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Multi-Temporal Satellite Data and Spectral Indices for Assessing Spatial Changes in Urban Farmlands in Lagos, Nigeria

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Abstract

To achieve sustainable development for the world's population food security is one of the environmental existential challenges that must be addressed. This study examined the trend in agricultural land use change, in Lagos Metropolis between 1984 and 2024. Data used included Landsat 5 Thematic Mapper (TM) image of 1984, Landsat 8 Operational Land Imager (OLI) image of 2013 and Landsat 9 (OLI) of 2024. The satellite images were processed using ArcGIS 10.5 and IDRISI Selva software. The processed images were classified using a combination of Normalized Difference Vegetation Indices (NDVI), visual interpretation and Maximum Likelihood Classification algorithm. An inventory of the extent of land use/land cover for each year and the rate of change were determined, the pattern of conversion of urban farmlands to other land uses was also examined, using the Land Use Change Modeller of the IDRISI software. Findings from the study indicated that farmlands in the study area declined by 13.03% between 1984 and 2013 and by 21.79% between 2013 and 2024. So also between 1984 and 2013 as much as 89.48% of farmlands were converted to other land uses, while only 10.52% remained unchanged and between 2013 and 2024 as much as 73.51% had been converted to other land uses, while 26.49 % remained unchanged. Furthermore, the NDVI results indicated a deterioration in the environmental condition of the urban farmlands. The study concluded that the present status of urban farming in Lagos Metropolis has far reaching implications for food security that needed to be addressed.

Key Words: Sustainable, land use/land cover, food security, urban, farmlands, wetland

Introduction

Urban farming have been variously defined as agricultural activities, involving the growing and marketing of different types of crops and animals, either on a subsistence or commercial scale, within a town, city or metropolitan area (Mougeout, 2000;Veenhuizen and Danso, 2007; Azunre *et.al.,* 2019). The practice of urban farming have been attributed to the daily demand of consumers, for food and income supplements (Smit *et.al.,* 2001). Urban farming is a spatial attribute of every metropolis and contributes significantly to the socio-economic development of urban centres throughout the world (Veenhuizen, 2006; Chiara, 2014).

Food security implies physical, social and economic access of all people, at all time, to adequate, safe and nutritious food which meets their dietary needs and food preferences, for an active and healthy life (Pratheeba, 2021). A significant concern in urban areas is food security in the face of rapid urbanization and rising emigration to urban areas, resulting in inadequate supply of land and water, as these crucial inputs for agricultural production remained insufficient and unsuitable. Industrial and residential development in urban areas have usurped arable lands, which were initially being used for food production, and hence a decline in farming activities in the face of a high increase in food demand driven by sustained population growth (Djan, 2023).

Even though urban farming have been recognized as contributing to a wide variety of urban issues and is increasingly being accepted and used as a tool in sustainable city development, there are currently challenges to its integration into city planning and facilitation of its multiple benefits for urban inhabitants (Veenhuizen 2006, Omisore *et.al.*2011). This is as a result of the limited understanding of its spatial attributes, social, economic and environmental functions. To this extent many studies have been conducted on urban farming and urban food security, providing data on the manifestation of urban farming in cities and its importance for urban food security and income generation for the urban poor (Dongus, 2001; Kareem and Raheem 2012; Azunre, *et.al.,* 2019). A number of these studies have explored urban farming as a livelihood support system and have provided useful information (Firdissa 2007, Aina *et al*. 2012).

However, urban farming as a spatial phenomenon remains poorly understood, because of its dynamism and transitory nature. The space and resources available to UF practitioners vary both quantitatively and qualitatively over short periods of time, as has been noted by some researchers on the subject (Arturo and Simon, 2003; Smit and Joe, 1992; Losada *et. al.,* 1998; Foeken, 2012). This spatiotemporal dynamics of urban farming has implications for food security as a component of sustainable city planning. More so, studies have shown that rapid urban sprawling keeps driving the practice to marginally unsustainable lands and continue to undermine the sustainability of UF

(Azunre, *ett.al.,* 2019). Understanding the contributions of UF to food security and sustainable livelihood presupposes the understanding of its spatiotemporal dynamics, so as to stem the tides of inadequate, unreliable and irregular access to food and lack of purchasing power by the urban poor (Veenhuizen,. 2007).

The sustainability of urban farming, especially in developing nations, is premised on better planning and availability of accurate geospatial information to enable sustainable management of the practice (Addo, 2010). An in-depth understanding of the spatial and temporal dynamics of urban agricultural is therefore necessary, to put its practice in proper context and to take the threat to its sustainability from the realm of conjectures to empirical findings. The objectives of this present study therefore, is to examine the spatial extent of urban farmlands, the rate of change and pattern of conversion to other land uses over time and assessed the implications of these for food security. The study is structured into six parts, with the previous introduction focusing on the spatial attributes and dynamics of urban farms. The second section provides information about the physical and cultural settings of Lagos Metropolis. The third section presents the materials and methods, while the fourth presents the results of the study. The fifth section presents a discussion of the results and their implications for urban food security, while the sixth presents the conclusion of the study.

Study Area

Lagos State is a megacity that is located between Longitude 2^0 42' and 3^0 22' East of the Greenwich Meridian and Latitude 6^0 22'and 6^0 42' North of the Equator. It shares border in the West with the Republic of Benin, with Ogun State in the North and the East and is bounded in the South by the Atlantic Ocean. It has a population of over 10 million people (NPC, 2007), and a population density of 5,926 persons per square kilometer (Komolafe, *et.al.,* 2014). The metropolitan area of Lagos comprises of seventeen out of the twenty Local Government Councils which make up the State (Akinmoladun and Adejumo, 2011). Four of these Local Government Councils, in particular, including Agege, Ifako/Ijaye, Oshodi/Isolo and Ojo (Figure 1) have had a sustained history of urban/peri-uban farming, dated back to the creation of Lagos State in 1967.

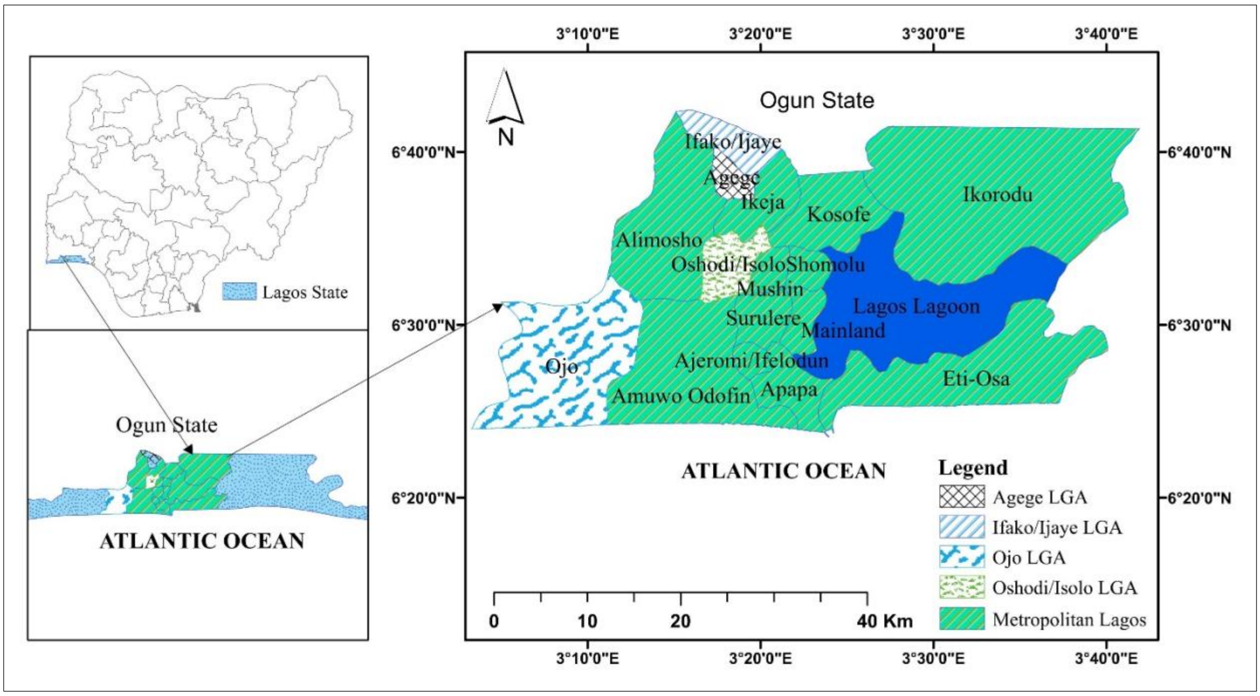


Figure 1: Map of metropolitan Lagos comprising 17 Local Government Area out of the 20 LGAs that made up Lagos State

The state experience the sub-equatorial climate, characterized by rainfall throughout the year with two maxima (May to July and September to October). December and January have low rain, and the annual rainfall ranges between 1500 to 2000 mm. Annual temperature ranges between 32 and 36°C while, the highest air temperature occurs in April/May and the lowest occurs in December through February.

The vegetation of the region is swamp and marsh forest, part of which had given way to real estates and commercial infrastructures development. Tree species consist of typical colonizer or invaded species. These are plants with numerous and easily dispersed seeds and capacity for fast and vigorous establishment in cleared or open location. The river channels are characterized by vegetation of the wet southern segment of the rainforest belt. The characteristic vegetation include tall trees like *Tarriefa utilis*, *Geophila* sp., epiphytic ferns (*placycerina* sp.), *Tuchomanes* sp. *Nephrolepis* sp. Mosses and Lierworts (Ogunbajo, 2005).

Methods

Image data acquisition

Satellite	Sensor	Acquisition Date	Path/Row	Spatial Resolution	Source
Landsat 5	Thematic Mapper (TM)	18/12/1984	191/055-056	30 m	USGS
Landsat 8	Operational Land Imager (OLI)	18/12/2013	191/055	30 m	USGS
Landsat 9	Operational Land Imager (OLI)	08/02/2024	191/055	30 m	USGS

Table 1. Data Types, Characteristics and Sources

Three sets of cloud free satellite imageries, including Landsat Thematic Mapper (TM) (r191p055/56), Landsat 8, Operational Land Imager (OLI) (r191p055), both acquired on 18th December 1984 and 2013 respectively and Landsat 9 (OLI) (r191p055), acquired 8th February 2024, were obtained from the United States Geological Survey (USGS) website (Table 1). A preliminary survey was conducted to identify urban farmlands using the high resolution Google Earth image and a handheld Global Positioning System (GPS), between May and September 2023.

Satellite data processing

The linear contrast stretching, spatial filtering and band compositing were the preprocessing operations performed on the images to enhance their visual interpretability. Also, the two scenes of the 1984 image (i.e. path 191, row 55/56) were mosaic into a continuous scene and thereafter subsets of the satellite images were created using the polygon shapefile of the study area.

Land use/land cover classification and accuracy assessment

Spectral indices (SPI) are widely used for climate studies, vegetation density, urban greening, and estimation of nitrogen levels in vegetation and soil (Caroline and Hidayati, 2016; Gessesse *et al.*, 2019). Therefore, in this study the Normalized Difference Vegetation Index (NDVI) was used in conjunction with visual interpretation and supervised maximum-likelihood methods, to classify the land cover types into seven types of land cover: built-up, farmland, light forest, open space, shrub, waterbody and wetland.

NDVI is a numerical difference in reflectance between the red and near-infrared wavelengths over the overall brightness of each pixel in those wavelengths. Specifically, NDVI in the context of this work is given as:

$$NDVI_{L5} = \frac{NIR-R}{NIR+R} = \frac{b4-b3}{b4+b3} \quad \text{(Landsat 5 TM)} \qquad (1)$$

$$NDVI_{L8\ \&/9} = \frac{NIR-R}{NIR+R} = \frac{b5-b4}{b5+b4} \quad \text{(Landsat 8 and 9 OLI)} \qquad (2)$$

The NDVI discriminates land cover categories by segregating the changes in values of the green biomass, the content of chlorophyll and the canopy water stress. The NDVI ranges from -1 to +1 with the highest values indicating vegetated areas like coniferous and deciduous forests while the low values indicate the absence of vegetation, water or built-up (Marina-Ramona and Bogdan-Andrei, 2016).

Accuracy assessment was performed for each of the classified imagery using the post classification comparison. A confusion matrix was generated within ArcGIS 10.5 environment, with each row showing land-use classes in the classified map while each column represented the reference land-use classes. By using the matrix, the user accuracy, the producer accuracy, the overall accuracy (%) and kappa co-efficient (K) were generated for each classified map (Nwaogu *et al.*, 2017).

Change detection analysis

The post-processing technique was used to detect spatial changes in LULC between 1984 and 2024. The rate of change and percent of change were computed for LULC classes by using Equation (3) and (4):

$$\textit{Rate of change} = \frac{Ae_y - Ae_x}{T} \qquad (3)$$

$$Percent\ Annual\ Rate\ of\ Change = \frac{Ae_y - Ae_x}{Ae_x} * 100 \quad (4)$$

Where Ae_x is the areal extent of an earlier land cover image, Ae_y is the areal extent of a later land cover, and T is the time interval between Ae_x and Ae_y in years.

The pattern, location and magnitude of conversion of urban farmlands to other land uses were analysed through the process of topological overlay of the various classified land use/land cover maps generated within the IDRRISI software, which resulted in the generation of a two-dimensional change matrix. These two-dimensional matrix was used to assess the transition between urban farmlands and other land use/land cover, between 1984 and 2013 and between 2013 and 2024.

Results

Accuracy assessment

The results of accuracy assessment as presented in Table 2 indicates a total accuracy of 76.84 %, 80.13%, and 78.65% for the classified images of 1984, 2013, and 2024, while kappa statistics were 0.76, 0.82, and 0.75 respectively. On the other hand the producer accuracy (PA) and User accuracy (UA) for farmlands were 77.59(%), 78.95(%) (1984), 75(%), 78.95(%) (2013), and 79.31% 79.31% (2024) respectively.

Table 2: LULC Accuracy (1984–2024)

		Land use Land cover classes								
Years		BU (%)	FL (%)	LF (%)	OS (%)	SB (%)	WB (%)	WL (%)	Overall Accuracy (%)	Kappa Coefficient (K)
1984	PA	67.42	77.59	91.55	90.67	73.68	58.21	87.32	76.84	0.76
	UA	84.51	78.95	84.42	69.39	65.12	86.67	84.93		
2013	PA	78.42	75.00	86.67	82.09	70.15	67.31	87.32	80.13	0.82
	UA	76.32	78.95	84.42	75.34	72.21	85.37	84.93		
2024	PA	75.28	79.31	86.30	81.08	70.59	82.69	75.53	78.65	0.75
	UA	84.81	79.31	88.31	76.92	82.76	71.67	72.44		

Bu = Built-up, FL = Farmland, LF = Light Forest, OS = Open Space, SB = Shrub, WB = Waterbody, WL = Wetland; PA = Producer Accuracy, AU = User Accuracy

Source: Authors' image analysis, 2024

Spatial distribution of farmlands in Lagos (1984, 2013 and 2024)

As shown in Table 1 and Figure 2, in 1984 farmland covered 20,103.21 ha (12.64%), and in 2013 it constituted 17,484.51 ha (10.69%), while in 2024 it covered 13,674.18 ha (8.36%) of the study area (Figure 2). Thus, it could be observed that between 1984 and 2013 farmlands decreased by -2,618.7 ha (-13.03%) and by -3,810.33ha (-21.79%) between 2013 and 2024, even though between1984 and 2013 other land use categories such as light forest, open space, shrub and waterbody decreased by -23,427.65ha (-69.05%), -3,294.81 ha (-17.74%) and -5,051.88 ha (-16.52 %) respectively. However, between 2013 and 2024 the rate of decrease of farmlands lands has increased to -3,810.33 ha (-21.79%), while other categories of land use such as light forest, open space, shrub and waterbody decreased by -6,410.43 ha (-61.04%) -4750.02ha (-31.08%), -10,738.17 ha (-47.38%) and -3,574.53 ha (-14.00%) respectively. On the other hand, built up increased by as much as 22,538.34 ha (34.22%), while wetland increased by 2,829.96 ha (16.69%) (Table 2).

It could also be observed in Table 1 that between 1984 and 20213 the annual rate of decrease of farmlands was -0.45 while light forest, open space, shrub and waterbody had -2.38%, -0.61%, -1.63% and -0.57% annual rates of decrease. Whereas, within this period waterbody, built up and wetland increased at the average rates of 4.94% and 2.06% per annum. On the other hand in Table 2 between 2013 and 2024 the average annual decrease in farmland had risen to an average rate of -2.42%, light forest, open space, shrub and waterbody decreased at the average rates of -6.78%, -3.45%, -6.36% and -1.56% respectively. However, within this period built up and wetland increased at the average rates of 3.80%, and 1.85% per annum.

Table 3. Spatial extent and rate of change of Farmlands in relation to other LULC between 1984 and 2013

	1984		2013		Change b/w 1984 & 2013		Av. Annual Rate of Change	
LULC	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
BU	27,073.27	16.55	65,856.15	40.27	38,782.88	143.25	1,337.34	4.94
FL	**20,103.21**	**12.29**	**17,484.51**	**10.69**	**-2,618.7**	**-13.03**	**-90.3**	**-0.45**
LF	33,929.64	20.75	10,501.99	6.42	-23,427.65	-69.05	-807.85	-2.38
OS	18,577.35	11.36	15,282.54	9.34	-3,294.81	-17.74	-113.61	-0.61
SR	22,664.79	13.86	11,926.62	7.29	-10,738.17	-47.38	-370.28	-1.63
WB	30,587.1	18.70	25,535.22	15.61	-5,051.88	-16.52	-174.20	-0.57
WL	10,607.06	6.49	16,955.39	10.37	6,348.33	59.85	218.91	2.06
Total	163542.51	100	163542.51	100	-	-	-	-

*LULC = Land use/Land cover; BU= Built-up, FL= Farmland, LF= Light forest, OS= Open space, SR= Shrub, WB = Waterbody, WL = Wetland

Source: Authors' image analysis, 2024

Table 4. Spatial extent and rate of change Farmlands in relation to other LULC between 2013 and 2024

	2013		2024		Change b/w 2013 & 2024		Av. Annual Rate of Change	
LULC	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
BU	65,856.15	40.27	88,394.49	54.05	22,538.34	34.22	2,504.26	3.80
FL	**17,484.51**	**10.69**	**13,674.18**	8.36	**-3,810.33**	**-21.79**	**-423.37**	**-2.42**

LF	10,501.99	6.42	4,091.56	2.50	-6,410.43	-61.04	-712.27	-6.78
OS	15,282.54	9.34	10,532.52	6.44	-4750.02	-31.08	-527.78	-3.45
SR	11,926.62	7.29	5,103.63	3.12	-6,822.99	-57.20	-758.11	-6.36
WB	25,535.22	15.61	21,960.69	13.43	-3,574.53	-14.00	-397.17	-1.56
WL	16,955.39	10.37	19,785.35	12.10	2,829.96	16.69	314.44	1.85
Total	163542.51	100	163542.51	100	-	-	-	-

*LULC = Land use/Land cover; BU= Built-up, FL= Farmland, LF= Light forest, OS= Open space, SR= Shrub, WB = Waterbody, WL = Wetland

Source: Authors' image analysis, 2024

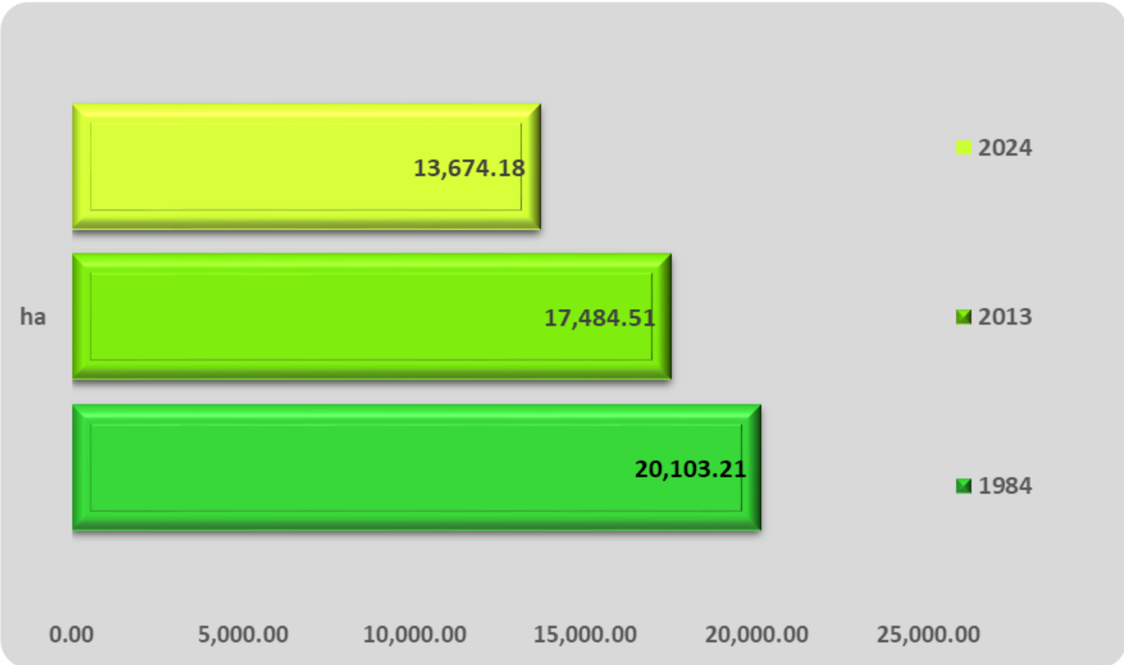
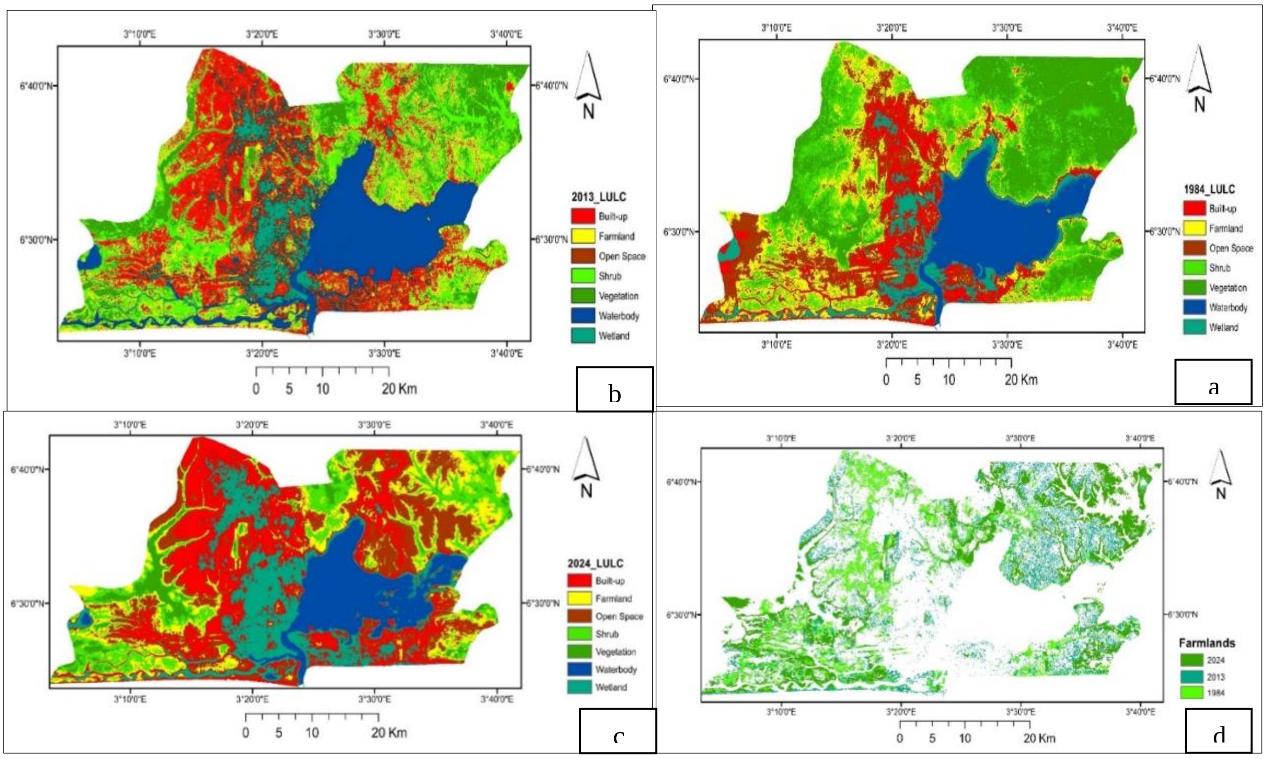


Figure 2: Extent of Urban farmland between 1984 and 2024

Figure 3a indicates that in 1984 farming activities were prevalent in the western part of the city which was then peri- urban in places like Agege, Ikotun Egbe, Isolo Ipaja, and Abule Egba. Indeed as at that time there were commercial farms in Agege Area popular referred to as Oko Oba, as well as at Oke-Afa in Isolo. So also around Iba and present day Lagos State University Campus as well as Ojo military barracks in Ojo Local Government, there were concentration of migrant farmers engaging in vegetable gardening. By 2013 however in figure 3b these urban farms have been edged out of the city centre and driven westward to Ikorodu, Ketu and Ijaye, while by 2024, figure 3c urban farmlands have been completely uprooted from the city centre, and are now confined to intensively cultivated peri-urban water courses and tidal surge wetlands. However, some vestiges of urban farmlands are still to be found at the city centres in form of horticultural, home gardens, beautification and urban greening projects initiated or supported by Lagos State Government.



Figures 3a-d. The spatial pattern of farmlands in the Lagos Metropolis; map (a) 1984 is the base year during which clusters of farmlands carpeted the metropolis; map (b) 2013 indicate the relocation of urban farmlands to urban fringes; map (c) 2024 urban farmlands have relocated to waterfronts and shrinking wetlands; map (d) spatial pattern of urban farmlands within the given period.

Conversion pattern of farmlands between 1984 and 2013

Although urban agriculture is a permanent element of the urban system, its locations within the city may vary over time. Further analysis of urban farmlands as presented in Table 5 indicated that between 1984 and 2013, 2,114.86 (10.52%) of farmlands remained unchanged while as much as 8,118.94 (40.39%) have been converted to built-up, 1,405.21 ha (6.99%) have reverted to light forest, 3,479.87 ha (17.31%) have been converted to open space, 1,397.17 ha (6.95%) to shrub, 1,085.57 ha (5.40%) to waterbody, and 2,501.59 ha (12.44 %) to wetland. In contrast 1,112.71 ha (4.11%) of built-up, 5,045.34 ha (14.87%) of light forest, 1860.54 ha (10.02%) of open space, 4,843.47 ha (21.37%), of shrub, 382.34 ha (1.25%) of waterbody and 2,125.24 ha (20.04%) of wetland were converted to farmland, within this period. So also between 2013 and 2024 (Table 6), as much as 4,631.05 ha (26.49%) of farmlands remained unchanged, while 6,768.93 ha (38.71%) have been converted to built-up, 935.42 ha (5.35%) to light forest, 1,577.51 (9.02%) to open space, 886.46 ha (5.07%) has reverted to shrub, 8.74 ha (0.05%) to waterbody and 2676.4 ha (15.31%) to wetland. Whereas 2,828.25 ha (4.29%), of built-up, 1,385.26 ha (13.19%) of light forest, 591.89 (3.87%) of open space, 2592.56 ha (21.74%) of shrub, 466.3 (1.83%) waterbody and 1178.94 (6.95%) of wetland were converted to farmlands.

Table 5. Pattern of Conversion of Farmlands between 1984 and 2013

		Land use/Land cover classes of 2024 (ha)							
	LULC	Built-up	Farmland	Light Forest	Open space	Shrub	Waterbody	Wetland	TOTAL
Land use/Land cover classes of 2013 (ha)	BU	**56,427.87**	2,828.25	6.59	4,350.94	645.39	731	866.11	65,856.15
		85.68%	4.29%	0.01%	6.61%	0.98%	1.11%	1.32%	100
	FL	6,768.93	**4,631.05**	935.42	1,577.51	886.46	8.74	2676.4	17,484.51
		38.71%	**26.49%**	5.35%	9.02%	5.07%	0.05%	15.31%	100
	LF	4,140.76	1,385.26	**1471.86**	684.73	1,020.79	445.89	1,352.70	10,501.99
		39.43%	13.19%	**14.02%**	6.52%	9.72%	4.24%	12.88%	100
	OS	12,487.84	591.89	1.53	**1,265.80**	92.56	61.13	781.79	15,282.54
		81.71%	3.87%	0.01%	**8.28%**	0.61%	0.40%	5.12%	100
	SR	3,820.37	2592.56	814.59	735.87	**1,535.63**	10.73	2,416.87	11,926.62
		32.03%	21.74%	6.83%	6.17%	**12.88%**	0.09%	20.26%	100
	WB	2212.24	466.3	61.28	852.87	107.25	**20,091.11**	1,744.17	25,535.22
		8.66%	1.83%	0.24%	3.34%	0.42%	**78.68%**	6.83%	100
	WL	2,536.50	1178.94	800.29	1,064.80	815.55	612.09	**9,947.31**	16,955.48
		14.96%	6.95%	4.72%	6.28%	4.81%	3.61%	**58.67%**	100
	TOTAL	88,394.51	13,674.25	4,091.56	10,532.52	5,103.63	21,960.69	19,785.35	163,542.51

*LULC = Land use/Land cover; BU= Built-u, FL= Farmland, LF= Light forest, OS= Open space, SR= Shrub, WB = Waterbody, WL = Wetland

Source: Authors’ image analysis, 2024

Table 6. Pattern of Conversion of Farmlands between 2013 and 2024

		Land use/Land cover classes of 2013 (ha)							
	LULC	Built-up	Farmland	Light Forest	Open space	Shrub	Waterbody	Wetland	TOTAL
Land use/Land cover classes of 1984 (ha)	BU	**20,197.19**	1,112.71	1,156.03	2,312.64	671.42	502.42	1,120.79	27,073.20
		74.60%	4.11%	4.27%	8.54%	2.48%	1.86%	4.14%	100
	FL	8,118.94	**2,114.86**	1,405.21	3,479.87	1,397.17	1,085.57	2,501.59	20,103.21
		40.39%	**10.52%**	6.99%	17.31%	6.95%	5.40%	12.44%	100
	LF	**14,124.92**	5,045.34	**4,018.94**	1,297.83	5,402.76	135.72	3,904.13	33,929.64
		41.63%	14.87%	**11.84%**	3.83%	15.92%	0.40%	11.51%	100
	OS	6,843.82	1,860.54	1,008.75	**4,464.54**	1,648.95	1,233.54	1,517.21	18,577.35
		36.84%	10.02%	5.43%	**24.03%**	8.87%	6.64%	8.17%	100
	SR	9,880.75	4,843.47	2,703.91	1,280.56	**1,939.78**	448.76	1,567.63	22,664.86
		43.59%	21.37%	11.93%	5.65%	**8.56%**	1.98%	6.92%	100
	WB	1,599.71	382.34	21.41	1,076.67	159.05	**21,776.28**	5,571.64	30,587.10
		5.23%	1.25%	0.07%	3.52%	0.52%	71.19%	18.22%	100
	WL	5,090.82	2,125.24	187.74	1,370.43	707.49	352.93	**772.41**	10,607.06
		47.99%	20.04%	1.77%	12.92%	6.67%	3.33%	**7.28%**	100
	TOTAL	65,856.15	**17,484.51**	10,501.99	15,282.54	11,926.62	25,535.22	16,955.48	163542.51

*LULC = Land use/Land cover; BU= Built-u, FL= Farmland, LF= Light forest, OS= Open space, SR= Shrub, WB = Waterbody, WL = Wetland

Source: Authors’ image analysis, 2024

NDVI assessment of the status of urban farmlands in Lagos Metropolis

NDVI has often been used by researchers as a measure of healthiness or greenness of plants. This is because healthy vegetation which has been shown to be rich in chlorophyll absorbs more wavelength of blue and red portion of visible spectrum and reflects more in the green and near infrared wavelength regions (Jagadish *et.al.,* 2019) ,Table 4. Hence, in this study NDVI was used to assess the status of urban farmlands in the study area. In the year 1984 (Figure 4a-c) NDVI ranges between -0.09 to 0.36 indicating a typical urbanised environment, even though it could be observed on the NDVI map that the practice of urban farming was wide spread in that year. In contrast, in the year 2013 the index ranges between -0.01 to 0.49, an indication that there was improvement in the health status and environmental condition of urban farms. It should also be noted that 2013 was the year following 2012 during which there was an unusually high flooding incident in Lagos Metropolis (Oshodi, 2013). Therefore, while urban farming have become a peri urban activity by that year (Figure 4b), more water courses and wetlands might have enhanced the health and environmental conditions of urban farmlands However, ten years after, by 2024 the NDVI ranges between 0 and 0.24 indicating a deterioration in the environmental condition of the farmlands and the attenuating effects of highly urbanised environment with the attendant soil degradation and desiccation of the crops planted on the farms.

Table 7: NDVI Values and Health Status of Plants

NDVI Values	Health Status of Plants
-1 to 0	Dead plants, bare land or impervious surfaces
0 to 0.33	Unhealthy or stressed plants
0.33 to 0.66	Moderately healthy plant
0.66 to 1	Very healthy plants

Source: (Jagadish *et.al.,* 2019)

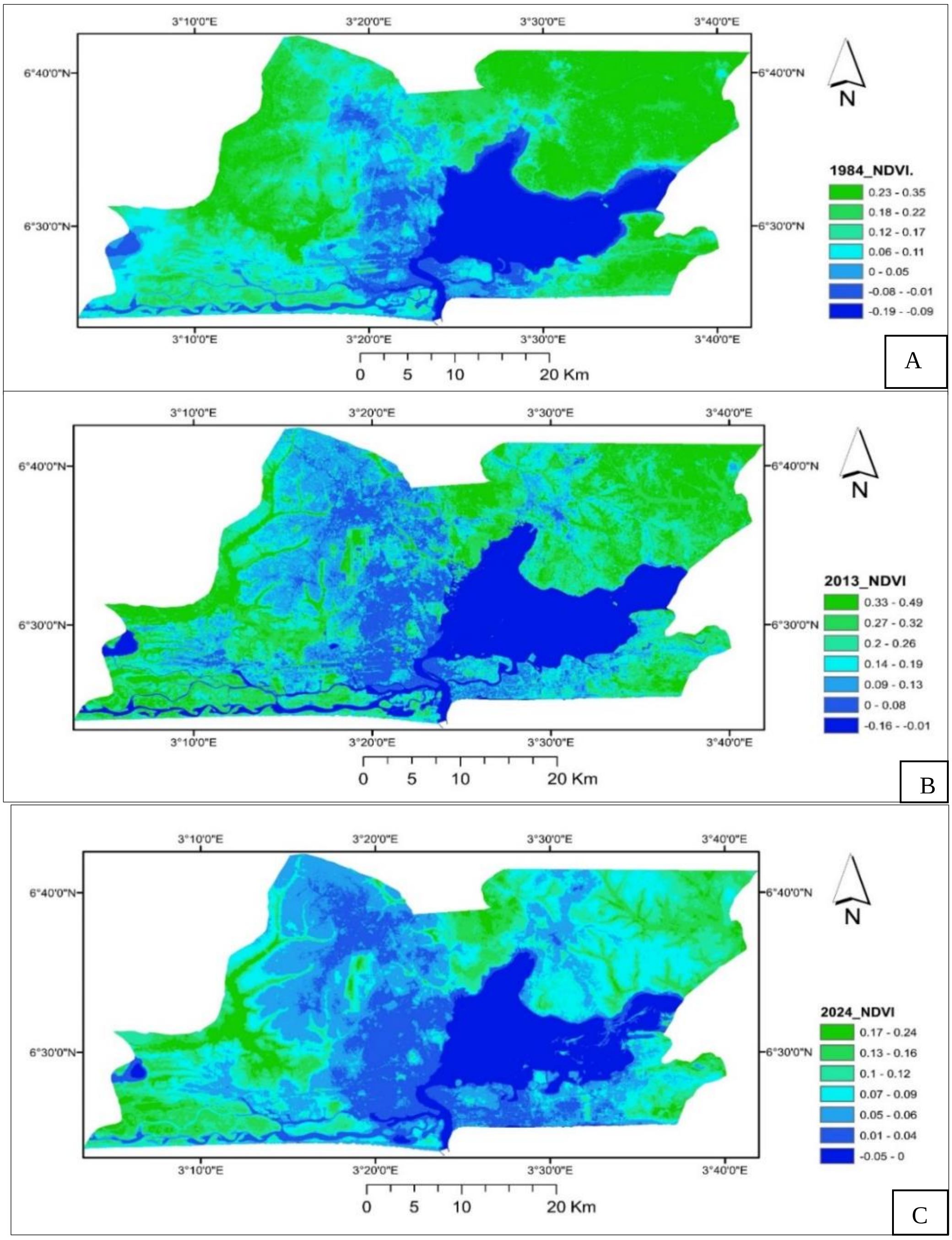


Figure 4a-c: Temporal variation of NDVI between 1984 and 2024 as an indication of the status of urban farming in Lagos Metropolis

Discussion

Implications of the spatial patterns of urban farmlands for food security

This study established the fact that the practice of urban farming have been declining progressively within Lagos Metropolis as a result of conversion to other land uses, especially residential estates and infrastructure. Although the practice of urban farming is gradually being embraced as a livelihood strategy in the Metropolis, as can be seen from the reduction in the conversion pattern above between 2013 and 2024, more farmlands are being converted to built-up than any other land use type. The NDVI analysis carried out in the study indicated that even where the practice of urban farming is being sustained in the city the environmental condition of the farmlands has deteriorated and by extension the quality and yield of crops.

The results of this study reinforce the findings of earlier scholars on the status of urban farming in metropolitan cities across the global south (Addo, 2010; Azunre *et.al.,* 2019; Osayomi and Lawanson, 2022). Even though the call for sustainable cities has become quite passionate, urban farming is increasingly under significant threat from other competing urban land uses, especially urban built up which has continued to consume more and more lands at the expense of other land uses. Therefore, one of the greatest constraints to the widespread adoption of urban farming is the challenge of access to land, for those who would like to engage in the practice, particularly where the production functions are competing with commercial developments that provide greater profit for the landowner (Azunre *et.al.,* 2019). Marginalized groups and minority populations are particularly vulnerable to the problem of land access and security, since they often do not have the means to purchase land (Redwood, 2009). Thus urban farming as practiced in most cities of developing countries, remain a survivalist enterprise, undertaken by people unable to secure a regular wage employment or access to an economic sector of their choice.

The concern expressed about the fate of urban farming and food security is not limited to cities in developing countries of the global south. Djan (2023) in a review of literature identified decline in both the quantity and quality of cultivated land, as a potential threat to China's food security. Conversion of agricultural land to urban uses resulting from rapid growth and escalating land values threaten farming on prime soils, while existing farmland conversion patterns often discourage farmers from adopting sustainable practices and a long-term perspective on the value of land. At the same time, the close proximity of newly developed residential areas to farms increases public demand for environmentally safe farming practices (Dresher 2003). Comprehensive new policies to protect prime soils and regulate development are therefore needed to sustain the practice of farming in the city. By encouraging farmers to adopt practices that reduce use of chemicals and conserve scarce resources, sustainable agriculture research and education can play a key role in building public support for agricultural land preservation.

Addo (2010), in a study carried out in Accra, the capital city of Ghana, identified reliable data on the extent of urban/peri-urban areas being used for farming, spatial distribution of such areas, types of crops and proximity to market places as challenges to urban food systems. According to FAO, the World Bank and RUAF (2017) in a recent collaborative work on urban food system advocated for the use of geospatial technologies, such as Geographic Information Systems (GIS), the Global Positioning System (GPS), remote sensing and drones for mapping food supply chains or identifying the location of food deficient and food junks areas across cities. This study is a response to this identified gaps in literature.

Conclusion

Findings from the study showed that farmlands in the study area decreased by 13.03% between 1984 and 2013 and by 21.79% between 2013 and 2024. So also between 1984 and 2013 as much as 89.48% of farmlands had been converted to other land uses while only 10.52% remained unchanged and between 2013 and 2024 as much as 75.64% had been converted to other land uses while 24.36% remained unchanged. The results indicated that the land available for urban farming is shrinking due to pressure from rapid urbanization, displacement by land speculators, and increased incident of flooding as a result of climate change. Deliberate efforts are therefore required to attenuate this potential threat to urban food security in Lagos Metropolis.

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