

# The Impact of Urbanization Expansion on Agriculture Land in Rwanda: Case Study of Runda Sector, Kamonyi District

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**Abstract:** Urban expansion, a type of LCLU change that leads to substantial gains in urban/built-up areas at the expense of green or open spaces, is a common occurrence in developing countries. Documentary review was used to carry out a thorough examination of the pace of urban growth and its effects on agricultural land. Landsat images had to be retrieved, preprocessed, and their accuracy assessed before being used to calculate the trend of LCLU change. The findings for the first objective illustrated that between the years 2001-2011-2016-2019-2022, the urban area has grown at an estimated annual average rate of 53%, while the vegetation area witnessed an overall sharp decline of 22%, mostly; due to a tremendous augmentation in urban area. The findings for the second objective indicated that Agricultural land area has faced an overall reduction rate of approximately 27%; population growth being the main driver for this reduction. This population growth, together with the emigration of settlers from Kigali city to Runda sector, is the main driver of this increase. The findings for the third objective illustrated that there is a clear linkage between urban growth and agricultural land degradation in Runda sector. Basing on the results of this study, there is actual urge for further public backing of the vertical construction of homes and companies to preserve green space. Farmers still need to be instilled how to make the most of a small plot of land in order to produce more. Moreover, supplementary policy implications are also required in order to accommodate a delegated responsibility that is environment-conscious.

**Keywords:** Urban Expansion, Agricultural, Population Growth, Land Use and Land Cover Change

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## 1. Introduction

Urban expansion, which is a type of land use conversion, is a common occurrence in developing countries [4]; Urbanization manifests itself as the main source of farmland loss because urban populations are increasing rapidly than rural residents, especially in developing countries [5].

The process of urbanization is marked by significant gains in urban/built-up areas at the expense of green or open spaces, the urban/built-up land-cover class encompasses all non-vegetative, human-constructed elements such as buildings, asphalt, and concrete, but also residential, commercial, industrial, and office space, and transportation space, Golf courses, urban green parks, and nature areas are not included in the urban/built-up group [2].

Urbanization is ramping up the reduction of farmland, raising problems of foodstuff shortage for the poor and the livelihoods of peri-urban farmers [7].

Based on 2008 orthophoto and 2014 imagery, analysis of recent housing development trends in Kigali city illustrates inadequate use of available urban land and a faster encroachment on peri-urban land. Runda, Shyorongi, Nyakaliro, Muyumbu, Fumbwe, and Mwogo all have more urban housing development. Initially, these areas were used for agriculture. Average of 1,200 ha of peri-urban around Kigali city was built up each year, the constructed area was 8,900 ha in 2005 but was augmented up to 12,100 ha in 2014 [6].

The aim of the study was to assess the impacts of urbanization expansion on agricultural land in Rwanda. The

specific objectives of the study namely being to assess the rate of urbanization expansion in Runda sector, evaluate the agricultural land reduction over time in Runda sector and to determine the linkage between urbanization expansion and agriculture land reduction in Runda Sector.

## 2. Materials and Methods

### 2.1. Site Description

The study was piloted in Runda sector, one among the 12 Sectors that make up Kamonyi District, Southern Province of

Rwanda. Its geographical coordinates are between 29°56'0" and 30°0'0" Longitude East, 1°53'30" and 1°59'30" Latitude South [8].

Runda sector is neighbored by Kigali and Kinyinya sectors of Nyarugenge district in the East, Shyorongi and Ngamba sectors in North, Rukoma sector in the West, Gacurabwenge sector in South-West, and Rugalika sector in the South. The study area covers an area of 50.84sqkm with total population of roughly 46, 565 inhabitants. The population density is 861 people/Sq. km [9].

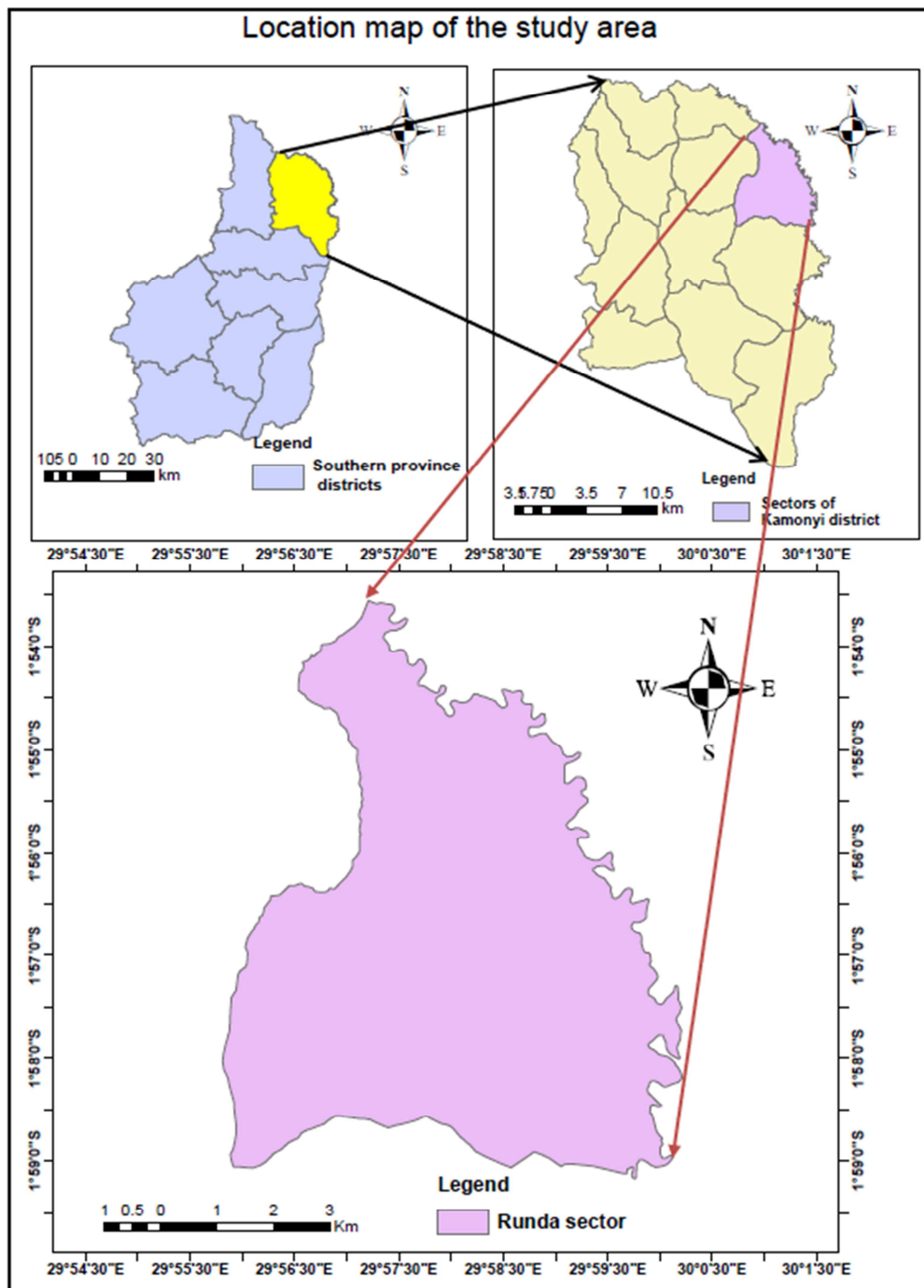


Figure 1. Location of Runda sector in Kamonyi district.

## 2.2. Data Type, Sources and Data Analysis

Satellite images were collected from USGS Earth Explorer where Landsat satellite image of year 2001, 2011, 2016, 2019 and 2022 were retrieved and stored for further examination to attain the goals of the research [10].

Layer stacking of satellite bands, clipping the study area, image, image enhancement, image classification and accuracy assessment report were performed using Erdas imagine 2014, After that Arc GIS 10.8 was used to generate land use/land cover map of the study area and computation of areas of each and every land cover type [11], Google Earth pro was for ground truth validation to check whether the land cover class in classified image corresponds to the land cover on the ground [12].

## 3. Results and Discussion

### 3.1. The Rate of Urbanization Expansion in Runda Sector

Landsat images have been classified in order to extract thematic information in terms of Land use /land cover types

of Runda Sector [10]. ERDAS IMAGINE 2014 software was used to retrieve the land cover situation from the landsat-7 ETM+, Landsat-5 TM, AND Landsat-8 OLI acquired in 2001, 2011, 2016, 2019, and 2022 respectively.

The results indicate that in 2001, 2011, 2016, 2019, and 2022; urban area occupied 1020600 m<sup>2</sup>, 4060800 m<sup>2</sup>, 5003580 m<sup>2</sup>, 8987621 m<sup>2</sup>, and 12376600 m<sup>2</sup> respectively. Vegetation occupied 30664400 m<sup>2</sup>, 27075200 m<sup>2</sup>, 27673039 m<sup>2</sup>, 24925528 m<sup>2</sup>, and 23950300 m<sup>2</sup> in year of 2001, 2011, 2016, 2019, and 2022 respectively. Agriculture area occupied 13807800 m<sup>2</sup>, 18032800 m<sup>2</sup>, 16745134 m<sup>2</sup>, 14902401 m<sup>2</sup>, and 12989400 m<sup>2</sup> in the year of 2001, 2011, 2016, 2019, and 2022 respectively. Water body covered the area of 649800 m<sup>2</sup>, 657000 m<sup>2</sup>, 404947 m<sup>2</sup>, 410900 m<sup>2</sup>, and 425200 m<sup>2</sup> in 2001, 2011, 2016, 2019, and 2022 respectively. Bare land in 2001, 2011, 2016, 2019, and 2022 occupied 693900 m<sup>2</sup>, 1010700 m<sup>2</sup>, 1009800 m<sup>2</sup>, 1610050 m<sup>2</sup>, and 1095000 m<sup>2</sup> respectively. The total area of Runda sector is 50836500 m<sup>2</sup>.

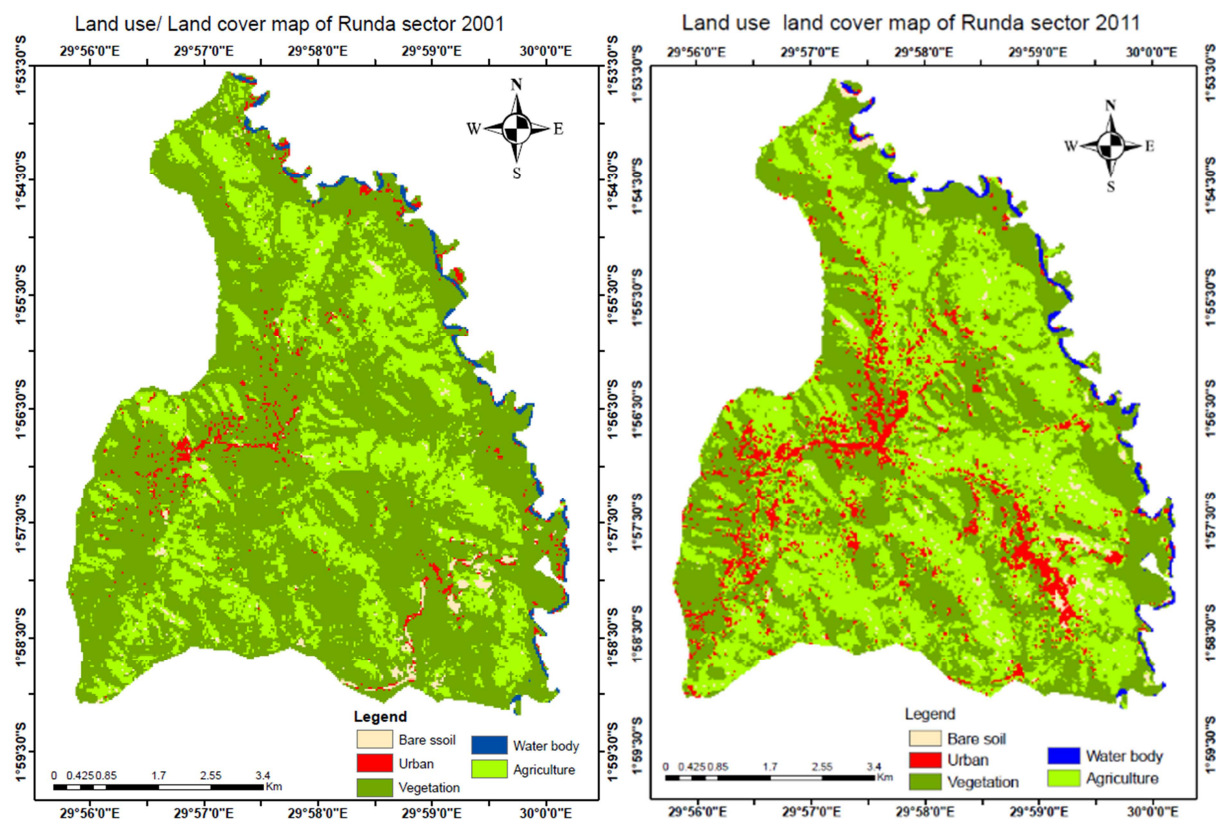


Figure 2. LULC maps of Runda sector, 2001 and 2011.

From 2001 to 2011, urban area increased from 1020600 m<sup>2</sup> to 4060800 m<sup>2</sup>, with increment of 3040200 m<sup>2</sup>. Vegetation decreased from 34664400 m<sup>2</sup> to 22075200 m<sup>2</sup> with decline of 12589200 m<sup>2</sup>. Agriculture increased from 17807800 m<sup>2</sup> to 18032800 m<sup>2</sup>, with increment of 225000 m<sup>2</sup>. Water body increased from 649800 m<sup>2</sup> to 657000 m<sup>2</sup>, with increment of 7200 m<sup>2</sup>, and bare land increased from 693900 m<sup>2</sup> to 1010700 m<sup>2</sup> with increment of 376800 Sq. m.

From 2011 to 2016, urban area increased from 4060800 m<sup>2</sup> to 5003580 m<sup>2</sup>, with increment of 942780 m<sup>2</sup>. Vegetation decreased from 27075200 m<sup>2</sup> to 26673039 m<sup>2</sup> with decline of 402161m<sup>2</sup>. Agriculture decreased from 18032800 m<sup>2</sup> to 17745134 m<sup>2</sup>, with decline of 2287666 m<sup>2</sup>. Water body decreased from 657000 m<sup>2</sup> to 404947m<sup>2</sup>, with decline of 252053 m<sup>2</sup>, and bare land decreased from 1010700 m<sup>2</sup> to 1009800 m<sup>2</sup> with reduction of 900 m<sup>2</sup>. Runda has



experienced rapid urban expansion in the last few decades, as demonstrated by the area's demographic changes and

expanding urban landscape as illustrated on the in figure 2, this has been reported in a previous research [1].

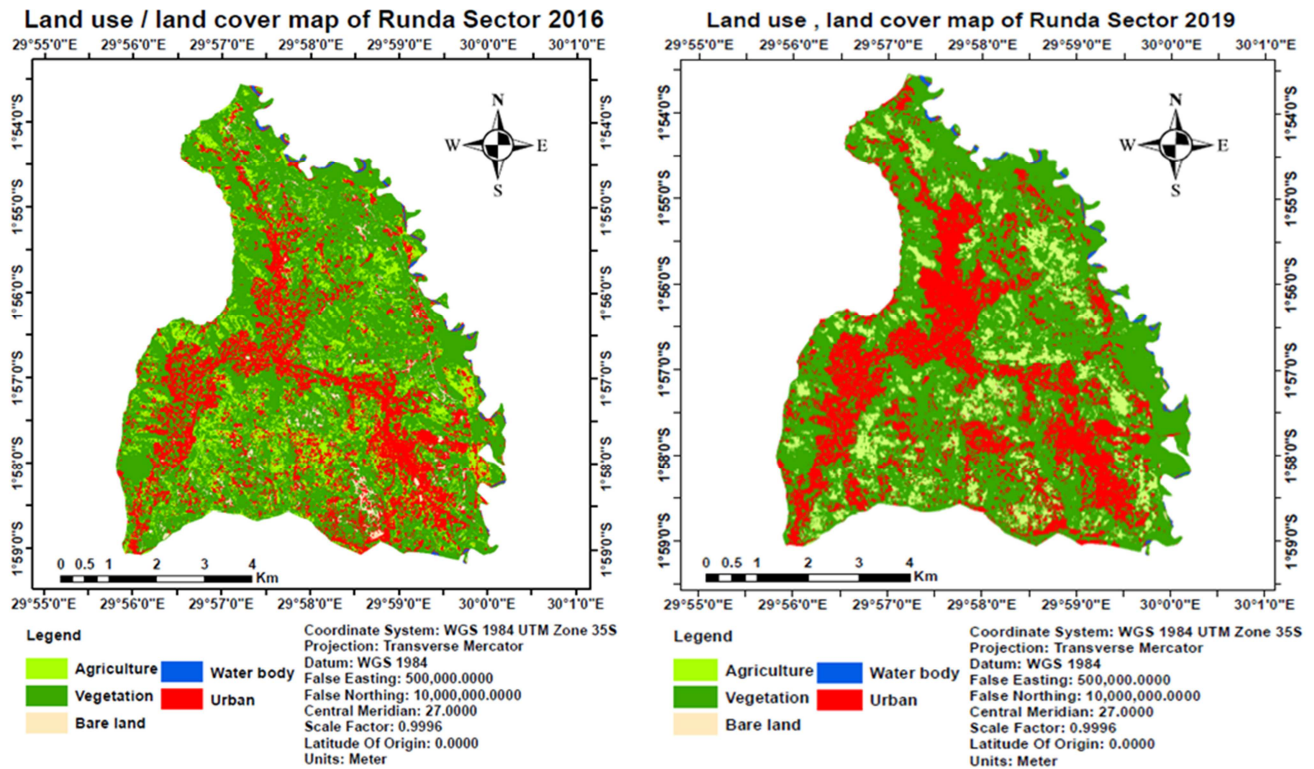


Figure 3. LULC maps of Runda sector, 2016 and 2019, Source: GIS.

As indicated in Figure 3 above, from 2016 to 2019, urban area increased from 5003580 m<sup>2</sup> to 8987621 m<sup>2</sup>, with increment of 3984041 m<sup>2</sup>. During this period, the trend of increasing of urban areas was related to the population growth, Table 1 and figure 3. Vegetation decreased from 26673039 m<sup>2</sup> to 24925528 m<sup>2</sup> with decline of 1747511m<sup>2</sup>, which were suggested to be the conversion of vegetation cover to agricultural area, table 3. Agriculture decreased from 17745134 m<sup>2</sup> to 14902401 m<sup>2</sup>, with decline of 2842733 m<sup>2</sup>. Water body increased from 404947 m<sup>2</sup> to 410900 m<sup>2</sup>, with surplus of 5953 m<sup>2</sup>, and bare land increased from 1009800 m<sup>2</sup> to 1610050 m<sup>2</sup> with surplus of 600250 m<sup>2</sup>.

From 2019 to 2022, urban area increased from 8987621 m<sup>2</sup> to 12376600 m<sup>2</sup>, with increment of 3388979 m<sup>2</sup>. Vegetation decreased from 24925528 m<sup>2</sup> to 23950300 m<sup>2</sup> with decline of 975228 m<sup>2</sup>. Agriculture decreased from 14902401m<sup>2</sup> to 12989400 m<sup>2</sup>, with decline of 1913001 m<sup>2</sup>. Water body increased from 410900 m<sup>2</sup> to 425200 m<sup>2</sup>, with surplus of 14300 m<sup>2</sup>, and bare land decreased from 1610050 m<sup>2</sup> to 1095000 m<sup>2</sup> with reduction in area of 515050 m<sup>2</sup>.

The overall change from 2001 to 2022, urban area increased from 1020600 m<sup>2</sup> to 12376600 m<sup>2</sup>, with increment of 11356000 m<sup>2</sup>. Vegetation decreased from 30664400 m<sup>2</sup> to 23950300 m<sup>2</sup> with decline of 6714100 m<sup>2</sup>. Agriculture decreased from 17807800 m<sup>2</sup> to 12989400 m<sup>2</sup>, with decline of 4818400 m<sup>2</sup>. Water body decreased from 649800 m<sup>2</sup> to 425200 m<sup>2</sup>, with reduction of 224600 m<sup>2</sup>, and bare land increased from 693900 m<sup>2</sup> to 1095000 m<sup>2</sup> with area of

401100 m<sup>2</sup>.

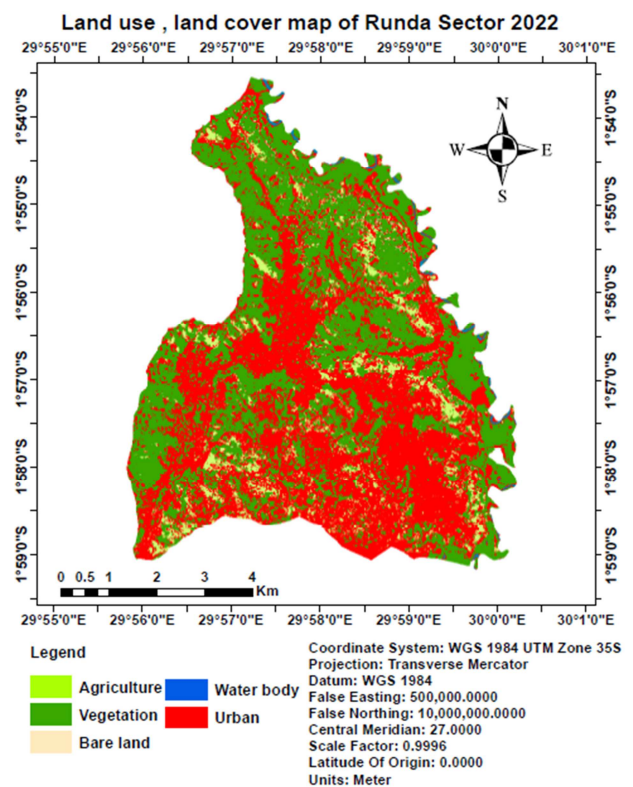


Figure 4. LULC map of Runda sector, 2022.

### 3.2. Agricultural Land Reduction over Time in Runda Sector

The results reveal that there is tremendous augmentation of urban area, where the driving forces for this increment includes immigration of population who moves from Kigali city to Runda sector. Due to high living cost in the city of Kigali, people chose to quit this city and go to live in its

proximity [13]. This causes the population growth in Runda sector, and of course, people need plots of land to build residential and commercial houses. Vegetation area was affected but agricultural area has not been affected as indicated by the results. Other remarkable change was manifested in bare land; this is due to mining and quarrying activities due to well-known good sand exploited from this area.

**Table 1.** Land cover in meter square.

Land cover type	Area in 2001 (m <sup>2</sup> )	Area in 2011 (m <sup>2</sup> )	Area in 2016 (m <sup>2</sup> )	Area in 2019 (m <sup>2</sup> )	Area in 2022 (m <sup>2</sup> )
Urban	1020600	4060800	5003580	8987621	12376600
Vegetation	30664400	27075200	26673039	24925528	23950300
Agriculture	17807800	18032800	17745134	14902401	12989400
Water body	649800	657000	404947	410900	425200
Bare land	693900	1010700	1009800	1610050	1095000
Total Area	50836500	50836500	50836500	50836500	50836500

Source: GIS

Within the period of 2011 to 2022, a remarkable change in urban area continued to manifest. Continuously, people moved from the city of Kigali due to its proximity to the study area. Due to population growth of Runda Sector, and immigrants from its surrounding areas especially Kigali city, the agriculture land have been affected at this period where remarkable reduction prevailed [13]. Vegetation area

continued to reduce due to both agricultural activities and construction of houses and infrastructures facilities.

As shown in Table 2, the areas vegetation and agriculture changed significantly from 2001 to 2022 and of the urban area exhibited an increasing trend, whereas the area of other land use types indicated slight change trend.

**Table 2.** Land cover changes from 2001 to 2022.

Land cover type	Area changes 2001-2011 (m <sup>2</sup> )	Area changes 2011-2016 (m <sup>2</sup> )	Area changes 2016-2019 (m <sup>2</sup> )	Area changes 2019-2022 (m <sup>2</sup> )	Area changes 2001-2022 (m <sup>2</sup> )
Urban	+3040200	+942780	+3984041	+3388979	+11356000
Vegetation	-3589200	-402161	-1747511	-975228	-6714100
Agriculture	+225000	-2287666	-2842733	-1913001	-4818400
Water body	+7200	-252053	+5953	+14300	-224600
Bare land	+316800	-900	+600250	-515050	+401100

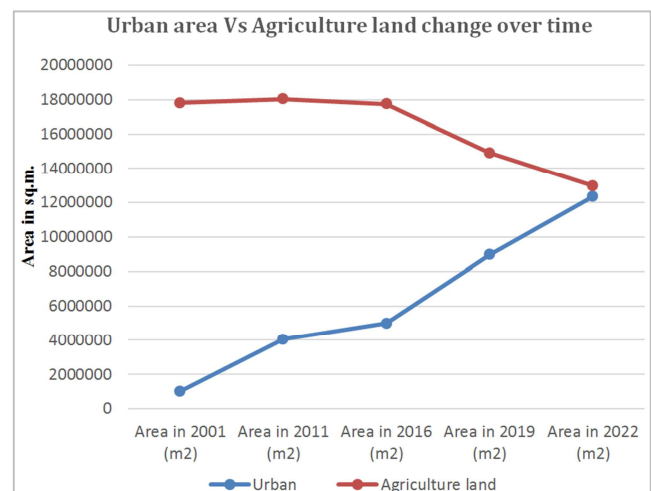
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Within the period of 2011 to 2022, a remarkable change in urban area continued to manifest. Always people moved from the city of Kigali due to its proximity to the study area. Due to population growth of Runda Sector, and immigrants from its surrounding areas especially Kigali city, the agriculture land have been affected at this period where remarkable reduction manifested. Vegetation area continued to reduce due to both agricultural activities and construction of houses and infrastructures facilities.

Moreover, as shown in Table 2, the areas of vegetation and agriculture changed significantly from 2001 to 2022 and of

the urban area exhibited an increasing trend, whereas the area of other land use types indicated slight change trend.

From 2001 to 2022, there has been an aggregated inverse link between urban area and Agriculture area [14] as shows the graph below:



**Figure 5.** Urban area Vs Agriculture area change over time in Runda sector.

### 3.3. Population Growth Pressure on Agricultural Land Reduction over Time in Runda Sector

In order to evaluate the agricultural land reduction over time in the study area, population growth data were used to assess its effects on agricultural land. According to National Institute of Statistics of Rwanda, population of Runda sector was 34839 in 2011, 38,825 in 2016, 42,809 in 2019 and 46565 in 2022. Population data of 2001 were not used in the

analysis because at this time Runda sector was not namely in existence. The population data of 2011, 2016, 2019, and 2022 were considered more important to analyze the impact of population growth on agricultural area reduction over time.

The rapid population growth in Runda triggered numerous challenges, such as agricultural land reduction, loss of biodiversity, excessive deforestation, water shortages, and difficulty in ensuring security from weather-induced disasters [15].

**Table 3.** Population growth pressure on agricultural land reduction over time in Runda sector.

Year	Population	Population growth rate (%)	Agriculture area (m <sup>2</sup> )	Urban area (m <sup>2</sup> )	Urban growth rate (%)
2001	-	-	17,807,800	1,020,600	-
2011	34,839	11.4	18,032,800	4,060,800	297.8
2016	38,825	10.2	17,745,134	5,003,580	23.2
2019	42,809	8.7	14,902,401	8,987,621	37.7
2022	46,565	-	12,989,400	12,376,600	-
2011-2022		33.6			204.78

Table 3 illustrates that in 2011, the population was 34839 with agricultural land of 17807800, in the same year the urban area was 1020600, however, in eleven year from 2011 to 2022, and the population growth rate recorded was 25.18%, which equals to 11726-population count. This was also indicated in term of agricultural areas reduction in eleven year which equals to 5,043,400 m<sup>2</sup>. The Urban area was increased to the rate of 67.18% with an increasing of 8,315,800m<sup>2</sup>. The previous research illustrates that the population growth is the main driver for agricultural areas reduction in rural and urban areas [3].

## 4. Conclusion

With the help of GIS and remote sensing, this study reveals the possibility of analyzing the spatial distribution of land use and land cover without the ultimate need to circle all around the place, visiting the whole site area. Once making a decision about how to utilize and manage land, politicians can gain from integration and utilization of the two most often antagonistic terms, Urbanization and Agriculture.

The research findings surprisingly indicate that, in only as much as 22 years; the agriculture land area is now roughly equal to the urban area as the research findings indicate. With urban expansion holding a positive rate of change, while Agriculture area exhibits a negative rate of change, by expectation; the results of this same study in projected other 20 years would be astonishing.

The reduction in both vegetation area and agricultural land may lead to severe problems in the future if no protective measures are taken. As more as urban expansion reduces the agricultural and vegetation areas, farmland becomes smaller and smaller, which may lead to insufficient crop production to feed the population. In general, we can say that the increment rate of urban expansion leads to and cause the high loss of agriculture and vegetation land. The study primarily recommends the Ministry of Infrastructure, Rwanda Housing Authority, Rwanda Land Use and Management Authority, and Rwanda Environmental Management Authority, to

promote and mobilize vertical construction of residential and commercial buildings in order to save agriculture and green space. The Ministry of agriculture is recommended to train farmers on agronomic practices of modern agriculture to produce high quantity of crop on small land, for the time being; this would limit and save agriculture and vegetation land over-all.

The urbanization policy in Rwanda is a priority because it groups people together and facilitates the provision and distribution of services to the population. Policy makers are urged to take the issue in question into consideration even before the situation could escalate. Planning for a sustainable development implies including all the three aspects of environment, society and economy. Whenever any among the three is left out; this notion can no longer be in existence.

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