

How University Establishment Influence Land Use and Land Cover Changes in Kenya: A Case of Rongo University, Migori County, Kenya



George Ouma Ochola*, JB Okeyo Owuor and Daniel Odinge Nyamai

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*Corresponding author: George Ouma Ochola, Department of Agronomy and Environmental Studies, Rongo University, P.O. Box 103-40404 Rongo, Kenya

Abstract

In the last two decades, there has been considerable increase in the establishment of both public and private universities. The expansion has been across the different geographical regions as well as demographically. The increase in the number of universities has resulted in environmental challenges in terms of land use and land cover changes in the areas where they are established owing to increased human settlement, infrastructure development, among other necessities. In most cases informal settlements/ slums have been created as a result of influx of people for various reasons such as employment, businesses and student's accommodation. Rongo University which was established eight years ago has seen rapid increase in human population and development of infrastructure among others whose environmental impacts are yet to be investigated and quantified. Therefore, the study sought to investigate how establishment of Rongo University has contributed to land use and land cover change in Rongo Sub-county, Migori County, Kenya with particular focus in North Kanyajuok Sub-Location where the main campus is situated. Both primary and secondary data were used for the study. Supervised classification was used to analyze land-use/cover change data generated from GIS and remote sensing which facilitated defining of the training data set/signature that indicated the pixels to be selected and the type of software to be used for land-cover categories. Basing on the results of this study, it has been established that significant land use and land cover changes have taken place which negatively impacted the environment where the university is established. The study has cited increased human settlement and related developments such as infrastructure development in Rongo Sub-County to have made the area highly vulnerable to environmental degradation as a result of modification of natural landscape and ecology to built environment. Decline of indigenous biodiversity during and after establishing the university as well as increased pollution have been reported as causal factors for environmental degradation. Further, developments associated with university establishment has led to overexploitation of natural resources, reduction in the quality and quantity of water, biodiversity and atmospheric air conditions. In the prevailing circumstances, the study recommends adherence to sustainable environmental planning, including land use, waste and pollution management, among other environmental conservation practices.

Keywords: Rongo university; Establishment; Land use; Land cover; Changes, Kenya

Introduction

All living organisms, human beings inclusive depend on the environment in which they exist Great significance to human and other life forms are attached to the environment. Anything that disrupts, damage or degrade the environment tends to disrupt the very survival of humanity and other life forms. Environment is a habitat for different forms of organisms and a source of food to humanity. It is a source of all manner of resources that humanity depends on. Despite the positive impacts that accrue from universities such as job creation, promotion of socio-economic development among others, their establishment leads to land use/land cover changes which cause negative impacts on the environment. Clearance of vegetation and subsequent exposure makes land susceptible to agents of erosion and also interferes with water cycle. Also, vegetation cover plays an important

ecological role of recharging the atmospheric moisture which is easily compromised human development initiatives such as university establishment. In built environments, constructed pavements hinder the infiltration of water into the soil hence interfere with ground water recharge. Major implications such as over withdrawal of underground water is also evidenced as an impact of university established due to increased water demand. Haphazard developments in the immediate university neighbourhoods has often created slums development which is characterized by poor waste management. Rongo University is one of the universities established in upcoming urban with a transition from rural area. Its environmental impacts are evident in Kitere and its environs where it is situated. It has attracted informal settlements characterized by different structures which are being modified to suit different purposes. Similarly,

farm-lands are being transformed to other land uses to meet the growing demand created by the increased settlement around the university. It is perceived that these alterations and modifications are not in accordance with the provisions of the National Environmental Management Authority (Environmental Management and Coordination Act 1999 reviewed in 2015), the Physical Planning Act of 1996, Urban Areas and Cities Act 2011 and the Universities Act 2012 whose stipulations are well spelt out. Further, it is noted that there is a gap in policy specification for the externalities that are associated with establishment of the universities both at the national and county levels. There is also lack of data especially on how university establishment may lead to land use and land cover changes specifically for Rongo Sub-County. Enrolment of students are on the rise which require more facilities and other services and social infrastructure. Considering that the university might not be able to provide for all, rapid land use and land cover changes occur in terms of development to provide extra facilities the university has not provided. Several studies concerning the effects of university establishment on various aspects of the environment have been conducted but none has ever been carried out in Rongo University. Against this background, this study was conducted to examine the degree of which Rongo University as a driver of land use/land cover changes and to propose mitigation measures for ensuring environmental sustainability.

Literature Review

Countries' development considers universities among other institutions as the important impetus that influence the socio-economic, environment and physical characteristics of the areas of their locations by nature of their capacities (Okong'o, 2014). Universities offer education services, research and outreach/extension which attract populations. Even though there are several universities in Kenya, with chartered standing at 47, their equitable distribution across the country still remains a concern. Key universities in Kenya still remain factors in pulling large number of people who also call for accommodation services and other basic needs in areas where they are located.

According to Odhiambo (2014), Boston city in United States of America remains a good example of towns whose developments have majorly been influenced by universities i.e. Cambridge University and Harvard University which was founded in 1636 for training clergy for the new commonwealth. It is evident that communities around such areas have also not been left behind in such development. They seek for jobs in such institutions, conduct businesses and also benefit from infrastructure such as roads developed by the universities. According to Burton (1996) [1] establishment of universities like Harvard have contributed immensely to community development through provision of financial support for local economic expansion. They have improved public health as a result of establishment of the health facilities which not only cater for service provision to the university employees but also to the neighborhoods.

Other cooperate social responsibilities that are enjoyed by the community around universities include transformative project, local roads, street-tree side walk improvements, meeting-houses, outreach programs and development programs such as creating a permeable campus that removes existing impediments to pedestrian circulation and includes street-facing, community-activating uses among others.

Similarly, socio-economic improvements brought about by the universities established in areas cannot be overstated. Rowan University whose growth has revitalized and enhanced and fueled economic development/boom for the Glassboro town is a good example. New research centres, housing, small and medium enterprises and hotels are some new redevelopments in Glassboro town which have come as a result of partnering with the university despite the town developed on the manufacturing of glass (Okong'o, 2014).

Steinacker [2] argued that among other contributors to city's economy, universities too can be valuable. He considered them immobile institutions which are fairly resistant to business cycle fluctuations. As such, they are a steady presence in the community which tend to attract revenue from outside the immediate area through endowment income, tuition and state tax allocations. Besides, they attract employees from national market and significant human capital-students and employees from a national market. This contributes to the growth of area's economy.

As various universities' importance is being recorded, a number of impacts accrue. The population drawn by these institutions, call for increased housing services, demand for food and supply of other goods and services. The general expansion of the university in term of schools, programs, departments and services translates to general increase of its populace. As a consequence, small and medium enterprises become prominent to help cater for the rising demand of the area's increased population. Bondinuba et al. [3] asserted that current increase in enrollment of students in institutions of higher learning has become a major concern. They stated that scholars and practitioners have become so concerned with issues of accommodation provision to students. Subsequently, it is evident that there is supplementary provision of housing facilities for students within or off the campus by other educational stakeholders who have come on board. Private participation in housing provision in institutions of higher learning in developing countries has greatly contributed to the urbanization process within the University vicinity.

According to Oanda & Jowi [4] the quest for education has risen based on development requirements and economic and social demand which have led to increased enrollment of students in institutions of higher learning. This is basically to cater for the need to improve competencies for one to become relevant in the changing market demands and attract better

remuneration packages. This has been instigated by less competing job opportunities especially in Kenya. As such, the number of institutions has increased exponentially over the past two decades in Kenya. Education support provided by the Kenyan government higher education loans to universities and college students has improved access to education by many. In lieu of this, more demand for higher education has been realized hence establishment of more universities across the country.

Despite the many benefits provided by universities the study has demonstrated that their unplanned establishment has also negatively affected the environment of the surrounding areas. Road construction, learning, housing facilities together with small and medium enterprises within the university and outside the compound have led to land use and land cover changes (LULC). These threaten the environment in various ways as the ecological roles played by the environment are compromised yet these new land covers do not perform these ecological roles. Haphazard settlements created by the presence of university have given rise to slums thus compromising sustainable environmental planning and management. Against this background, the study sought to investigate the ecological impact created by the establishment of Rongo University.

Theoretical Framework

Land-use/land cover change detection theory

According to Briassoulis [5] land use change theories can be classified into three. These include; nature-society (human-nature), sociological (political economy) and the urban and regional economic theories. The three categories are concerns of human role in instigating global changes in environment. Further, Briassoulis [5] argued that land use change is the outcome of a complex interconnections between bio-physical and socioeconomic powers between space and time. He emphasized that it is impossible to tackle the complexity for practical reasons like making policy and management of land to realize sustainable land use unless simplification of the relationships in the complexities are achieved, manageable and made in an understandable dimension. Considering the above constraint, it is imperative to define a land use change model which expresses operationally the relationships between the main factors of interest as Turner II et al. [6] postulated.

As was articulated by Lambin [7], models along theories can be conceived simultaneously and can be applied in place of each other to signify theoretical and working statements based on real situations as expressed by von Thunen's and Alonso's theories and models. Briassoulis [5] deputed this argument asserting that there is a lack of a clear theory in several models. Singh (1996) established that theories of change detection attempts to identify differences in the state of an object or phenomenon by observing and quantifying it at different times. This was further affirmed by Lu et al. [8]. Detection of change in land use/land cover is crucial for monitoring earth's surface features changes

in order to understand connections and interactions between the environment and human for better management and use of natural resources [8]. As Lu et al. [8] puts it change detection comprises the application of multi-temporal datasets which are mostly remotely sensed to quantitatively analyze the temporal effects of the phenomenon.

Principal component analysis, image differencing and post-classification comparison are the methods commonly used in detecting land use/and cover changes [8]. Some scholars have highlighted that land use changes of the multi-temporal images are usually complex and non-linear. Non-linear change detection theories and techniques have great importance in resolving change detection. Jianya et al. [9] stated that there are two groups in which a general overview approaches in change detection approaches can be characterized. These include; the bi-temporal change detection (direct comparison, post-analysis comparison and uniform modeling) and temporal trajectory time series analysis. According to Jianya et al. [9] the bi-temporal change detection evaluates changes on the basis of a simple 'two-epoch' timescale comparison while temporal trajectory examines the changes on the basis of a 'continuous' timescale, with major focus on both alterations between dates and the evolvement of the change within a specified period of time [9].

Lu et al. [8] stated that provision of spatial distribution of changed types, area change and change rate, change trajectories of land-cover types, accuracy assessment of change detection results is some of the features of a good change detection research. He added that cross-tabulation and cross-classification using two geo-referenced images of the same area, taken at different dates and classified to the same set of N classes is the straightforward method to detect changes in terms of thematic classes. Eastman [10] established that Land use Change Modeler (LCM) algorithm which is based on processing problems associated with accelerated land alteration and a particular analytical requirement of biodiversity conservation is one of the important tools to analyze land use land cover changes. He argued that the fact that LCM is structured around a set of five major task areas that includes: forecasting the course of change into the future, assessing its consequence to biodiversity, analyzing earlier land cover change, evaluating planning intercession for maintaining ecological sustainability and modeling the prospective land alterations makes it suitable.

The study adopted a temporal trajectory time series analysis as one of the Non-linear change detection theories. This theory allows for change examination on the basis of a 'continuous' timescale, with major focus on both alterations between dates and the evolvement of the change within a specified period of time. In addition, the study used the local people knowledge, remotely sensed image classification and Geographic Information System (GIS) considering that they are the most efficient and widely-used techniques in the accuracy assessment of change detection.

Study Methodology

The study used both primary and secondary data. Primary data was collected through questionnaire administration, Geographic Information System and remote sensing. Secondary data comprised of review of relevant literature on land use and land cover changes. Also, the study used both closed and open-ended questionnaires where the respondents gave their comments and elaborations on questions asked during household interviews. Key informants' consultations and focus group discussion surveys were also conducted. Both qualitative and quantitative methods were used to analyze data. For qualitative data from the questionnaires, the study coded the information into thematic areas then analysed using Statistical Package for Social Scientists (SPSS). A code book was created through SPSS for analysis of section of the questionnaire with quantitative data.

Concerning remotely sensed data, Landsat images for 2003, 2010, 2013, 2014, 2015, 2016, 2017 and 2018 were acquired through extraction of individual bands from the raw image for detection of land use and land cover changes. Supervised classification method was used where a shape file was created and Areas of Interest (AOI) determined. The study adopted the use of the AOI shape file which was renamed. The images

were classified for the time stamp interval that was 2010-2013 by drawing some polygons with the help of colour key on the image using interactive supervised classification. This is because it allows for definition of the training data set/signature that indicated the pixels to be selected and the type of software to be used for land-cover categories. Analysis of this data was performed by the use of IDRISI Selva 17.0 where the classified image in Arc map 10.3.1 were converted to ASCII for IDRISI to display the image. The IDRISI Selva was then launched and converted images imported.

Results and Discussion

The study used data from questionnaire, interview schedule and the satellite images for 2003, 2010, 2013, 2014, 2015, 2016, 2017 and 2018. The questionnaires were designed to generate information which enabled, the study to determine the state of the environment at the time the respondent started staying in the study area. This was critical in providing the baseline from which it would be possible to evaluate the amount of environmental changes which have taken place following the establishment of Rongo University. Figure 1 summarizes the information obtained from the respondents on the state of the environment at the time they started staying in the study area.

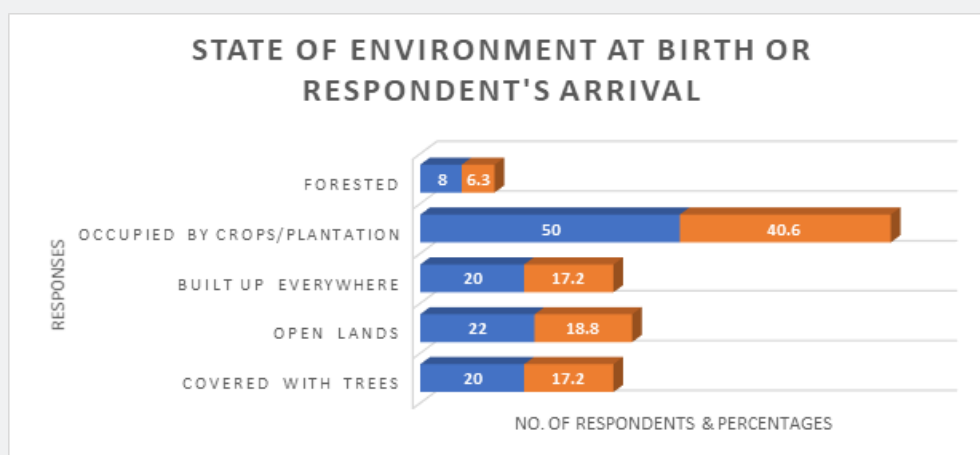


Figure 1: State of the environment at respondent's birth or during arrival within Rongo Sub-County.

N/B: The blue section of the bars represents the number of respondents while the red is percentages

The results presented in Figure 1 show that most respondents started living in the study area when it was occupied by crops and agricultural plantation crops at a rate of 40.6 percent of the land use/land cover. According to the respondents, large pieces of land in the region were occupied by sugarcane plantations. Other lands were mostly occupied by food crops, fruit trees and trees. Further, the respondents indicated that sugarcane was considered as the major cash crop to generate income to the community thus prompting many people to engage in its growing. Other crops like maize and a variety of cereals were mainly food crops which were grown for subsistence. The respondents

emphasized that sugarcane as a cash crop was helping the community in issues such as fee payment and boosting their businesses. The study was informed that sugarcane crop has been grown under contract farming arrangement with the nearby South Nyanza Sugar Company factory. In addition, 18.8 percent of the respondents also stated the landscape was open at the time when they started settling in the study area. This implies that the area had only few structures and crop growing was not intensive. The open lands are interpreted as areas which were not subjected to human settlement and cropping which in real sense was not necessarily open during their arrival in

the study area. Such lands could be used by the community as grazing and fallow lands which were not supporting structures and farming during that period.

Similarly, 17.2 percent of the respondents also described their areas as having been covered with trees. This information is similar to the one which was provided by the 6.3 percent respondents who also indicated that at the time they started settling, their areas were forested. The study considers that the areas which were forested at the time the respondents were settling contributed to the protection of the environment. For instance, the trees conserved the soil, water and biodiversity while at the same time ameliorated the area's micro-climate and acted as carbon sinks, among many benefits.

The results (Figure 1) also indicated that 17.2 percent of the respondents described the environment at the time of arrival as

already built area. Possibly this group represented the earlier settlers who had settled much earlier as residents of Kitere shopping centre, Rongo town and other centres like Kanga and Rakwaro among other centres where data was collected. This group of residents emphasized that the areas they presently occupy were not natural environment, but those areas had been transformed into a built environment with many structures for accommodation and businesses. In this case, what these respondents described as built everywhere represents Rongo town and the shopping centres aforementioned.

Based on the respondents' descriptions regarding patterns of settlement in figure 1, the study established that the majority (88 percent) of the respondents overwhelmingly confirmed that the state of environment has changed as further illustrated by Figure 2.

Whether the State of the Environment is Changing in Rongo University and its Environs

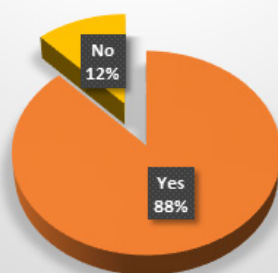


Figure 2: Whether the State of the Environment is changing.

Some of the respondents claimed that what they have seen over the period that they have stayed in the study area is alarming. In their opinion, there has been rapid transformation of natural environment into a built environment. Vegetation has been cleared to pave way for the development of various infrastructure. They also argue that Rongo University is developing at a faster rate and as a result of this several development activities and services are being drawn. The study has also indicated that land that used to be inhabited by various forms of biodiversity have been cleared. This implies loss of genetic resources. The information obtained from the focused group discussion and interview schedules revealed that there has been change of use even for structures which were initially established to serve as business premises. In the respondents' opinion, some business premises have changed to serve as hostels. Further, the respondents noted that initially there were fewer high-rise buildings but as a result of the establishment of Rongo University, a number of storey buildings have emerged in the area despite the fact that there is no adequate plan to support such transformations.

In a related development, the focused group discussion has established that sugarcane plantations are fast disappearing as land fragmentation into smaller units and change of use of buildings and lands occasioned by high demand for accommodation and premises for business sets in. The land parcels where such agricultural practices were taking place have been sold to private developers leaving the natives with small pieces which cannot support large scale sugarcane plantations. It was also revealed that the issue of selling land to private developers is leaving some of the community members landless thus precipitating family conflicts. Equally, concern was raised over the rapid transformation of Kitere shopping centre into a new town outfit. The main concern is that the shopping centre is developing into a slum with no planning at all. The characteristics of structures coming up is basically a mixture of different structures and orientations for unclear utilization. Worse still, some structures which are old, and dilapidating have not been demolished nor renovated to meet current or changing demands. Also, the on-going developments do not provide for services such as packing and loading areas, waste management, among other utilities.

Finally, the results showed that 12 percent of the respondents represented people who are not able to identify any change in the environment. Their reasoning could be attributed to lack of capacity to monitor environmental changes or altogether they have no idea of what change exactly means. Alternatively, there could be a possibility that actual change had not taken place at all in their places of residence. In rare cases, this group could represent individuals who have no concern at all about their immediate environment or surroundings hence it might not matter to them whether there are changes or not.

The study also determined the direction of changes that took place in the state of environment. The results (illustrated in Figure 3) demonstrate that majority of the respondents (63 percent) were of the opinion that the change in the state of environment were heading in the right direction, that is from bad to good. This group represents members of the community that view transformation of natural environment into built-up

environment to be of more value. In the contrary, 37 percent of the members felt that transformation of natural environment into built-up environment has greater consequences. For instance, loss of genetic diversity, interference will atmospheric moisture recharge, displacement of various organisms and even total extinction of some species, among others were cited as negative impacts brought about by the changes taking place. The significance of this study and in particular the direction of change show that there are fundamental challenges in value judgment by the majority of the public. This is so because most people in our communities ordinarily value structures and other development activities on land more than the environmental value and its resources (tangible and intangible). The inability to understand how the environment functions and its countless benefits may not be easily comprehended by most people. The gap in understanding of our environment and its role is perhaps one of the major contributors to environmental degradation in our communities.

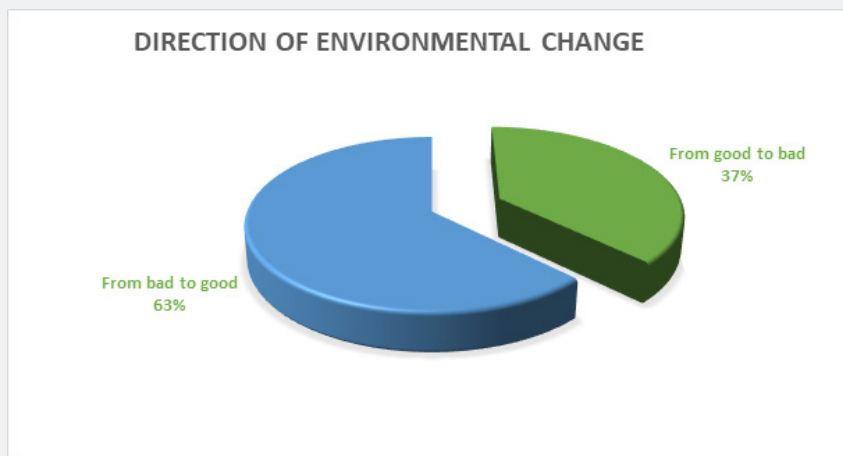


Figure 3: Direction of Environmental Change.

Further, the study analyzed the responses of interviewees who perceived the change in the environment to be taking the right direction (i.e. from bad to good) and noted that people still advance reasons that the area used to be bushy and occupied by sugarcane plantations which could harbour dangerous animals but currently these places have been transformed and nice structures can be seen even from far. This position qualifies the existing gap in knowledge and information regarding the environment and the natural resources thereof (i.e., environmental illiteracy). The 63 percent of respondents shown in figure 3, indicates the number of people in our society that we have to educate and empower on the issues of environmental conservation and management. Apparently, they may not totally fail to understand the kind of losses we realize when we substitute the natural resources such as vegetation with structures, rather, they vaguely understand the implications of such changes. It is a fact the ecological roles performed by natural resources such as vegetation on the environment is compromised in such changes. Equally, the aesthetic value of the natural environment is also

lost. The 63 percent of the respondents also claimed that the area has been opened up for development and they could cite some of the benefits like availability of market, job creation by the university, availability of various services created by the university, income from rentals among others. The important and fundamental message this study is alluding to is that the nature of development which unfortunately majority of people in our society/ community promotes in many cases is not sustainable considering that it does not adequately integrates environmental issues in our development activities. The study therefore established how critical it is to build capacity and empower our community on environmental matters so as to enable them to understand and become part of the custodians of the environment. The study has also established that a number of development activities undertaken under the banner of development are indeed injurious to our environment owing to lack of adequate understanding or knowledge by the communities and those tasked with the responsibility to execute them.

Having determined the nature of change, the respondents were subjected to a question of describing how the environment is like currently. The results are shown in figure 4 in which there was overwhelming acceptance that the environment had been transformed into buildings currently. A number of structures of various forms are evidenced in the study area of which some of the prominent ones are Rongo University learning facilities and accommodation structures while others belong to private

developers and business owners from various corners of Migori and Kisii County majorly. The 75 percent who contended that the environment had been transformed into buildings could be compared with the 10.9 percent representing people who were of the opinion that the environment has lost its original state. This is because losing original state implies that environment must have undergone modification or transformation.

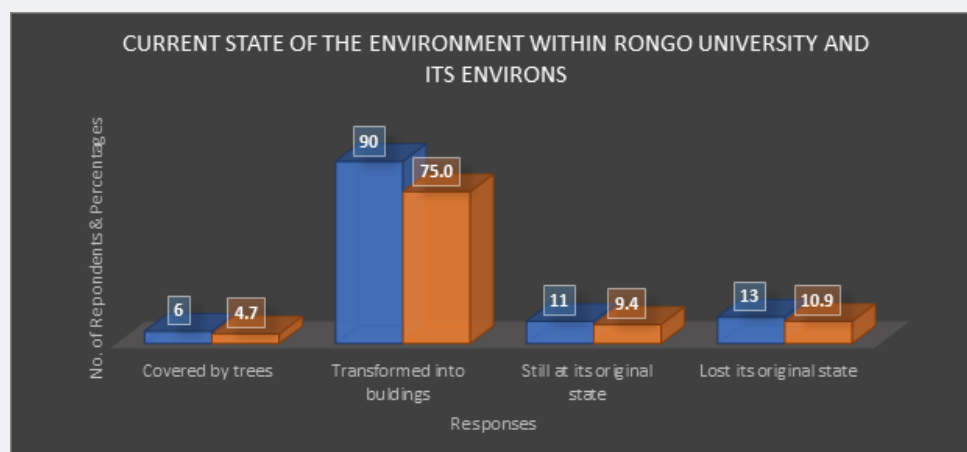


Figure 4: Current State of the Environment in Rongo University and its Environs.

The study established that the area is still undergoing further changes considering the fact that most of the areas visited are being sub-divided and fenced awaiting development. Therefore, it is imperative that appropriate plans be drawn to guide proper utilization of our environment. As already highlighted in objective one under policy and institutional framework, most development activities in the area do not follow the laid down procedures and the provisions of the policies guiding development. While development activities are already taking place, it is prudent to introduce appropriate plans where possible to remedy the flaws in developing without guidelines. The starting point is to monitor these development activities to determine their status and ensure that they are undertaken in a sustainable manner. For instance, the results illustrated in figure 4 show that only 4.7 percent of the area is currently covered by trees. If appropriate interventions are undertaken it would be possible to change or alter the status quo by increasing the tree cover.

A focused group discussion revealed that further changes in the status of the environment in the study area should be expected since Rongo University is still a young university with potential for more future developments to take place. According to some of the focused group discussion members, the university still expects more enrolments which will attract increased demand in accommodation facilities as well as for learning facilities. Similarly, private developers are also eyeing the area since it has great potential in terms of new businesses coming

up which will result in land acquisition for further developments and attendant changes.

Despite the information which was provided by the majority of the respondents, 9.4 percent stated that the state of the environment still remains at its original state. It is possible these respondents represent the people who stay away from Rongo University main campus at the time data was collected which was as far as Omware and other places like Nyamuga which is several kilometres from Kitere where Rongo University main campus is established. Even though Omware and Nyamuga are within Rongo Sub-County, they are far from where the main campus is established hence rapid housing development catalyzed by the university might not be visible to them. The study did not single them out during analysis of the questionnaires.

The study also sought to establish the drivers of land use and land cover changes in the area where the university was established. As a matter of fact, immigration to could be one of the factors that could lead to influx of people in a particular area, hence bringing changes. The respondents were therefore subjected to a question seeking to determine reasons why they settle in their current places. The findings of the study were summarized in figure 5. The study findings revealed that majority of the respondents (32.8 percent) were settling in the study area for business reasons. In their view, a market had been created in the region by the students and the staff at Rongo University therefore it became a potential place for business activities. Among them, some were hotel operators, others were hair dressers, while others were running other businesses like

printing and photocopying, M-PESAs, shop keeping among others. Also, 6.3 percent noted that they were settling in their current location for schooling reasons. This group represented students who were engaged in data acquisition during questionnaire administration. In their view, despite the fact that they have come from various areas, they settle in the study area for knowledge acquisition. It is because of the Rongo University that has made them to come to Rongo Sub-County.

Figure 5 also indicates that 21.9 percent of the people interviewed are settling in their current locations because of job opportunities they secured. Majority of them were Rongo University employees while others were working in various business enterprises around the University. Similarly, 23.4 percent of the respondents represented individuals who were born within the Sub-County and they had not changed their places of residence. This group were the natives of

North Kanyajuok Sub-Location, North Kamagambo Ward who understand how Rongo University came about and the changes it has brought in the area. Also, those who were married (women who might have come from various areas for marriage purposes) constituted 10.9 percent. On the other hand, 4.7 percent of the respondents represented the private developers and the business owner who perceived the region to be a potential place for development. They see a lot of opportunities such as developing accommodation facilities and business enterprises. One of the respondents contended that with the view of trend in development in the area and continued increase in students' population, Kitere region remains the highest area with potential to attract more developments. In his view, there is a ready market for various commodities and services in the region considering the increasing population in the area.

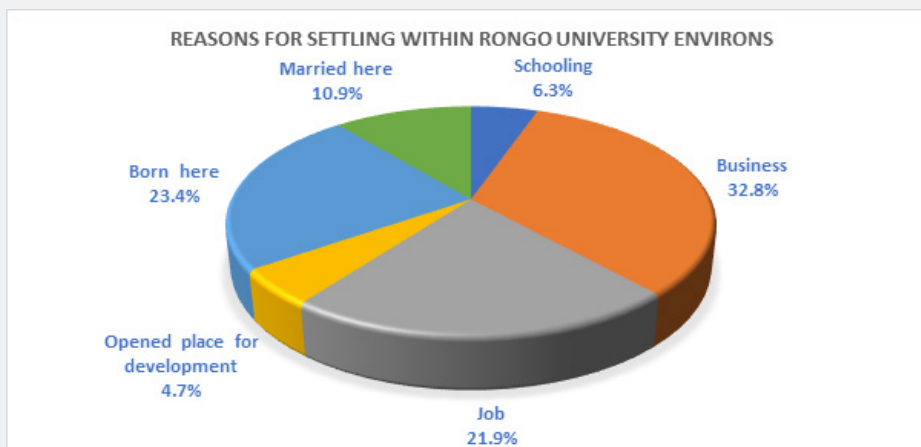


Figure 5: Reason for Settling in the Current Location in Rongo Sub-County.

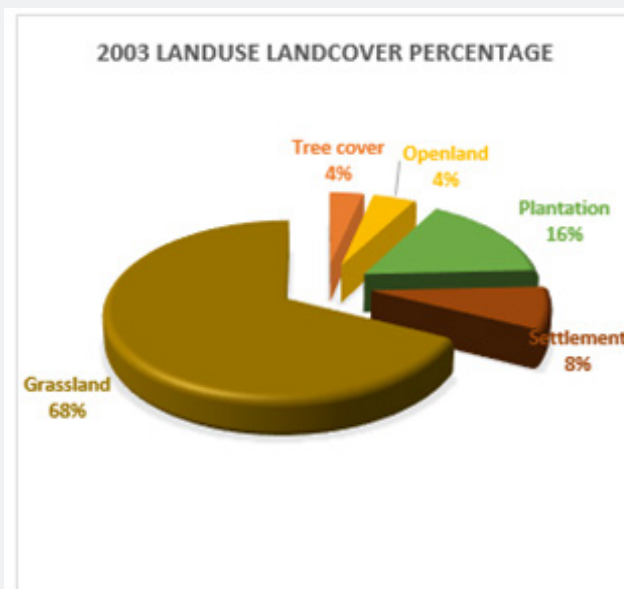


Figure 6a: LULC for 2003.

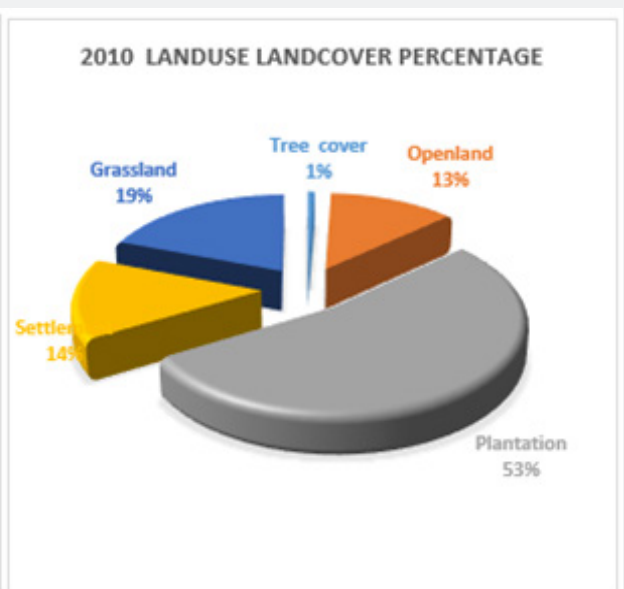


Figure 6b: LULC for 2010.

The study acquired information from the regional centre, Nairobi on the various land uses and land cover which existed in Rongo Sub-County, North Kanyajuok Sub-Location where Rongo university main Campus is established. Figure 6a & 6b are graphical representation of the information gathered.

These two years (2003 & 2010) were used to determine the landmarks showing how environmental changes have taken place over time. They contain the land use and land cover information of the area before the establishment of Rongo University. The major land uses as presented in Figure 6a & 6b represents settlement and plantation/farming activities. This table represents information from North Kanyajuok Sub-Location where Rongo University main campus is established. They intended to establish the environmental status long before the university was established. From the table, grassland had the largest percentage in terms of coverage in 2003. The grassland in this case combine the shrubs in the area. During this period there was relatively large sugarcane plantation coverage as indicated in the table. Tree cover and the open/bare land had almost the same coverage but with little difference. The study also considered the year 2010 when the University was almost being conceived and land use and land cover during that period was as indicated in Figure 6a & 6b. The study established that tree cover percentage has changed from 4 to 1 percent in terms of coverage in 2010. The open land has increased from 4 percent

to 13 percent. This could be due to loss in tree cover. There was also increase in plantation or farming activities from 16 to 53 percent. This could have also contributed to the loss in tree cover and grass land which also lost from 68 percent to 19 percent. The study learnt that it is possible that much of the land that was considered grassland could have been transformed into farm land due to the large change in percentage from 68 to 19 percent. This implied significant change in land cover between 2003 and 2010 because both tree cover and the grass land tremendously reduced in percentages.

Considering settlements as portrayed in Figure 6a & 6b, it almost doubled. It increased from 8 percent to 14 percent. This implies a significant increase. Vegetation is cleared to pave way for space where the structures are to be constructed. Therefore, the losses realized under grassland and tree cover could be as result of intense farming activities during 2010 and increase in settlements.

The period between 2003 and 2010 were used to determine earlier rate of environmental changes before establishment of Rongo University. The study also considered 2013 Landsat images of the study area in order to capture information on land use and land cover immediately when Rongo University was established. By this time the University was hardly two years old. The land use and land cover were as indicated in table 1.

Table 1: Land and Land Cover for 2013.

LULC_2013	Sum Area Ha	Percentage %
Grass land	380.6442	19%
Open land	500.7563	25%
Plantation	302.803	15%
Settlement	647.628	32%
Tree cover	171.4293	9%
	2003.261	

Source: Regional Center, Kasarani, Nairobi, 2019

Immediately after the establishment of Rongo University, the land use and land cover information/data in 2013 indicates that grassland has retained the 19 percent compared to 2010 data. The tree cover increased from 1percent in 2010 to 9 percent in 2013. It was evident during data collection that in a number of homes there were Eucalyptus tree species around them. The study findings under this section revealed that significant change in land use and land cover as open land increased from 13 percent in 2010 to 25 percent in 2013. This could be possible with the reduction in plantations which was indicated in table 1 that there was a significant reduction in plantation or farmland from 53 percent to 15 percent. This could have contributed to increase in open land. Similarly, there was significant increase in settlement which from 14 percent in 2010 to 32 percent in 2013. This was more than a double increase. This could

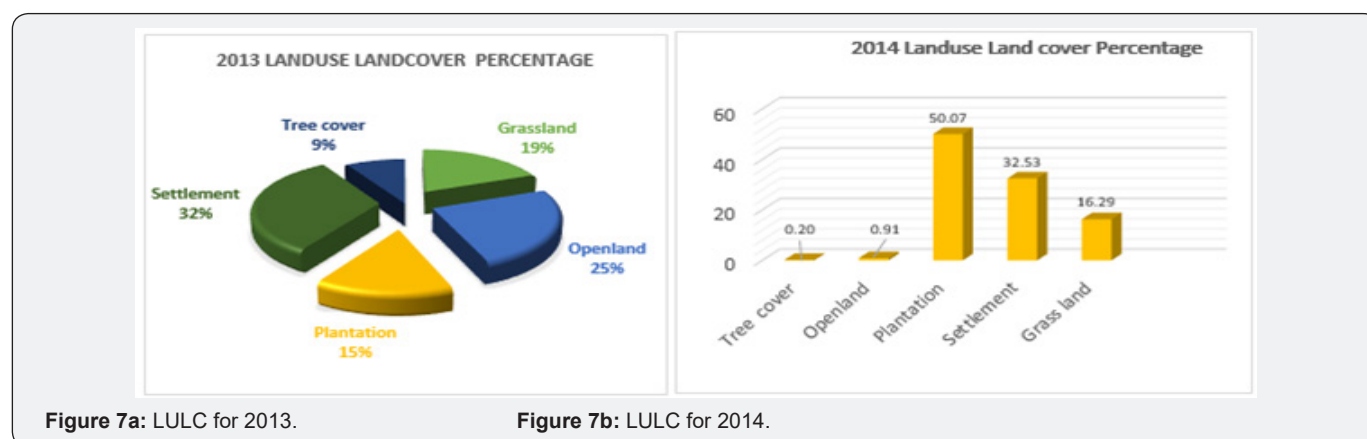
have been caused by increase in student population following new enrollment of students which had started as well as the sudden population explosion in the area and businesses from various sources. It is also possible there occurred increased development of infrastructure for learning and accommodation facilities during this period. The local residents and private developers had started noticing the potential of the area in terms of development activities. The information contained in the 2014 Landsat images indicate that in the year 2014, there was no significant change in the rate of settlement development as it stood at 32 percent. Based on these results summarized in table 2, the tree cover has again declined to 0.2 percent. Similarly, plantation has increased significantly from 15 percent to 50 percent.

Table 2: Land Use and Land Cover for 2014.

LULC_2014	Sum in Area Ha	Percentage %
Tree cover	4.075295	0.203464
Open land	18.18726	0.90802
Plantation	1002.884	50.07016
Settlement	651.4791	32.52586
Grassland	326.3317	16.2925
	2002.957	

Considering these changes in land use, the study established that the land cover (tree cover and grassland) reduce with increase in agricultural activities (sugar cane plantation or food crops farming). This shows that in most cases the land cover is cleared to pave way for other land uses such as agricultural practices. For example, in 2013 grassland was 19 percent but it

reduced to 16 percent in 2014 while plantation had increased to 50 percent from 15 percent in 2013. Similarly, the study has demonstrated that open land reduced with increase in plantation or agricultural activities. Figure 7a & 7b illustrate the comparison between land use and land cover in 2013 and 2014.



The study also assessed the changes in land use /land cover which took place within Rongo University and its environs four years after its establishment. The Landsat images for the year 2015 and 2016 were examined and the results summarized in table 3. The study noted that settlement increased by 10 percent from 32 percent in 2014 to 42 percent in 2015. As already indicated in the previous results, a decrease in plantation or farming practices results in an increase in tree cover, grassland and open lands. The results further indicated that the rate of increase were 4, 16 and 3 percent for tree cover,

open land and grassland respectively while plantations reduced from 50 percent to 18 percent. It appears that the increase in settlement was almost constant and was associated with Rongo University expansion in terms of putting up more leaning and accommodation facilities. Similarly, private developers have also developed hostels and business enterprises in the area to supplement what the university provides. Other settlement has taken place as a result of increased settlement by people drawn from various places within and outside Migori County for business and development reasons.

Table 3: Land Use and Land Cover for 2015.

LULC_2015	Sum Area Ha	Percentage %
Tree cover	83.20963	4%
Open land	339.8372	17%
Plantation	354.2426	18%
Settlement	849.7911	42%
Grassland	375.9637	19%
	2003.044	

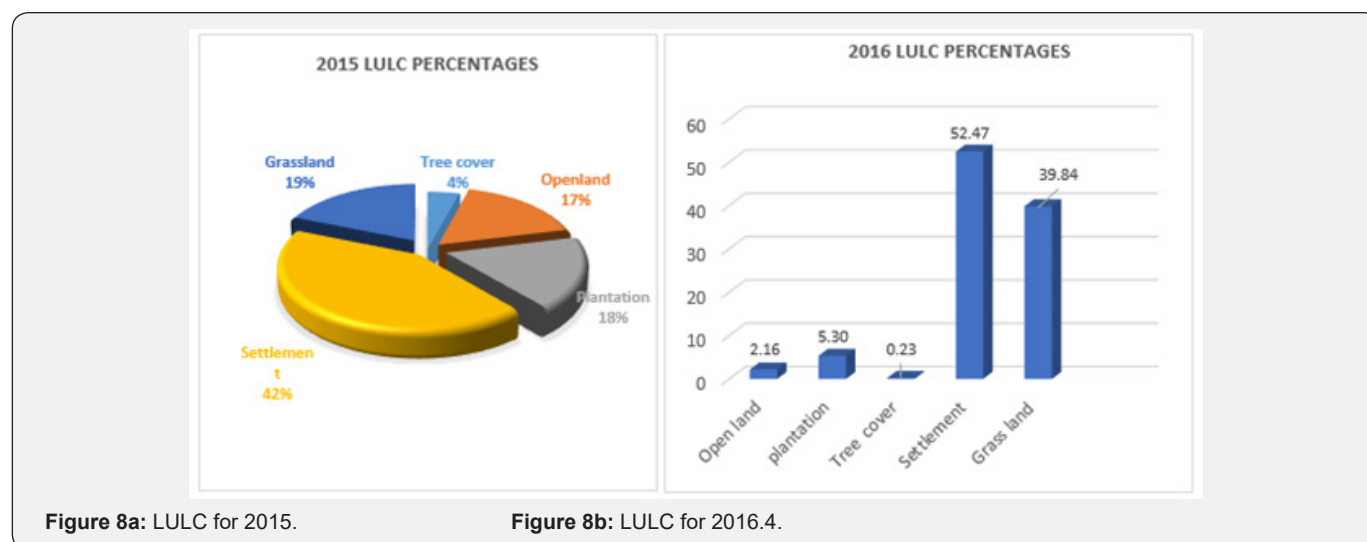
Source: Regional Center, Kasarani, Nairobi, 2019.

Further analysis of land use/ land cover changes during later years after University establishment, in this case from the year 2016 show that tree cover, plantation and open land have significantly reduced as indicated in table 4. During this period, settlement has also increased by 10 percent that is from 42 percent to 52 percent. These results show how rapid natural environment is constantly transformed into a built environment. This demonstrates that as time goes, there is proportionate loss in land cover. The loss in tree cover compromises the ecological roles tree cover and related vegetation play in the landscape and the environment. The study further revealed

that plantation agriculture has been on constant decrease from 2015 as settlement increases. Loss of agricultural land is likely to cause food insecurity in the area. Most agricultural land is sold to private developers who transform it into a built environment. The infrastructure development is focusing on residential and students' hostels. There exists potential conflict in the on-going land transactions considering the fact that the local people / natives might not use the money they get from sale of their lands to acquire the same size or piece elsewhere. In that case their offspring remain landless resulting in serious family conflict.

Table 4: Land Use and Land Cover for 2016.

LULC_2016	Sum Area in Ha	Percentage %
Open land	43.23383	2.159055
Plantation	106.2021	5.303628
Tree cover	4.638769	0.231656
Settlement	1050.582	52.46501
Grassland	797.7863	39.84065
	2002.443	



The study also noted that while a significant loss was realized on plantation with gains in settlement, there was nevertheless an increase in grassland. This might be helpful in control of soil erosion. It is to be noted that gains in grassland is always associated with loss in plantations. The study also demonstrated constant loss of open land from 2015 onwards. The changes

realized in 2015 and 2016 were summarized in table 4 and further illustrated in Figure 8a & 8b.

The year 2017 also showed similar changes in environmental transformation. Table 5 presents a summary of land use and land cover change in 2017.

Table 5: Land Use and Land Cover for 2017.

LULC_2017	Sum Area Ha	Percentage
Tree cover	43.09286	2%
Grass land	527.9345	26%
Plantation	120.8317	6%
Settlement	1165.575	58%
Open land	145.3668	7%
	2002.801	

The year 2016 results in land use change indicated that tree cover was 0.23 percent while in 2017 the results (table 5) show an increase in tree cover with a decrease in grassland from 39 percent to 26 percent. Initially, these land cover parameters were earlier decreasing with increase in plantations or farming activities. However, in the year 2017, there was a slight increase of 1percent in plantation which did not affect tree cover but to some extent affected the grassland. This could show a possibility of subjecting the land which was initially grassland to farming practices. Open land has also increased from 2 percent to 7

percent. This could be attributed to more farmland being left fallow for some period without planting crops in it. Like in other years, results indicate that settlement has increased by 6 percent in 2017 implying that natural environment is rapidly converted into built environment.

The year 2018 marked the end of the field study. It was used to consolidate the information as well as address gaps in data related to changes which have taken place since the establishment of Rongo University. The results for the year 2018 concerning land use and land cover are presented in table 6.

Table 6: Land Use and Land Cover for 2018.

LULC 2018	Sum Area Ha	Percentage (%)
Tree cover	68.72713	3.431002
Open land	2.598234	0.129709
Plantation	82.95347	4.141211
Settlement	1252.413	62.52306
Grassland	596.4296	29.77502
	2003.121	

The results show an increase in tree cover by 1percent from 2017. Open land has significantly reduced from 7 percent in 2017 to 0.12 percent in 2018. Similarly, settlement has increased by 4 percent. Also, the study noted a constant increase in settlement all through from 2010. This implies that large pieces of land that were initially open, or were grassland, including those that were

covered with trees and or plantations, have been transformed into buildings. The study also noted a decrease in plantation by 2 percent during this year. In general, the year 2018 saw an increase in land cover or tree cover and grassland. Figure 9a & 9b illustrates the changes in land use which took place as reflected in the table 6.

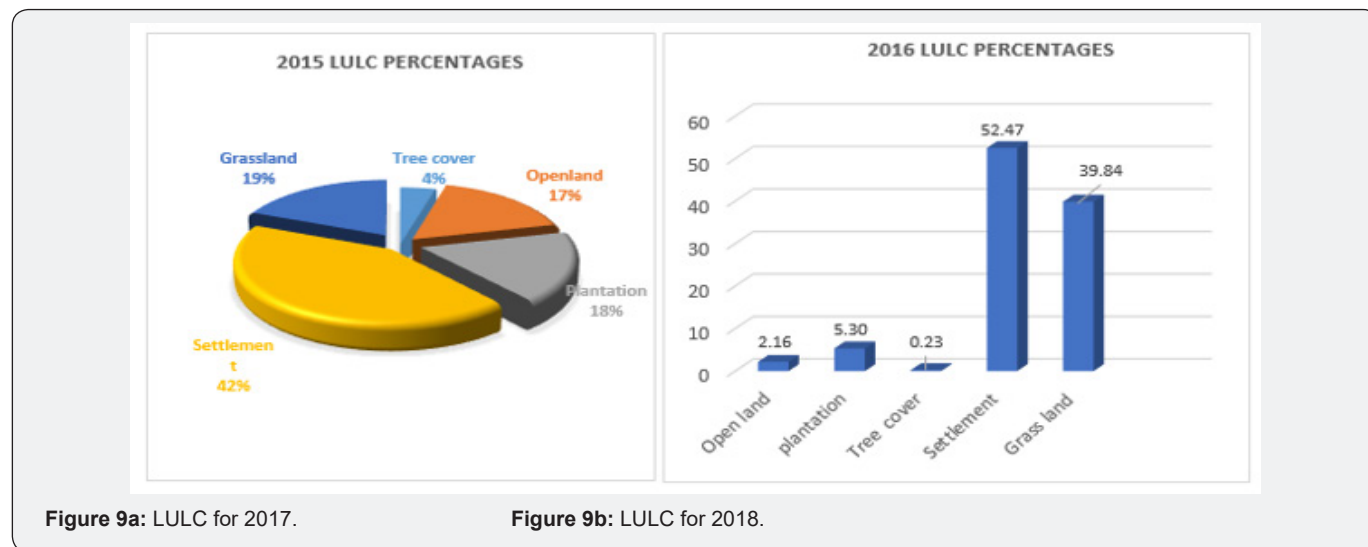


Table 7: Land Use and Land Cover for 2018.

LULC	2003_%	2014_%	2015_%	2016_%	2017_%	2018_%
Tree cover	4%	0.20%	4%	0.23%	2%	3.43%
Open land	4%	0.91%	17%	2.16%	7%	0.13%
Plantation	16%	50.07%	18%	5.30%	6%	4.14%
Settlement	8%	32.53%	42%	52.47%	58%	62.52%
Grassland	68%	16.29%	19%	39.84%	27%	29.78%

Table 7 presents the overall changes in land use and land cover as depicted by Landsat images and subsequently translated into percentage changes.

The study used table 7 as a summary table showing the information gathered from 2003 to 2018. Under this section, the study established that settlement has shown a constant increase totaling to 48.53% that is from 14% coverage in 2010 to 62.52% in 2018. This increase is expected to continue in that trend. Considering the fact that Rongo University is less than ten years old, someone can imagine how the area will look like in the next ten years. There is constant transformation of the natural environment into a built-up environment. More housing

facilities are required in the area to be used as rentals and provide accommodation to the increasing number of students. Others will also be needed for business purposes. Similarly, the study noted that plantation/farmland has tremendously lost. In the year 2010, farmland or plantation covered 53% while in 2018 it covered 4.14. This shows a negative deviation of 48.86%. Loss of agricultural land is a direct threat to food security in the area. Besides, open land was 13% in 2010 but it has greatly lost since in 2018 it was seen to be covering only 0.13%. This means that it has also shown a negative deviation of 12.87. The study learnt that the areas which used to open, or fallow have been built up. The presentations under this section are summarized in figure 10.

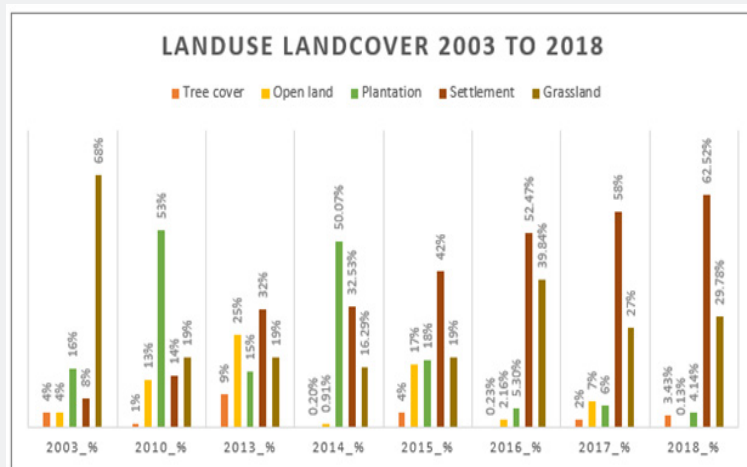


Figure 10: Summary of Land Use and Land Cover between 2003 and 2018.

The data used to compute the changes in land use and land cover changes between 2013 and 2018 were obtained from Landsat images. These were organized according to the years and considered the period before the establishment of Rongo

University and after the university has been operational for some time till 2018. Further, the results are demonstrated in Figure 11a & 11b using the maps generated from Landsat images for 2003 and 2010.

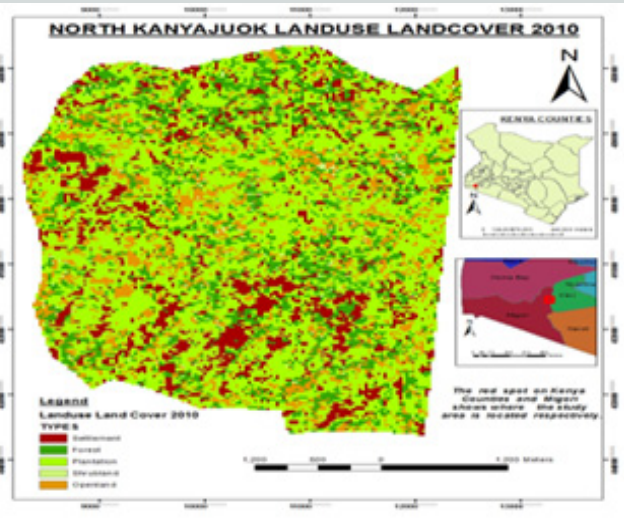
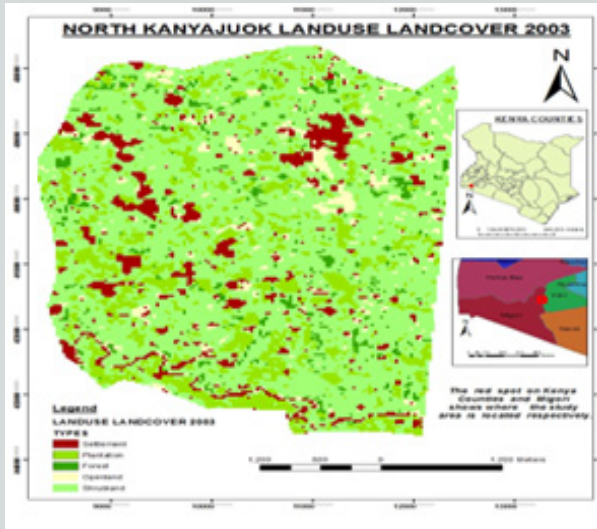


Figure 11a: Landsat Image for 2003 LULC.

Figure 11b: Landsat Image for 2010 LULC.

The land use land cover image in 2003 clearly show little modification of the natural environment at the time. The area was well covered with trees as represented by the dark green colour. There were also large areas covered with grass plantations as depicted by the light green colour. The red colour representing settlement is seen to be scattered in 2003. On the other hand, the intensity on the red colour increased in the 2010

image even though plantation also increased. Grassland and tree cover reduced as illustrated in the 2010 image. Similarly, the changes were also evidenced in the images for the year 2013 and 2014. More modifications in the environment in terms of transformation of the natural environment to built-up environment was also evident in the aforementioned images. Figure 12a & 12b highlight these changes in image forms.

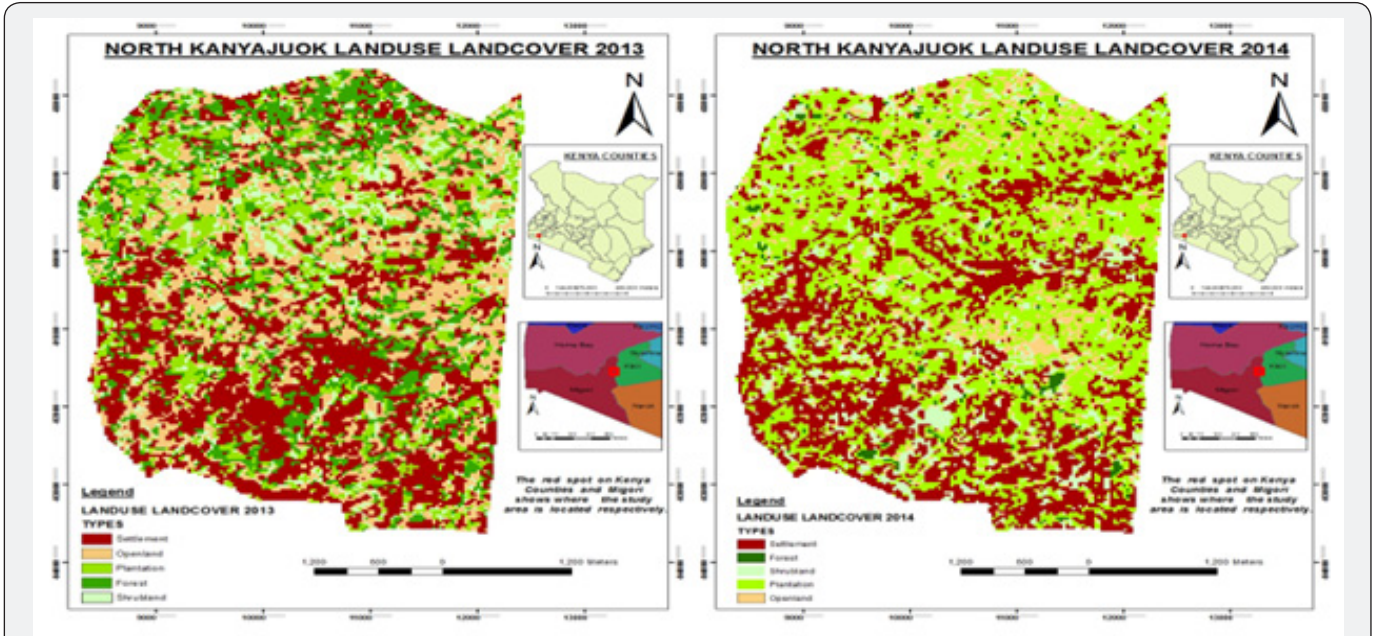


Figure 12a: Landsat Image for 2013 LULC.

Figure 12b: Landsat Image for 2014 LULC.

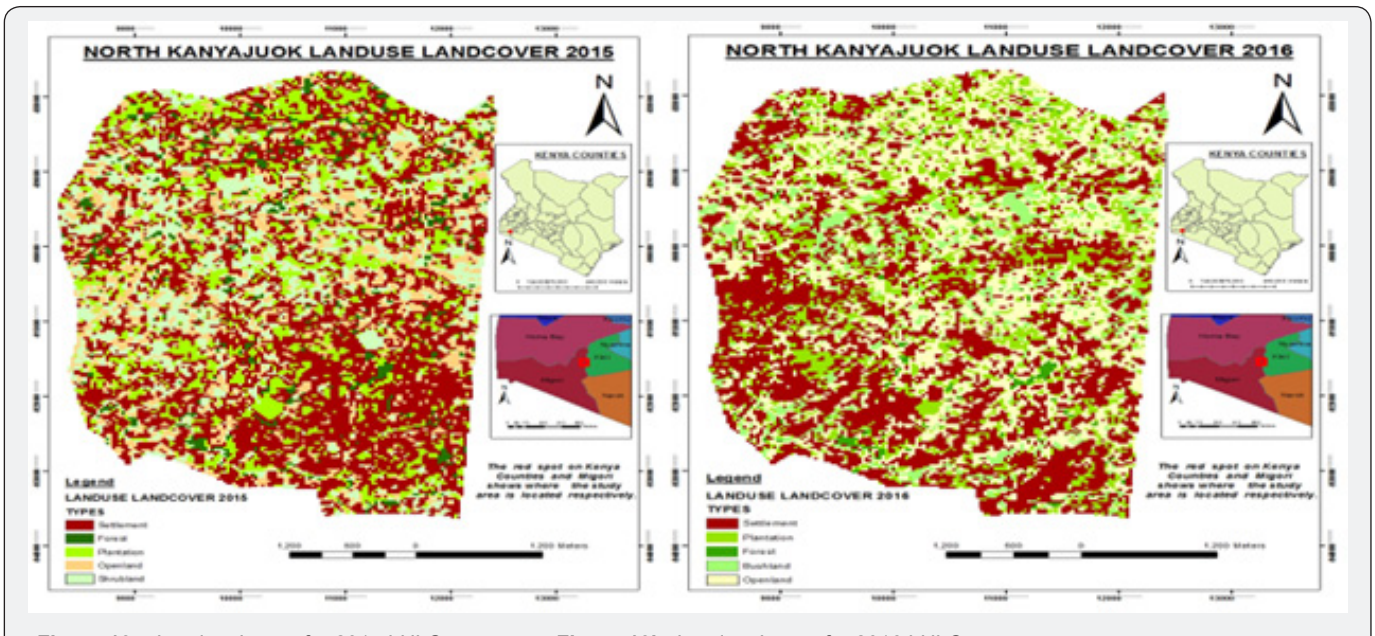


Figure 13a: Landsat Image for 2015 LULC.

Figure 13b: Landsat Image for 2016 LULC.

In 2013, the image shows significant increase in tree cover and open land. The settlement has also increased even though grassland has not recorded visible changes. Plantation has also decreased which was consistent with the earlier observation

which indicated reduction in plantations. Additionally, the results show that in most cases there was an increase in open land and to some extent the tree cover. The 2014 image reveals a reduction in tree cover and open land as the plantation increased. From

the above Figures, there is no remarkable change in settlement as compared with the 2013 images. Further, grassland had decreased but not significantly from what was depicted in 2013. Similarly, the study also analyzed the images for the year 2015 and 2016 as indicated in Figure 13a & 13b. The 2015 image shows an increase in tree cover and open land as plantation reduces tremendously. The results further show that settlement had also increased as depicted by the by almost all the images which showed red colour thus indicating settlements. There was also a little increase in the grassland as depicted in Figure 13a.

The 2016 image showed a reduction in tree cover and open land compared with what is indicated in Figure 13a representing 2015. Based on the 2016 image, the study noted that it is not obvious that when plantation increases then there is a corresponding decrease in open land and tree cover f as was seen in the previous images. The settlement together with grassland in 2016 have on the other hand increased. Finally, the study also examined the 2017 and 2018 images representing the latest Landsat images that were used to determine changes after a reasonable period since the establishment of Rongo University (Figure 14a & 14b).

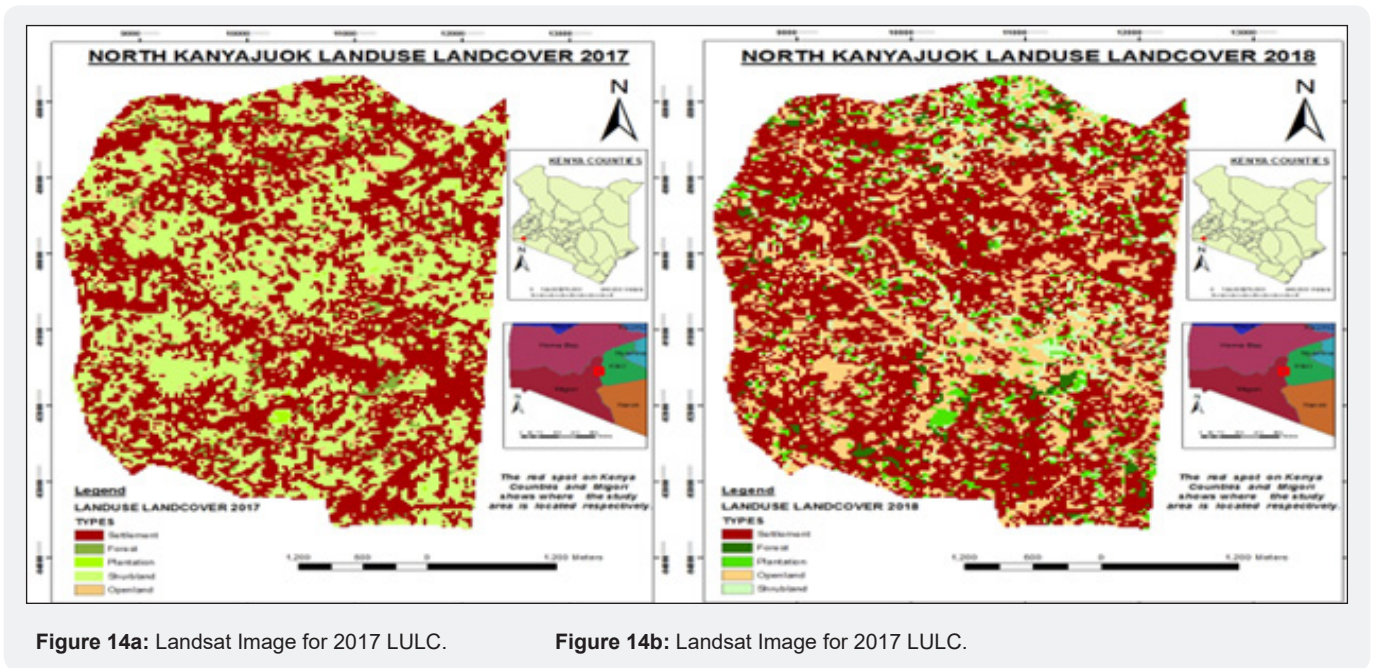


Figure 14a: Landsat Image for 2017 LULC.

Figure 14b: Landsat Image for 2017 LULC.

The year 2017 showed an increase in tree cover, open land and plantation though plantation has increased marginally compared with the situation in 2016 image. Grassland had reduced while settlement had increased. Considering the

constant increase in settlement, a trend emerged in which natural environment consistently modified while was built up environment increased as structures replaced vegetation.

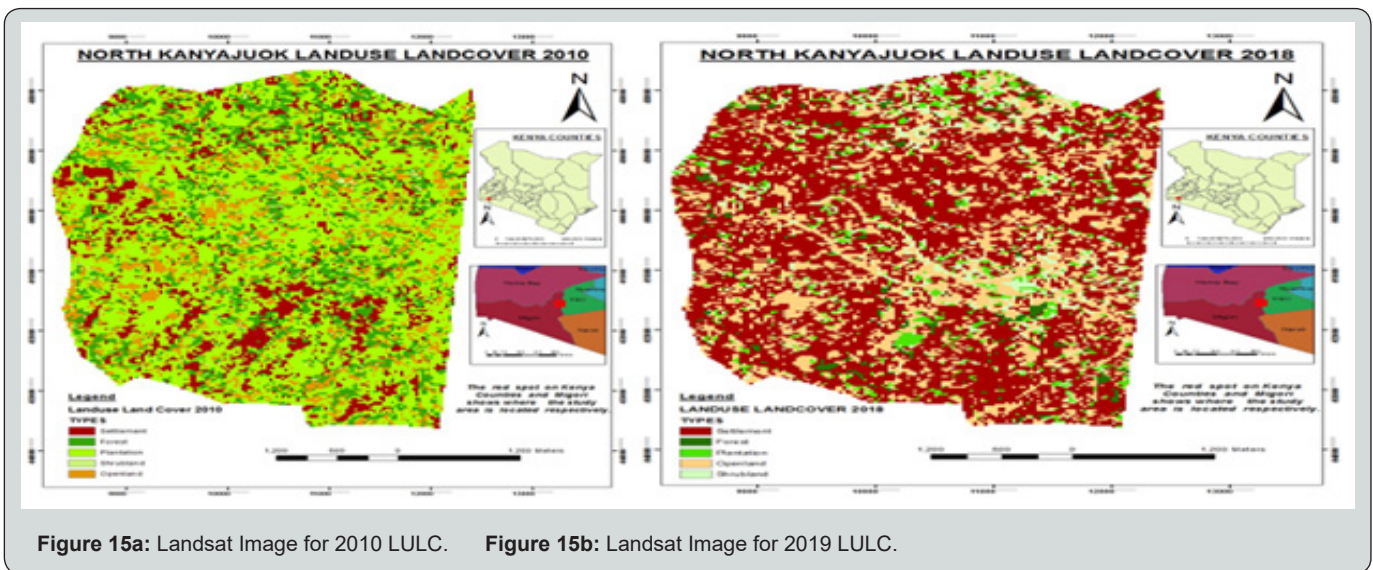


Figure 15a: Landsat Image for 2010 LULC.

Figure 15b: Landsat Image for 2019 LULC.

It is significant to note dramatic change in land use land cover between the year 2010 before the establishment of Rongo University and the year 2018 after it has been operational for around seven years. The respective images of 2010 and 2018 speak volumes in terms of the nature and extent of change as illustrated by Figure 15a & 15b.

Figure 15a & 15b show clearly that the green shade representing grassland, tree cover and plantation in 2010 had quickly been lost. Consequently, the red shade representing settlement had replaced the natural environment in 2018. Rongo University is less than ten years old and the impact of its establishment can be seen and spoken about even by the dumb. With this trend of change and modification of the environment, the study sought to undertake a long-term projection to determine what would be the situation in the year 2030 (being a

year of development vision by the government of Kenya). Table 8 gives a summary of the 2030 projection with respect to land use/ land cover changes considering the current status quo of unplanned and unmonitored developments or land use/ land change. Based on this projection, the study has predicted that settlement will occupy 75 percent of North Kanyajuok sub-location with almost total loss of open land. On the other hand, plantation was projected to be at 3 percent indicating loss of agricultural land which implies a threat to food security. The projection revealed that open land has been lost. The lost open land could be as a result of many development activities taking place in the area such as development of housing facilities. The study also learnt that the transformation and modification realized contributed to environmental degradation as well as loss of genetic resources. Also, a number of species of organisms might face extinction.

Table 8: 2030 Projection of LULC in North Kanyajuok Sub-Location.

Projected Land Use Land Cover 2030	Area in Ha	Percentage %
Tree cover	74.42229	3.717974
Open land	1.991672	0.0995
Grass land	349.0456	17.43755
Settlement	1506.719	75.27236
Plantation	69.51087	3.47261
	2001.689	

Source: Regional Centre Kasarani, Nairobi, 2019.

The study predicts the 2030 image of North Kanyajuok sub-location as it is illustrated in Figure 16 in red shade. The red shade seen occupying almost all the area is an indication that the area will be built everywhere. This has raised a lot of

concerns with regards to environmental conservation in which the natural environment is being rapidly transformed into built environment.

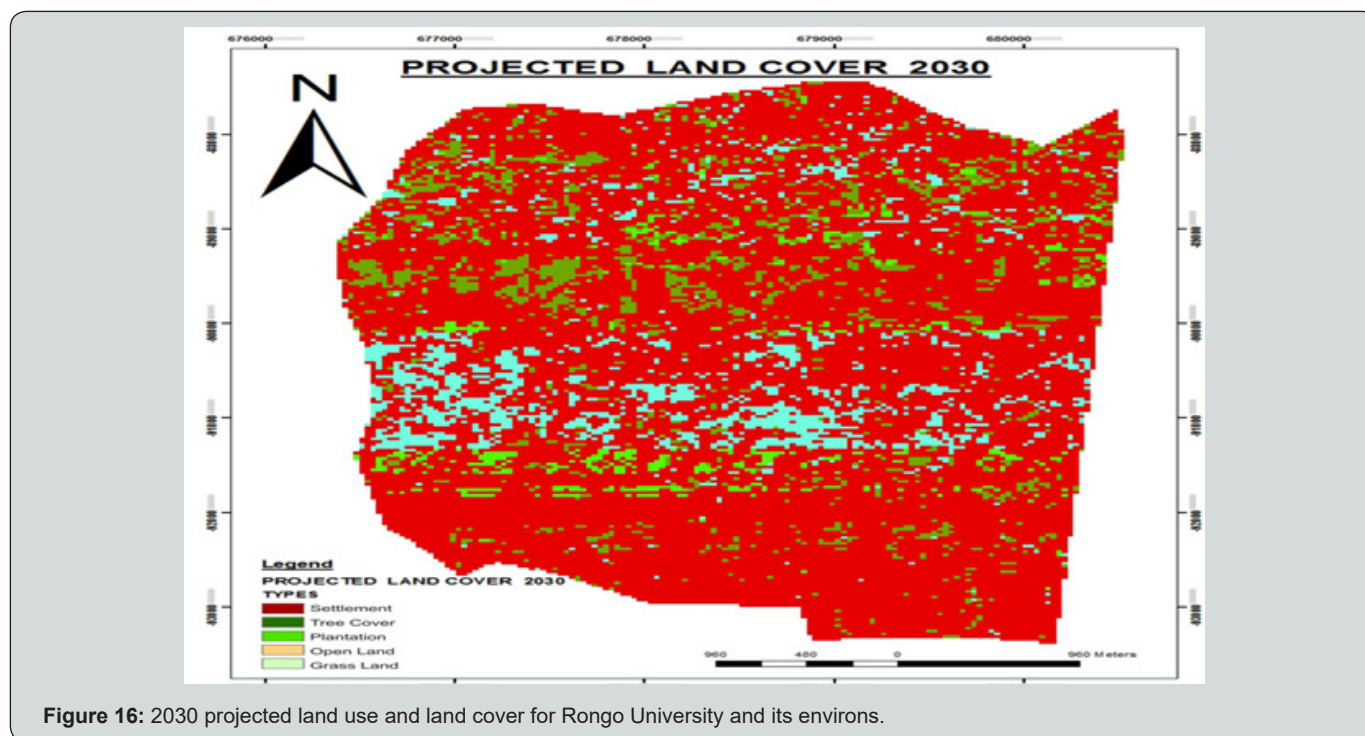


Figure 16: 2030 projected land use and land cover for Rongo University and its environs.

Conclusion

Based on the results of this study, it has become apparent that university establishment significantly influenced land use and land cover changes which took place during the period 2013 to 2018 in the study area. It is obvious that as a learning institution which admits students locally, regionally, nationally as well as internationally, thus demands more facilities to support learning resulted in increase of built environment. The general trend in land use /land cover change was transformation of natural or planted vegetation into a built-up environment had significant impact on environmental resources including the risk of species extinction or loss of biodiversity and genetic resources. Similarly, existence of a university in an area creates the perception that such an area has automatically the potential for development and businesses. Finally, the study confirmed that the establishment of Rongo University just like in other areas did contribute to the development of small towns which are unplanned (slums).

Recommendations

On the basis of the results of this study, the following recommendations should be considered can be adopted to realize sustainable environmental management and development of our universities:

- a) Develop devolved environmental policy at county level to guide development activities, especially around Rongo University and the large town environment;
- b) Ensure enforcement in the proper implementation of environmental regulations and set standards as well as monitoring and evaluation of the same to regulate sprawling development around the university;

- c) Enhance awareness creation and capacity building on sustainable environmental conservation and management, including effective coordination of enforcement agencies responsible for policy and legislation.

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