River Hydro-Potential & Selection of Possible Hydropower Sites Using Open Source Software and Open Data

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Presentation Outline

- Research objectives
- Use of OS software and open data
- Methodology
- Use of QGIS
- Use of graphical modeler for spatial query
- Results / Outcomes
- Demonstration of spatial query model

Research objectives

General Objectives:

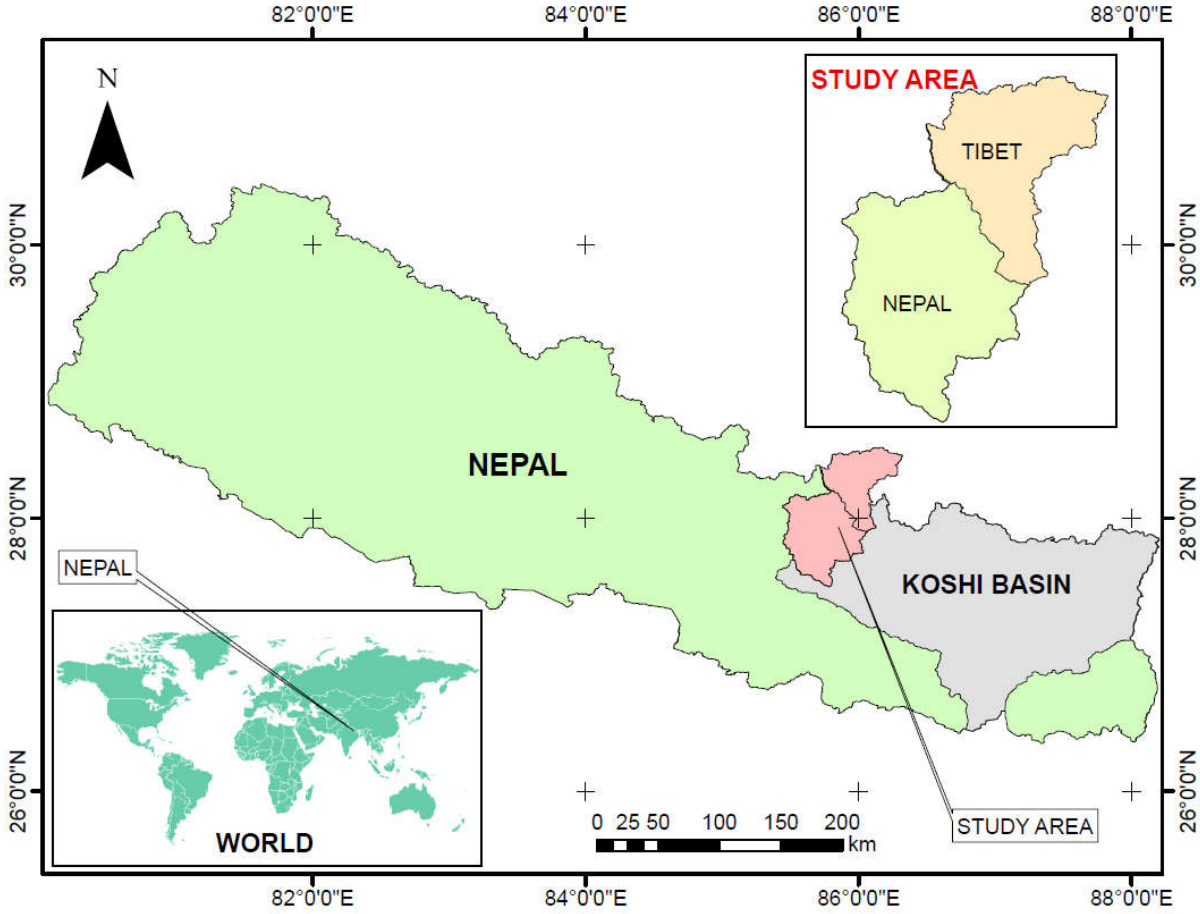
To determine river hydro potential of a region of interest and to locate possible hydropower sites.

Specific Objectives

1. To build a methodology that uses open source software and open data to assess river hydro potential.
2. Study of potentially restricted sites and superimpose it over a study area to calculate feasible hydropower potential.
3. Assessment of pixel based and specific hydro potential of a river.
4. Generate flow duration curve at every pixel of a stream.
5. Identification of possible RoR and reservoir hydropower sites.

Study Area

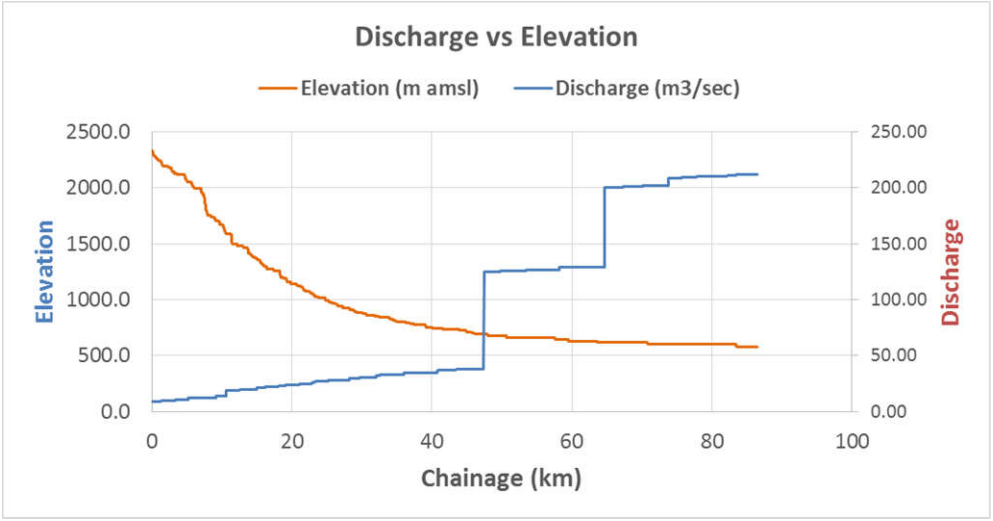
- Lies in the **Koshi Basin** of Nepal.
- Transboundary basin originating from high Himalaya at Tibet and draining into Ganga in India
- Study area is approximately 5000 Sq. km out of which ~40% of area lies in Tibet and remaining area lies in Nepal
- Only a stretch of river is studied for power potential assessment

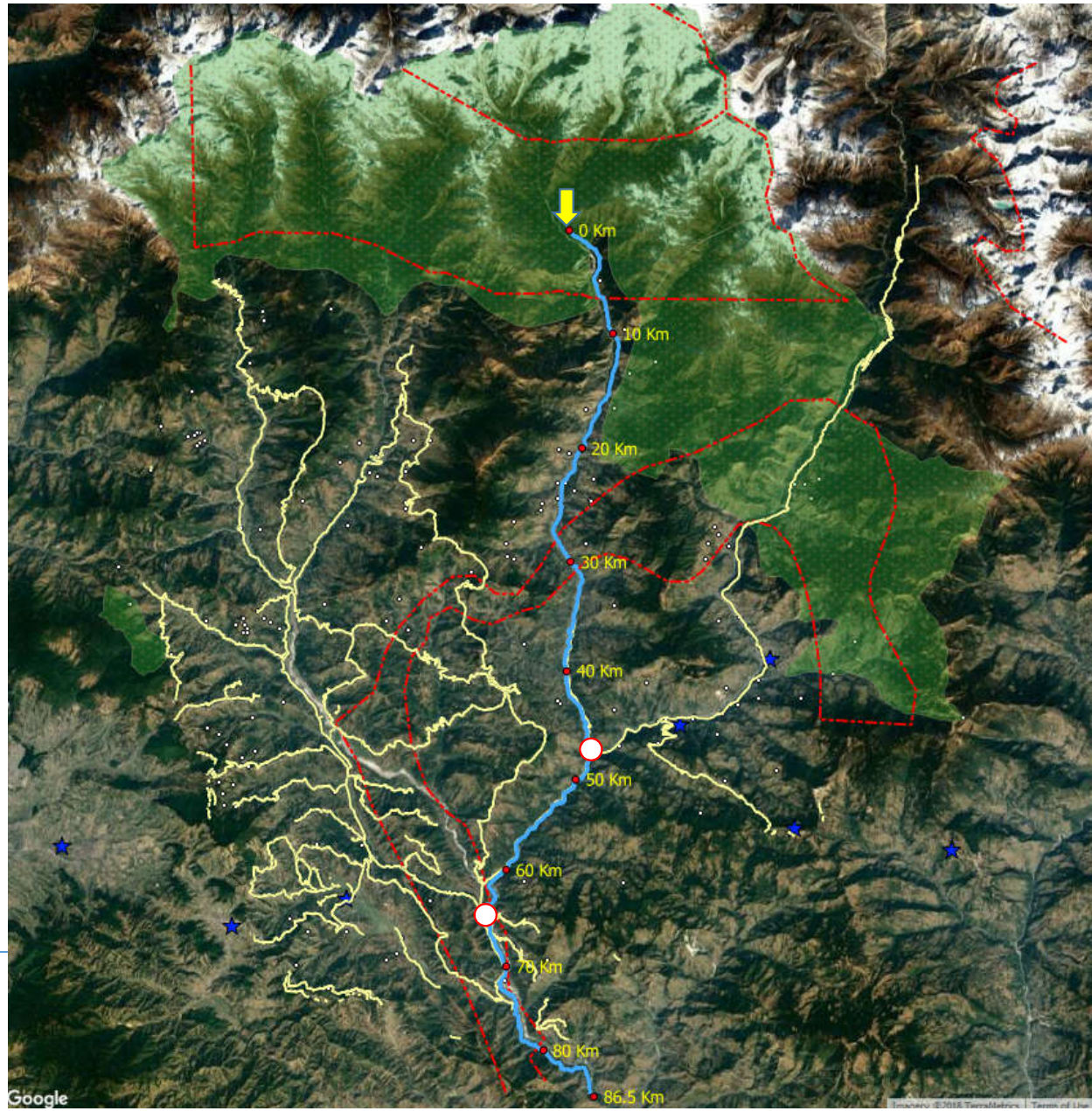


Study Area

Length of river considered: **86.5** km
Elevation: **2334** amsl to **576** amsl
Discharge (Q40%): **3.41** m^3/s to **122.45** m^3/s

Total pixel along river: 2465 (30 m x 30 m)
Feasible pixel for power: 1746 (~**70%**)





Methodology

1. Hydrology

- **PCRaster library in python** to accumulate rainfall along stream
- **APHRODITE** and **TRMM** open rainfall product

- Runoff generated from open rainfall data is corrected with gauged discharge
- Development of FDC at every pixel, Q40% PoE as design discharge

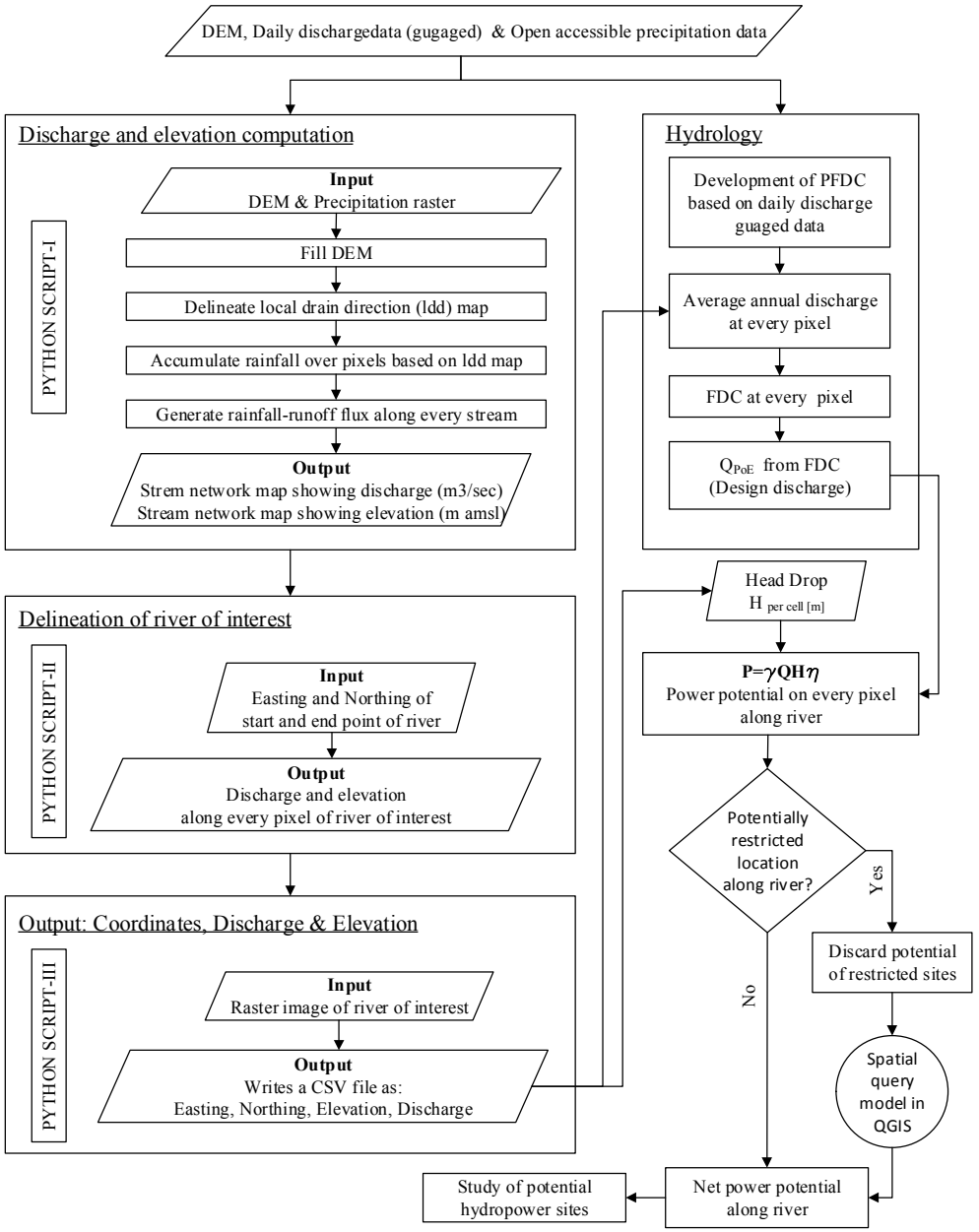
2. Power Potential assessment

- Elevation is extracted from DEM
- Grid based power potential assessment

3. Study of restricted sites

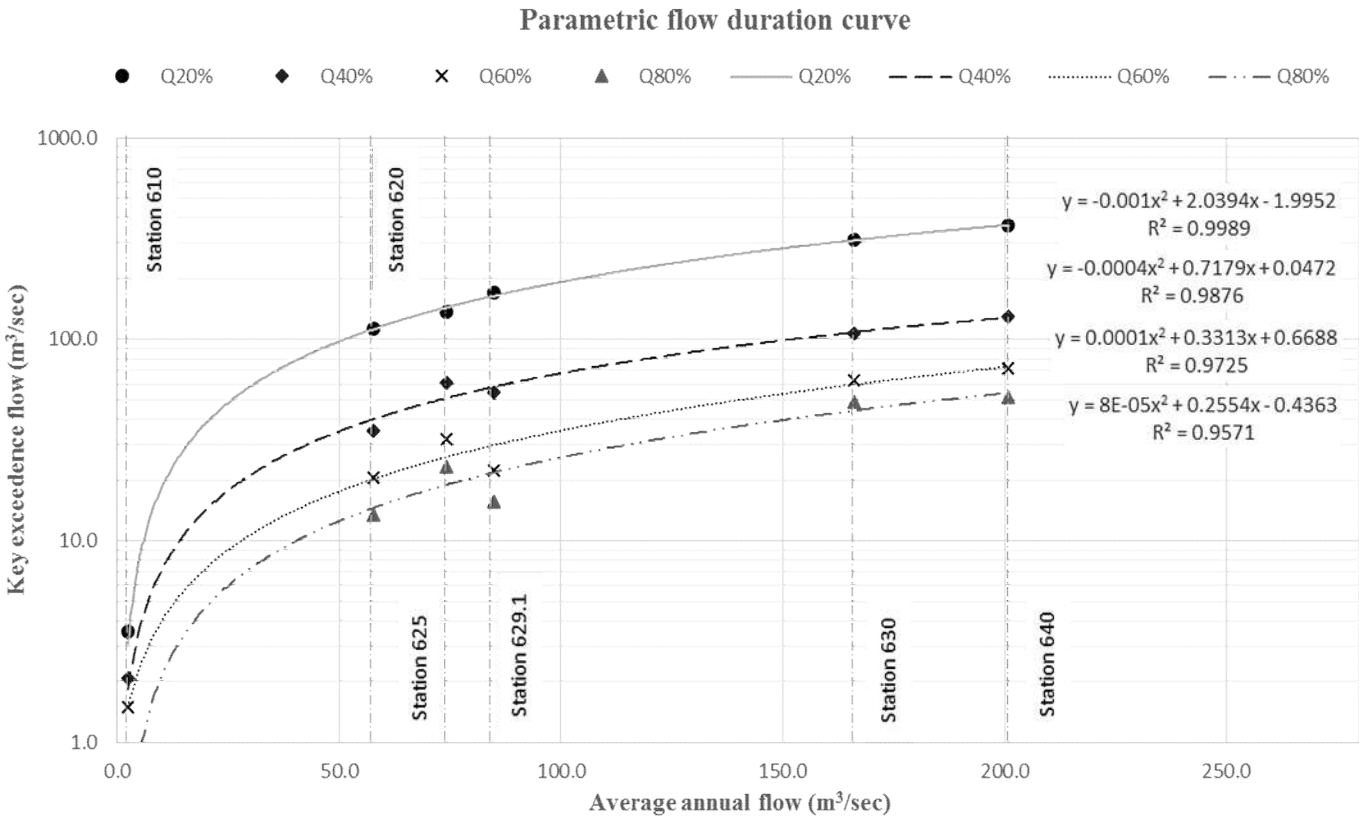
- Graphical modeler in QGIS

4. Site Spotting



Hydrology: PFDC

- Plot of average annual discharge vs key exceedance flow measured at discharge measuring station.
- Average annual runoff from open rainfall data >> corrected with gauged discharge data
- Corrected average annual discharge data is used in equations for different PoE flow
- Q40% PoE as design discharge.



Graphical Modeler in QGIS : Spatial query model

Purpose

- Screen the restricted location
- Select feasible locations for hydropower production.

Input…

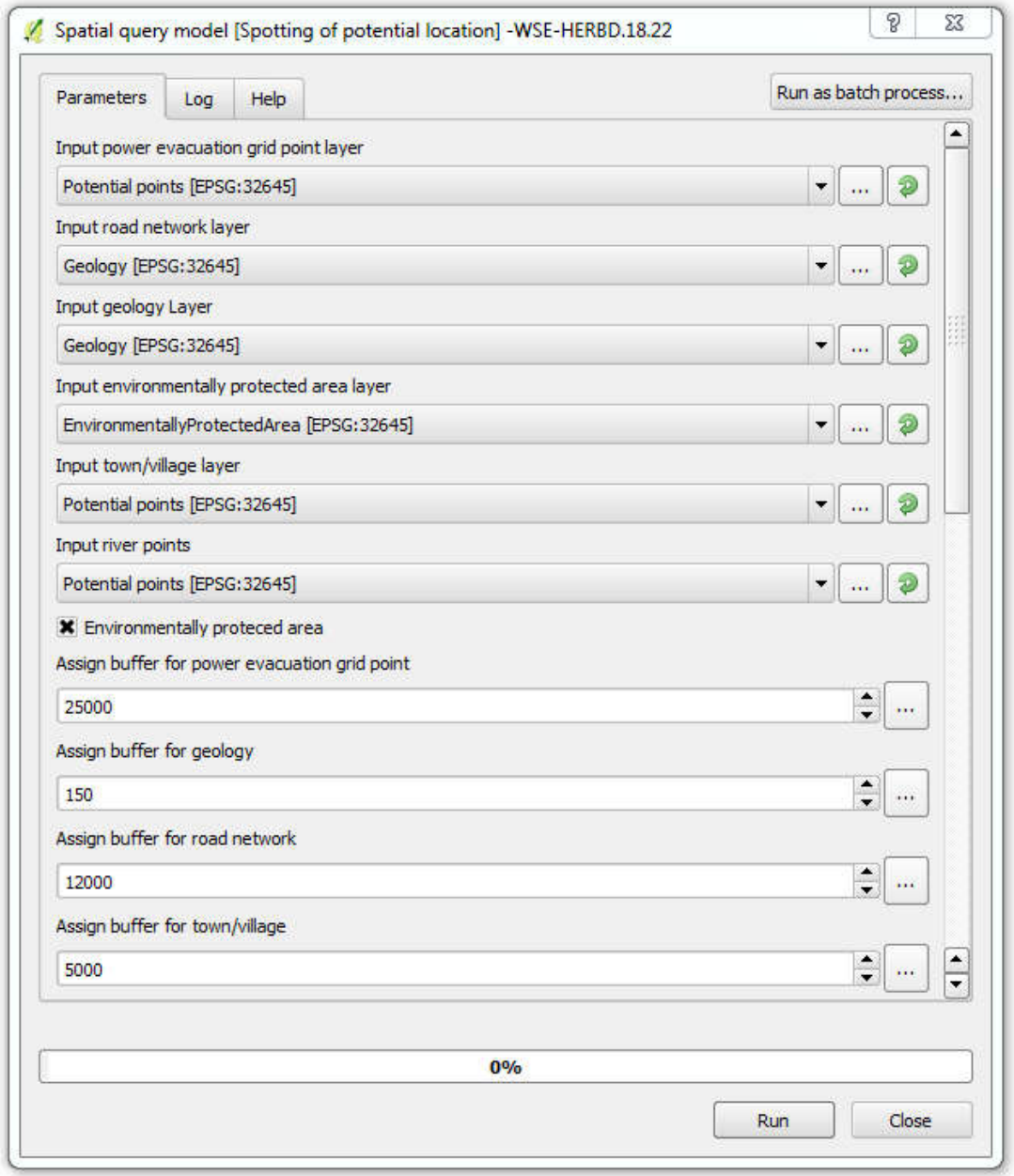
- A shape file with series of points representing river,
- Shape files of constraints (Geology, PA, Accessibility…)
- Buffer distance

How it work…

- Uses algorithms included processing toolbox of QGIS to execute series of vector overlay operations.

Output…

- A layer file containing points that are feasible for developing hydropower plant



Graphical Modeler in QGIS : Spatial query model

Input criteria layers

To be a feasible for power potential assessment, the location:

- **Should be accessible to**
  1. Power evacuation grid point (Transmission line)
  2. Road network
  3. Village/Town (Consumers)

- **Should not lie in**
  1. Geologically vulnerable area
  2. Environmentally protected area

Fixed distance buffer used in this study:

S.N	Layer (.shp in same projection, EPSG:32645)	Buffer distance	Criteria
1	Power evacuation grid point	25 km	Should lie within the buffer
2	Road network	10 km	Should lie within the buffer
3	Town/Village	5 km	Should lie within the buffer
4	Geologically vulnerable area	150 m	Shouldn't lie within the buffer
5	Environmentally protected area	-	Shouldn't lie with in the area

Spatial query model in QGIS

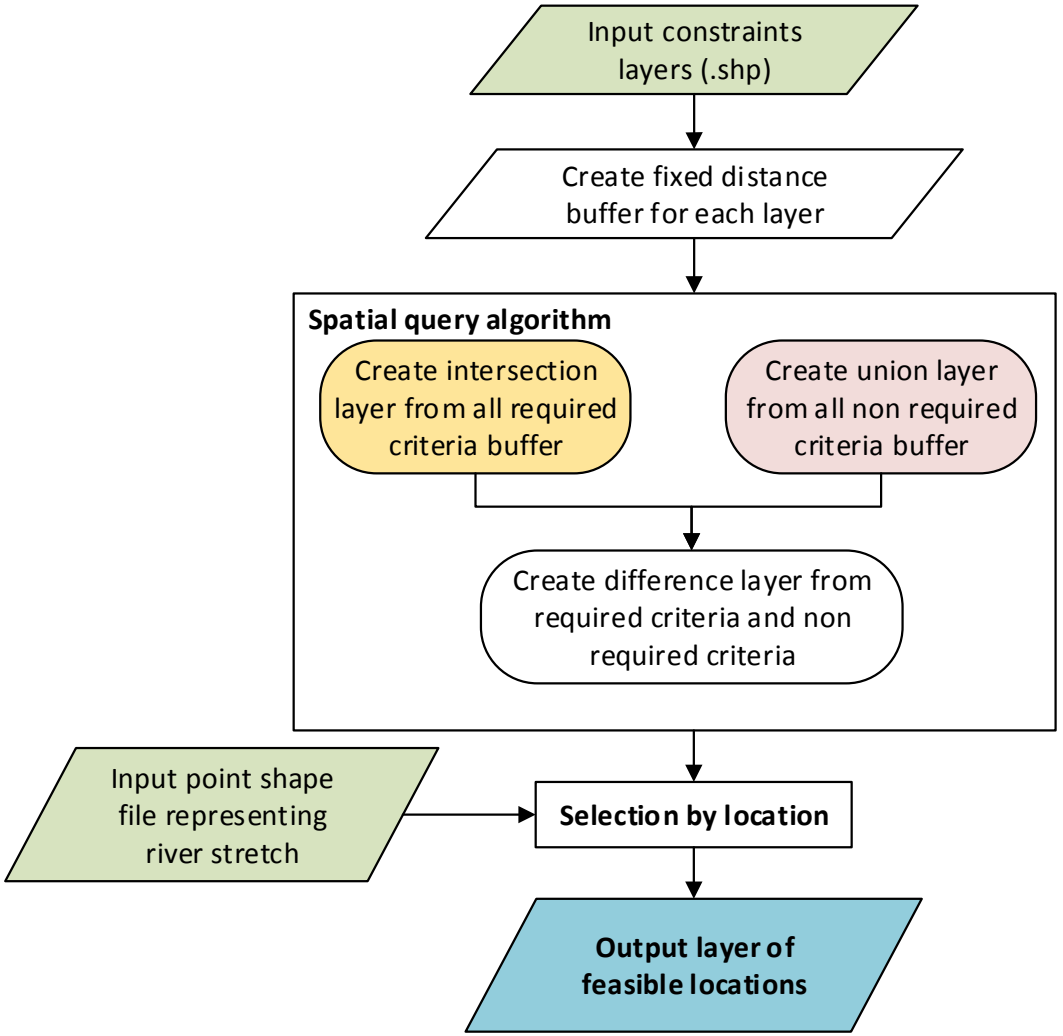
How does this work…

Vector overlay operations

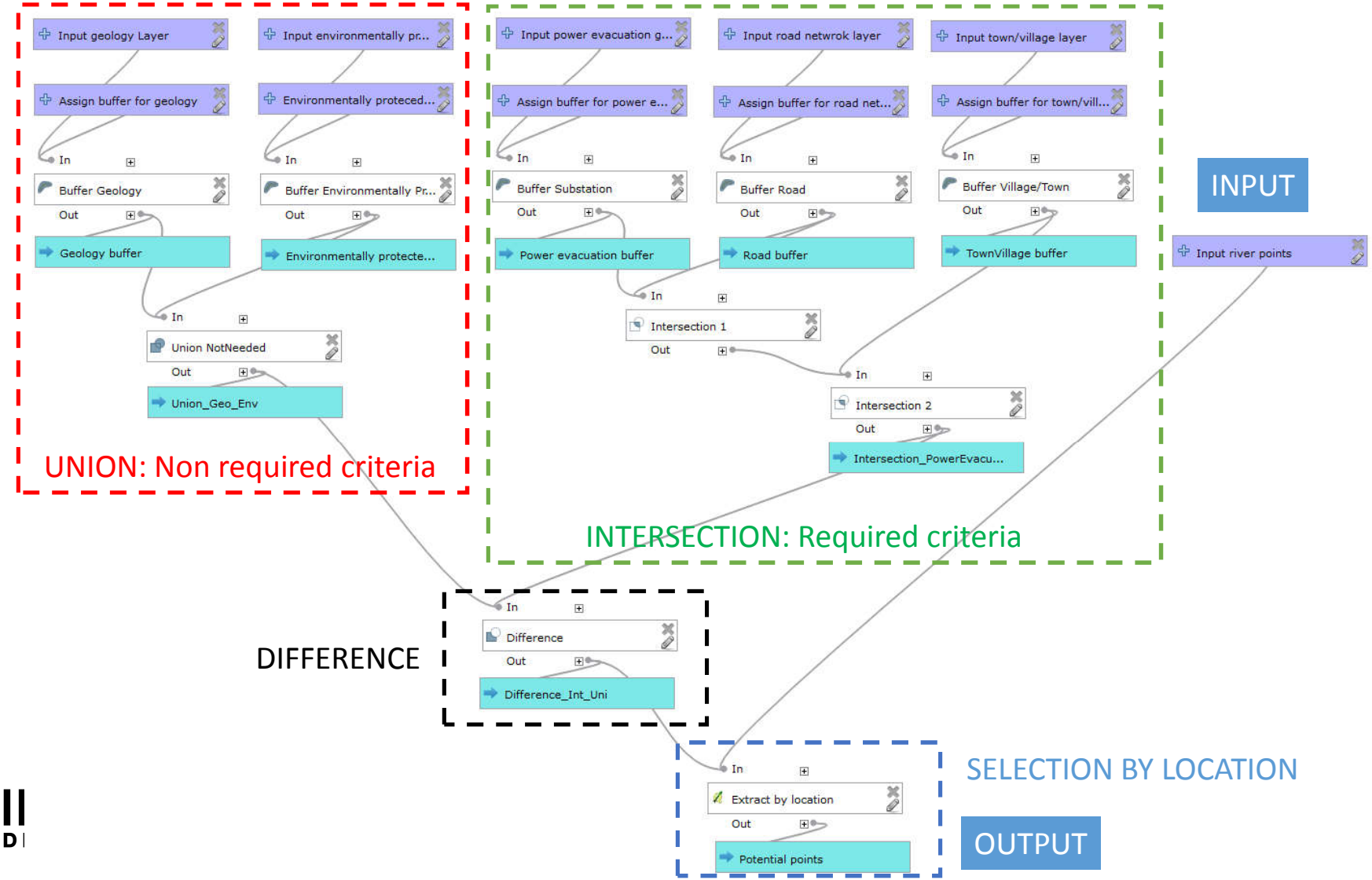
- Fixed distance buffer for constraints layers
- Intersection for required criteria
- Union for non required criteria
- Dissolve &
- Difference layer

Selection by location

- Points that lies within the buffer of all required criteria and at the same time does not lie in either one or both of non required criteria >>>>**feasible location**



Algorithm: Spatial query model in QGIS



Open data used in spatial query model in QGIS

Open Data source:

Digital elevation model

ASTER DEM (30 m x 30 m) (https://earthexplorer.usgs.gov)

Geology:

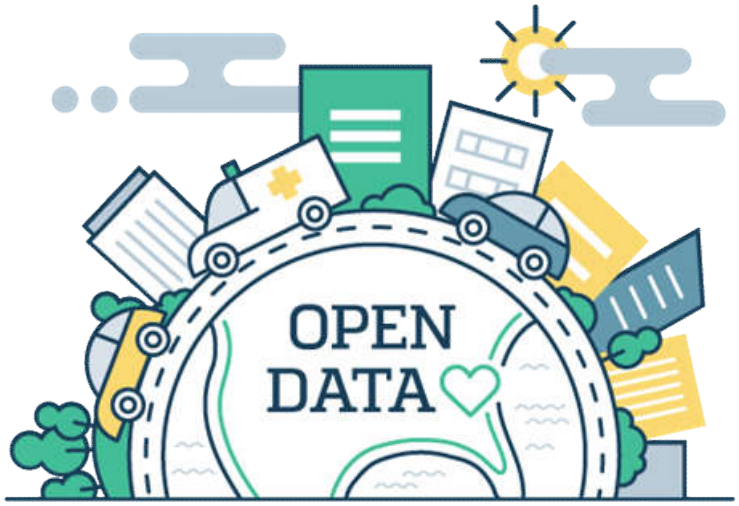
USGS (World Ecology) Database (https://rmgsc.cr.usgs.gov/outgoing/ecosystems/Global/World_Ecological_2015.zip)

Environmentally protected areas:

Global statistics from the World Database on Protected Areas (WDPA), UNEP-WCMC (2017).

Road & City/Village:

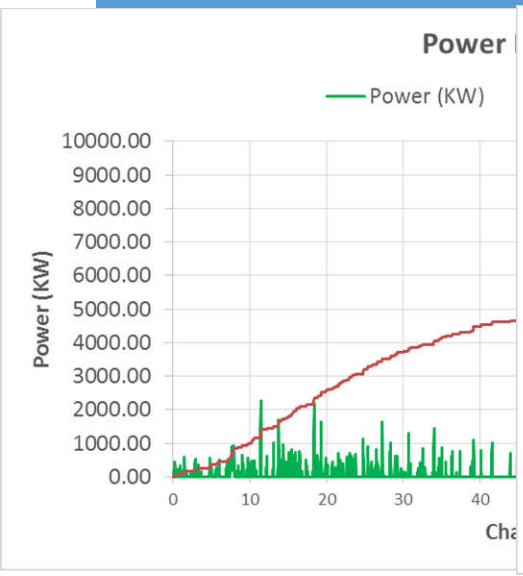
OpenStreetMap (https://www.openstreetmap.org)

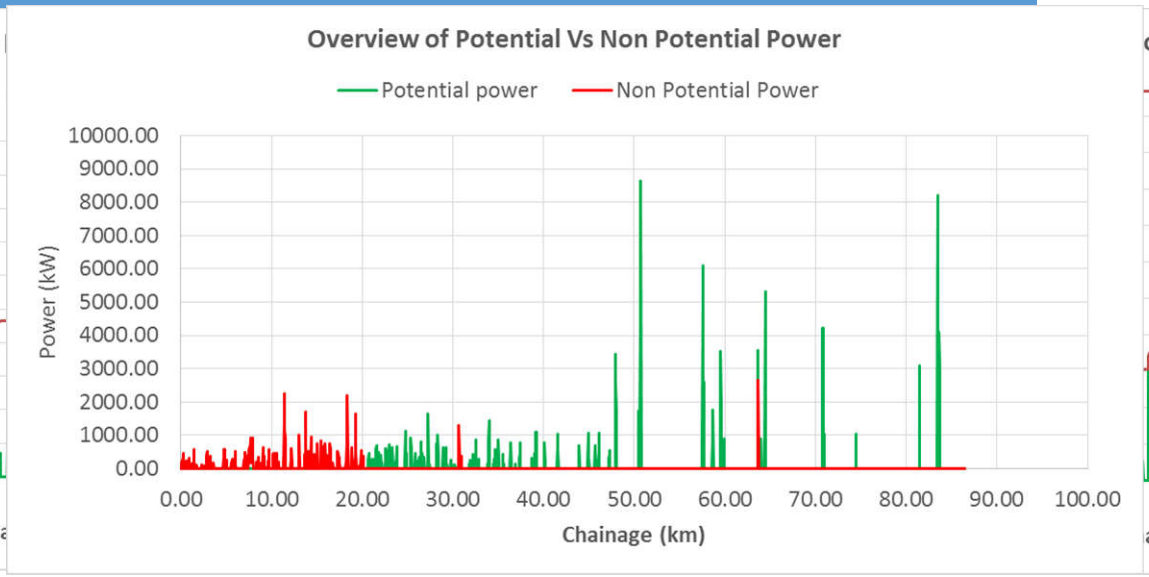


Power Evacuation Grid point (Transmission line):

Country specific database (not open data)

Power Potential Overview : Based on Aphrodite Data and TRMM Data





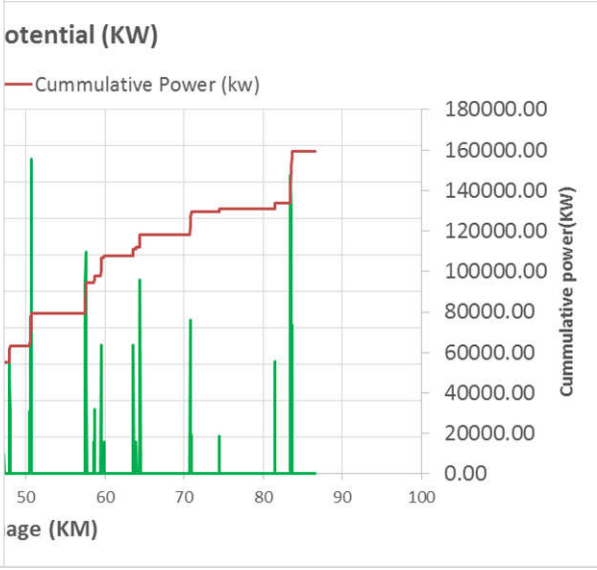


Fig I : Overview of power potential before screening of restricted sites

Fig II : Overview of power potential after screening of restricted sites

DESCRIPTION	Units	Aphrodite	TRMM
Power before screening of restricted sites	MW	229.60	218.27
Power after screening of restricted sites	MW	159.43	154.01
Specific Power before screening of restricted sites	MW/km	2.65	2.52
Specific Power after screening of restricted sites	MW/km	1.84	1.78

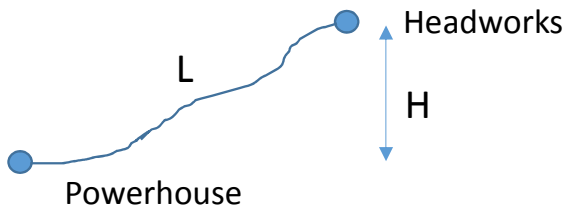
Site Selection

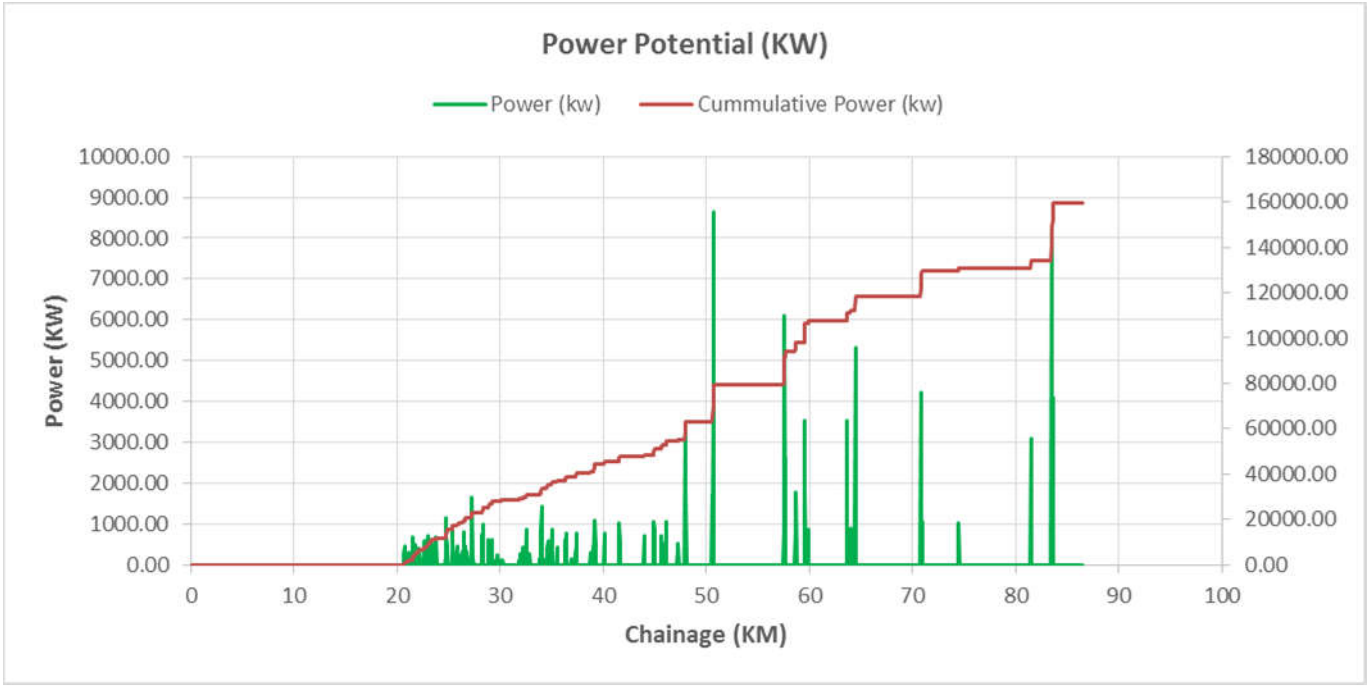
1. Look for area with higher power potential confinement

2. Calculate power (kW) & specific power (kW/m) for attractive Headworks- Powerhouse configuration

3. Look for combination with higher specific power

Specific power = $\gamma QH\eta / L$

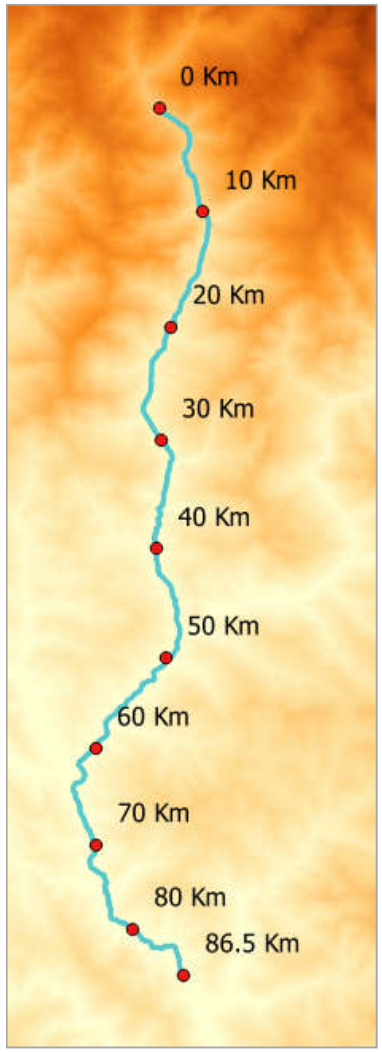




Some useful plugins….

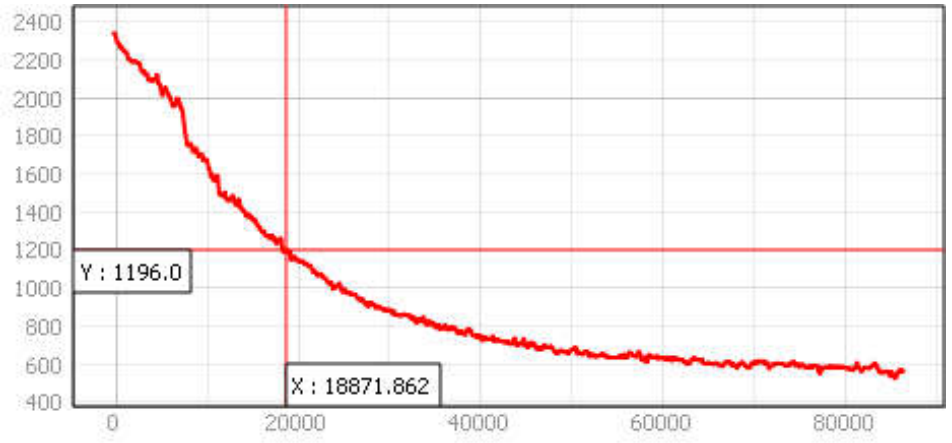
Qchainage

- Can be used to create chainage along River/ Tunnel/ Road/ Waterways

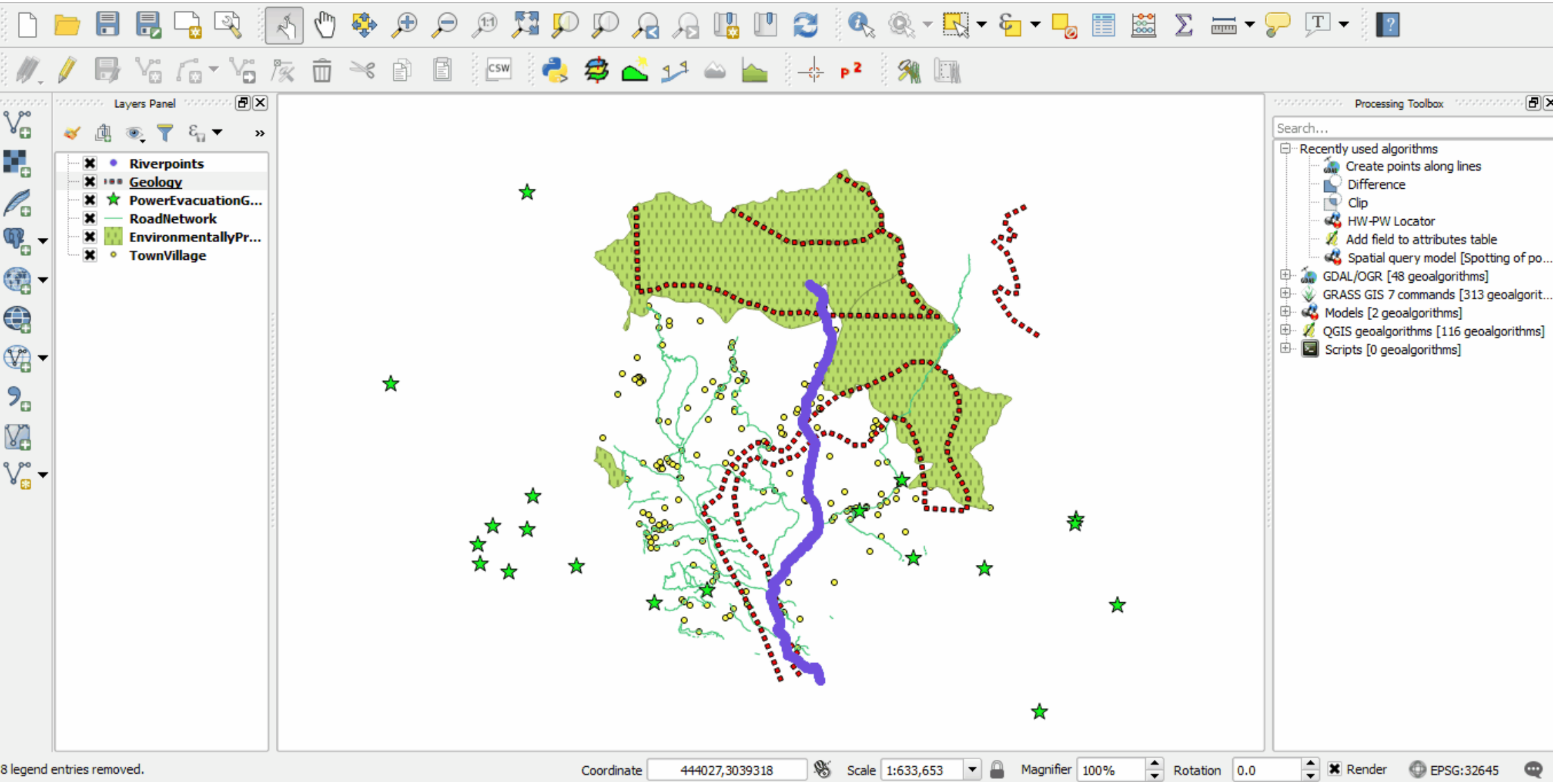


Terrain Profile

- Can be used to generates topographic profiles



Demonstration of graphical model



Thank You