

Impacts of Refugees' Settlement on Land Cover: A Case Study of Mahama Camp, Kirehe District

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ABSTRACT

The international community has been well aware of the severe impact that large scale refugee populations can have on the social, economic and political life of host developing countries. Nevertheless, few studies have quantified the environmental impact of the growing number of internal and external refugees flow created by political, economic or environmental crises, particularly in the case of Rwanda. The present study was aimed at assessing the impacts of Mahama refugees' camp settlement on land cover change. The current study tries to provide an insight on using Google earth and ArcGIS to assess the environmental impact of large-scale refugee movements and concentrations. The change detection analysis integrated with spatial metrics performed in this research allowed to examine the levels of environmental impact caused by establishment of Mahama refugees' camp, and therefore allowed to determine the effects that refugees' settlement had had both inside and around the refugees' camp through image classification of land cover changes overtime and space. The findings revealed that the effects of refugees' settling on the land cover in the surroundings of Mahama refugees' camp by using images of the area for 2010 and for 2020 which outcome that the vegetation cover changed to bare land and cultivation field whilst the cultivation field from forest and unchanged area was detected. The vegetation cover which was 91.8% decreased to 30 % and bare land which was 8.2% increased to 11.2 % of total area. The study also presents different causes of changes in land cover, and emphasizes that the level of environmental degradation observed has been accentuated by the establishment of Mahama refugees' camp in area close to protected area such as Akagera wetland.

Keywords: Refugee, Settlement, Land cover, GIS, Mahama, camp.

I. INTRODUCTION

Environmental degradation is a worldwide phenomenon. Virtually, every nation on Earth is experiencing some form of habitat destruction or degradation. On a global scale, the impact of refugees on the environment is not significant. Nevertheless, given a due consideration, the environmental impact of refugee is not to be neglected either. The instance, of the refugee crisis in Tanzania in 1994-1996, saw a total of 570 square kilometers of forest was affected, of which 167 square kilometers was severely deforested. In Zimbabwe in 1994, when Mozambican refugees had returned to their homelands, showed a reduction of 58 per cent in the woodland cover around camps (UNHCR, 2017).

Since the late 1970s, the international community has been well aware of the severe impact that large scale refugee populations can have on the social, economic and political life of host developing countries (UNHCR, 1997). By the end of 2017, there were 25.4 million refugee men, women and children registered across the world (UNHCR, 2020), with 84% being hosted by developing countries (i.e., low and middle-income countries), including those that belong among the poorest countries in the world (OECD, 2017). Added to that is the fact that approximately two-thirds of the total refugee population remain trapped in protracted refugee situations, many of which have dragged on for decades (Miller, 2018; UNHCR, 2017).

The presence of refugees' complexes the already prevailing economic, environmental, social and, at times, political difficulties in the host developing countries. Often host countries are confronted by a combination of all four of these factors. The presence of refugees, and demands on the already severely strained economy, services and infrastructure add to the extreme hardship affecting

the local populations. In many instances, refugees become an added impediment to, or risk jeopardizing the development efforts of the host country. Their negative aspects may be felt long after a refugee problem is solved; for example, the damage to environment is a process and does not end with the repatriation of refugees (UNHCR, 2017).

Environmental degradation is a decline of environmental quality due to various human activities that degrade the natural environment in the present as it compromises the future of the next generation (Li & Reuveny, 2006). Eventually, increase in the number of refugees can cause hosting areas to struggle for basic needs such as water, food, housing, education, medical services and infrastructures. Therefore, effective measures are needed in order to mitigate negative impacts of refugee settlement and these should comprise environmental protection programs (Frew, 2019).

Today, Rwanda hosts 150,574 refugees living in six camps and four reception centers occupying 3.56 sq. km in six districts (UNHCR, 2019). Therefore, in consideration of all the effects associated with refugees' settlements, understanding the impacts of hosting refugees is at the centre of crafting responses that minimize the costs and risks assumed by host countries and communities, maximize the protection available to refugees, and utilize resources efficiently and effectively (Miller, 2018). This study tried to identify settlement pattern, to examine the levels of environmental degradation in the neighborhood of the camp by focusing on land cover and to determine the effects of refugees' settling on the land cover.

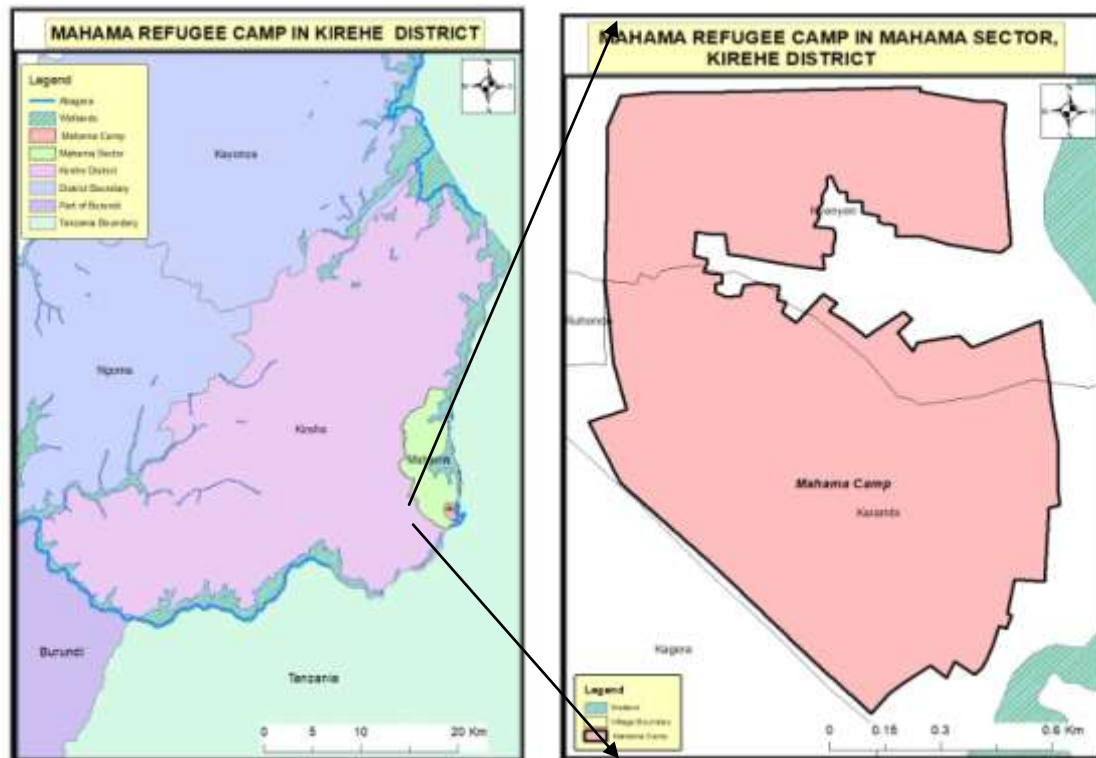
II. MATERIALS AND METHODS

2.1. Study Area Description

The study area is Mahama refugees camp located in Mahama sector which is found in Kirehe district in the Eastern province of Rwanda. Dominated by a relief of low plateau area, Kirehe presents also a chain of mountains dividing the region into two geographical entities. These are characterized by a low altitude plain of more or less 1350m, separated by isolated hills and mountains such as Mahama and Migongo Mountains. The average elevation of the District is 1500m above sea level. The mean annual temperature is 19.4° C and the rainfall oscillates around 898 mm. The principal water course of the District is the Akagera River which surrounds the south-eastern part of the District and continues northward into Lake Victoria (MINEMA, 2019).

Some areas are characterized by loamy and sandy soils with loam mixture in other area. Fertile soils are exploited and give satisfactory production for food crops like banana, maize, beans, soya beans and cassava (Kirehe District, 2013). The dominating vegetation types are the ones of the savanna, very dense and dominated by acacia trees. Apart from natural forests which are tending to disappear completely, there are other forests planted by the District and those belonging to local inhabitants (MINEMA, 2019).

Kirehe district borders Tanzania in East and Burundi in South. Its economic status is based on agriculture and livestock for at least 90% of the population. It is made up of twelve administrative sectors of which Mahama sector is among them. Mahama sector is the one hosting the refugees' camp which is the target area of this research. This sector is divided into four cells with its 23,643 number of population (NISR, 2012) and hosting 59,843 Burundian refugees since it was opened in April 2015 have fled violence and insecurity. Rwanda is hosting 164,561 refugees in total, who are primarily from Burundi and Democratic Republic of Congo.



Picture 1. Map showing location of Mahama camp, Kirehe district

Source: Author, 2020

2.2. Sample and Data Collection Techniques

2.2.1 Primary data

In this study, primary data obtained by digitizing the imagery from Google Earth, were used to assess the environmental impact of refugees' settlement in Mahama camp, Kirehe district. However, the study focuses on the land cover change, where deforestation was considered as the impact of refugee's camp. Furthermore, refugee's influxes intensify normal green environmental problem due to over-exploitation of forest resources due to rising populations, and inappropriate environment management practices. Moreover, data of the study area obtained from National Institute of Statistics of Rwanda (NISR) and online data were needed in order to assess the environmental impact of refugees' settlement in Mahama camp, Kirehe district using ArcGIS software and google earth.

Land cover and deforestation due to refugees' activities were analyzed using land cover and land use change was assessed to identify the possible changes resulting from refugee establishment on the study area. This was achieved by using ArcGIS methods and techniques. Land cover and land use change before and after refugee camp were used to examine the effects of refugees' settling on the forest cover in the surroundings of

Mahama refugees' camp. This was achieved by identifying the level of land cover and land use change that were converted from vegetation cover such as forest cover to bare land.

The results from this were interpreted due to the crowd dwellers of refugee, with fundamental assumption that refugee camp is the principal factor that contributes to forest deforestation, land cover change in Mahama. Hence, the transformation of land from forest or cropland to residential and bare land is earmark to the refugee camp activities in Mahama area. The land cover and land use maps of Mahama refugee camp area was produced using georeferenced google earth images obtained in 2010 before camp installation and compared to the google earth images obtained in 2020, after the camp installation.

2.2.2 Secondary data

In this research, the researcher also used secondary data related to the research topic, these data were used to get useful, sufficient meaningfully and consistent data. Different documents that might be relevant to the topic under research such as on settlement patterns, and on land cover or deforestation as an impact of refugees in Rwanda and elsewhere were consulted. These documents consist of reports from various

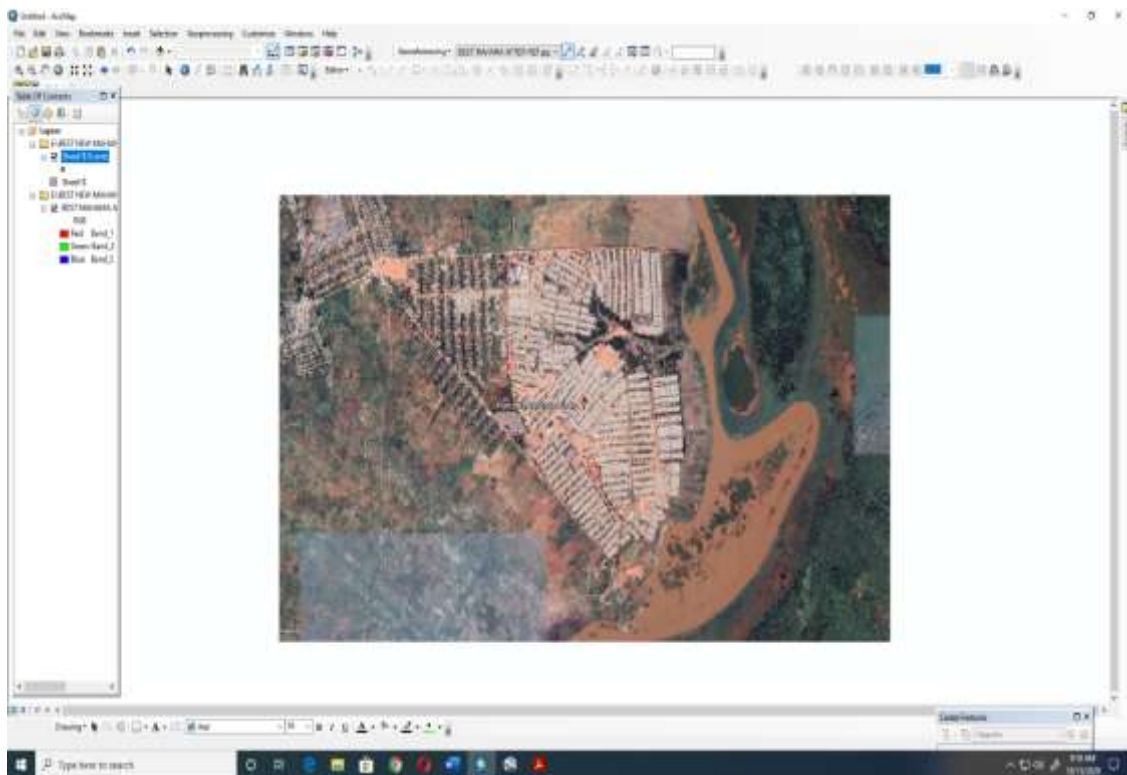
institutions, scientific papers, books, articles, thesis and others. Administrative map of Rwanda were used in order to produce and visualize extended map. Furthermore, different shape files that contain on environmental information such as geomorphology, hydrology data were used. The raw data for administrative boundary were obtained from the National Institute of Statistics of Rwanda (NISR), whereas the image of 2010 and 2020 of Mahama refugee camp were obtained from Google Earth in order to examine the levels of environmental degradation in the neighborhood of Mahama refugees' camp by focusing on deforestation.

2.3 Geo-referencing google earth imagery

At this step, the study area navigated from google earth before making Geo-referencing process and excel sheet were needed; here the coordinate captured from google earth image. Moreover, excel sheet X as longitude Y as latitude using place mark on google earth four-point coordinate were captured to excel sheet which increase data quality and reduce the error. After downloading the images from google earth, the necessary steps were used to import the image in JPEG format (*.jpg) into ESRI's ArcMap software

and then to assign real-world coordinates to the image. Therefore, image was able to overlay other digital spatial data with the image; this done by using excels sheet where real-world coordinates of four corners were recorded and the tools available in ArcMap's Geo-referencing Toolbar. Then, the points identified and assigned their real-world coordinates.

These points referred to, as 'control points'. By stepwise, firstly, Geo-reference tool bar were active from ArcMap tool bar. Then, un-referenced image and excel sheet of four coordinate corner were added to ArcMap, by using the 'add data' button. After that X, Y was displayed in ArcMap by clicking, right click on the data table and select display X,Y data, Y is typically latitude and X is typically longitude then, to define a coordinate system, do that points were shown up in the correct area of them in data view. WGS 1984 selected as coordinate system. Using the control points tool, pick a "common point" on the image, then select the same point on the existing layer and join to X,Y data point displayed from excel sheet. Finally, select Geo-referencing, update display to view results. Image was able to overlay other data that provided and used the same coordinate system Geo-referenced image exported in imagery format.



Picture 2. The result after Geo-referencing an image from google earth

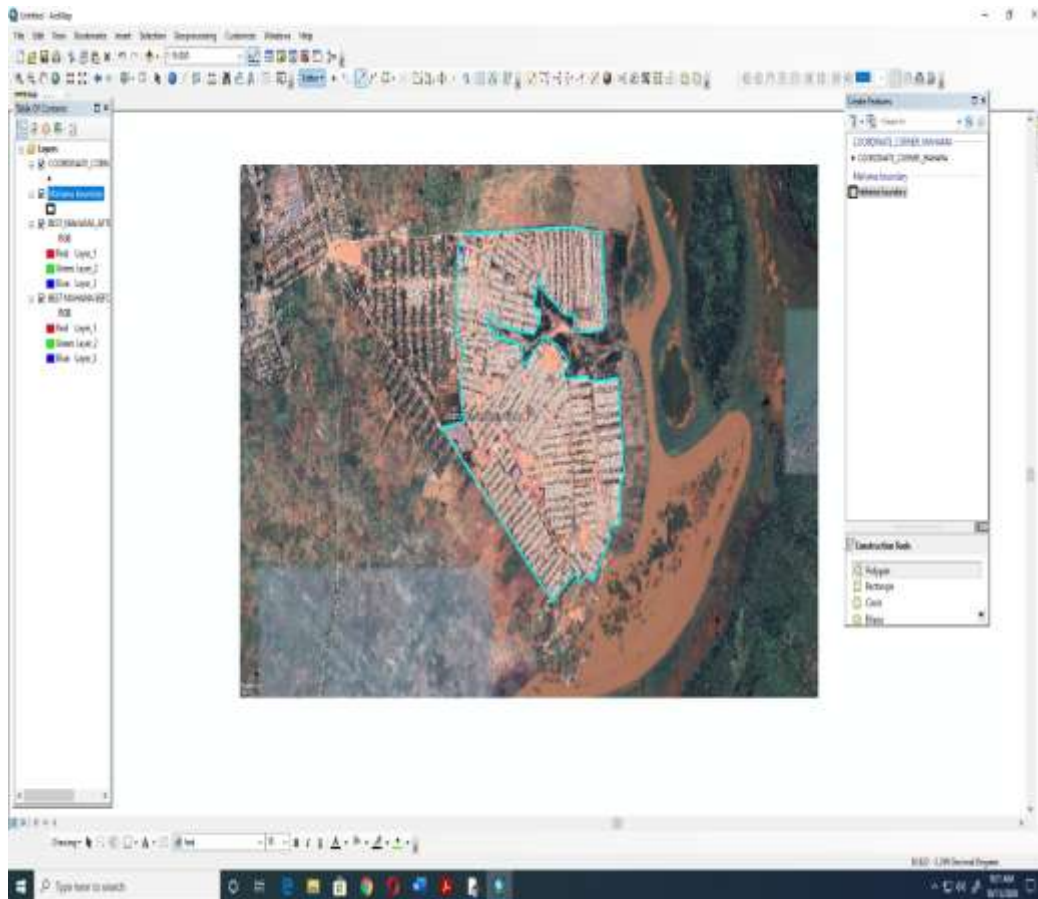
Source: Author, 2020

2.4 Digitizing Process

From Geo-referenced image, digitizing process was performed. Digitizing is the process of making features from Geo-referenced image, for making digital versions of objects that had an attribute table associated to the Mahama refugee camp. The primary goal was to digitize the Mahama refugee camp boundaries, which are objects that occupy an area on the map, once they became digitized they had an associated attribute table; these objects were also identified as polygon features. When digitizing was made, digitized polygons feature as boundary of refugee, these features, made them available for mapping once you have added the tabular data to the attribute table. Firstly, the digitizing process was started by creating new layers in ArcCatalog, and then adding features to them in ArcMap. An empty shapefile was created, by opening ArcCatalog, and a new shapefile was created and edited in ArcMap, this resulted in a polygon feature shapefile. The latter, sector of Rwanda boundaries was added to where Mahama refugee camp boundaries are located.

To perform the analysis the following steps were followed:

- Select New Shapefile, to create folder in which new shapefile was saved.
- Then after, open the Create New Shapefile window.
- Use the polygon shapefile to name as Mahama refugee camp.
- Clicking on Edit to see the Coordinate System of the file.
- Use the Spatial Reference Properties window to import the Geographic Coordinate Systems WGS 1984.
- Click OK and OK again to create the shapefile.
- Use editor toolbar to activate ArcMap toolbar to digitizing Mahama refugee camp.
- View, toolbars, editor. On the toolbar, click on the editor menu and start editing. In the Editor Toolbar, Start Editing. From the menu to the Editor, the Sketch tool chosen then start to digitize by tracing the polygon feature to finish, user returned to editor tool then save editor and a stop editing. (see Picture 3)



Picture 3. The result after Geo-referencing an image from google earth

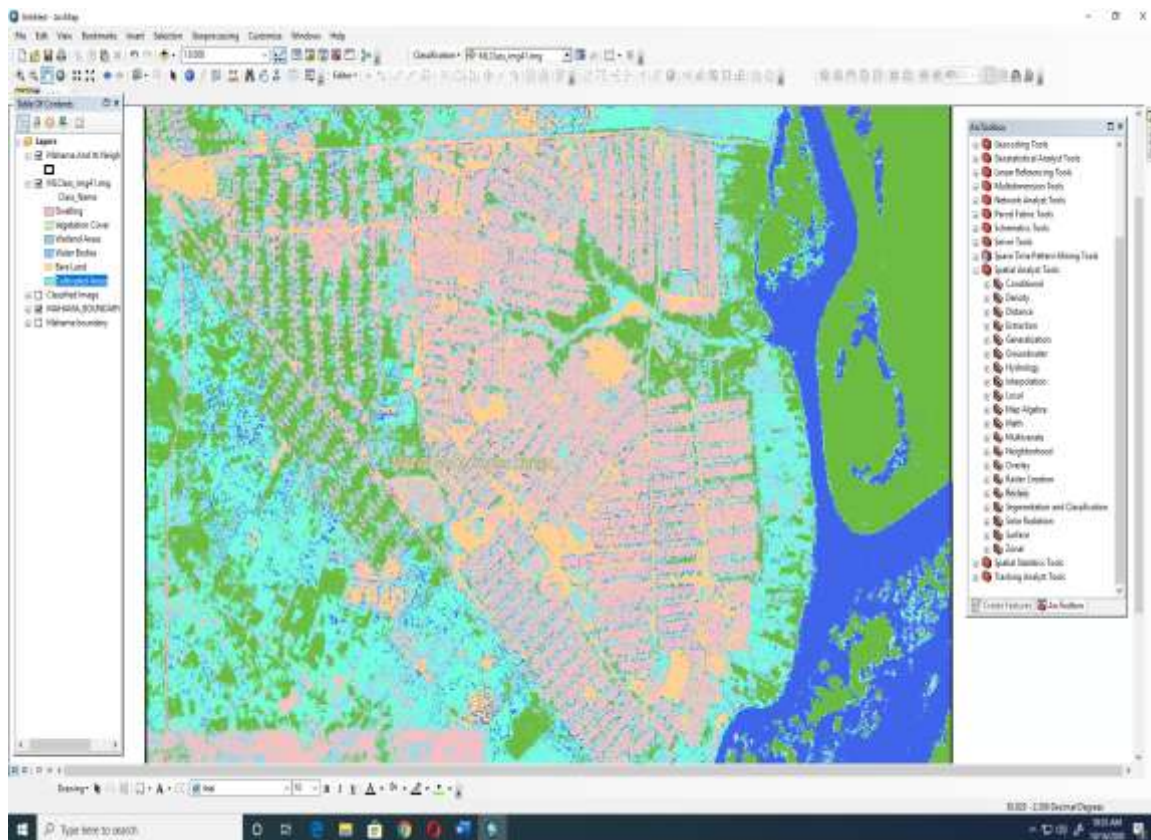
Source: Author, 2020

2.5 Imagery Classification of Before and After Refugee Installation

After Geo-referencing images of study area, ESRI's ArcMap software used to clip them to the outer boundary of Mahama refugee camp concessions using the 'Extract by Mask' from Spatial Analyst Tools in Arc Tool box tool. The clipped imagery projected to WGS 1984 to make them ready for image classification. The selection of the image classifier was limited to what ArcMap offers and thus, the Maximum likelihood method was chosen.

The land cover and land use performed on two image of Mahama refugee camp before and after camp installation, on classes used in the classification were selected based on our familiarity

with the study area. The following parameters were concerned such as (1) Refugee Dwelling, (2) Vegetation cover, (3) Bare land (6). This technic used to identify the land cover change in classes before and after Mahama refugee camp installation and its neighborhood. Training samples prepared by drawing on familiarity with the study area and based on image from google earth that uses high-resolution. In addition, proceeding in steps such as Subset or extract the desire location, creating signature file for supervised classification, perform maximum likelihood classification, area calculation and map presentation. This image classification process was selected to assess the environmental impact of refugees' settlement to the neighbor in Mahama camp, Kirehe district.



Picture 4. Image Classification of research area land cover

Source: Author, 2020

2.6 Data Analysis Techniques

The collected data analyzed through spatial analysis using ArcGIS software; the processed data exported to ArcGIS for digitizing, image classification, spatial analysis and visualization. The main analysis done based on manual digitizing, supervised classification proximity and density types of analysis. However, intended field data and some of spatial analysis

were not be undertaken due to the global health crisis caused by Covid-19 that prevents the researcher from travelling, and due to the sensitive nature of information related to refugee camp. For instance, lack of high-resolution Landsat image of Mahama refugee camp from USGS and lack of permit for field survey for data collection in Mahama refugee camp. Therefore, instead of refugee camp dwellers data, dwelling units

digitized from the Geo-referenced image and proxy for dwellers refugee were used.

To assess environmental impact of refugees' settlement around the neighborhood of Mahama camp, Kirehe district, the proximity of Mahama refugee camp in the study areas were mapped and a benchmark of 2 Kilometers distance were used for analysis. The use standard 2 Kilometer, as a minimum distance from a camp's fence to the protected zones, is the national benchmark to establish the refugee camp on given place. Proximity analysis, vector analysis in particular, performed to find out the most affected protected zone to refugee dwellings.

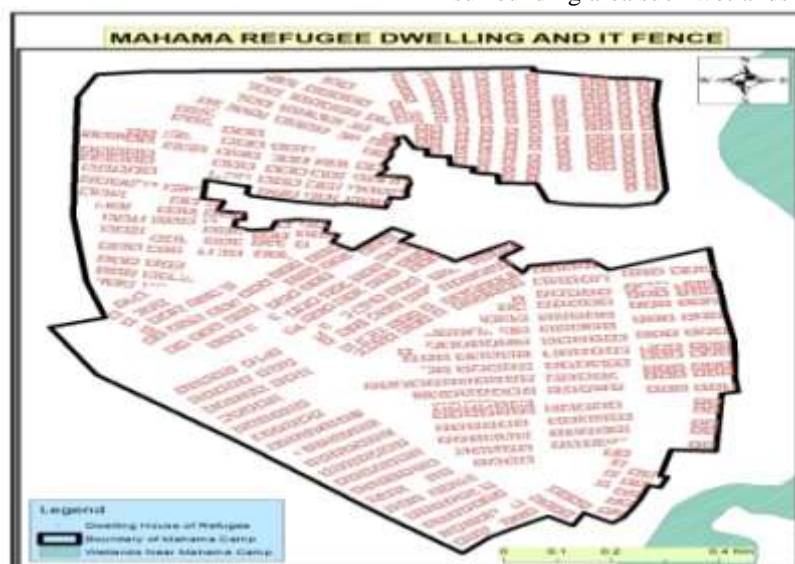
To facilitate the analysis, buffer and near tools were both used to find out level of environmental degradation in the neighborhood of refugee camp by a particular refugee fences within a radius of 2 Km, which was, affect coverage of that particular neighborhood. To assess settling pattern of refugees in Mahama refugees' camp in Kirehe district digitizing process were performed, all dwelling of refugee were digitized in order to find out the settling pattern of refugees by analyzing overuse of resources in study areas. Moreover, from digitizing the refugees dwelling were determined number of household's refugees and how the overcrowd refugees assist the deforestation in way to boost the levels of environmental degradation in the neighborhood of Mahama refugees' camp by focusing on deforestation.

III. RESULTS AND DISCUSSIONS

3.1 Settlement patterns used in Mahama refugees' camp

The images of the camp indicated that the settlements of refugees are typically associated with patterns of grouped settlement, because is very closely together (see Picture 3). Camps usually present a higher risk than refugee settlements in open situations, as there is overcrowding and insufficiency of basic facility, such as water supply and health care services. Location of site of Mahama refugee's camps is more difficult to organize for very large camp populations, such as some of the Burundian and Congolese refugee camps in Rwanda, which contains more than 160,000 refugees.

Therefore, overcrowding dwelling increases risk of outbreaks of communicable diseases, degradation of the surrounding environment, security problems within the camp. Securing stable permanent housing is critical to the settlement process for refugees to promote integration and establish a full and meaningful life in Rwanda. Doing so is especially difficult for refugees due to low incomes, limited social networks, and pre-arrival histories, which often involve trauma. Asylum seekers confront further challenges beyond those experienced by offshore processed refugees, including the uncertainty of legal status and conditional, typically lower and shorter, levels of government income support, housing support and support for various other necessities of life. Therefore, above map showing us the dwelling, which is very closest together in Mahama, camp refugee site in that case they contribute environment degradation on the surrounding area such wetlands and river.



Picture 5. Map representing grouped settlement pattern used in Mahama refugees' camp Source: Author, 2020

3.2 Assessment of effects of refugees' settlement on environment in Mahama

3.2.1 State of Mahama refugee camp location and its surrounding in 2010

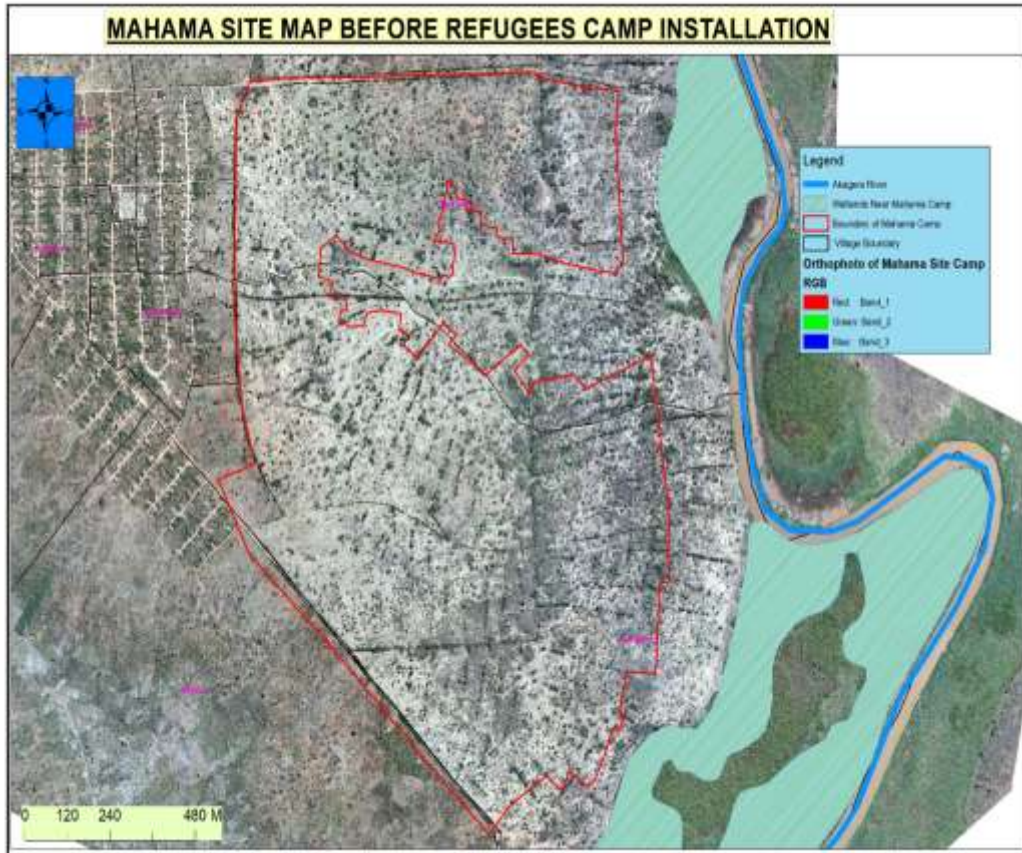


Photo 1. Image of Mahama site (red line) before the camp refugees' establishment in 2010

Source: Author, 2020

As seen on the image some of the surrounding of the camp site area, are protected areas such as wetlands which are comprised of water and vegetation cover in the South-Est parts of the site, whereas located in the rest are farming areas and forest areas. The camp site is situated on

two mountains one in Nyenyeri and another in Karambi separated by a valley stretching from the North to the South on a surface area of 22,123.18 m² and connected to the Akagera River by a vast wetland. The valley seats in the middle as if it was to divide the camp site in two almost equal parts.

3.2.2 Mahama refugees' camp and surroundings as seen in 2020



Photo 2. Presentation of grouped settlement pattern used in establishing Mahama refugee camp taken in 2020

Source: Author, 2020

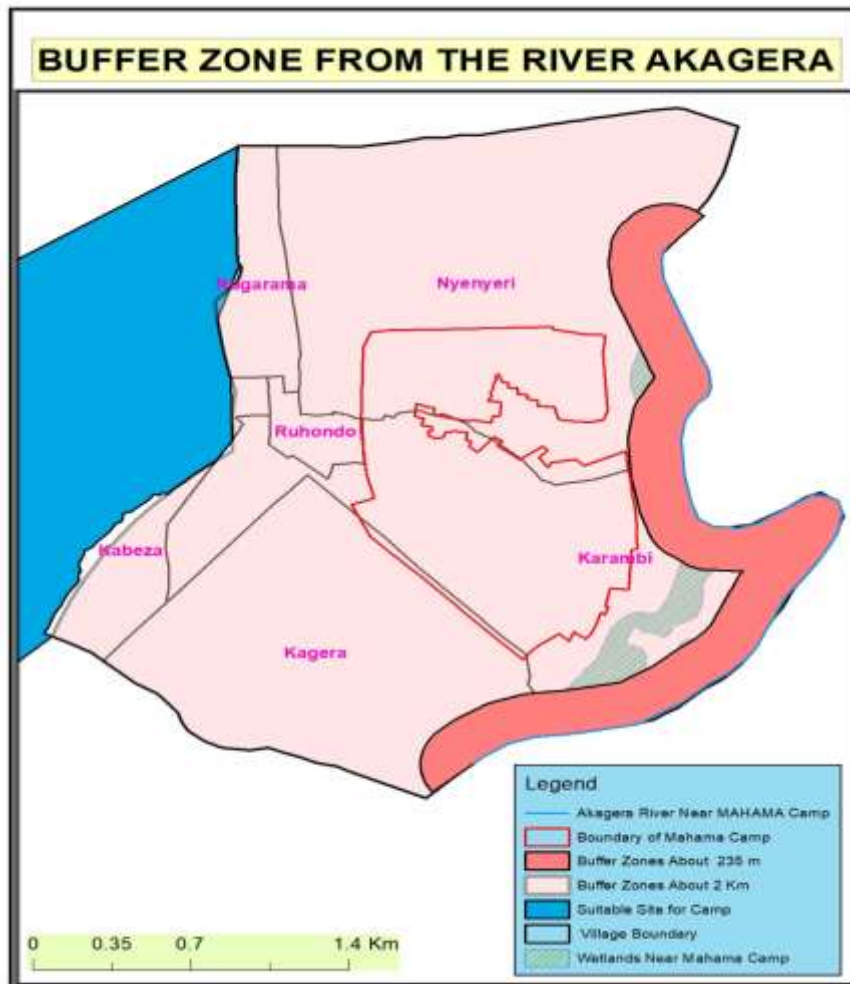
Since the camp establishment in 2015, many activities have taken place in Mahama camp. These activities pertain to providing basic needs (food, energy, water, shelter and health care) for 54,000 Burundian refugees. After 5 years of occupation the Google Earth image of Mahama refugee camp, shows the destruction of natural cover (bushlands, grasslands) in the area where the houses of refugees have been established.

There is visually a remarkable change in land use with increased agricultural activities around the camp site. Several small-scale farms are more present than before the camp establishment especially in the Western and Eastern parts of the camp. There are many sites of clay mining to meet the need of construction materials for refugees, and other alterations resulting from refugee camp installation.

Extensive deforestation is also observed in the area currently occupied by Mahama refugees' camp and its neighboring areas. The imagery reveals how since Mahama refugee camp was established in 2015. After the arrival of refugees in

Mahama, the rate of deforestation increased as in because of increased searching for firewood by refugees and of timber for construction, purposes in the area and resulting in land use changes altered the state of the environment. In addition, it is obvious that different types of wastes (solid waste, chemical and human waste) would have been released in the surrounding environment especially in the wetlands of Akagera River, hence contaminating the water bodies.

The most important environment challenges were caused by vegetation demolition and deforestation at the camps site and in the surrounding areas during the camp installation (see Photo 2). Moreover, increased pressure on land resources and loss of biodiversity are among implications that have followed the establishment of the camp. In addition, to understand the environmental impacts of refugee settlements on the site as it is, it must be noticed that the majority of the threats are related to the location of the camp itself, where the camp is close to Akagera wetland and river (see Photo 3).

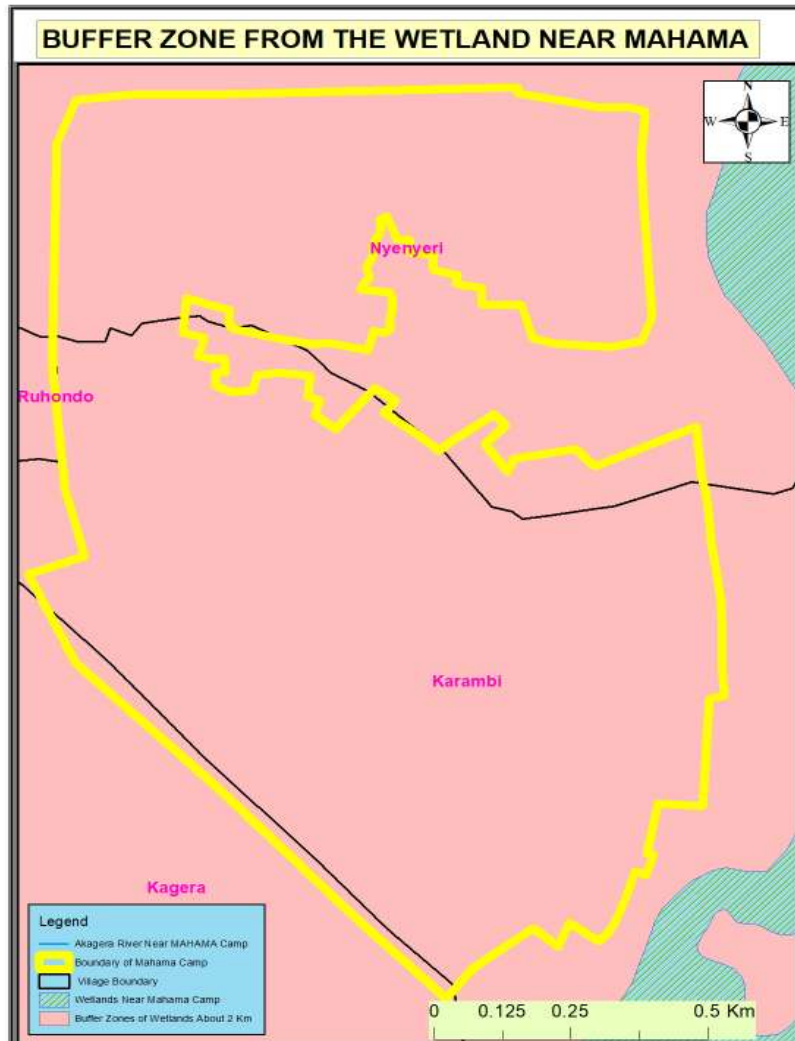


Picture 6. Map of Mahama refugee camp from Akagera River

Source: Author, 2020

As seen from the map (See Picture 1), the camp is established at only 235 meters from Akagera River. This implies that the camp is not separated from the wetland adjacent to the water flow, hence exposing refugees to mosquitoes and other related challenges. On the other hand, the wetland is exposed to different forms of pollution resulting from refugees' daily activities. According to the Rwanda national land use planning

guidelines published in 2017, MINIRENA recommends that sites for refugee camps should be located outside protected areas. For instance, the camp should be located about 2 Km away from buffer zones. In the case of Mahama, the camp is very near the river at about 235 meters only instead of 2 Km recommended by the guideline (the map below shows that the camp is located in the buffer zone from Akagera river.



Picture 7. Map of location of Mahama camp vis-à-vis the buffer zone area

Source: Author,2020

Wetlands are transitional areas between land and water. During wet seasons some of the establishment of refugees' camp of Mahama, get flooded by large amounts of water from Akagera River, as the boundaries between the wetlands and uplands or deep water are not distinct. The map colored in rose quartz, represent the areas that are exposed to flooding in the refugees' settlement (see Picture 2). Although, the site of the camp was also chosen to ensure the protection of interests of the existing communities, and to prevent conflicts between them, however, the buffer zone between the refugee camp and the local communities should not hinder the protection of environment and put the lives of refugees in danger.

In addition, the question of hazard arises from refugee camp in the fact that, in ecological terms, everything must go somewhere. Wetlands

are able to degrade, transform, or assimilate many contaminants, such as nitrogen, and are sinks for some materials. Evidently, persistent materials, such as phosphorous and metals might pollute the wetland through the spread chemicals and hazardous materials leading to degradation of biodiversity in the Akagera wetlands area.

3.3 Land cover classes

Studies of land use and land cover structure change usually needs development and definition of more or less homogeneous land use/land cover units before the analysis is started. These have to be defined and spatially differentiated using the available data sources (e.g. online google earth pro) and any other relevant information and local knowledge. Hence, the land cover classes used in this research are defined

based on the google earth imagery to identify the situation before and after refugee settlement in Mahama camp. This study considers the period from 2010 to 2020.

The google earth imagery of land cover consists of an image that delineates the earth based on the interpretation of satellite images. It provides comparable digital image of land cover for each country. This has been particular useful for environmental assessment and analysis in this study. Initially, four-land cover classes were selected in the year 2020 while in year 2010 three classes were able to be grouped. Hence, the subsequent spatial and temporal land use/land cover change analyses were based on these classes.

3.3.1 Land covers image classification before and after refugee’s camp installation

After the images were geo-referenced and geometrically corrected, image clipping and extracting were performed. This pre-process was performed using spatial analyst tool on a sub-scene from the full geo referenced image, based on a study area frame covering the Mahama camp. These preprocessing tasks allowed the researcher to export the google earth images to the ArcGIS software imagine for classification and extracting land cover information.

In this study image classification and interpretation was performed using Arc GIS 10.3. Using georeferenced images (e.g. digital google earth of Mahama camp boundaries (2010 and 2020) land cover situation before and after refugee establishment Mahama camp from 2010 to 2020

was identified and mapped accordingly; training samples were gathered from different points as signatures for each google earth images. These signatures were then used in a supervised classification method. Land use/land cover was mapped by means of visual interpretation of google earth images. The classification was performed and four-land cover classes were selected for the year 2020, while in year 2010 three classes were grouped.

The major classes in 2020 were artificial, these include: Built-up area of refugees, vegetation cover areas, and other building. For 2010 the land use/cover included Low Shrubs Vegetation, Scrub Vegetation and Bare Land and bare land or open area. Furthermore, land cover maps were generated taking into account the time frame of ten years. Area estimates and percentage change were computed for 2010 and for 2020. Individual class area and coverage change for the period of ten years were summarized in two delineated maps.

Land cover before refugee’s camp installation in 2010

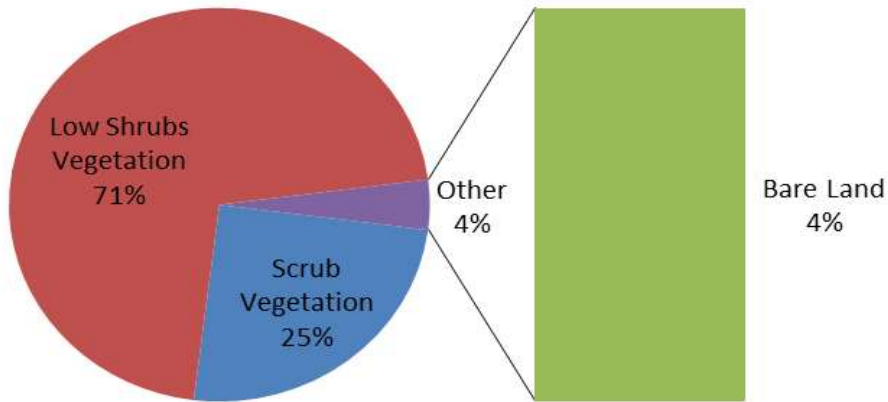
In 2010, the major land cover classes were classified and includes scrub vegetation, low shrubs vegetation and bare land. The results (see Table 4 and figure 1) indicated that low shrubs made up the predominant type of land cover type, with an estimated area of 71 % in their spatial extent in the study area, before the refugee camp settlement, whereas scrub accounted for 24.9 % and bare land occupied a percentage of 4.1% of the total area of the region representing the small proportion of the land cover classification.

Table 1. Presentation of the land use/cover in 2010

No	Categories/Types of land cover/use	Area in Ha	Percentage (%)
1	Scrub Vegetation	38.2433	24.9
2	Low Shrubs Vegetation	109.24	71.0
3	Bare Land	6.31633	4.1
Total		153.8	100

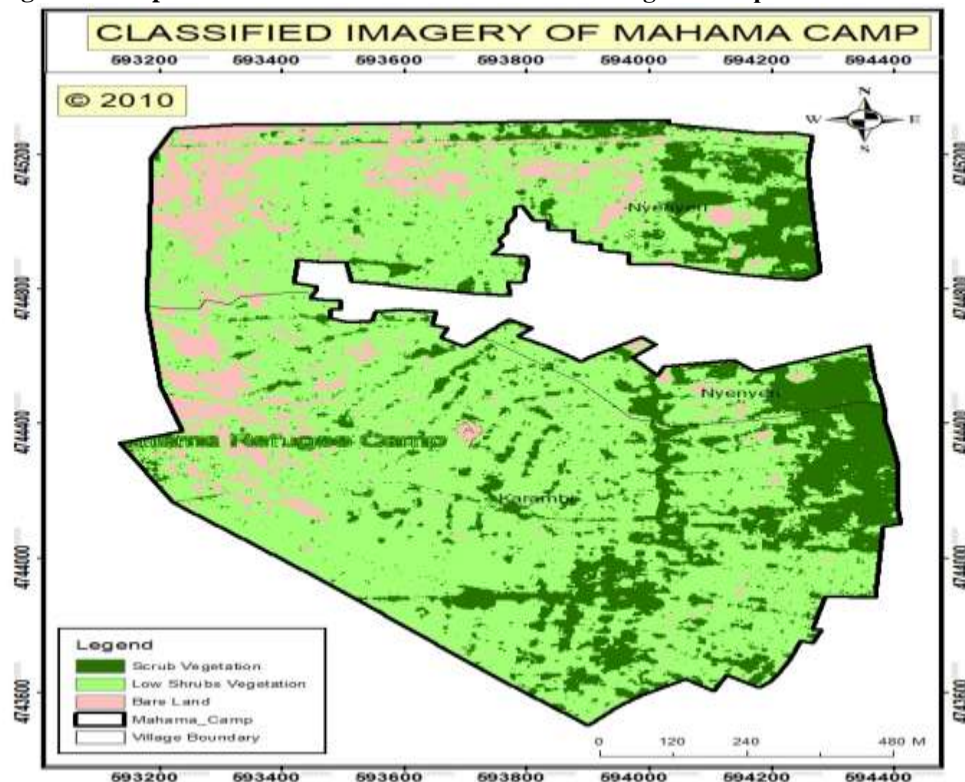
Source: Author, 2020

Figure 1. Presentation of the land use/cover in 2010
Percentage (%)



Source: Author, 2020

Figure 1. Graphic of land cover classification before refugee’s camp installation in 2010.



Source: Author, 2020

Land cover change 10 years after refugee’s camp installation in Mahama

The results indicated that in 2020, the major land cover classes identified in the study area included built-up area of refugees, bare land, vegetation cover, and other buildings within the camp area. The types of land cover identified in

2020, included vegetation cover and artificial-built up surfaces. Particularly, built-up area made by refugees’ dwelling constituted the predominant type of land cover with an approximate area coverage of 58.4 % in their spatial extent in the region. Forest, and bare land accounted for 23.3% and other building occupied 18.2 % of the total

area of the region representing the small proportion of the land cover classification.

Table 2. Percentage of the land use/cover units in 2020

No	Categories/Types of land cover/use	Area in Ha	Percentage (%)
1	Built-Up Area of Refugees	89.9	58.4
2	Bare Land	17.7	11.5
3	Vegetation Cover	18.1	11.8
4	Other Building	28.0	18.2
Total		153.8	100.0

Source: Author, 2020

There are several ways to quantify the land cover change results. Among others methods, basic method was used to perform image classification in order to classify the total land cover changes for each land use/land cover type and examine the trends of change between the years. During the delineation of maps were based on the periods, distinct changes have occurred on the major land use/land cover types.

In 2020, the built-up area of refugees' environment increased approximately to 89.9 ha (58.4 %) and other buildings within the camps were 28.1 ha (18.2 %), bare land 17.7 ha (11.5 %), while vegetation cover land decreased 17.7 ha (11.8%) in 2020. In 2010 scrub vegetation occupied 38.24 ha (24.9 %), low shrubs vegetation occupied 109.24 ha (71 %) and bare land had 6.31 ha (4.1% %) in 2010.

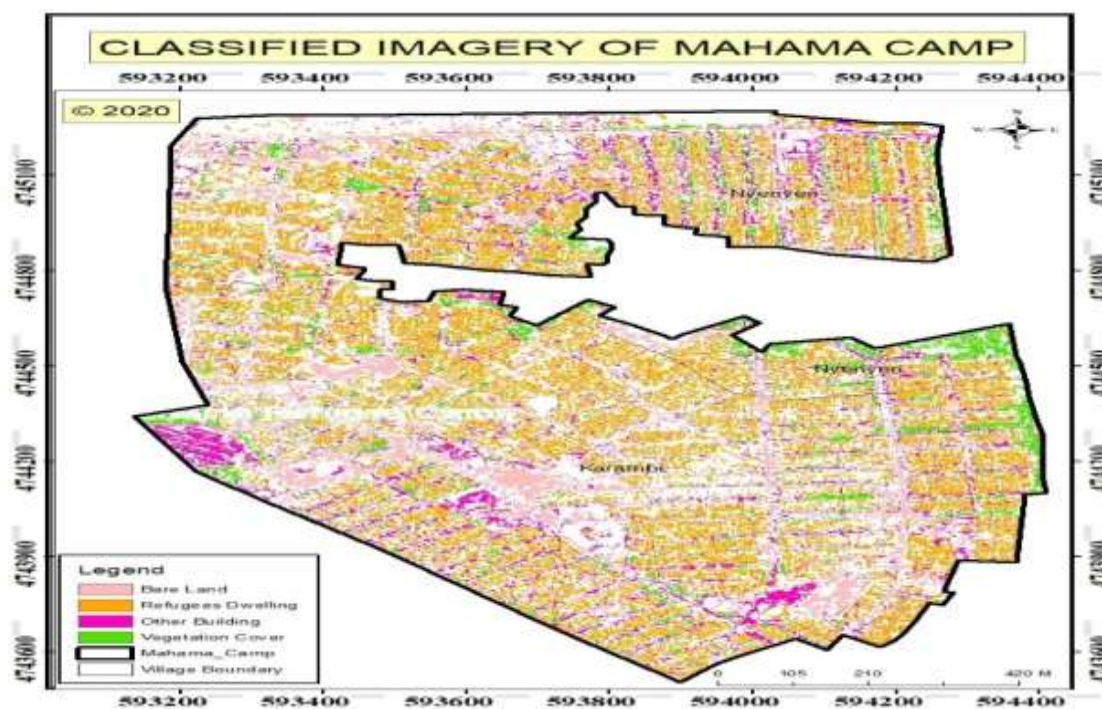


Figure 2. Imagery of land cover classification after refugee's camp installation in 2020

Source: Author,2020

3.3.2 Land covers classification in areas bordering the camp in 2010 and 2020

The next results are from image classification and bordering of study area before and after refugees' camp. Two google earth imageries were classified in order to compare these two images, to examine the levels of environmental degradation in the neighborhood of Mahama refugees' camp by focusing on deforestation. Therefore, the tendency of land-cover change on surrounding area were examined in Arc GIS 10.3 in the process of image classification by comparing with several two images navigated in google earth. Using the differences between images acquired in 2010 and 2020, which has the total hectares of 137.6 ha, vegetation cover changed to bare land and cultivated field, bare land, and cultivated field changed from forest and unchanged area was detected. Such that the analysis was performed

with ArcGIS 10.3, program and boundaries of each class were calculated and delineated easily.

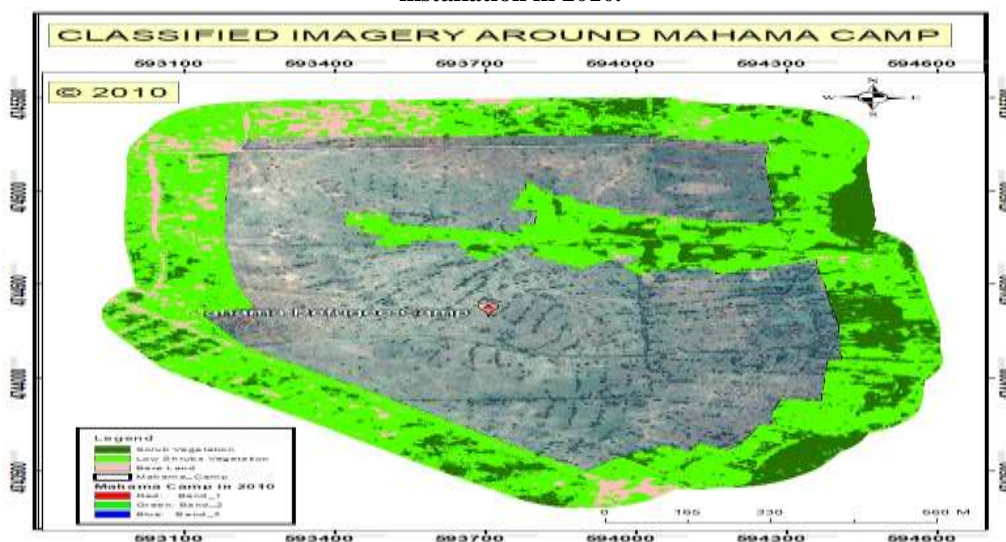
The following results show spatial distribution of vegetation cover changed in 2010. Therefore, the result of this study showed that built up areas were absent in 2010, while in most area bordering Mahama camp occupied by vegetation such that scrub vegetation taken the 29.9 ha (21.7 %), low shrubs vegetation occupied 96.4 ha (70.0 %), and then bare land and other open area taken about 11.3 ha (8.2 %). Generally, in 2010 the bordering area before refugee's camp installation in 2010 the vegetation area around refugees camp environment increased approximately 126.3 ha (91.8 %). As shown on the map below (see figure 5) the imagery classification of around camp, showing us before of Mahama refugee camp covered by mainly grassland or scrublands by which land predominately covered the vegetation with grasses or shrubs.

Table 3. Percentage of land use/cover on bordering area of Mahamacamp in 2010.

No	Features	Area in Ha	Percentage (%)
1	Scrub Vegetation	29.9	21.7
2	Low Shrubs Vegetation	96.4	70.0
3	Bare Land	11.3	8.2
Total		137.6	100

Source: Author, 2020

Figure 3. Google earth imagery land cover classification of on bordering area before refugee's camp installation in 2010.



Source: Author, 2020

In general, the analysis of land cover change revealed that the bare land and cultivated field area has increased over the period of 10 years from 2010 to 2020. In addition, it was found that the vegetation cover had decreased in the area bordering the refugees' as seen in 2020. The vegetation cover decreased hugely by 41.3 ha (30%) due to the daily activities of refugees in resources exploitation around the camp while bare land or open area had increased 15.4 ha (11.2 %).

Particularly, in this period, a huge volume of surface water has increased on that area due to

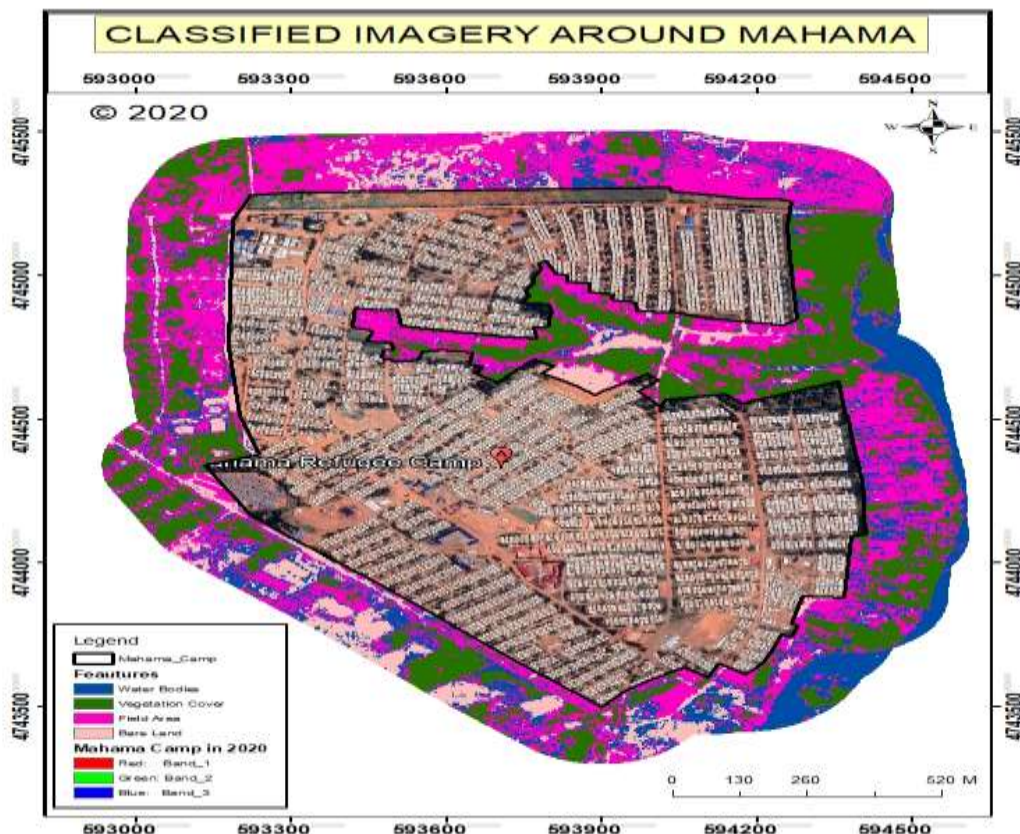
the presence of refugees dwelling that occupy over 25.2 ha (18.3 %). According to the image classification, it is clear that the reductions in natural cover (bushlands, wetland, grasslands) and increase in land use activities like dwellings of refugees, has led to reduction in forest cover. After refugees' camp installation other serious environmental problem created by the refugees were also identified in addition to the change in land use/land cover; these include solid waste, human waste within and around all the study area.

Table 4. Percentage of the land use/cover around the refugees' camp installation in 2020

No	Features	Area in Ha	Percentage (%)
1	Vegetation Cover	41.3	30.0
2	Field Area	55.6	40.4
3	Bare Land	15.4	11.2
4	Water Bodies	25.2	18.3
Total		137.6	100.0

Source: Author,2020

Figure 4. Imagery of land cover after refugees' settlement in 2020



Source: Author,2020

3.4 Discussion

The present study was aimed to assess the impact of refugees' settlement on land cover change taking the case of Mahama refugees' camp in Kirehe district. First, the study endeavored to find out the type of settlement patterns used in establishing Mahama refugee camp. The study realized that Mahama refugees' camp was established following grouped settlement pattern method. Secondly, it identifies the levels by which the establishment of the camp has affected the Mahama camp surroundings' environment by focusing on land cover change in and around the refugees' camp in Mahama. Secondary data that consist of satellite imagery were utilized to identify the site before (in 2010) and after refugee camp installation (in 2020). ArcGIS was used to generate necessary maps and to calculate each land use cover and land change was expressed in percentage.

GIS has been used to combine a number of factors(layers) into a single composite surface, which has facilitated comparison of alternative power lineroutes and an evaluation of impacts on, inter alia,land-use types and environmentally sensitive areas. In the study by (Lodhi et al. (1998), the use of multi-date satellite imagery provides significant capability for land cover and forest change detection. Thus, findings from the study showing the effects of refugees' settling on the land cover in the surroundings of Mahama refugees' camp by using different images acquired 2010 and 2020 which outcome that the vegetation cover changed to bare land and cultivation field whilst the cultivation field from forest and unchanged area was detected whereas the vegetation cover taken 91.8% decreased to 30 % and bare land taken 8.2% increased to 11.2 % of total area.

The study revealed that there have been changes in land cover, due to increased intensive farming activities around the camp leading to land degradation, diverse forms of pollutions (surface water production, etc.), deforestation, as forests in the area appear to have been cleared to meet the timber, and fuel wood for the refugees. Increase in build-up area caused by buildings establishment by refugees, deforestation and reduction in different form of vegetation in and around the camp. The study emphasizes that the level of environmental degradation observed has been accentuated by the establishment of Mahama refugees' camp in area close to protected area such as Akagera wetland, which not only put the wetland biodiversity at risk but also exposes the refugees at the risk of contracting Malaria and other threats.

IV. CONCLUSION

The main purpose of this research was to assess the impacts of refugees' settlement on land cover using the case study of Mahama camp at Kirehe district. This study used Google earth and ArcGIS to generate maps and for data analysis in environmental impact assessment. The results indicated that refugees' settlement had the effects on the forest cover in the surroundings of Mahama refugees' camp through image classification of land cover changes overtime and space. The produced maps can help in the understanding of the nature and breadth of changes in land use/ land cover, where they are occurring and monitoring these changes at local scale, as there is high change in forest cover and cultivated and bare land for refugee movements and concentrations.

The analyses provide valuable insight into the extent and nature of changes that have taken place in and around Mahama refugees' camp since 2010 to 2020. The establishment of Mahama refugees' camp footprint can be summarized as: the observed land cover change underlines other issues such as pressure on land resources, water and energy demand, soil destruction, air pollution, deforestation, waste production and others. Therefore, the study concludes that the level of environmental change observed through diverse changes in land cover has been caused and heightened by the establishment of Mahama refugees' camp in area close to protected area such as Akagera wetland, which not only put the wetland biodiversity at risk but also exposes the refugees at the risk of contracting Malaria and other threats. Nevertheless, it is too early to establish a relationship between grouped settlement and the level of environmental impact observed in Mahama and as this requires a more deepened analysis including socio-economic surveys which were not undertaken under this study.

Conflict of Interests

The authors have not declared any conflict of interests.