Patterns and Drivers of Land Development in (Greater) Eastern Bypass Peri-Urban area of Metropolitan Nairobi

Kinuthia, H[1,2], Majale, C[2], Letema, S[2].

[1] Kenyatta University, KENYA [2] Kirinyaga University, KENYA

Correspondence: hkinuthia@kyu.ac.ke

Abstract

Peri-urban areas are transitional zones characterised by subdivision of agricultural land to urban plots which foreruns sprawled development. Whereas forms of urban sprawl and patterns are well articulated in the literature, the drivers are not explicitly linked to the patterns. This paper asserts that in absence of systematic planning, development control and provision of basic environmental infrastructure to guide development; peri-urban land development is shaped by different drivers at different developmental period depicted by organic growth patterns. This paper examines pattern and drivers of land development in (Greater) Eastern Bypass peri-urban areas of Nairobi Metropolitan area over the last two decades. Overlay of subdivision shape files and satellite images for the period 2000 to 2020 at intervals of five year intervals are used to depict pattern of development. Leapfrog measure for the land abutting the major roads is calculated to determine the rate of development. Maps on development patterns are overlaid with utility and amenities maps to relate patterns and drivers. The different patterns of development observed at different period are attributable to drivers such as developed road infrastructure, history of the place, availability of amenities and utilities. Leapfrogged development characterized by clustered and dispersed settlements marks onset of development in the peri-urban area, but decreases over time depending on development of basic infrastructure. Increased land subdivision triggered by speculation does not imply readiness of land for development, but it foreruns land conversion and leapfrog development. Land development should be preceded by planning of land use and provision of basic infrastructure, amenities and services to reduce the effects of sprawled urban expansion.

Keywords: Peri-urban, leapfrog development, drivers, development patterns

Received: Sept 7, 2022

Accepted: 17, Sep 2022

Published : 9th Nov 2022

Introduction and Background

Peri-urban areas are transitional zones that are shaped by political, economic and social factors that are specific to each country (Kombe, 2005; Doan & Oduro, 2012; Jimu, 2017; Varkey & Manasi, 2019). These zones are areas where cities and rural villages merge through integration of urban and rural economies and expansion of urban infrastructure (Varkey & Manasi, 2019). The process of peri-urban land development is seamless, but sometimes characterized by discontinuous and leapfrog development (Heim, 2001; McGregor et al., 2012; Doan & Oduro, 2012). The changing patterns in land development shapes the character of peri-urban land (Webster & Muller, 2009; McGregor et al., 2012). Population pressure due to rural-urban migration and inadequate land use planning are viewed as causes of leapfrog development in peri-urban of African cities (Doan & Oduro, 2012; Dekolo et al, 2015; Cobbinah & Aboagye, 2017). On the contrary, cities in China experience leapfrog expansion due state-led extension of urban infrastructure to increase land under investment leading to oversupply of land for urban use in the peri-urban (Yue, 2013; Tian et al., 2016). That urban expansion in developing countries is perceived to be amorphous due to reduced capacity of governments to plan and provide infrastructure (Doan & Oduro, 2012; Dekolo et al., 2015) partly explains the growth of informal settlements in the peri-urban of African and Latin American cities (Doan & Oduro, 2012; Cobbinah & Aboagye, 2017; Baye et al., 2020).

Development patterns, ribbon, dispersed, radial, cluster and compact, are discernible and attributable to various growth drivers (Doan & Oduro, 2012; Baye et al., 2020). Several scholars have described the peri-urban of African cities as characterized by leapfrog development that is reminiscent of non-contiguous and unplanned growth (Cobbinah & Aboagye, 2017; Dekolo et al., 2015; Doan & Oduro, 2012; Salem, 2015). Leapfrog development is defined as sporadic physical development induced by commercial and residential activities in the peri-urban causing inefficient use of land (Doan & Oduro, 2012; Yue, 2013). Leapfrog, strip, non-continuous low-density development are viewed as the major spatial forms of urban sprawl (Aldosary & Khan, 2010; Heim, 2001) attributed to lack of systematic planning of peri-urban land (Baye et al., 2020; Varkey & Manasi, 2019; Webster & Muller, 2009). The character of peri-urban land is shaped by three attributes, spatial appearance resulting from land development, peri-urban life i.e. interplay between land uses and activities, and peri-urban change i.e. drivers and temporal aspects of change (Varkey & Manasi, 2019; Kleemann et al., 2017; Woltjer, 2014). In many African cities, peri-urban space is on demand for residential use to cater for rural-urban migration (Nuhu, 2019). Management of growth in the peri-urban areas require an integrated approach of all activities, land uses and the changes happening on the available land (Clawson, 2013; Tian et al., 2016). Leapfrog, ribbon, clustered and low density development seen during urban growth is temporary, transitional and its extent depends on drivers that trigger development in a given area (Heim, 2001; Aldosary & Khan, 2010; Zhang et al., 2017). Land

speculation, zoning policies and expansion of urban infrastructure have been viewed as key drivers of leapfrog development in peri-urban areas (Yue, 2013; Kleemann et al., 2017; Zhang et al., 2017; Varkey & Manasi, 2019). However, different authors have also attributed it to high urban poverty leading to search for cheaper shelter in the peri-urban (Kombe, 2005; Doan & Oduro, 2012; Dekolo et al., 2015; Salem, 2015; Baye et al., 2020). History of a place, customary land tenure system, rural land reclamation and global investment are also described as having significant influence on peri-urban leapfrog development (Kombe, 2005; Doan & Oduro, 2012; Kleemann et al., 2017; Baye et al., 2020).

Extension of government programs and subsidies into the peri-urban in areas of technology, transport and industries, has largely contributed to leapfrogging and in most cases, the land speculators and developers are not fully confronted with social costs and benefits of their decision (Triantafyllopoulos, 2017). Speculators opt for peri-urban land where there is minimal development control (Ayonga, 2015) compared to urban land. This leads to unregulated land fragmentation which accentuates leapfrog development. Infrastructure development and subsidization of infrastructure such as water supply and roads in the peri-urban promotes conversion of agricultural land into urban use (Archer, 1973; Heim, 2001; Clawson, 2013). Local and national governments have major roles in rezoning of land in peri-urban areas originally used for agriculture to allow for residential, commercial and other urban use after extension of urban infrastructure such as sewer lines (Zhang et al., 2017). Absence of prior planning of the peri-urban land, speculators and landowners determine preceding land uses through subdivision of agricultural land into more residential units at the expense of other urban uses (Napier et al., 2013; Byamugisha, 2013; Clawson, 2013). This paper asserts that land subdivision does not necessarily lead to development of land, but contributes to conversion of peri-urban land from agriculture to urban use. The focus of the paper is to analyse land development after land subdivision and relate patterns to drivers of development in peri-urban Northland of Nairobi Metropolitan defined by the Greater Eastern Bypass.

Methods

Pattern of development, change in land use/cover, leapfrog measure were used as key components to quantify urban growth. GIS techniques were used in land use/cover analysis, classification, buffering and analysis of land parcel development between 2000 and 2020 based on five-year time series. The timing is pegged on the period before and after construction of Eastern Bypass between 2008 and 2012 and planning for Greater Eastern Bypass and Link Road in 2009. The study period from 2000 to 2020 represent a time when most public infrastructure policies and programmes were planned and initialized as part of Kenya Vision 2030, Millennium Development Goals and Sustainable Development Goals. This period is important as it enables observation of development

pattern before planning and construction of major transport infrastructure in the area that are perceived to influence land development.

Satellite images for 2000, 2005, 2010, 2015 and 2020 were used to analyse change in land use/cover and pattern of land development. Pattern of development was analysed through overlaying satellite images with subdivision shape files using ArcGIS 10.5 where developed plots are identified using parcel numbers and labelled using colour coding. Details of developed plots such as year of development are entered into the attribute table. The subdivision shape files are generated through digitizing Registered Index Maps (RIMs) sourced from Survey of Kenya (Figure 1). Registered Index Maps used for the study were based on parcellation and land adjudication carried out between 1988 and 1996. Buffering to measure leapfrogging was done along five major roads in the study area; Thika Highway, Eastern Bypass, Link Road, Greater Eastern Bypass and Juja Farm Road, two of which were planned and were yet to be constructed. Maps are then used to show the pattern of development every 5 years.

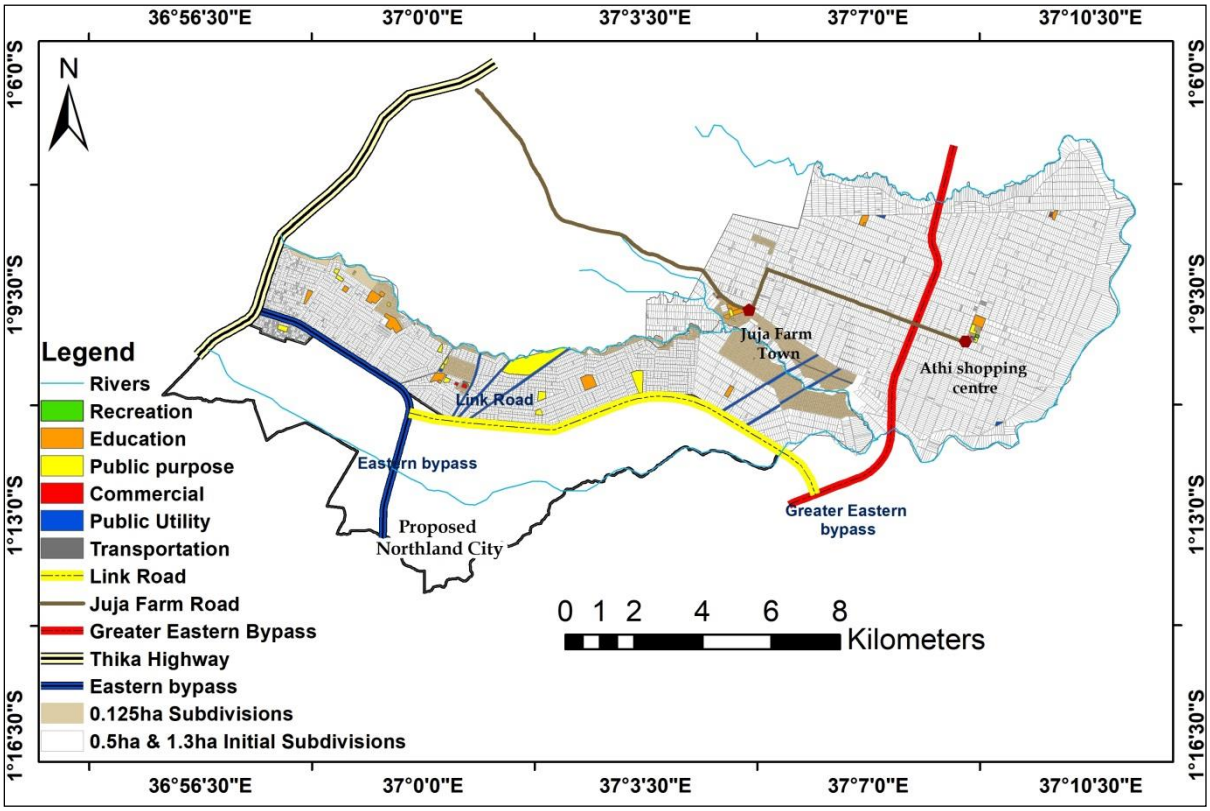


Figure 1: Characteristics of the Greater Eastern Bypass Peri-Urban Area

Leapfrog measure for 2000, 2005, 2010, 2015 and 2020 was carried out on buffers of 250m, 500m and 1000m established around Thika Highway, Eastern Bypass, Link Road, Greater Eastern Bypass and Juja Farm Road since they are perceived to be the growth nuclei. In order, to calculate the

proportion of leapfrog development, total area of leapfrogged parcels in a given buffer and year is divided by total area of developable land within the buffer, which includes all undeveloped land and total area of developed land as expressed in the equation:

$$\text{LFjts} = \frac{Undeveloped\ land\ in\ Time\ s\ in\ Buffer\ j\ in\ Year\ t}{All\ Undeveloped\ Land\ and\ Developable\ land\ in\ Time\ s\ in\ Buffer\ j\ in\ Year\ t} \ldots.1$$

Leapfrog measure or index is expressed as a percentage of total amount of vacant land to quantity of developable land within a given period and distance from the road (Yue, 2013). The value varies between zero (no land available for development) and one (all land is developable). The index measures intensity of leapfrog development, where an index is greater than 0 indicates leapfrog development has occurred (Yue, 2013). Leapfrog development measure that combines spatial and temporal aspects which other measures of urban sprawl have forgone is used to explain leapfrog patterns and extent of urban expansion (Tian et al., 2016; Yue, 2013). It is used to account for developed land at given location and timing and corresponding leapfrogged land along expedient commuting routes (Zhang et al., 2017). The land abutting the five roads was originally subdivided into parcels of 0.5Ha, 1.3Ha and 0.125Ha for small-scale farming. The parcels are used to examine development patterns and measure leapfrog development. 0.5Ha parcels are concentrated along Eastern Bypass and Link Road, 0.125Ha are close to the river and 1.3Ha are along Greater Eastern Bypass (Figure 1). Subdivision shape files and satellite images are used to identify vacant parcels falling in a given buffer and year. All the underdeveloped parcels are not developed are considered leapfrogged unless they are identified as reserved land for public purpose and other specified land uses (Figure 1).

Primary data was sourced through interviews to utility agencies such as Kenya Power and Lightning Company and Ruiru and Juja Water and Sewerage Services Company and Water Resources Authority. These agencies were interviewed on level of coverage of basic infrastructure in the peri-urban area. Layers of utilities and amenities in the peri-urban such as electricity, water, sewer distribution, schools, residential associations, boreholes, and motorable roads are used to identify possible drivers of peri-urban leapfrog development. Map on amenities and utilities distribution was overlaid with maps on development patterns, to link patterns to drivers.

Results

Land Use/Cover Change in (Greater) Eastern Bypass Area

Analysis of land use indicates that grassland had the highest coverage, followed by farmland and riparian reserve while the lowest was built up area (Figure 2). Table 1 shows analysis of change in land cover from one period to the other, where the built up experience the highest positive growth while farmland experienced negative growth from 2000 to 2020. Grassland accounts for the highest

coverage possibly because part of the land is owned by absentee owners who are residing elsewhere. The collapse of large scale farms that occupied the study area between 1907 and 1970 led to increase in growth on natural vegetation on the abandoned land hence increasing the area under grassland. Small scale sisal farming that began after subdivision of land accounts for the percentage of land under farming (Figure 2), which declined as more land was either taken out for development or sold to land entrepreneurs who kept it idle, waiting for development. Decline in farming is also attributed to the fact that the study area is located in semi-arid area and most of the farming relies on rains. The poor performance of market for sisal products may have contributed to reduction in farming. Concentration of the built up area is along Thika Highway, which was developed in 1970s, and partially along the Eastern Bypass which was planned in 1970s but part of development plans such as excavation works and clearing the road corridor began in 2003 but were later abandoned until 2008 when construction of the road started again (Figure 2). Construction of Eastern Bypass between 2008 and 2012 coupled with upgrading of Thika Highway to a super highway between 2007 and 2009 further increased the built up area along the two roads. Concentration of development into the interior and along the other three roads is less dense is characterized by scattered and clustered development. This could be attributed by the fact that the Link Road and Greater Eastern Bypass have not been developed to open up the area while Juja Farm Road which links the study area to Thika Highway is not an all-weather road hence reduced transport connectivity into the area. Though farming declined by 3% from 2015 to 2020 (Table 1), there are commercial farms developing along rivers possibly taking advantage of the improving transport connectivity to allow transportation of produce to towns closer and increasing population in the study area.

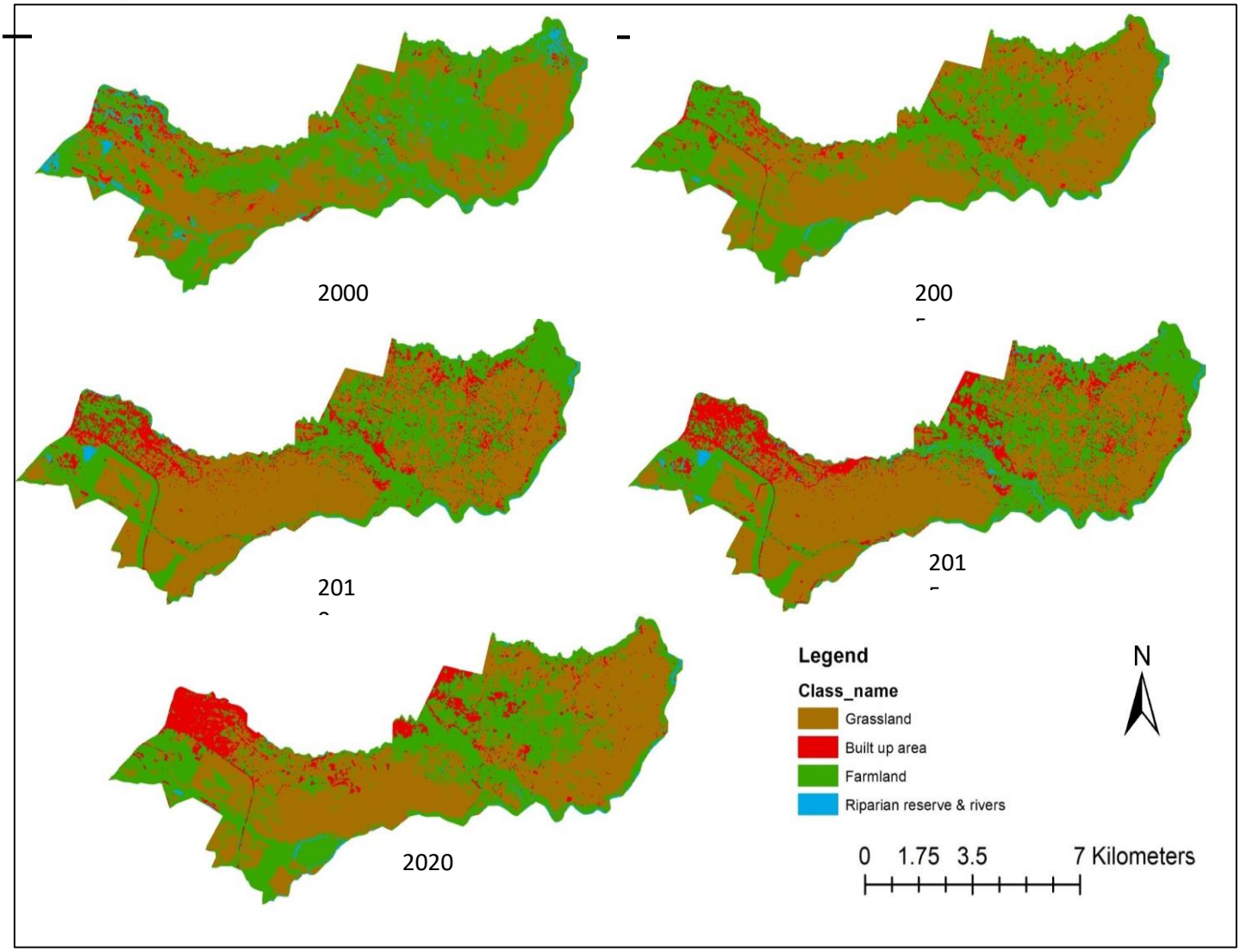


Figure 2: Land Use/Cover Change for 2000-2020

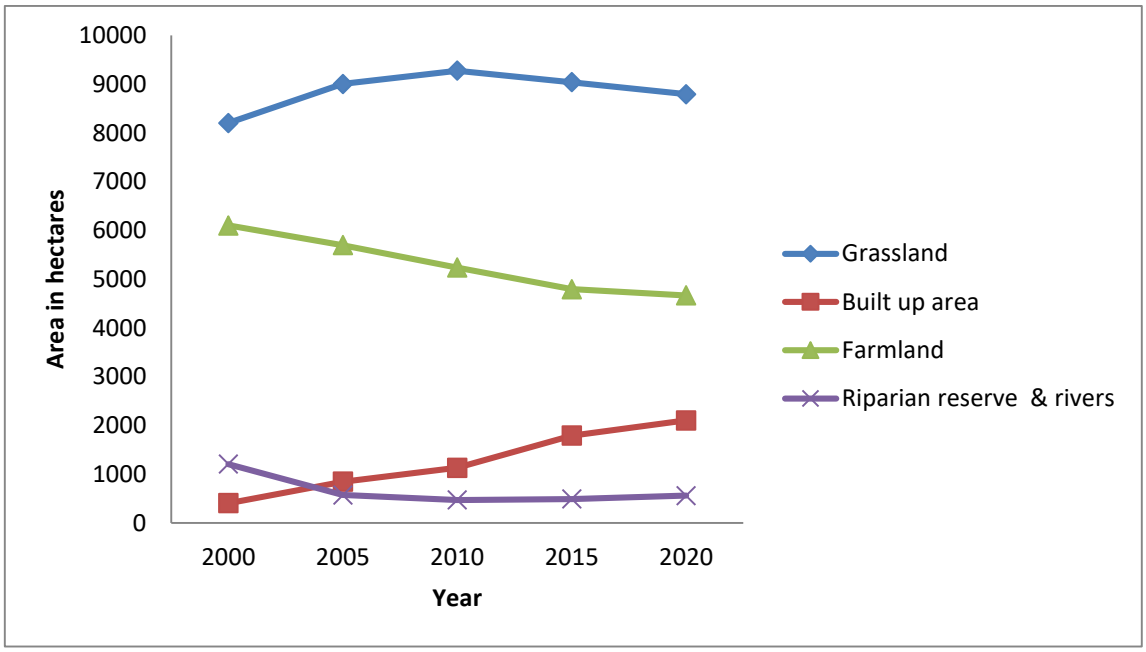


Figure 3: Land Use/Cover Trends between 2000 and 2020

From the summary in Figure 3, only the built up area has experienced positive change within the study period, which is attributed to urbanization that has been spurred by infrastructure development. Farmland declined within the same period and can be attributed to land subdivision where at least 45% of parcels originally used for small-scale farming have been subdivided into smaller plots for urban use, which are not economical for agriculture. In addition, the subdivided land was sold out to buyers whose interest is either to speculate on the land and sell it when land value increases or to hold the land until it is suitable for development. Grassland area increased between 2000 and 2010, possibly as a result of farmers abandoning farming while the decline between 2010 and 2020 is as a result of increasing built up area. There is an inverse relationship between the area under grassland and the built up area since as grassland decreases the built up area increases which suggests that grassland is a transitional use when land is converted from farming to urban use.

Land Subdivision

A spike in subdivision of 0.5ha and 1.3ha into urban and residential plots is observed between 2008 and 2012 the period which construction of Eastern Bypass began and planning the Link Road and Greater Eastern Bypass. The subdivision observed between 2005 and 2008 are characterized with structural speculators who had prior information on planning and development of the roads and deliberately bought and hoarded land before public notification. Structural speculators comprised of officers in road planning authorities and land companies associated with state officers.

There is a gradual decrease of subdivision along Eastern Bypass and Link Road between 2013 and 2018, the period after completion of Eastern Bypass construction while a sharp rise is observed

within the same period along Greater Eastern Bypass because land in the area is more marginal hence less accessible. The 0.5ha parcels were subdivided into 10-14 plots while 1.3ha into about 24-26 plots of 0.035-0.042ha average sizes. Approximately 75% of land along Eastern Bypass had been subdivided between 2005 and 2018, 45% of land abutting the Link Road and 42% of land along Greater Eastern Bypass.

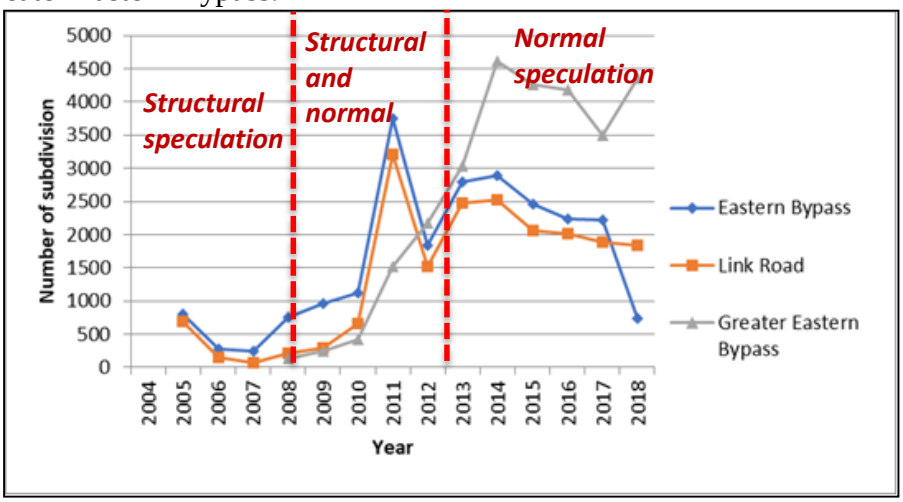


Figure 4: Trend in Land Subdivision in (Greater) Eastern Bypass Area

Development Patterns

Land development in 2000 is characterised by dispersed development with about 3% of the land developed with most of the development is concentrated along Thika Highway, which is the major transport infrastructure along the peri-urban area. The density per 0.5Ha parcel of land decreases as distance from the highway increases, with the number of settlement units reducing from 3-4 units to one unit per parcel. Figure 4 demonstrate that part of the land along Eastern Bypass and Link Road has leapfrog development while Greater Eastern Bypass area is characterised by cluster and ribbon development along rivers.

Development in 2005 is mostly concentrated on the land adjoining Thika Highway with scattered development on the interior (Figure 4). The density of developed parcels decreases as distance from Thika Highway increases. At 1Km buffer from Thika Highway the density per parcel are at least 4 buildings on a 0.5Ha parcel, while at 3-4Km buffer the density per parcel decreases with most parcels being vacant. Land abutting Link Road, Greater Eastern Bypass and Juja Farm Road is characterised by scattered development with 90% being undeveloped. Linear/ribbon development is observed along Ndarugu, Ruiru, Juja and Nairobi Rivers, where water from the rivers supports farming and household activities. There are clusters of development along Eastern Bypass concentrated on the interior. Development along Greater Eastern Bypass and Juja Farm Road is largely scattered, with clusters observed within 1Km radius of Juja Farm Town.

Construction of Eastern Bypass in 2010 triggered linear development along the road characterised by food eateries that were serving upcoming businesses and hardware shops were to support increased construction and land development in the catchment (Figure 4). Development on 250m buffer of Eastern Bypass is majorly mixed, comprising of apartments, shopping malls, shops and vacant parcels that are under farming. However, as one moves into 500m and 1000m buffer, the character changes to mixed density residential units built on different sizes of plots and vary from townhouses, detached, apartments and single units. High-density continuous development is observed at the road junction of Eastern Bypass and Thika Highway, which had been upgraded to a dual carriage way. Other road junctions such as Eastern Bypass and Link Road have no growth since the Link Road had not been developed. Development along the Link Road is largely leapfrogged with a few settlements along the 250m buffer. There is low density linear development along Juja Farm Road and radial development around Juja Farm Town.

By 2015, linear development along the Eastern Bypass is more pronounced with 80% of plots on 250m buffer being developed (Figure 4). Character of development is changing from retail shops, hardware's and eateries to high-rise office blocks and warehouses with lower floors being taken up by chain stores such as Naivas and Quick Mart. Beyond the 250m buffer, there is continuous low density residential which contrasts the linear high-density development on 250m buffer of Eastern Bypass.

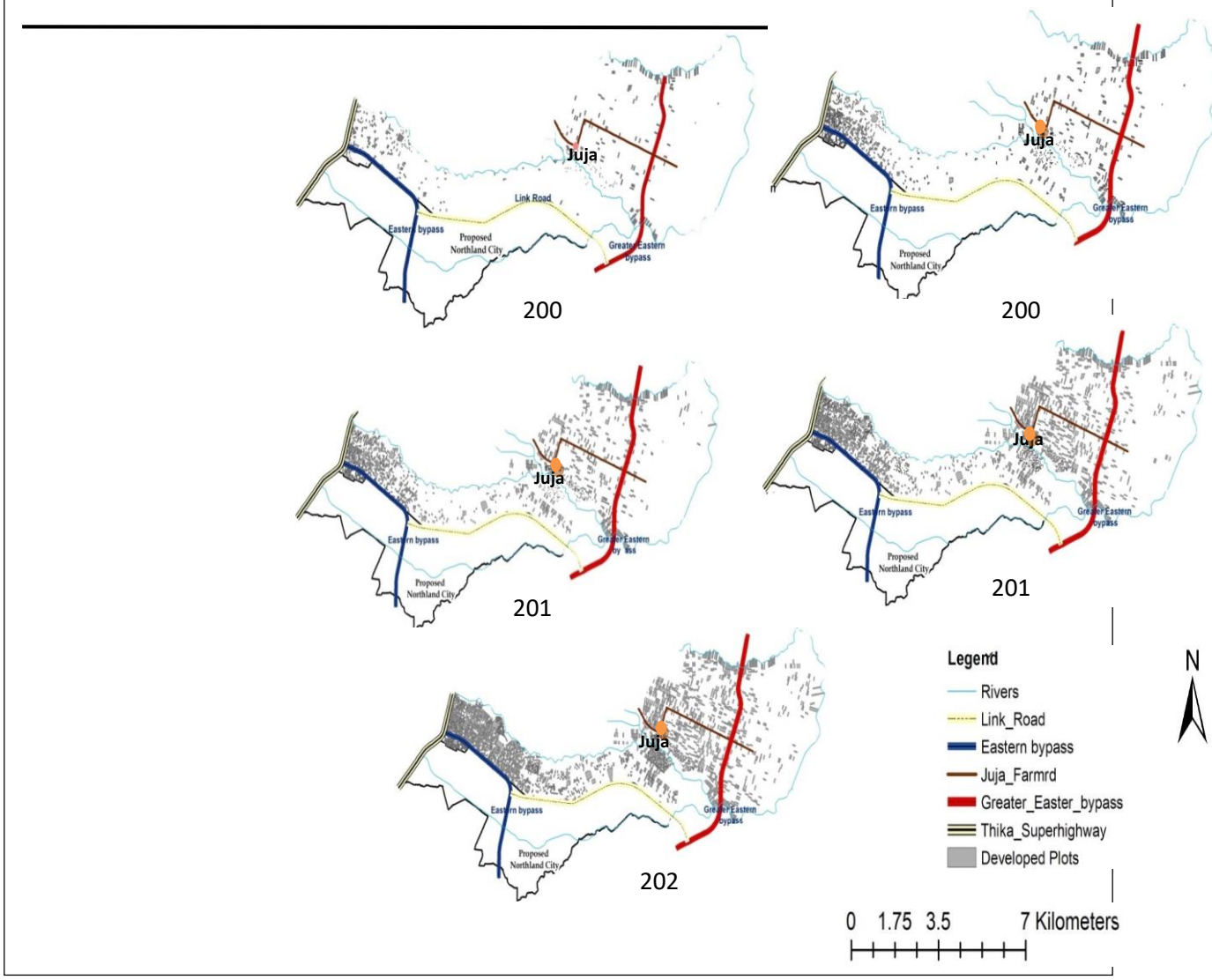


Figure 5: Land Development Pattern in (Greater) Eastern Bypass 2000-2020

Partial linear development is observed along the Greater Eastern bypass and Juja Farm Road, while the land along the Link Road is characterized by cluster and dispersed development.

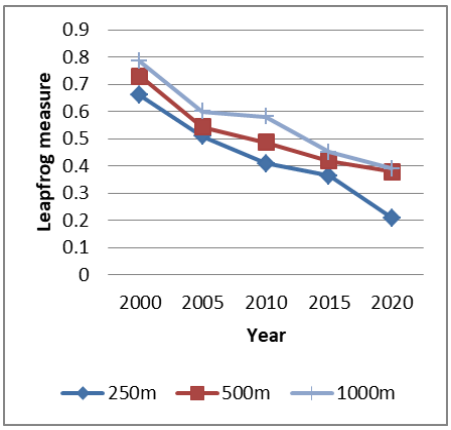
Between 2015 and 2020, the density of development increased to 85% along the Eastern Bypass and Thika Highway and is more continuous with a few undeveloped parcels (Figure 4). The land along Link Road and part of Greater Eastern Bypass is largely leapfrogged and development is low-density with a parcel of 1.3Ha having one settlement. Development is concentrated on the western side of Greater Eastern Bypass, along Juja Farm Road and around Juja Farm Town. Notably, the number of planned gated community developments increased along Eastern Bypass consisting of 10-15 residential units occupying 0.5Ha contributing to continuous, compact, low-density development pattern along Eastern Bypass. Partial low-density linear development is observed along the Greater Eastern Bypass, which had not been developed and Juja Farm Road, which is earmarked for upgrading to an all-weather road.

3.1 Measure of Leapfrog Development

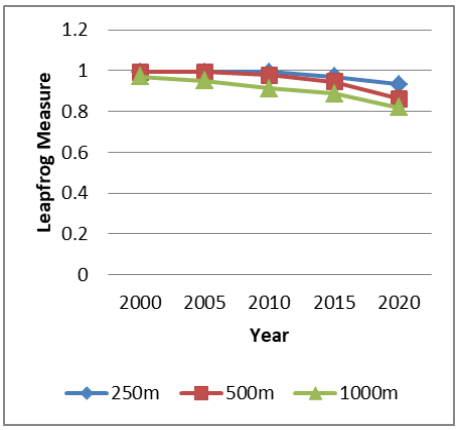
Thika Highway has the lowest leapfrog index ranging from 0.91 in 2000 to 0.25 in 2020 on 500m buffer (Figure 5). Along the Eastern bypass, leapfrogging declined significantly after construction of the road between 2008 and 2012, with leapfrog measure of 0.4 in 2020 on 1000m buffer and drops to 0.25 in 250m buffer of the 2088 parcels analysed in 250m buffer of Eastern Bypass, approximately 60% of developable land had not been developed in 2005, 55% in 2010, 43% in 2015 and 25% in 2020. Steady growth is observed along the Eastern Bypass between 2010 and 2015 with a 20% decline in leapfrog measure compared to the Link Road, which experienced moderate growth with less than 10% change. The highest regression of leapfrog is observed on 250m buffer along Thika Highway between 2015 and 2020, with a change of 25%. Along Juja Farm Road a decline of about 30% was noted along the 250m buffer between 2005 and 2015, indicating there was significant development compared to land along Greater Eastern Bypass (Figure 5).

Leapfrog measure along the Greater Eastern Bypass and Link Road is significantly high ranging between 0.95-0.92 in 2000, with change from one period to the other being minimal. However, leapfrog measure for Juja Farm Road, which passes through Juja Farm Town, is lower in 2005 at 0.7 and it decreases to 0.4 in 2020. Leapfrogging on 1Km buffer along Link Road decrease from 0.95 in 2000 to 0.85 in 2010 while on the 250m the decline is from 0.92 to 0.90, which is less significant (Figure 5). This suggests that land closer to the proposed road is less accessible for development. Along Greater Eastern Bypass leapfrog measure decreases from 0.78 in 2010 to 0.65 in 2020 suggesting that planning and design of Greater Eastern Bypass between 2009 and 2013 may have influenced development to a greater extent. The land abutting the Link Road and Greater Eastern Bypass has been a hot bed for land speculation from early 2010 when planning and design of the roads were in process. However, the land along the two roads exhibit the highest leapfrog measure ranging between 0.9 and 0.75, thereby suggesting that presence of

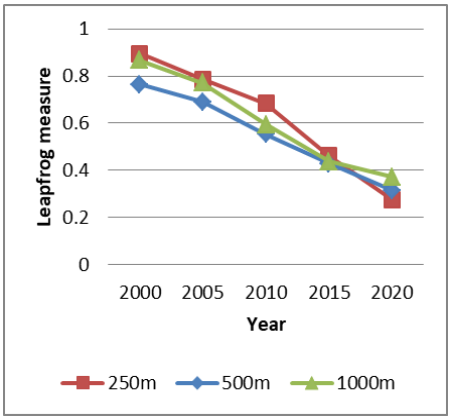
land speculation does not necessarily infer development of land. A notable observation is that leapfrog measure along all roads has declined over time albeit at different rates.



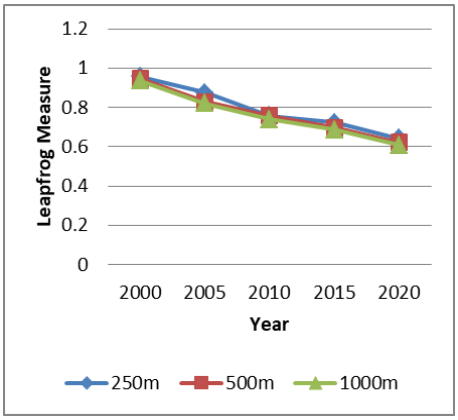
a) Eastern Bypass



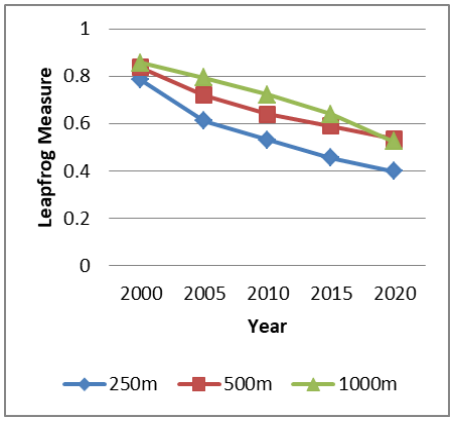
b) Link Road



c) Thika Highway



d) Greater Eastern Bypass



e) Juja Farm Road

Figure 6: Leapfrog Measure in (a) Eastern Bypass, (b) Link Road, (c) Thika Highway (d) Juja Farm Road and (e) Greater Eastern Bypass

Drivers of Land Development

Development in the Greater Eastern Bypass area is characterized by linear, clustered, low density and leapfrog development. Patterns of development observed between 2000 and 2020 are triggered by a myriad of drivers. Reliable source of water is identified as a key driver of land development in the Greater Eastern Bypass area and explains linear development along the rivers and cluster development around water sources, which characterizes initial development in the area. Nucleated development was also observed within radius of 500-700m from boreholes. This may explain the increase in number of private boreholes along the Greater Eastern Bypass peri-urban area. There are 3 county boreholes and 27 private boreholes in the area (Figure 6), suggesting that the municipal water is inadequate or absent. Interview with a technical staff in charge of regulating sinking of boreholes from Water Resources Authority (WRA), revealed that there are more illegally sunk boreholes in the area because selling of water in the neighbourhood is a lucrative business. Juja Farm area has the lowest municipal water connection and most homes get their supply from private boreholes and rainwater harvesting. The private boreholes are concentrated around Juja Farm Town where 60% of land development has occurred.

Juja Farm Town is a pre-colonial administrative and amenities centre with chief's office, land agents offices, a primary and secondary schools, hospital, police station and polytechnic. Development around this town was further influenced by settlement of Catholic Missionaries in 2003. The missionaries also have built a primary and secondary school, a convent, a monastery and sunk two boreholes that supply water to the neighbourhood. Radial development is observed along roads radiating from the town to other small centres of Juja Farm catchment. The historical nature makes it a growth nucleus due to availability of basic infrastructures and services.

Construction of primary roads such as Eastern Bypass triggered linear development along the bypass. However, there is no clear linear development observed along Greater Eastern Bypass and Link Road, the two major roads that have been planned, but not developed. Construction of primary roads opens up opportunities for upgrading and maintenance of access roads by local authority and private developers, which increases accessibility and prompts infill and continuous development. The growth seen on the 250m buffer along Thika Highway and Eastern Bypass between 2012 and 2020 can be attributed to infill commercial development, which is triggered by the upgrading of the roads. This explains why the land abutting Eastern Bypass has 85% motorable roads and 80% of land developed by 2020; compared to 90% of roads along Link Road and Greater Eastern Bypass are impassable during rainy seasons (Figure 6) and only about 20-30% of land is developed. This is not uncommon in Kenya since the county governments focuses on improving roads and provision of services in areas with high development density and social and political pressure. Local access roads and streets in the peri-urban area are under Kiambu County Government while the major roads - Thika Highway, Eastern Bypass, Link Road, Greater Eastern Bypass and Juja Farm Road - are developed and maintained by the National Government. Maintenance of Juja Farm Road which links Juja Farm Town to Thika Highway and Juja town contributed to partial linear and

leapfrog development along 1Km buffer between 2015 and 2020. Plans to upgrade the road to asphalt concrete, further triggered leapfrog development due to anticipated increased accessibility.

Electricity connectivity to towns like Juja Farm Town and other local centres like Athi and Mumba along the Greater Eastern Bypass has resulted to nucleated development characterized by small businesses such salons, welding, cereal millers and retail shops. Along Eastern Bypass increase in electricity coverage to 90% by 2020 led to infill development. Reticulation of electrical power lines follows road development in Kenya because way leaves become more clearly defined after primary and access roads are developed. This may explain why the land along Greater Eastern Bypass and Link Road has low electricity connectivity.

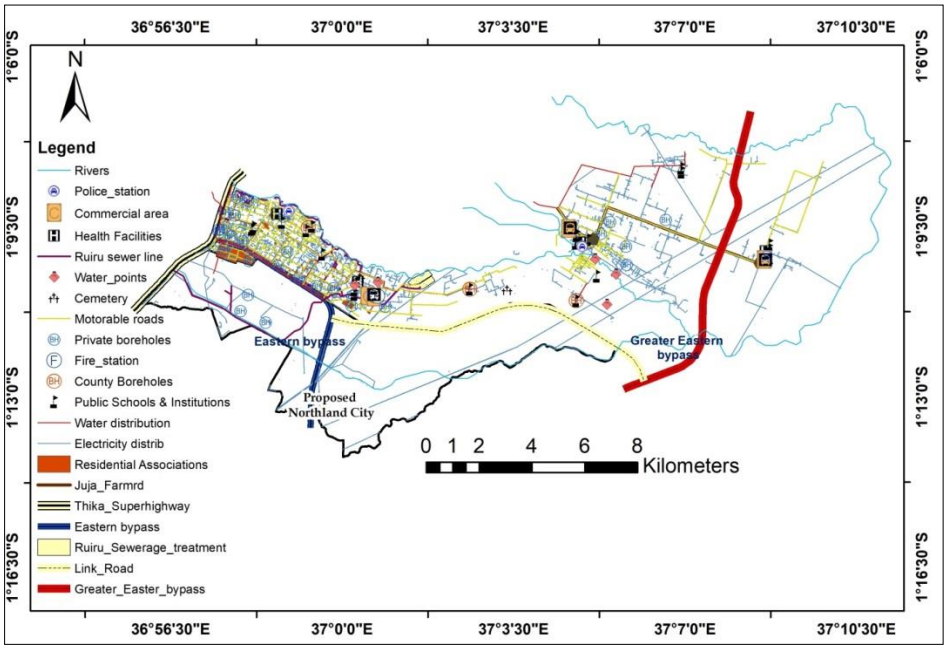


Figure 7: Infrastructure, Amenities and Services in (Greater) Eastern Bypass Area

Public schools in the Greater Eastern Bypass area were among the first developments in the area. Clustered settlements are observed between 2015 and 2018 around two primary schools along the Link Road and one along Greater Eastern Bypass suggests that they may have influenced development of land. The Last Mile Connectivity Program by Kenya Government, which commenced in 2015, led to schools in peri-urban and rural areas being connected to electricity. The transformers near the schools are designed to serve households within at least 600m radius thereby resulting into cluster development around schools.

Resident associations are associated with compact low density development in the peri-urban area. Of the 12 residential associations in the area (Figure 6), 5 are operating neighbourhood estates between 5Ha and 25Ha. These associations are formed by individuals either working together or those with common

interest such as welfare groups commonly known as *"Chamas"*. They acquire large parcels of land then subdivide into urban use plots, majorly for residential use and sell to members who are required to adhere to bylaws on land development set by the association. Crime rate in Kenya is high, with the Annual Crime Report of 2019 rating Kiambu County (RoK, 2019), where the peri-urban area is located, third with a 0.37% increase from 4.93% in 2018. The high crime rate has led to increased security measures by associations and private developers by either developing within vicinity of developed land or pulling of numbers to develop together to be secured through numbers. Ten of the identified associations are concentrated along Eastern Bypass and two along the Link Road. These associations lobby for supply and improvement of infrastructure such as roads and sometimes work closely with county governments to ensure development control in the neighbourhood so as to safeguard the quality and standard of the neighbourhood estates. Cluster development observed between 2000 and 2010 along Eastern Bypass and along Link Road and Greater Eastern Bypass is associated with early settlers mainly comprising of urban poor in search of cheap shelter.

Discussion of Findings

Results show that peri-urban development patterns observed in the Greater Eastern Bypass are reminiscent to organic development occurring due to lack of structured and planned development. Scholars have pointed out that leapfrog development observed in peri-urban areas of African cities emanate from population pressure preceding provision of basic infrastructure and services due to low capacity of local governments (Doan & Oduro, 2012; Dekolo et al., 2015; Varkey & Manasi, 2019). Settlement in peri-urban land is informed by certain drivers depicted by development patterns. Infrastructure and utilities such as roads and water sources are viewed as primary drivers of peri urban land development while amenities such as schools and urban centres ride on presence of certain utilities such as electricity to trigger development. Construction of sewerage treatment plant along Eastern Bypass in 2017 did not prompt any further development, possibly because it was developed when 70% of land was already developed and most developers were accustomed to onsite sanitation. There has not been a push, sensitisation or requirement for connections to a sewer line as per the Public Health Act (RoK, 2012). Kleemann et al. (2017) highlighted that provision of infrastructure for sanitation and waste management is a general problem in most developing countries hence their low potential to drive peri-urban development. The linear pattern along the rivers is an aspect of agrarian civilization where rivers support small scale farming and are a source of livelihood (Soulard et al., 2017). Lack of development and extension of water programmes to the areas has led to people settling along the rivers due to reliable source of water. However, settlements along rivers are more clustered near Juja Farm Town which is an established colonial town and centre of amenities in the area.

Presence of non-governmental organizations have an influence of peri-urban development especially when they have a strong influence on decision making in relation to zoning, land use planning and provision of utilities and amenities (Kleemann et al., 2017). Private developers and residential associations manipulate provision of utilities and amenities through lobbying to favour their prospective developments, hence directing development through pulling numbers and structuring development in the peri-urban. The Catholic missionaries through provision of domestic water in an area where municipal water is absence contributed to clustered development. Historical towns, even with few amenities and utilities are growth nuclei which are likely to attract public investments more than newly developed towns. Kleemann et al., (2017) pointed out that development of the urban and peri-urban areas can be traced to the history and post-colonial administration and governance of a place.

Construction of roads triggers development on abutting land, first, because of increased connectivity to towns and urban centres. Second, construction of major or primary roads creates an opportunity for development of access roads by private developers or local government. Third, it spurs development of previously speculated land that was inaccessible. Leapfrogging along the Greater Eastern Bypass declined significantly during the study period. However, a higher regression was observed along Eastern Bypass after construction of the road between 2010 and 2015, suggesting that development of primary roads prompts more development in the peri-urban. Private developers ride on provision of primary roads, which are mainly developed by national governments, to develop their land since they are able to provide other basic services such as water and amenities such as schools, which county governments may take long to provide. Planned roads triggers leapfrog development and this explains why land along Greater Eastern Bypass and Link Road has high leapfrog measure (Figure 5). Development of un-serviced land is attributed to early settlers who develop land anticipating development of basic infrastructure. Planning of infrastructure such as roads may trigger speculative land subdivision in the peri-urban, but continuous land development and decrease in leapfrogging is prompted by construction of infrastructure.

The urban poor in search of cheap shelter buy and develop the un-serviced sub-plots in the peri-urban and wait for the local authority to plan and develop infrastructure such as access roads (Kombe, 2005; Poku-Boansi & Amoako, 2015). To ensure smoother settling process, they organize themselves in small groups mostly of close family members or workmates and then they buy and develop land together. Clustering by these groups act as a source of security and an avenue for residents to lobby and collaborate for supply of utilities such as electricity. As more clusters develop access to services becomes easier and small centres start developing to serve the incoming population. The residential associations, families and small groupings that drive development in the peri-urban have one aspect in common that they work together to bring people to develop a certain area as a source of security and access to utilities, amenities and services. The difference between the small groupings and residential associations is that the former is after cheaper shelter and whereas the latter can comprise of land speculators who aim to benefit maximally

from the development of the peri-urban land. Kombe (2005) implied that the organic pattern of peri-urban land development in Sub-Saharan Africa is informed by urban poverty level. These initial settlers prefer cheap housing in the peri-urban where there is minimal development control that increases cost of development. Varkey & Manasi (2019) also pointed out that lack of cheap housing facilities in the urban areas and increasing demand for real estate development has led to rapid spatial expansion of peri-urban areas moving margin further into the rural areas. Although real estate developers look out for cheap land in the peri-urban, they ride on provision of primary infrastructure such as roads by government, to commence development.

Peri-urban planning plays a critical role in regulating the space to accommodate urban expansion and promoting space growth to attract investment (Tian et al., 2016). In absence of systematic planning of peri-urban, land development is dominated by political, social and economic forces resulting into mushrooming of informal settlements (Baye et al., 2020; Varkey & Manasi, 2019). Conversion of land use in peri-urban is stimulated by infusion of new investments such as infrastructure development by the local government and private developers (Ingram& Brandt, 2013). The conversion process is highly diffused and is made complex by actors involved that greatly impact on the decision making process (Clawson, 2013). Land use policies and provision of public infrastructure and services that accompanies peri-urban land conversion shapes land development and promotes rational land use (Baye et al., 2020; Tian et al., 2016). Municipal authorities are manipulated by the residential association and groups in extension of urban services and infrastructure causing infrastructure backlog in the peri-urban (McPherson & Guy, 2012; Woltjer, 2014).

Conclusion

Absence of development control and phased development in the peri-urban areas gives way to certain drivers like roads, water sources, schools, and towns to influence development patterns; which inform the organic character of peri-urban. Onset of unplanned development in peri-urban is characterized by leapfrogging depicted by cluster, dispersed and radial development patterns that are associated with some growth drivers. Some drivers such as roads and water supply influence development pattern more compared to electricity and sewer system. Utilities and services provided by local authorities are secondary drivers of peri-urban development. Planned development units, boreholes, associations/groups, and insecurity have emerged as new drivers of peri-urban developmental patterns; with no new developmental patterns. Initial developers collaborate and lobby to pull resources and influence provision of basic infrastructure. Leapfrog measure is high in peri-urban areas devoid of basic infrastructure. Planning of some infrastructure such as primary roads prompts a slight regression in leapfrogging, while development of major roads leads to infill development of adjacent land and reduced leapfrog measure. Planning of major infrastructure in the peri-urban leads to land speculation, which stimulates land subdivision and change of land use from agriculture to urban use. Increased peri-urban land subdivision

does not imply readiness of land for development, but foreruns leapfrog development. This research underlines the need for controlled and planned development in the peri-urban to reduce organic growth spurred by certain drivers.

References

Archer, R. W. (1973). Land Speculation and Scattered Development; Failures in the Urban-Fringe Land Market. *Urban Studies*, *10*(3), 367–372. Retrieved from http://www.jstor.org/stable/43194618

Ayonga, N. J. (2015). Real Estate Development Outside the City County of Nairobi and the Escalation of Urban Sprawl: Could Developers be Avoiding Zoning-related Costs in the City? *Journal of Geography and Regional Planning*, *8*(10), 261.

Baye, F., Wegayehu, F., & Mulugeta, S. (2020). Land Use Policy Drivers of informal settlements at the peri-urban areas of Woldia : Assessment on the demographic and socio-economic trigger factors. *Land Use Policy*, *95*(February), 104573. https://doi.org/10.1016/j.landusepol.2020.104573

Byamugisha, F. F. (2013). *Securing Africa's land for shared prosperity: A program to scale up reforms and investments*. Washington DC: The World Bank.

Clawson, M. (1962). Urban sprawl and speculation in suburban land. *Land Economics*, *38*(2), 99–111. Retrieved from http://www.jstor.org/stable/3144612

Clawson, M. (2013). *Suburban land conversion in the United States: An Economic and Governmental Process* (1st Edition). New York: Routledge.

Cobbinah, P. B., & Aboagye, H. N. (2017). A Ghanaian twist to urban sprawl. *Land Use Policy*, *61*, 231–241. https://doi.org/10.1016/j.landusepol.2016.10.047

Dekolo, S., Oduwaye, L., & Nwokoro, I. (2015). Urban sprawl and loss of agricultural land in peri-urban areas of lagos. *Regional Statistics*, *5*(2), 20–33. https://doi.org/10.15196/RS05202

Doan, P., & Oduro, C. Y. A. W. (2012). Patterns of Population Growth in Peri-Urban Accra , Ghana. *International Journal of Urban and Regional Research*, *36*(6), 1306–1325. https://doi.org/10.1111/j.1468-2427.2011.01075.x

Heim, C. E. (2001). Leapfrogging, Urban Sprawl, and Growth Management: Phoenix, 1950-2000. *The American Journal of Economics and Sociology*, *60*(1), 245–283. Retrieved from https://www.jstor.org/stable/3487953

Ingram, G. K., & Brandt, K. L. (Eds.) (2013). *Infrastructure and land policies*. Massachusetts: Lincoln Institute of Land Policy.

Jimu, M. (2017). *Peri-urban Land Transactions: Everyday Practices and Relations in Peri-urban Blantyre, Malawi*. Bamenda: Langaa Research & Publishing CIG.

Kleemann, J., Inkoom, J. N., Thiel, M., Shankar, S., Lautenbach, S., & Fürst, C. (2017). Peri-urban land use pattern and its relation to land use planning in Ghana, West Africa. *Landscape and Urban Planning*, *165*, 280–294. https://doi.org/10.1016/j.landurbplan.2017.02.004

Kombe, W. J. (2005). Land use dynamics in peri-urban areas and their implications on the urban growth

and form: The case of Dar es Salaam, Tanzania. *Habitat International*, *29*(1), 113–135. https://doi.org/10.1016/S0197-3975(03)00076-6

McGregor, Duncan & Simon, D. (2012). *The peri-urban interface: Approaches to sustainable natural and human resource use*. New York: Routledge.

McPherson, A., & Guy, E. X. (2012). *The Planner's Guide to Natural Resources Conservation: The Science of Land Development Beyond the Metropolitan Fringe* (1st Edition). New York: Springer. https://doi.org/10.1007/978-0-387-98167-3

Napier Mark, Stephen Berrisford, Caroline Wanjiku Kihato, Rob McGaffin, L. R. (2013). *Trading Places: Accessing land in African cities*. Somerset West: African Minds.

Nuhu, S. (2019). Peri-Urban Land Governance in Developing Countries: Understanding the Role, Interaction and Power Relation Among Actors in Tanzania. *Urban Forum*, *30*(1), 1–16. https://doi.org/10.1007/s12132-018-9339-2

Poku-Boansi, M., & Amoako, C. (2015). Dimensions of spatial inequalities in Ghanaian cities. *Journal of Geography and Regional Planning*, *8*(5), 131–142. https://doi.org/10.5897/jgrp2014.0477

Republic of Kenya. (2009). *Planning and Building Regulation of 2009*. Nairobi: Government Printer.

Republic of Kenya. (2012). *Public Health Act*. Nairobi: Government Printer.

Republic of Kenya. (2019). *Annual Crime Report*. Nairobi: Government Printer.

Salem, M. (2015). Peri-urban dynamics and land-use planning for the Greater Cairo Region in Egypt. *Sustainable Development*, *168*(1), 109–119. https://doi.org/10.2495/sd150101

Tian, L., Ge, B., & Li, Y. (2016). Impacts of state-led and bottom-up urbanization on land use change in the peri-urban areas of Shanghai : Planned growth or uncontrolled sprawl ? *Cities*. https://doi.org/10.1016/j.cities.2016.01.002

Triantafyllopoulos, N. (2017). On the origins of tourist urbanisation in Greece: Land speculation and property market (in)efficiency. *Land Use Policy*, *68*, 15–27.

Varkey, A. M., & Manasi, S. (2019). A Review of Peri-Urban Definitions , Land Use Changes and Challenges to Development. *Urban India*, *39*(1), 96–111.

Yue, W. (2013). Measuring Urban Sprawl and Its Drivers in Large Chinese Cities: The Case of Hangzhou. *Land Use Policy*, *31*(3), 358–370. https://doi.org/http://dx.doi.org/10.1016/j.landusepol.2012.07.018

Webster, D., & Muller, L. (2009). Peri-urbanisation: zones of rural-urban transition. *Human Settlement Development*, *I*, 281–290.

Woltjer, J. (2014). A Global Review on Peri-Urban Development and Planning. *Jurnal Perencanaan Wilayah Dan Kota*, *25*(1), 1–16.

Zhang, W., Wrenn, D. H., & Irwin, E. G. (2017). Spatial heterogeneity, accessibility, and zoning: An empirical investigation of leapfrog development. *Journal of Economic Geography*, *17*(3), 547–570. https://doi.org/10.1093/jeg/lbw007