The Impact of Urban Expansion on Agricultural Land and Crop Output in Ankpa, Kogi State, Nigeria

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Abstract:
Urban expansion is a human induced phenomenon with inherent effects on the environment. The aim of this study was to examine agricultural land loss and its effect on crop yield in the study area. Two methods of data collection were applied in this research. The first was geospatial technology used to obtain Land use/Land cover and to check the rate of urban expansion. The land-sat image of Ankpa was acquired for three different years of 1987, 2001 and 2016 with the aid of Idrisi Andes land use change modeler and Arc GIS 9.3 used to generate the statistics to show change over the period of 29 years of study. The second data was on crop yield obtained from Kogi Agricultural Development Project. The study revealed that land use and land cover of the study area had undergone considerable changes over the period examined. Built-up areas had expanded significantly during the twenty-nine years period under review. Agricultural lands, vegetation and bare surface declined due to the growths in population and physical developments. The trend analysis of farmland from 1995 to 2016 showed a decreasing pattern. The study therefore recommended the need for government to control urban development from spreading to agriculture land as this would have serious repercussion on food production.

Keywords:
Urban Expansion, Agricultural Lands, Crops Yield, Ankpa

1. Introduction

In recent time, due to the spate in urbanization and industrialization, cities in developing countries are experiencing the most rapid spatial expansion of all regions, people move to the city in search of better employment and opportunities [1,2]. The increase in the number of urban populace and the need for housing among other urban needs have brought about a substantial growth in urban areas with inherent impact on agricultural land area mostly at the periphery [3,4,5].

[6] Defined urban expansion as the horizontal or vertical outward extension of urban area over the neighboring agricultural land; it is a natural process which consumes many hectares of major agricultural lands from their adjoining every year. It comes about through the alteration of non-urban land, for example, farmland into urban land such as parks, shops, residences, and factories. According to [3], the expansion of urban landscape as a result of increase in urban population (caused by increased urbanization) has affected the food production in multiple ways: age-old farming land has been altered traditional practice of farming from farmers and family farms have decreased due to migration to urban areas and scarcity of labour.

Urban expansion has also resulted loss of million hectares of farmland each year to the expansion of roads and industries as well as residential houses among others. Change in agrarian land uses and land cover as a result of increasing urbanization can be adequately monitored and evaluated using remote sensing techniques. These techniques can provide information about land cover with a high level of detail as well as high temporal frequency and has already shown their value in mapping urban areas [7,8]. Besides the observation of a status at a particular time, remote sensing provides also the possibility to observe the development of an investigation area by change detection [9,10]. These techniques also enable changes in land cover and agrarian land area to be monitored across different locations and time. Such analysis enables locations that experience high urbanization rate to be adequately monitored as well as the time or season of increase in land conversion. Therefore, spatiotemporal analysis using time series of remote sensing data enables the derivation of urban footprints to be monitored and quantitatively describe the urban structure and development [7].

Every Nation attempts to address the prevalent issue of food security. In Africa, agriculture provides food for the teeming population and contributed about 33% to the Gross Domestic product (GDP) of the nation [11]. [12] Evaluated the long term urban expansion of Ranchi urban agglomeration. The study analysed urban agglomeration over a period of about 8 decades from 1972–2005. Satellite images and topographical maps were used to evaluate land use dynamics during these periods. Built up growth of 474.7% during 1972–2005 was primarily at the expense of agricultural land, agricultural land reduced by 94.61km^2. The built of growth of 473.7% reflects negative impacts of built up expansion. [13] Also reported that the urban expansion on agricultural land is associated with both shrinking agricultural land area and a higher level of urban development. The former triggers greater land pressure and the latter indicates increasing off-farm employment opportunities.

Ankpa is an emerging urban center in Kogi State that has experienced tremendous urban expansion since creation of Local Government Headquarters in the area in 1979. The establishment of local government headquarters in these areas has had a phenomenal impact on agricultural land as well as the establishment of the Kogi State College of Education among other institutions which trigger development. The aim of this study is to examine the agricultural land loss and its effect on crop yield in the study area.

2. Materials and Methods

2.1. Study Area

Ankpa is located in the estern part of Kogi State, Nigeria. The people are predominantly Igala speaking; farming and trading are the major occupations of the people. It lies between longitude 7°36'E to 7°39' E and latitude 07°23' N to 07°26' N. Ankpa lies on a gently undulating plateau bisected by the river Anambra which drains most of the area. Ankpa falls within the Nigeria meteorological zone that is characterized by warm temperature days and moderately cool nights. Two distinct climatic divisions are demarcated as the dry and rainy seasons representing two broad periods of significant but contrasting variations of weather parameters.
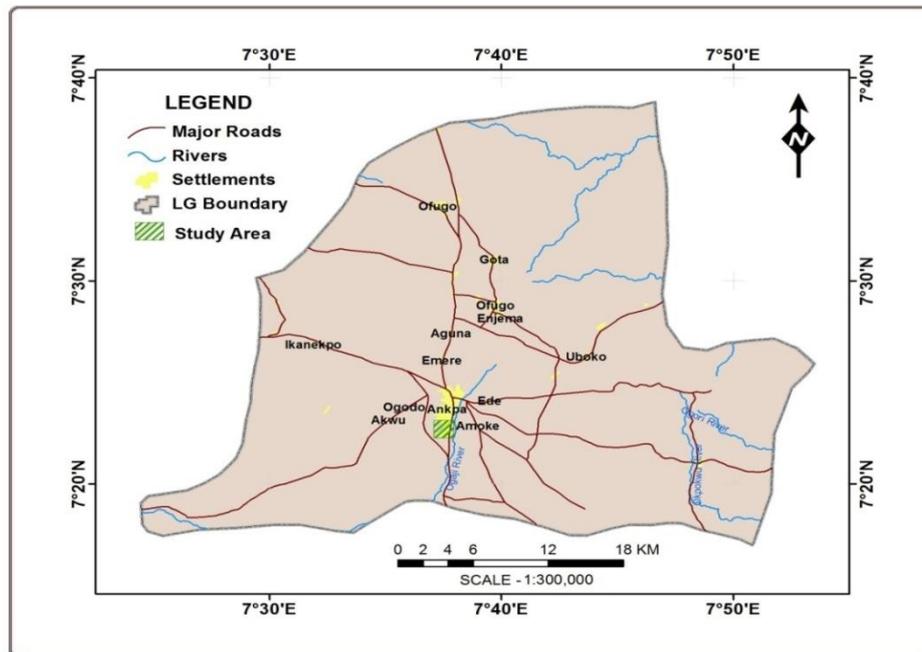

Figure 1.Ankpa and settlements.

2.2. Data Collection

The major data input for this study are remotely sensed satellite images of varied resolutions obtained from GLCF (Global landcover facility), which covered the study area and its environs for a period of 29 years. The three images used for the study are the landsat thematic mapper of 1986 with 30 meters resolution, landsat thematic mapper 2001 with 30 meters resolution and landsat image ETM of 2016 with 30 meters resolution. Images are generally subjected to various processes to ensure qualitative extraction and interpretation. These were done in other to achieve accurate change detection. The multi-temporal images were pre-processed both geometrically and radiometrically to correct errors arising from imaging sensors, cloud cover and earth"s curvature. The Image enhancement was to optimize their appearance to the visual system i.e. to improve the visual quality and recognition of features in attaining specific goals of interpretation. This was done by displaying individual wavelength bands of the original satellite data through an appropriate colour combination to obtain a false colour composite. In testing for the accuracy of the classification, 30 Ground truth points for each land use types were randomly obtained from the field with the aid of handheld germin 97 GPS. These points were imported into ArcGIS 10.1 environment and Kappa tool was used to assess the accuracy of the classification. According to [14], Kappa coefficient expresses the proportional reduction in error generated by a classification process compared with the error of a completely random

classification. Kappa coefficient value of 0.58 was obtained which indicated moderate classification accuracy as reported by [15].

The standard methods of visual interpretation techniques were employed for the interpretation, classification and delineation of land use and land cover categories based on tone, shape, size and pattern. Also areal changes were calculated for each land use and land cover class in different time scale. Data on their crop yield was obtained from Kogi Agricultural development project and was used for the trend analysis. Interpolation techniques were used to estimate the missing values for both crop yield data and farm land date. In this study, linear interpolation method was used. Linear interpolation is to connect two data points with a straight line. The equation of the linear interpolation provided by [16] was employed and it is defined thus:

$$f_1(x) = b_0 + b_1(x-x_0)$$

Where x is the independent variable; x_0 is a known value of the independent variable; $f_1(x)$ is the value of the dependent variable for a value x of the independent variable

3. Results and Discussion

3.1. Land Use Land Cover Change in Ankpa

Table 1 and Figure 1, 2 and 3 show the classified image of Ankpa with five (5) distinct land use types. Farmland in Ankpa are represented by lemon color, and it showed that in 1987 farmland occupied 16.2 km^2 and this covered 17.4% of the land uses in the area [Table 1, Figure 1]; built up land are represented by red color, in1987 it occupied 26.4 km^2 and it covered 28.4%; bare surface are represented by sahara sand color and it occupied 21.3 km^2 representing 22.7% of the total land use area, while vegetation are represented by green color and it account for 28.8 km^2 representing 31% of the total land area. In 2001 [Table 1, Figure 2], the farmland increased to 22.2 km^2 and it covered 23.9% of the total land use area. The increase in farmland is in agreement with [17] when they reported that agricultural land increased by 2.18km^2 with percentage change of about 28.17%, they attributed the increase in agricultural land to the adoption of new agricultural practices which made some un-usable land before 2008 usable due to technological advancement.

The same 2001, built-up area also increased and occupied 38.1 km^2 representing 41%; vegetation occupied 20.2 km^2 representing 21.5%, while bare surface occupied 12.2 km^2 and it covered 13.1% of the total land use area. Also, in 2016 [Table 1, Figure 3], the farmland area decreased and occupied 10.2 km^2 representing 11% of the total land use area; built up occupied 67.2 km^2 and covered 72.2%; vegetation occupied 7.1 km^2 and covered 7.6%, while bare surface occupied 8.1 km^2 representing 8.7% of the total land use area. The result presented above simply implies that the land use and land cover of the study area has undergone considerable changes over the period examined. While the built-up areas have expanded significantly during the twenty-nine years period under study, the agricultural lands, vegetation and bare surface declined. Growths in population and physical developments have led to the sprawling of urban area.
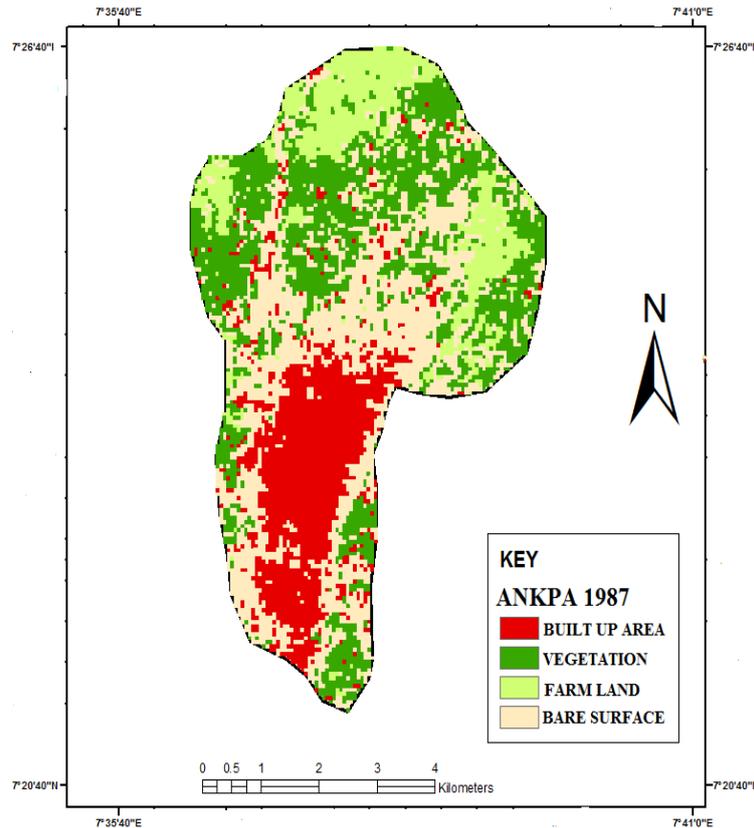
Figure 2. Land use Land Cover Change of Ankpa.

The increasing development and change in land use from farmland to residential and commercial among others that are prevalent in the area may be responsible for the considerable reduction in agrarian land use. The significant rapid urban growth could be associated with the sitting of Local Government Headquarters in 1979 in Ankpa and the establishment of the Kogi State College of Education in 1981 in Ankpa. The result also substantiates the findings of [18] who reported direct relationship between rapid urban growth and factors such as creation of states and local governments; and sitting of universities, polytechnics, colleges of education, commercial centres, industrial centres, tourism resorts and population influx in Nigeria. Also [19] reported that some of these factors are responsible for the growth of Lagos State, Nigeria.

Table 1. Land use Land Cover table for Ankpa Town.

Land- use type	1987 (km^2)	%	2001 (km^2)	%	2016 (km^2)	%
Farm Land	16.2	17.4	22.2	23.9	10.2	11
Vegetation	28.8	31	20.2	21.5	7.1	7.6
Built Up	26.4	28.4	38.1	41	67.2	72.2
Bare Surface	21.3	22.7	12.2	13.1	8.1	8.7
Water Body	0.3	0.3	0.5	0.5	0.4	0.4
Total	**93**	**100**	**93**	**100**	**93**	**100**

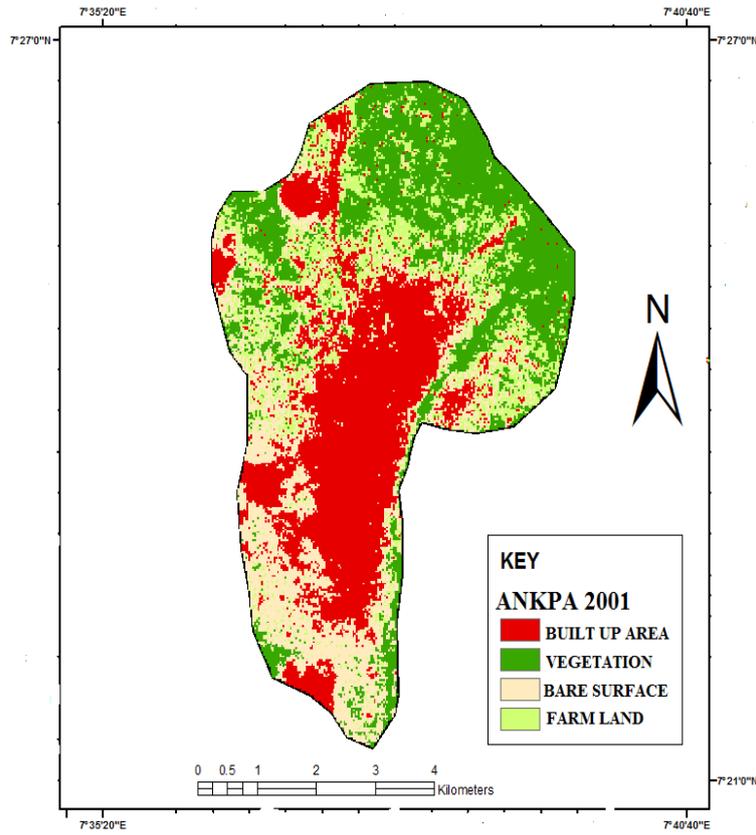*Source: Analysed Satellite Image*

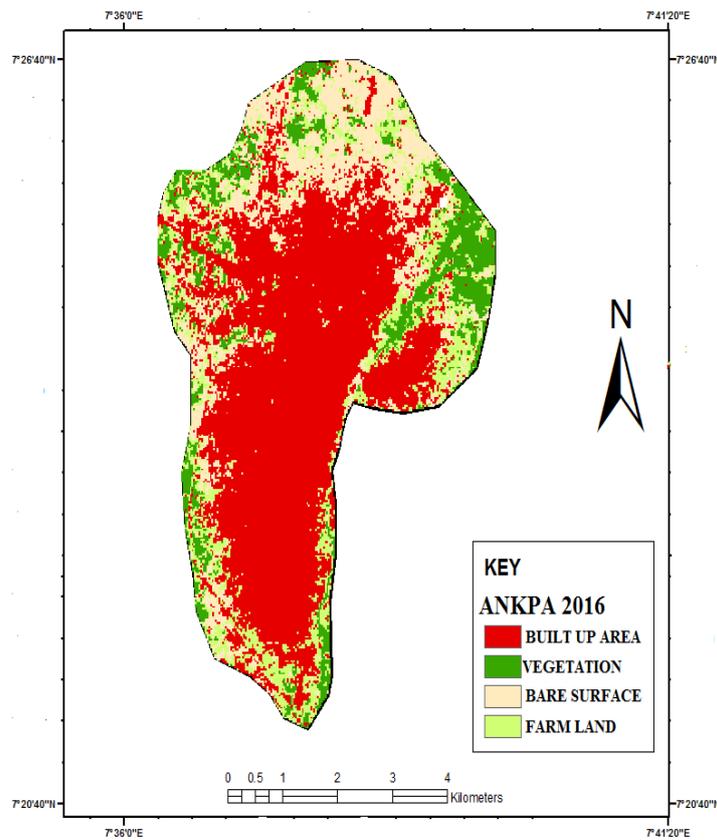**Figure 3.** *Land use Land Cover Change of Ankpa.*

Figure 4. *Land use Land Cover Change of Ankpa.*

3.2. Trend Analysis of Farmland in Ankpa

Figure 5 gives information on the size of farmland in Ankpa over time (22 years). It showed that in 1995, the size of farmland was 9.6 square kilometers. This value decreased by 11.5% to 8.5 square kilometers in 2000. However, the size of farmland in the area increased sharply in 2001 to 11.3 square kilometers, and in 2002, it decreased to 10.8 square kilometers and in 2003, it declined slightly to 10.1 square kilometers. After this period, the size in farmland in the area declined or decreased abruptly. From 2003 to 2010, the size of farmland in the area decreased by 38.6% to 6.2 square kilometers. From 2010 to 2016, there was 27.4% reduction in farmland in Ankpa. The trend in the size of farmland from 1995 to 2016 showed a downward or decreasing pattern and it showed that farmland for the 22 years decreased by 53.1%. In addition, the intercept of the trend line (the point at which the line crosses the y-axis) is 28.4 and its slope (the decrease per period) is 579.0. Also, the R^2 showed that the time period was responsible for 76.4% of the reduction in farmland. The decrease in farmland is associated with urban expansion in the area which led to the conversion of farmlands to residential, institutional, administrative, commercial and industrial land uses among others. The continuous conversion of farmland to other land uses has tremendous effects on the availability of farmland in the area. This is in agreement with [20] when they reported that Asaba has enjoyed rapid growth and development over the years at the expense of agricultural land around the city. Many of the surrounding villages, such as Okpanam, Ibusa, OkoAnala and Obiofu have been absorbed into Asaba in the process of urban growth. Farmlands around these villages are also being taken up by urban development.
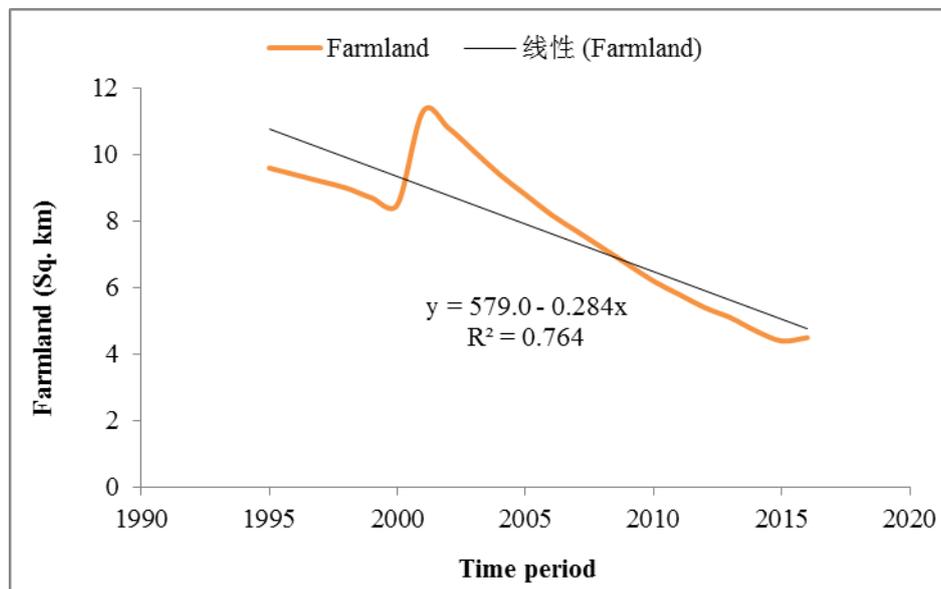

Figure 5. Size of farmland in Ankpa for 22 years.

3.3. Trend in Maize and Cassava in Ankpa

The trend in maize and cassava from 1995 to 2016 in Ankpa is shown in Figure 6. The pattern of maize and cassava in the area and over time (22 years) depicted a downward trend. This implies that for 22 years, the yields of maize and cassava decreased. Looking at the respective trend in crop yield, it showed that from 1995 to 2016, maize yield decreased by 78.5%. High yield of maize was recorded in 1996 and 2001 with values of 35.6 and 29.4 metric tons respectively, low yields maize were recorded in 2016 and 2015 with values of 4.8 and 6.1 metric tons respectively. For

cassava, the time series data over time showed that it decreased by 57.2% with high yield of cassava recorded in 1997 (82.5 metric tons) and 1998 (80.3 metric tons).

Low yields of cassava were recorded in 2016 and 2013 with values of 32.7 and 33.8 metric tons respectively. In addition, the intercept of the trend lines (the point at which the line crosses the y-axis) are 230.4 and 127.8 respectively for maize and cassava and its slope (the decrease per period) are 4674 and 2582. The linear equation for maize and cassava with slopes of -2.304 and -1.278 suggest there are significant linear trends. The yields in maize and cassava decrease with increasing years which implies that yield decreases with the increase in the conversion of farmlands to other land uses. The study is in agreement with the work of [21] who studied Crop Yield & Production Trends in Western Canada and revealed that from 1982-2013, for every hectare taken out of wheat production; total wheat production was reduced by 1.03 tonnes. (Average spring wheat yield over period = 2.22 t/ha).
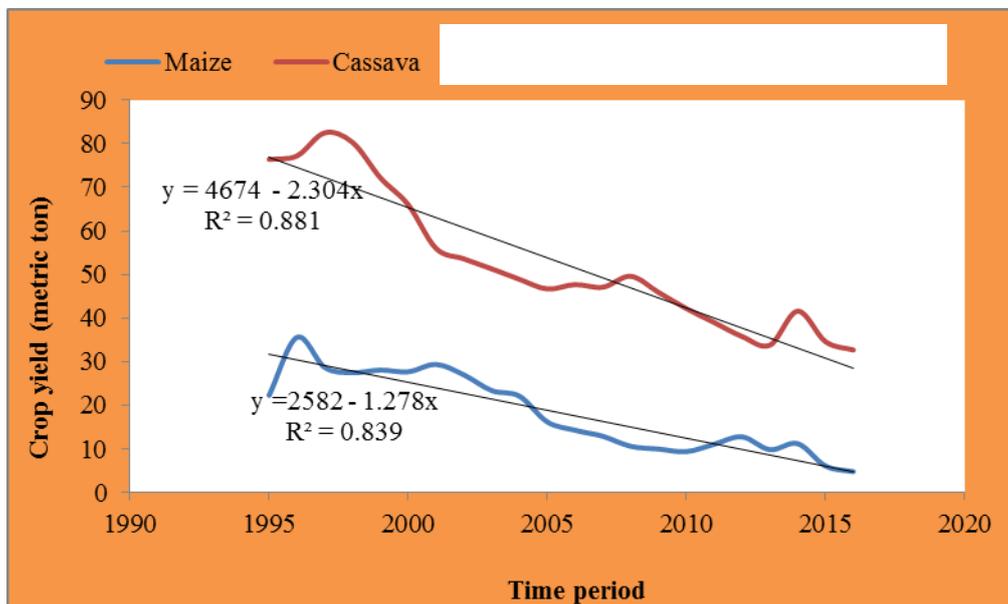

Figure 6. Trend in maize and cassava in Ankpa.

3.4. Trend in Yam and Okro in Ankpa

The information in Figure 7 showed that from 1995 to 2016, the yields in yam and okro in the past 22 years showed downward trends. This implies that for 22 years, the yields of yam and okro decreased. The result showed that from 1995 to 2016, yam yield decreased by 27.4%. High and low yields of yam were recorded in 1998 and 2013 with values of 10.1 and 5.3 metric tons respectively. For cassava, the information displayed in the Figure showed that it decreased by 28.6% with high and low yields of okro recorded in 2001 (2.9 metric tons) and 2014 (0.86 metric tons). The linear equation for yam and okro with slopes of -0.174 and -0.078 suggest there are significant linear trends as well as represent decrease in yields of yam and okro over time. The decrease in the yields of yam and okro is associated with the increase in the conversion of farmlands to other land uses.
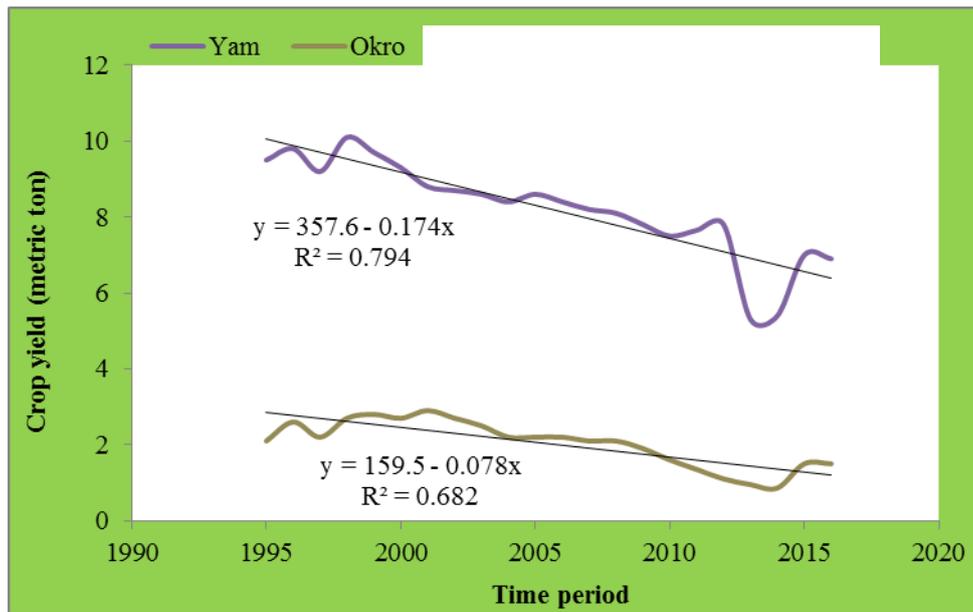
Figure 7. Trend in yam and okro in Ankpa.

3.5. Trend in Mellon and Groundnut in Ankpa

Figure 8 showed that from 1995 to 2016, the yields in melon and groundnut depicted downward trends. The pattern that emerged means that for 22 years, the yields of melon and groundnut decreased. The result showed that for the period under review, melon yield decreased by 38.9% with high and low yields of melon recorded in 1997 (4.1 metric tons) and 2014 (1.2 metric ton). For groundnut, the trend showed that it decreased by 51.1% with high and low yields of groundnut recorded in 1995 (22.1 metric tons) and 2014 (2.1 metric tons). The linear equation for melon and groundnut with slopes of -0.664 and -0.111 imply there are significant linear trends as well as depict decrease in yields of melon and groundnut in 22 years. The decrease in the yields of melon and groundnut is associated with the decrease in farmlands due to its conversion to other land uses.
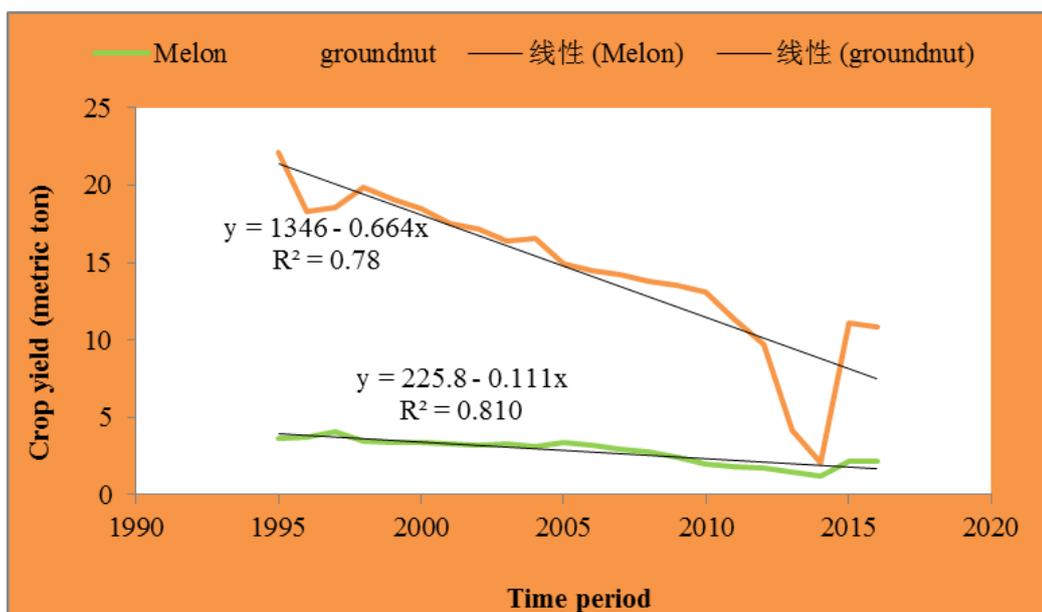

Figure 8. Trend in melon and groundnut in Ankpa.

3.6. Trend in Cowpea and Babaranut

The trend in cowpea and babaranut from 1995 to 2016 is shown in Figure 9. The Figure revealed downward trends in the yields of cowpea and babaranut in 22 years. The result showed that for 22 years, cowpea yield decreased by 32.8%; it further showed that high and low yields of cowpea were recorded in 1996 and 2014 with values of 19.6 and 3.0 metric tons respectively. For babaranut, the trend in crop yield showed that it decreased by 64.4% in the period under review. The information further showed that high and low yields of babaranut were recorded in and 2014 with values of 5.5 and 0.2 metric tons respectively. The linear equation for cowpea and babaranut with slopes of -0.489 and -0.257 entail there are significant linear trends and that the yields of cowpea and babaranut decreased in 22 years. The decrease in the yields of cowpea and babaranut is associated with the decrease in farmlands.
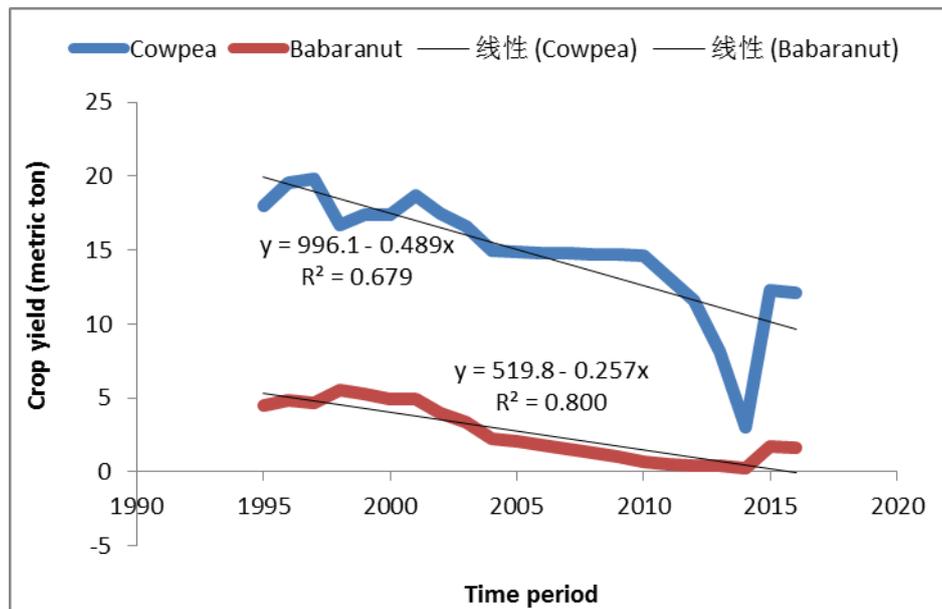

Figure 9. *Trend in cowpea and babaranut in Ankpa.*

3.7. Association Between Reduction in Farmland and Crop Yields in Ankpa

Pearson's correlation analysis was employed to examine the nature (positive or negative) and strength (weak, moderate and high) of the association between reduction in farmland and crop yields (maize, cassva, yam, okro, melon, groundnut and babaranut). The result in Table 2 showed that there were high negative and significant associations between farmland reduction and crop yields. The correlation coefficients for the crop yields ranged from -0.689 to -0.889. The Pearson's result corroborates the trend analysis that shows decrease in farmland and crop yields over time. This again substantials the fact that urban expansion in Ankpa has over the years had significant impacts on the yields of maize, cassava, yam, okro, melon, groundnut, cowpea and babaranut. The loss of agricultural land reduces the potential for food production and aggravates food shortages resulting in food insecurity [2,8]. To meet the future demands of increasing food production by the peri-urban farmers, more land under agriculture is required (Smith, 2013).

Table 2. *Pearson's correlation between reduction in farmland and crop yields in Ankpa.*

Crop yields(metric ton)	Farmland	
	Correlation coefficient	Significance (p-Value)
Maize	-0.849*	0.000
Cassava	-0.689*	0.000
Yam	-0.791*	0.000
Okro	-0.889*	0.000
Melon	-0.859*	0.000
Groundnut	0.816*	0.000
Cowpea	-0.799*	0.000
Babaranut	-0.781*	0.000

Correlation is significant at the 0.05 level (2-tailed); N = 22

4. Conclusions

The research has made used of remote sensing images and GIS techniques to analyze the extent of urban expansion around Ankpa and its environs. It reveals land use and land cover changes that have occurred around Ankpa and its environs over the period of years under review (1987-2016). Residential land use has a noticeable increase. From the analysis, we can see that residential development is very high and a decreasing trend in agricultural farmland. This is the major cause of the changes in land use and land cover in Ankpa and its environs. The significant rapid urban growth in the area could be associated with the sitting of Local Government Headquarters in Ankpa in 1979 and the establishment of the Kogi State College of Education in 1981. If the rate of decline in agricultural land remains unchecked, in the nearest future food production will be a serious challenge and rural livelihood will negatively be impacted. Land use and land cover change is a difficult task to perform accurately. There is therefore, need for proper land use planning and enforcement of development control to forestall the negative socio-economic consequences of land use and land cover changes.

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