Bn ASSESSMENT OF ENVIRONMENTAL AND SOCIO ECONOMIC BENEFITS OF RIVER SITI HYDROPOWER SCHEME IN MOUNT ELGON BIOSPHERE RESERVE, UGANDA

Abstract

The study was carried out to assess the perceptions and responses of targeted beneficiaries of Siti Hydropower on the impact and benefits of the renewable energy scheme. Households in proximity to the power supply line were purposefully selected as a sample population. A semi-structured questionnaire was administered to 38 randomly selected household heads living on both sides of the power supply line. Face to face interviews with staff working with hydropower project and Mt. Elgon National Park (Biosphere Reserve) as well as the District Natural Resource Managers were conducted. In addition, nine focused group discussions involving 72 people, (eighteen of whom were women) were held. The results show that 78.9% of the respondents were of the view that the hydropower project had caused significant environmental problems and 21.1 % of the respondents did not think that the project had any significant negative impact on the environment. About 47.4% of the respondents associated the project with soil erosion along the water channel as the most negative environmental impact of the project, while 21.4% of the respondents highlighted the disruption of the water flow of R. Siti and R. Nyalit and 13.2% of the respondents identified deforestation especially inside Mt. Elgon National Park where the weir (intake) of the power station was located. However, 18.4% of the respondents did not believe that the project caused any negative environmental problem. Regarding the anticipated benefits, 42.1% of the respondents associated the project with social economic improvement of residents, 36.8% reduction on the reliance on fuel wood energy and 21.1% protection of R. Siti and R. Nyalit banks.

Introduction

Biosphere Reserves are sites established by countries and recognised under UNESCO's Man and Biosphere (MAB) Program to promote sustainable development based on local community efforts and sound science. The Biosphere Reserve Sites are considered to be models for adaptation to the impact of climate change especially the domain of sustainable land use, green economies, safeguarding ecosystem services, energy efficiency and use of renewable energy resources (UNESCO, 2011). It is worth noting that one of the Dresden Declaration recommendations emphasises the use of biosphere reserves as learning sites for sustainable development. The United Nations Sustainable Development Goal number 7 is about affordable clean energy. This is crucial because energy is at the heart of human, social, economic and sustainable development issues. It is also at the core of the climate mitigation agenda (UNESCO, 2013; Adebayo *et al*., 2018; Meng et al., 2019). The desire for modern energy services which are clean, affordable and reliable is real as many countries and States strive to pursue and promote sustainable green growth development (Chen et al., 2015; Akashie, 2022). In addition, energy drives all other sectors of the economy such as food, health, environment, water and others (Adebayo *et al*., 2018; MEMD, 2015) In light of this, Mayor et al., 2017 consider two key benefits of hydropower, provision of renewable low carbon and endogenous energy and increasing the capacity of water storage.

USA- Department of Energy, 2015 advises that the energy systems should be secure and resilient in terms of price shocks, disruption and critical equipment and materials. Furthermore, the development of clean energy system should be based on advanced technology to minimise environmental footprint and underpin every facet of the nations' economy and modern way of life.

Uganda is considered to have one of the lowest per capita power consumption rates in the world and low grade forms of energy, especially traditional biomass fuel which accounts for more than 90% of the total energy consumption (Kees & Von Fije,2018; Nafuna, 2013). Nevertheless, Uganda is recognised as one of the few countries that are richly endowed with renewable energy resources such as hydropower (UNIDO, 2016), biomass, solar energy, geothermal and wind which are capable of producing and providing power worth over 5,300MW. However, it is noted that these sources of energy remain largely unexploited due to technical and financial limitations (Kees & Von Fije, 2018; WWF, 2015)

In 2012 the Government of Uganda allowed the Elgon Hydro PVE Ltd Uganda, a private company to construct a small hydropower station on R. Siti but also tapping water from the neighbouring R. Nyalit, with generation capacity of 21.5 MW. Like other small hydropower technology projects, Siti Hydropower depends on small river water flow (Ferreira & Camacho, 2016), The power project was implemented in two phases. The first phase was designed to generate about 5 MW and the second phase with the capacity of 16.5 MW. The power generated from the whole power scheme was integrated into the national power grid.

. The project implementation was in line with government's policy of increasing the use of modern renewable energy from 4% to 61% of the total energy consumption as well as the use of renewable energy resources for both small and large scale applications (MEMD, 2007). In this regard therefore, the power station was aimed at stimulating rural development by availing clean renewable energy.

The weir (intake) of the power station is about 1.2 Km inside Mt Elgon National Park, which is a biosphere reserve and part of Mount Elgon trans-boundary ecosystem. The whole hydro power scheme infrastructure falls within Mt. Elgon Biosphere Reserve, Uganda. The weir is located within the buffer zone and the power generation house as well as power line system in the transition zone. It should be noted that Mt Elgon ecosystem is an important water catchment for both Kenya and Uganda. Like any other forest ecosystem in the country, the neighbouring communities depend on Mt Elgon Biosphere Reserve as a key source of fuel wood for domestic use, including cooking and a source of light and heat Bamwesigye et al., 2020; Egeru 2014). Overdependence on the biosphere reserve for fuel wood has led to deforestation and degradation of the protected area. Therefore, the idea of establishing of Siti Hydro Power would be wise and environmentally acceptable because it creates alternative source of energy which would in long run reduce human pressure on the protected area. Besides, extension of clean renewable energy to the protected area dependant community would in turn stimulate socio–economic transformation of the society and improve livelihoods. However, the key question is whether this form of energy would be affordable and the residents well prepared and willing, to utilise the power. In light of this therefore, the study was conducted to understand the local community's perception on the role and benefits of Siti Hydropower scheme in terms of nature conservation and community livelihoods.

According to Environmental and Social Impact Assessment (ESIA) report, the project was designed in such a way that 1.5MW of power would be supplied to local people through rural electrification program. In this way, one would ideally expect the project to reduce human pressure on Mt Elgon National Park as a source of fuel wood. The ESIA also indicates that the scheme was expected to boost economic development, create employment and improve infrastructure as well as quality of life. Therefore, this study was undertaken purposely to assess the ways local people intended to utilise power. In light of the anticipated negative impacts of the project; sedimentation and siltation of downstream, water pollution, land degradation as well as disturbance of wildlife. The study was also aimed at establishing whether the targeted beneficiary residents were aware of anticipated negative impacts and planned mitigation measures to address the problems associated with the projects. In this case, community awareness about the project was important because it empowers the beneficiaries to understand their roles, rights and benefits. In long run, this would enhance their capacity to actively participate in the implementation of mitigation measures which are aimed at avoiding or minimising the negative impacts of the hydroelectric power project.

Methods and materials

Study area

Siti Hydropower project is situated in the north- western slopes of Elgon National Park (Biosphere Reserve) in Chesowero Village, Bukwo District. The catchment upstream of the take-off points for River Siti is 202.3 square kilometres. The drainage basin for the project comprises of two rivers; Siti and Nyalit with their head water arising from Mt Elgon National Park (Biosphee Reserve) as shown in Fig.1.. However, R. Siti catchment contains several narrow sub-water sheds which are between 2,0 -2.5 square kilometres. The Siti hydraulic stake off points are located at coordinates $34^{o}38'6''$ E $1^{o}21'5''$ N on River Siti and $34^{o}38'6''$

E 1°20’26’’ N on River. Nyalit.. The study area was sparsely settled (on average there were 20 homesteads per square kilometre) because it is largely a rocky area and the southern part is occupied by Mt Elgon National Park (Biosphere Reserve).

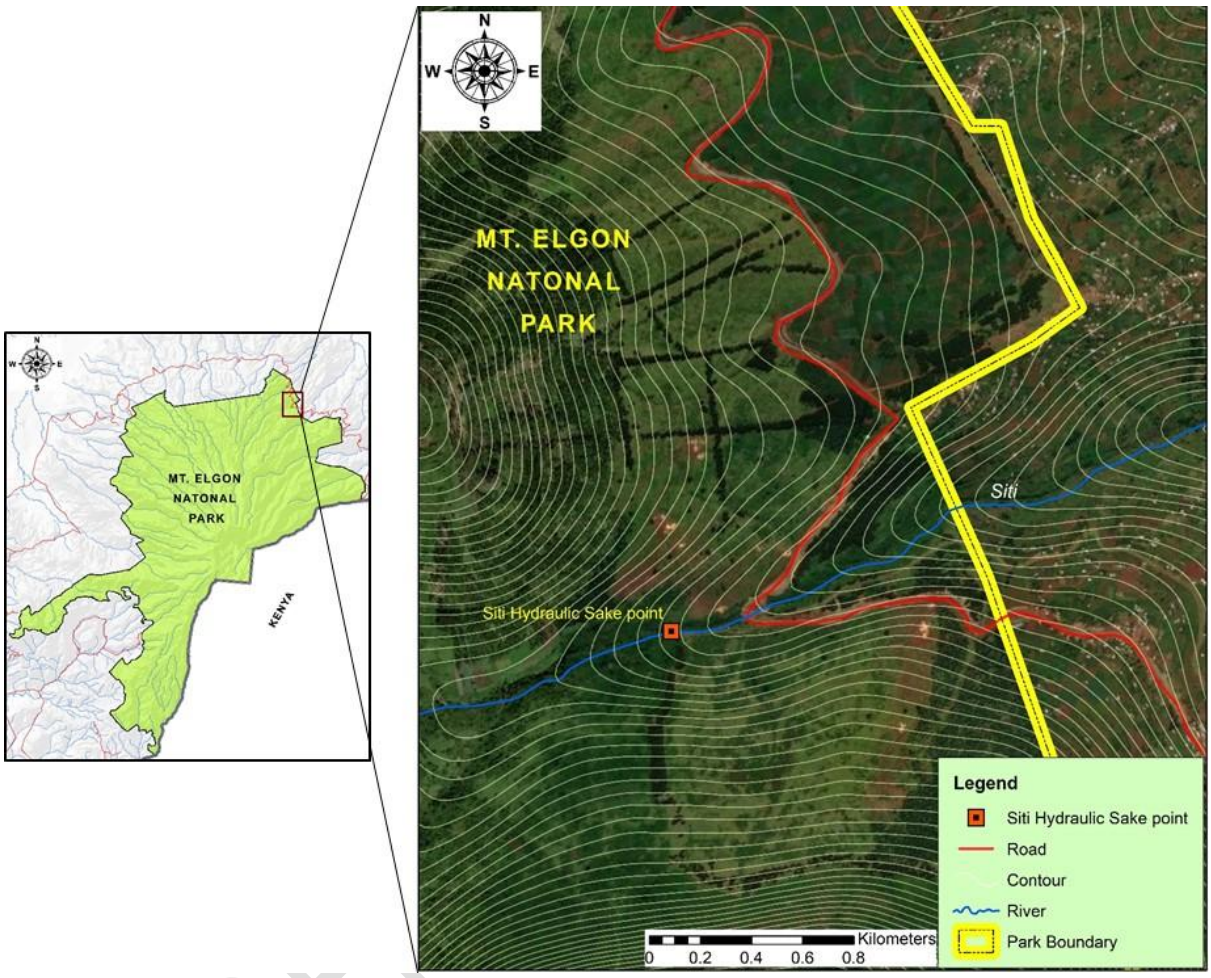

Fig. 1: Location of Siti Hydropower water source (stake off points).

Research design

The study covered the construction phase of the project 2014 to 2016 to assess the perception of targeted beneficiaries and power supply phase 2017 to 2020 to ascertain the planned benefits and mitigation measures were being implemented. The unit of observation was a household and a unit of analysis was the household head. Households in proximity to the power line were purposefully selected as sample population because unlike the rest of the households, they were not going to incur much cost (upfront cost) to purchase power supply poles. They would need just one electric pole to install power in their houses. This was a key comparative advantage that created uniformity (opportunity to access electric energy at the least upfront cost compared to the rest of the households which were distant) in the sample population. A semi-structured questionnaire was administered to randomly selected household heads living on both sides of the power supply line. The questionnaire was designed in a manner that it would be able to capture the perception of the potential

beneficiaries on the key environmental and social economic impacts such as biodiversity conservation, infrastructure development, social benefits, employment, community empowerment as well as health and safety issues as suggested by Karytsas et al., 2020.

In order to minimise biases in the selection of respondents (household heads), the targeted households were chosen in a zigzag pattern by selecting the second household opposite the previous selected household. Where the homesteads were completely very far from the power line or not there, for instance, where the power line passed through Mt. Elgon National Park (where there was no human settlement), such areas were skipped. Where the human settlement was on one side of the power line, the pattern of selecting the second household was adopted until the entire line covering three sub-counties of Kapkwata, Kwanyiny and Mayok that fall within R. Siti catchment area were covered. In total 38 house hold heads, whose homesteads were found along the power line were administered with a questionnaire. The effects of the project were assessed along the segments of value chain; planning and designing, power installation and connectivity as well as power utilisation operations. Aspects that were anticipated to create community impulse or response such as household income, benefits from the project, negative impacts and household capacity to install and utilise the renewable energy as highlighted by Borbonus, 2017 were carefully emphasised without undermining the privacy of respondents and ensuring confidentiality.

The questionnaire was supplemented by expert face to face interviews with staff working with hydropower project and Mt. Elgon National Park (Biosphere Reserve) as well as District Natural Resource Managers. In addition, focused group discussions with representatives of local communities were held. In total, nine focused group discussions were held in the study areas involving on average eight people (in total 72 people were involved in group discussion, eighteen of whom were women). The field observations also were made during the construction phase in 2018 as well as power installation and utilisation in 2021.

RESULTS

Demographic information on respondents

The demographic background information is presented in Table 1. About 92, 1% of the respondents were male and 7.9% female household heads. The majority of the respondents (60.5%) were within the active age group of 31 to 40 years, followed by 18 to 30-year age group (18.4%), the age group of 41 to 50 years was about13.2% of the respondents and those that were above 50 years were 7.9% of the respondents. In terms of marital status, majority of the respondents were married (81.6%), 13.2% of the respondents were still single, only one respondent (2.6%) was divorced and another one widowed. When it comes to the level of education of respondents, all of them had at least attended formal education, with 42.2% having completed primary education, while equal proportion of the respondents (28.9%) had attended ordinary and advanced level of education respectively.

Table 1: Demographic information on respondents

Category	Respondents	Frequency	Percentage
Sex	Male	35	92.1
	Female	3	7.9
Age	18-30 years	7	18.4
	31-40	23	60.5
	41-50	5	13.2
	51-60	1	2.6
	Above 60	2	5.3
Marital status	Married	31	81.6
	Single	5	13.2
	Divorced	1	2.6
	Widow/widower	1	2.6
Education	Primary	16	42.2
	O'Level	11	28.9
	A'Level	11	28.9
Household size	1 to 4people	10	26.3
	5 to 10 people	22	57.9
	More than 10 people	6	15.8
Duration of stay in the study area	1-5 years	4	10.5
	6-10 years	1	2.6
	More than 10 years	33	86.6

As far as the occupation of the respondents is concerned, the majority of them were engaged in subsistence crop farming (60.5%) followed by those that were in formal employment, mainly the civil service (28.9%), livestock farming (5.3%) and casual labour (5.3%) as indicated in Fig. 2.

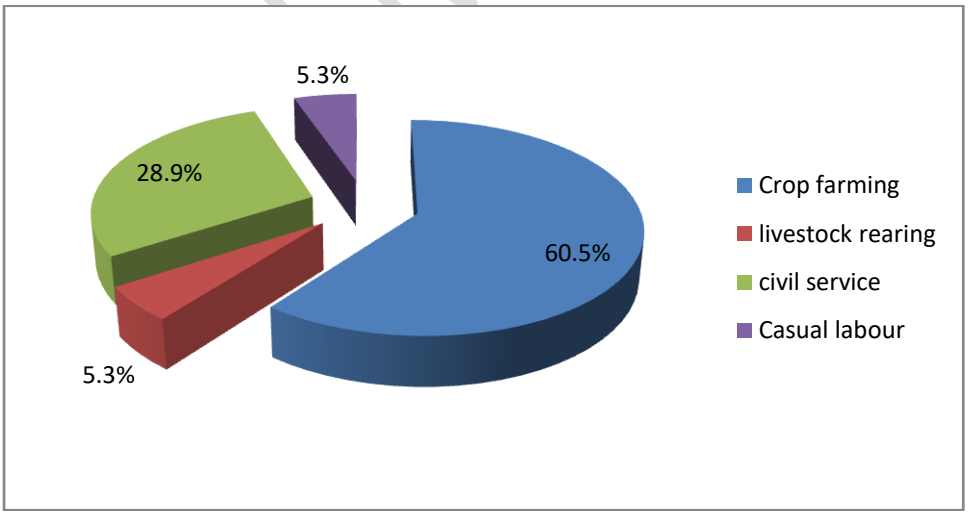

Fig. 2: Occupation of the respondents

Benefits of the hydro power project

About 94.7 of the respondents were of the view that the hydroelectric power project was most likely to benefit local communities, while 5.3% of the respondents did not expect many benefits from the project. To them, the project was not going to address the livelihoods of the poor residents but to benefit the well to do members of the society.

To those who expected to benefit from positive values of the project, majority of them (42.1%) attached socio-economic benefits. They expected the project to avail clean, accessible and affordable electric power to the existing health and education facilities, small and medium scale enterprises, food processing and value addition factories as well as creation of employment and improvement security of residents and their property. In addition, the availability of power was expected to improve communication and information sharing as it would help the residents to charge and run their communication gadgets. Approximately, 36.8% of the respondents indicated that the project was likely to reduce the reliance on the fuel wood and 21.1% emphasized the value of protecting the river banks as indicated in Fig. 3.

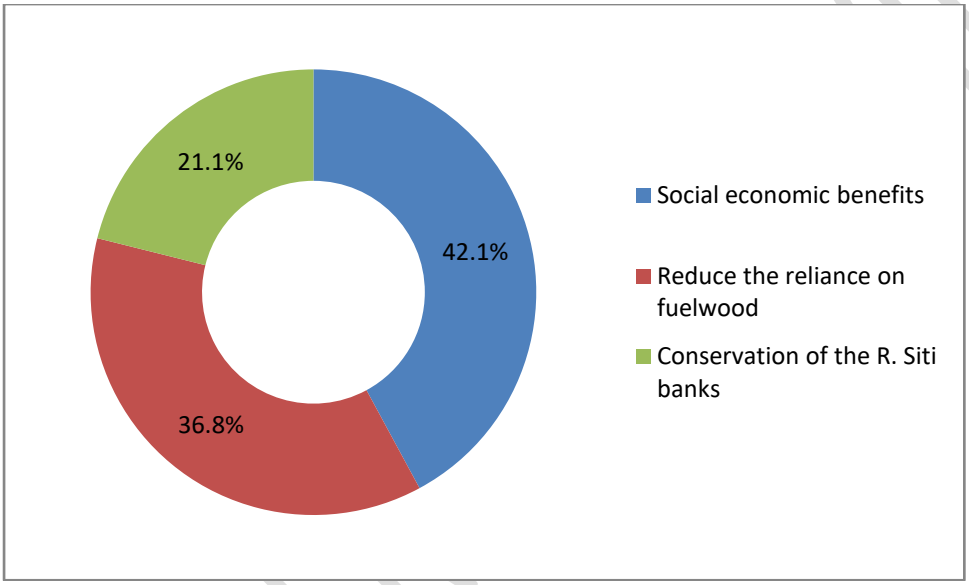

Fig. 3: anticipated benefits of Siti Hydroelectric Power project

On the auxiliary benefits and services derived from the project, 44.7% of the respondents identified the security of water supply as the most important unintended benefits they were likely to derive from the project. In the process of establishing a hydropower station, the R. Siti water was held back to form a reservoir which people expected to utilise as a source of domestic water especially during the prolonged droughts. Another 44.7% of the respondents indicated that the project helped the youth to be employed by the project. Active employment empowered some of the youth to acquire some skills in construction and maintenance which they would apply to earn a living, even after the project was completed. About 3.5% of the respondents highlighted the improved road network in the rural project area, which was initially put in place (constructed) to ease the delivery of construction materials but had significantly improved accessibility and eased the movement of people and goods within and outside the study area. Equally important was the support the community received in the form of cooperate social responsibility program by the hydropower company towards the local communities as expressed by3.5% of the respondents as indicated in Figure 4.

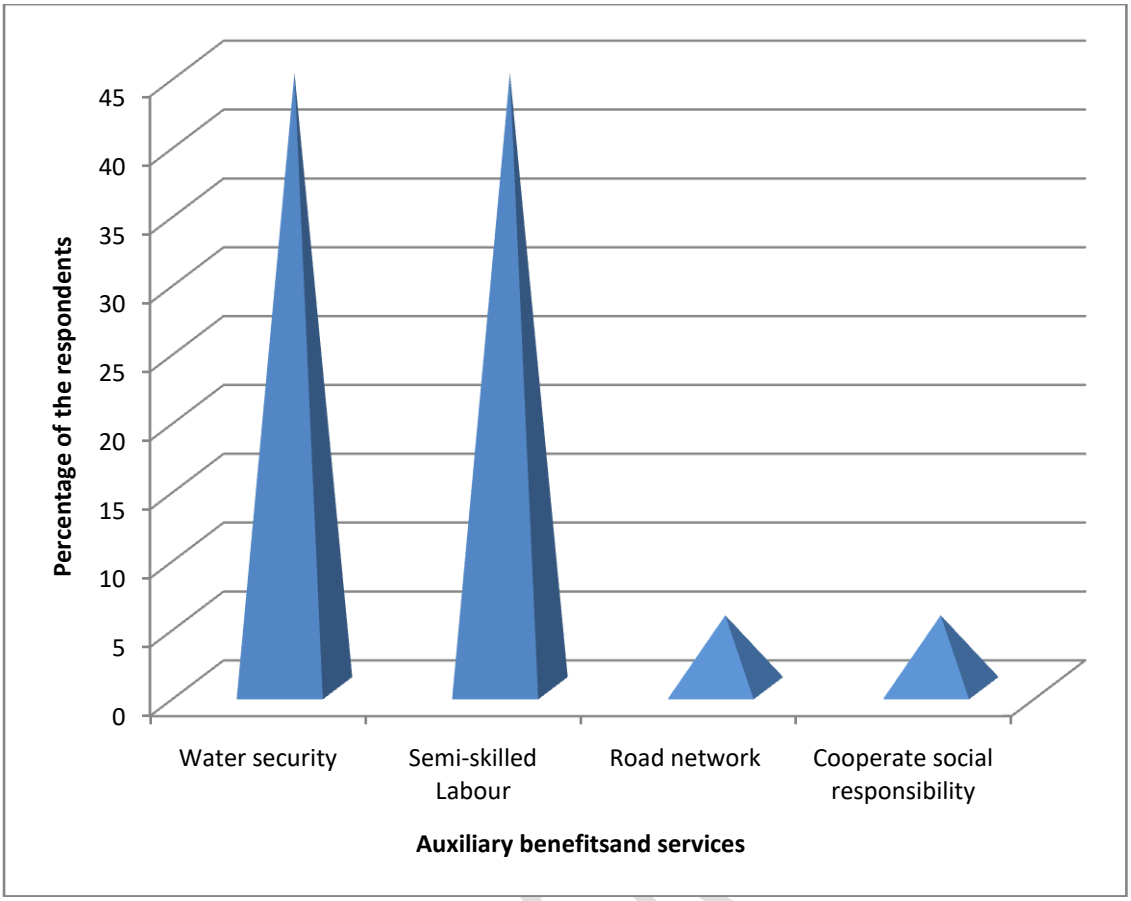

Fig.4: Auxiliary benefits and services of Siti Hydro Power Project.

Turning to employment opportunities created by the project, the respondents were asked whether they recognized the electric power generation scheme as a key source of employment opportunities for the residents, in response, 92.1% of the respondents provided affirmative answer and 7.9% did not think that the project had created viable and meaningful jobs to the society. Turning to the overall impact and performance of the project in terms of the benefits, the residents were expecting to get from the project, 34.2% of the respondents ranked it extremely positive, 63.2% positive and 2.6% negative as presented in Fig. 5.

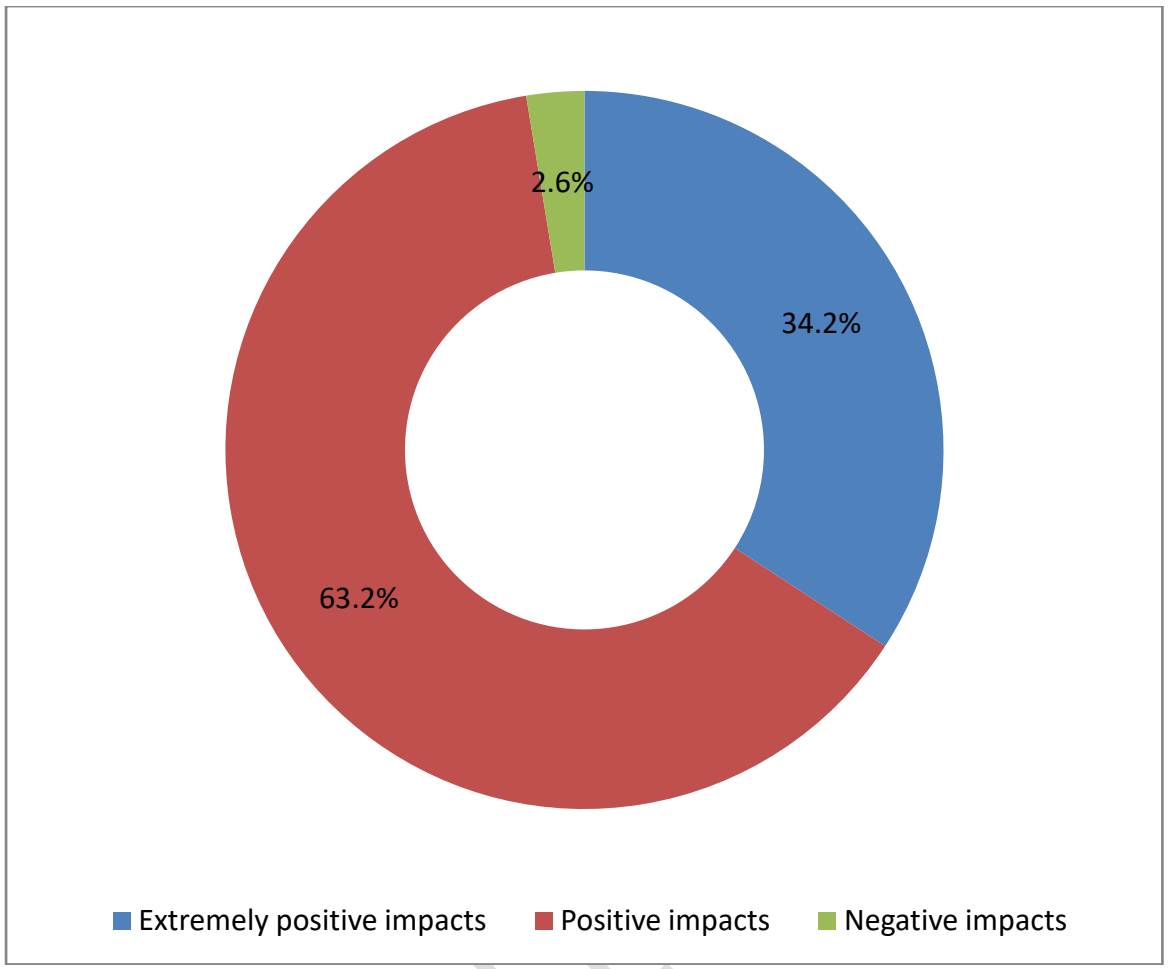

Fig.5: Community ranking of the performance and impact of the hydropower

Perceived negative environmental impact of the project

On the negative side of the project, 78.9% of the respondents were of the view that the power project had caused significant environmental problems and 21.1 % of them did not think that the project had any significant negative impact on the environment and Mt. Elgon National Park (Man and Biosphere Reserve). About 47.4% of the sampled household heads associated the project with soil erosion along the water channel as the most negative environmental impact, while 21.4% of the respondents mentioned the disruption of the water flow of R. Siti and R. Nyalit and 13.2% to deforestation especially inside Mt. Elgon National Park where the weir (intake) of the power station is located. However, 18.4 of the household heads did not believe that the project caused any negative environmental problem (Fig. 6).

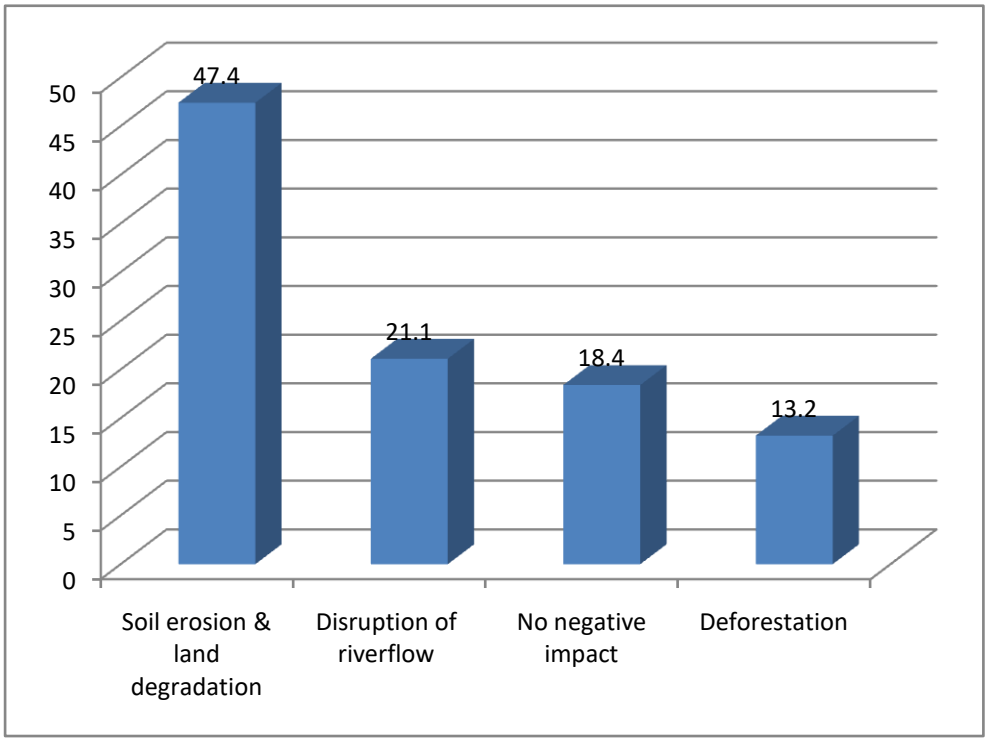

Fig. 6: community perception on the negative environmental impact

As to whether the environmental and social impact assessment exercise adequately addressed the negative impact of the project, about 63.2% of the respondents were of the view that ESIA provided adequate mitigation measures, 31.6% did not think that mitigation measures were adequate, while, the minority (5.2%) were undecided. Some of the areas that respondents thought that were not well addressed by the environmental social impact assessment study include loss of land and property (36.8%), displacement of residents (34.2%) and unemployment (13.2%). However, about 15.8% of the respondents were confident that the study fully addressed most of the issues and there was no major threat that was not covered by the assessment exercise as reflected in Fig. 7.

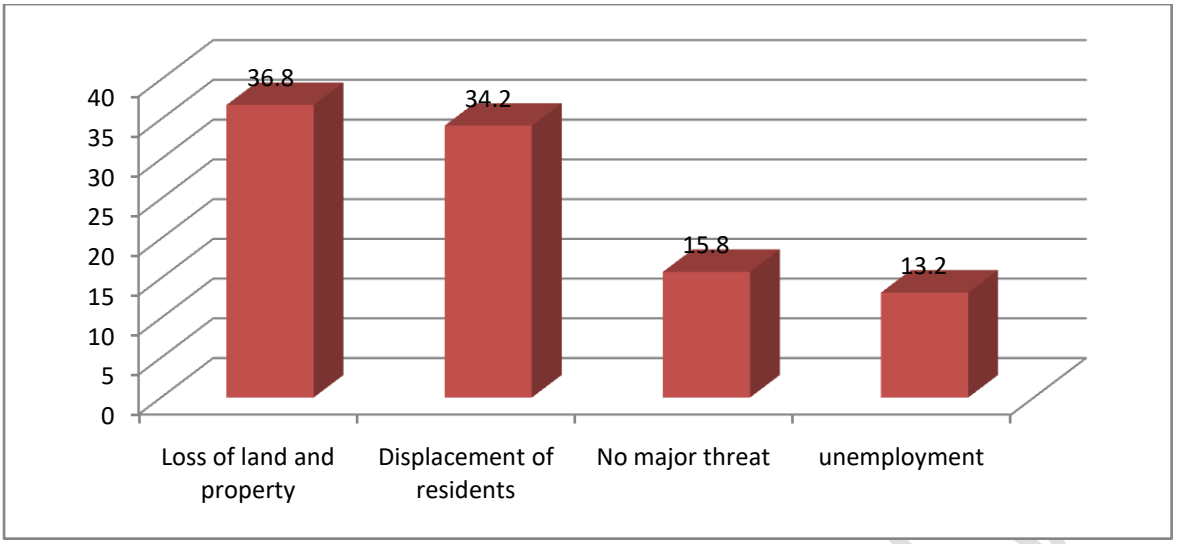

Fig. 7: impacts that were not adequately addressed by ESILocal cap

Local capacity to utilize electric power

Whereas, there was explicit willingness, desire and interest of having the generated electric power utilized by local community and residents in the study area, as exemplified by the provision of 1.5MW in the project design to serve the local needs, the respondents were concerned that the unit price of the power consumed would impact on their ability and willingness to install and utilize power for domestic and commercial purposes. However, this fear, notwithstanding, about 81.6% of the respondents indicated that they would be willing to pay the power bill if it was in the range of Uganda Shillings 100,000-500,000 (US $ 27-135) per annum. Only 15.8% of the respondents would be willing to pay more than 500,000 shillings (US $ 135) and 2.6% indicated that they were too poor to pay the electric bill at whatever cost. This category of resident did not have a reliable source of income to sustain the cost of electricity.

Turning to household income which determines the ability to utilise, power and other related utilities and services, no respondent indicated that his/her monthly income was above Shs 500,000 (US$ 135). About 65.8% of the respondents earned on average between US $ 27 and US$ 81 while 31.6% of the residents lived on monthly income of more than US $ 81 but less than US $ 135. The respondents who did not have reliable and sustainable source of income and at most lived on monthly income of less than US $ 27 were composed of 2.6% of the household heads as highlighted in Fig.8.

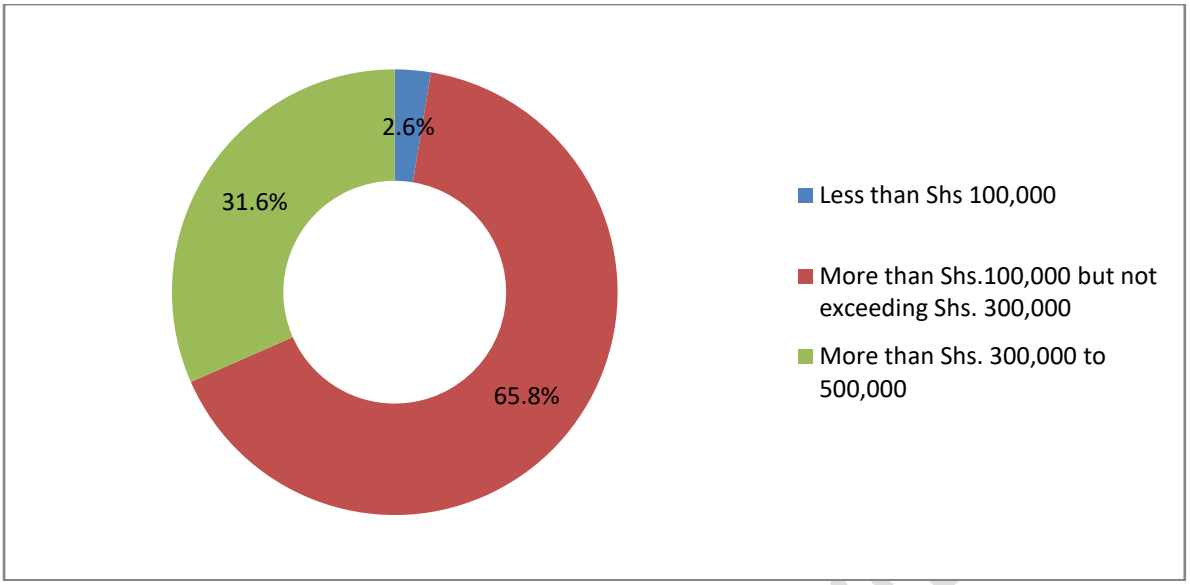

Fig.8: Monthly household income

Use of power by local communities

Regarding the utilization of power, majority of the respondents indicated that they would use the power of lighting homes and run small scale enterprises (60.5%) and the rest of the respondents would use it for only lighting (39.5%). As shown in Table 2.

Table 2: Intended use of hydroelectric power

Use of power	Frequency	Percent	Valid Percent	Cumulative Percent
Lighting only	15	39.5	39.5	39.5
Lighting & small scale industry	23	60.5	60.5	100.0
Total	38	100.0	100.0	

Power connections and supply

Assessment of the power supply and connections revealed that contrary to the initial plans and the residents' expectations, the priority was given to urban centers, ignoring many residents, including those whose homesteads were located along the power supply line. Face to face interviews with affected homesteads revealed that residents had failed to raise adequate financial resources to cover power installation costs.

Mitigation measures against environmental impacts.

The hydropower company invested in the restoration of areas above points a weir (intake) of the power station by planting trees. The channel drawing water from River Sit which is about 1.2 Km running inside Mt Elgon National Park was covered with soil and natural to minimise the footprint of the project to the environment. To keep the water flow in the river, only 3% of water was being drawn and utilised by the dam to generate power.

DISCUSSION

The profile of respondents reveals the extent of remoteness of hydroelectric power project and weak capacity of residents to utilise the generated power. That said, the installation of hydropower system in the study area coupled with the recent construction of tarmac road (Kapchorwa- Suam Road) through the project area was unprecedented development that had created public excitement and sense of hope. Perhaps this excitement explains the reason as to why some of the respondents could not realize that although there were some benefits to gain from the hydroelectric power station, the project had some inherent and inevitable negative environmental and social impacts, including the diversion of river water flow The above shortcoming notwithstanding, the Siti hydropower station has been able to provide clean renewable energy to rural community that would have taken long to access power from the national grid-

Regarding the auxiliary benefits, almost all respondents were able to appreciate, recognize, notice and identify benefits that were indirectly associated with Siti Hydropower project. This could be attributed to the direct attachment and linkage of those benefits with the community livelihoods and development. Preservation of water source through damming and water retention was a clear guarantee of sustainable source of water for domestic use. Similarly, acquisition of skills through artisan, machine work and labor offered by residents was a great opportunity for enhancing the capacity of the youth and future employment even after the project is accomplished. Indeed, as highlighted by Mohammed et al., 2018, hydropower is important form of renewable energy but if it is not well planned and constructed, it may impede the flow of the river and lead to habitat loss. However, some of the key auxiliary benefits like control of floods and opportunity for food security, reduction in greenhouse gas emission and recreation facility were not mentioned by the respondents. This is attributed to low public exposure to similar clean energy projects and inadequate awareness about the impact of climate change as well as the existing mitigation and coping mechanism. Yet, efforts by nations to increase the use of clean renewable energy is of paramount importance in reducing carbon emission and devastating effects of climate change (Smiet, 2016).

It is worth noting that the majority of respondents were fully aware of negative environmental and social impacts of the project because either they actively participated in the construction phase (as hired casual laborers) which involved a lot of earthwork, including; excavation, drainage of river water, diversion and retention of R. Siti and R. Nyalit water or directly observed the whole implementation stages of the project, including the construction and power installation operations, making the expected impact visible to the general public.

That said, a significant number of respondents (36.8% of the respondents) could not tell whether the proposed mitigation measures against anticipated negative impact of the project as stipulated in the Environmental and Social Impact Assessment Report were adequate or more wanting. This could be attributed to inadequate participation of residents in identifying potential negative environmental and social impacts as well as low level of community engagement in setting and implementing mitigation interventions. It is well known that in most cases experts who undertake environmental and social impact assessment studies do not adequately and actively consult the varsity majority of local communities as stake holders (Hughes et al., 1998; Kabir & Momtaz, 2011; Esteves *et al*., 2011; Taako *et al*., 2020). The stakeholder consultation tends to be limited to community leaders, technical staff of the district local governments and other responsible institutional stakeholders. This is done more or less to legitimize the assessment process but rarely focuses on the affected individual residents. This raises the need for Elgon Hydro PVE Ltd and other stakeholders in the catchment area to develop and implement public awareness strategy aimed at informing and mobilizing residents to effectively participate in the implementation of mitigation measures. At the same time, residents should be supported or facilitated to install power in their homes, if they are to directly benefit from the project. In this way, residents will increase their capacity to benefit from the project and be motivated to participate in the implementation of mitigation measures.

At the same time, residents should be supported or facilitated to install power in their homes by offering them incentives such as discount or tax holiday for small scale artisans, if they are to directly benefit from the project. In this way, residents will Provision of incentives for rural people to utilize generated power is crucial because although, setting aside1.5 MW power for local residents was a good gesture and aimed at stimulating social-economic development of the project area, the residents' capacity and willingness to pay for power was heavily dependent on the level of household income. In a community where most of the

residents earn less than US $ 135 a month, very few people would be able to pay monthly electricity bills. To make matter worse, the outbreak of COVID 19 in 2020 significantly affected the local and national economy, compromising the capacity of individual residents to install power in their houses. Factually, by the time this study was completed, only a few residents in trading centers and townships (Kapkwiok, Nyarit, Kapkwata and Kapchorwa) had installed power into their homes. The power supply was confined along and close to the main road and the power line. Majority of residents (88.4%) had not yet managed to cover the cost of wiring and installation of electricity in their houses. Added to this, no respondent indicated that they would utilize generated power in cooking and heating. In this context therefore, the dependence on wood fuel for cooking will not be avoided at least in short and midterm. This calls for a well-designed and community centered strategy for promoting on farm tree planting and woodlot establishment which would in long run reduce the degradation of Mt. Elgon National Park.

Essentially, this implies that residents were still depending on fuel wood extracted from Mt. Elgon National Park (Biosphere Reserve) as a source of domestic energy. This is in agreement with the study by Gurunga et al., 2011 which reveals that although benefits of micro hydropower rural electrification in Nepal were immense, more than 44% of the people did not have access to electricity.

Recommendations

- The government in collaboration with Elgon Hydro PVE ltd should develop and implement conservation education and awareness strategy aimed at facilitating residents to effectively participate in the implementation of mitigation measures against inherent negative impacts of the project.
- The government should put in place incentives and mechanisms for strengthening the capacity of local communities within the hydropower project area to access and utilize the generated electricity. In this way, reliance on the fuel wood energy will be reduced and in long run minimize the rate of deforestation and degradation of protected area. This is in line with the Rural Electrification Agency (REA) of Uganda's strategic goal of improving rural electrification access to 26% by 2022 from 7% in 2013 and 100% access by 2040 (REA, 2013). Also, the agency gives the priority and support to small scale power generation facilities as local sources of power supply. The most plausible strategic idea of REA regarding the extension of financing and support towards end-

user especially at lower income households, as contained in the agency's rural electrification strategy and plan 2013-2022.

CONCLUSION

Elgon Hydro PVE Ltd, one of the private investors in Uganda that has decided to put resources in the provision of modern renewable energy services in a rural area like Bukwo District has played a key role in social economic development and transformation of rural communities by generating clean hydro power. However such an investment to have a meaningful impact on the livelihoods of targeted people and environment, the energy generated and supplied must be affordable to the majority of the residents and reliable at all the time. In other words, the power supplied to rural communities should be secure and offered at affordable price. In addition, the hydropower projects should be designed in a manner that minimises environmental footprint and underpin every facet of the nations' economy and modern way of life.

In light of this therefore, it is important for the Government of the Republic of Uganda to put in place mechanisms to create incentives for residents in the project area especially those whose houses are located along the power supply line to install and utilize the renewable energy. Effort should be made to ensure that the hydropower supply system contributes towards the reduction of community reliance on fuel wood as source of energy which has a bearing on deforestation and land degradation.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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