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Urban Expansion and Agriculture Land Use Change in Rwanda, 2011-2020

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ABSTRACT
Rwanda's expanding economy and population have resulted in the growth of building settlements area throughout the nation; yet, there has been an uneven trend in the change of agriculture land use in past decades. This study analyzed the impacts of urban expansionon agriculture land use change in Rwanda from 2011 to 2020. We used the Geographical Information System (GIS) to observe and evaluate two maps of different time span on land use and land cover change. The results confirmed a significant change in cropland, grassland. Forestland and wetland and building settlements. To assess the impact of urban expansion on agriculture land use change we used ESA/CCI provided statistics on land use/land cover and a population variable from World Bank. Using STATA a linear regression model have been applied to analyze the impact of population growth and increase in building settlements on outcome variables. The results showed that population growth and increasing building settlement has a significant impact on area change in cropland (R^2= 0.89, P= .0004), grassland (R^2=0.77, P= .0052) forestland (R^2=0.86, P= .0009) and wetland (R^2=0.88, P= .0005). The founding reveal that there is a positive correlation and statistically significant model of 5% confidence level between population growth and increasing building settlement area on outcome variables based on the literature, this explain that urban expansion use encroachment land form agriculture land to expand in the study area. The outcome demonstrated thaturban land expansion is corresponding with a decline in agricultural land use change overall. Generally, the greater the degree of urban expansion, the greater the loss of agricultural land. The adoption of new technologies in expanding our building settlements, to make sure it grows vertically not horizontally.

KEYWORDS: Urban expansion, Agriculture land, land use change, Impact

I. INTRODUCTION

Rwanda's urbanization described by population increase and relocation to urban areas, as well as the resettlement of dislocated people and repatriates following the Tutsi genocide in 1994 (Uwimbabazi, P & Lawrence, R, 2011). The urban residents has grown from 4.6 percent in 1978 to 16.5 percent in 2012 significantly, Vision 2020 plan calls for a 35 percent participation rate by 2020, the average urban density, which was 1,871 people per square kilometer in 2012, has more than quadrupled since 2002(NISR, 2014).

The urban residents is now growing at a 4.1 percent annual rate. Kigali, Rwanda's capital is dwelling to nearly halve of the country's urban residents in 2012(NISR, 2014). Private residence will increase from 2.4 million to 5.3 million. It will triple in cities but only increase by 83 percent in rural areas. The average household size will decrease somewhere, from 4.3 people in 2012 to 3.1 in 2032, with minimal variance across urban and rural regions. Annually, the figure of newly formed residencies will rise steadily, from beyond 94,000 in 2013 to around 198,000 in 2032 (NISR, 2014).

This will result in the rising land pressure in Rwanda and poses a serious danger to the country's population and development. aside from the existing measures targeted at decreasing population growth, the government must implement specific strategies to cope with the inevitable and predictable population, congestion land and, communities, physical infrastructure, and resources would all be put under more strain as the urban population grows(REMA, 2011). This would entail reconsidering urban groundwork and tracking related interferencein the context of rapid increase in population, with a focus on future settlement development, roads, transportation networks, electricity supply, water, health and educational facilities, and other essential community facilities that are all available, as

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appropriate(Bibri, S. E., Krogstie, J., & Kärrholm, M., 2020).

Nevertheless, measures exists, the future of Rwanda is jeopardized by an abnormally high frequency of urban expansion, which have a severe impacts on agriculture land use change(RLMA, 2017). Rwanda, in fact, has one of the topmost population densities in Africa; urban enlargement on agricultural land is associated with a decrease in agricultural land as well as an increase in urban development. The former indicates increased off-farm employment opportunities, whereas the latter indicates increased land pressure(Nishimwe Grace, et al., 2020).

Change of land usage is anticipated to be triggered by residential expansion and land scarcity caused by a decrease in agricultural land. Later researchers expanded on the notion, claiming that other factors of demand like consumer diets and wealth might affect the change of agricultural land usage (Haberl, 2015).

The growth of an urban area entails covering the earth with artificial surfaces and includes all areas of development such as construction, roads, recreation parks, water supplies, and so forth, all of these factors are based on the accumulation of land, primarily land utilized for agricultural purposes(Nduwayezu, G., Sliuzas, R., & Kuffer, M., 2016). Despite the fact that agriculture is critical to human growth, urban expansion should be closely managed to ensure that it does not disrupt the agricultural production system, which might result in food shortages and ecosystem collapse (RLMA, 2017).

Rwanda's urban expansion status confronts by difficulties of demographic growth and economic development. Growing informal settlements, Increasing environmental deterioration, lack of integrated resource planning across sector Ministries, Departments, and Agencies, weak urban governance and institutional coordination, limited data and information on urban areas,weak urban economy, inefficient land-use, master plan abuse, and. Others like inadequate urban services, urban poverty, growing informal settlements,and inadequate urban pull factors,weak rural-urban linkages, and inadequacies in urban governance are some of these problems(MININFRA, 2015).

As one of Africa's fastest-growing economies, Rwanda's urbanization must provide not consumption alone, but alsodomestic growth through job creation, commercial and industrial production, and environmental resource protection, this provides opportunities for sustained and intensified growth, as well as a better standard of comfort living in for the booming population(REMA, 2011).The density of Rwanda population in a limited territory with rough topography and subsistence agriculture, being the most common mode of lucrative activity, poses a physical, social, and economic difficulty to long-term development; these problems highlight the areas to consider when adjusting changing, coordination, densification, conviviality, and economic growth (UNIDO, 2020).

II. SURVEY DESIGN AND DATA

2.1. Description of study area

Rwanda is an equatorial landlocked country with a land surface area of approximately 26,338 square kilometers, positioned in middle of 1°-3° south latitude and 28°-31° east longitude(RNRA, 2022). The nation's boundary are formed by Uganda in the north, Burundi in the south, Tanzania in the east, and the Democratic Republic of the Congo (DRC) in the west. Rwanda has a mountainous terrain, withelevations ranging from920to 4495 meters.

Figure 1. Map of the study area: Rwanda administrative districts and elevation.

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The climate in the country is humid temperate, with mean air temperatures varying from 16 to 20 degrees Celsius. (Twagiramungu, 2006) , Every year, there are two pluvial seasons (March-May and September-December) and two arid seasons (January-February and June-August). Long-term annual rainfall intensity ranges from 805 mm to 1725 mm, with an average mean of 1116mm/year from 1900 to 2016.(Karamage, et al., 2017). Rwanda is divided into 30 administrative districts.

2.2. Research design and data collection

We performed a critical evaluation of the literature for this study in attempt to build a theoretical framework for better comprehension and tracking the current research gap that was filled by the findings.

This research consisted of using secondary data related cropland, grassland, forestland, wetland, and building settlements area variation around. The data were collected from ESA/CCI and we added the population variable, which was collected at WORLDBANK open data. After we analyzed those data by using Geographic Information System (GIS) to produce maps of LU/LC changes. Statistical Software for Data Science (STATA) was used to perform the linear regression model between dependent and independent variables.

2.3. Framework of analysis

Following the collection of the above data, the researcher using STATA. Performed a multiple linear regression analysis of population and settlements on cropland, grassland, forestland and wetland respectively; then we assessed if our model were statistically significant by comparing the p values obtained with the standard error we used which is 95%. The obtained p value must be less than the standard error.

After that, we were able to analyze the contribution of urban enlargement on agriculture land use in Rwanda using STATA. This approach is based on the assumption that if the R^2 value obtained from regression analysis is larger than 0.5 or 50%, the correlation between the dependent and explanatory variables is extremely strong. Spatial data of land use/land cover was manipulated utilizing a Geographic Information System (GIS) tool, and this tool aided in the creation of maps depicting the change land use/ land cover from 2011 to 2020.

III. RESULTS AND DISCUSSIONS

3.1. Results presentation

Comparing Figure 2 and 3. I have observed that there is a notable change in land use of Rwanda from 2011 to 2019. More agriculture land have been transformed into artificial building settlements and infrastructures. Capital city of KIGALI has experienced more change in settlement, as have those district's secondary cities, which is RUBAVU, MUSANZE, HUYE, RUSIZI, RWAMAGANA and NYAGATARE. As well as other places that experience changes include KAYONZA, BUGESERA, GICUMBI, NYANZA and MUHANGA Districts, and part of KAMONYI because it is close to the capital city of Kigali.

In a developing nation like RWANDA, there is a need for infrastructure to support the expanding economy, which necessitates the transformation of more land into artificial surfaces. A growing population also means that there are more household moving created and needing a place to live, which necessitates the transformation of more land into building settlement.

Figure 2. Rwanda land use/land cover in 2011.

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Figure 3. Rwanda land use/land cover in 2020.

Figure 4.The population of Rwanda is dispersed throughout the country's districts. You can see a relatively high population density in the capital city of Kigali as well as secondary cities like RUBAVU and RUSIZI that are located close to the DR Congo border.Additionally, nearly every district's city center, such as MUSANZE, MUHANGA, HUYE, KAYONZA, etc…, has a higher density. You can also see the moderate density outside of those cities, for instance:Ruyenzi area in the KAMONYI District. The rest of the country has a very low and low density.

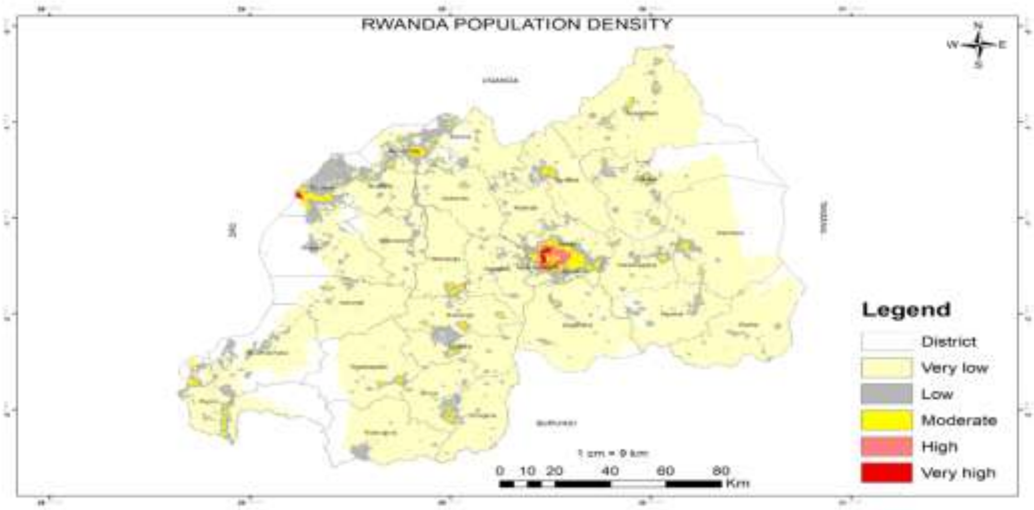

Figure 4. Map of population density in RWANDA.

As a result, Figure 5. Every year from 2011 to 2020, Rwanda's population increased, going from 10 039 338 to 12 952 209 people respectively. Over the course of these ten years, Rwanda's population continue to grow every year. There isn't a single year that Rwanda population did not increased.

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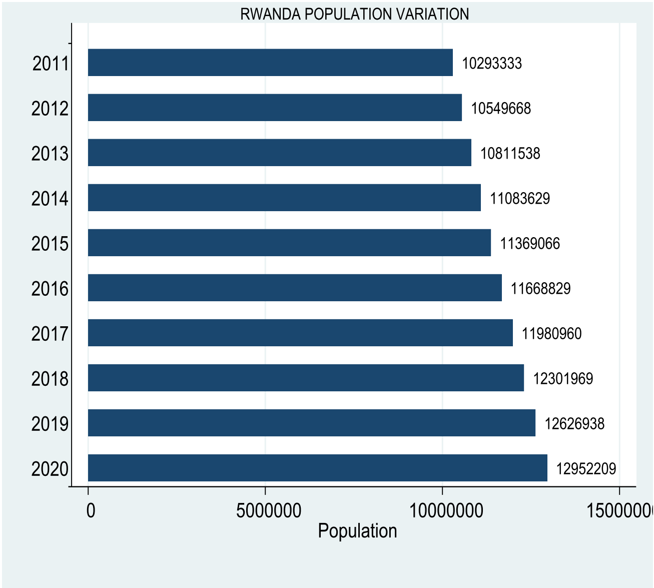

Figure 5. Rwanda population from 2011 to 2020.

Source: WORLDBANK. (2022)

Figure 6. Between 2011 and 2020, Rwanda's settlement went from 11 116 hectares to 18 170 hectares. The transformation of land use into artificial places during a ten-year period has undergone tremendous change. It slopes upward linearly. Due to the increase in Rwandan population, the Rwanda settlement will continue to expand.

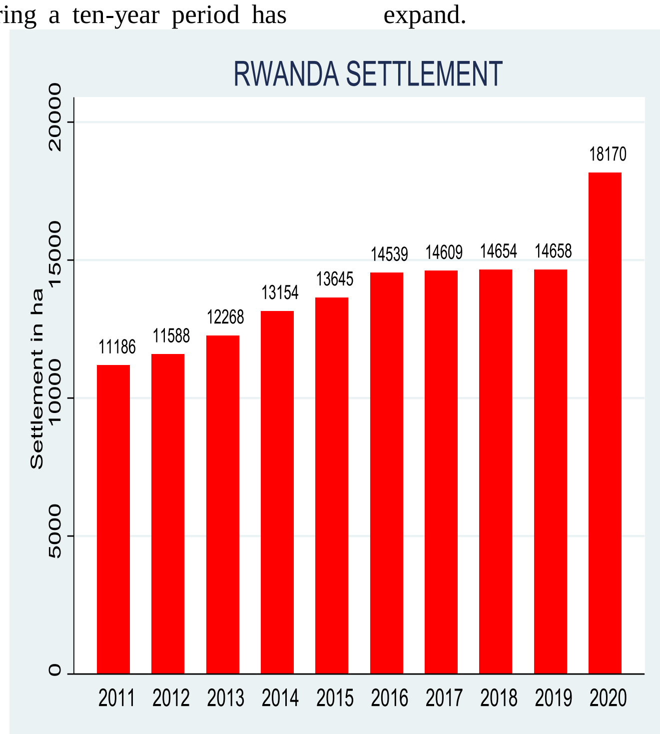

Figure 6. Rwanda settlement from 2011 to 2020.

Source: ESA/CCI. (2022)

From 2011 to 2020.In order to more clearly illustrate the observed changes, the researcher examined the cropland, grassland, forestland, and wetland in relation to each year of observation.

Figure 7. Between 2011 and 2015, Rwanda Cropland decreased yearly going from1 753 968 ha

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to 1 753 027 ha respectively. Then from 2015, It decreased dramatically to 1 726 561 ha in 2016. After 2016, Rwanda cropland continue to decrease every year to reach 1 708 861 ha in 2020.

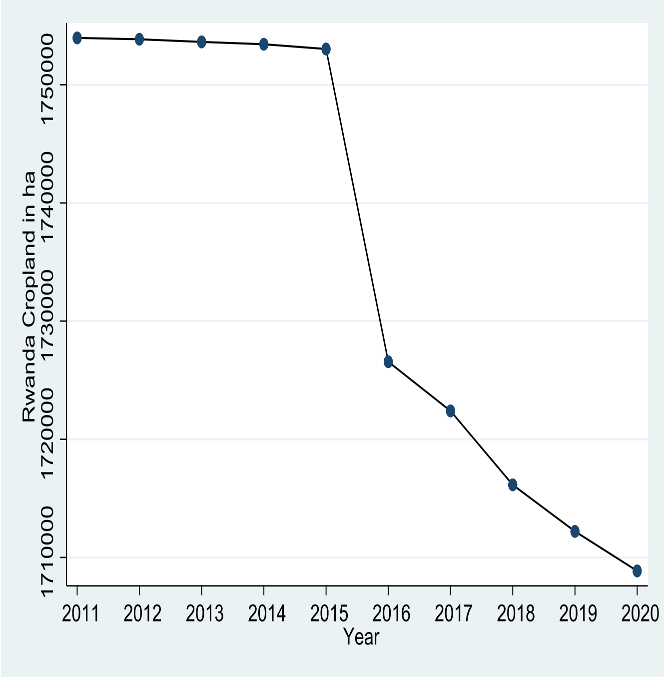

Figure 7. Rwanda cropland from 2011 to 2020

Source: ESA/CCI. (2022)

Figure 8.In a period of 10 years, Rwanda grassland have experienced transitional transformation between 2011 and 2015, Rwanda's grassland decreased from 153 586 ha to 153 327 ha respectively, after 2015, itdecreased significantly until 2017 at 152 494 ha. After that in 2018 it increased to 152 797 ha to fall again in 2020 at 152 539 ha.

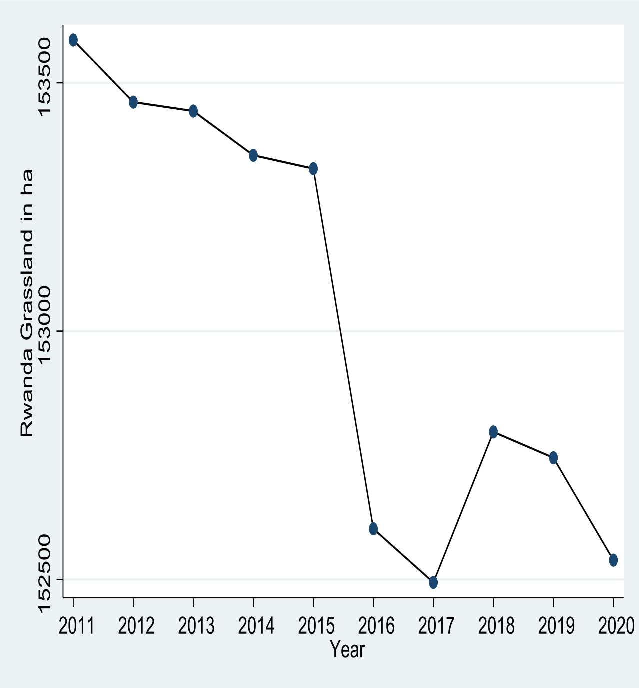

Figure 8. Rwanda grassland from 2011 to 2020

Source: ESA/CCI. (2022)

Figure 9. shows that in general, Rwanda's forestland has grown in period of 10 years. From 2011 to 2015 forestland had decreased from 378 103 ha to 376 514 ha respectively, although prior to 2015, it had grown at a significant level every year, from 2016 to 2020, it increased from 403 916 ha to 417 809 ha respectively. The increase happened on planted forest other than the protected forest like Nyungwe national park

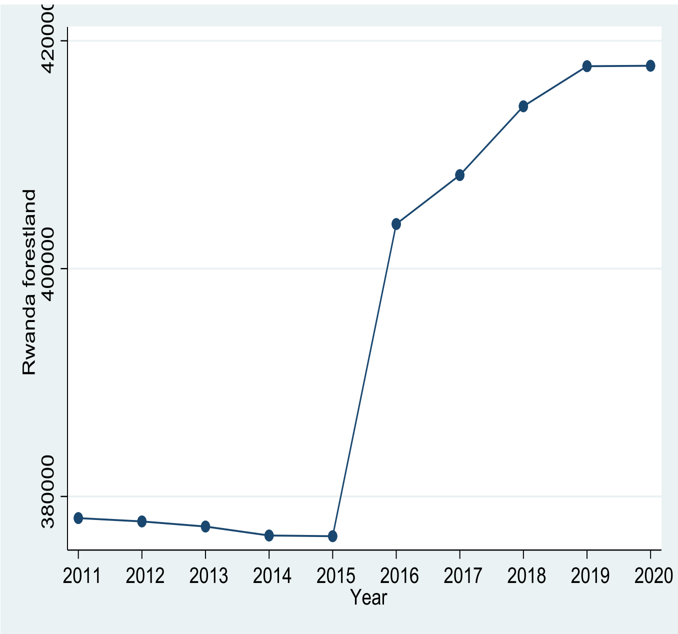

Figure 9. Rwanda forestland from 2011 to 2020

Source: ESA/CCI. (2022)

Figure 10. Illustrates how Rwanda's wetland area has dropped overall over the period of ten years; specifically, it shows how the wetland area decreased from 82 569 ha to 82 444 ha between 2011 and 2015. It continued to significantly decrease after 2015, fluctuating from 81 318 hectares in 2016 to 81 116 ha in 2018, before decrease once more to 79 847 ha in 2019 where it remained constant in 2020 as well.

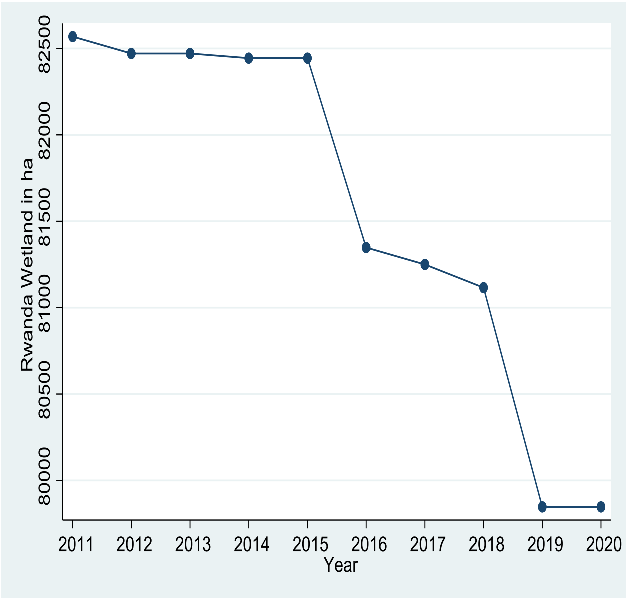

Figure 10. Rwanda wetland form 2011 to 2020.

Source: ESA/CCI. (2022)

Additionally, the researcher examined the annual change with reference to the mentioned variables in order to more clearly illustrate the recorded changes in agriculture land use change (cropland, grassland, forestland and wetland) shift due to urban expansion (population and settlement). The findings in Table 1. Demonstrated that each variable that employed experiences a yearly change.

Table 1. Variation of urban expansion (population and settlement) and trend of agriculture land use (cropland, grassland, forestland and wetland) 2011 to 2020.

Year	Population	Settlement in hectares	Cropland in hectares	Grassland in hectares	Forestland in hectares	Wetland in hectares
2011	10293333	11186	1753968	153586	378103	82569
2012	10549668	11588	1753851	153461	377810	82471
2013	10811538	12268	1753627	153443	377363	82471
2014	11083629	13154	1753429	153354	376576	82444
2015	11369066	13645	1753027	153327	376514	82444
2016	11668829	14539	1726561	152602	403916	81348
2017	11980960	14609	1722400	152494	408211	81250
2018	12301969	14654	1716145	152797	414252	81116
2019	12626938	14658	1712208	152745	417770	79847
2020	12952209	18170	1708861	152539	417809	79847

Source: WORLDBANK (2022), ESA/CCI (2022).

4.2. Linear regression analysis

We used a linear regression analysis. We employed the findings to indicate the extent to which an increase in population and settlement have consequences on cropland, grassland, forestland and wetland in Rwanda. In order to fulfill the research's third objective, which was to analyze the impact of urban expansion on agriculture land use in Rwanda.

The regression analysis result in Table 2. With the findings between population and settlement on cropland of Rwanda, the multiple linear regression analysis show a strong correlation, with a very high R^2= 0.89 or 89%. At a significance of 5% of confidence level, the model is judged statistically significant with theP= .0004 observed is less than 0.05. Rwanda's cropland change do depend on population growth and settlement between 2011 and 2020.

Table 2. Regression of cropland with population and settlement.

Source	SS	df	MS
Model	3.1275e+09	2	1.5638e+09
Residual	385753887	7	55107698.1
Total	3.5133e+09	9	390362140

Number of obs	=	10
F(2, 7)	=	28.38
Prob > F	=	0.0004
R-squared	=	0.8902
Adj R-squared	=	0.8588
Root MSE	=	7423.5

cropland	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
population	-.0251802	.0074583	-3.38	0.012	-.0428163	-.007544
settlement	2.172015	3.338638	0.65	0.536	-5.722609	10.06664
_cons	1996511	46588.08	42.85	0.000	1886347	2106674

Y_1= 1996511 -0.025 X_1 + 2.17 X_2 +
Where: Y_1 = Cropland,
X_1= Population,
X_2= Settlement,
 = Error.

The multiple linear regression equation of population and settlement on Rwanda’s cropland is Y_1= 1996511 -0.025 X_1 + 2.17 X_2 + . This equation implied that, if one unit of population increased that will lead to a decrease of 0.025 in Rwanda’s cropland if other variables remain constant. In other hand, an increase of one unit of settlement will increase 2.17 unit of Rwanda’s cropland if other variables remains constant.

The regression analysis result in Table 3. With the regards between population and settlement on grassland of Rwanda, the multiple linear regression analysis show a strong correlation, with a very high R^2= 0.77 or 77%. At a significance of 5% of confidence level, the model is judged statistically significant with theP= .0052 observed is less than 0.05. Rwanda's grassland change do depend on population growth and settlement between 2011 and 2020.

Table 3. Regression of grassland with population and settlement.

Source	SS	df	MS			
				Number of obs	=	10
				F(2, 7)	=	12.23
Model	1326066.6	2	663033.299	Prob > F	=	0.0052
Residual	379429.003	7	54204.1432	R-squared	=	0.7775
				Adj R-squared	=	0.7140
Total	1705495.6	9	189499.511	Root MSE	=	232.82

grassland	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
population	-.0003353	.0002339	-1.43	0.195	-.0008884	.0002178
settlement	-.0435574	.1047079	-0.42	0.690	-.2911522	.2040374
_cons	157515.3	1461.117	107.80	0.000	154060.3	160970.3

Y_2= 157515 -0.0003 X_1 - 0.043 X_2 +
Where: Y_1 = Grassland,
X_1= Population,
X_2= Settlement,
 = Error.

The multiple linear regression equation of population and settlement on Rwanda’s grassland isY_2= 157515 -0.0003 X_1 -0.043 X_2 + . This equation implied that, if one unit of population increased that will lead to no change because 0.0003 is equal to zero in Rwanda’s grassland if other variables remains constant. In other hand, an increase of one unit of settlement will decrease 0.043 unit of Rwanda’s grassland if other variables remains constant.

The regression analysis result in Table 4. With the findings between population and settlement on forestland of Rwanda, the multiple linear regression analysis show a strong correlation, with a very high R^2= 0.86 or 86%. At a significance of 5% of confidence level, the model is judged statistically significant with theP= .0009 observed is less than 0.05. Rwanda's forestland change do depend on population growth and settlement between 2011 and 2020.

Table 4. Regression of forestland with population and settlement.

Source	SS	df	MS			
				Number of obs	=	10
				F(2, 7)	=	22.13
Model	2.7944e+09	2	1.3972e+09	Prob > F	=	0.0009
Residual	441902669	7	63128952.7	R-squared	=	0.8635
				Adj R-squared	=	0.8244
Total	3.2364e+09	9	359594668	Root MSE	=	7945.4

forestland	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
population	.0261657	.0079827	3.28	0.014	.0072896	.0450417
settlement	-3.244903	3.573365	-0.91	0.394	-11.69457	5.204764
_cons	137190.2	49863.52	2.75	0.028	19281.67	255098.7

Y_3= 137190.2 +0.026 X_1 - 3.24 X_2 + □
Where: Y_3 = Forestland,
X_1= Population,
X_2= Settlement,
□ = Error.

The multiple linear regression equation of population and settlement on Rwanda's forestland isY_3= 137190.2 +0.026 X_1 - 3.24 X_2 + □. This equation implied that, if one unit of population increased that will lead to an increase of 0.026 in Rwanda's forestland if other variables remains constant. In other hand, an increase of one unit of settlement will decrease 3.24 unit of Rwanda's forestland if other variables remains constant.

The regression analysis result in Table 5. With the findings between population and settlement on wetland of Rwanda, the multiple linear regression analysis show a strong correlation, with a very high R^2= 0.88 or 88%. At a significance of 5% of confidence level, the model is judged statistically significant with theP= .0005 observed is less than 0.05. Rwanda's wetland change do depend on population growth and settlement between 2011 and 2020.

Table 5. Regression of wetland with population and settlement.

Source	SS	df	MS			
				Number of obs	=	10
				F(2, 7)	=	26.38
Model	9220367.12	2	4610183.56	Prob > F	=	0.0005
Residual	1223100.98	7	174728.712	R-squared	=	0.8829
				Adj R-squared	=	0.8494
Total	10443468.1	9	1160385.34	Root MSE	=	418.01

wetland	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
population	-.0013113	.00042	-3.12	0.017	-.0023044	-.0003182
settlement	.0901647	.1879946	0.48	0.646	-.3543718	.5347012
_cons	95495.89	2623.317	36.40	0.000	89292.73	101699

Y_4= 95495.89 -0.001 X_1 + 0.09 X_2 + □
Where: Y_4 =Wetland,
X_1= Population,
X_2= Settlement,
□ = Error.

The multiple linear regression equation of population and settlement on Rwanda's wetland is Y_4= 95495.89 -0.001 X_1 + 0.09 X_2 + Error. This equation implied that, if one unit of population increased that would lead to a no change because 0.0001 is almost zero in Rwanda's wetland if other variables remains constant. In other hand, an increase of one unit of settlement will increase 0.09 unit of Rwanda's wetland if other variables remains constant.

We combined linear regression analysis between variations on urban expansion (population and settlement) with trend of agriculture land use change (cropland, grassland, forestland and wetland) in Rwanda. The analysis shows a statistically significant (positive) relationship between population and settlement variation on cropland change with the correlation R^2=0.89 or 89% with the p= .0004 less than 0.05. In the other hand showed a statistically significant (positive) relationship between variation of population and settlement on grassland change with the correlation R^2= 0.77 or 77% with the p= .0052 less than 0.05. Then the analysis between the variation of population and settlement on forestland change has also a significant (positive) correlation R^2=0.86 or 86% with the p= .0009 less than 0.05. Lastly the correlation analysis of variation of population and settlement on wetland change shows the positive relationship with the R^2=0.88 or 88% with the p= .0005 less than 0.05.

3.2. Discussion

Urban expansion aggregate in a continuing decline of agricultural land, both straight and circumstantial through land encroachment and by farming land for rural non-productive activities such as horse keeping, recreation, or hobby farming(Veronique, B., et al., 2020). These urbanization activities put farmers under strain, making farming more hard due to decreasing agricultural area, negative expanse, and rivalry for land(FAO, 2017).

Urban expansion has reduced agricultural land available, which has had a significant impact

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on farmers, who are sometimes stay with little or no land to cultivate, increasing their vulnerability(Assefa, A.,& Tarekegn, K., 2020). Attributableto a lack of government intervention to the tendency of informal settlement expansion, housing encroachments have been noted to be uncontrolled. Because major urbanization accompanying the agricultural land reduction has a positive link along production drop(MININFRA, 2018).

Since the 1990s, Rwanda has experienced rapid growth in population and economic development, resulting in dramatic changes in the country's land use and land cover pattern, Rwanda is heavily reliant on rain-fed agriculture, making agricultural production and food security at risk to changes in precipitation(Karamage, et al., 2017).

Recognizing the foregoing, we undertook a study on how urban expansion affects the agriculture land use change in Rwanda. The study used secondary data on population, settlement area, cropland, grassland, forestland and wetland in Rwanda between 2011 and 2020.Figure 5 and 6, the data shows that Rwanda urban expansion (population and settlement area) continue to increase over years. In that period Rwandan population rose from 10293333 to12952209, similar to settlement are that increased from11186 ha to 18170 ha. In the other hand, the Rwanda agriculture land (cropland, grassland, and wetland) decreased significantly. Figure 7, 8, 10. The data show a significant decrease in cropland it decreased from 1753968 ha to 1708861 ha, also in grassland from 153586 ha to152539 ha, and wetland dropped from 82569 ha to 79847 ha. An exception in Figure 9, occurred in forestland which increased in that period from378103 ha to 417809 ha, but overall the Rwanda agriculture land use diminished.

Recent studies (Jiang, L., Deng, X., && Seto, K. C. , 2013)(Khan S., 2019)(Karamage, et al., 2017)on the consequences of urban expansion on agriculture land use change specify that agriculture land use will likely decrease or be harmed as a result of urban expansion. This is due to the fact that countries land doesn't change that implies agriculture land use change depend on change in urban expansion, but other factors such as economic growth, behavior change, technology, and so on may also contribute to agriculture land use change.

This confirmsby the results in Tables 2, 3, 4, and 5. Which demonstrated a linear relationship between population and settlement with cropland with correlations(R^2=0.89 or 89% with p= .0004) on the grassland with (R^2=0.77 or 77%with p= .0052), on the forestland with (R^2=0.86 or 89% with p= .0009), and finally on the wetland with (R^2=0.88 or 89% with p= .0005). This conclude that agriculture land use change depend on urban expansion.

IV. CONCLUSION

This study was carried out to determine the pressure of urban expansion on Rwanda's agricultural land use change. According to this study, there has been a compellingchange in land usage and land cover in Rwanda from 2011 to 2020.Urban expansion have intensified agriculture land use change due to encroachment especially that of new residential development in to the whole country. The study used a multiple linear regression models to explore the dominance of urban enlargement (population and settlement) on agricultural land use change (cropland, grassland, forestland and wetland). The outcome demonstrated thaturban land expansion is corresponding with a decline in agricultural land use change overall.

According to data we had Rwanda's settlement area grows 6 984 ha in only a period of 10 years, similar to the Rwandan population which grows 2658876 people which is approximately 2.5% every year. We had seen that according to results obtained after using linear regression model, there is higher chance that population and settlement affect the agriculture land use change in Rwanda. Rwanda cropland decreased by 45 107 ha, the grassland by 1 047 ha, wetland by 2722 ha, at the exception of forestland which increased by 39 706 ha from 2011 to 2020. Overall Rwanda's agricultural land have decreased significantly due to rapid population growth that lead to an increase in building settlement area.

Generally, the greater the degree of urban expansion, the greater the loss of agricultural land.

Policy implication

- Adoption of new technologies in expanding our building settlements, make sure it grows vertically not horizontally,
- It is advised that the government should monitor and enforce laws to tackle informal settlement. And encourage social behavior change to tackle the demographic problem,
- It is important to ensure that the urban expansion (population and settlement) provide off-farm activities and job creation in order to adapt appropriately on its rapid growth,
- Since agriculture land use change reveals its impact food production, we should adapt modern agriculture practices like the introduction of irrigation system, monoculture,

improved seeds, chemical pest control, mechanization, resilient crops, etc… to increasing the food production,

- More community mobilization to preserve natural resources like farmland ,recreation area, protected areas, etc… to promote environmental awareness,

REFERENCES

[1]. Assefa, A., & Tarekegn, K. (2020). The impact of urbanization expansion on agricultural land in Ethiopia: A review,Environmental & Socio-economic Studies, 8(4), 73-80.

[2]. Avis, W. R. (2016). Urban Governance (Topic Guide). Birmingham, UK: GSDRC, University of Birmingham.

[3]. Biallas, M., & Fook, A. (2016). IFC Mobile Money Scoping. Country Report: Rwanda. International Finance Corporation (IFC). World Bank Group.

[4]. Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. Developments in the Built Environment, 4, 100021.

[5]. Combridge. (2022). impact. Retrieved from https://dictionary.cambridge.org/dictionary/english/impact.

[6]. Diao, X., Randriamamonjy, J., & Thurlow, J. (2017). Urbanization and the Future of Economic Development in Rwanda. Washington, DC: International Food Policy Research Institute,Washington, DC. Background paper for Future Drivers of Growth in Rwanda.

[7]. Ellis, C. E., Kaplan, O. J., Fuller, Q. D., Vavrus, S., Goldewijk, K. K., & Verburg , H. P. (2013). Used planet: a global history. Proceedings of the National Academy of Sciences USA, 110, 7978–7985.

[8]. FAO. (2016). Boosting Africa's Soils. Food and Agriculture Organization of the United Nations.

[9]. FAO. (2017). The future of food and agriculture – Trends and challenges. Rome: MINISTRY OF INFRASTRUCTURE.

[10]. Faridatul, M., Adnan, S. M., & Dewan, A. (2022). Nexus of Urbanization and Changes in Agricultural Land in Bangladesh. 10.1007/978-3-030-92365-5_26.

[11]. Gardi, C., Florczyk, A. J., & Scalenghe, R. (2021). Outlook from the soil perspective of urban expansion and food security. Heliyon, 7(1), e05860.

[12]. Güneralp, B., Lwasa, S., Masundire, H., Parnell, S., & Seto, K. C. (2017). Urbanization in Africa: challenges and opportunities for conservation.

[13]. Haberl, H. (2015). Competition for land: A sociometabolic perspective. Ecological Economics, 119, 424-431.

[14]. Heilig, K. G. (2012). World urbanization prospects: the 2011 revision. United Nations, Department of Economic and Social Affairs (DESA), Population Division, Population Estimates and Projections Section,New York, 14, 555.

[15]. Hitayezu, P., Rajashekar, A., & Stoelinga, D. (2018). The dynamics of unplanned settlements in the City of Kigali. Final Report. C-38312-RWA-1, International Growth Centre.

[16]. Hommann, K., & Lall, S. V. (2019). Which Way to Livable and Productive Cities? : A Road Map for Sub-Saharan Africa (English). International Development in Focus; Washington, DC: World Bank.

[17]. Jaganyi, D., Njunwa, K., Nzayirambaho, M., Rutayisire, C., Manirakiza, V., Nsabimana, A., .Nduwayezu, G. (2018). Rwanda: National Urban Policies and City Profiles for Kigali and Huye. GCRF Centre for Sustainable, Healthy and Learning Cities and Neighbourhoods (SHLC)/ University of Rwanda.

[18]. Jiang, L., Deng, X., && Seto, K. C. . (2013). The impact of urban expansion on agricultural land use intensity in China. Land use policy, 35, 33-39.

[19]. Jianga, L., Deng, X., & Seto, K. C. (2013). The impact of urban expansion on agricultural land use intensity in China. Land use policy, 35, 33-39.

[20]. Karamage, F., Chi Zhang, Xia Fang, Tong Liu, Felix Ndayisaba , Lamek Nahayo, Jean Baptiste Nsengiyumva. (2017). Modeling Rainfall-Runoff Response to Land Use and Land Cover Change in Rwanda (1990–2016). MDPI, Water 2017, 9, 147.

[21]. Karamage, F., Shao, H., Ndayisaba, F., Nahayo, L., Kayiranga, A., & Zhang, C. (2016). Deforestation Effects on Soil

Erosion in the Lake Kivu Basin, D.R. Congo-Rwanda. Forest, 7(11), 281.
[22]. Karamage, F., Zhang, C., Fang, X., Liu, T., Ndayisaba, F., Nahayo, L., . . . Nsengiyumva, B. J. (2017). Modeling Rainfall-Runoff Response to Land Use and Land Cover Change in Rwanda (1990–2016). MDPI, Water 2017, 9, 147.
[23]. Khan S. (2019). The impact of urban expansion on agricultural land use changes in Aligarh, Uttar Pradesh, India. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 42, 381-384.
[24]. Lall, V. S., Henderson, V. J., & Venables, J. A. (2017). Africa's Cities: Opening Doors to the World. World Bank Group.
[25]. Lasisi, M., Popoola, A., Adediji, A., Adedeji, O., & Babalola, K. (2017). City expansion and agricultural land loss within the peri-urban area of Osun State, Nigeria. Ghana Journal of Geography, 9(3), 132-163.
[26]. Li, C., Yang, M., Li, z., & Wang, B. (2021). How Will Rwandan Land Use/Land Cover Change under High Population Pressure and Changing Climate? Applied Science, 11(12), 5376.
[27]. McGrane, S. J. (2016). Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: a review. Hydrological Sciences Journal, 61(13), 2295-2311.
[28]. Miklyaev, M., Jenkins, G., & Shobowale, D. (2020). Sustainability of agricultural crop policies in rwanda: an integrated cost–benefit analysis. Sustainability, 13(1), 48.
[29]. MINAGRI. (2022). ANNUAL REPORT 2020-2021. Kigali: MINISTRY OF AGRICULTURE AND ANIMAL RESOURCES.
[30]. MINALOC. (2013). Economic Developmnet and Poverty Reduction Strategy II. Kigali: Ministry of local governance.
[31]. Mind'je, R., Li, L., Amanambu, A. C., Nahayo, L., Nsengiyumva, B. J., Gasirabo, A., & Mindje, M. (2019). Flood susceptibility modeling and hazard perception in Rwanda. International journal of disaster risk reduction, 38, 101211.
[32]. MININFRA. (2013). Urbanisation and Rural Settlement Sector: Strategic Plan 2013-2018. Ministry of Infrastructure, Republic of Rwanda.
[33]. MININFRA. (2013). Urbanisation and Rural Settlement Sector: Strategic Plan 2013-2018. Ministry of Infrastructure, Republic of Rwanda.
[34]. MININFRA. (2015). NATIONAL URBANIZATION POLICY. KIGALI: MINISTRY OF INFRASTRUCTURE.
[35]. MININFRA. (2018). URBANISATION & RURAL SETTLEMENT. Kkigali: MINISTRY OF INFRASTRUCTURE.
[36]. Mohajan, H. (2017). Two criteria for good measurements in research: Validity and reliability. Annals of Spiru Haret University Economics Series, (4).
[37]. Muhire, I., & Ahmed, F. (2015). Spatiotemporal trends in mean temperatures and aridity index over Rwanda. Theor Appl Climatol, 123, 399–414.
[38]. Nabalamba, A., & Sennoga, E. (2014). Analysis of Gender and Youth Employment in Rwanda. ESTA & RWFO. May 2014. Tunis: African Development Bank (AfDB).
[39]. Nduwayezu, G., Sliuzas, R., & Kuffer, M. (2016). Modeling urban growth in Kigali city Rwanda. Rwanda journa, 1.
[40]. Neumann, K., Verburg, H. P., Stehfest, E., & Müller, C. (2010). The yield gap of global grain production: A spatial analysis. Agricultural Systems, 103, 316-326.
[41]. Nishimwe Grace, Rugema, M. D., Uwera , C., Graveland, C., Stage, J., Munyawera , S., & Ngabirame, G. (2020). Natural Capital Accounting for Land in Rwanda. MDPI.
[42]. NISR. (2014). Fourth Population and Housing Census, Rwanda,. Kigali: National Institute of Statistics of Rwanda.
[43]. NISR. (2018). Rwanda Labor Force Survey (2018). Kigali: National Institute of Statistics Rwanda, Government of Rwanda,.
[44]. NISR. (2022, march 30). Size of the resident population. Retrieved from www.statistics.gov.rw: https://www.statistics.gov.rw/publication/size-resident-population
[45]. Oecd. (2022). agriculture land. Retrieved from https://data.oecd.org/agrland/agricultural-land.htm

[46]. Paul, B. K., & Rashid, H. (2016). Chapter Six - Land Use Change and Coastal Management. Non-Structural and Structural Solutions.
[47]. Popkin, M. B. (2017). Relationship between shifts in food system. Nutrition Reviews, 75, 73-82.
[48]. REMA. (2010). Agriculture and Land Degradation. Rwanda Environmental Management Authority.
[49]. REMA. (2011). Green Growth and Climate Resilience. Kigali: RWANDA ENVIRONMENTAL MANAGEMENT AUTHORITY.
[50]. RLMA. (2017). Rwanda National Land Use Planiing Guidelines. Kigali: RWANDA LAND MANAGEMENT AND USE AUTHORITY.
[51]. RNRA. (2022, march 30). National Land Use Planning Portal. Administrative. Retrieved from rwandalanduse.rnra.rw.
[52]. Siebert, A., Dinku, T., Vuguziga, F., Twahirwa, A., Kagabo, D. M., delCorral, J., & Robertson, A. W. (2019). Evaluation of ENACTS-Rwanda: A new multi-decade, high-resolution rainfall and temperature data set—Climatology. Int. J. Climatol, 39, 3104–3120.
[53]. Tonne, C., Adair, L., Adlakha, D., Anguelovski, A., Belesova, K., Berger, M., Adli, M. (2021). Defining pathways to healthy sustainable urban development. Environment International, 146.
[54]. Tull, K. (2019). Links between urbanisation and employment in Rwanda.
[55]. Twagiramungu, F. (2006). Environmental Profile of Rwanda. Kigali, Rwanda: Consultancy Report; European Commission.
[56]. UNCCD. (2017). Sustainable Land Management contribution to successful land-based climate change adaptation and mitigation. United Nations Convention on Climate Change.
[57]. UNIDO. (2020). Industrial Diagnostic Study.Kigali: UNITED NATIONS INDUSTRIAL ORGANIZATION.
[58]. Uwimbabazi, P, & Lawrence, R. (2011). Compelling Factors of Urbanization and Rural-Urban Migration in Rwanda. Rwanda Journal, 22, 9-26.
[59]. Veronique, B., Poemans, L., Van Rompaey, A., & Dendonckera, N. (2020). The impact of urbanization on agricultural dynamics: a case study in Belgium. Journal of Land Use Science, 15(5), 626-643.
[60]. Worldbank. (2013). Agricultural Development in Rwanda. kigali: worldbank group.
[61]. Worldbank. (2017). Reshaping Urbanization in Rwanda. Kigali: WORLD BANK GROUP.
[62]. Worldbank. (2018a). Leveraging Urbanization for Rwanda's Economic Transformation. World Bank Group.
[63]. Worldbank. (2018b). Future Drivers of Growth in Rwanda: Innovation, Integration, Agglomeration, and Competition (English). Washington, DC: World Bank Group.
[64]. Worldbank. (2019). Lighting Rwanda. Rwanda Economic Update: June 2019. Edition No. 14. World Bank Group.