.

  Consultant's role: develop the draft report.

  IREP's role: review and approve the draft report.

- *Deliverable IV: Wrap-Up Mission*

  During the Wrap-Up Mission, a workshop will be held in Vientiane to present the results to the Client, to get feedback from the stakeholders and to discuss the next steps. The workshop shall have two day duration: the first day to present the results to IREP (session A), the second half-day to present the results to the stakeholders (session B). Both session A and B intend to promote a framework and comprehensive explanation of the development work, but to different group targets. In the presentation to the Client, a deeper focus on the methods will be made, while for stakeholders a focus on results,

lessons learned and consequences will be made. Nonetheless, a single session joint workshop for both IREP and stakeholders might be considered, if found more fruitful.

Additionally, the Wrap-Up Mission will take into account the Consultant's relevant experience in providing training and capacity building on renewable energies mapping and development, since knowledge transfer is a key subject in this Technical Assistance. In fact, notwithstanding the permanent interaction with the Client and the WB's local staff while developing the project, which allows an overall awareness of the processes deployed and an ongoing exchange of knowledge, the Consultant is keen on providing this capacity building in more specific formats, usually in the form of workshops and seminars. The focus, in this case, will be in GIS software operation and in the project's results interpretation and handling (Annex III).

Start: 2 weeks after the deliverance of Deliverable III: Draft Hydropower Mapping Report.

Duration of the task: 2 weeks.

Consultant's role: prepare a slide deck summarizing the main findings of the report for presentation during the mission; prepare training.

IREP's role: select the participants to the workshop; accommodate the event (venue, catering, and equipment).

- *Deliverable V: Revision of Hydropower Mapping Report*

  The final revision and approval of the Report will occur after the Wrap-Up Mission, to take advantage of feedback from IREP and from end-users attending this event. Nonetheless, a preliminary revision by IREP and by the WB may occur previous to the Workshop.

  The Final Report should be delivered two weeks after the workshop. The comments and proposals on the draft, as well as the feedback received during the workshop, will be included and will shape the Final Report to be approved by the WB, in consultation with IREP.

  Start: After the end of the Wrap-Up Mission.

  Duration of the task: 2 weeks.

  Consultant's role: revise the final reports.

  IREP's role: approve the final reports.

- *Deliverable VI: Phase 2-3 Implementation Plan*

  The Phase 2-3 Implementation Plan will be developed at the completion of the assignment and will have the following objectives:

  → to outline the gap mitigation measures to implement;

→ to describe the proposed monitoring and site investigations to undertake
→ to state the key specifications of the required equipment, works and investigations;
→ to detail the planning and the budget for an adequate execution.

Following the delivery of the Phase 2-3 Implementation Plan, decision to proceed to PHASE 2-3 from the WB and Client will occur and, in case of a positive decision, the Scope of Work will be reviewed and the Consultant will revise the Technical and Financial Proposal for Phase 2-3.

Start: After the deliverance of Deliverable V: Hydropower Mapping Report.

Duration of the task: 2 weeks.

Consultant's role: prepare the report.

IREP's role: review the report; decide to proceed to Phase 2-3.

5.2.6 WORK PLAN

Based on the descriptions, responsibilities and durations presented above, the revised work plan and schedule is presented in Figure 5.2. The work plan includes important milestones such as deliverables, travel missions and approval processes.

The project duration at this moment is estimated in 46 weeks, including approval periods.

	Month	May		Jun				Jul				Aug				Sep				Oct				Nov				Dec				Jan				Feb				Mar				Apr			
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
	INCEPTION																																													
Task 1	INCEPTION MISSION																																												
Task 2	INITIAL COMPILATION OF EXISTING INFO AND DATA																																												
Task 3	DETAIL OF PRELIMINARY METHODOLOGY																																												
Deliverable I	*INCEPTION REPORT*																																												
Task 4	FINAL METHODOLOGY																																											
	RESOURCE ASSESSMENT																																											
Task 5	COLLECTION OF TEMPORAL AND SPATIAL DATASETS																																											
Task 6	DATASETS PROCESSING AND VALIDATION																																											
Task 7	HYDROLOGICAL STUDIES																																											
Task 8	SURFACE RUNOFF MAP MODELLING																																											
Task 9	MAPPING OF HYDROPOWER POTENTIAL																																												
	PRIORITIZATION AND GAP ANALYSIS																																											
Task 10	IDENTIFICATION OF AREAS OF HIGH POTENTIAL																																											
Task 11	PRIORITIZATION OF THE HYDROPOWER SITES																																											
Task 12	SITE VISITS																																											
Task 13	GAP ANALYSIS																																												
Deliverable II	*SITE REPORTS*																																												
	REPORTING																																											
Deliverable III	*DRAFT HYDROPOWER MAPPING REPORT*																																											
Deliverable IV	*WRAP-UP MISSION*																																											
Deliverable V	*REVISION OF HYDROPOWER MAPPING REPORT*																																											
Deliverable VI	*PHASE 2-3 IMPLEMENTATION PLAN*																																											

Travel to/from Laos
Field work
Deliverable
Training/Capacity Building
WB/IREP decision

Figure 5.2 – Work plan and schedule.

6 CONCLUSIONS

The objectives of the Inception Mission were accomplished (section 3.1). It allowed the Consultant to take the pulse of the current status of hydropower development and geographical information systems at IREP, as well to assess the overall framework for hydropower development in Lao PDR.

The Consultant identified the major challenges for the development of the project (section 3.5), addressed their impact (section 5.1) and revised the implementation plan accordingly (section 5.2).

The Consultant already performed a compilation of globally available data (section 4).

The Consultant concludes that the methodology originally presented was adequate for the study, but the work plan needed to be slightly reviewed to take into consideration the feedback obtained during the Inception Mission (section 5.2).

After the approval of the Inception Report, the Consultant will resume the work and proceed with the agreed implementation plan.

REFERENCES

[1] WorldClim, [Online]. Available: http://www.worldclim.org/. [Accessed 12 2014].

[2] Protected Planet, [Online]. Available: http://www.protectedplanet.net/. [Accessed 12 2014].

[3] GlobCover, [Online]. Available: http://due.esrin.esa.int/globcover/. [Accessed 12 2014].

[4] GeoNetwork, [Online]. Available: www.fao.org/geonetwork/. [Accessed 12 2014].

[5] Open Street Map, [Online]. Available: https://www.openstreetmap.org/. [Accessed 12 2014].

[6] SRTM, "Shuttle Radar Topography Mission," [Online]. Available: http://srtm.usgs.gov/. [Accessed 12 2014].

[7] GADM, "Global Adminstrative Areas," [Online]. Available: http://www.gadm.org/. [Accessed 12 2014].

[8] GNS, "Geonet Names Server," [Online]. Available: http://earth-info.nga.mil/gns/html/. [Accessed 12 2014].

Annex I – Preliminary list of existing and planned hydropower projects under 15 MW

Name	Province	Capacity (MW)	Status	Investor	Status 2015
Nam Phouan	Oudomxay	-	-	-	-
Nam Khon	Oudomxay	-	-	-	-
Houay Tadlai	Oudomxay	-	-	-	-
KCL Cement Factory	Khammouan	-	-	-	-
Xekaman 3A	Sekong	-	-	-	-
Xekaman 3B	Sekong	-	-	-	-
Xekaman 4B	Sekong	-	-	-	-
Houay Samong	Attapeu	1.7	Existing	-	IPP Operated
Nam Theun 2 (PH)	Khammouan	-	Existing	-	IPP Operated
Xebanghieng Upstream	Savannakhet	10.0	MOU	-	-
Nam Khan 1	Luangphabang	-	MOU	-	-
Nam Xam 2	Huaphan	-	MOU	-	-
Nam Neun 2	Huaphan	-	MOU	-	-
Nam Tha Hat Mouk	Bokeo	14.0	MOU	-	-
Nam Ham 2	Xayabouly	-	MOU	-	-
Tad Sakhoy	Savannakhet	12.5	MOU	-	-
Nam The	Xiangkhuang	15.0	PDA	-	-
Houay Palai Downstream	Champasak	3.0	Under Construction	-	-
Houay Gnoy-Khod	Champasak	11.2	Under Construction	-	-
Nam Houng-Nua Pakmed	Xayabouly	5.0	MOU	3 Liem Co.	-
Nam Pot	Xiengkhuang	15.0	PDA	ACE Company 100%	-
Nam Gnala	Bolikhamxay	5.0	MOU	Anousin Construction & Trade	-
Nam Mang	Bolikhamxay	4.0	MOU	BML	-
Nam Sen(Tad lang)	Xiengkhuang	5.0	Existing	Bothong Insi Co.,LTD	-
Nam Long	Huaphan	13.1	MOU	Boukthalou Co.	-
Houay Dak kan	Sekong	5.0	MOU	BSS	-
Houay Het	Sekong	5.0	MOU	Chaleun Construction Co.	-
Nam Sang	Bolikhamxay	5.0	MOU	Chaleunxup Group	-
Nam Bi 3	Sekong	12.0	PDA	Chanthavone Bridge Construction Co.	-
Nam Boun	Phongsaly	0.1	Existing	China	Gov. Operated
Nam Feung 2	Vientiane Pro.	-	MOU	China	-
Nam Feung 3	Vientiane Pro.	-	MOU	China	-
Nam Gnon	Borkeo	3.0	Existing	China / France	IPP Operated
Houay Champi Oudomsouk	Champasak	5.0	MOU	Daoheuang	-
Nam Lik (Kengluang)	Vientiane Pro.	15.0	MOU	DMD Co.	-
Nam Ngao	Oudomxay	12.0	PDA	DPS Co., LTD	-
Nam Bak	Luangprabang	5.0	MOU	DSK Group	-

Name	Province	Capacity (MW)	Status	Investor	Status 2015
Nam Pha Gnai	Vientiane Pro.	15.0	Under Construction	DSK Lao	-
Nam Houn 2	Phongsaly	15.0	MOU	Duangchaleun	-
Nam Houn 1	Phongsaly	15.0	MOU	Duangchaleun Co.	-
Nam Houn 3	Phongsaly	15.0	MOU	Duangchaleun Co.	-
Nam Hao	Huaphan	15.0	Under Construction	Duangchaleun Co.	-
Nam Ban	Phongsaly	12.0	MOU	ECI	-
Nam Meuk 1	Phongsaly	10.0	MOU	ECI	-
Nam Meuk 2	Phongsaly	-	MOU	ECI	-
Nam Sim	Houaphanh	9.0	Under Construction	ECI(Lao)25%/Norway85%	-
Nam Tha 3	Luangnamtha	1.3	Existing	EDL	IPP Operated
Nam Sana	Vientiane Pro.	14.0	Existing	EDL	EDL Operated
Xe Set 4	Champasak	10.0	MOU	EDL	-
Nam Ken (Dam)	Xayabouly	-	MOU	EDL	-
Nam Et 5	Huaphan	7.5	MOU	EDL	-
Nam Et 6	Huaphan	1.8	MOU	EDL	-
Nam Seng	Luangprabang	1.2	MOU	EDL	-
Houay Avien	Salavanh	3.0	MOU	EDL & Korea Corporation	-
Xelabam	Champasak	5.0	Existing	EDL 100%	EDL Operated
Nam Dong	Luangprabang	1.0	Existing	EDL 100%	EDL Operated
Nam Ko	Oudomxay	1.5	Existing	EDL 100%	EDL Operated
Nam Xong	Vientiane Pro.	6.0	Existing	EDL 100%	EDL Operated
Mekong Thakho	Champasak	-	MOU	EDL/Lah'rone	-
Nam San (Xamtai)	Houaphanh	0.1	Existing	Gov.	Gov. Operated
Nam Long	Luangnamtha	5.5	Existing	Gov.20%/Luangpaseut Co.80%	IPP Operated
Nam Noua 1	Phongsaly	15.0	MOU	Heuangpaseut Co.	-
Nam Ngao	Bokeo	15.0	PDA	Heuangpaseut Co.	-
Nam Nga 2	Oudomxay	14.5	Under Construction	Heuangpaseut Co.	-
Nam Hoy	Xayabouly	5.0	MOU	Hongkham Co.	-
Houay Phouang	Sekong	5.0	MOU	Hongkham Construction Co.	-
Houay Por	Salavan	15.0	Under Construction	Houay Por Power Co.	-
Xe Set (B. Beng)	Salavan	13.0	PDA	Houay thon power Co.	-
Xelanong 3	Salavan	12.0	MOU	Houysuanlao inter development	-
Nam Chiane Downstream 1	Xaysomboun	15.0	MOU	Hydro Lao Co.	-
Nam Ham	Xayabuly	3.5	MOU	India	-

Name	Province	Capacity (MW)	Status	Investor	Status 2015
Nam Xan 1	Bolikhamxay	7.0	MOU	Intra Group	-
Nam Ghot Ou	Phongsaly	0.5	Existing	JICA	Gov. Operated
Nam Kem	Huaphan	0.7	MOU	JICA	-
Nam Pouy Upstream	Xayabouly	5.0	MOU	Keochaleun Co.	-
Houay Palai Upstream	Champasak	1.5	PDA	KT Engineering	-
Xe Namnoy 6 (Houay kadeup)	Champasak	5.0	Under Construction	KTX Co.	-
Houay Kapheu 2	Salavan	5.0	MOU	Lao Engineering Co.	-
Xebangnouan 2	Salavanh	-	MOU	Lao PDR	-
Irrigation Downstream	Khammouan	5.0	MOU	Lasita Energy Co.	-
Nam Hong Upstream	Bolikhamxay	12.0	MOU	LBSS	-
Nam Tha 2	Bokeo	14.8	Under Construction	Micro Hydropower Co.	-
Sugar Power Plant	Savannakhet	5.0	Existing	Mit Lao sugar Factory	IPP Operated
Nam Boun 3	Phongsaly	15.0	MOU	MP Construction Co.	-
Nam Hong	Bolikhamxay	14.0	MOU	Nalinny Co.	-
Nam San (Hatto)	Bolikhamxay	15.0	MOU	Nalinny Co.	-
Nam Long 2	Luangnamtha	12.5	PDA	Nam Long Power Co.	-
Houay Namsai 1 (Tad Kalei)	Salavan	6.1	PDA	Nam Sai Power venture Co.	-
Nam Xenoy	Khammouan	5.0	MOU	Namsok Electric Survey	-
Houay Se	Oudomxay	0.1	Existing	NEDO	EDL Operated
Nam Nga	Phongsaly	0.1	Existing	NEDO	Gov. Operated
Nam Mong	Luangprabang	0.1	Existing	NEF	EDL Operated
Nam Ngiep 2A	Xiangkhuang	13.0	PDA	Nonghai Co.	-
Nam Ngiep 2B	Xiangkhuang	9.0	PDA	Nonghai Group	-
Houay Salay	Salavan	5.0	MOU	P & P Construction Co.	-
Houay Salouang	Salavan	2.0	PDA	P & P Construction Co.	-
Houay Lai	Salavan	3.0	PDA	P & P Construction Co.	-
Houay Tay	Sekong	5.0	MOU	Panyaphon Develop Co.	-
Houaychampi km 35	Champasak	5.0	PDA	Pasakon Construction Co.	-
Ang Namhin	Oudomxay	0.7	MOU	PCC	-
Houay Kasen	Oudomxay	0.3	PDA	PCC	-
Nam Kay	Vientiane Pro	3.0	MOU	Phadeng Construction Co.	-
Nam Houng Upstream	Xayabouly	5.0	MOU	Phanthamith	-
Nam Met	Xayabouly	5.0	MOU	Phanthamith	-
Nam Mon	Huaphan	10.0	PDA	Phongsup Co., LTD	-
Xe Namnoy 6	Champasak	5.0	Under Construction	Phongxupthavi Co	-
Xe Namnoy 5	Champasak	5.0	MOU	Phongxupthavi Co.	-

Name	Province	Capacity (MW)	Status	Investor	Status 2015
Xe Namnoy 1	Attapeu	15.0	Existing	Phongxuthavi Co.100%	IPP Operated
Nam Sanan	Luangprabang	5.0	MOU	Phousi Co.	-
Houay Kouat	Xayabouly	1.0	MOU	Phuangphet Co.	-
Nam Et	Houaphanh	0.1	Existing	Province	Gov. Operated
Nam Sat (Viengthong)	Houaphanh	0.3	Existing	Province	Gov. Operated
Nam Peun	Huaphan	0.1	Existing	Province	Gov. Operated
Houay Namphak	Oudomxay	9.0	PDA	Raien	-
Nam Ngum 2	Xayabouly	5.0	MOU	Raien Co.	-
Nam Boun 2	Phongsaly	8.0	PDA	Right Engineering Co.	-
Houay Namsai 2 (Kengtoung)	Salavan	5.0	MOU	SDS Co.	-
Houay Kantrong	Salavanh	5.0	MOU	SDS Co.	-
Nam Houng 1	Xayabouly	12.5	Under Construction	Simeuang Group	-
Nam Phao	Bolikhamxay	1.7	Existing	Simuang Group 87% / Phoudoy Co. 13%	IPP Operated
Xe Set - Kengsan	Salavan	13.0	MOU	Sokxaisavanh Co.	-
Nam San 2	Bolikhamxay	15.0	MOU	SPS Construction	-
Houay Champi Khamnoseap	Champasak	5.0	MOU	STL	-
Nam Ka 1-2	Xiengkhuang	0.1	Existing	Sunlabob	IPP Operated
Xe Katam 1	Champasak	5.0	MOU	SV Group	-
Nam Ken	Vientiane Pro.	5.0	PDA	SV Group / PPNK	-
Tad Salen	Savannakhet	3.2	Existing	Thailand100%	IPP Operated
Dak E Moun Dam	Sekong	-	PDA	TK Construction	-
Nam Leng 2	Phongsaly	15.0	PDA	Venture Capital and Equity Investment Inc 100%	-
Nam Leng 3	Phongsaly	7.0	PDA	Venture Capital and Equity Investment Inc 100%	-
Nam Leng 4	Phongsaly	1.6	PDA	Venture Capital and Equity Investment Inc 100%	-
Houay Pa Gnu	Sekong	5.0	MOU	Vientiane Automation	-
Houay Kapheu 1	Salavan	5.0	Under Construction	Vientiane Automation Engineering Co.	-
Nam Sor	Bolikhamxay	4.2	PDA	Vientiane Techno Construction	-
Nam Heung	Bolikhamxay	12.5	MOU	VSK Co.	-
Nam Samoiy	Vientiane Pro.	5.0	Under Construction	Xasaxai Co.	-
Xe Namnoy 2	Champasak	13.4	Under Construction	Xekatam 2 Power Co.	-
Don Xom 2	Champasak	5.0	MOU	XJC	-
Somphamith	Champasak	5.0	PDA	XJC Group	-
Nam Peun 2	Huaphan	12.0	Under Construction	Yodchaleun Co.	-

Annex II – GIS Proficiency Questionnaire

GIS Proficiency Questionnaire

Please answer the following questionnaire that will allow us to better assess IREP's department/division Geographic Information System (GIS) capacity. The questionnaire was designed to be answered by a single representative of each department/division, having in mind the average level of proficiency of the users.

1. **Name of department/division within IREP:** Alternative Energy Dept / IREP

2. **How many people in your department/division are GIS users?** Answer: 1 people
   Total people in the department/division: 5 people

3. **How do you classify the average GIS capacity of the users?**
   Basic ✓ Intermediate__ Advanced__

4. **Identify all GIS applications that you work with and corresponding level of proficiency:**

ArcGIS	QGIS	MapInfo	Global Mapper	_____ (please name other)	_____ (please name other)	_____ (please name other)
Basic_ ✓	Basic_	Basic_	Basic_	Basic_	Basic_	Basic_
Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_
Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_

5. Does the average user knows how to...	YES	NO
create/manipulate vector data? Example: Intersect, union, clip, join, etc.		✓
create/manipulate raster data? Example: Extract by mask, statistics, reclassify, matrix calculations etc.		✓
georeference topo maps?		✓
create contour lines based on a DEM (Digital Elevation Model)?		✓
create a DEM based on contour lines?		✓
create stream lines based on a DEM?		✓
create a watershed based on a DEM?		✓
export/import data from other types of software?		
• CAD files (dxf, dwg)		✓
• Google Earth (kml)	✓	
• Table format as Excel (xls,csv, txt)	✓	
• MapInfo (TAB)		✓
• _____ (please name other)		

6. **Briefly describe the training package you think that would better improve your department GIS capacity.**
   Answer: We would like to have a building capacity on GIS for basic use.

GIS Proficiency Questionnaire

Please answer the following questionnaire that will allow us to better assess IREP's department/division Geographic Information System (GIS) capacity. The questionnaire was designed to be answered by a single representative of each department/division, having in mind the average level of proficiency of the users.

1. **Name of department/division within IREP:** Rural electrification division

2. **How many people in your department/division are GIS users?** Answer: 3 people
   Total people in the department/division: ____ people

3. **How do you classify the average GIS capacity of the users?**
   Basic✓ Intermediate__ Advanced__

4. **Identify all GIS applications that you work with and corresponding level of proficiency:**

ArcGIS	QGIS	MapInfo	Global Mapper	_____ (please name other)	_____ (please name other)	_____ (please name other)
Basic_✓	Basic_	Basic_	Basic_	Basic_	Basic_	Basic_
Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_
Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_

5. Does the average user knows how to...	YES	NO
create/manipulate vector data? Example: Intersect, union, clip, join, etc.	✓	
create/manipulate raster data? Example: Extract by mask, statistics, reclassify, matrix calculations etc.	✓	
georeference topo maps?	✓	
create contour lines based on a DEM (Digital Elevation Model)?	✓	
create a DEM based on contour lines?		✓
create stream lines based on a DEM?	✓	
create a watershed based on a DEM?	✓	
export/import data from other types of software?		
• CAD files (dxf, dwg)	✓	
• Google Earth (kml)	✓	
• Table format as Excel (xls,csv, txt)	✓	
• MapInfo (TAB)		✓
• _____ (please name other)		

6. **Briefly describe the training package you think that would better improve your department GIS capacity.**
   Answer:
   understand the process, methods and practice using different tools in the process of spatial analysis

GIS Proficiency Questionnaire

Please answer the following questionnaire that will allow us to better assess IREP's department/division Geographic Information System (GIS) capacity. The questionnaire was designed to be answered by a single representative of each department/division, having in mind the average level of proficiency of the users.

1. **Name of department/division within IREP:** FE&C Division

2. **How many people in your department/division are GIS users?** Answer: 5 people
   Total people in the department/division: 8 people

3. **How do you classify the average GIS capacity of the users?**
   Basic ✓ Intermediate__ Advanced__

4. **Identify all GIS applications that you work with and corresponding level of proficiency:**

ArcGIS	QGIS	MapInfo	Global Mapper	_____ (please name other)	_____ (please name other)	_____ (please name other)
Basic_✓	Basic_	Basic_	Basic_	Basic_	Basic_	Basic_
Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_
Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_

5. Does the average user knows how to...	YES	NO
create/manipulate vector data? Example: Intersect, union, clip, join, etc.	✓	
create/manipulate raster data? Example: Extract by mask, statistics, reclassify, matrix calculations etc.		✓
georeference topo maps?		✓
create contour lines based on a DEM (Digital Elevation Model)?		✓
create a DEM based on contour lines?		✓
create stream lines based on a DEM?		✓
create a watershed based on a DEM?		✓
export/import data from other types of software?		
• CAD files (dxf, dwg)		✓
• Google Earth (kml)		✓
• Table format as Excel (xls,csv, txt)		✓
• MapInfo (TAB)		✓
• _____ (please name other)		

6. **Briefly describe the training package you think that would better improve your department GIS capacity.**
   Answer:
   We would like to learn about the subjects on all aspects.

GIS Proficiency Questionnaire

Please answer the following questionnaire that will allow us to better assess IREP's department/division Geographic Information System (GIS) capacity. The questionnaire was designed to be answered by a single representative of each department/division, having in mind the average level of proficiency of the users.

1. **Name of department/division within IREP:** Renewable Energy Development Division

2. **How many people in your department/division are GIS users?** Answer: 1 people
   Total people in the department/division: 10 people

3. **How do you classify the average GIS capacity of the users?**
   Basic ✓ Intermediate__ Advanced__

4. **Identify all GIS applications that you work with and corresponding level of proficiency:**

ArcGIS	QGIS	MapInfo	Global Mapper	_____ (please name other)	_____ (please name other)	_____ (please name other)
Basic_✓	Basic_	Basic_	Basic_	Basic_	Basic_	Basic_
Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_
Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_

5. Does the average user knows how to...	YES	NO
create/manipulate vector data? Example: Intersect, union, clip, join, etc.		✓
create/manipulate raster data? Example: Extract by mask, statistics, reclassify, matrix calculations etc.		✓
georeference topo maps?		✓
create contour lines based on a DEM (Digital Elevation Model)?		✓
create a DEM based on contour lines?		✓
create stream lines based on a DEM?		✓
create a watershed based on a DEM?		✓
export/import data from other types of software?		
• CAD files (dxf, dwg)		✓
• Google Earth (kml)		✓
• Table format as Excel (xls,csv, txt)		✓
• MapInfo (TAB)		✓
• _____ (please name other)		✓

6. **Briefly describe the training package you think that would better improve your department GIS capacity.**
   Answer: It will be good if we will start to learn or review all GIS Applications from basic and also will be good for the the interested people that would like to learn.

GIS Proficiency Questionnaire

Please answer the following questionnaire that will allow us to better assess IREP's department/division Geographic Information System (GIS) capacity. The questionnaire was designed to be answered by a single representative of each department/division, having in mind the average level of proficiency of the users.

1. **Name of department/division within IREP:** Administration division

2. **How many people in your department/division are GIS users?** Answer: 1 people
   Total people in the department/division: 7 people

3. **How do you classify the average GIS capacity of the users?**
   Basic ✓ Intermediate__ Advanced__

4. **Identify all GIS applications that you work with and corresponding level of proficiency:**

ArcGIS	QGIS	MapInfo	Global Mapper	_____ (please name other)	_____ (please name other)	_____ (please name other)
Basic✓	Basic✓	Basic✓	Basic✓	Basic_	Basic_	Basic_
Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_	Intermediate_
Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_	Advanced_

5. Does the average user knows how to...	YES	NO
create/manipulate vector data? Example: Intersect, union, clip, join, etc.		✓
create/manipulate raster data? Example: Extract by mask, statistics, reclassify, matrix calculations etc.	✓	
georeference topo maps?	✓	
create contour lines based on a DEM (Digital Elevation Model)?		✓
create a DEM based on contour lines?		✓
create stream lines based on a DEM?		✓
create a watershed based on a DEM?		✓
export/import data from other types of software?		
• CAD files (dxf, dwg)		✓
• Google Earth (kml)		✓
• Table format as Excel (xls,csv, txt)	✓	
• MapInfo (TAB)		✓
• _____ (please name other)		

6. **Briefly describe the training package you think that would better improve your department GIS capacity.**
   Answer: I think GIS it's good lesson and important for my department, because some work in my division don't use GIS for work, but some work must be to use GIS such data collection RE (Renewable Energy) each province in Laos and another countrys in the world, maps, etc...

Annex III – Training Program

Session A: Introduction to GIS

The introduction to GIS is designed for individuals without previous knowledge (or very little knowledge) of GIS. The main objectives of the Introduction to GIS is to provide knowledge to IREP for the creation of GIS maps, exploration and analysis of data stored in databases, as well as adding external data do maps to elaborate maps with different context. The topics covered by this module are described below:

- Create and explore a GIS map
- Components of a GIS
- Geographic data and tabular formats
- Metadata
- Coordinate systems
- Sources of GIS data
- Navigating on a GIS map
- Finding features
- Identify features and gather information
- Feature symbology
- Solving beginner spatial problems
- Best practices to share maps and results
- Best practices on geographic data organization for a mapping project

Duration of the session: 12 hours

Session B: Editing and data creation

The editing and data creation module will provide IREP with the skills to create, explore, manage and analyze geographic data, with special care to the information collected and created under the current Technical Assistance. The topics covered by this module are listed below:

- Geographic data creation, organization and editing
- Layers management, symbology and labels
- Design page layouts and printing
- Setting scale ranges in layer display
- Querying data
- Grouping layers
- Solving intermediate spatial problems
- Storing data in a database
- Qualitative and quantitative data
- Symbology by attributes and classification
- Fields and value calculation
- Join and relate

Duration of the session: 12 hours

Session C: Analysis and mapping

The analysis and mapping module will prepare IREP's staff to develop a workflow for any GIS analysis. The first step of the workflow is the placement of the problem and the consideration of the available criteria. The topics covered by this module are listed below:

- Workflow steps
- Data quality and coordinate systems
- Buffer
- Voronoi and Thiessen Polygons
- Distance matrix
- Overlay tools
- Terrain analysis
- Hydrology models
- Raster statistics
- Thematic Maps
- Layouts

Duration of the task: 8 hours

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