Evaluation of land use change pattern of Kajulu-Riat hill peri-urban area near Kisumu City, Kenya

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Abstract

Land-use and land-cover changes are so pervasive that, when aggregated globally, they significantly affect key aspects of the Earth's ecological integrity and ecosystem functioning. Such changes determine the vulnerability of places and people to climatic, economic or socio-political perturbations. This paper seeks to examine the pattern of land use change in a peri-urban set-up of Kajulu-Riat hill in Kisumu City, Kenya. The geographic information system technique of remote sensing was employed to evaluate land use land cover changes. Analysis of driving factors on land use change was done through survey and review of secondary data. The results showed a continous increase in Built-up land cover with a continous decrease in bush land. Other land uses affected by increase in built up are crop land and bare land covers. The results indicate the need for appropriate land use planning decisions at various spatial levels to minimize future unsustainable land use changes.

Keywords: Land use; Land cover classification, Remote sensing, peri-urban, GIS

1. Introduction

Space necessities development in cities is much related to the population growth, whether natural growth or because of immigration, this is done with invasion into empty land/plots outside the already congested City. This result into land use change which is an inevitable consequence of economic activity. Such changes determine, in part, the vulnerability of places and people to climatic, economic or socio-political perturbations (Kasperson and Kasperson, 2001).

The UN Population Division projects that between 2007 and 2050, the world's urban population will increase by more than 3 billion, with almost all future population growth expected to take place in the cities and towns of developing countries (UN, 2011). Recent studies suggest a significant increase in land requirements for urban uses in the next 40 years – potentially an additional 100–200 million hectares (Bettencourt *et al.,* 2007). This increase is expected to occur primarily in sprawled patterns (Lobo *et al.,* 2010). It is the concentration of population, economic activities and wealth generation in urban areas that drives the impacts on the global environment. Demands for food, energy, water and production materials also have significant consequences for land-use change around the world (Grimm *et al.,* 2008).

According to the World Bank, Kenya's population is growing fast, increasingly so in urban areas. Every year more than 250,000 Kenyans are moving to urban areas and formerly rural areas are becoming increasingly urban (World Bank, 2012). Kisumu City which is the third largest City in Kenya after Nairobi and Mombasa has been experiencing a more or less steady population increase since 1948. Between the years 1948 to 1969 its population was growing at the rate of 5.7% per annum (Wera, 1981). Between the years 1969 to 1979 the increase was at the rate of approximately 5.0% and by 1979 the city had a population of 152,643. The City is still experiencing a high rate of population increase estimated to be 2.8% per annum well above the international rate of 1.33%. The total population of the municipality is estimated to be about 500,000 people (GOK, 2012). It is estimated that approximately 55% of Kisumu Municipality's population has grown due to natural increase while 25% due to rural-urban migration (GOK, 2012).

The Kisumu Integrated Development Plan 2013-2017 recognizes urbanization and environmental degradation as some of the challenges that the city faces (CGK, 2013). Sensitive ecological zones such as wetlands (e.g. at Obunga, Nyamasaria and Dunga) and forested hilly slopes such as the Riat and Kajulu hills are being degraded to create room for housing and commercial business development. The main objective of the study was to examine the trend in land use change pattern in the peri-urban establishment of Kajulu and Riat hills. The study further investigated the socio-demographic characteristics of the area in order to determine other factors influencing land use change in the study area.

The study focused on Riat and Kajulu hills peri-urban which are located immediately after the old Municipal boundary and approximately 10 km from the Kisumu City Central business district. The two suburbs which were formerly rural were found to attract more settlers and development with time, real estate development was the major investment that had gained momentum. Peri-urban areas have been often ignored by urban planning professionals and city managers, (Grimm et al., 2008), in Kisumu the situation is no difference especially given the fact that land holding in these areas is on private and customary basis. Achieving sustainability in these areas require an urgent need for spatially explicit and interdisciplinary research to

provide a better understanding of the land use change processes, analysis of past and current trends of land use change and the effect of cities expansion on the peri-urban zones.

Similar study done in the City of Ibadan in Nigeria between 1972 and 1984 showed a total of 205.73 2 km² of vegetal cover has disappearance for urban development (Oluyesi, 2006). A study in Nairobi by (Bosco et al., 2011) also showed riverine vegetation and forest land decreasing in a real coverage by about 67 and 60%, respectively, while barren surfaces and urban areas increased by more than 100 and 98%, respectively, between 1976 and year 2000. This study sought to examine the pattern of land use change in a peri-urban set-up of Kajulu-Riat hill in Kisumu City, Kenya. Kajulu-Riat hill is a unique site with both rural and urban features. The area therefore experience mixed land use activities, land use management is key in disaster risk reduction thus called for research on the trend in these land uses in the area.

2. Materials and methods

2.1 Description of the Study Area

Kisumu City is the third largest town in Kenya and the principal town in the Western part of the country. It stands on the shores of Lake Victoria, the second largest fresh water lake in the world, at an altitude of 1160 m above sea level. Kisumu City is situated approximately 00^0 06' South of the Equator and 34^0 45' east of Greenwich. It is connected by rail, road and air to major cities and towns in Kenya like Nairobi, Nakuru, to the east Eldoret to the north east Busia to the West and Kakamega to the North. The town covers an area of approximately 417 Km², of which 35.5% is under water. Similarly, Kisumu also experiences a wide mean annual range of temperatures. It has a maximum annual temperature that range from 25ºC to 30ºC while the mean annual temperature ranges from 18ºC to 20ºC (Wera, 1981).

The Riat and Kajulu Hills peri-urban is located approximately 8 km from Kisumu City Central business district. The area is characterized mainly by mixed land use which includes empty parcels of plots on the hill slopes occupied by shrubs and trees, agricultural, hospitality industry, residential development with some commercial and industrial land uses. The study area is also the main source of sand and rocks used in various construction activities in the City. Land in the area is mainly owned on customary basis although private holding system is increasing. Currently the Riat-Kajulu hill area has attracted a lot of interest due to its location which offers a beautiful view of the Winam Gulf of Lake Victoria and Kisumu City down slope.

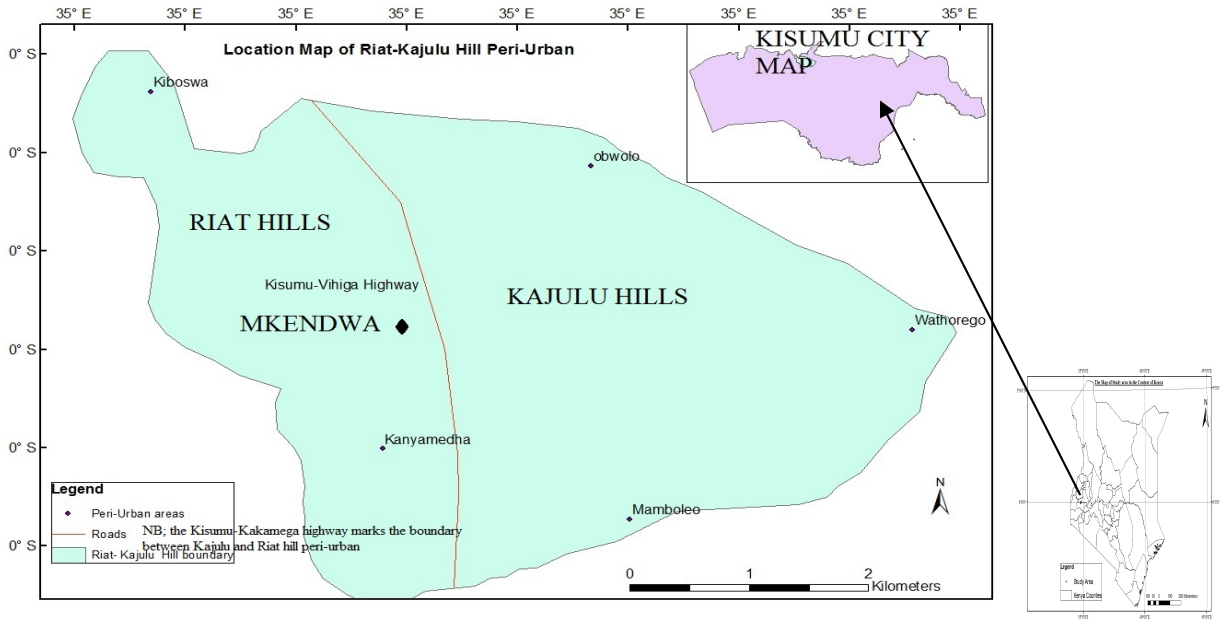


Figure 3.1: Study area map (Source: Rakama, 2017)

2.2 Land use/land cover classification

A multi-temporal set of remote sense data of the area of interest was used to study and classify land cover (Lucas et al., 2007). This dataset included satellite imageries (1985, 1995, 2005 and 2015) from the United States Global Survey (USGS). Digital image-processing software ERDAS imagine (v. 2015) and (Arc GIS v.10) was used to Process, analyse and integrate the spatial data and geographic information so as to achieve the above mentioned goals. All the aerial photos, satellite images and maps produced were geo-referenced in the Universal Transverse Mercator (UTM) projection with datum World Geodetic System (WGS) 1984 UTM zone 36S for Kisumu City. Table 1 captures the main characteristics of the aerial photographs used.

Table 1: List of satellite images collected for the study area.

Satellite data	Date	Time of capture	Spatial resolution	Producer
Land sat 5- TM	5th March 1985	1106 Hrs	30 m	USGS Global Visualization Viewer
Landsat 5-TM	2nd April 1995	1232 Hrs	30 m	USGS Global Visualization Viewer
Landsat 5-TM	6th April 2005	1133 Hrs	30 m	USGS Global Visualization Viewer
Land sat 8. 0LI/TIRS	15th August 2015	1213 Hrs	30 m	USGS Global Visualization Viewer

To mitigate the seasonal effects, which often lead to errors in change detection, images used were those captured in different years but during the same season. Image classification was done through Arc GIS and using supervised approaches, four classes were defined; bushes, built-up, bare soil, and crop-land.

2.3 Change Detection and analysis

From the above described dataset of multi-temporal classified images, the process of digital change detection developed allowed to determine and describe changes in land cover between three fundamental intervals: 1985÷1995, 1995÷2005 and 2005÷2015. "Post classification comparison" was used in change detection on the land use imageries (Ward *et al.,* 2000). Such approach allows determining the difference between independently classified images from each of the dates in question and it is the only method in which "from" and "to" classes can be calculated for each changed pixel. This method offers the advantage to allow the creation and the update of GIS databases, as class/categories are given, and quantitative values of each class can be determined.

Jointly with "Post-classification comparison", a GIS approach (Taylor *et al.,* 2000) was combined, to efficiently integrate land cover maps and to quantitatively reveal the change dynamics in each category. The advantage of GIS techniques is not only linked to exploitation of database capabilities, but also to the ability to manage different land cover maps by means of typical vectorial operators like "intersect" and "union", in order to easily evaluate the amount of change (Petit and Lambin, 2001). It was possible to determine the changes in land cover at different years from 1985 to 2015. In addition to ERDAS Imagine, ESRI Arc GIS Desktop (v. 10) was used to analyse and integrate land cover maps and extract the GIS layers describing changes and dynamics of land cover (Fichera *et al.,* 2011).

2.4 Socio-demographic characteristics

Demographic and socio-economic data of the study population was collected through field survey to assess the decision variables and underlying factors of the land use change process. The sample consisted of 384 respondents from the local community in the study area. The demographic characteristics considered for this study include: occupation, education level, land tenure system and the household monthly income. These were used to cross-tabulate the responses for analyses which were done to establish relationships between them and the variables on the main issues of peri-urban land use and land cover change dynamics in the study area.

3. Results and Discussions

Four different land cover maps were produced. The 1985, 1995, 2005 and 2015 maps (Figure 1), originally in raster format (30 m pixel resolution), were converted into the shape file (*.shp) vector format. Post-classification comparison was done to efficiently integrate land cover maps and to quantitatively reveal the change dynamics in each category. The four land cover classes were defined according to European Environment Agency: (Built-up) surfaces Consisted of Urban fabric, Industrial, commercial and transport units, mine, dump and construction sites, and artificial non-agricultural vegetated areas. (Crop land) consisted of arable land, permanent crops, pastures and heterogeneous agricultural areas. (Bushes) consisted of Forests, shrub and/or herbaceous vegetation association. (Open/barren) areas consisted of open spaces with little or no vegetation, beaches, dunes sands, bare rocks, sparsely vegetated areas.

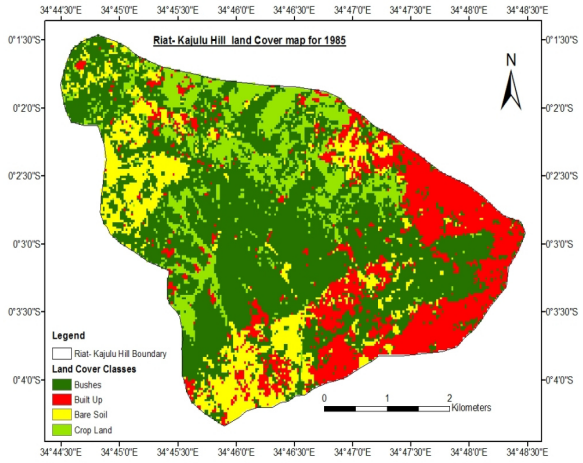
3.1 Land use trends The results indicate that urbanization has considerably modified the land cover of the study area, with significant land conversions. In particular, during the three decades analyzed, the built up land cover type has almost tripled passing from 4926 hectares to 13392 (from the 20.13% to the 54.73% of the total area of study), mostly at the expense of the cultivated areas, bare soil and areas with trees and shrubs, which have most suffered the effects of the expansion of the built-up areas (Table 1, Figure 1).

Table 1: Area statistics of the land use and land cover units from 1985-2015

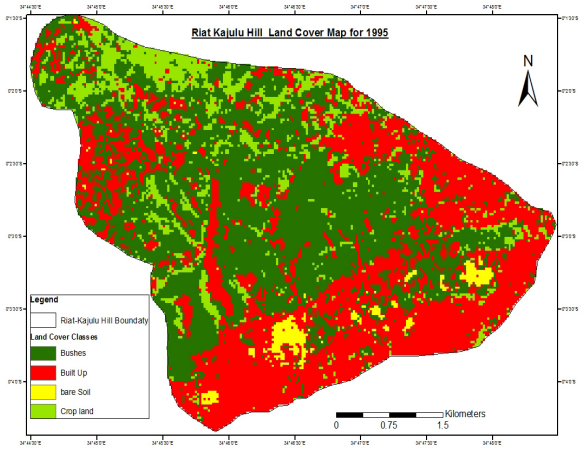
Land cover Classes	1985		1995		2005		2015	
	Area (M^2)	%	Area (M^2)	%	Area (M^2)	%	Area (M^2)	%
Bushes	12629	51.62%	11408	46.62%	9278	37.92%	6592	26.94%
Built Up	4926	20.13%	9444	38.60%	12347	50.46%	13392	54.73%
Bare Soil	3533	14.44%	515	2.11%	216	0.88%	780	3.19%
Crop Land	3380	13.81%	3101	12.67%	2627	10.74%	3704	15.14%

The increase in built-up land use can be explained by the proximity of the study area to Kisumu City which has over 500,000 inhabitants. Kisumu city is currently in a territorial continuity with the main establishment of ultra-modern real estate being done within Kajulu–Riat hill. According to Bhatta, (2009), the transformation of urbanized areas is generally related to population dynamics which drives the built-up area to expand. The growth rate of urbanized areas in the study area could also be attributed to ineffectiveness of Master Plans, which haven't allowed a reduction in house cost and encouraged people to build in the countryside where construction is often cheaper. Another aspect could be related to the low quality of neighbourhoods built in last decades (i.e. lack of parking and green spaces), that has led to many citizens to live in the countryside where there is space.

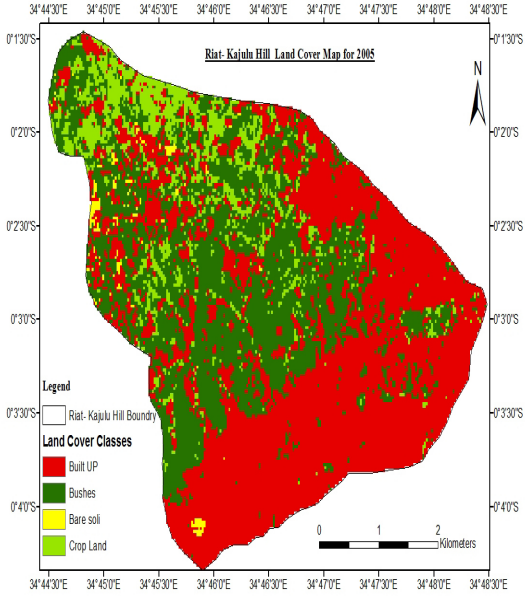
Figure 1 depicts changes and dynamics of land cover that happened during the overall period (1985÷2015), which shows bare land as almost insignificant with the trend of bushes and crop-land concentration around built-up land use by 2015. This could be attributed to the increase in trees and crops being planted near houses, along roads and other built-up establishments together with the influence of agro-forestry practices; a clear indication of increased inhabitation in the area.



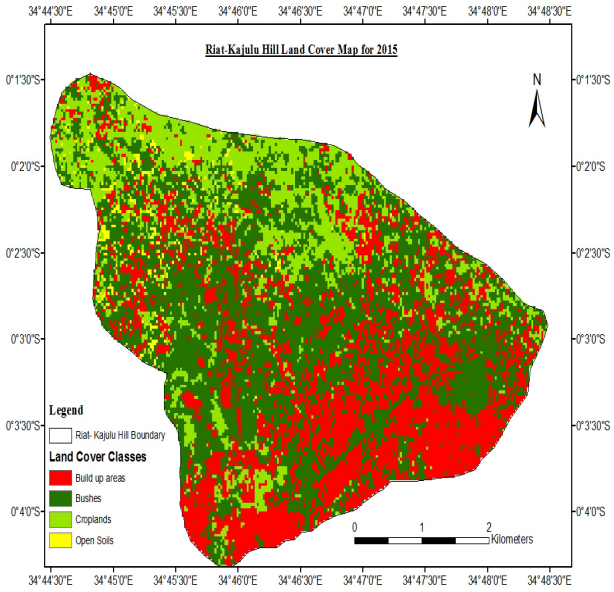
(a); Land use map for 1985



(b); Land use map for 1995



(c): Land use map for 2005



(d); Land use map for 2015

Figure1: Land Cover Map of Riat-Kajulu Peri-urban in Kisumu City for 1985 , 1995 , 2005 and 2015 .

Continued decrease of bush land could be attributed to a trend of vegetation clearance to pave room for real estate development. From the analysis of respondents' views on the major drivers of land use change, real estate establishment was viewed as the leading force in the degradation of plant biodiversity in the study area. This finding is in agreement with (Liu and Diamond, 2005) who in their study on urban land cover in china find out that much of deforestation was for residential, industrial and commercial use rather than for agriculture. It is evident that plant biodiversity conservation is facing competition from other socio-economic needs such as housing. The study revealed that land use change pattern was influence by the` land economics` factors whereby; Land owners and land managers, operating within certain constraints, make decisions regarding transformations in land uses, based on factors that are largely political and socio-economic; however in most cases economic rationality has been the main driver (Irwin and Geogeghan, 2001). These are invariably defined within a range of directly related variables such as subsidies; rent prices, land values and

the associated benefits of space in preferred areas (Patrick *et al*., 2015). Under these conditions, pertinent non-market/noneconomic factors including, environmental conditions and societal decision making systems are not often considered (Owusu, 2008).

Crop land showed continous decrease which can be explained by the competition for the same land by urban development and agriculture. From the analysis of socio-economic data on livelihoods, small scale agriculture was found to be an important source of livelihood in the study area. Cities expansion has typically taken place on former agricultural use. Just to mention some data, the amount of land consumed by urban areas and associated infrastructure throughout Europe was about 800 km² between 1990 and 2000 (EEA, 2006). Moreover, population outside central cities has grown faster than downtown areas in many developed and developing regions, demonstrating a certain tendency of the outward expansion of urban areas (Angel *et al.,* 2005). In fact, several cities are quickly growing at their fringes, transforming the surrounding rural areas into dense industrial and commercial ones, or less dense suburban developments (Huang *et al.,* 2012). Particularly, in Kajulu-Riat hill experience, it is possible to observe over the years an increase of the pressure on countryside due to land renting and displacement of some typical functions outside the cities.

This increase of bare land in 2015 could be attributed to establishment of various rock and sand mining sites in the study area in 2010 which has led to intensive mining. From the key informants, the study area was the main source for sand and rocks used in construction within the City. According to Mwanje and Nathan, (2015), Kisumu city relies on a bit of mining as a means of economic development, more especially the Mamboleo murram extraction site which is situated within the study area. Initially miners used crude equipments to extract murram, such equipments were greatly slow thus covered smaller areas. However the emerging trend whereby rich miners often rent from local site murram owners, the extraction is done on a wider scale due to use of machineries. Some bare lands in the study area were deserted after mining which formed points of stagnant water collection.

3.3 Human influence on Land use change process

Human socio-cultural and economic characteristics have been extensively investigated as a potential strong control over urban land use change (Luck *et al.,* 2009). Analysis of socio-demographic data from the respondents showed small scale farming is an important source of livelihood in the study area (32.3%) with other occupations including self-employment (29.9%). Those who fall in the self-employment cadre in the study area included traders, miners, riders and mechanics. The results showed statistically significant difference among the occupations $\chi^2 = 23.688$, $p<0.05$ which shows small scale farming was an important source of livelihood in the area. However crop farming is becoming economically unreasonable in the study area due to subdivision of land to settle the increasing urban population. This is the reason why other form of livelihoods such as small scale business are reported in higher percentage in the area Majority of the population in the study area earn low average monthly income of less than Kshs. 10,000 (42.7%), with less than 25% earning an income of above Kshs.30000.

The customary land tenure system dominates in the study area (44%) followed by private land tenure system (26%), the trust land (22%) while the public land recorded 8% of the respondents. The (26%) of private tenure may mean that many people are buying land in the area for settlement from other areas or the customary land is being subdivided among family and clan members to cater for the changing demands of land in the area.

Statistical significance difference in the land tenure system of the area was, $\chi^2 = 100.875$, $p<0.05$ a clear indication that more people were buying land in the area. According to Wamukaya (2008), in the peri-urban areas of Kisumu city, successive local authorities have shown an apparent weakness in controlling or guiding urban land use development. Property owners can do as they wish with their lands subject to family and communal obligation that may apply depending on the prevailing land tenure. Municipal officials have found it nearly impossible to achieve harmony, delight and efficiency in the planning process when ownership of large parcels of land adjacent to the city is held under customary tenure.

Majority of the respondents had stayed in the study area for 15 to 20 years (30.2%). Those who had stayed in the study area for more than 20 years were 35.4%, the result was significant different $\chi^2 = 132.177$, $p<0.05$. This is a clear indication of the increasing migration of people to the Kajulu – Riat area for settlement; meaning that the population growth in peri-urban areas of Kajulu in Kisumu City is highly due to migration than birth rates from original residents. The rising land prices in the city centre may have caused many middle and low-income earners to migrate to peri-urban areas and fringes, where cheaper land is available. Environmental dynamics and constraints such as fixed geographic features such as a hill have shaped the pattern of urban development in Kajulu-Riat peri-urban. The Kajulu – Riat hills peri-urban has attracted real estate development for the middle and high class citizens due to its aesthetic view of Kisumu city and the winam gulf of lake Victoria. The Riat Kajulu hills offer a panoramic view of Kisumu town, from certain areas one can see breathe taking views of the sunset, which is reflected on the waters of Lake Victoria. Some of the residential estates in the area include "*Uhura estate, Uzima estate, Kajulu estate, Kanyakwar and Kanyamedha* estates off Kisumu Kakamega Highway". According to Simon (2008), peri-urban areas are increasingly attracting middle-class and higher income people whose lives exhibit lifestyles reflective of inner-city dwellers in a predominantly rural setting.

Conclusions and recommendations

Urban land use is increasing in Kajulu peri-urban area while agricultural and forest land use is reducing. Land-use activities, most of which involve converting natural landscapes for human use, have changed a large percentage of land cover of Kajulu-Riat hills area. Deforestation, expanding built environments are human actions which are changing the land use in essentially irreversible ways. Built environments, in particular, increase vulnerability to extreme events such as heavy rainfall due to the diminished absorptive capacity of the land. Land-use change is associated with rainfall-runoff transformation and hydrologic routing of the run-off which are key considerations in flood risk management.

Throughout the study however, the role of the Kisumu County government through its town planning and environment department was silent. The county assembly of Kisumu needs to regulate and oversee the management of land use. Land use arrangements such as agro-forestry should be integrated with other land uses to ensure environmental sustainability even as the City expands to former rural areas.

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