Chapter 13
Achieving Regional Development Through Enhanced Connectivity in the Nairobi Metropolitan Region

Daniel Githira, Romanus Opiyo and Dennis Mwaniki

Abstract Reliable transport and ICT connectivity are frequently cited as primary factors affecting regional development patterns. This is informed by the fact that such connectivity has great potential to enhance concentration (agglomeration) of economic growth. Transport and ICT connectivity impact on the productive sector through the flow of products and labour markets in a smart manner. This chapter examines the potential of enhanced transport and ICT connectivity in driving smart development in Nairobi Metropolitan Region (NMR), as well as the operational regulatory and institutional framework that is currently facilitating (and/or creating positive prospects for) the region's smart growth. It details the historical challenges associated with connectivity in the NMR, plots the region's economic nodes and their spatial connectivity, and analyses elements of transportation and ICT connectivity in the region. The chapter concludes by highlighting key economic and governance factors which are critical in maximizing the two connectivity parameters (transport and ICT) in achieving smart NMR development.

Keywords Nairobi metropolitan region · Connectivity · Smart region

13.1 Introduction

Smart regional development focuses on infusing intelligence into the management of regions to improve their functionality while reducing costs [1]. For a region to qualify as experiencing smart development, it must have ICT-enabled governance,

D. Githira
The County Government of Taita Taveta, Nairobi, Kenya
e-mail: dangithira@gmail.com

R. Opiyo (✉)
University of Nairobi, Nairobi, Kenya
e-mail: romanop2000@gmail.com

D. Mwaniki
Freelance Consultant and Researcher, Nairobi, Kenya
e-mail: dennmwa02@gmail.com

T. M. Vinod Kumar (ed.), *Smart Metropolitan Regional Development*,
Advances in 21st Century Human Settlements,
https://doi.org/10.1007/978-981-10-8588-8_13

a desired mix of land use, financial sustainability, enhanced mobility, efficient utilities, citizen involvement in governance and meaningful private-public partnerships [1, 2]. Kumar [3] defines a smart city or region as having the closely-interconnected building blocks of smart economy, mobility, environment, living, and governance. Whereas these aspects are difficult to measure in absolute terms, various direct and proxy indicators can be applied to appraise the 'smartness' of a city or region.

This chapter focuses on enhancing economic development for Nairobi Metropolitan Region (NMR) though enriching its connectivity. Accordingly, it places emphasis on smart economy and smart mobility for NMR. Based on the features of smart economy [3], the chapter explores how the NMR is interacting with innovative and creative connectivity, offering entrepreneurial leadership and opportunities, tackles economic challenges of globalization, promotes sharing economy, supports tourism, excels in productivity, offers flexibility in labour market, and utilizes its natural resources prudently. Further, it proposes connectivity strategies for addressing gaps in the realization of a smart economy for this region. This includes ensuring smart mobility and enhanced virtual connectivity.

Mobility impacts on human interaction either by impeding or facilitating circulation in the urban space [4]. Street networks, which are primary measures of spatial connectivity, enable cities to function and have a shared life [5]. Other elements of connectivity, which are components of urban form, include street layouts, transportation, densities, centricity and land use mix [6]. Each urban location, either based on size, geography, history, politics or culture has a unique set of connectivity attributes which give it a connectivity signature. Many studies have found that this signature has an apparent relationship with performance of regions [5, 7, 8]. According to Kumar [3], smart mobility is realized when a city has vibrant streets, pleasurable routes, balanced transport options, mass rapid transit systems, highly-integrated mobility systems and has regard for cycling and walking.

Indeed, better connected locations are more likely to experience prosperity than lesser connected regions. A study on the importance of spatial connectivity of centres on regional economic development in the United Kingdom established that by modelling and redesigning problematic transport linkages, the value of places can drastically be improved [9]. It is therefore unsurprising that transportation corridors are key among drivers of land use change [10]. Locations that have already established fast modes of transportation have eliminated the distance barrier, and the land-value-drop away from the business nodes as anticipated in some economic theories of land use is fast changing [11].

In assessing NMR's level of 'smartness' in terms of economy and mobility, this chapter contributes to the discussion on the influence of urban form to economic prosperity of regions. This analysis creates an opinion on economic significance of inward *vis-a-vis* outward growing regions. For spatial connectivity, it explores how improvement of linkages (roads) has impacted on growth of settlements in the NMR. As an integral part of modern economic landscape, the chapter assesses virtual connectivity in the region to propose strategies for its improvement.

13.2 The Nairobi Metropolitan Region

13.2.1 Region's Formation

Urbanization in Kenya just like in many global South countries is characterized by rapid population growth. Consequently, many adjacent urban settlements have spatially expanded forming urban agglomerations. Whereas the optimum size of a well-performing region is largely debatable, urban growth will eventually lead to agglomeration of economies, triggering the need for joint regional management [12]. Additionally, when interaction between urban regions intensifies, social-economic and political challenges extend beyond administrative boundaries, requiring establishment of special management authorities. Accordingly, the Nairobi city's sphere of influence continually expanded such that there was a felt need to create for it a metropolitan hinterland based on functionality (interaction between core and hinterland), morphology (trends of land use change) and administration (gazetted local authorities) [13].

The NMR was officially delineated in 2008 through a presidential decree and its management placed under a government ministry named Nairobi Metropolitan Development (MoNMED). At its formation, the region was zoned along local authority boundaries as (a) the core Metro, which covered the city; (b) the Northern Metro, which covered local authorities within Kiambu County; (c) the Southern Metro, which covered local authorities within Kajiado County and (d) the Eastern Metro, covering local authorities within Machakos County. The region, which is no longer identified by local authorities, covers four administrative counties[1] (Nairobi City, Kajiado, Kiambu & Machakos) (Fig. 13.1) and is approximately 32,000 km^2 with a projected population of nine million [13].

Urbanization within the NMR surpasses the average rate for Kenya (42%) with Nairobi county having rates of 100%; Kiambu, 60.8%; Machakos, 52%; and Kajiado, 41.4% [14]. Of the estimated 9 million residents in the NMR, 48% are in Nairobi county, 25% in Kiambu, 17% in Machakos, and 10% in Kajiado counties. Comparing these statistics to spatial coverages of the counties, it is apparent that population densities are highest in Nairobi, followed by Kiambu. Kajiado and Machakos have vast stretches of undeveloped land with concentration of population being majorly in urban centres.

The vision of the MoNMED was to make the NMR a world class African metropolis that is able to create sustainable wealth and offer a high quality of life to its residents, investors, people of Kenya and visitors. These were premised on the recognition that there is a close nexus between economic, social, cultural and environmental wellbeing of a region. The Ministry's mission was be to build a robust internationally competitive, dynamic and inclusive world class infrastructure to

[1]Kenya is divided into 47 independent governance structures called counties, each with its own governance structure under the leadership of a County Governor.

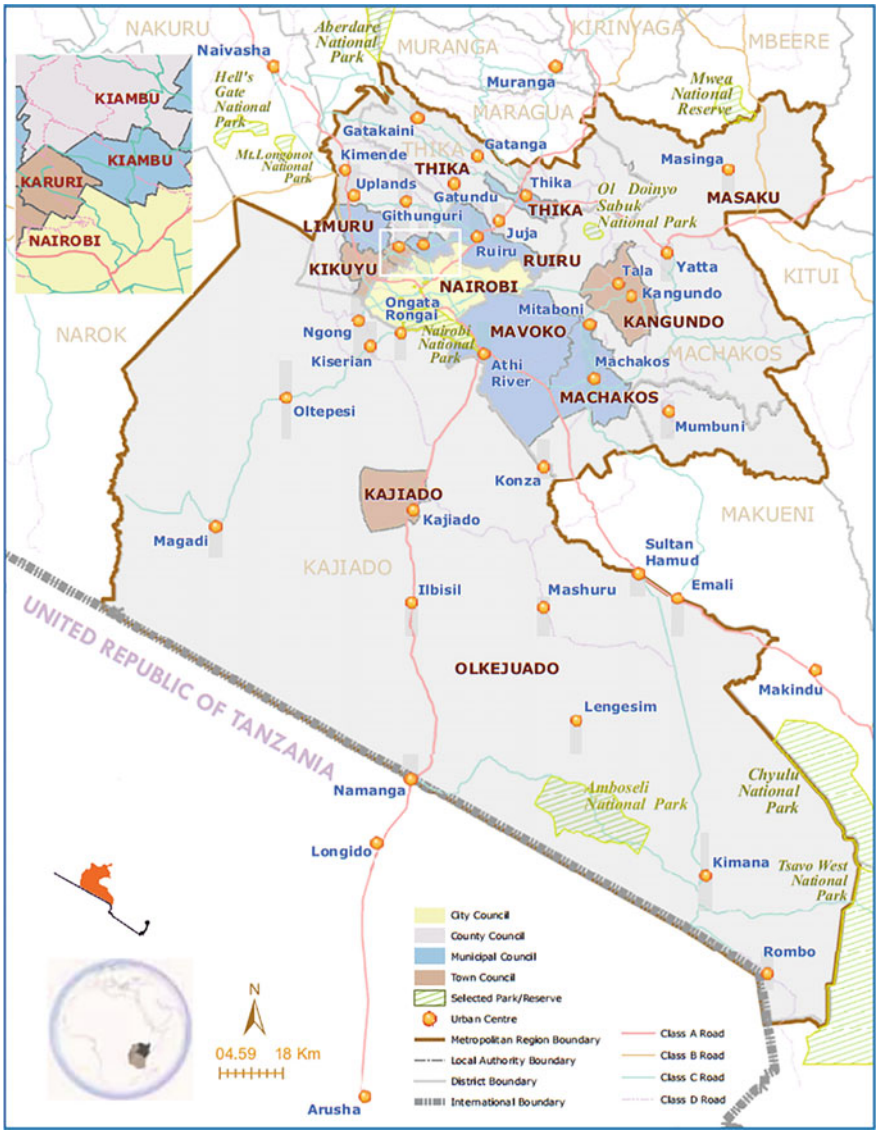

Fig. 13.1 The administrative boundaries of NMR. *Source* Government of Kenya [13]

support development, enhance linkages and accessibility to national, regional and global contexts [13].

To achieve this vision and mission, the MoNMED formulated the Nairobi Metro 2030 strategy with seven key result areas that included: building an internationally competitive and inclusive economy for the metropolitan region's prosperity; deploying world class infrastructure and utilities; enhancing the quality of life and

inclusiveness; delivering a unique image and identity through effective place branding; ensuring safe and secure region; and building and sustaining inclusive and efficient metropolitan governance structures. This chapter focuses on the connectivity aspects of this strategy alongside planning opportunities that the NMR can leverage towards becoming a smart region.

13.2.2 Region's Functionality Challenges

The achievement of the Nairobi Metro 2030 strategy—and subsequently the infrastructure and connectivity goals—has been hindered by several challenges. First, the manner in which the metro region was formed has served to largely hinder its smooth operationalization and function. The top-down approach to its formation undermined ownership by some of the local authorities thus creating coordination challenges. The formation of the region brought together 15 independent local authorities, and at its inception, most of the municipalities (now defunct following the formation of county governments) affected were reluctant to actively be part of the metro region. This challenge was compounded by the shift in Kenya's governance structures in 2010. The new structure, functionalized by a new constitution, created independent county governments and empowered them to create and foresee management structures of urban settlements within their jurisdiction.

Second, the NMR seems to have a broken link between governance and institutional management. This has translated into hitches in coordination, including duplication of functions. Upon the region's establishment in 2008, MoNMD was charged with the responsibility of coordinating its activities. The governance structure however failed to acknowledge the functional, financial and political independence of the involved municipalities. At its inception, which happened under Kenya's old governance system, the metro region consisted of 15 independent local authorities, and even though these authorities partly relied on the national government for financial support, each local authority largely controlled its budget and local revenue. As a result, metro wide projects could only be funded and executed by the MoNMD, usually with limited support from affected local authorities. Further, in a bid to achieve the limited number of ministries specified by the 2010 constitution, the MoNMD ministry was transformed to a state department under the ministry of Land, Housing and Urban Development, reducing its institutional significance and budgetary allocations.

The challenges facing the region were identified in the Nairobi Metropolitan Service Improvement Program (NaMSIP) as including uncompetitive economy, inadequate infrastructure, poor transportation and mobility, poor quality of life, poor safety and security, and poor governance [15]. Under connectivity, which is of key focus in this chapter, the NaMSIP notes that the region has inadequate transport management institutions, incomplete road networks and poor intermodal connectivity. This has translated into congestion on transport networks, expensive transport services and huge economic losses.

13.2.3 Region's Economic Nodes

There are numerous economic centres in the NMR, Nairobi Central Business District being the core centre (Fig. 13.2). A formal classification of the centres within the region does not exist; however, the Nairobi Metropolitan Strategy [13] proposed the hierarch of centres to be as: (a) Regional complex, (b) Sub-regional centres, (c) Priority towns, (d) Growth centres, and (e) Market centres. Since the NMR strategy has not been fully implemented, centres such as "Priority towns"

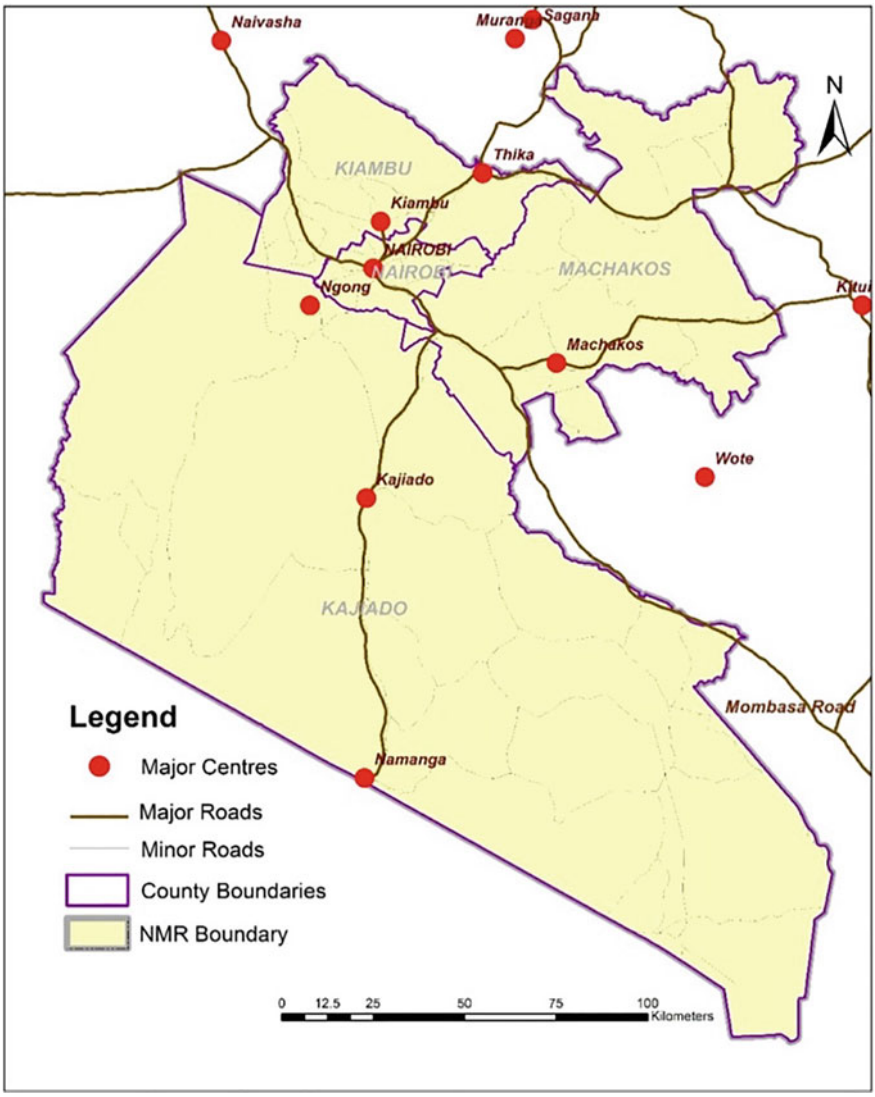

Fig. 13.2 NMR major economic centres and their connectivity

which includes Aerotropolis, Knowledge-cum-health City, Cyber City, Transport New Town, Sports City, and Amboseli New Town, are still non-existent, making this classification inoperative. By their sizes and economic importance, the centres can be classified as:

(a) **The Core Centre**

Nairobi city is the heart of the NMR region and acts as the region's organizing component. It has a Central Business District which is the Kenya's business capital. Surrounding the CBD are satellite centres that house majority of workers in the city. The city has a mixture of low, middle and high density settlements, with majority of the city dwellers residing in high density informal settlements. Other regions in the metropolitan region endeavour to have enhanced connectivity with Nairobi so as to leverage the city's economic strength.

A major challenge facing core centre is congestion—of both traffic and settlements. Prior to the establishment of the devolved governance in Kenya, the city yielded a lot of political and economic powers such that virtually everybody in the country hoped to reside in it. This resulted to rapid population growth, which in the absence of commensurate provision of housing, infrastructural services and utilities, resulted in emergence and proliferation of informal settlements [16].

Currently, the affinity to reside in Nairobi has reduced for some city resident, with most pursuing opportunities in the county regions. This has shifted the balance of power with other centres within the NMR gaining prominence, for example, Machakos, Thika, Kiambu and Kijiado. It's mobility and connectivity status is still high as compared to other parts of the metropolis.

(b) **Major Economic Hubs**

Centres that follow the Metro Core in ranking are major economic hubs, and they include Thika, Kiambu, Machakos and Kajiado. These centres (apart from Thika town) are county headquarters and therefore of high political significance. The biggest of the centres is Thika which is an industrial town linked to Nairobi by an international trunk road, class A2. Alongside Kiambu town, Thika town has a rich agricultural hinterland which makes the town a significant food supplier to Nairobi city. On the other hand, Machakos and Kajiado are in semi-arid states and only practice subsistence agriculture in maize and drought resistant crops such as sorghum. The economy of Kajiado town is driven by tourism and animal farming [17]. Whereas precise data on the growth rates of these towns are hard to obtain, spatial-temporal assessments of their developments on imagery show that these centres are top among the fast growing centres in Kenya.

(c) **Minor Centres**

Under this category are lower level centres within the NMR. They mostly connect to the Metro Core through other major centres. Such centres in Kiambu include Kikuyu, Limuru, Ruiru and Karuri. Kajiado's notable centres include Ngong (its biggest centre), Kitengela, Kiserian, Ongata Rongai, Olkejuado and Bissil; and centres in Machakos include Kangundo–Tala and Athi River. Centres within Nairobi city are considered part of the city and are therefore viewed as satellite towns. Spatial linkages of these centres to major centres is majorly by road.

13.2.4 Region's Connectivity

Regional connectivity can be spatial or virtual. While virtual connectivity focuses on how a region is connected through ICT, spatial connectivity is concerned with ease in which people, good and services are able to move from one location to another while interacting with desired spaces [4].

13.2.4.1 Transport Connectivity in the Nairobi Metropolitan Region

The previous section of this chapter has established that centres within the NMR are relatively spread out. This implies that people, goods and services are required to travel long distances between centres, underlining the need for enhancing connectivity. Although there are several airports and airstrips within the NMR, transportation within the region is majorly by road, and minimally by rail. The only reliable rail transport within the region connects Syokimau, which is at the edge of Nairobi City towards Machakos, and Nairobi CBD. Inter-county train transport is only possible by the standard gauge rail connecting Nairobi and Mombasa; the line is however on high demand for intercity traffic which limits its NMR service capacity.

Road transport therefore remains key in connecting economic centres in the NMR. Major connections include: Thika road, an A2 class road linking Nairobi and Thika road; Mombasa Road, an A 109 road that is part of the link between Nairobi and Machakos town; and Nairobi–Kajiado link which takes two routes, one through Kiserian and another through Kitengela along Mombasa road. There are other numerous roads connecting other centres, for example, Kiambu road which branches from Thika road to Kiambu town. Within Nairobi city, attempts to divert through traffic from the core metro led to the establishment of the Northern Bypass (connecting Thika Road and Limuru Road); the Southern Bypass (connecting traffic from Mombasa road to Kikuyu through Langata and Ngong); and the Eastern Bypass (connecting Ruiru and Mombasa Road). Other notable projects for improving connectivity within the core metro include construction of Outering road, and rehabilitation of several other roads.

13.2.4.2 ICT Connectivity in the Nairobi Metropolitan Region

In the case of the Nairobi metropolitan region, development of ICT infrastructure has been impressively progressing over the last decade. The region today enjoys the highest level of connectivity as a result of overall increase in the country's internet bandwidth, which grew from a mere 28 Megabits per second (Mbps) in 2004 to 193.58 Gigabytes per second (Gbps) in 2015 [18, 19]. The rolling out of the National Optic Fiber Backbone Infrastructure (NOFB) in two phases served this goal effectively, with connections in the first phase focusing on sections of the NMR. As a result, most areas are now connected with reliable internet. High investment in the mobile telecommunications industry by various players has tipped the balance on the need for physical internet hardware/cabling, as more people and

offices are adopting wireless forms of internet services as opposed to landline cables. Decreasing cost of internet (data) has also made it possible for high adoption of the services. Today, the cost of accessing internet services is relatively constant between the Nairobi city core and the other outlying centres, with similar speeds, broadly implying increasing connectivity. Equally, previously unconnected centres are becoming more and more served with internet services, further contributing to enhanced connectivity. Additionally, a change of regional management to a county governance structure, where counties are developing their own web-based systems and offering online services, has been greatly contributing to enhanced connectivity within, between counties, and to the rest of the world.

13.3 An Appraisal of Smart Economy and Connectivity for NMR

13.3.1 NMR and Smart Economy

The question whether Nairobi has a smart economy or not does not have a definitive answer. Based on the conceptualization of 'smart economy' within the building blocks of 'smart cities'—as defined earlier in this chapter—analysis shows NMR as performing fairly well. The region has notable university sponsored innovations, a noteworthy entrepreneurial leadership, a flexible labour market, a climate that promotes tourism and investors and a fast growing ICT industry, among other 'smart' economy measures. The JLL [20] in their ranking of dynamic city regions placed Nairobi at position 10 out of 134 major business hubs globally. Within Africa, the city was ranked first, with notable ability to adopt technological changes and absorb population growth. Ranking criteria consisted of adventure, citizenship, cultural influence, quality of life, power, movers, open for business, heritage, entrepreneurship and open for business (see [20]). On entrepreneurship and being open for business, the city was ranked 65th and 53rd respectively.

Nairobi is recognized as the gateway to East Africa. It is a leader in global innovation, a regional tech-hub, and a frontrunner in mobile payment technologies. Employment of cutting-edge research by its expanding universities is being seen in science, industry and business. Yet, the NMR is still dealing with common urbanization challenges of the global south, effectively pulling it away from the quintessential smart region.

These challenges are related to poverty, spatial planning, infrastructural development and housing [21]. In effect, the region has apparent development neutralization forces. Examples of such situations include businesses losing profits in traffic jams; a booming housing industry with majority of city residents being unable to own a house; a highly educated populace but without job opportunities; an increasing car ownership without commensurate transport planning; and a growing population of high-income earners against a burgeoning population of low income groups. For having a capitalistically inclined economy, capital accumulation and manipulative wage labour have brought about huge income gaps, tilting

the balance of the economy. The supply chain is minimally regulated by the government, and brokers and middlemen often exploit gaps in information which disadvantages primary producers. A scrutiny of these challenges show that they fall within the economic as well as other blocks of smart cities, namely mobility, people, living and governance. Accordingly, a key aspect of smart economy that needs to be addressed in the NMR is creating a balance in sustainable economic development, one that particularly considers enhanced connectivity.

13.3.2 NMR and Smart Connectivity

Similar to the case of smart economy, the NMR offers a resemblance of smart connectivity while at the same time exhibiting obvious connectivity deficiencies. This section analyses connectivity at two levels: spatial and virtual.

(a) **Spatial Connectivity**

Spatial connectivity implies mobility. In smart mobility, key indicators of smartness include availability of balanced transport options and linkages, cycling and walkable spaces, pleasurable spaces, vibrant streets, mass rapid transit, integrated high mobility systems, assured mobility for all (including people living with disabilities), and effectively managed traffic [3]. In the NMR, realization of these smart city desirables has only been met partially. In terms of mass-rapid transit, the region lacks a metro rail, a light metro, a high speed mobility 'skytrain', and even a high-capacity bus system. Public transport is majorly by low-capacity busses and vans which do not have dedicated lanes. The public vehicles share routes with private vehicles, often on very congested roads. Rail transport is limited to a few routes, and only operates in the in the morning and evening hours when people travel to and from work. Inter-modal traffic transfer plan is often lacking, and this compels train commuters to walk long distances to and from the stations.

The region has currently invested hugely on road expansion, particularly on routes connecting major business nodes [22]. Traffic has in effect been moving faster; while this is commendable, heavy traffic jams are experienced at the slightest disturbance of traffic, for example due to a road accident or weather change. Balance in transport modes is lacking in the NMR, with private transport unfavourably competing for carriageway with public transport. Walkability of streets has only received limited attention, and walkable and pleasurable streets only exist in few areas, majorly in the central business district and affluent neighbourhoods. In addition, the NMR does not have bicycle infrastructure, and only a few road users prefer this green mode of transport. This is attributed to poor road safety for cyclists. In a nutshell, it is observed that while the NMR had an evolving economy, people, environment and living, mobility is among the key areas where progress has been acutely limited.

(b) **Virtual Connectivity**

This kind of connectivity concerns linkages that do not involve physical interaction. Virtual connectivity is an integral part of smart connectivity. The NMR is a leading

region in Africa in this regard, enablers of connectivity being ICT. Gustaf and Knut [21] note that among all other sectors of development, Nairobi's ICT-sector is the most developed. Application of ICT has been used in the NMR business sector to enable voice and video communication, make mobile money payment, shop and order delivery of goods, and even trade in stocks. Geo-spatial ICT applications involving GIS tools are employed by businesses for identification of business opportunities, understanding the region's landscape, monitor transportation fleets, routes planning and navigation among others [2]. The NMR's utilization of virtual connectivity in doing business is limited by poor spatial connectivity during delivery of good and services, common challenges being unpredictable traffic flows, lack of seamless modal transfers and a poorly regulated public transport industry [23]. As such, a proper foundation in 'smart' mobility is a necessity for optimal virtual connectivity. Various smart transport initiatives have been launched and tested in Nairobi, ranging from Beba pay card which was a collaborative initiative of Equity Bank and Google to come up with public transport travelling payment card system instead of cash system. Another smart transport service idea is the *magic bus* system which is an initiative by a group of university students from Earlham College in the US to enable public service vehicles commuters to book for a seat of a matatu from their phone without having the trouble of making long queues at the Bus stop. Use of NMR as test ground for these initiatives including other initiatives such as digital matatu, is an indication of primacy of NMR when it comes to absorption and adoption of innovative ideas in as far as smart connectivity is concerned.

13.4 Analysis of Economic Development, Spatial Structures and Connectivity of Regions

Studies show that there is a relationship between spatial organization or regions and their levels of economic development [24, 25]. This organization is what constitutes urban form. Patchy urban developments over a landscape, for instance, may translate into need for more spatial linkages, including motorized travel for accessing economic and social facilities such as shops, schools and parks. Such could impact on the economic success or failure a region. In this section, we include a study that assess the relationship between urban form and economic prosperity of regions; the analysis serves as input to our recommendations for creating a better connected and prosperous NMR.

Urban form is defined by urban sizes, centricity and density. In this study, we have compared city regions with sizes close to that of Nairobi and have employed spatial metrics to measure centricity of regions. These metrics analyse density within centricity measures of compactness and dispersion. In principle, regions with compact development are dense and will have high centricity; conversely, dispersed urban development will have low centricity. This index is generated from classified imagery [26].

Comparing a region's urban form and measures of economic development can give an indication of how the former impacts on the latter. However, it is to be noted that economic development is a multivariate concept with no single agreed upon definition [27]. Measures that have been used to quantify economic development have included population growth, urbanization, infrastructure, gross national product (GNP) and Gross Domestic Product (GDP) per capita, consumption per capita, labour force occupational structures, and social conditions such as life expectancy, health care, mortality, literacy rates and even calories intake among others [28]. Regions found in countries with substantially different economic potentials can therefore not be objectively compared. To overcome this limitation, this study only compares indicators of economic performance and spatial structures of metropolitan regions found in the same IEF (Index of Economic Freedom) bracket [29] with Kenya, and within the same population bracket with the NMR [30]. Based on this criteria, metropolitan regions picked for comparison are: Nairobi in Kenya, Dar Es Salam in Tanzania, Abidjan in Ivory Coast, Khartoum in Sudan, and Alexandria in Egypt.

To establish each of the 5 regions' centricity of built-up development, the study employed a landscape analysis application, Fragstats [31]. Aggregation index (AI), which is a spatial metric computed for a raster surface with a goal of establishing the extent of spread or clumping in a landscape, has been used as a measure factor for centricity. The index ranges from 0 to 100, where 100 represents a completely packed block of cells, all sharing adjacencies [32]. It is computed as given in the equation below [33].

$$\mathrm{AI} = \left[\frac{g_{ii}}{\max - g_{ii}}\right](100)$$

where g_{ii} is the joins between pixels of the classes being analysed; and max-g_{ii} is the maximum number of joins between pixels of a classes being analysed.

The study uses Global Human Settlement Layer (GHSL) [32] data as input to the Fragstats Application. The data has a spatial resolution of 38 m. All the layers for built-up areas were aggregated to a single layer (Fig. 13.3), and their aggregation indices generated.

The AI for the five regions are captured in the table alongside measure of economic wellbeing of the regions. It is to be noted that very little data on Africa is available, and this makes it challenging to rank African metropolitan regions by their per capital GDP strengths. However, Fraym [34] carried out a survey of the biggest markets in Africa, ultimately ranking 169 metropolitan regions in Africa by their estimated GDP, consumer size (which considered number of people owning assets that characterize middle-class consumers) and trade relationship and economic linkages. Rankings for the five regions under study are captured in the Table 13.1.

(a) **GDP Ranking and Aggregation**

Results show that Nairobi is the least compact of the 5 regions under analysis. Its GDP is ranked 19th in Africa behind Khartoum, Alexandria and Abidjan. It is only ahead of Dar es Salam which apparently ranks second least compact region.

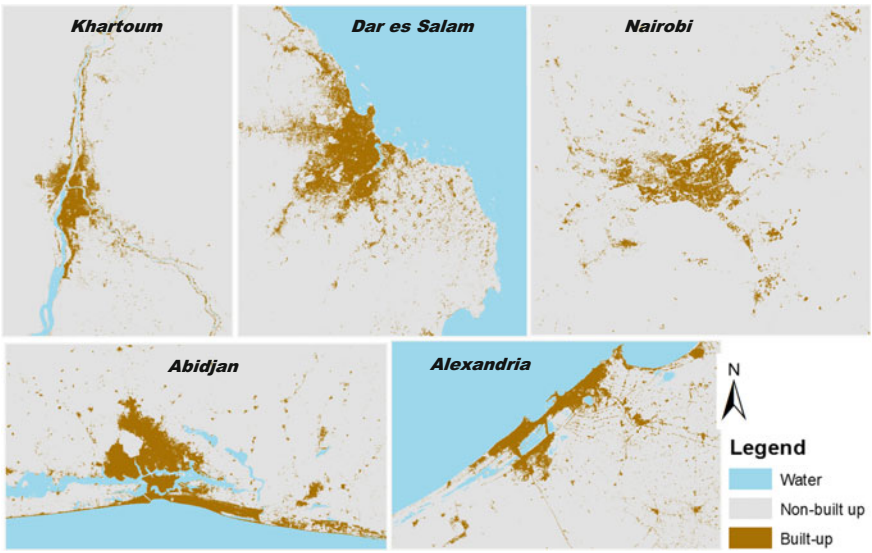

Fig. 13.3 Built up area of selected metropolitan regions

Table 13.1 AI and economic indicators of regions in African

Metro regions	GDP rank (x/169)	Consumer size (x/169)	Travel & trade (x/169)	Aggregation index of regions
Nairobi	19	13	6	58.0108
Dar es Salam	23	9	13	67.3613
Khartoum	8	7	10	69.0140
Abidjan	16	8	11	84.1308
Alexandria	6	6	16	71.2912

Whereas the five cities do not pass the threshold for a statistical analysis such as correlation and regression, it can be deduced from these findings that more aggregated regions generally perform better in GDP than less aggregated regions.

(b) **Consumer Size and Aggregation Index**

Under consumer size, Fraym considered the population within each cluster/region that owns a television, car, motorbike or a refrigerator, these being characteristics of middle-class population. Incidentally, Nairobi—which has the lowest AI—is ranked 13, lower than the rest of the cities. The rest of the regions are closely ranked with Dar es Salam following Nairobi at the lower ranks. Even though the relationship is not linear, with Abidjan being the most aggregated but ranking two regions below Alexandria, the general trend indicates reducing consumer size with reduction in AI.

(c) **Trade-Travel and Aggregation**

The trade and travel ranking was based on the gravity model approach [35]. It takes relationships between clusters in terms of trade and flight travels. It does not consider trade within the sub-sections of the clusters. This measure is therefore largely influenced by links outside a region, and therefore has not direct bearing on a region's urban form. Unsurprisingly, Nairobi—being a regional hub—ranks better than all other regions in this factor. Consequently, no clear relationship is observed between AI and this factor.

Based on the analysis above—and the available data for Africa—there is an apparent positive correlation between prosperity of regional economies and increase in centricity. The United States has more available data on economic development to allow a complementary analysis. Its case is analysed below:

13.4.1 Spatial Pattern of United States Metropolitan Regions and GDP

A complimentary study of centricity of city regions was carried out by Metropolitan Research Centre; the organization analysed spatial design of cities and generated scores for compactness or sprawl developed for each metropolitan areas based on development density, land-use mix, activity cantering and street connectivity [36]. The score of 100 represented regions that are neither compact nor sprawled, and scores above and below it represented increasing compactness and sprawl respectively. To assess how urban form impacts on economic performance of these American regions, the plot below show indices of the biggest 20 city regions in the US [37] against their gross-domestic produce per capita (Fig. 13.4).

The regression analysis shows a positive but weak relationship between increasing compactness of urban form and increasing economic development. While the relationship is not strong enough for a conclusive inference, it is notable that the relationship is positive just as it is in the case of Africa. This study, similar to the Fraym study, concludes that more compact regions are smarter and more productive.

13.5 Analysis of Spatial Connectivity and Economic Development for NMR

Nairobi has historically grown as the main political and economic hub of Kenya. At the same time, however, other small centres which have played the role of regional growth hubs around the city grew at a rapid rate, mostly stimulated by the level of productivity within the hinterlands they serve. Towns which were directly linked to Nairobi (e.g. by their virtue of supplying various services to the city), or which were

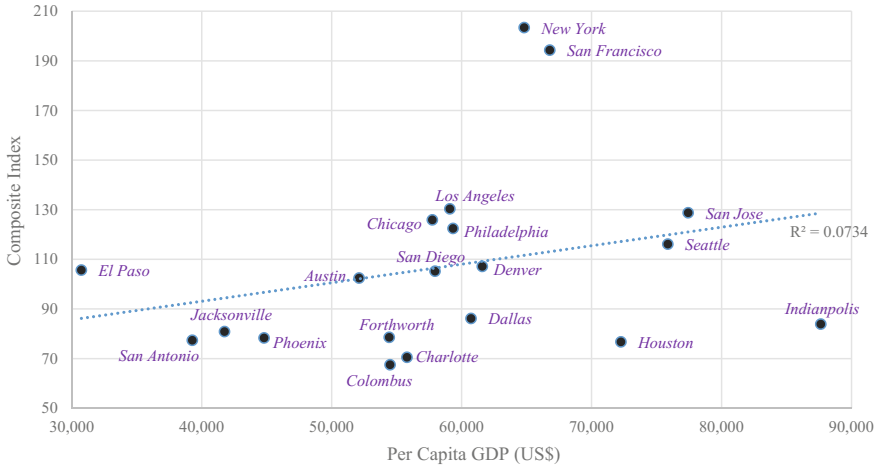

Fig. 13.4 Spatial pattern indices of American metro regions and per capita GDP

within its periphery benefitted from the broader city influence and grew faster than those in more rural hinterlands. The level of influence by the city however also relied on the nature of physical connections via road or rail systems, with towns closer to the core and where better transport networks were provided, growing faster than those with poor networks. This trend has greatly shaped the structure of the Nairobi metropolitan area, and can be associated with the existing form today, wherein majority of the larger towns are located along the main transport corridors converging at the city centre.

Investment in construction and upgrade of transport networks in the broader Nairobi metropolitan region over the past decade has greatly boosted the development of these towns, with built up areas changing by upwards of 50% in areas where such investments have taken place. This finding follows the conventional logic of development, wherein more connected and accessible areas have a greater potential for growth. While majority of the initial urban developments were residential in nature, the need for commercial services closer to the people has resulted in the development of alternative commercial centres adjacent to the main transport networks.

Using remote sensing techniques, we analysed change in built up area for locations abutting key transport infrastructure over the past ten years. We specifically compared areas where new infrastructure installations have been made over the study period against areas where no such investments have been made in order to assess the rate of development change. Figure 13.5 illustrates an analysis of the broader growth trend of the metro region.

The above figure presents low resolution automatic extraction of built up area in a select section of the Nairobi metropolitan region. As per the figure, areas close to the city, and which are along main transport corridors have experienced varying levels of growth over time, with the Nairobi–Thika connection and its connected by-passes exhibiting a high level of linear developments.

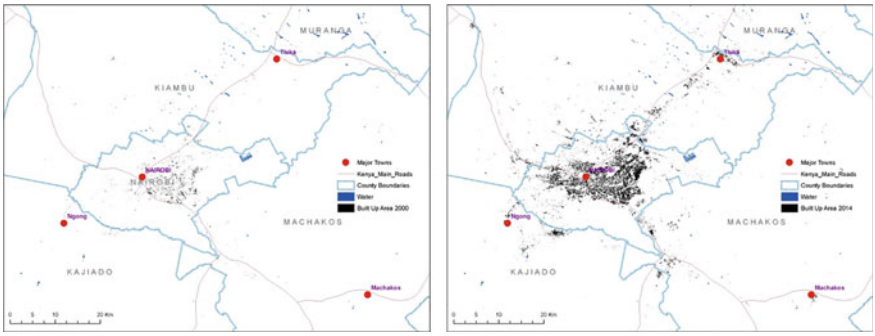

Fig. 13.5 Change in built up for select area of NMR, 2000 and 2014. *Source* Global Human Settlements Layer

The *Nairobi–Thika Connection* is the major road—53.6 km in length—connecting the industrial town of Thika and Nairobi City. Between the years 2009 and 2012, this link was upgraded from a single carriageway with mixed sections of 2 to 4 lanes to an 8-lane controlled access highway. This upgrade reduced traffic time from Nairobi to Thika from 2 hours to 40 minutes [22]. Further, it triggered a sharp appreciation of land values along the route, and since then, there have been an upsurge of investment on land and businesses along the route. Consequently, Thika town has become more connected to Nairobi, and urban zones of intermediate centres such as Ruiru, Juja, and Githurai have increased tremendously with investors and entrepreneurs relocating there for strategic access to emerging markets as well as access to space for expansion. Additionally, the construction of the road has boosted transport of daily and horticultural produce and traders to Nairobi [22].

An in-depth analysis of two single points along the highway and its connected Northern by-pass indicates that the new road developments have resulted in change in built up area by more than 40% over the period 2007–2017 (red pixels in Figs. 13.6 and 13.7).

Thome is located in between the Thika highway (south) and the Northern by-pass (north), and the area between the two roads experienced the most growth between 2007 and 2017.

Ruaka, a previously tiny village located along the Northern by-pass, has now turned into a major residential and (growing) commercial hub at the periphery of the city.

We compared the findings from the Nairobi–Thika connection with developments along another major road, the Nairobi–Namanga road, which branches off Mombasa road and links Kenya to Tanzania. In particular, we focused on the urban area comprised of Athi-River and Kitengela towns, and Kajiado town, all located along this connection. Despite these towns being located along an important road, their rate of growth (both internally and outwards) was less than 25% over the period 2007–2017 (shown by high number of green pixels in Figs. 13.8 and 13.9).

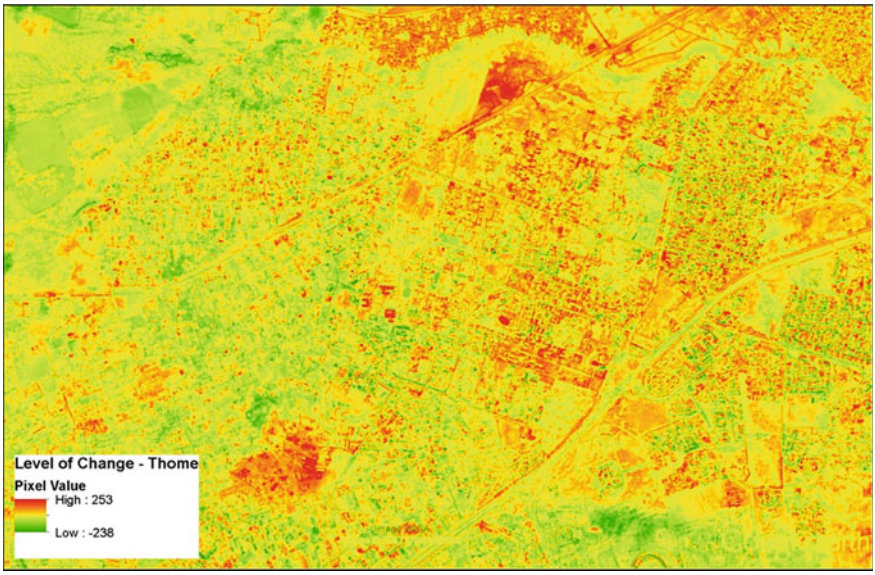

Fig. 13.6 Illustration of level of change in Thome along Thika road and the Northern by-pass

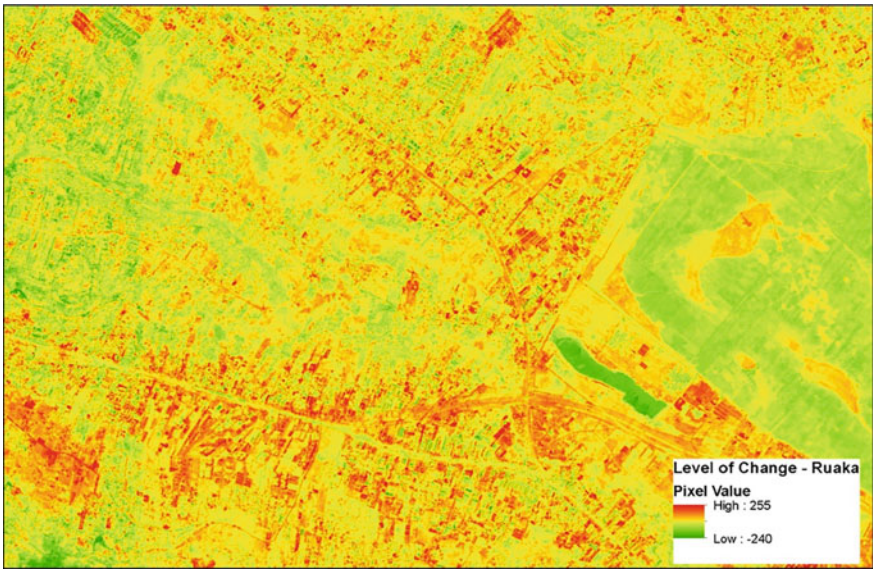

Fig. 13.7 Illustration of level of change in Ruaka along the Northern by-pass

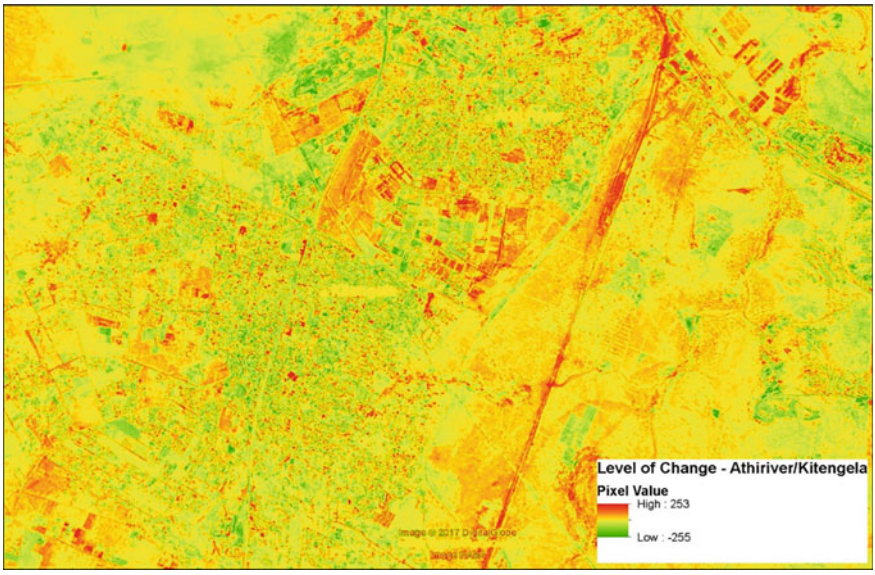

Fig. 13.8 Illustration of level of change in Athi-River—Kitengela area along Nairobi–Namanga road

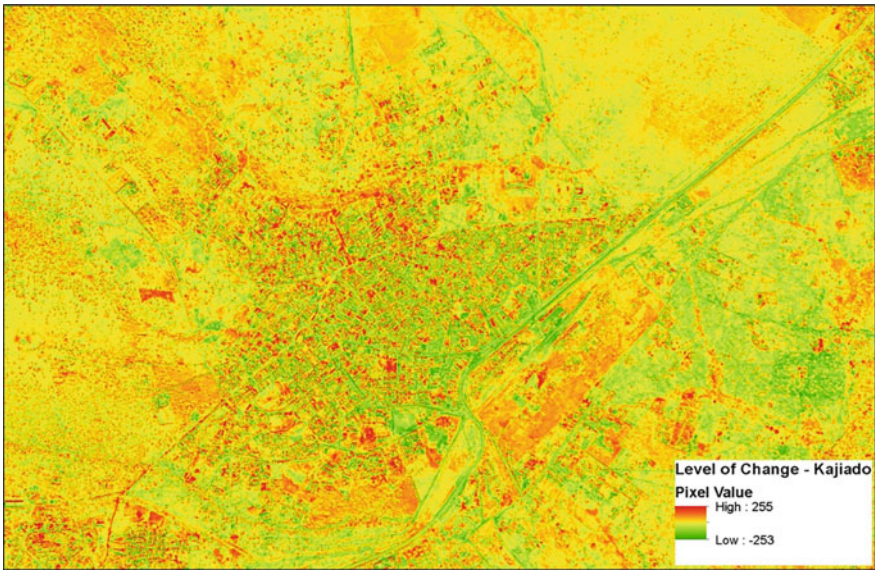

Fig. 13.9 Illustration of level of change in Kajiado town along Nairobi-Namanga road

Recent upgrades to this road stretch is attracting investments in the area, and massive changes are expected in the next five to ten years.

All locations analysed above have largely grown as residential areas, with their residents commuting on a day to day basis to the Nairobi city core. Over time however, demand for commercial services has attracted new forms of development, which constitute business premises (supermarkets, cyber-cafes, restaurants, and car sale yards), office space, ware-houses, factories and informal road-side businesses. The connectivity of the areas to internet is today also enabling many people to work from home, promoting the growth of a smart economy.

The development of commercial centres/services within the newly developed areas is a good indicator of enhanced productivity within the larger metro region. Increased connection to, and use of improving ICT structures is further reducing the need for back and forth movement to the city, while at the same time promoting economic growth. For example, with increasing prices of rental warehouse space within Nairobi's industrial area, several businesses have opted to adopt online marketing (e.g. in OLX platform) for their goods, which are stored in cheaper warehouses within the newly growing areas. These businesses only rent out small offices in strategic locations within the core city, which act as show rooms. Customers can order for the goods online and visit the show rooms, then the goods are delivered to them straight from the warehouses. This has broadly improved business efficiency and is contributing to enhanced incomes for such businesses. New jobs are also being created within these newly developing areas, and as the need for related/supporting services emerge, new business opportunities are continuously emerging. All these are largely boosting the economic development for the larger region.

13.6 Analysis of Policy, Legal and Institutional Framework Shaping NMR

In discussing legal, institutional and policy framework shaping up NMR in relation to connectivity, it will be important to borrow some of the principles raised by Ortiz [38] who noted that:

> Metropolises are not to be planned or managed as cities. The (Deoxyribonucleic acid) DNA is different. Cities, even large, are conurbations with a single administration and require a political dialogue about the future between the citizens and their administration. Metropolises are multifaceted systems with layers of different administration agencies and governance institutions. The dialogue is between those institutions. DNA is different. And you should act accordingly. [39]

This section will look at the legal, policy and institutional transport and ICT framework which can enhance smart connectivity within the Nairobi Metropolitan Region (NMR) which cumulatively lead to its development as a region.

13.6.1 Transport Legal Framework

a. **The Constitution of Kenya**

Transport connectivity matters in the constitution is mentioned thrice, with the first mention with reference to the bill of rights in Article 54(1c) *which notes that; a person with any disability is entitled to reasonable access to all places, public transport and information.* Secondly, it is mentioned twice in fourth schedule with regards to distribution of functions between the National Government and the County Government. Part 2 of the fourth schedule indicates that the functions and powers of the county in relation to county transport include:

(a) *County roads*
(b) *Street lighting*
(c) *Traffic and Parking*
(d) *Public road transport and*
(e) *Ferries and harbours excluding the regulation of international and national shipping and matters related thereto.*

Transport connectivity is given constitution prominence both at national and county level. The constitution though is not clear on metropolitan as an area but gives positive pointers which can be best operationalized at metropolitan level due to unique interaction between neighbouring counties forming a metropolitan region which can be enabled to handle connectivity mandates in an efficient and effective manner. This is the window of opportunity which the president of Kenya used to propose, the Nairobi Metropolitan Area Transport Authority. The Bill for formation of this Authority is still under consideration by the parliament.

b. **The Kenya Roads Act, No. 2 of 2007**

The act was enacted for management and provision of road Infrastructure including NMT in all classes of roads through various authorities. Under part two section 3 (1), the act establishes the Kenya National Highways Authority (KeNHA) as a body corporate. The Highways Authority is responsible for the management, development, rehabilitation and maintenance of national roads.

Some of the functions of KeNHA include:

(a) Constructing, upgrading, rehabilitating and maintaining roads under its control;
(b) Controlling national roads and road reserves and access to roadside developments;
(c) Implementing road policies in relation to national roads;
(d) Ensuring adherence to the rules and guidelines on axle load control prescribed under the Traffic Act;
(e) In collaboration with the Ministry responsible for transport and the Police. Department, overseeing the management of traffic and road safety on national roads;

(f) Collecting and collating all such data related to the use of national roads as may be necessary for efficient forward planning under this Act;
(g) Preparing the road works programmes for all national roads;
(h) Liaising and coordinating with other road authorities in planning and on operations in respect of roads.

Under part two section 9(1), the act establishes the Kenya Urban Roads Authority (KURA) as a body corporate.

The Urban Roads Authority is responsible for the management, development, rehabilitation and maintenance of all public roads in the cities and municipalities in Kenya except where those roads are national roads. Some of its functions include:

(a) Monitoring and evaluating the use of urban roads;
(b) Planning the development and maintenance of urban roads:
(c) Collecting and collating all such data related to the use of urban roads as may be necessary for efficient forward planning under this Act
(d) Preparing the road works programmes for all urban roads;
(e) Liaising and coordinating with other road authorities in planning and on operations in respect of roads.

Under section 6(1) the act establishes the Kenya Rural Roads Authority (KeRRA) a body of corporate. Under section 7(1) The Rural Roads Authority shall have responsibility for the management, development, rehabilitation and maintenance of rural roads.

This act reformed the roles of former ministry of roads and public works and gave specific mandates to different roads agencies in as far as development, management and rehabilitation of various roads is concerned. A lot has been achieved under this arrangement and duplication of roles and mandates greatly reduced which has opened up many parts of the country thus inducing development in all regions. This approach can give metropolitan authorities such as Nairobi a more visible role of coordinating connecting roads for different counties within a metropolitan area since this forms the basis at which smart connectivity routes can be developed in achieving smart mobility within a metropolis.

c. **The County Government Act**

An Act of parliament to give effect to Chapter Eleven of the Constitution; to provide for county governments' powers, functions and responsibilities to deliver services and for connected purposes. This Act gives county government powers to control development and investments including infrastructure investments in their areas of jurisdiction through various plans such as County Integrated Plans and land use plans.

This Act is important since the constitution is clear on the two levels of governments and mandates and responsibilities including connectivity and development funding is distributed through the two levels. The metropolitan area is made up of counties and therefore their operations must be within the confines of the law for optimal development driven by good transport connectivity.

d. **The Traffic Act**

This Act consolidates the law relating to traffic on all public roads. The Act also prohibits encroachment on and damage of roads including land reserved for roads. The Act ensures that there is harmony on laws guiding traffic. It is assumed that good connectivity strategies within a metropolitan area should be safe and responds to the mobility needs of the metropolitan residents and visitors. Nairobi metropolitan area is one of the region which is best endowed with good connectivity roads in the country and unfortunately it is the region which leads in terms of incidences of road related accidents leading to injuries and loss of life. It will therefore be critical to use resources within the region to reduce such negative incidences which is a threat to development and gains associated with good transport connectivity corridors.

e. **The Kenya Roads Board Act**

The act outlines the major tasks of the Kenya Roads Board (KRB) as follows:

(a) Coordinate implementation of all policies relating to the maintenance, rehabilitation and development of the network
(b) Coordinate maintenance, rehabilitation and development of the road network with a view to achieving efficiency, cost-effectiveness and safety
(c) The KRB Act provides for broad allocation of funds, with 60% going to international and national trunk roads and primary roads, 24% to secondary roads, and 16% to rural roads.

The successful implementation of the KRB Act is expected to translate into the physical improvement of the road network, improved utilization of the fuel levy funds, reduction in vehicle operating costs and travel times, open and accountable procurement of road works, and effective financial and technical auditing of road works. This has potential of fast tracking metropolitan regional development through rapid and reliable connectivity with support from KRB kitty.

f. **The Nairobi Metropolitan Area Transport Authority (NAMATA) Bill, 2017**

This is a bill whose ultimate aim is to be an ACT of Parliament to give effect to Article 189(2) of the Constitution: to establish the Nairobi Metropolitan Area Transport Authority; to provide for an integrated and sustainable Public Transport System within the Nairobi Metropolitan Area; and for connected purposes.

Article 189(2) states that:

> Government at each level, and different governments at the county level, shall co-operate in the performance of functions and exercise of powers and, for that purpose, may set up joint committees and joint authorities.

Due to mobility and connectivity challenges NAMATA bill is handy in changing the negative transport connectivity bedevilling the region. Initiatives such as the proposed five (5) Bus Rapid Transit (BRTs) routes will go along away in improving mobility and flow of goods and services within the metropolis which

will definitely catalyse development for the region given that studies have shown that Nairobi Metropolitan Area controls over 50% of Kenya's Gross Domestic Product (GDP) and it is estimated that USD 1 Billion is lost annually due to congestion [40].

13.6.2 Transport Policy and Planning Framework

a. **Kenya Vision 2030**

Kenya's Vision 2030 is the current long-term development blueprint for the country. The aim of Vision 2030 is to realize "a globally competitive and prosperous country with a high quality of life by 2030." It aims at transforming Kenya into "a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment". The Vision is anchored on three key pillars: economic; social; and political governance. The economic pillar aims to achieve an economic growth rate of 10% per annum and sustain the same until 2030 in order to generate more resources to address the Sustainable Development Goals (SDGs).

The demand for transport infrastructure and services is expected to be influenced by the economic policies to be implemented under Vision 2030, population growth, urbanization, increased volume of trade and productivity both in Kenya and in the neighbouring countries. Transport sector is expected to play an even greater role than it had ever previously done in all key sectors of the economy, namely; agriculture, manufacturing, building and construction, mining and quarrying, tourism, and in the service sectors, including wholesale and retail trade. These are reliable sectors which well-connected metropolitan regions can capitalize on achieving great heights of development.

To achieve vision 2030 the Government identified the following infrastructure projects, among others, for implementation:

(1) Developing a 50-year Integrated National Transport Master Plan which is linked to the National Spatial Plan. It will ensure that the investment and location of transport infrastructure and services are consistent with other public policies. Also, it will ensure optimal transport infrastructure investment to position Kenya as the most efficient and effective transport hub of the East and Central African region and promote national aspirations for socio-economic reconstruction and development. It will also facilitate improvement and expansion of transport infrastructure in a manner that will reduce transport costs and also open new frontiers for economic development.
(2) Developing Nairobi metropolitan region Bus Rapid Transit System to cover three transport corridors
(3) Development of light rail for Nairobi and its suburbs. It is projected to serve at least 150,000 passengers daily.

The implementation of the second and third Medium Term Plan (MTP) of vision 2030 will focus on the competitiveness and rebalancing growth so as to make Kenya globally competitive. The government will increase investment in expansion, development and modernization of roads, rail, ports, ICT and telecommunications in order to make Kenya a top logistics hub which is all critical in achieving smart equity development for all Kenya metropolitan regions

b. **Integrated National Transport Policy**

The INTP guides the development of all the sub-sectors including: road, rail, aviation, maritime and inland water transport and pipeline transport system.

The Integrated National Transportation Policy (INTP) covers key challenges related to transport infrastructure planning, development and management, legal, institutional and regulatory framework for the sector, safety and security, funding, gender mainstreaming, utilization of Information and Communication Technology (ICT), and environmental considerations, among others. Its aim is to provide a policy that is conducive to the stimulation of rapid development and efficient management of a safe, widely accessible transport system that responds to modern technological advancement in a rapidly changing and globalized environment

The policy is comprehensive and anticipates key participation of various authorities as anticipated in the constitution in transportation matters through: Committing the national government to improve governance and service delivery at the local level (County) and this will call for increased responsibilities and greater managerial competence. Some of the reform initiatives at this level will involve improvement of local finances including utilization of cess.

It also gives county governments powers in collaboration with the relevant government agencies and stakeholders, to focus on development and management of transport infrastructure as appropriate, implementation of urban policy, development of local transport plans and integrating these with overall urban land use planning, environmental management, enforcement and local traffic management.

c. **County Integrated Development Plans**

This stems from Sect. 104 (1) of the County Government Act of 2012 which requires all county governments to plan for the county and no public funds shall be appropriated outside a planning framework developed by the county executive committee and approved by the county assembly. All current CIDPs are aligned to vision 2030 and are running from the year 2013 to 2017.

The CIDPs for the all 47 counties have addressed transportation matters under infrastructure and access chapter. They have listed all the ongoing and proposed transport related projects in their respective counties.

d. **Nairobi Integrated Urban Development Plan (NIUPLAN)**

This is the plan guiding development of Nairobi County after the expiry of the Nairobi Metropolitan Growth Strategy (NMGS) in the year 2000. Nairobi has been lucky to have had plans since 1920s. The first master plan was developed in 1927 to

capitalize on Nairobi strategic location as the hub of the Kenya Railway line which is transport oriented. The most elaborate plan for Nairobi was the 1973 Nairobi Metropolitan Growth Strategy (NMGS).

NIUPLAN builds from the Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area (NUTRANS) which was supported by JICA in 2006 in terms of addressing missing links in Nairobi transportation system. NIUPLAN is the first deliberate attempt to integrate land use in transportation planning in Nairobi. It also emphasizes on modal integration though heavy on motorized transport including heavy expenditure on public transport infrastructure such as Bus Rapid Transit (BRT).

e. **Integrated Strategic Urban Development Plans**

Various counties such as Mombasa, Kisumu, Kiambu, Nakuru, Machakos, Kitui, Embu, Nyeri have recently prepared Integrated Strategic Urban Development Plans (ISUDP) though support from World Bank, Japan International Cooperation Agency (JICA) and French Development agency (AFD), where transportation issues have been addressed exhaustively including elaborate urban transport baseline information which is good but based on the methodology used, this can be expanded to cover entire county to help the counties develop metro wide transport policies to guide provision and management of transport sectors in counties. This will help initiatives such as NAMATA for Nairobi metropolitan in linking land use and transportation planning which has been a major gap hindering connectivity in Nairobi metropolis.

13.6.3 ICT Legal Framework

At the end of the 20th century, the world witnessed a move from industrial revolution toward an information revolution. Principal to this revolution has been the rapid growth of the new technologies otherwise known as the information and communication technologies (ICTs) which include the internet, email, and mobile telephony among others [41]. Legal framework affection the NMR include:

a. **The Kenya Information and Communication Act**

An Act of Parliament to provide for the establishment of the Communications Commission of Kenya to facilitate the development of the information and communications sector (including broadcasting, multimedia, telecommunications and postal services) and electronic commerce, to provide for the transfer of the functions, powers, assets and liabilities of the Kenya Posts and Telecommunication Corporation to the Commission, the Telcom Kenya Limited and the Postal Corporation of Kenya, and for connected purposes. The Act establishes the Communication Authority of Kenya which has the mandate of regulating ICT sector in Kenya.

Other relevant regulations important in understanding the legal framework are listed as:

- The Kenya Communications Regulations 2001
- Universal Access and Services Regulations, 2010
- Interconnection and Provision of Fixed Links, Access and Facilities Regulations, 2010
- Fair Competition and Equality of Treatment Regulations, 2010.

13.6.4 ICT Policy Framework

a. National Information and Communication Technology of 2006

The policy seeks to facilitate sustained economic growth and poverty reduction; promote social justice and equity; mainstream gender in national development; empower the youth and disadvantaged groups; stimulate investment and innovation in ICT; and achieve universal access. It is based on internationally accepted standards and best practices, particularly the COMESA Model adopted by the COMESA Council of Ministers in March 2003.

The policy is based on four guiding principles: infrastructure development, human resource development, stakeholder participation and appropriate policy and regulatory framework.

13.7 Analysis of the Impacts of the County Governance on the Functionality of NMR

In synthesis, we note that devolution, which came into the fore with a change in the country's constitution in 2010, changed the governance structure of the NMR [42]. The result of this has been new growth trends that have manifested in the rapid growth of new towns, particularly those designated as county headquarters. These new towns, whose administration is vested within county-based governance systems, are growing at a fast rate and are likely to shape the country's urbanization in the next decade.

As a desired effect of this governance structure, huge investments in business are beginning to happen more in the counties. Furthermore, in their quest to be outstanding, counties have attracted huge investments in infrastructure and public facilities that migration from centres like Kajiado and Machakos to Nairobi in search of better services and facilities is drastically reducing. While this is a good thing, per se, it could weaken regional bonds between the counties in the NMR. In fact, the new setup has encouraged inter-county business competition which—though boosting development of counties within the region—has broken major

links between them and Nairobi city. The primacy of Nairobi has started to feel the effects of limited capital inflow (albeit at a minimal level) as more developers eye cheaper land and growing opportunities in the counties.

In spite of their robust take-off, the newly set up county governments are still struggling to operationalize basic administration functions; additionally, they are faced with a huge challenge of administering and directing sustainable urbanization. The emerging challenges in counties are related to, among other things, limitations in staff and their capacity to perform different duties, lack of adequate laws and policies to guide actions, as well as lack of know-how in establishing workable programmes. Some basic planning structures are yet to be institutionalized in counties; for example, a survey by the Council of Governors [43] found only 4 out of 30 counties with GIS labs, a vital department in mobility planning. Challenges cites against the realization of this goal included budgetary constraints, inadequate capacity and lack of political goodwill.

Regional economic development—wise, one of the undesirable effects of the new governance structure was the introduction of new forms of taxes to meet budgetary demands. For instance, in 2013 many counties introduced produce cess charges, which is a form of tax for goods moving between counties. The implication of this is that a person transporting goods through three counties has to pay a charge to each county. This has largely impacted on the cost of doing business throughout the metro-region. For the product value of maize, for example, a 16% cess cost is paid, while in transporting vegetables and animals, the cess value of 10% paid [44].

13.8 Synthesis of Connectivity Factors Impacting Regional Economic Development

Regions with high centricity generally perform better economically than less compact regions. Characterized by high-densities and mixed-land use, compactness of a region supports in the realization of sustainable development [45]. For a region experiencing financial constraints such as the NMR, compact development will reduce per capita infrastructure demand, ease provision of public service, and create sustainability for mass rapid transit. Incidentally, the NMR has spatially spread out developments, particularly to the east and southern parts. It would have benefitted the NMR if Machakos and Kajiado were closely knit spatially. Despite availability of space for expansion, measures to limit urban extents should be prioritized if this goal is to be realized. Incidentally, spatial modelling of landscape pattern of the NMR shows that the NMR's built-up area is spatially expanding while becoming more aggregated—even though with non-linear, complex, disconnected patches [46]. This is desirable if it can be embedded in urban planning policy, and implemented comprehensively.

Further analysis on transport connectivity within the NMR shows that locations along transportation routes get an immediate boost in development when the route is upgraded. Such is the case along major transportation routes in the NMR as the analysis of Thome, Ruaka, Kitengela and Kajiado settlements have shown. This translates to mean transport connectivity is a prerequisite for regional growth. It is to be noted that, in a competitive economy, businesses anticipate improvement of transportation linkages. For example, the Nairobi's satellite towns experienced a growth of 21.4% in 2014 following the government's declaration of its plans to start up major infrastructure projects including the standard gauge railway, the western bypass and a commuter rail. Locations impacted directly by these planned projects such as Juja, Ruiru and Limuru experienced a rise in property prices by 43, 42 and 34% respectively [47]. Such was the case in Isinya town where plot values doubled in one year upon the commencement of upgrading of the Athi River–Namanga road. Today, Isinya, which was barely recognizable as settlement 5 years ago, is emerging as a leading centre in Kajiado County alongside Ngong, Kitengela, Kiseran and Ongata Rongai.

Policy analysis show that the NMR has made considerable progress in establishing the relevant policy, legal, and institutional framework. Whereas some laws were developed prior to the formation of devolved governance units—and did therefore not anticipate regional governance—the necessity for regional integration is conveyed in the constitution and recent policy documents. Implementation gaps are however manifestly wide in most of the well intentioned connectivity policies. For example, the need to develop a rapid mass transit system for the region is expressed in numerous policy strategies including the Nairobi Integrated Urban Development Plan but implementation efforts are not evident. This points to the fact that it is not enough to have policy documents and legal frameworks; the policy makers should first grasp the issues limiting implementation of existing policies and work more on implementation strategies. Such calls for the establishment of a monitoring and evaluation system able to holistically look at the existing metro-region operationalization and management setups.

13.9 Towards Enhanced Connectivity in the NMR for Economic Development

The NMR possesses huge potential in major sectors of the economy such as modernization of the service industry, industrial growth and upgrading, agricultural sector diversification and marketing. From the NMR vision and mission, for example, the Kenyan government commits to come up with various strategies including developing and pursuing a Smart strategy for Nairobi Metropolitan Region. In pursuance to this, the government has come up with various smart metropolitan enablers such as the recent formation of the Nairobi Metropolitan Area Transport Authority (NAMATA) which will provide a comprehensive and dynamic platform for addressing the challenges in the transport sector that have affected the

Metropolitan Area [48]. The body shall formulate a sustainable integrated public transport strategy that will be the basis for the orderly development of the proposed Metropolitan Area mass-transit system, which incorporates both bus rapid-transit and commuter rail. This may be a concept borrowed from Washington Metropolitan Area Transit Authority (WMATA) which can help the NMR in achieving the principle of delivering sustainable transport choices which has an impact on other principles such as promotion of clean energy and attracting investments which will lead to increase in employment and business opportunities, given that NMR has itself a big consumer market for most of its products.

Another intervention which is likely to facilitate achievement of smart NMR is the Nairobi Metropolitan Service Improvement Project (NaMSIP) which is focusing on different development projects such as sewerage, roads, boreholes, and markets. The project also pushes for capacity development of officers working in NMR counties, including purchasing of software and furniture among others. These interventions will help the NMR to achieve some aspects of interconnectedness within the NMR which is also a principle of smartness. A key component of NaMSIP that makes it promising is its partnership strategy. The project brings together various counties forming the NMR as well as the national government and the World Bank. This approach ensures that governance is strengthened in the realization of regional development goals.

Development of better roads infrastructure, particularly between centres of economic significance is an apparent intervention. Infrastructure-based or infrastructure-driven economic development school of thought which combines growth models from various world regions holds that in order to stimulate long-term economic growth and efficiency, particularly in economically lagging regions, a substantial proportion of a nation's resources must be strategically invested in long-term infrastructure assets, such as transportation, energy and social infrastructure [49]. Development of connectivity enabling infrastructure opens up areas for development, and in turn promotes economic growth and/or enhances productivity. Emphasis on 'smart' infrastructure planning must however be made. In an example, good roads comparable to Thika road, if created for major link routes such as Mombasa-Machakos, appeal to the mind as the missing link between perfect connectivity in the NMR. Yet, all facts considered along the long-term nature of planning, this would barely withstand the test of time. In the Nairobi Metro Strategy, projections show that the NMR will swell to 14.3 million by 2030 if the present conditions prevail. This translates to 58.8% growth from the present. The fact that Thika road is already experiencing occasional traffic jams particularly during peak hours show that a futuristic approach to enhancing mobility beyond road expansion is required. Perhaps much can be learnt from city regions that are bigger than Nairobi, both in developed and developed countries.

In Istanbul, arguably the most populous city region in Europe with a population of about 15 million, transport is bound to be a problem. However, the city is partially able to solve the traffic gridlock by use of public transport, which includes high capacity busses, the Metro tram and funicular for steep terrains [50]. Without these options, movement would be virtually impossible in the city region. With a

population lesser than half of Istanbul, the NMR could function efficiently if smart mobility approaches were employed. At present, transport linking major NMR regions is majorly by mini-buses and 14-seater vans. For being minimally regulated, the condition of the vans are often not satisfactory for the most middle and high income earning groups, a result of which majority who own cars prefer to travel by private means.

While there are numerous proposals to establish a rail transport for the NMR, implementation of these programs has not happened majorly due to governance challenges. Only the rail link between Nairobi and Syokimau has been reliable, yet with the Nairobi-Mombasa standard gauge rail station at Syokimau, this connection is mostly utilized in feeding traffic to the intercity train. The current traffic situation in the NMR challenges the delivery of food items to the city, with most transportation only happening in very early morning hours, beyond which food perishables become stale in traffic.

13.9.1 Key Strategies for a Better Connected NMR

The NMR is potentially able to realize huge economic gains with better connectivity. From enormous losses occasioned by traffic jams, poor inter-modal linkages, gaps in land use planning, to failure to leverage advancements land use and mobility management, the NMR is considerably operating below its optimal economic potential. Business models show that cities or regions that embraced principles of smart-city management greatly reduce their cost of doing business, boost their profit margins and subsequently attract more investors [1]. To place the NMR at this strategic locus, adoption of the following strategies is desirable.

(a) **Urban Growth Management and Spatial Temporal Modelling**

The connectivity analysis in this chapter has shown that regions perform better economically when they have a compact urban form. It is to be noted that urban growth, while unchecked against sprawl, is often associated with lack of proper planning policies, speculation, and legal disputes [51]. This phenomena affect the NMR; spatial planning policies in the region, though elaborate, are not explicit in promoting compact growth. Subsequently, for a county like Kiambu where land was predominantly agricultural a decade ago, urban growth is now sprawling into agricultural regions on a thin density fabric. The fact that Kajiado and Machakos have land for expansion creates even more urgency in limiting the expanse of their urban regions. For Nairobi city, which is fully urbanized, a more realistic approach would involve protecting areas that must be preserved as non-built up, and eliminating low rise development in high-density areas. This will involve revising the city's zoning ordinance. Congestion of settlements in Nairobi will reduce if vertical growth strategies were implemented, particularly in informal settlements. These measures will lead to the realization of wider roads which would yield economic benefits.

To tackle urban sprawl, it is imperative that the NMR adopts a policy of forward planning which limits urban centres to definite boundaries and ensures strict compliance. This intervention will yield compact regions with crisp urban-rural boundaries as has been the case with many West-European towns. This policy will lead to a realization of a productive urban hinterland and aggregation of numerous fragmented market locations. More business competition will be realized as well as economies of scale.

Implementation of the aforementioned spatial policies has been made easier by the advances in spatial modelling technologies. Spatial data, complemented by social-economic data, can guide in the identification probable growth locations which can be used to direct future growth. Using spatial modelling tools, for example, the Cellular Automata, Agent Based Modelling and Logistic Regression Modelling, the NMR's planners and managers can study human behaviour in the region and model settlement locations in a manner that is desirable [52].

(b) **Smart Transportation**

With Nairobi's economy suffering over $360 million in losses from traffic jams [53], it is obvious that the NMR requires a well-thought out transport system and that fully meets the needs of the residents. Previous section of this chapter have proven that the region requires an elaborate transport plan, more so beyond intensified road expansion projects. Mass transit is often at the core of successful transport plans. In the United States, for example, adoption of high occupancy, express and carpool lanes have been used to lessen traffic congestion [54]. Accordingly, major business nodes within the NMR need to be connected by a mass transit systems, particularly rail.

The rail is favourable in that it can handle huge capacity of travellers and can adjust fast to a growing population. In this regards, a rail line taking major transportation axis connecting Nairobi to Kiambu, Thika, Machakos and Kajiado is desired. In planning, Ortiz [42] advises that connectivity networks in Nairobi should not be targeted to be orbital-radial as the city is not circular; nonetheless, prioritization of rail access should be to and from the city centre. A complementary system of bus-rapid transit will be required, especially in connecting settlements that are distant from main rail line. This arrangement will translate into reduced usage of private means of transportation and use of vans. However, it is worthwhile to note that some travellers will not use public transport even when it appears expedient for them; in this regard, a modelling approach, particularly ABM, is required to establishing travellers' behaviours, including their motivation to choose a mode of travel over another. Such a study has not been carried out for NMR. It could be well that some travellers prefer quiet vehicles or spacious seats. As such, a conclusive research may propose development of train transport with silent or family cabins among other options. Studies observe that overlooking consumer needs lead to failures even for the most appealing product [55].

Yet another key consideration of smart transportation is modal shift. In Nairobi, it is observed that there is user travellers' reluctance in using the train where a

convenient mean of connecting to their final destination is not provided for. Indeed, even the time spent transitioning from one transport mode to another can contribute to favourability of a travel mode. Smart transit must therefore be ensured for all transport modes. Regions that have adopted such transportation strategies leverage the improving information and communication technologies.

ICT is an integral part of smart transportation. Current milestones in the sector allow exploitation of information technologies in traffic data management and application of mobile applications in booking and monitoring traffic. With internet usage in Kenya projected at over 67%, these ICT capabilities are primary inputs to smart regional mobility. The success being enjoyed by mobile applications (Apps) for booking taxi cab services (such as Taxify and Uber) and traffic monitoring and carpooling apps (such as Ma3Route and Waze) is a pointer to the potentials in the NMR. Advancement of these Apps will happen immediately, including through public initiatives, if a base infrastructure such a reliable, round-city metro rail can be put in place.

(c) **Regional Integration and Governance**

Managing urban growth and embracing smart transportation strategies will only work if attached to a dedicated implementer. Project implementation is a major challenge undermining plan making processes. In many regions of the world, it is not uncommon to find a costly plan making process superseding a well-intentioned plan that is not implemented. In fact, it is true to assert that the gap between plan making and implementation has been the biggest failure for planning in the NMR, and generally African cities. While, for example, the Integrated Urban Development Master Plan laid a groundwork for classification of centres, including setting out strategies that would improve Nairobi's outlook, the development projects presently being implemented do not make reference to this policy document. Thus, a plan that would be guaranteed to be implemented first requires to be articulate in defining its goals, especially at short, medium and long terms [56], and second, requires to secure commitment from the implementing authorities.

Unfortunately, the NMR is spread over four counties. This means greater efforts in respect to coordination are required in the regional planning. Indeed, regional integration is one of the principles of smart urbanism [57]. A shared planning vision for the four counties is therefore desired. This should start with harmonizing development visions of the four county authorities—as may be stated in their different planning frameworks such as their County Integrated Development Plans, County Spatial Plans and County visions. Ultimately, a regional planning authority, formed by administrators and technocrats from the four regions, should serve as the integrating body. On a continuous basis, the authority should review trade barriers, such as double taxation through county cess, and endeavour to improve connectivity of the region.

13.10 Conclusion

Nairobi Metropolitan Region (NMR) has great potential in uptake of smart and innovative ideas which can propel and sustain the region as one of the key regional development hubs in Sub-Saharan Africa. This will be achieved through completion of on-going initiatives such as Mass Rapid Transit (MRT) including Light Rail Transit (LRT) and Bus Rapid Transit (BRT). If embedded with online booking platforms such as the one currently used by the Kenya commuter train service from Mombasa to Nairobi, enhanced efficiency will be experienced in the transport sector, translating to increased metro-wide productivity.

The region is also benefitting from the national government goodwill to transform the region as shown by the commitment by the office of the President to support it to have a spatial plan, as well as a transport authority.

The chapter therefore concludes that though transport and ICT connectivity will continue to play a critical role and function in NMR development, it is not a sole panacea to fully unlock its economic and growth potential. Just like other metropolises in Africa, sustainable NMR development will require wide consultations with all relevant stakeholders in a bid to build consensus and commitments, which should take cognizance of the complex multi-level governance associated with such regions. This should be embedded on such metro region's own competitiveness and innovations which in most cases is highly boosted by their location as knowledge and economic hubs, which in itself is the main driver in speedy uptake of innovative ideas which are critical ingredients of making them sustainable regional development hubs.

Bibliography

1. Batagan L (2011) Indicators for economic and social development of future smart city. J Appl Quant Methods 6(3):27–34
2. Mwaniki D (2017) Smart city foundation, the core pillar for smart economic development in Nairobi. In: Kumar TV (ed) Smart economy in smart cities. Springer, New Delhi, p 1094
3. Vinod Kumar T (2017) Smart economy in smart cities. Springer, Singapore
4. Trova V (2012) Measures of street connectivity: spatialist_lines (MoSC). In: Hull A, Silva C, Bertolini L (eds) Accessibility instruments for planning practice. Technical University of Denmark, Copenhagen, pp 103–109
5. Peponis J, Allen D, French S, Scoppa M, Brown J (2007) Street connectivity and urban density: spatial measures and their correlation. In: Proceedings of the 6th international space syntax symposium, p 12
6. Jabareen YR (2006, Sep) Sustainable urban forms. J Plan Educ Res 26(1):38–52
7. Melo PC, Graham DJ, Brage-Ardao R (2013) The productivity of transport infrastructure investment: a meta-analysis of empirical evidence. Reg Sci Urban Econ 43(5):695–706
8. Jain V, Sharma A, Subramanian L (2012) Road traffic congestion in the developing world. In: Proceedings of the 2nd ACM symposium on computing for development—ACM DEV '12, p 1
9. Woollett N, Knight P, Redfern R (2009) The importance of transport connectivity in supporting regional economic development. In: European transport conference, 2009 association for European transport, April 2006, pp 1–20

10. Githira D (2016) Growth and eviction of informal settlements in Nairobi. University of Twente—ITC
11. El-barmelgy MM, Shalaby AM, Nassar UA, Ali SM (2014, Jan) Economic land use theory and land value in value model, vol. 2
12. Cottineau C, Finance O, Hatna E, Arcaute E, Batty M (2016) Defining urban agglomerations to detect agglomeration economies, 2004
13. Government of Kenya (2008) Nairobi metro 2030 strategy. Nairobi
14. Open Data Kenya (2017) Opendata.go.ke. [Online]. Available: http://www.opendata.go.ke/. Accessed 11 Nov 2017
15. World Bank (2011) Nairobi metropolitan service improvement project. Nairobi
16. UN-HABITAT (2006) Nairobi urban sector profile. United Nations Human Settlements Programme, Nairobi
17. J. I. C. A. JICA (2014) The project on integrated urban development master plan for the city of Nairobi in the Republic of Kenya. Nairobi
18. Export Processing Zones Authority (2005) Kenya's information and communications technology sector 2005
19. Communications Authority of Kenya (2015) First quarter sector statistics report for the financial year 2015/2016
20. Jones Lang LaSalle (JLL) (2017) City momentum index 2017. Chicago
21. Ankarcona G, Holm K (2016) The entrepreneurship ecosystem and its supports in Nairobi. Lund University
22. Road Traffic Technology (2017) Nairobi-Thika superhighway—Verdict Traffic. [Online]. Available: http://www.roadtraffic-technology.com/projects/nairobi-thika-superhighway/. Accessed 13 Nov 2017
23. Salon D, Aligula EM (2012, May) Urban travel in Nairobi, Kenya: analysis, insights, and opportunities. J Transp Geogr 22:65–76
24. Huggins R, Piers T (2017) Networks and regional economic growth: a spatial analysis of knowledge ties. Environ Plan A
25. UN-HABITAT (2014) The economics of urban form : a literature review. Nairobi
26. Kuffer M, Barros J, Sliuzas RV (2014) The development of a morphological unplanned settlement index using very-high-resolution (VHR) imagery. Comput Environ Urban Syst 48:138–152
27. Dialoke I, Edeja MS (2017) Effects of Niger delta militancy on the economic development of Nigeria (2006–2016). Int J Soc Sci Manag Res 3(3):25–36
28. Harper College Education Foundation (2017) Economic geography: measures of economic development. [Online]. Available: http://goforward.harpercollege.edu/foundation/index.php. Accessed 16 Oct 2017
29. Heritage.org (2017) Index of economic freedom. [Online]. Available: http://www.heritage.org/index/heatmap. Accessed 16 Oct 2017
30. CityPopulation.De (2017) Major agglomerations of the world—population statistics and maps. [Online]. Available: http://www.citypopulation.de/world/Agglomerations.html. Accessed 11 Nov 2017
31. UMass Landscape Ecology Lab (2017) FRAGSTATS: spatial pattern analysis program for categorical maps. [Online]. Available: https://www.umass.edu/landeco/research/fragstats/fragstats.html. Accessed 12 Nov 2017
32. He HS, DeZonia BE, Mladenoff DJ (2000) An aggregation index (AI) to quantify spatial patterns of landscapes. Landscape Ecol 15(7):591–601
33. UMassAmhrest (2017) (C116) Aggregation Index. [Online]. Available: http://www.umass.edu/landeco/research/fragstats/documents/Metrics/Contagion-InterspersionMetrics/Metrics/C116-AI.htm. Accessed 09 Nov 2017
34. Fraym (2017) Where are Africa's biggest markets? Washington, DC
35. Anderson J (2016) The gravity model of economic interaction. Boston
36. Ewing R, Hamidi S (2014) Smart growth America: making neighbourhoods great together. Houston

37. United States Census Bureau (2017) American factfinder—results. [Online]. Available: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. Accessed 16 Oct 2017
38. Ortiz P (2015) Metropolitan pentalogue: five commandments for metro management. [Online]. Available: https://www.linkedin.com/pulse/metropolitan-pentalogue-five-commandments-metro-management-ortiz/. Accessed 12 Dec 2017
39. Ortiz P (2015) Metropolitan pentalogue. Five commandments for metro management. https://www.linkedin.com/pulse/metropolitan-pentalogue-five-commandments-metro-management-ortiz
40. NaMATA (2017) Nairobi Metropolitan Area Transport Authority (NaMATA). [Online]. Available: kenas.go.ke/wp-content/uploads/NAMATA-WAD-2017-June-9th.pptx. Accessed: 09 Nov 2017
41. Kenya Human Rights Commission (2014) Internet legislative and policy environment in Kenya. Accessed from https://www.sbs.ox.ac.uk/cybersecurity-capacity/system/files/The%20ICT%20Legislative%20and%20Policy%20Ennvironment%20in%20Kenya_0.pdf
42. Ortiz P (2017) Reports for Nairobi—Pedro Ortiz online. [Online]. Available: http://www.pedrobortiz.com/display-articles/listforcity/city/36. Accessed 13 Dec 2017
43. Mutua F, Mwaniki D (2017) GIS needs assessment in Kenya. Report prepared for Kenya's Council of Governors (CoG) and United Nations Development Programme (UNDP). Nairobi
44. Bayensia Consulting Group (2016) The burden of produce cess and other market charges in Kenya. Nairobi
45. Chen H, Jia B, Lau SSY (2008) Sustainable urban form for Chinese compact cities: challenges of a rapid urbanized economy. Habitat Int 32(1):28–40
46. Mundia CN (2017) Nairobi metropolitan area. In: Murayama Y, Kamusoko C, Yamashita A, Estoque R (eds) Urban development in Asia and Africa. Springer, Singapore, pp 293–317
47. Nairobi Business Monthly (2017) Rising demand for housing spurs Kenya's real estate sector. [Online]. Available: http://www.nairobibusinessmonthly.com/rising-demand-for-housing-spurs-kenyas-real-estate-sector/. Accessed 25 Sep 2017
48. Office of the President (2017) Executive order: nairobi metropolitan area transport authority. [Online]. Available: http://www.president.go.ke/2017/02/10/executive-order-the-nairobi-metropolitan-area-transport-authority-namata/. Accessed 27 Apr 2017
49. Era AN, Budgetary OF (2011) Infrastructure investments in an age of austerity: the pension and sovereign funds perspective, pp 34–37
50. Gerçek H (2007) Transportation planning and decision-making in Istanbul: a case study in sustainable urban transport policy development, March 2006
51. Mohammed I, Alshuwaikhat H, Adenle Y (2016) An approach to assess the effectiveness of smart growth in achieving sustainable development. Sustainability
52. Arsanjani JJ, Helbich M, Kainz W, Boloorani AD (2012) Integration of logistic regression, Markov chain and cellular automata models to simulate urban expansion. Int J Appl Earth Obs Geoinf 21(1):265–275
53. Construction Business Review (2017) Nairobi mass rapid transport systems plan. [Online]. Available: http://www.constructionkenya.com/3480/nairobi-rapid-bus-transit/. Accessed 23 Sep 2017
54. Konishi H, il Mun S (2010) Carpooling and congestion pricing: HOV and HOT lanes. Reg Sci Urban Econ 40(4):173–186
55. Singh H (2006) The importance of customer satisfaction in relation to customer loyalty and retention by Harkira. Kuala Lumpur
56. UN-HABITAT (2010) Citywide strategic planning. UNON—Publishing Services Section, Nairobi
57. Spalding J, Gard A, Brown B, Hadian S, Salaris K, Toner B, Moughtin C, Shirley P, Trudeau D, Lydum D, Rahnama MR, Roshani P, Hassani A, Hossienpour SA, Vanderbeek M, Irazábal C, Knaap G, Talen E, Trudeau D, Chang H, Parandvash GH, Shandas V (2005) A typology of New Urbanism neighborhoods. Int Reg Sci Rev 28(2):267