AN ASSESSMENT OF URBAN AGRICULTURAL LAND USE CHANGES USING GEOSPATIAL INFORMATION SYSTEM: A CASE STUDY OF JOS-BUKURU

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ABSTRACT
The urban agricultural land use change of Jos-Bukuru between 1961 and 2002 is assessed. The aim is to generate relevant, accurate and timely data that would enhance the quality of decisions and actions in an attempt to ensure the survival, expansion and the sustainability of urban agricultural land use. A geospatial information system approach was adopted in the mapping and assessment of urban agricultural land use change in the study area Topographic map of Jos-Bukuru urban at the scale of 1:50000, Landsat TM image of 1986 and 2002 with spatial resolution of 30m, among others. Data conversion, digitizing, editing, analysis was carried out using ILWIS 3.2 and Arc-View 3.2 software. The study reveals among others that agricultural land use increased substantially between 1961 and 1986. However, between 1986 and 2002, about 63% of agricultural land was lost. Out of this, about 68% was lost to urban development. The percentage increase in urban in urban expansion was 3.5% from 1961 to 1986 and 3.8% from 1986 to 2002. While the percentage in urban agricultural land use between 1986 and 2002 was 3.9%. Overall, while urban spatial expansion is increasing agricultural land use is decreasing. The study recommends among others that urban agricultural land use should be made a legitimate in urban expansion planning; specific agricultural practices should be zoned to specific locations within the city; and, that urban farming should be incorporated into the poverty alleviation programme of the Federal government

INTRODUCTION

During the 20th century, urban growth reached unprecedented levels in most parts of the world. In the three recent decades alone, the urban population in developed countries doubled, from 448 million in 1950 to 875 million in 1990. In the same period the urban population in developing countries more than quintupled, from 280 million to 1.6 billion. By the end of the 21st century, six of the largest cities will be found in developing world. Having urban settlement approaching 30 million people will likely strain already overburdened services in countries with limited resources and extreme income inequalities (Deelstra et al 2000).

The cities of the 21st century are where human destiny and the future of the biosphere will be determined. It is unlikely that the planet will be able to accommodate an urbanized humanity that continues to draw upon resources from ever more distant hinterlands, or which uses the biosphere, the ocean and the atmosphere as a sink for its wastes at the current accelerating rates. The challenge before us today is how to make a world of cities viable in the long term – socially, economically as well as environmentally or how to transform cities into self-regulating sustainable systems. The answer to this question is critical to the future well being of the planet, as well as of humanity because according to Deelstra et al (2000) "there can be no sustainable world without sustainable cities".

Historically, poverty has been predominantly a rural phenomenon. Yet, as the majority of the world's population moves to urban areas, there is a considerable reversal in the regional distribution of poverty. World Bank (1993) estimated that by 2000 about 50% of the poorest segments of the developing world would be living in urban areas. In sub-Sahara Africa, poverty and malnutrition are becoming increasingly urban to a magnitude that African urbanization, which was once with modernization and growth, has since been branded as a "parasitic process" and a cause of underdevelopment (Baker and Pedersen 1992). Between 1985 and 1992, total extreme poverty in Nigeria increased by 37.6 percent, from 10.1 million to 13.9 million people. In the urban areas, the population of extreme poor increased nearly threefold, from 1.5 to 4.3 million people (UNDP 1998). In an overview of the urban food situation, Atkinson (1995) suggested that given the current trend, the question of urban food security may become the "greatest humanitarian challenge of the next century" – yet food security in African cities is relatively invisible to policy makers and is scarcely recognized in contemporary political debate.

Urban agriculture is not a novel phenomenon; it is likely as old as the earliest urban settlement. Throughout the globe, agriculture today is increasingly, a part of city landscape. Like many urban trend, agriculture crosses borders north and south and is evident in both rich and poor countries. It is found in small towns and the major metropolis, in temperate and tropical latitudes, and at sea level and high in the mountains (Bourque 2000). In 1996, the United Nations Development Programme (UNDP) estimates that about 800 million urban residents are involved in commercial and subsistence agriculture in or around cities (UNDP 1996 & Smit et al, 1996). Over the past couple of decades, urban agriculture has increasingly gained recognition as a viable intervention strategy for the urban residents to sustain themselves and to earn extra income. In Jos City for example, there is a considerable weight of evidence to confirm that farming as an activity is markedly on the increase. Throughout the year, a substantial amount of farming activities takes place. In this respect, Jos City is unique, both in Nigeria and many other countries in Africa where urban farming is practiced. Yet, relevant scientifically derived geospatial data and information regarding the nature and scale of farming and farmlands within the context of competing urban land uses in Jos is still lacking.

Because of the uniqueness of Jos in the production and supply of agricultural products, there is therefore a growing need to establish a proper place for urban agriculture within the boarder image and role of the city in national development. This would help to evaluate urban agriculture from its current "trivial" status to one of a respectable urban economy. To achieve these, food growers and would be growers, consumers, development facilitators, policy makers etc, would depend on quality data for decisions and actions. With relevant geospatial data and information, Jos could establish itself as an example of a 'sustainable city' and a blueprint for other local and international cities to adopt in promoting the sustainable use of urban landscape for human welfare

THE AREA OF STUDY

Location

The Jos-Bukuru urban area lies between latitude 9^0 45" and 10^0 North and longitude 8^0 50" and 8° 57″ East and only a distance of about 300km from the new Federal Capital Territory, Abuja. The numerous headstreams and rivulets on the Plateau are indications of the availability of water in several places including in the rock joining system and deeply –weathered profiles of the older granites and basalt in the regions, which has a considerable advantage regarding agriculture.

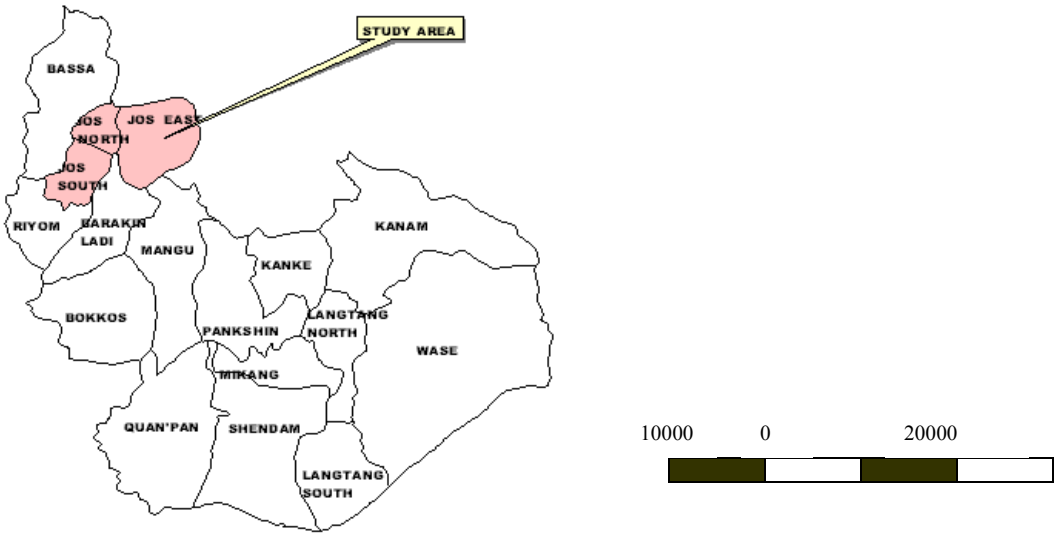

Figure 1: Map of plateau state showing the study area

METHODOLOGY

Sources of Materials

Primary source: This includes field surveys. The field exercise started with a reconnaissance survey and thereafter, the actual field work for ground truthing, taking of GPS reading, taking of photographs of some farm sites, water bodies, etc.

Secondary source: Through this source, we obtained the following:

- Existing Topographic map of 1961 of Jos-Bukuru urban area and its environment at the scale of 1: 50000 from Federal Surveys.
- Landsat TM image of 1986 with a spatial resolution of 30m from United States Geological Surveys (USGS).
- Landsat TM image of 2002 with a spatial resolution of 30m from United States Geological Surveys (USGS)
- Existing literatures contained in relevant Textbooks, Journals, Magazines, etc.

Data Analysis

The procedure for the analysis of urban growth and agricultural landuse (fadama) change was designed to Identify and calculate the basic landuse;

Quantify the growth of urban area between 1961 and 2002; Quantify the increase or decrease in fadama lands/wetlands; and, Analyse the pattern of landuse changes 1961-2002.

Calculating the basic land use change for three years.

In calculating the basic land use data for three years, each of the polygon map was rasterised using the operation polygon to raster in ILWIS operation list. Using the function New Table in the operation list, we created an attribute table, land use with the domain land use. This table was opened and the following formula was typed in the command line to calculate the area for each land use: Area:=Landuse61.His.Area

In calculating the area in hectares for each land use class, we typed in the command line:

Area ha =Area/10000, with a precision of 0.1.

The percentage for the different land use classes was also calculated. This was done using the aggregate sum Aggsum command. We created a column Areatot by typing: Areatot=aggsum(Areaha). With the formula: Perc=100*Areaha/Areatot we derived the percentages of each land use. This procedure was repeated for the years 1986 and 2002 landuse/landcover raster maps.

Quantifying the growth rate of Urban area and the increase or decrease in the Agricultural Lands

The data in the attribute table created earlier was used to quantify the urban growth rate as well as the behavior of the agricultural lands within the study period. The total urban area for each year was extracted from the attribute table. This was used to calculate the changes between the years (Urban Development per year in hectares). The percentage change between 1961 and 1986 was calculated with the assumption that the urban area in 1961 is 100%. Similarly, the percentage change between 1986 and 2002 was also calculated with the assumption that the urban area in 1986 is 100%. This was followed by the calculation of the mean change per (arithmetic mean in ha/year) and %/year for the two periods. The same procedure was used to calculate for the increase or decrease in wetlands or fadama land use.

Analysis of the land use change 1961-1986 and 1986-2002

The attribute table provides information on the land use assigned to each pixel in the years, 1961, 1986 and 2002. By extracting the areas in hectares, a quantified overview of the type of change was made. Thus, pattern of change was analyzed for the two periods using the cross function. The cross operation was used to overlay the raster maps landuse61 and landuse86 and an output map landuse6186 and output table landuse6186 was created. The formula: Area=Areaha/10000 with a precision of 0.1 was used to calculate the combination of different land uses/landcover in hectares. The same procedure was repeated was for the raster maps landuse86 and landuse2002. The output of this operation gives us an insight into the internal dynamics of landuse/landcover change.

RESULTS

Basic Land use Landcover Change

Table 1: Main Land use and Land cover (ha and %) in 1961,1986 and 2002

	1961		1986		2002	
Landuse	Area(ha)	%	Area(ha)	%	Area(ha)	%
Mining Areas	10959.8	31.1	0	0	0	0
Mining Camp	840	2.4	0	0	0	0
Plantation& Cultivation	3324	9.4	0	0	0	0
Rocky Surface	4583	13	4172	14.9	4042	11.4
Scattered Cultivation & Srub	13394.3	38	0	0	0	0
Urban Development	1133.3	3.2	9083	22.9	23507.8	66.9
Water Body	973.3	2.8	1823.3	5.2	1114	3.2
Bare Surface	0	0	5624.8	15.9	727.3	2.1
Wildlife Park	0	0	1116.5	3.2	927.5	2.6
Agricultural Land	0	0	13388	38	4889.8	13.8
Total	35207.7	100	35207.6	100	35208.4	100

As revealed in Table 1, mining areas and mining camps constitutes about 31 % and 2.4 % of the total land use respectively. This is because Tin mining was the dominant economic activity and the major source of income to the people. Both formal and informal mining activities were carried out. As a consequent, the environment was severely abused and degraded. There were patches of farmland scattered all over the un mined areas intermixed with scrubs and this accounted for about 38% of the land use

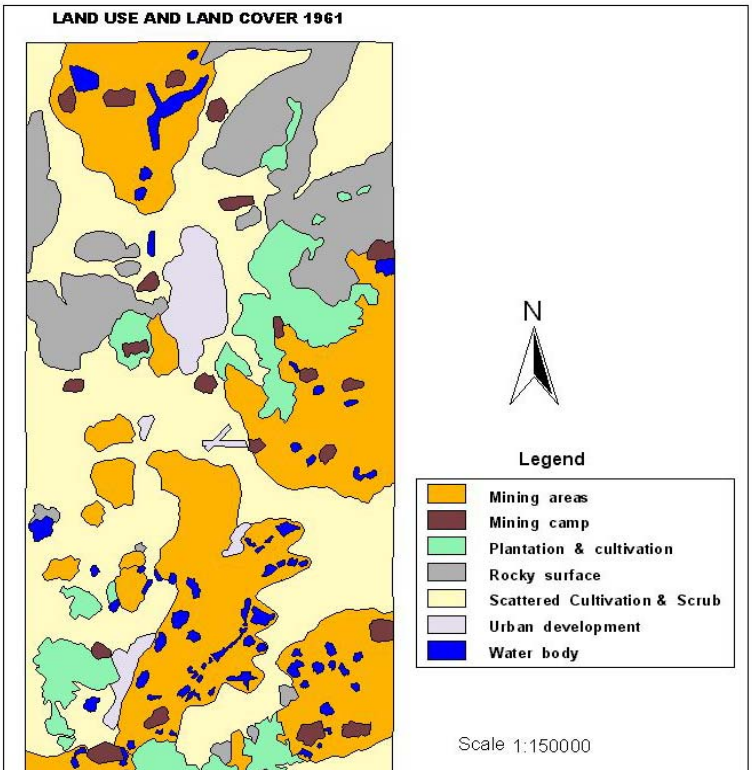

Fig. 2: Land use Landcover of Jos-Bukuru urban area in 1961.

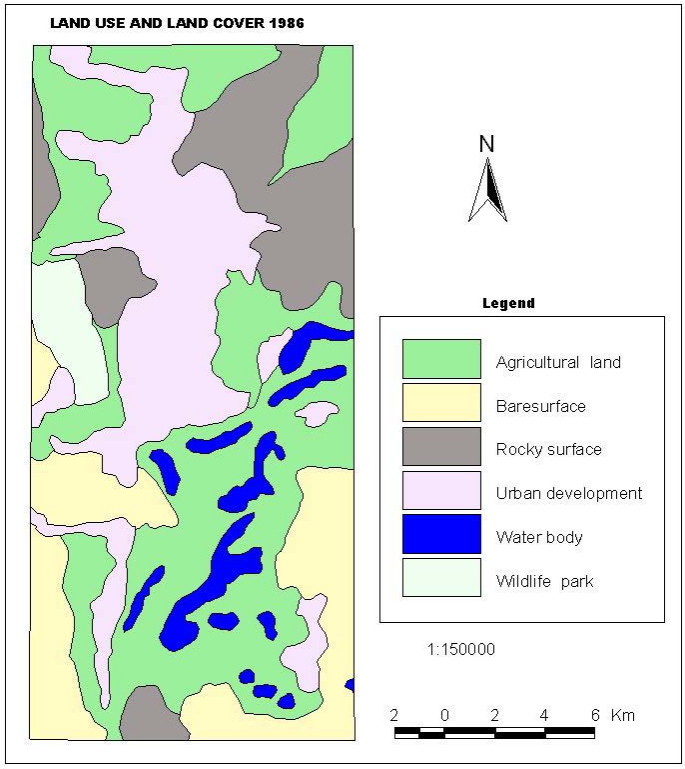

Fig. 3: Land use Land cover of Jos- Bukuru Urban Area in 1986

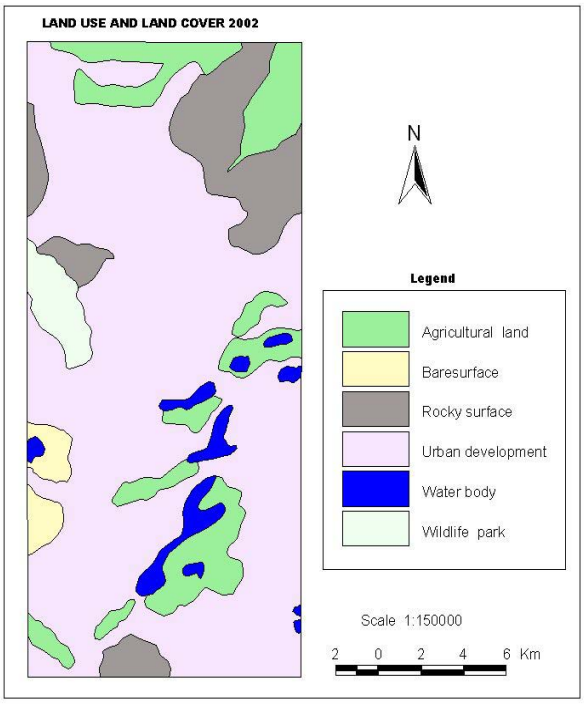

Fig 4: Land use Landcover of Jos-Bukuru Urban Area in 2002.

Quantification of Urban growth rate

Table 2: Urban expansion in ha per year and % per year.

	1961	1986	2002
Total Urban (ha)	1133.3	9083	23507.8
Total change		7949.7	14424.8
Changes per year in (ha)		317.99	901.6
% change in total urban		87.5	61.4
% change in per year urban		3.5	3.8

The urban area witnessed a considerable spatial expansion within the study period. As reported in Table 2 above, this is 87.5 % and 61.4 % for the period 1961 to 1986 and 1986 to 2002 respectively. The percentage change in per year urban was 3.5 between 1961 to 1986 and 3.8 between 1986 to 2002. Overall, the built up area which constitutes about 25.8 % in 1986 had increased to 66.8 % 2002. This would have serious implications for urban agriculture and the urban economy.

Spatial and temporal change in Agricultural (Fadama) Land use

Table 3: Change in Agricultural (fadama) Land use in ha per year and % per year.

	1986	2002
Total Agricultural Land	13388	4889.8
Total change		8498.2
changes per year in (ha)		531
% change in total Agricultural Land		63
% change in per year Agricultural Land		3.9

As reported in Table 3, about 8,498.2 or 63 % hectares of agricultural land use was lost between 1986 and 2002. Changes per in hectares was 531 hectares while the percentage change or decrease per year was 3.9. This rate of decrease could pose serious threat to food security within and outside the region.

DISCUSSION

Pattern of Land use and Land cover change

A close examination of the pattern of change reveal the internal dynamics of how some land use and land cover types replaced the other. Table 4 Replacement or change from one land use and land cover by another between 1961 to 1986. The Table 4 below reveal among others that about 23.8 % of scattered cultivation and scrubs had turned to bare surface, about 40.7 % changed to urban agriculture and about 30 % of the area changed to urban development. About 38.6 % and 20.8 % of the Plantation or forest reserve had changed to urban agriculture and urban development respectively. Significant to note is the mining areas which gave way to urban agriculture 51.5 %, bare surface 14.1 %, urban development 21.8 %, etc. About 47.2 % of the mining camp had become agricultural areas while 37.1 % turned into urban development. By 1986 urban agriculture and urban development accounted for 38 % and 25.8 % of the urban land uses respectively.

As reported in table 5.5, there were changes from some land use and land cover into others between 1986 to 2002. Of particular importance is the agricultural land use which lost about 68 % of its area to urban development. About 22.4 % and 34 % of the land covered by water body was lost to agricultural land and urban development respectively.

Table 4: Pattern of land use and land cover change between 1961 and 1986

Landuse/Landcover	Bare surface		Agricultural land		Rocky surface		Urban development		Water body		Wild life park		% Total
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	
Scattered cultivation and scrub	3186.8	23.8	5447.3	40.7	2.5	0.2	4029.3	30	227.5	1.7	483.3	3.6	100
Plantation and cultivation	625.8	23	1038.8	38.96	420	15.6	560.5	20.8	46.8	1.74	0	0	100
Mining Areas	1522.9	14.1	5550.3	51.5	10	0.1	2347.3	21.8	1305.8	12	45.4	0.4	100
Mining camp	83	10.9	357.5	47.2	0	0	280.8	37.1	8	1.1	28.3	3.7	100
Water Body	92.8	9.6	396.3	40.8	0	0	271.1	27.9	210.5	21.7	0	0	100
Rocky surface	113.5	2.3	446.3	9	3739.5	75	126.6	2.5	0	0	559.5	11	100
Urban development	0	0	151.5	9	0	0	1467.4	1467	25.3	1.5	0	0	100
Total	5624.8		13388		4172		9083		1823.9		1116.5		

Table 5: Pattern of land use and land cover change between 1986 and 2002.

Landuse/Landcover	Bare surface		Agricultural land		Rocky surface		Urban development		Water body		Wildlife park		%Total
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	
Rocky Surface	0	0	27.3	0.5	3906.2	73	1435.8	26.7	0	0	3	0.1	100
Agricultural Land	101.3	0.76	3901.5	29	0	0	9147.3	68	220.3	1.7	7.3	0.1	100
Water Body	0	0	408.3	22.4	0	0	617	34	795.3	44	0	0	100
Urban Development	5.5	0.1	208.5	2.6	0	0	7875.2	97	15.5	0.2	0	0	100
Bare Surface	620.5	11	344.2	6.3	0	0	4422.8	80.6	82.9	1.5	15.3	0.3	100
Wildlife Park	0	0	0	0	135.8	12	67.5	6	0	0	902	82	100
Total	727.3		4889.8		4042		23507.8		1114		927.5		

Determinants of Urban Agricultural land use change

There are numerous factors that can account for the rapid urban growth and progressive decline in agricultural land use. Chief among this is population growth. By 1963 census, the population of Jos was 40000. Over the years, the population had grown to 681,768 in 1991 and it is estimated at 1,122,140 by 2002. A number of people of people were attracted to the city as a result of the tin mining industry and also because of its cool near-temperate climate. Until very recently, Plateau state was known as the home of peace and tourism relative to its neighbouring states. States like Kano, Kaduna and Bauchi have constantly been plagued by communal and religious crisis.

Besides, the unproportionate impact of the small but powerful affluent class, in the case of Jos, the military officers who had competitively taken over thousands of hectares of good agricultural lands because of the unbridled urge for material acquisition is point that has promoted rapid urban expansion.

Constraints to Urban Agriculture

Agricultural land use is traditionally foreign in an urban environment. While urbanization in Jos-Bukuru region presents considerable advantages, it also constitutes some major constraints. In the study area, urban spatial expansion has resulted to complex changes. Thus, it can be appreciated that so much agricultural land have been largely taken over by urban uses.

Moreover, as the city sprawls outwards, there is constant changing of the configuration of the configuration of the land uses especially in the peri-urban areas. The major constraint is that the hitherto available land is continuously being threatened by such encroachment and competition from alternative urban uses.

Pollution of water bodies, soil and even the crops is another major constraint. So much urban wastes is generated in the city daily. The indiscriminate dumping of such wastes is another threat to the effective utilization of urban agricultural resources.

Urban agriculture up until now lacks official support. We do not have laws that would protect and promote the sustainability of urban farming activities. The government is yet to realize the importance of the sub-sector in enhancing food security.

Socio-economic and planning implications of Urban Agricultural change

The dynamics of change from urban agriculture to urban development reveal among others that since 1986, urban agricultural land use have continue to experienced progressive decline. From a total of 13388 ha in 1986 to 6910 ha in 1996 and 4889.8 ha in 2002. It is interesting to note that while the population is growing, the urban agriculture industry which had consistently helped to boost food production and supply is fast declining. The decline in agricultural land use particularly in Jos-Bukuru urban has a direct relationship to food production, income generation and employment. Several studies have shown that urban agriculture in the less developed countries is a noteworthy source of income; a survival strategy for the vulnerable households and the economically marginalized people, mostly women who are trying to improve their family income. Well over 40 % of the fruits and vegetables consumed within the Jos-Bukuru urban area are produce from urban and peri-urban agriculture which employ about 30 % of the labour force in the region. Therefore, a considerable decline in agricultural land use would mean low food production, low income, high food prices and a growing unemployment and under employment. This situation calls for a rethinking and proper planning of urban expansion to accommodate agricultural land use.

RECOMMENDATIONS AND CONCLUSION

Recommendations

Urban agriculture should be recognized and encouraged to move from its current 'Trivial Status' to a legitimate urban land use especially in urban expansion planning. The government should come up with a law to guide, protect and manage agricultural practices in a city system.

Different agricultural practices should be zoned to specific locations within the city as practiced in some parts of the world e.g. USA, Britain, China, Cuba, Mexico, South Africa, Dar es Salaam, Kinshasa, etc. Urban agriculture should be incorporated into the poverty alleviation programme of the government as this would help to boost national food security.

The need for legislation promote the sub-sector cannot be over emphasized. This would help to address major constraints such as urban encroachment and pollution; promote harmonious relationships between rapid and healthy

urban development and sustainable agricultural practices; enhance the perception of and value for agricultural land use and ultimately, facilitate the development/emergence of sustainable cities ie where various land uses complement each other to promote the well-being of man and his environment within the city system.
There cannot be sustainable world without sustainable cities. Thus, the need to make our cities viable in the long term- socially, economically as well as environmentally or to transform them into self regulating sustainable systems cannot be overemphasized.

Conclusions

The Jos-Bukuru urban area had undergone remarkable spatial transformation as a result of the tin mining industry which lasted for decades. The decline and subsequent collapse of the tin industry in the 1960s led to the widespread acceptance and practice of urban agriculture as a survival strategy by the affected tin miners. This led to a major shift from one economic activity (tin mining) to another (urban agriculture).The open cast tin mining led to the massive devegetation as well as the degradation of the entire land. This devastation later presents unique opportunities for urban agriculture. Water now accumulates in the degraded areas to form water bodies or mined ponds. Such ponds scattered all over the area now sources of irrigation water. This made it possible for the people to farm all year round.

The Jos-Bukuru urban is experiencing rapid urban expansion, growing population and declining agricultural land use. The rapid urban spatial expansion could pose serious threat to food security within the region. The progressive decrease in agricultural land use have led to a shift from extensification (extensive use of land) in around 1986 to land fragmentation, intensification and diversification of agricultural practices. Further decrease in agricultural land use could lead to substantial decrease in food production and provision, rising food prices especially for fruits and vegetables, low income particularly for the low and middle income group or the vulnerable and marginalized population, growing unemployment and under-employment, etc. Throughout the globe, agriculture is increasingly becoming a part of the city landscape. It has gain recognition as a viable intervention strategy for urban residents. This is the time for the Nigerian government to come up with laws to regulate and sustain the practice of urban agriculture.

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