

Pilot projects: Justification for selection, challenges and next steps

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The HYPOSO Project (funded under the H2020 programme by the European Commission) aims at supporting the European hydropower industry while at the same time fostering a sustainable development in selected target countries in Africa (Cameroon and Uganda) and Latin America (Bolivia, Colombia and Ecuador).

The project tackles several objectives: increase the share of renewable energy in targeted regions, increase of rural electrification rate, better investment conditions in the target countries, promotion of the European hydropower industry. These objectives are going to be achieved by a combination of tools and activities: framework analysis concerning the small hydropower up to 30 MW for the selected target countries, identification and mapping of more than 2000 potential hydropower sites in the target countries, education of new hydropower experts through capacity building activities, elaboration of 15 dedicated business case studies of SHP projects (three in each of the five target countries) with a focus on local financing, leading to at least 5 signed Memorandum of Understanding (MoU) between stakeholders from target countries and the European hydropower sector, and bringing together relevant actors from the EU hydropower sector with stakeholders in the target countries.

Interaction with stakeholders is therefore an integral part of the activities.

The presentation will deal with the procedure for the selection of 15 high potential hydropower sites to be considered as pilot projects for the elaboration of comprehensive business case studies (containing pre-feasibility, ecological, economic and political studies). Starting from a preliminary list containing the information of several high potential hydropower sites for each target country, a simplified multi-criteria approach has been applied in order to identify the most valuable sites from a quantitative point of view. A focus has been laid on the active involvement of the public: project partners and local stakeholders met to discuss about the potential projects in order to make a consensus decision on the selection of the high potential sites to be considered as pilot projects.

Finally, the selection procedure had to face several challenges which will be explained in the presentation.

Following the final selection, further steps have already been carried out in order to start with the activities on the selected sites foreseen in the project.

1. Background

Within the HYPOSO project, Frosio Next is the leader partner of the work package number 5, “Case studies”. The objective of WP5 is the elaboration of 15 comprehensive business case studies, containing pre-feasibility, ecological, economic and political studies, for 3 selected sites in each target country. This activity is expected to lead to at least 5 signed Memorandum of Understanding (MoU) between stakeholders from target countries and the European hydropower sector.

The elaboration of the comprehensive business case studies will be carried out by means of different tasks:

1. Based on a list of the pre-selected high potential hydropower sites collected by the local partners together with the local stakeholders, the identification and the **selection of the sites to be considered as case studies** will be executed. The selection of the sites is based on a series of criteria like economic attractiveness, regional electricity demand, ecological impact, availability of grid connection but also expectations of the community and others will be applied. Although each site is very specific and individual, these business case studies shall be exemplary and replicable in the target regions. A focus will be laid on the active involvement of the local stakeholders and project partners: the final selection will be the result of a consensus decision made by all the involved parties.
2. Once the selection of the sites to be considered as case studies will be finalised, the first analysis which will be carried out will be the **pre-feasibility studies** which represent a milestone in any project development process aimed at giving an overview of the main technical data of the project and other information deemed important to the decision-making procedure.

A precondition for carrying out a pre-feasibility study is the **expert's survey** to get a complete overview of the surroundings and to create the first project ideas, as well as to collect detailed information about the project. The inclusion of local and regional experience will be essential.

3. Assessment and stakeholder involvement in projects with environmental, health related, and socio-economic impacts have the highest priority: **environmental and socio-economic impact assessments** will be carried out in order to determine the type and level of effects the proposed projects would have on either the natural environment or the population and its living conditions. The assessment will help to identify and evaluate effects; decide if the effects are acceptable or have to be reduced; design mitigation and management measures and propose alternatives.
4. The chance to realise a project is directly related to the economic viability (taking into account political and financial frameworks in the target countries). For this reason, **business case studies** will be carried out including the results of the pre-feasibility studies and local/regional conditions referring to the price of electricity. The economic viability is determined from the investment necessary on the one hand and the income from selling the energy on the other hand. Additionally, capital cost (financing), operation cost and other criteria will be included in the first economic estimation. As these business case studies will show highly promising opportunities for the hydropower sector, HYPOSO aims at signing at least 5 (one for each target country) Memorandum of Understanding (MoU) between stakeholders (e.g. project developers and local communities)) in the target countries and the European hydropower sector (e.g. equipment producers, investors, technology providers, project developers).

2. Ongoing tasks

2.1 Identification and selection of the sites to be considered as case studies

Based on a list of pre-selected high potential hydropower sites collected by the local partners together with the local stakeholders, the identification and the selection of the sites to be considered as case studies will be executed.

Domestic stakeholders and project partners will meet to present and discuss the potential projects and to select the best locations for case studies. The target will be the selection of three locations per target country.

The selected sites will be the objects of complete business case studies which will include an analysis of economic viability and opportunities for financing as well as environmental and socio-economic impact assessments and pre-feasibility studies.

The selected locations will differ as good as possible in head and flow and in type (weir type, diversion type). The selection will be based on a series of criteria like economic attractiveness, regional electricity demand, ecological impact, availability of grid connection but also expectations of the community and others will be applied. Although each site is very specific and individual, the business case studies shall be exemplary and replicable in the target regions.

A focus will be laid on the active involvement of the public: local stakeholders and project partners will evaluate the catalogue of features and criteria to create a consensus decision.

The identification of the community with the project will ensure the long-lasting functionality and avoid opposition. Per target country, one webinar or workshop will be organised.

The final selection of the three high potential hydropower sites will be performed following different steps:

1. Development of a selection strategy;
2. Evaluation of the data about the preselected high potential sites and application of the selection strategy;
3. The application of this selection strategy (quantitative approach) leads to a ranking of the sites (each site is linked to a score) and it allows to identify the most valuable sites for each target country (those sites with higher score);
4. Meeting with the local partners and the local stakeholders: the involvement of the local stakeholders is an important issue for the success of the task;
5. Final identification of the three high potential hydropower sites per target country based on a consensus decision made by the local parties and the project partners.

2.1.1 Sites' selection strategy: a simplified multi-criteria approach

Frosio Next has developed a method, based on a numerical approach, aimed at the selection of 3 sites per target country to be considered as case studies. The proposed method follows a simplified multicriteria approach to avoid

subjective evaluations as much as possible but taking into consideration the low level of the preselected sites' data quality, typical of a preliminary assessment.

The approach is based on 12 main criteria (*Table 1*). Each main criterion is analysed through the evaluation of different sub criteria.

Each sub criterion is evaluated by means of three parameters:

1. a maximum rank expressed by a percentage. It is fixed and standard. It has been set according to the importance of the sub criterion: higher its importance, higher its weight (and, as consequence, its percentage);
2. the availability or the possibility to obtain the required data;
3. the actual rank expressed by a percentage. It can be 0 if there isn't the required data set or, vice versa, it can be equal to the maximum rank assigned to the sub criterion.

The final rank associated to the main criterion is given by the sum of the actual ranks of each sub criterion.

The evaluation of each main criterion comes from the determination of three parameters:

1. an absolute weight expressed by a number. It is fixed and standard for all sites. It has been set according to the importance of the criterion: higher the importance of the criterion, higher its weight (and, as consequence, the number);
2. a rank coming from the evaluation of each single sub criterion (the sum of the actual ranks of each sub criterion related to the main criterion);
3. the score associated to each main criterion, as the product between the previous two parameters.

Finally, the whole site is characterized by a number, the total score, as the weighted average of the scores of each main criterion.

#	Main criteria
1	Plant location
2	Hydrologic assessment
3	Topographic data
4	Engineering information level
5	Plant characteristic
6	Project cost evaluation
7	Incomes evaluation
8	Environmental assessment
9	Financial analysis
10	Authorization procedure state and perspectives
11	Social relevance of the energy production
12	Multipurpose use of the water or/and of the plant infrastructures

Table 1. Main criteria

1	Plant location
1.1	Already existing plant
1.2	Catchment area identification [km ²]
1.3	River identification
1.4	Intake coordinates
1.5	Powerhouse coordinates
1.6	Existing access road to the main plant parts
1.7	Access road to the main plant parts to be built
1.8	Quite difficult access facilities to the main part of the plant
1.9	Uncultivated land owned by the State
1.10	Land owned by local communities
1.11	Land owned by private people
1.12	Distance of the available main construction material
1.13	Users' number identification ONLY FOR STAND-ALONE SYSTEM
1.13'	Easy connection to the national grid ONLY FOR CENTRAL GRID CONNECTED SYSTEM

Table 2. List of sub-criteria concerning the main criterion PLANT LOCATION

2	Hydrological assessment
2.0	Plant flow rate from international databases
2.1	Assessment based on flow rate record
2.1.1	Location of the available gauge station
2.1.1.1	<i>At the intake structures</i>
2.1.1.2	<i>On the river to be exploited</i>
2.1.1.3	<i>On a river close to the one to be exploited</i>
2.1.2	Measures rate of the flow rate
2.1.2.1	<i>Daily</i>
2.1.2.2	<i>Weekly (or decades)</i>
2.1.2.3	<i>Monthly</i>
2.2	Assessment based on the rainfall and catchment area
2.2.1	Location of the available rainfall data
2.2.1.1	<i>Catchment area of the river to be exploited</i>
2.2.1.2	<i>Catchment area of a river close to the one to be exploited</i>
2.2.2	Measures rate of rainfall data
2.2.2.1	<i>Daily</i>
2.2.2.2	<i>Weekly (or decades)</i>
2.2.2.3	<i>Monthly</i>

Table 3. List of sub-criteria concerning the main criterion HYDROLOGICAL ASSESSMENT (The evaluation of the sub criteria in the yellow rows comes from the evaluation of the characteristics written below)

3	Topographic data
3.1	Site specific survey
3.1.1	Total station detailed survey
3.1.2	Total station survey
3.1.3	GPS survey
3.2	Maps available
3.2.1	Large scale maps 1:1.000 or less
3.2.2	Large scale maps 1:10.000 or less
3.2.3	Large scale maps 1:25.000 or less
3.2.4	Large scale maps 1:50.000 or less
3.2.5	Large scale maps >1:50.000
3.2.6	Sketch map only

Table 4. List of sub-criteria concerning the main criterion TOPOGRAPHIC DATA (The evaluation of the sub criteria in the yellow rows comes from the evaluation of the characteristics written below)

4	Engineering information level
4.1	Pre-feasibility study
4.2	Feasibility study
4.3	Detailed design

Table 5. List of sub-criteria concerning the main criterion ENGINEERING INFORMATION LEVEL

5	Plant characteristics
5.1	Run of river
5.2	Storage
5.3	Installed capacity < 100
5.4	100 ≤ Installed capacity < 1.000
5.5	1,000 ≤ Installed capacity < 10,000
5.6	10,000 ≤ Installed capacity
5.7	Max flow rate
5.8	Average flow rate
5.9	Gross head
5.10	Net head
5.11	Expected annual energy production
5.12	Capacity gradient
5.13	Stand-alone functioning ONLY FOR CENTRAL GRID CONNECTED SYSTEM

Table 6. List of sub-criteria concerning the main criterion PLANT CHARACTERISTICS

6	Project cost evaluation
6.1	Detailed quantities estimation
6.2	Costs from preliminary offers of possible suppliers
6.3	Costs from similar projects in the country
6.4	Parametric evaluation of the construction costs
6.5	O&M costs detailed evaluation
6.6	O&M costs parametric evaluation
6.7	Possible incentives/contribution on the construction costs of rural lines
6.8	Possible incentive/contribution for investment in rural area

Table 7. List of sub-criteria concerning the main criterion PROJECT COST EVALUATION

7	Incomes evaluation - Price of the energy delivered to insulated grids ONLY FOR STAND-ALONE SYSTEM
7.1.1	Survey on the users' amount and typical energy consume
7.1.2	Users' willing-to-pay analysis
7.1.3	Mandatory tariffs from the legislation rules
7.1.4	Not justified value

Table 8. List of sub-criteria concerning the main criterion INCOMES EVALUATION for stand-alone systems

7	Incomes evaluation ONLY FOR CENTRAL GRID CONNECTED SYSTEM
<u>7.1</u>	<u>Plant supplying energy to an insulate grid and to the national grid</u>
7.1.1	Price of the energy delivered to insulated grids
7.1.1.1	<i>Survey on the users' amount and typical energy consume</i>
7.1.1.2	<i>Users' willing-to-pay analysis</i>
7.1.1.3	<i>Mandatory tariffs from the legislation rules</i>
7.1.1.4	<i>Not justified value</i>
7.1.1.4	Price of the energy delivered to the national grid
7.1.1.5	<i>Purchase obligation by law</i>
7.1.1.6	<i>Purchase tariff by law</i>
7.1.1.7	<i>Signed contract with the energy authority/public utility</i>
7.1.1.8	<i>Not justified value</i>
<u>7.2</u>	<u>Plant supplying energy supplying energy to the national grid only</u>
7.2.1	Price of the energy delivered to the national grid
7.2.1.1	<i>Purchase obligation by law</i>
7.2.1.2	<i>Purchase tariff by law</i>
7.2.1.3	<i>Signed contract with the energy authority/public utility</i>
7.2.1.4	<i>Not justified value</i>

Table 9. List of sub-criteria concerning the main criterion INCOMES EVALUATION for central grid connected systems (The evaluation of the sub criteria in the yellow rows comes from the evaluation of the characteristics written below)

8	Environmental assessment
<u>8.1</u>	<u>General overview</u>
8.1.1	Normal environmental requirement
8.1.2	Strong environmental requirement (sensitive environmental area)
8.1.3	Reserved flow evaluation
8.1.4	Sediment transport evaluation
<u>8.2</u>	<u>Preliminary assessment</u>
8.2.1	Preliminary water quality survey
8.2.1.1	<i>Direct on the river to be exploited</i>
8.2.1.2	<i>Literature data on the river to be exploited</i>
8.2.1.3	<i>Literature data on similar rivers</i>
8.2.2	Measures rate of water quality parameters
8.2.2.1	<i>Six months</i>
8.2.2.2	<i>One year or more</i>
<u>8.3</u>	<u>Analysis of impacts during the construction</u>
8.3.1	Transport impacts
8.3.2	Noise impacts
8.3.3	Pollution impacts
8.3.4	Positive impact on the economy at regional/country level
<u>8.4</u>	<u>Analysis of impacts during the plant operating life</u>
8.4.1	Impact on the water quality
8.4.2	Transport impacts
8.4.3	Noise impacts
8.4.4	Possible pollution impacts
8.4.5	Social impact at village/region/country level
8.4.6	Positive impact on the economy at regional/country level
8.4.7	Avoided climate change gas emission
8.4.8	Other positive environmental issues

Table 10. List of sub-criteria concerning the main criterion ENVIRONMENTAL ASSESSMENT (The evaluation of the sub criteria in the yellow rows comes from the evaluation of the characteristics written below)

9	Financial analysis
9.1	Incentives on produced energy
9.2	Financial support for the investors

Table 11. List of sub-criteria concerning the main criterion FINANCIAL ANALYSIS

10	Authorisation procedure state and perspectives
10.1	Signed agreement with landowners and/or local communities
10.2	Water licence already issued
10.3	Preliminary positive evaluation by local communities
10.4	Preliminary positive evaluation by the relevant authorities

Table 12. List of sub-criteria concerning the main criterion AUTHORIZATION PROCEDURE STATE AND PERSPECTIVES

11	Social relevance of the energy production
11.1	Energy delivered to rural area not connected to the national grid
11.2	Support to existing weak rural grid
11.3	Local communities involved into the plant ownership
11.4	Local investors

Table 13. List of sub-criteria concerning the main criterion SOCIAL RELEVANCE OF THE ENERGY PRODUCTION

12	Multipurpose use of the water or/and of the plant infrastructures
12.1	Additional irrigation/fish breeding facilities
12.2	Road or other plant infrastructures multipurpose use
12.3	Plant sharing a potable water supply grid

Table 14. List of sub-criteria concerning the main criterion MULTIPURPOSE USE OF THE WATER OR/AND OF THE PLANT INFRASTRUCTURES

2.1.2 Application of the selection strategy

This method has been applied to the preselected high potential sites for each target country and thanks to the quantitative approach of the method, it has led to the definition of a ranking of the sites, from that site characterized by the highest score to that site characterized by the lowest score. It has allowed to prioritize the sites according to the total score based on the available data and to identify the most valuable sites to be considered as case studies.

Besides the ranking coming from the application of the selection strategy, additional criteria must be taken into consideration for the final selection in order to get the most suitable selection of the sites, in terms of compliance with the HYPOSO objectives.

Variety of schemes

The selected locations should differ as good as possible in head and flow (high/low head, installed capacity range) and in type (weir type, diversion type, grid connected/stand-alone).

Involvement of local stakeholders

The involvement of the local stakeholders has been an unavoidable requirement since the first stages of the project. The success of the project is strictly bounded by the constant support of the local parties. Within the selection procedure, local stakeholders are expected to attend meetings with the project partners in order to make a consensus decision about those sites to be considered as case studies. The final decision will be made taking into account not only the rankings coming from the application of the selection strategy, but also the requirements and the preferences stated by the local stakeholders.

Possibility to ensure the site for HYPOSO purposes

In order to ensure the selected site for HYPOSO purposes, a Partnership Agreement between the site's responsible person/people and the HYPOSO project partners is an important precondition for the work. It's a guarantee aimed at reserving the site for the project's purposes only. It has to be provided before proceeding with the following tasks and it will avoid useless work.

2.1.3 Project developer's workshops for case studies

In order to involve the local stakeholders in the sites' selection procedure, per target country one workshop is expected to be organised. Domestic stakeholders and project partners will meet to select the really best locations.

To date, the workshops for the selection of the case studies have already been held for Cameroon, Uganda and Ecuador. Besides the European and local project partners, the webinars were attended by representatives of local institutions such as Ministry of Energy, investors, projects' developers, local engineering companies, local authorities.

After an initial introduction of HYPOSO project and of the workshop's purposes, the selection strategy and its application to the list of preselected sites have been presented. The resulting sites' rankings have been shown as starting point for a proactive discussion among the participants. It was not possible during the workshops to reach a consensus on which 3 potential sites should be selected as case studies. After the workshops, the stakeholders have evaluated independently and individually the catalogue of features and criteria to finally create a consensus decision.

2.1.4 Final selection

The final selection of the 3 high potential sites to be considered as case studies strictly depends on the opinion and requirements of the local stakeholders. Despite the application of the simplified multicriteria approach leads to the identification of those sites which should be preferred based on the preliminary availability of data, the involvement of the local institutions in the project will ensure the long-lasting functionality and avoid oppositions. At the same time, their support will be an unavoidable requirement in order to comply with the HYPOSO tasks. For this reason, the final selection was taken by the local stakeholders, after a technical review provided by the experts of the HYPOSO project.

Cameroon:

For this country, the selection of the sites is strictly bounded by the constraints from the political point of view and from the institutional point of view, as well as, by the technical aspects. With the aim of ensuring the support of most of the key stakeholders in order to count on them for the sustainability of the action in the long term, the final selection is based on the availability of data and on the guarantee of the local stakeholders to support HYPOSO activities. The 3 final selected sites are located in Southern Cameroon and in Western Cameroon.

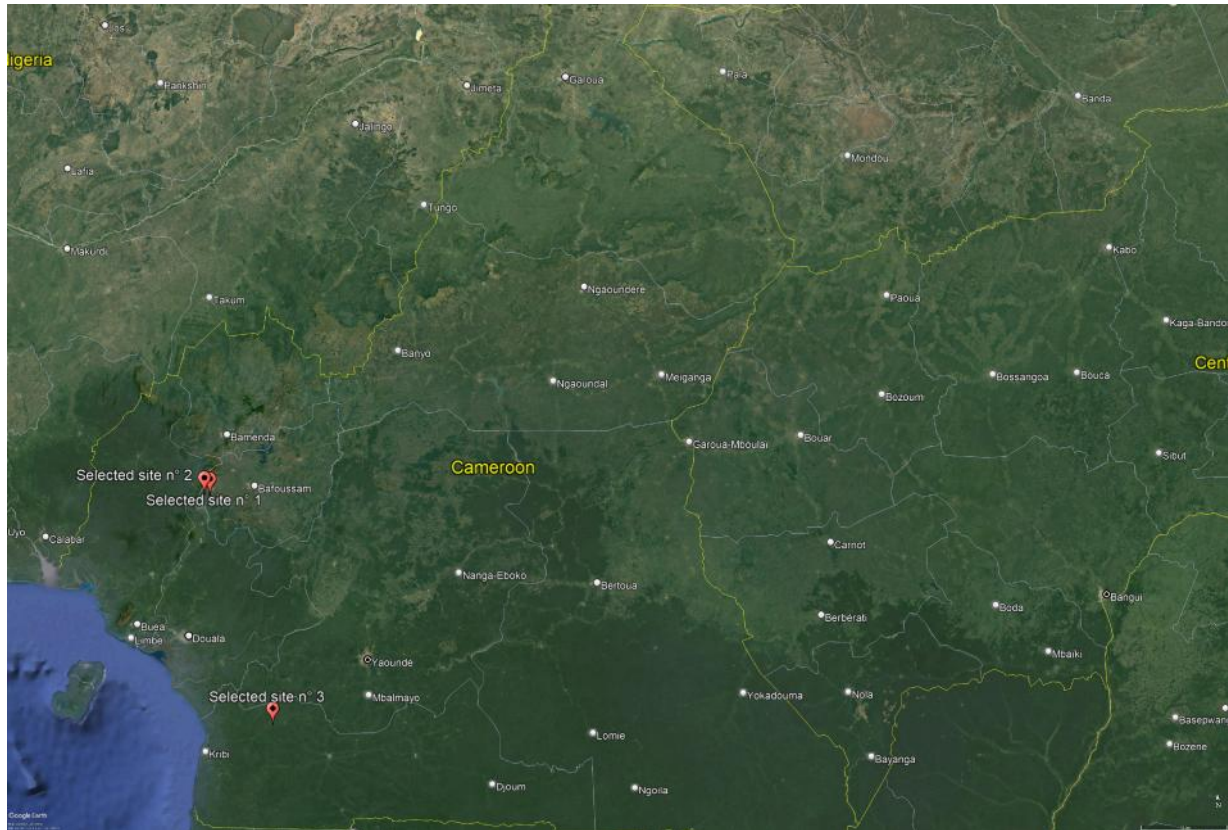


Fig. 1. Cameroonian selected sites for case studies

Uganda:

For this country, the local stakeholders pointed out the need to ensure regional balance concerning the sites involved in HYPOSO project in order to promote the electrification of the rural areas in different parts of the country. In this regard, the selected sites are located in different parts of Uganda, as well as, they represent different hydraulic and hydrological schemes. The 3 selected sites are located in 3 different parts of Uganda.

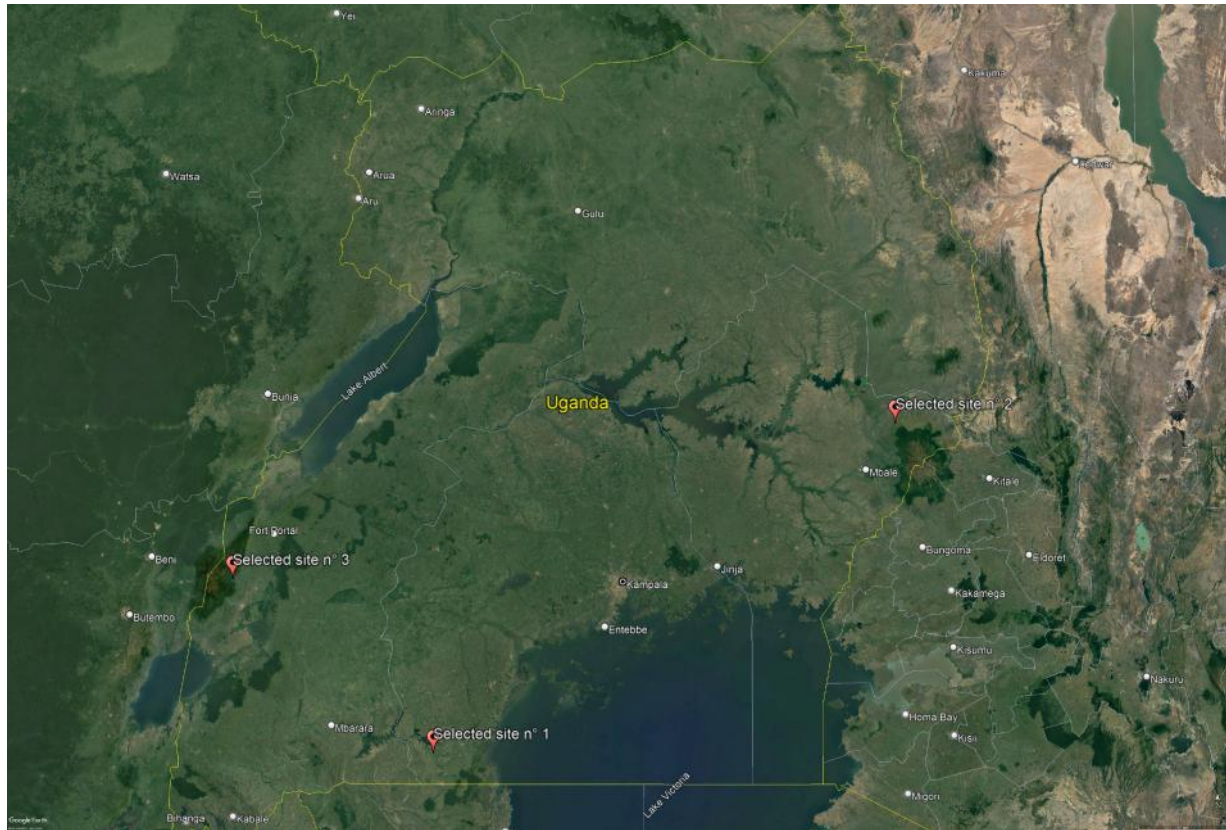


Fig. 2. Ugandan selected sites for case studies

Ecuador:

The Government of Ecuador, through the Ministry of Energy and Non-Renewable Natural Resources – MERNNR, is committed to the diversification of the energy matrix and the inclusion of new sources of clean and accessible generation, as well as the efficient consumption of electricity. In relation to HYPOSO, the Ministry of Energy and Non-Renewable Natural Resources stated the need to give priority to those projects that are in the basin that discharges to the Pacific Ocean and that the energy delivery (plant factor) of the project should preferably be greater than 60%. In this context, the final selected sites are located in the country as shown in *Fig. 3*.



Fig. 3. Ecuadorian selected sites for case studies

2.1.5 Further actions

In the next months, the European project partners together with the Bolivian and Colombian project partners and the local stakeholders are expected to carry out the project developers' workshops in order to identify the 3 sites (per country) to be considered as case studies.

2.2 Prefeasibility studies

Once the selection of the sites to be considered as case studies is finalized, the prefeasibility studies will be carried out. Pre-feasibility studies typically give an overview of the main technical data like head and flow, the power output, the annual production, the construction works necessary, the capital requirements, the main needs and challenges and any other information deemed important to the decision-making process. A precondition for carrying out a pre-feasibility study is the expert's survey to get a complete overview of the surroundings and to create the first project ideas. In a second step it is necessary to have the detailed topography. The most crucial part of such a study is the availability of hydrological data. It will be the same situation in the project proposed and the inclusion of local and regional experience will be essential.

A detailed structure of the prefeasibility studies has been already developed and it includes several topics (Table 15).

Prefeasibility studies contents	
1	General regional description
1.1	Geography
1.2	Social structure
1.3	Energy consumption
1.4	Climate
2	General site description
2.1	Selected river and site location
2.2	Existing studies or projects
2.3	Available mapping

3	Hydrology and sediment transport
3.1	Catchment area
3.2	Precipitation
3.3	Rivers
4	Layout alternatives
4.1	Setting of selection criteria
4.2	Setting of alternatives
4.3	Final layout
5	Project description
5.1	General layout
5.2	Costs estimation
6	Feasibility check and risk analysis
6.1	Legal feasibility
6.2	Technical feasibility
6.3	Financial feasibility
6.4	Environmental feasibility
6.5	Political feasibility
6.6	Organisational feasibility
6.7	Resources related feasibility
6.8	Socio-economic feasibility
7	Conclusion and recommendations

Table 15. Prefeasibility study: general structure

2.2.1 Selected sites visit

The visit of the selected sites is a preliminary step in order to carried out the prefeasibility studies. Due to the COVID pandemic, the organisation of the onsite surveys has been very challenging. During the second half of August 2021, the visit to the Ugandan selected sites has been performed by some European project partners, thanks to the efforts of the local partner in the organisation and thanks to the support of the local stakeholders.

The onsite activities have been performed successfully and the HYPOSO experts gathered all the useful information, as well as the available hydrological data, in order to proceed with the studies. Furthermore, HYPOSO experts and local sites' developers had the chance to discuss about the possible layouts of the plant in order to find together the scheme which best fits with the site's characteristics.



Fig. 4. HYPOSO experts and local stakeholders visiting the selected site n° 1



Fig. 5. HYPOSO experts and local stakeholders visiting the selected site n° 2



Fig. 6. HYPOSO experts and local stakeholders visiting the selected site n° 3

2.2.2 Further actions

Following the Ugandan sites' visit and the layout alternatives discussed with the sites' developers, the European experts are going to start with the in-depth analysis foreseen in the prefeasibility studies.

Furthermore, the sites' surveys in Cameroon are planned to be held during the second half of January 2022.

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