The Status of Wind Energy Utilization in Uganda: A review

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ABSTRACT
Uganda is one of the countries with the fastest growing populations in the world and a GDP growth rate of 5-6% p.a. for the last two decades. The county's Vision 2040 agenda outlines the countries aims to attain an upper-middle income status by year 2040 and among the targets set forth is the electricity generation target of 41,738 MW. Of these a significant fraction is to be generated from renewable energy sources such as hydro power (4,500 MW); geothermal (1,500 MW); solar (5,000 MW); biomass (1,700 MW) and wind. This Vision is also outlined in the country's blueprint Renewable Energy Policy for Uganda of 2007. While a lot of progress has been registered in the development of hydropower - specifically small hydropower, and solar energy, there is a very limited information on wind energy utilization. This paper sought to review the status of wind energy utilization in Uganda, presenting the country's energy situation, available information on existing and planned electricity generation and non-electricity wind energy utilization. The study shows that while potential exists for small scale utilization of wind, there is little progress and that investment in wind energy is further hamstrung by the lack of detailed and countrywide wind data. The study suggests that supportive government policies need to be accelerated toward wind energy development so as to provide enabling environment for investment by private sectors, development partners and other interested parties.

Index Terms- Renewable Energy, Sustainable Development, Uganda, Vision 2040, Wind energy

I. INTRODUCTION
Uganda is the third largest economy in East Africa with an estimated GDP of UGX 138,283 Billion (approx. USD 38.8 Billion) [1]. In 2007, Uganda set forth a path, through the Vision 2040 aimed at "A transformed Ugandan society from a peasant to a modern and prosperous country within 30 years". It primarily aims at transforming the country from a predominantly peasant and low-income country to a competitive industrialized upper middle-income with a country per capita Gross Domestic Product (GDP) growth from USD 506 (2010 baseline) to USD 9,500 in 2040. This is being implemented through a series of 5-year development plans, the current of which is the Third National Development Plan 2020 – 2025 (NDP III).
Except for a few oil-exporting countries in developed and emerging economies, there exists a strong positive correlation between industrialization and rapid development for most economies. Uganda therefore needs to develop and generate modern energy to drive the industry as well as the services sectors.

According to the Vision 2040 document, in order for the Uganda to achieve the development targets, the country will require an estimated 41,738 MW by 2040, increasing its electricity per capita consumption to 3,668 kWh. This is to be met through generation from various sources such as hydro power (4,500 MW); geothermal (1,500 MW); nuclear (24,000 MW); solar (5,000 MW); biomass (1,700 MW); peat (800 MW) and thermal (4,300 MW) to be determined after detailed feasibility studies of energy mix in order to provide a competitive tariff compared to other countries [2].

In a bid to achieve the NDP III Goals, the Energy Sector Government Priorities to foster transformation , as outlined in the Electricity Regulatory Corporate Strategy [3], are:

- Increase Access to and Utilization of Electricity;
- Increase the Generation Capacity of Electricity;
- Increase Adoption and Use of Clean and Renewable Energy; and,
- Promote the Utilization of Energy-Efficient Practices and Technologies

Due to the noted negative effects on the use of fossil fuels, such as climate change, the Government of Uganda (GoU) intends to put emphasis to promote and harness other renewable forms of energy including; wind, solar and biogas through investment in R&D and provision of incentives to encourage use of renewable energy [2].

This study aimed at reviewing the progress made in wind power utilization in Uganda.

II. Data Sources

Several sources of information were used. These included Government Publications such as the Vision 2040, The National Development Plans, Mid and End of Term reviews of the government documents, publications by Government Ministries such as Ministry of Energy and Mineral Development (MEMD), Ministry of Water and Environment (MWE) and Ministry of Finance, Planning and Economic Development (MoFPED). Literature from regulatory agencies such as the Electricity Regulatory Authority, and parastatals such as Uganda Electricity Generation Company Limited (UEGCL), Uganda Electricity Transmission Company Limited (UETCL), Uganda Electricity Distribution Limited (UEDCL), publications and information from private companies and associations with interest in the Uganda energy sector, particularly wind, were also used.

III. Findings

1. Electricity Landscape in Uganda

According to the Financial Statements of the GoU for the year ended 30 June 2020 [4], Electricity generation capacity in Uganda stood at 1,254 Megawatts. This was upon the completion of the 42 MW Agago – Achwa II, the 76 MW Kyambura, the 5.9 MW Ndugutu Power projects as well as the commissioning of the 183MW Isimba Power Project and its transmission lines was commissioned. In addition to these, the 600 MW Karuma Power Project was 98% complete and due for commissioning, with the Karuma – Kawanda Transmission Line also 82% complete by the end of the 2019/20 FY in June 2020. By the end of 2021, the total generation capacity will increase to 1,868 MW [5] as a result of the commissioning of the mentioned electricity generation projects, and up 3500 MW in 2025 [3].

1.1. Electricity generation Mix

In Uganda, the electricity generation mix comprises of hydro power (79.5% large and small plants), thermal plants (8.7%), bagasse co-generation (8.2%), solar PV (3.5%), with the remaining 1% imported from neighboring countries of Rwanda and Kenya as well as diesel and biomass constituting 0.1%. [1].

1.2. Electricity reach

As of May 2021, access to electricity stands at 28 percent of the population, up from 23 percent in 2017, representing total number of served consumers of 1.62 million customers [5]. with the Government aiming to

increase access by implementing Electricity Access Scale-up Project (EASP) leading to scale-up of access to 60 percent by 2027 for households, industrial parks, commercial enterprises, and health and education facilities. This is also envisioned to upsurge access to clean energy cooking services by supporting private sector enterprises that are promoting efficient and clean cooking solutions.

1.3. Electricity demand

The peak electricity demand as of 2019 stood at 723.8 MW versus a total Installed Capacity of 1,252 MW [6], The Electricity Regulatory Authority projected a peak demand of 767 MW for 2020.

The electricity demand, the available supply in Uganda (Installed Capacity) is sufficient to meet the Country's existing needs (compared with Peak Demand). Figure 30 shows a Peak Demand of 723.8 MW in 2019 compared to a total Installed Capacity of 1,252 MW. Whereas the Installed Capacity is projected to increase to 1,959.7 MW by the end of 2020; the Maximum Peak Demand is projected at 767 MW. The electricity supply and demand is depicted in the Figure 1 below.

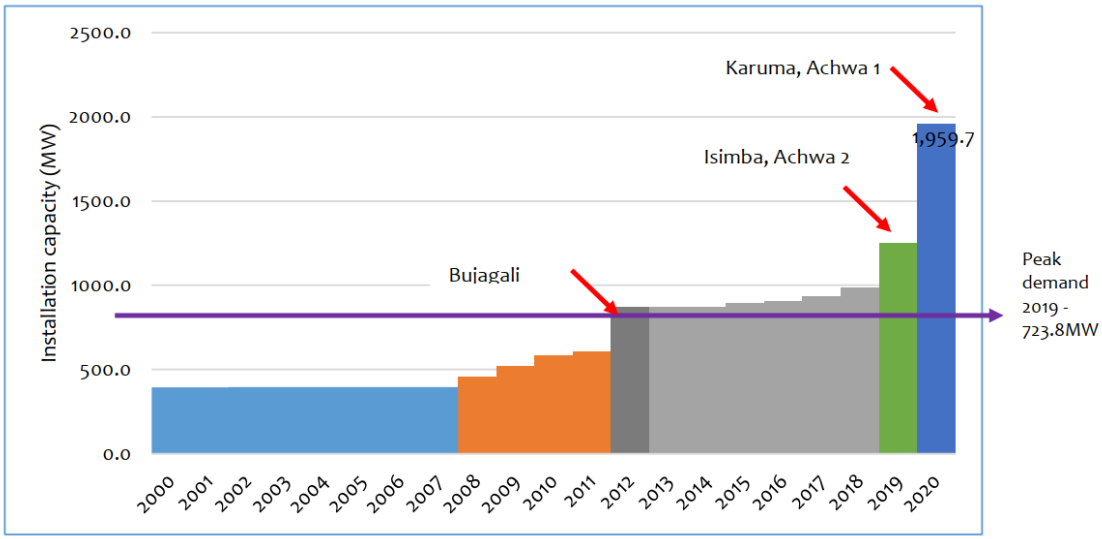

Figure 1: Electricity Supply/Demand 2000-2020. Source (ERA)

2. Wind Energy in Uganda

2.1. Electricity generation

Based on the latest Electricity supply industry performance report (for the year 2019) from the Electricity Regulatory Authority [6], there were no operational wind turbines for electricity generation installed in Uganda. However, from the ERA Least Cost Expansion Plan 2020 – 2030 [7], there is one Licensed Generation Projects in the pipeline, this is the 20 MW Rupa Wind Power Project licensed to Xsabo Wind Technologies Limited, with a Commercial Operations Date (COD) of 2023. In addition, by the end of 2019, one developer was in advanced stages in the feasibility study with the possibility of developing a 50 MW Wind Power Plant and an additional generation of 150 MW with the current technology is expected by 2027 on a need arises basis. To further obtain wind resource data for electricity generation, a total of 6 (Six) Wind Measuring Masts were expected to be installed in Northern/North Eastern Uganda by the end of 2020, however this was not done due to financial constraint posed by cancellation of initiated plan by development partner (African Development Bank) [8].

2.1.1. Tororo Wind Power Station

According to [9], the Tororo Wind Power Project is part of the EUR 450 million joint venture between Mola Solar Systems (Uganda) Limited (Executing Agency) and Bryan Xsabo Strategy Consultants (Uganda) Limited (Overall Project Coordinator) which aims to generate up to 100 MW of Wind Power and 150 MW of solar power in Uganda. At its full capacity, the project aims to generate 300 gigawatt hours of power per annum from solar from the total of five wind power parks, which include Tororo in Tororo District (50 MW), Kabulasoke in Gomba District (20 MW), Nkenda in Kasese District (10 MW), Nkonge in Mubende District (15 MW) and Opuyo/Offshore on River Awoja (5 MW).

The Tororo facility is the pilot with a planned cost of 40 million Euros and initial capacity of 20 MW (to be upgraded to 50 MW). The site is located about 8 km from Tororo town with coordinates 00 38 21N, 34 07 05E. The average wind speed ranges from 6 to 8 m/s at hub heights between 80 to 143 m above the ground.
Because the project was still in the early planning phase, some technical decisions such as the number of turbines to be used were not yet arrived at. However, evaluations using site wind speed data were done using three Leitwind GmbH turbines i.e., LTW80 (rated power: 1500 kW/1800 kW; hub-height: 65/80/100 m), LTW104 (rated power: 2000 kW/2500 kW; hub height: 95/143m) and LTW101 (rated power: 3000 kW; hub height: 95/143 m), which all have a cut-in and cut-out wind speed of 3 m/s and 25 m/s respectively. Tentatively, the use of 10 wind turbines rated at 2,000 kW to generate the target 20 MW was suggested.

2.2. Non -electricity utilization

While the utilization of wind for generation of electricity has not been adopted yet, GoU has promoted the use of Windmills for water pumping applications particularly in the Karamoja region in Northeast of the country which is arid and suffers persistent water shortages. According to the Budget Monitoring and Accountability Unit (BMAU) of the Ministry of Finance, Planning and Economic Development (MoFPED) forty three (43) Windmills had been installed at various sites by 2016 [10]. However, of these, only 8 were working, with the remainder in being in various states of disuse, with 37% of the wind mills not working, 27% of the windmills removed (mostly the district water office), and 9% either been abandoned, blown down, or vandalized. According to the MoFPED [10], the reasons for the perilous state of so many mills include;-continued lack of scheduled maintenance, serious lack of security measures at site to prevent vandalism, and looting of metal components with vandalism reaching very high levels and functional mills wantonly sabotaged by metal thieves leading to induced premature failure or even total collapse, which leads to the damaged parts to be taken away as scrap metal. In addition, some units became redundant due to community migration. In the Financial Year 2018/2019, the Ministry of Water and Environment (MoWE) completed construction of Fourteen (14) Windmill powered watering Supply Systems in Karamoja Sub-region, these were done in various districts within the region i.e., Amudat (2), Abim (2), Kaabong (2), Kotido (2), Moroto (2), Napak (2) and Nakapiripirit (2) Districts [11].

To ensure functionality of windmills, it is recommended that correct installation is done, scheduled reliable maintenance carried out, large water storage tanks for reliability of supply is utilized, and the mill site diversified for varied community needs, and security against vandalism and theft is provided. In addition, a training programme for repair and maintenance skills should be instituted in the region to ensure repair and maintenance by the locals themselves. There is therefore need to mobilize funds to repair the existing mills, and in the medium term to re-install those destroyed desirably in densely populated community centers to ensure safety of the equipment [10].

2.3. Wind Potential

Figure 2: A non-functional windmill for water pumping (a) and tap stand (b)in Rengen Sub County. Leaking pipes at a water pumping windmill site in Lokitalebeu Sub County. All in Kotido District. Source: MoFPED - BMAU

The indicative potential for wind power in Africa is 109,000 MW [12] with the best wind being found in the coastal regions, The Horn of Africa, eastern Kenya, parts of West and Central Africa bordering on the Sahara and parts of Southern Africa also show high quality wind resources. The potential for wind development in Uganda is currently estimated at 815 TWh/year [13], and the Electricity Regulatory Authority estimates that around

200 MW can be developed by 2027 [7]. The Renewable Energy Policy for Uganda (REPU) [14], underscored GoU's vision to increase utilization of renewable energy for sustainable development. The policy established that government shall promote wind power technology shall be promoted for electricity generation especially for small scale power projects (defined as those under 20 MW), water pumping and other applications. It noted that wind speed is moderate in most areas of Uganda, with the average wind speeds in low heights (less than 10 m) generally falling in the range from 2 m/s to about 4 m/s based on wind data collected by the Meteorology Department. It was concluded that the wind energy resource in Uganda is sufficient for small scale electricity generation – particularly in the 2.5 kV to 10 kV range suitable for rural areas and small-scale industries, as well as for special applications, such as water pumping mainly in the Karamoja region. However, the policy noted the lack of sufficient data on the renewable energy resource base, with the data on wind resource being acutely lacking. This is the reason why the estimates for other renewable energy resources were provided in the policy statement, while that for wind energy was not. According to the study done during the preparation of the REPU showed wind speeds at less than 10 m within the country. This is shown in the map on Figure 3. According to the DTU Energy

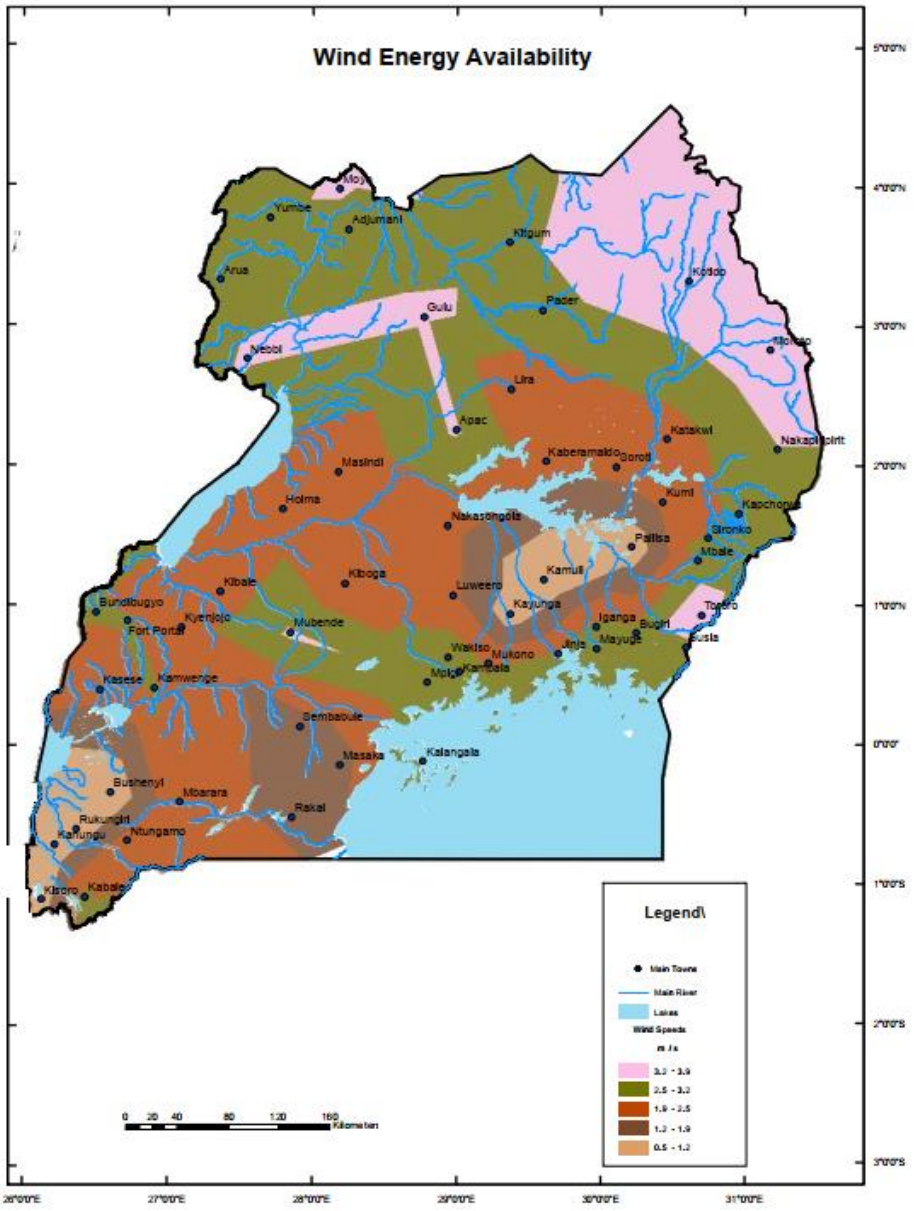

Figure 3: Map of Uganda showing windspeeds at less than 10m. Source REPU - 2007

– developed Global Wind Atlas [15], data for the 10% windiest locations in Uganda show an average windspeed at 100 m of 5.12 m/s with a power density of 149 W/m2, and average wind speed at 50 m of 74.32 m/s Power density of 105 W/m^2 both showing limited wind energy generation potential. A map of Kenya is provided for contrast as shown in Figure 5 and **Error! Reference source not found.**.

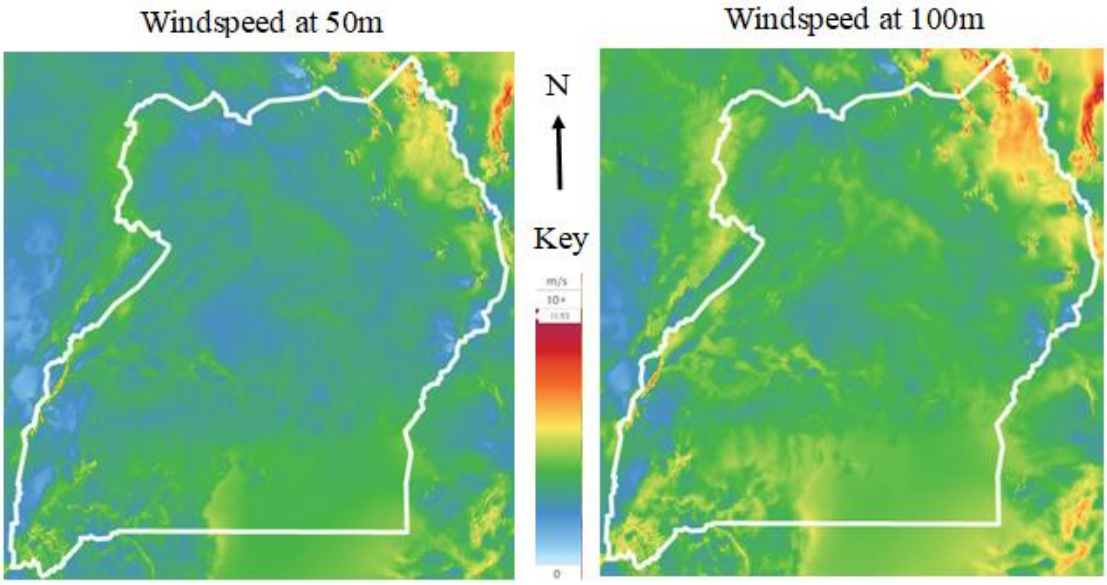

Figure 5: Map of Uganda showing windspeed at 50m and 100m. Source: Global Wind Atlas - DTU Wind Energy

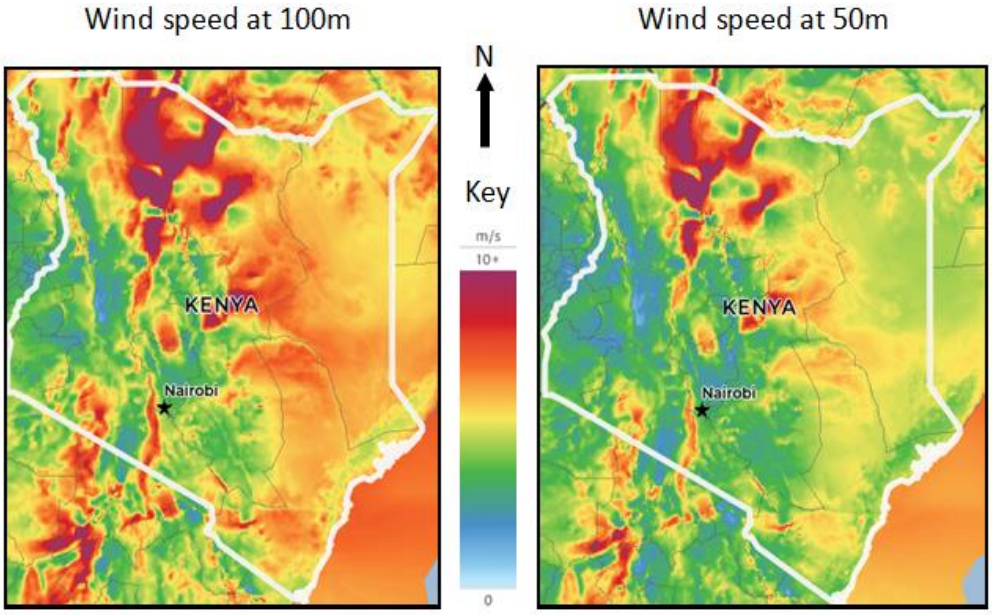

Figure 5: Map of Kenya Showing Windspeed at 100m and 50m Source: Global Wind Atlas

As can be seen, Uganda has moderate potential for electricity generation using wind, however, there is still need to undertake more studies to establish windspeeds at elevations suitable for commercial electricity generation for all potential locations, particularly in the Northeast (Karamoja region) and in the South west (Kigezi region) of the country.

2.4. Interventions to support renewable energy exploitation

In order to achieve the development targets, as well as the renewable energy targets as outlined in the REPU, the Vision 2040 and subsequent National Development Plans, GoU of Uganda has several interventions that can spur wind energy growth and utilization in the country. Among these include; -

2.4.1. The GETFiT Program

The Global Energy Transfer Feed-in Tariff (GETFiT) Program was a Public-Private Partnership (PPP) Program to leverages commercial investment in Renewable Energy Projects in Uganda. According to [7], the Programme is widely viewed as a PPP success story with Uganda now among the top destinations for Renewable Independent Power Producers (IPP) on the continent. A total of 17 Renewable Energy Projects (mostly small hydro and solar) were fast-tracked under the Global Energy Transfer Feed-in Tariff (GETFiT Program) and it significantly enhanced the number of Private Investors willing to undertake investment in Uganda even at less attractive terms than those that were given in the earlier years before its closure.

2.4.2. The REFiT Program

The Renewable Energy Feed-in Tariffs (REFiT) Program was initially established in Uganda and ran from 2007 to 2009 (Phase 1), with subsequent revision in 2010 (REFIT Phase 2), 2016 (REFIT Phase 3), and 2019 (REFIT Phase 4) [7]. The REFiT Guidelines provide clarity and guidance to Project Developers, Investors, and key Institutional Stakeholders, on the key components and operational structure of the Renewable Energy Feed-in Tariff (REFiT) and are in place to support the development of Small Renewables Technologies. As of 2019, the REFiT Phase 4 tariffs for Wind Power provides for a 13.5% Maximum Return on Equity, and a Tariff Ceiling of 10.4 USD Cent/kWh [16] These and other similar interventions by GoU is expected to enhance utilization of wind energy resource in the country.

IV. CONCLUSION

Wind energy development in Uganda is one of the renewable energy resources that can help to boost Uganda's economy for various small-scale production purposes such as water pumping, electricity generation among others. There is little development and exploitation of wind resource in the country as current utilization has mainly focused on water pumping purposes. The study suggests that supportive government policies need to be accelerated toward wind energy development so as to provide enabling environment for investment by private sectors, development partners and other interested parties.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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