

Hydropower solutions for
developing and emerging
countries – Bringing Africa,
Latin America and Europe
together



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IHE Delft Institute for
Water Education

The HYPOSO Map – a useful tool for academia and the industry

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agreement No 857851*



Overview

1. Introduction
2. Objectives
3. Materials & Methods
4. Results: the HYPOSO Map



1. Introduction

Assessment of SHP sites for development represents a high proportion of overall project costs. Moreover, the sites are often located in remote areas with limited access to engineering teams.

This assessment has been constrained by the lack of information on river flow, river topography and hydropower potential, especially in the African and some Latin American river systems.

Tools are needed to help in assessing preferred SHP sites.

The advent of GIS technologies has enormous use to capture the range of spatial information at a catchment level for hydropower purposes. The assessment is carried out automatically using the GIS tool (e.g., ArcGIS Spatial Analyst etc.).



- ❑ A number of countries using advanced GIS technology developed interactive web-based maps of hydropower resources (e.g., US ORNL: HydroSource Data Explorer; GECOSistema: Pan-European small hydropower atlas).
- ❑ Available at online platforms indicating individual site locations and various key datasets - energy, hydrology, environmental and economic parameters, enabling users to freely and instantaneously obtain the necessary information.
- ❑ Hydropower atlases (map viewers) are primarily published on commercial ESRI ArcGIS, ArcGIS Online, Google Earth or open-source QGIS software.
- ❑ Available in some parts of Africa (e. g., ECOWAS ECREEE & Pöyry: GIS Hydro Resource Mapping in West Africa), Tanzania, and Madagascar and Latin America (Atlas of Colombia's Hydropower Potential).

2. Objectives

Objective: develop a web-based map of hydropower resources (or interactive hydropower atlas) in the selected countries of Africa and Latin America (Cameroon and Uganda, Bolivia, Colombia and Ecuador).

Specific objectives:

- ❑ collect topographic, hydrographic, hydrological, climate, hydropower (e.g., operational HPPs) and environmental data in geospatial format.
- ❑ create the digital elevation model (DEM) and delineate river network and catchment and sub-catchment areas and develop longitudinal profiles of streams.
- ❑ model stream-reach theoretical hydropower potential.
- ❑ identify some 2,500+ potential hydropower sites with their key datasets.
- ❑ publish collected and modelled geospatial data onto an open-access web-based platform.

3. Materials & Methods

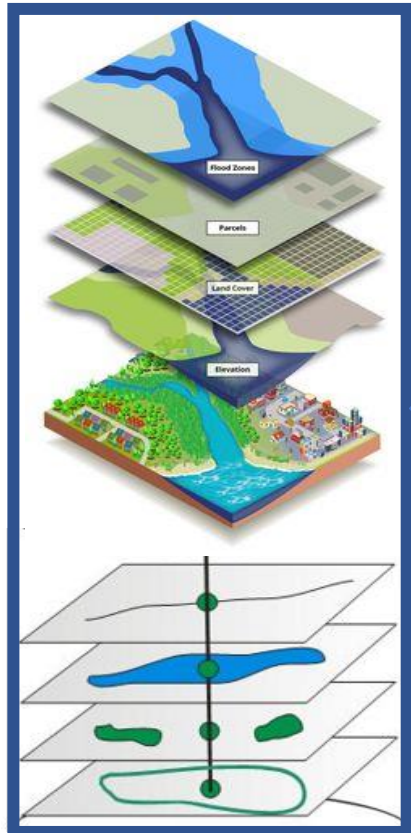
The HYPOSO Map – a web-based platform, an open-source GeoServer software. GeoServer is a GIS server written in Java and designed for high interoperability. It allows users to input, process and publish geospatial data and supports data interchange from most spatial data sources using open standards.

The HYPOSO Map consists of 20+ layers/sub-layers; they can be viewed on the map viewer.

Available in English, French and Spanish and accessible at
[https://www.opengis.lt/projects/hyposo/#9/-1.3944/-79.4295.](https://www.opengis.lt/projects/hyposo/#9/-1.3944/-79.4295)



Thematic layers

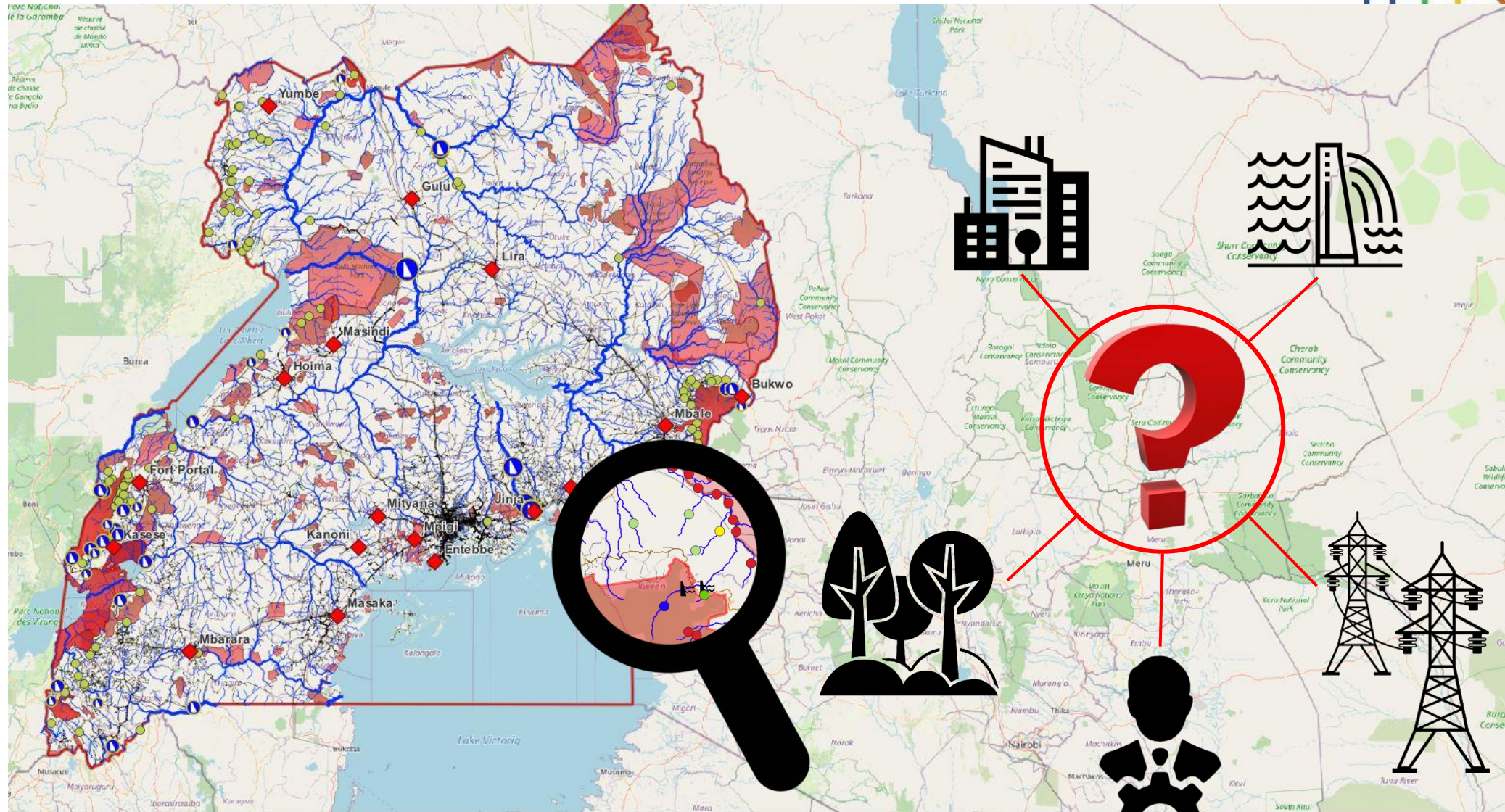


No	Group	Layer
1	Base map	1.1 Open Street Map (OSM)
		1.2 Open Topo map
		1.3 Satellite imagery
2	Background & Infrastructure	2.1 National Boundaries
		2.2 Protected Areas
		2.3 Power Grid
3	Operational Hydropower plants (HPP) and under construction	3.1 Large, Medium, Intermediate, Small, Micro and Mini Hydro
4	Climate and Hydrology	4.1 Climate Zones
		4.2 Mean Annual Precipitation
		4.3 Climate Change Projections of Precipitation
		4.4 River Basins
		4.5 Stream Order
		4.6 Small Catchments
		4.7 Gauging Stations
		4.8 Mean Annual Flow
		4.9 Normal Annual Specific Runoff
5	Hydropower (HP) Resources	5.1 Potential sites of hydropower plants
		5.2 Stream-reach potential capacity, MW
		5.3 Total hydropower potential of river basins, MW
		5.4 Specific hydropower potential, MW/km

**Target:
2,500+ sites**

The river network and sub-catchment GIS layers were created with relevant attributes showing the theoretical hydropower potential. Beforehand, to delineate the river network and catchment, the digital elevation model (DEM) was used. MERIT Hydro DEM was developed from the existing spaceborne DEMs (SRTM3 v2.1) and represented the terrain elevations at a 3 arcseconds resolution (~90 m). This DEM was hydrologically conditioned, and the drainage network was enforced.

Potential hydropower sites evaluation according to the GIS modelling



Climate change projections of the precipitation

Climate Change Knowledge Portal

The Climate Change Knowledge Portal (CCKP) provides global data on historical and future climate, vulnerabilities, and impacts. Explore them via **Country** and **Watershed** views. Access synthesized **Country Profiles** to gain deeper insights into climate risks and adaptation actions. [Disclaimer](#)

NEW! Please check out the introductory video for the CCKP

- COUNTRY
- WATERSHED
- DOWNLOAD DATA
- COUNTRY PROFILES
- GENERAL RESOURCES
- ABOUT
- TUTORIAL

Legend

Time periods: 2080-2099

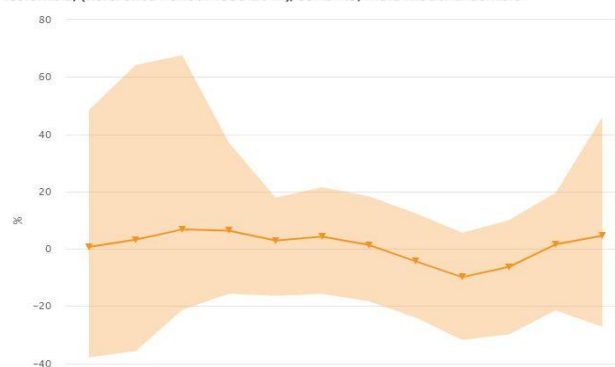
- < -4
- 4 - -2
- 2 - 0
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- > 16.0

Projected Precipitation Percent Change Anomaly for 2080-2099 (Annual)
Colombia; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble



PERCENT (%)

Projected Precipitation Percent Change Anomaly for 2080-2099
Colombia; (Reference Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble



There is a close relationship between precipitation and run-of-river (RoR) scheme generation. Therefore, any changing trend in precipitation level can be reflected in hydropower potential.



Potential sites of hydropower plants

Potential sites of hydropower plants, including stream reaches with high energy density, were compiled by local experts and GIS modelling tools.

Data is available for downloading (Shape and KML files). The following attributes are available:

#	Attribute	Description
1.	fid	Fid
2.	Id	ID
3.	Country Co	Country code
4.	Site Name	Site name
5.	Status	Status (planned, potential, not defined)
6.	River name	River or stream name
7.	River local	River or stream local name
8.	River Basin	River basin or hydrologic unit
9.	Address	Address
10.	Lat_Int	Latitude (decimal degrees North) at intake or dam
11.	Lon_Int	Longitude (decimal degrees East) at intake or dam
12.	Lat_PwH	Latitude (decimal degrees North) at Powerhouse (if relevant)
13.	Lon_PwH	Longitude (decimal degrees East) at Powerhouse (if relevant)
14.	Flow_m3_s	Discharge Q, m ³ /s
15.	Head_m	Head H, m
16.	Capacity_MW	Hydropower capacity, MW. Calculated: P=0.0085QH
17.	Exp_Q_m3_s	Expected flow (preliminary), m ³ /s
18.	Exp_Head_m	Expected head (preliminary), m
19.	Exp_P_MW	Expected power capacity (preliminary), MW
20.	Max_P_MW	Max power availability, MW
21.	Scheme	Scheme type (RoR, RoR-D; S, S-D)
22.	Site_read	Site readiness for development (or under planning): a) short-term (1 to 3 years); b) medium-term (4 to 9 years); c) long term (+ 10 years); d) not known
23.	Env	Environmental sensitivity
24.	Grid	On-grid or off-grid or distance, km
25.	Comments	Comments
26.	Date	Date

About this resource

1.	Categories	Hydropower resources
2.	Keywords	Potential sites of hydropower plants
3.	Language	English
4.	Legal constraints	The dataset is licensed under the Creative Commons Attribution-Share, like the 4.0 International license. You are free: • to share – to copy, distribute and transmit the work, • to remix – to adapt the work, Under the following conditions: • attribution – You must attribute the work to the source. • share alike – If you alter, transform, or build upon this work, you may distribute the resulting work only under the same or similar license to this one. https://creativecommons.org/licenses/by-sa/4.0/ https://www.openstreetmap.org/copyright

5.	Contact for the resource	© OpenStreetMap contributors ■ Colombia : CELAPEH, direccion@celapeh.org ■ Cameroon: SHW, josenfack@yahoo.fr ■ Ecuador: EPN, maria.guerra@epn.edu.ec ■ Bolivia : UMSS, andresgonzales.a@fcyt.umss.edu.bo ■ Uganda: HPAU, dmarlone@yahoo.com ■ Lithuania: VMU (Vytautas Magnus University): petras.punys@vdu.lt
6.	Technical information	
6.1	Update frequency	Not planned
6.2	Representation type	Geometry type – points visualised on OpenMap or OpenTopoMap. The mapping platform uses Geographic Information System (GIS) software: Cesium and Leaflet .
6.3	Coordinate reference system	WGS 84 (EPSG:4326)
6.4	Format	ESRI Shapefile, Google Earth KML, files.

Metadata information

- Contact: VMU (Vytautas Magnus University): petras.punys@vdu.lt
- Technological solution and support of the mapping platform: Geographic information technologies, opengis.lt, info@opengis.lt
- Publication date: 2023 04 30

INFORMATION ABOUT USAGE OF THE MAP VIEWER



INFORMATION ABOUT USAGE OF THE MAP VIEWER

Turn on the layer:

Potential sites of hydropower plants

Activate the identification of attributes on layer:

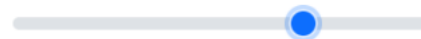
Potential sites of hydropower plants

More information about layer:

Potential sites of hydropower plants

Change the layer opacity:

Layer opacity



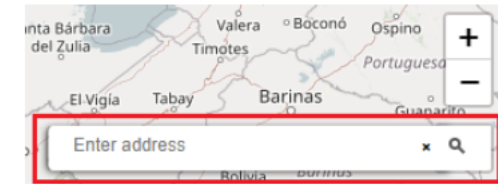
Download layer data in ESRI Shape and KML formats:



Measure distances and areas:



Enter address:



Zoom in, zoom out:



Enter coordinates:

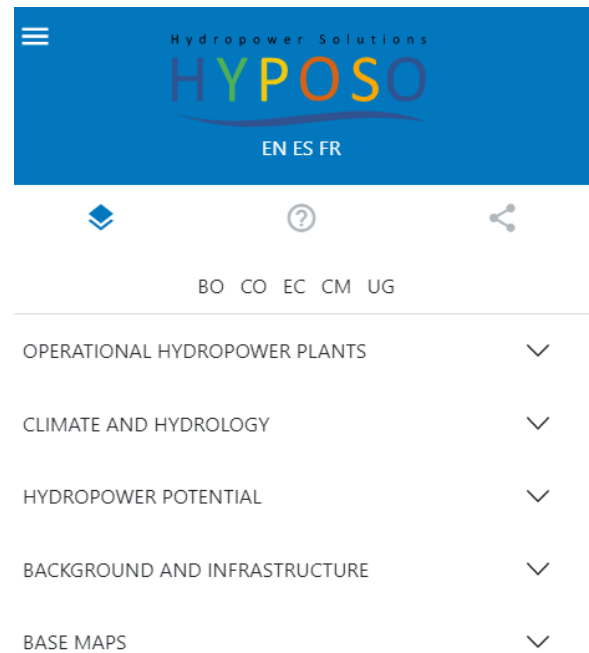


Use constraints: The estimates modelled or derived will not represent the actual numbers feasible for engineering design. It will be the users' sole responsibility to determine whether if any site is worthy for further investment.

Metadata



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857851.



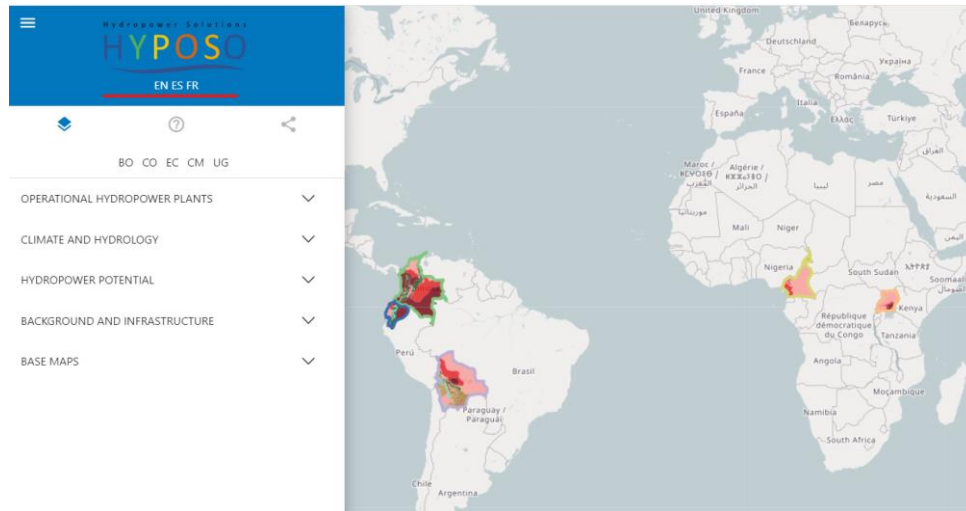
This virtual hydropower atlas will be only a kind of discovery automatically. It enables users to freely and instantaneously obtain the approximate information to guide them with decision-making around the likelihood of site development.

The estimates modelled and derived will not represent the actual numbers feasible for engineering design. It will be the users' sole responsibility to determine whether any site or river reach is worthy of further investment.

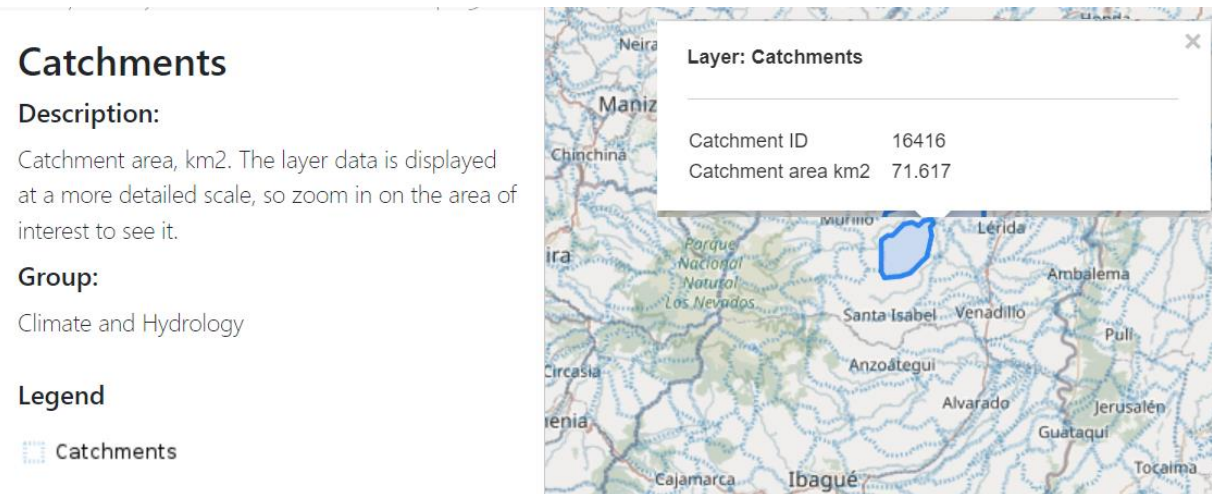
Spatial and other related inaccuracies of this assessment cannot be entirely avoided due to the nature of the input geospatial data.

4. RESULTS: Hyposo web-based interactive map

Frontpage of the HYPOSO web map viewer.



Generated small catchments (CO). A 71.62 square kilometres catchment boundary is shown.



The HYPOSO Map – a web-based platform, is an open-source GeoServer software. It allows users to input, process and publish geospatial data and supports data interchange from most spatial data sources using open standards.

Mean annual flow, m³/s (CO)

Mean annual flow

Description:
Mean annual flow m3/s. The layer data is displayed at a more detailed scale, so zoom in on the area of interest to see it.

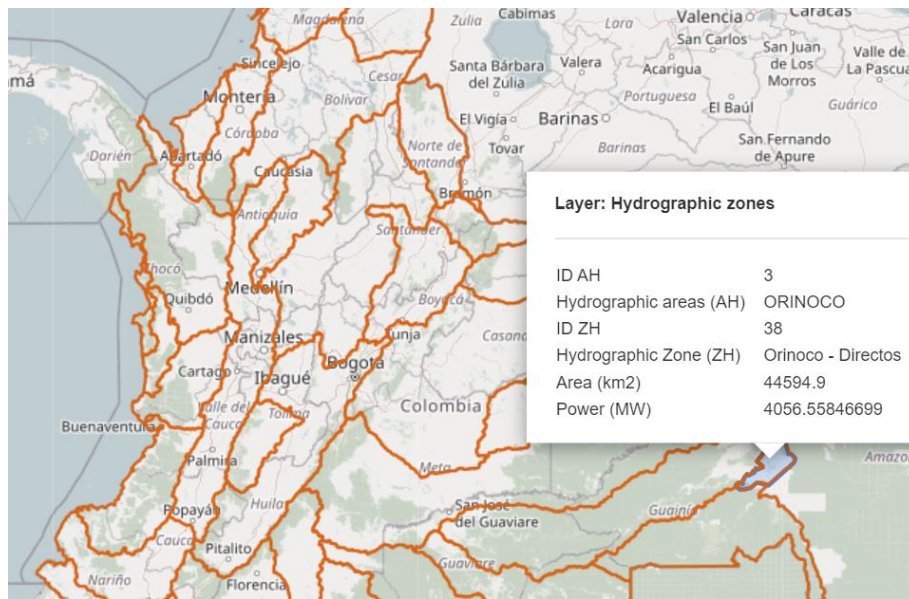
Group:
Climate and Hydrology

- Legend**
- 0 - 1
 - 1 - 10
 - 10 - 50
 - 50 - 100
 - 100 - 500
 - 500 - 1000
 - 1000 - 10000

fid	9957
GridID	14795
H_m	0.8
P_MW	0.10196195226
P_MW_km	0.01589423005
Length_km	6.41502935061
Country	Colombia
ISO	CO
A_us_km2	85.8186596859
A_ds_km2	95.8883000458
Q_us_m3_s	13.4235408484
Q_ds_m3_s	14.9944047445
Slope_m_km	0.12470714572
River	null
Riv_Order	2
Area_km2	10.0696403599
Env_sens	No
Exploited	null



HYPOSO Map



Layer: Hydrographic zones

ID AH	3
Hydrographic areas (AH)	ORINOCO
ID ZH	38
Hydrographic Zone (ZH)	Orinoco - Directos
Area (km2)	44594.9
Power (MW)	4056.55846699



Hydrographic zones

Description:
Hydrographic zones of Colombia

Group:

Legend

Layer: Gauging stations

Country	Colombia
Gauging Station ID	54017040
Gauging Station Name	TADO - AUT [54017040]
Station Type	Limnográfica
Measurement Technique	Automática con Telemetría
Current State	Activa
Year Opened	8/15/1973
Datum (m)	95
Latitude	5.265
Longitude	-76.563
Department	Chocó
Municipality	Tadó
Hydrometric Area	Area Operativa 09 - Cauca-Valle-Caldas
Hydrographic Area	Pacífico
Hydrographic Zone	San Juan
Hydrographic Sub-zone	Rio San Juan Alto
Location	San Juan

Gauging stations (CO)

River basins/Hydrographic zones (CO)

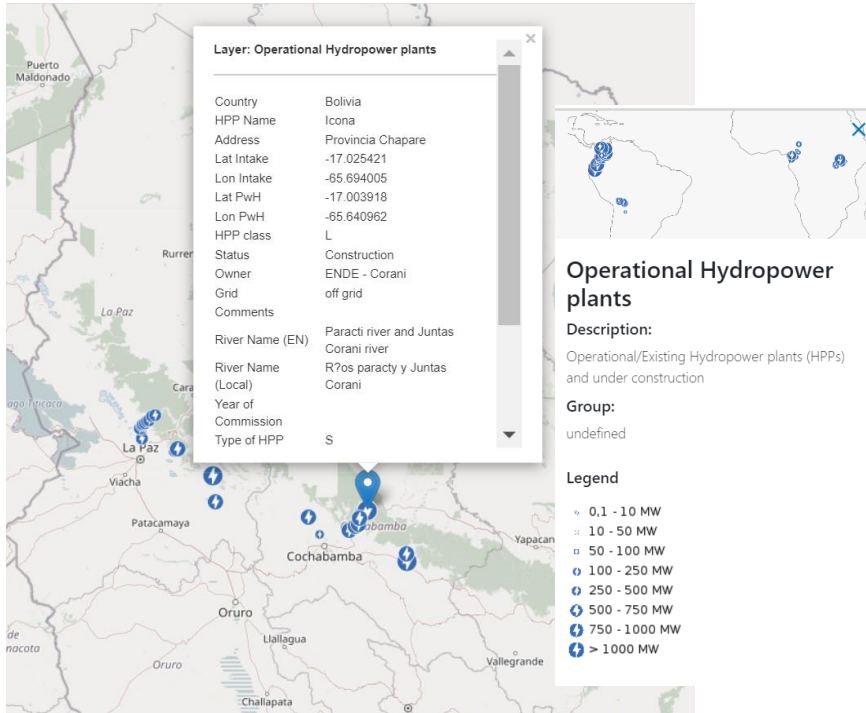


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HYPOSO Map

Operational hydropower plants (BO)

Theoretical potential of a river reach (new stream-reach development) with a pop-up providing a brief description

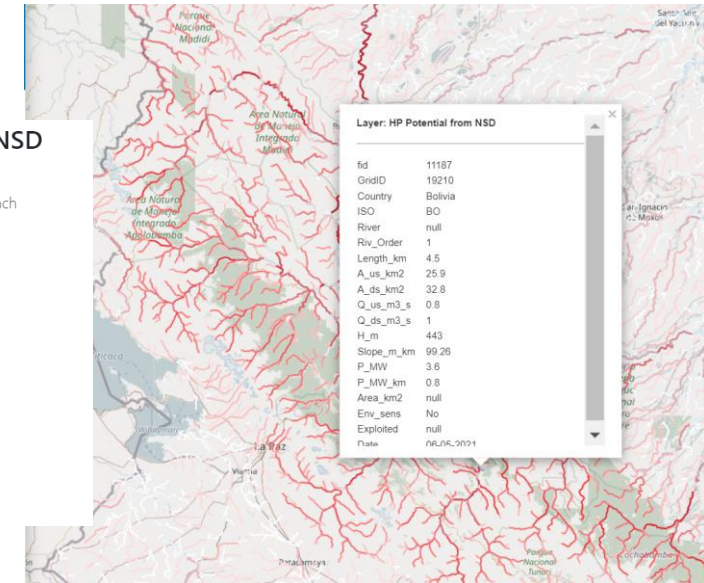


HP Potential from NSD

Description:
 HP Potential from New Stream-Reach Development (NSD)

Group:
 undefined

- Legend**
- 0.0 - 0.1
 - 0.1 - 1.0
 - 1.0 - 5.0
 - 5.0 - 10.0
 - 10.0 - 50.0
 - 50.0 - 100.0
 - 100.0 - 1500



Available geospatial data sets can be explored and visualised by zooming, panning, and clicking on the map layers or icons to open the legend to this map. There is also a possibility to download the geodata in KML or Shapefile format.

TARGET:

the HYPOSO Map includes information for 2,500+ **potential sites** (non-powered dams/weirs, new-stream reaches):

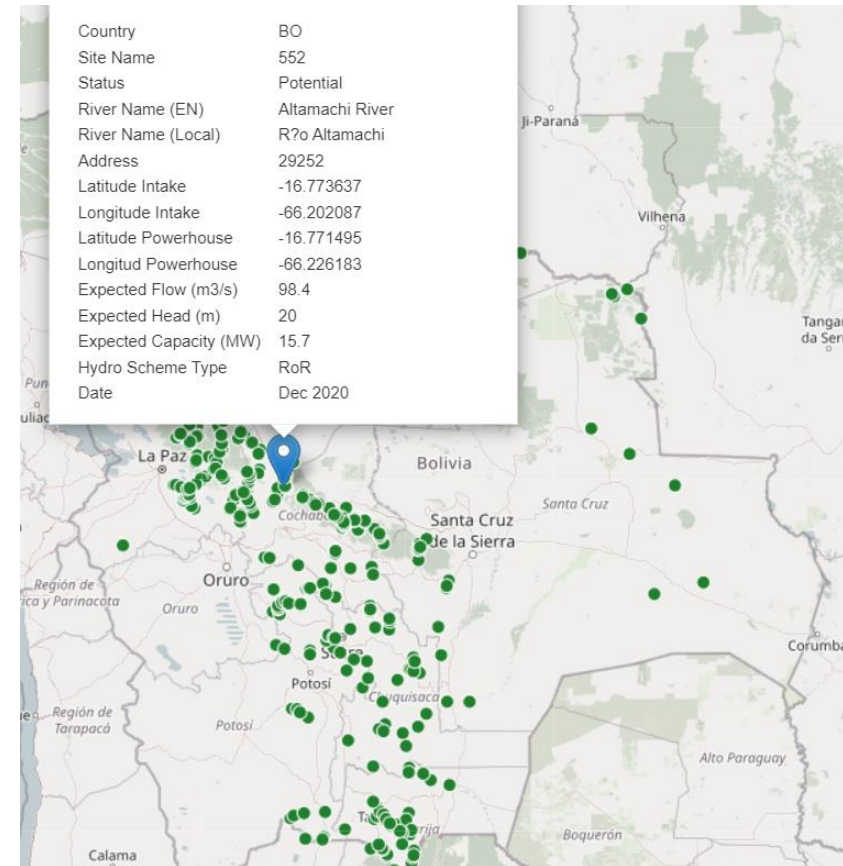
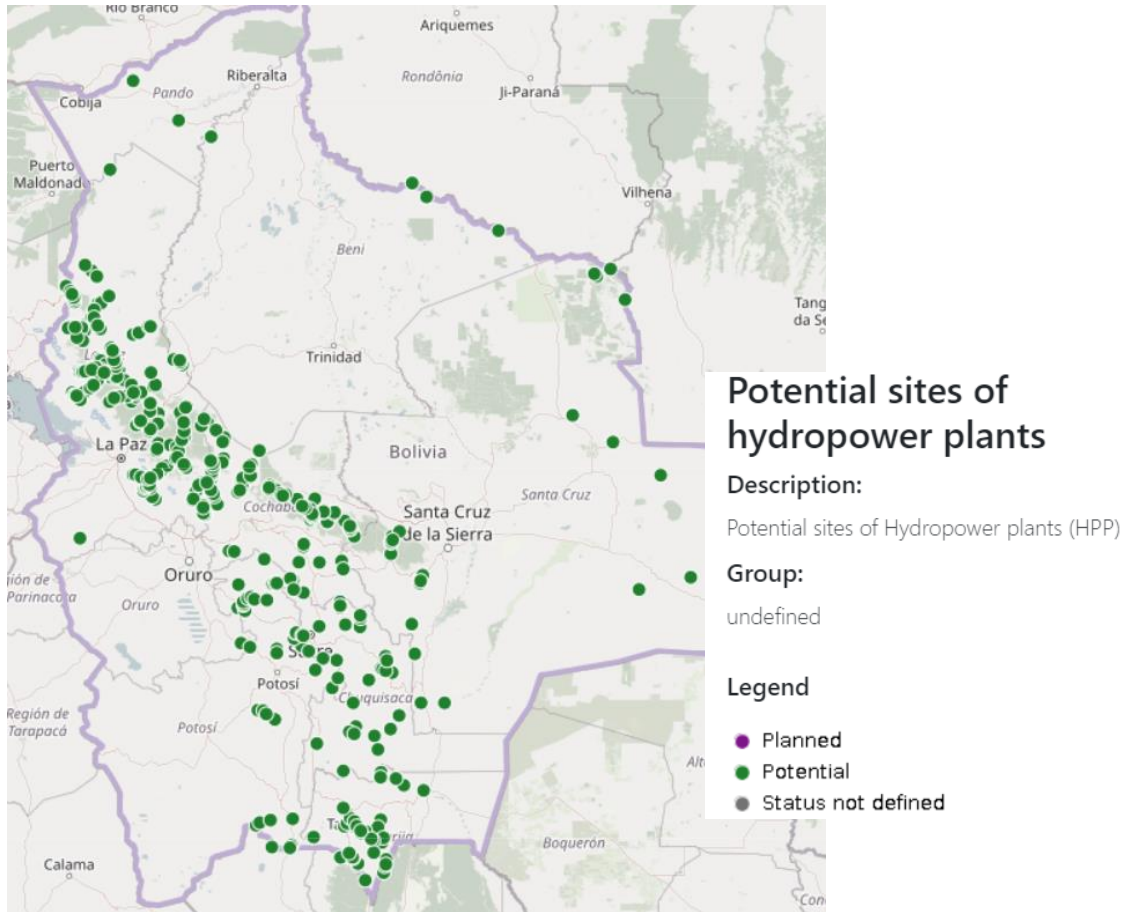
- Bolivia – 475+,
- Cameroon – 500+,
- Colombia – 500,
- Ecuador – 475+,
- Uganda: – 475+



Basic features

- Site type (e.g., run-of-the-river, reservoir, off-grid, or central grid);
- Address, stream name, basin (hydrologic unit, water management district), coordinates;
- Approximate capacity (MW), flow, and head;
- Environmental sensitivity (e.g., protected areas);
- Any opportunities for development (e.g., prior studies).

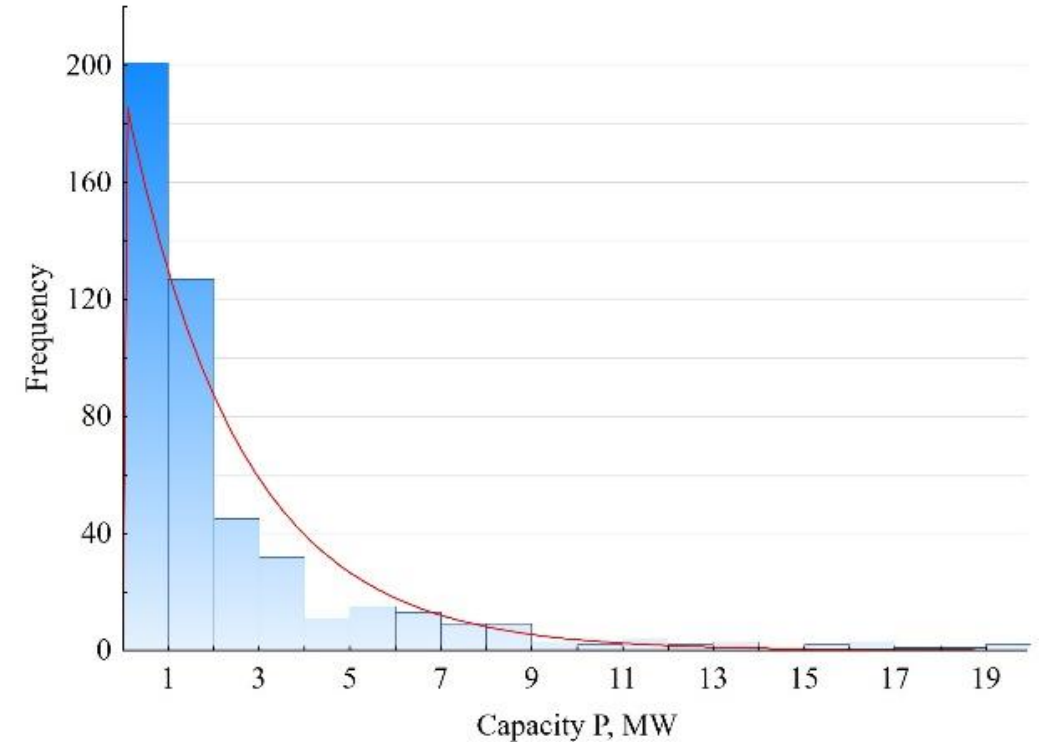
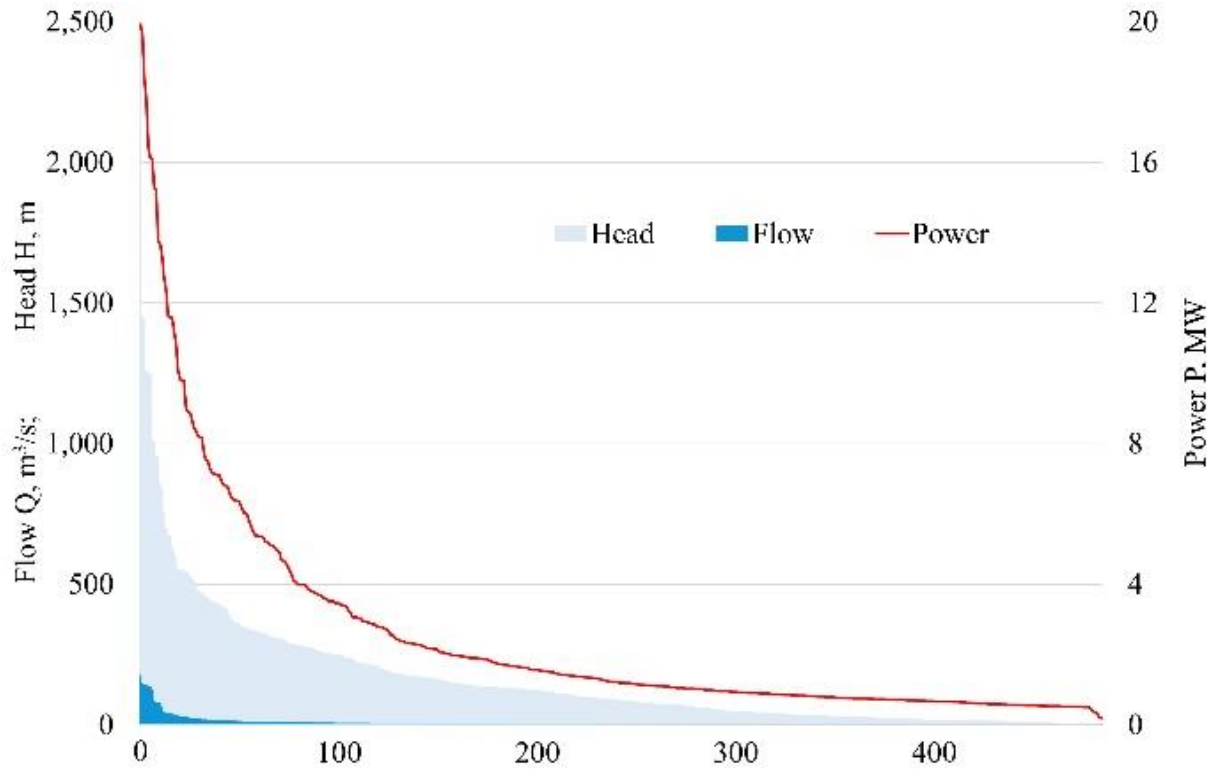
HYPOSO Map



Potential hydropower sites (BO).

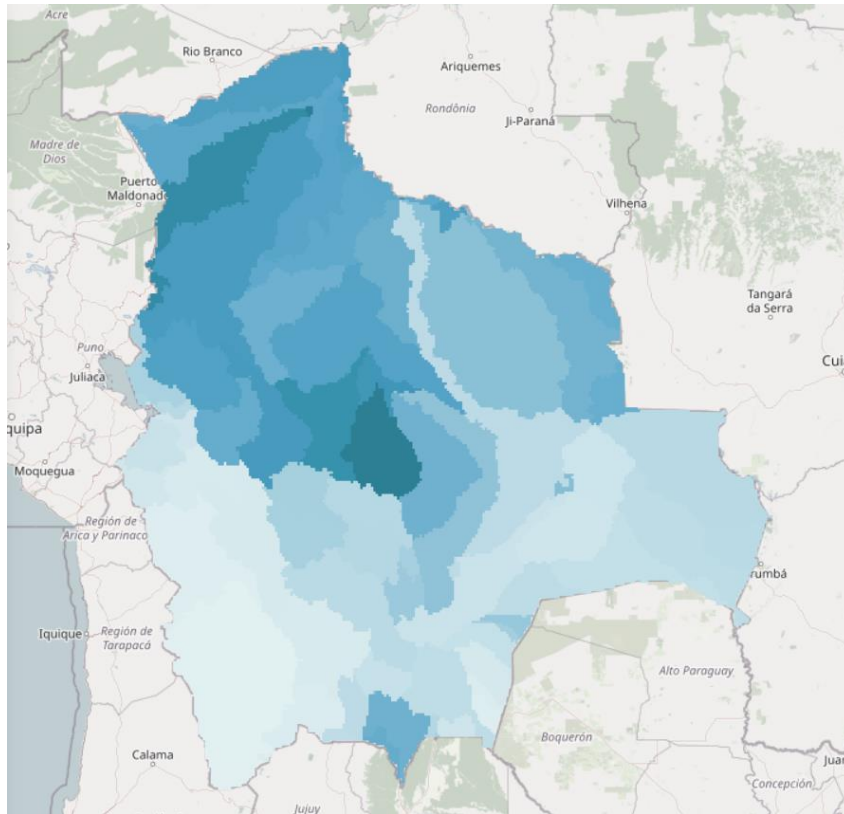
A pop-up providing a brief description.





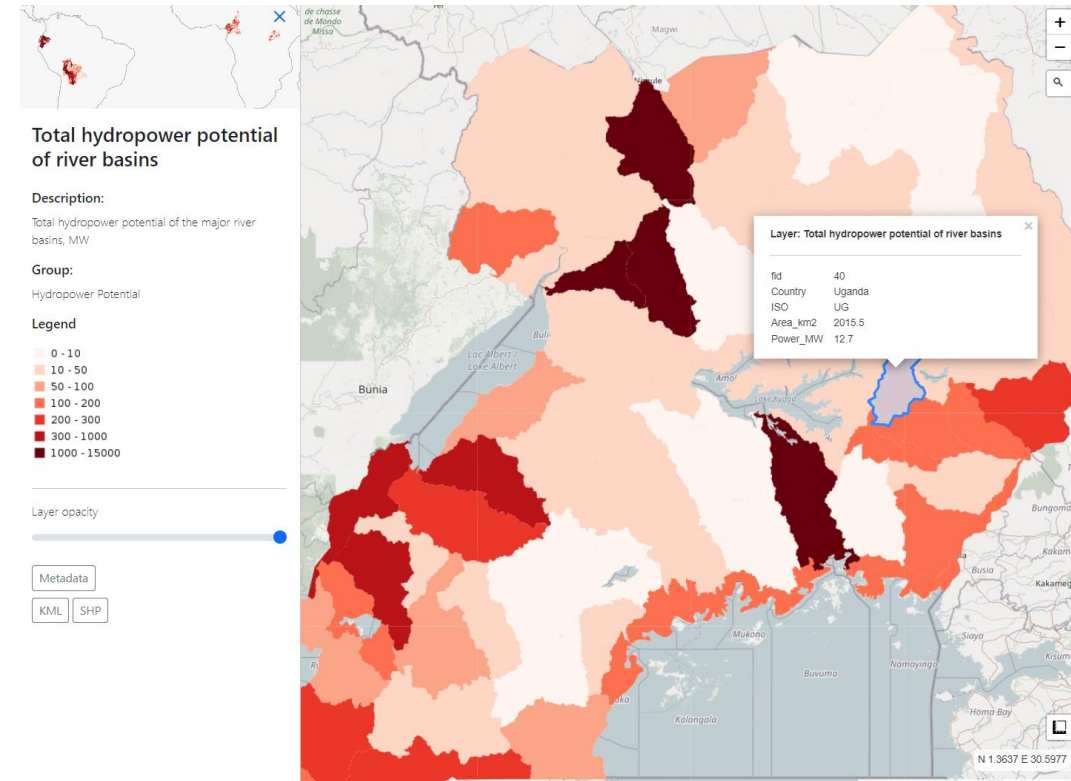
Key characteristics of the potential hydropower sites at large (L) and their frequency distribution density of capacities ($P < 20$ MW) in Uganda (data extracted from the HYPOSO Map datasets)

HYPOSO Map



Specific discharge (BO)

To characterise the mean annual river flow, the specific discharge ($l/s \cdot km^2$) was mapped



Total hydropower potential of the river basins (UG)



Concluding remarks

- ❑ Hydropower atlases (web-based maps) based on GIS can be only a kind of discovery, identifying sites automatically. In doing so, the pre-/feasibility assessment would be much quicker and affordable.
- ❑ The estimates modelled and derived will not represent the actual numbers feasible for engineering design. It will be the users' sole responsibility to determine whether any site or river reach is worthy of further investment.
- ❑ Minor refinements are still needed (text editing, proof-reading, copyright permissions, bugs and other updates).
- ❑ The HYPOSO Map is available on the HYPOSO project website:
<https://www.hyposo.eu>





Thank you!

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www.hyposo.eu



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