



Biomass Fuel Dependency in Rwanda and its Environmental Impacts. A case of Secondary Schools in Gisagara district.

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ABSTRACT: Rwanda's main energy source is biomass (firewood and charcoal), where 83.3 % of Rwandans depend on it for cooking. This study aimed to identify biomass fuel consumption trends in Gisagara secondary schools, to determine forest cover changes trend in Gisagara district and find out environmental effects derived from the use of biomass energy in Gisagara secondary schools. The study collected information by using both quantitative and qualitative methods and observations to gather data from secondary sources. For analyzing the collected data, Statistical Package for the Social Sciences (SPSS) software and qualitative methods were used to analyze the relationship between biomass fuel consumption and impacts on environment. Firewood consumption trend in Rwanda secondary is at high rate where the research findings showed that 6771m³ were consumed by three schools of Gisagara district namely, Groupe Scolaire Saint Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save from 2015 to 2021. This has also contributed a lot in the reduction of forestland cover in the area from 24.26% in 2015 to 19.16% in 2020. In addition, over dependency on biomass fuel in Rwanda secondary school has had various adverse effects on the environment such as deforestation, loss of biodiversity, soil erosion, high concentration of carbon dioxide in atmosphere, air pollution among others. In a bid to cope with the consequences of relying on biomass energy, the country has committed to increase and sustain the area covered by forest. This will be achieved through forest landscape restoration and reducing the number of households depending on firewood as main source of energy for cooking from 79.9% people in 2016/2017 to 42% by 2024. However, there is a gap between biomass production and consumption which would be resolved to make it a sustainable source of energy. Thus, various stakeholders in energy sector including government

institutions and non-governmental organization are advised work hands in hands to find out adaptation and mitigation measures to reduce over dependency on biomass fuel in Rwanda secondary schools.

Key words: Biomass, Firewood, Forest, Ecosystem, deforestation.

1. Introduction

Forests have great importance on the life of all living organisms worldwide because they provide air to breath, habitat for flora and fauna, water catchment areas, contribute to rain formation, purification of air as well as human livelihoods depend on them to get biomass energy, timber, constructional materials, among others. However, despite the relevance of forests, high increase of population coupled with anthropogenic activities such as high dependence on the use of biomass energy, search for agricultural lands, urban sprawl, industrialization, and development of infrastructures continue to pose serious threat to the sustainable protection of forest. This is explained by the facts that cutting down trees to satisfy human needs like getting timber, land for settlement, mining and farming practices have been proved to be the drive of high level of deforestation among much of the Amazon rainforest over the last 50 years, where 17% of this forest has been lost as result of agriculture activities (Carly, 2020).

More than 80% of the population in Sub-Saharan Africa (SSA) relies on solid biomass, such as firewood, charcoal, agricultural by products, and animal waste, according to study. These biomass fuels were burned in poorly ventilated kitchens with smoky and inefficient traditional stoves, resulting in high levels of harmful pollutants such as carbon monoxide and particulate.

In Rwanda, forests cover roughly 724,695 hectares (30.4%) of the total nation area, with 387,425 hectares (53.5%) being plantations, 130,850 hectares (18.1%) being natural mountain rainforests, 161,843 hectares being wooded savannah (22.3%), and 43, 963 hectares being shrubs (6.1 percent) (Ministry of Environment, Rwanda Forest Cover Mapping, November 2019). Although, forests have contributed greatly to the national economy where the fiscal year 2016/2017 showed US\$365 billion of Rwandan Gross Domestic Production (it means 5% of the total GDP) was derived from forest sector. Various studies have proved that changes from forest to other land uses primarily to satisfy the needs of a growing population which reached 12 million people in 2017 on 26,338 km² and expected to double by 2050 will continue to be a threat to forest resources (MoE, Forest Research Strategy and Guidelines for Rwanda (2018-2024), 2019).

Although, forest is a renewable source of energy, poor forest management, improper charcoal manufacture and wood fuel combustion were found to have detrimental impact on climate. For example, it is estimated that 1–2.4 Gt of CO₂e in greenhouse gases are emitted annually in the production and consumption of fuelwood and charcoal, accounting for 2–7% of global anthropogenic emissions (UNEP, Review of Wood fuel Biomass Production and Utilization in Africa: A desk study, 2019).

According to HAKIZIMANA (2020), biomass energy such as wood and charcoal have been proved recently to dominate the primary energy supply in Rwanda where firewood itself accounts at least 80.4 % of energy consumed and it has been blamed for significant deforestation across the country. In addition, research has proved that over relying on charcoal in urban areas by 2030 will seriously affect Rwanda's forestry plantations because population and urbanization continue to increase (MININFRA, 2015).

To address the above issues, the government of Rwanda established Rwanda's National Strategy for Transformation (NST1) where the country should increase and sustain the surface covered by forest at 30% till 2024 from 29.6% in 2017 as well as reducing the number of people who depend on firewood as a source of energy for cooking from 79.9% in the year 2016/2017 to 42% by 2024. In this context, more efforts have been made to reduce the rate at which firewood is used for cooking in big institutions such as hotels, schools, hospitals, prisons, police, and the army (HAKIZIMANA, 2020).

Therefore, this study aimed to identify biomass fuel consumption trends in Rwanda secondary schools, to determine the forest cover changes trend in Gisagara district and to find out environmental impacts resulting from the use of biomass energy in Rwanda secondary schools. It will also contribute a lot to the government of Rwanda, ministry of environment, various environmental institutions like REMA, local leaders, headteachers and other stakeholders in making decision, taking important strategies and right choice on the sustainable energy sources that would be used in secondary schools of Rwanda to resolve the problem of high dependence on firewood. These include the utilization of biogas and liquefied petroleum gas (LPG) in public and private schools.

2. Methods and Materials

2.1. Description of the study area

Gisagara District is located in Southern Province and covers 678.9 square kilometers. It is divided into 13 Sectors, namely Gikonko, Gishubi, Kansi, Kibilizi, Kigembe, Mamba, Muganza, Mugombwa, Mukindo, Musha, Ndora, Nyanza, and Save, 59 Cells, and 524 villages. The Republic of Burundi borders it to the south and east, Nyanza District to the north, and Huye and Nyaruguru Districts to the west (RoR, Gisagara district development strategy (2018-2024), 2018).

Gisagara District has a temperate climate by altitude even if it is geographically located near the Equator. However, it should be noted that the succession of seasons becomes irregular from year to year and that time vagaries give dryness. Average annual temperatures generally oscillate around 20°C with amplitudes changing between 15°C and 20°C and annual rainfalls of about 1200 mm (RoR, Environmental and Social Management (ESMP), 2019).

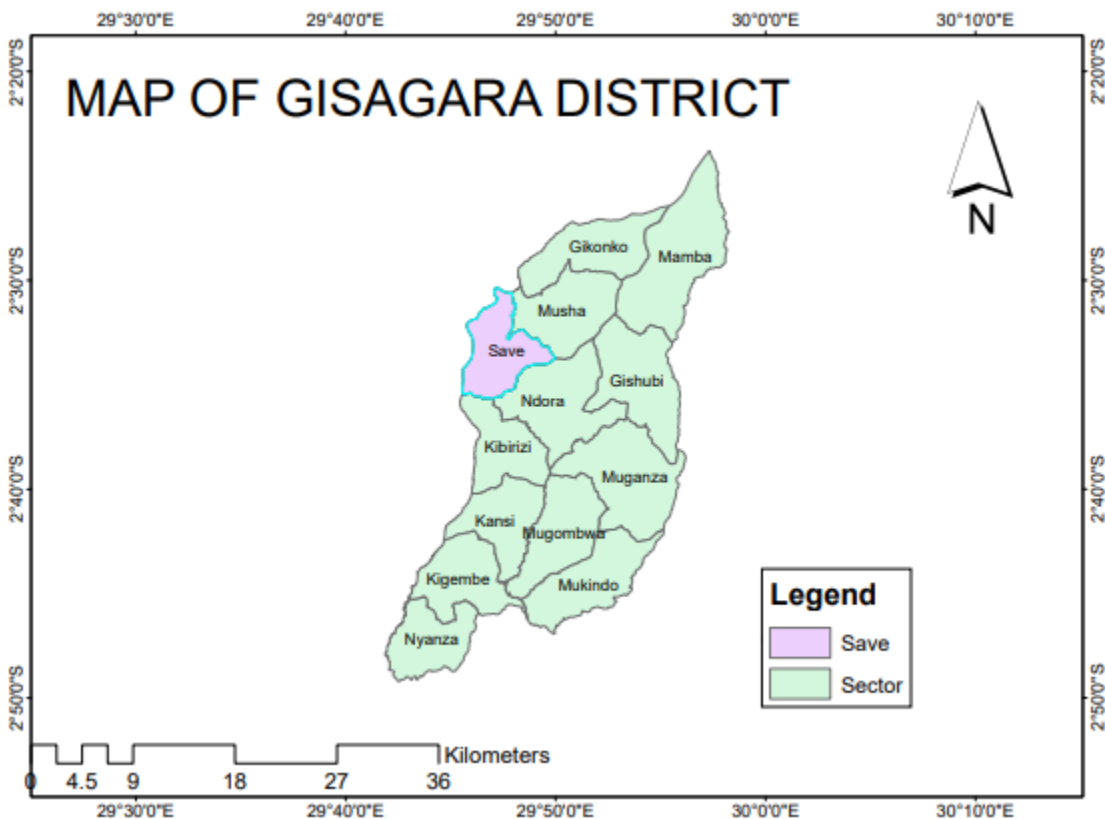


Figure 1: Map showing Save sector of Gisagara district.

According to Rwanda Forest Cover Mapping Report of November 2019, forest cover in Southern Province is about 177,537ha forests corresponding to 29.8% of the total province land.

Nyaruguru is the highest forested with 55,759ha of forest cover (i.e., 52.6% of the total district land), followed by Nyamagabe District with forested area about 54,018ha covering 49.5% of the total district land. Gisagara district is the least forested in the Southern Province with an average of 13% for forest cover. The report urged therefore need of specific program to uplift them to the average that was required by Vision 2020.

2.2. Data collection and analysis

In this study, secondary data on firewood consumption in Groupe Scolaire Sainte Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save from 2015 to 2021 were collected from these schools. The methodology employed to analyze the collected data was descriptive statistics. In this regard, quantity of firewood was recorded and analyzed using Statistical Package for the Social Sciences (SPSS) software. This method was used to analyze the correlation between the quantity of wood fuel used from 2015 to 2021 in three secondary schools of Save sector of Gisagara district. Qualitative method was also used to analyze the rate at which forest cover has changed and the impacts on environment as result of over reliance on wood fuel in the above said schools.

3. Results

3.1. Biomass consumption trends in secondary schools of Gisagara district

Result in table 1 showed that there was high dependency on firewood for cooking in three schools of Save sector of Gisagara district namely, Groupe Scolaire Saint Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save from 2015, 2016, 2017, 2018, 2019, 2020 and 2021.

Table 1: Firewood consumption trends in Gisagara secondary schools per year from 2015 to 2021

SCHOOL NAME	2015	2016	2017	2018	2019	2020-2021	Grand Total
Ecole Technique Saint Kizito Save	150	120	130	170	200	155	925
ES SAVE	142	135	131	143	141	144	836
GS Sainte Bernadette Save	810	810	810	810	810	960	5010

Grand Total	1102	1065	1071	1123	1151	1259	6771
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Source: Research data (2022)

The table 1 shows that from 2015 to 2021 Groupe Scolaire Sainte Bernadette Save has used high quantity of firewood for cooking compared to other schools where 5010 m³ of wood fuel were used, it is followed by Ecole Technique Saint Kizito Save that used 925 m³ of firewood, while Ecole Secondaire Save is the one that used low quantity of firewood (836) than other schools in all years. This is explained by the fact that Ecole Secondaire Save is not a boarding school like other two schools in the table above. In addition, data of 2020 and 2021 were combined because during the period of Covid-19 pandemic schools in this region stopped their activities for seven months, hence the extension of the academic year to 2021.

By putting more emphasis on the biomass fuel consumption trends in these schools. Generally, the quantity of firewood used has increased from 1102 m³ in 2015 to 1259 m³ in 2021. This has been proved to be a serious threat to forest resources especially eucalyptus tree species which are mainly used as firewood in these schools where 6771 m³ were used from 2015 to 2021.

Table 2: Firewood consumption trends in Gisagara secondary schools per term.

SCHOOL NAME	1	2	3	Grand Total
Ecole Technique Saint Kizito Save	278	277	370	925
ES SAVE	285	278	273	836
GS Sainte Bernadette Save	1590	1800	1620	5010
Grand Total	2153	2355	2263	6771

Source: Research data (2022)

Results in table 2 show the variation of the quantity of firewood per term used in Groupe Scolaire Saint Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save from 2015 to 2021. In general, large quantity of firewood (2355 m³) were used during the second term and the least quantity of firewood were used in first term (2153 m³) in all years. In addition, Groupe Scolaire Sainte Bernadette Save remains the first consumer of firewood in all terms from 2015 to 2021, where in the first term the school used 1590 m³ of firewood, 1800 m³ of firewood in the second term and 1620 m³ of firewood in the third term. This is explained by the fact that

the school had large number of students than other schools where the study was conducted from 2015 to 2021.

3.2. Forest cover change in Gisagara district

Results of this study have revealed that high dependency on biomass fuel as main source of energy for cooking in Rwanda, with special focus on the secondary schools in Save sector of Gisagara has had considerable effects on the reduction of forest cover in this area.

The study also analyzed forest cover change based on the results given by Figure 2 and 3. They show that forestland has reduced considerably from 24.26% in 2015 to 19.16 in 2020. Thus, although there are different causes of forest cover change in Gisagara district including increase of population, increase of built-up area, search of agricultural land, and use of biomass fuel. The results of this study proved that high dependency on biomass fuel in Rwanda, particularly in secondary schools of Gisagara district has contributed a lot in the reduction of forestland in the area and this may have severe effects on the environment in different ways.

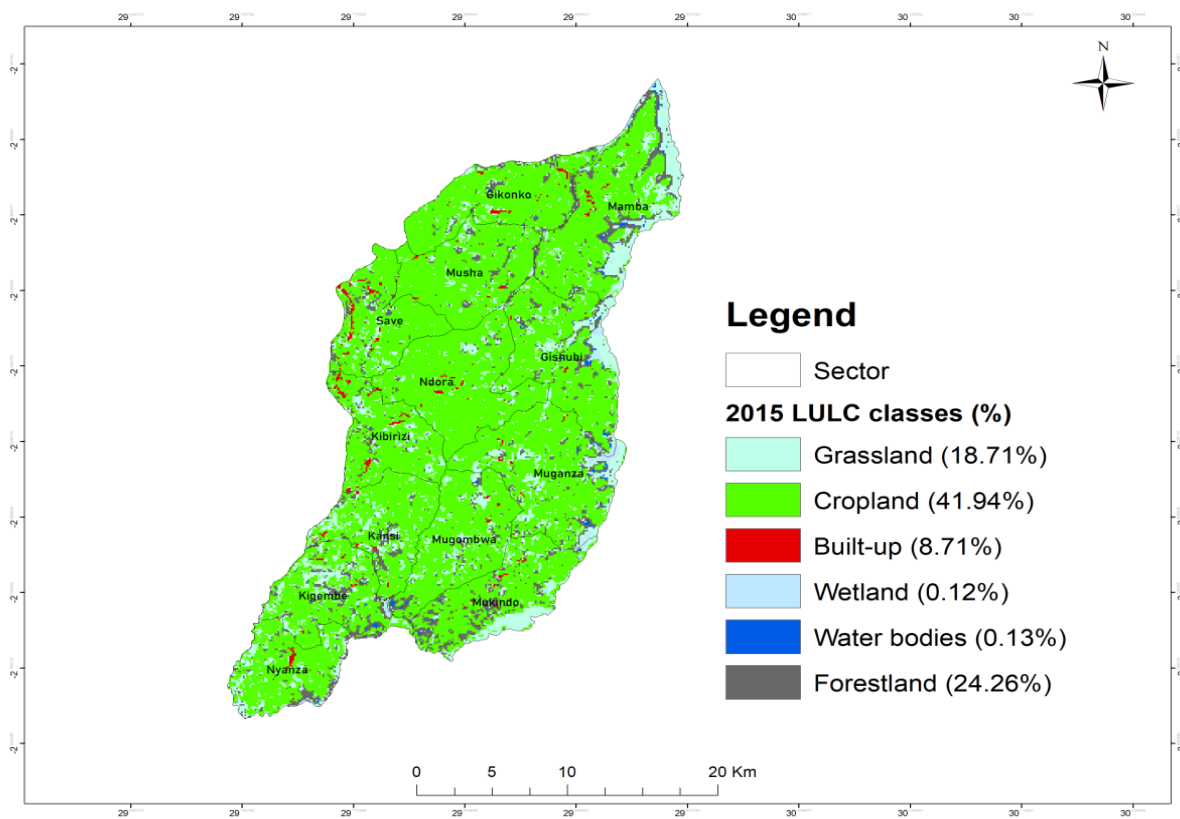


Figure 2. Map of Gisagara showing land use and land cover change in 2015.

Source: Research data (2022)

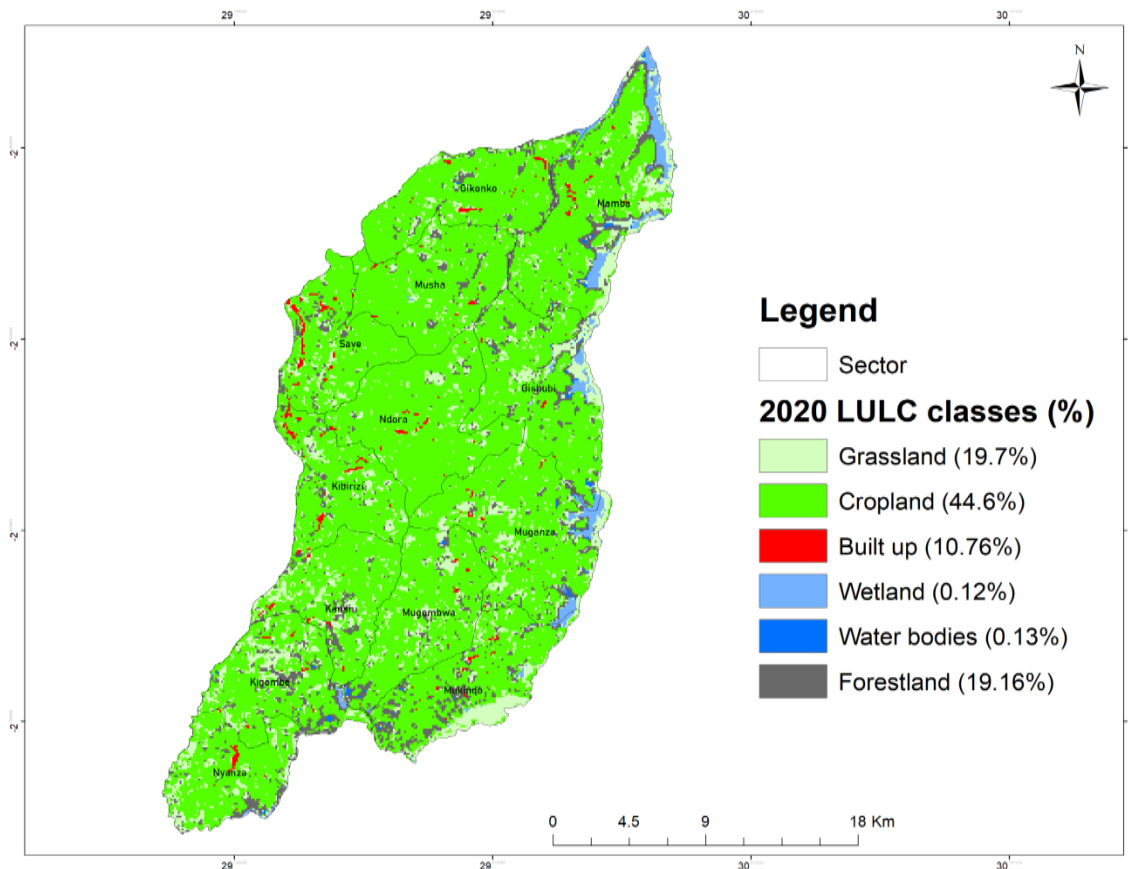


Figure 3: Map of Gisagara showing land use and land cover change in 2020.

Source: Research data (2022)

3.3. Environmental impacts of high dependency on biomass fuel

This study has revealed that secondary schools in Gisagara district particularly in Save sector have claimed large quantity of firewood for cooking. This has many environmental impacts in this area specific and to the whole district in general as well as to the country. The results of this study showed the following as common effects affecting the region.

Reduction in forestland, this study showed that high use of firewood in the above said schools has contributed to the reduction of the area covered by forest of 5.1% in Gisagara district from 2015 to 2020 as it has been demonstrated by maps that show land use and land cover change in the said period in that area. This has affected variety of living organisms that depended on forest to survive.

Loss of biodiversity, clearing forest to get biomass fuel has led to extinction of some tree species and animals. For instance, this study found that all schools investigated used eucalyptus tree as

energy source in terms of firewood, thus eucalyptus trees in Gisagara district are in danger unless other source of energy will be adopted in secondary schools located in the region for cooking to replace them.

Soil erosion, observation done in the areas such as Gatoki and Shyanda revealed that cutting down trees has exposed the region to various erosional agents like running water and wind. These have had number of negative effects including loss soil productivity and destruction of houses.

Occurrence of natural disaster, reduction of forestland on one extent has been accused to be one of the causes of the occurrence of different disasters such as floods and strong winds which used to destroy houses, schools, crops, and some people were injured. For instance, International Federation of Red Cross and Red Crescent Societies ,2020, reported that from 3rd to 5th of March 2020, extensive flooding and windstorm registered in Gisagara District led to extensive destruction of houses and crops (IFRC, 2020).

Reduction in rainfall totals, as the forestland will continue to be cleared at a high speed in search of biomass fuel. The district is in the risk of being affected by the problem of shortage of rainfall because forest contributes a lot in hydrological cycle through evapotranspiration. This will have severe effects on the livelihood of the population in the area as many of them depend on agriculture as their primary activity.

Pollution, although biomass is a renewable source of energy, high use of firewood in Gisagara poses threat to the health of people because it gives emissions that causes air pollution which has various negative effects such as pneumonia diseases, eye diseases among others.

Deforestation, high dependency on biomass fuel in secondary schools has result in extensive cutting down of trees that may result in severe environmental effect like increase of carbon dioxide in the atmosphere which may cause acidic rain. This is because forests absorb carbon dioxide and release oxygen which is most essential for living organisms. For example, forest cover in Gisagara district has reduced from 24.26% in 2015 to 19.16 % in 2020.

4. Discussion

MINILAF, 2018, has stated that Rwanda's main energy source is biomass which has accounted 83.3% of primary energy to come firewood, this trend has been justified by the facts that biomass provides energy in form of wood and charcoal, renewable source of energy, carbon neutral, reduce over reliance on fossil fuels, less expensive, source revenues and source of raw materials.

The results of this study have noticed that 6771 m³ of firewood was used by three secondary schools located in Save sector of Gisagara district namely Groupe Scolaire Saint Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save within a period of seven years from 2015 to 2021 for cooking.

Although, it's evident that schools in this region still highly enthusiastic about firewood for cooking. This has tremendous impacts to the environment, as an example, it's estimated that indoor pollution from biomass burning accounts for 4% of the world burden of disease (Bruce et al., 2000), and a preservationist study finds that biomass fuel use endangers the health of 400–700 million people worldwide and causes 2.8 million premature deaths annually (Bruce et al., 2000) (Bhola.R, 2010).

Furthermore, as stated by HAKIZIMANA (2020), that household consumption of biomass is putting pressure on existing forest resources, which proved to be a serious driver of deforestation. He also added that if the agricultural and concrete household continues to chop trees for firewood and timber, the country risks desertification. The study conducted in secondary schools of Gisagara district, discovered that it important also to acknowledge the role of those schools in deforestation because the use high quantity of biomass for cooking.

In addition, the imbalance between biomass supply and demand was seen as a significant threat to forest resources. Thus, to addresses this issue both supply and demand aspects of the biomass sector progressing to achieve a balance between supply and demand of fuel wood is very needed by 2030 (MININFRA, 2019). However, the results of this study showed that the progress is slow and reliance on non-sustainable biomass continues especially in secondary schools of Gisagara district.

Thus, the results of this study confirm that high dependence on biomass energy in Gisagara secondary schools has significant effects on the environment which require emergence efforts to scale back the overuse of firewood for cooking in these schools and substitution of this energy with other energy sources like biogas and liquefied petroleum gas (LPG).

5. Conclusion

Energy is the key factor for the development of the country worldwide. More than 83.3% Rwandans depend on biomass fuel in form of firewood as their main source of energy for cooking. From the above shown percentage, this study has revealed that firewood consumption in Rwanda secondary is at high rate where the research findings showed that 6771m³ were

consumed by three schools of Gisagara district namely, Groupe Scolaire Saint Bernadette Save, Ecole Technique Saint Kizito and Ecole Secondaire Save from 2015 to 2021.

This has contributed a lot in the reduction of forestland cover in the area from 24.26% in 2015 to 19.16% in 2020. This poses a serious threat to forest resources in Gisagara district which requires a rapid intervention. This is because high dependency on biomass fuel in secondary schools in this area is coupled with different environmental impacts such as reduction in forestland, soil erosion, loss of biodiversity, air pollution, occurrence of disasters, shortage of rainfall among others which require sustainable answers to ensure wellbeing of population living in this region. Therefore, various stakeholders in energy sector including government institutions and non-governmental organization are recommended work hands in hands to find out adaptation and mitigation measures to reduce over dependency on biomass fuel in Rwanda secondary schools including use of alternative sources of energy such as liquefied petroleum gas (LPG) and biogas.

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