Geospatial analysis on rural settlements electrification and scaling up strategies in Rwanda

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Abstract—The electrification target in 2017 to be at 70% of the whole population has a special focus in rural areas where the target is to have 70% of rural settlement sites living in viable and sustainable settlements and this will go in line in promoting the energy use for sustainable development in integrated model villages, in this paper the model for electricity distribution either on grid or off grid are discussed where the plans show the coverage for Rwanda is almost the whole country expect the hilly mountains and the wetlands regions, considerations for settlements electrifications are analyzed based on their relative location compared to the neighborhoods and the infrastructure in place, the spatial analysis is also done based on the settlements relative location to the existing and planned grid of electricity.

Cases studies in 4 provinces have been chosen based on their particular best practices and challenges present in that particular region, a geospatial analysis have been done on the patterns of these settlements and their electrification best practices models. Challenges in electrification for unplanned settlements are discussed.

It has been found that there are settlements which are not electrified yet they are closer to the grid, a quick fill in strategy is recommended where branches at local level will connect the households nearby and speed up the process.

As general recommendation the electrification direct fill in has been the recommended method to fast track the electrification process as well as the improvement on the planned settlements patterns to respect the demarcated areas.

Keywords—Geospatial analysis, Rural electrification, rural settlements, Rwanda, human settlement, Integrated Development program, settlements patterns, Geographic Information Systems

I. INTRODUCTION

The Integrated Development Program (IDP) is a model, pilot project for the promotion of integrated socio-economic development in Rwanda. It seeks to reduce poverty and promote growth and human development in the target areas (UNDP, 2009). The IDP model villages have been introduced in Rwanda as an innovative approach to sustainable settlements planning and developments with aim to fully implement The Integrated Development Program, IDP model villages have eleven pillars, the main pillar at the center being proper human settlement planning and among other pillars the efficient land use, Land consolidation, off farm activities promotion, ICT promotion, cooperatives promotion, improved agriculture. Renewable energy uses, youth promotion use of biogas.

This have been reiterated in the fact that proper Human settlement planning and efficient land use is a key Government program as it features as one of the four pillars of Rwanda Economic Development and Poverty Reduction Strategy sector priorities (EDPRS 2, MINECOFIN, 2012-2017).

In the area of human population settlements, the National Human Settlement Policy of 2009 (MININFRA, 2009) lays out the basis for planning resettlement of populations for improved service provision, particularly for people from the mountainous areas. The policy outlines the importance of orderly population settlement in Rwanda, spelling out the benefits of improvement of access to social services where people live closer to each. This eases planning for the provision of services including health care, education, water and sanitation, electricity, and other infrastructure thus enhancing the possibility of improved quality of life and meeting the Vision 2020 and EDPRS targets (70% of the whole population will be supplied with electricity by 2017) and MDGs (Millenium Development Goals) as well as SDG (Sustainable Development Goals) on making cities and settlements safe as well as on energy promotion thematic areas. (MINECOFIN, 2015).

Resolutions from Infrastructure projects retreat, in November 2014 have been made and recommended join efforts to speed up electrification process by mobilizing people to move from scattered areas to planned settlements and the issue of scattered settlements that hinders the speed of delivering on the electricity access targets and increase the cost of implementation is still regarded as one of the main challenges in achieving the targets. (MININFRA Report 2015).
II. METHODS

In this paper cases studies from the 4 provinces of Rwanda are discussed maps have been produced in Geographic Information System Environment based the existing geospatial data on settlements sites and electrification plans data. These maps show the geospatial patterns of rural settlements and their best practices in electrification process, a geospatial analysis is done also on the cases where electrification is hampered by the human settlements patterns which were unplanned.

To get accurate and updated information and data, Orthophoto images 2008, with 1.5cm resolution have been used where the need for details on the settlements were felt whereas google earth updated images, 2013-2015 have been used in order to have updated information on areas where dramatic changes in settlements patterns have been identified.

1.5km Buffer zones in GIS Environment, have been defined as a direct fill in zone from the existing grid data and using existing data on settlements geospatial analysis have been done to extract the number of settlements which can easily access the electrical network and those out of the zones which can be considered for off grid solutions.

The logic work flow indicate the selection of site settlement whether on grid or out of the grid based on its proximity to the existing and planned electrical network, then if a site settlement is on grid electrification plan, the first preference will be on the grid, if the settlement is planned and found far away from the electrical network the photovoltaic system is considered and when the settlement is out the grid and the population living in that area is below the thresholds.

III. RESULTS

From the first case study in the Western Province, from Birambo geographic context, in Gashari Sector, Karongi District on the need for proper settlement planning and efficient land use in order to speed up the rural electrification process.

On the road to Birambo, from the Town of Karongi, home to photogenic Lake Kivu and first 25 Megawatt Kivu Watt methane gas to electricity project to be commissioned in late...
There is a small but beautiful Mukiro natural forest and from Birambo to Kirinda Electrical substation there is around 5 km.

However, when looking on the hills around the road, there are scattered settlements along the route and this is reflected in the District Reports for human settlement 2014, where more than 17 thousands are reported to be still living in scattered areas in Karongi District and in one of the sectors the neighbor to Gashari, Which is Ruganda sector, they are still waiting to benefit from electricity as the sector is reported to be one of the few sectors which is not covered by any electricity connectivity.

Another fact, on the road to Birambo, is Bunyankungu IDP model village, planned for 383 houses for a total of 1500 inhabitants in 2011 with the possibility to expand to 700 houses. Now in 2015, 120 houses have been constructed and It’s home to around 300 households.

Bunyankungu, is one of the 5 first pioneering model villages across the country, every one in each Province and the City of Kigali. Initiated by the Government of Rwanda in partnership with UNDP. (it is also the first place where the now popular 4 in 1 types of houses credited to house 4 families in a 30x30m plot size, have been initialized, and this model have been re-engineered. As A reflection from the, City of Kigali rural areas, It have been implemented in Gasharu, Kinyinya, Gasabo in Rusheshe, Masaka, Kicukiro and is now being implemented in, Ruhashya, Huye District, in Kiyumba, Muhanga District in Kabyaza, Nyabihu District and elsewhere all over the country.

The second case study is in the southern province,

Buhimba IDP model village, Rusatira, Huye District case study, show the dramatic change from 2008 to 2013. The new settlers number have been boosted by the people leaving Nyakatsi tcated houses and scattered settlements around this serviced IDP model village as it can be seen from the Figure 1. These have contributed to the increased electrification rate in this village and surround areas.

The third case study is in the Eastern Province,

Nyagatovu, Kitazigurwa, Ntebe phased implementation of model villages arguably is the fully integrated village and has won numerous recognition from all over the seas. As a proper human settlement best practices model, resettling scattered people have boosted the land consolidation process as it can be seen from the Figure 2 of the 2014 google image.

It is one of the settlements sites which have been electrified in a short time possible, by the STEG Company, with Tunisian electrification experience of 100% rural areas.
The fourth case study is in the Northern Province, Nyagihinga centre, in Cyanika sector, Burera District on the border to Uganda, in the volcanic areas rich in potatoes produce, a center with agriculture business potential, in the plan to access electricity is another case study.

From the population of around 6,000 in their cell, An analysis on the existing settlements show that there is still need to work on the densification as 8 sites settlements in the nearby the Nyagihinga centre could be defined as one site. When you compare the distance from the one in the center to the surrounding sites there are 422m, 600 m, ..., up to 1350m (as showed in the map below Figure 3), which is a small distance between settlements which are normally defined to have a distance of 4 km between them.

Their business culture would encourage to develop a modern model village around the already existing 2 storey modern market, schools, health center, administrative buildings and the feeder road which is being constructed. This would also speed up the electrification process from the plan (showed in the map below Figure 3) and rich volcano soil land vacated would serve for agriculture purpose.

IV. DISCUSSION

A look at the BRICS good practices,

According to the comparative study conducted by International Energy Agency, on emerging countries rural electrification programs in Brazil, India, China, and South Africa (COMPARATIVE STUDY ON RURAL ELECTRIFICATION POLICIES IN EMERGING ECONOMIES)

Keys to successful policies, Alexandra Niez, March 2010

Recommendations have been drawn and may inspire the Rwanda electrification programs especially on rural areas as there are similarities in challenges encountered in electrification process especially for people living in informal settlements and in scattered areas.

South Africa case study, The Integrated National Electrification Programme (INEP) consists of a grid-connection programme, a non-grid programme, household connections, electrification of schools and of all registered clinics. The main focus is the grid connection, and non-grid connection is only used if there are no other feasible options to extend the grid within a foreseeable future.

Before 1994, South Africa only focused on electrification of urban areas. In 1993, some 30% of households were electrified. Since 1994, there has been a fundamental shift towards electrifying all. Including those living in rural areas. The grid electrification rate has since then increased from 50% in 1993 to 73% in March 2008 (Department of Minerals and Energy, 2008b), that is 4.5 million more households. The increase in coverage is the result of both extending the grid to new communities such as rural areas and connecting the unconnected in already electrified areas. The electrification rates vary depending on the complexities of grid extension and population density, with the relatively higher-density areas having been electrified first.9

In 2009, 3.4 million households were still remaining to be electrified in South Africa (Mketsi, 2009) of which about half (1.7 million) lived in informal settlements. The areas had to be either formalized, or the households had to move to other formalized human settlements before they can benefit from the national electrification programme. This is because it is not cost-effective to electrify an unstable dwelling that may be demolished or destroyed by any climatic occurrence.

South Africa has one of the lowest electricity tariffs in the world, with an average selling price (as illustrated below) at around USD 0.027 per kWh. Despite the tariff regime, there is argued and documented energy poverty among both electrified and non-electrified consumers (Department of Energy, 2009g). The poor segment of the population lives below the poverty line and, despite free installation, they may not be able to afford electricity if consumption goes above the free basic electricity allocation.

Specific guidelines have been put in place to cover those segments that cannot be covered by grid extension within the

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9 Comparative Study on Rural Electrification Policies in Emerging Economies – © OECD/IEA 2010 Page | 86 households,
average price and within a three-year plan. In parallel to the general electrification guidelines, special guidelines are in place for non-grid electrification.

Compared to these best practices in BRICS, following are cases analyzed in the Southern and Western Province where the direct fill in could yield tangible results in a shortest time.

It has been noticed that there are settlements which are not electrified yet they are closer to the grid, a quick fill in strategy is recommended where branches at local level will connect the households nearby and speed up the process.

Figure 6: Map and list of non-electrified settlement in the 1.5 km buffer zone

Source: Author

Nyasasheke District, in Western Province, in general the District is covered in its western part to Lake Kivu and plans are underway on the side to the Nyungwe forest, settlements in yellow are not electrified and direct fill in is a solution because they are in the buffer zone of 1.5km from the existing lines.

Nyanza District, in Southern Province, Electrification versus the settlements patterns in Nyanza District, there are a settlements which are situated in the 1.5Km buffer from the existing electrical lines and they can be serviced by direct fill in.

List of non-electrified Settlements in Nyanza District (in red in the map), which are in the buffer zone of 1.5 km from the existing electrical line

Source: Author
V. CONCLUSION AND RECOMMENDATION

As recommendations, in the electrification field as it has been shown in the map (Figure 5) the coverage of the electrification plan is very good and could be of almost the total whole country with exceptions of hilly mountains and regions far from roads networks. As the electrification plan is clear and phased in time the awareness of it at local level especially in rural areas would serve as tool for mobilization for people who are still settled in scattered areas. It has been noticed that there are settlements which are not electrified yet they are closer to the grid, a quick fill in strategy is recommended where electricity company branches at local level will connect the households nearby and speed up the process.

In human settlement sector – Improvement on the planned settlement patterns will yield tangible results as is has been noticed, settlement patterns have to be improved to accommodate a big number of households and discourage linear patterns. Demarcation of imidugudu boundaries to have a clear number of those still in scattered areas. The demarcation of imidugudu settlements site have a potential to improve on the densification and electrification process, as people will be bounded to settle in areas specified for construction and leave other areas for other activities. And when people still living in scattered areas will move to planned settlements, this will contribute on electrification process as they will be settled on the already serviced areas.

The study has uncounted a limitation on the number of settlements considered as case studies and could be improved in detailing all aspects in all villages to have a comprehensive picture on electrification of rural settlements sites.

VI. REFERENCES

- World Bank, Scaling up electricity, the Case of Rwanda [http://www.wds.worldbank.org/external/default/WDSContentServer/WDS/IB/2015/02/27/090224b082b6d3e9/2_0/Rendered/PDF/Scaling0up0acc000the0case0of0Rwanda.pdf](http://www.wds.worldbank.org/external/default/WDSContentServer/WDS/IB/2015/02/27/090224b082b6d3e9/2_0/Rendered/PDF/Scaling0up0acc000the0case0of0Rwanda.pdf)

**Rural electrification** is the process of bringing electrical power to rural and remote areas. **Electricity** is used not only for lighting and household purposes, but it also allows for mechanization of many farming operations, such as threshing, milking, and hoisting grain for storage. 

[Rural electrification - Wikipedia](https://en.wikipedia.org/wiki/Rural_electrification)