GIS approach for rural electrification

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Geographical Information System (GIS) data are gaining importance in the field of rural electrification. Modern tools exploit the potential of georeferenced information to study the optimal electrification strategy in wide areas, choosing among centralized and decentralized solutions [1], [2], [3]. However, the tools are often very generic and use simplified assumptions to deal with a huge quantity of data.

The authors propose a holistic geospatial based procedure that overcomes the limit of available literature, by autonomously performing electric network design processes and optimal energy strategy planning.

The proposed procedure is composed by different steps, it allows to design the optimal distribution grid topology in non-electrified rural areas and to define the best solution among connection to the national grid, microgrid installation or electrification with off-grid systems. The procedure has been coded in Python and tested with the real case study of Namanjavira province, in Mozambique, thanks to the collaboration with the ngo COSV.

Chosen a defined case study area, GIS based data, related to energy resources, load distribution and terrain characteristics are collected and combined together. The territory is subdivided into a regular grid of points, at a distance equal to the desired resolution, and to each point are assigned all the characteristics relative to its location (e.g. population, elevation, distance from road). The information is useful to identify a weighting factor, which represents the cost of connecting each point with electric grid lines, e.g. points on rivers, mountains or situated in thick forests have a higher penalty cost The population density in each location can be used as a proxy indicator of the geographical distribution and intensity of the future energy demand. The **spatial clustering** algorithm **DBSCAN** is applied to identify areas (clusters) with higher population density and sparse populated locations (outliers). The outliers are locations that are suited to be electrified with off grid systems.

LoadProGen tool and Homer are then used to respectively find the energy demand of each cluster and the optimal microgrid size [4].

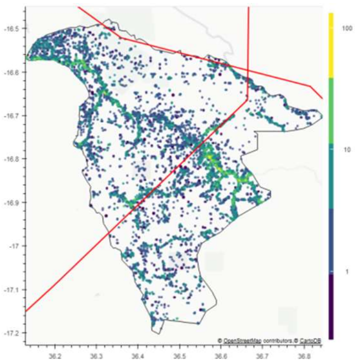

Figure 4 Population distribution in Namanjavira

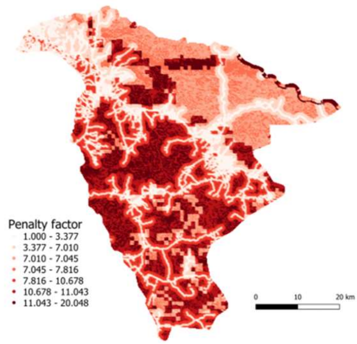

Figure 5 Penalty factor distribution in Namanjavira

The **optimal distribution grid topology** is designed for each cluster, using graph theory algorithms. An innovative procedure, which is a combination of **Kruskal** and **Dijkstra** algorithms, is used to connect populated points passing by convenient routes, such as roads, and avoiding difficult paths. The connection cost of each cluster to the nearest national grid primary substation is also evaluated.

As a final step, the LCOE of microgrid, comprehensive of the distribution grid cost, is compared to LCOE of national grid connection and the best electrification solution, the one with lowest cost, can be defined.

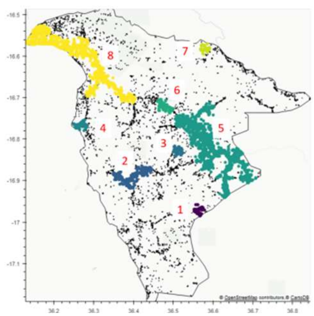

Figure 6 Clustering process

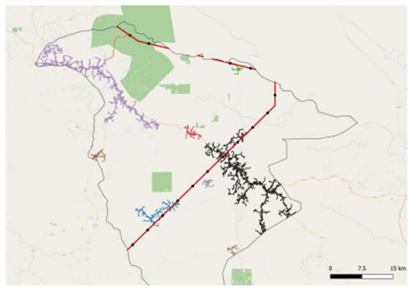

Figure 7 Grid routing output

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