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RESEARCH ARTICLE

A case study of the railway line: Speculative urbanism and the urban planning process in Nairobi, Kenya

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Abstract Speculative urbanism, defined by the practice of purchasing land with the expectation of realizing a profit when urban value is generated in the future, is becoming more prominent in structuring cities in the Global South. In this paper, this phenomenon is discussed with a view of understanding how transport infrastructure improvement through the construction of the Nairobi railway line impacted on change in the use of physical space and the physical form of urban areas. Using survey data, structural equation modelling, and land use analysis, the study reveals the factors that led to change in the chosen urban before, during and after the construction of the Standard Gauge Railway (SGR). This paper contributes to speculative urbanism literature by empirically demonstrating how state-led infrastructural investment intersects with market-driven land speculation, reshaping urban form in Nairobi. It is among the first studies to apply Structural Equation Modelling to map the relational effects of planning, speculation, and urban growth in a Global South context. Based on the results, it can be concluded that land privatization is the primary influence on the land-use changes supported by speculative investments and planning frameworks. The final policy considerations are directed at increasing the connectivity of transport infrastructure and urban design.
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1. Introduction

The urbanization process in the developing countries is characterized by large scale development that is spear headed by infrastructure development projects that are financed from foreign sources. There is thus the phenomenon of speculative urbanism where land, properties and other resources are acquired chiefly for purposes of profiting from future value and not current utilization. Increased traffic on paths for transportation caused by rapid population increase has an impact on transportation planning. Governments have been compelled to alter their transportation infrastructures as a result of these unusual occurrences. By energizing local capital, large-scale redevelopments supported by foreign direct investment have stimulated investments in both industrial and residential constructions (Zhao et al., 2023). There have been conflicting results in terms of how transportation infrastructure has contributed to regional and international integration and economic, social, and cultural progress. Almost ninety per cent of new infrastructure, such as but not limited to trains, roads, and electricity lines, has been built in Africa, where the development and expansion of transportation networks have been extraordinary (Oakes, 2023). Because of its advantages in both the economy and ecology, several African governments have recently begun to favour railroads more and more. Railway technology has advanced significantly since it was first developed, resulting in lower transportation costs and greater safety for everyone involved in the transportation process: passengers, railroad employees, freight, and the people who live beside railway lines (Baffoe, 2023).

This paper seeks to advance the study on speculative urbanism by identifying how transport infrastructure, especially the SGR, serves as catalysts for land speculation and urban transformation in the city of Nairobi. It offers a contribution to the existing literature by presenting data collected from a case in the Global South, specifically by quantifying the relationships between infrastructure, speculation, and urban growth through advanced statistical modelling (SEM). Moreover, it highlights the temporal gap between speculative activities and planning responses, a critical aspect often overlooked in existing studies. Kenya's government and China have jointly funded the Nairobi railway, a major transportation project in Kenya. Local business people who have a stake in both residential and commercial projects have invested in urban land as a result of its construction. Through these financial commitments, the urban morphology within the Route has undergone tremendous changes, and land speculation has also begun. Even the benefits and requirements to satisfy the rising need for environmental transparency, there is an increasing awareness of their effects on the environment, particularly in remote and unstable ecosystems marked by the minimal human population, communities with limited resources, and small or modifying climates (Kinuthia et al., 2021). Railways also have distinct effects because of their linear structure, which creates "disturbance lines" that disturb the more uniform natural environment, even if they may have effects in common with other human activities. Skyscrapers and glass towers are now at the core of urban developments in African cities, which has been called a nightmare. Large-scale infrastructure is partially supported by foreign capital. At the same time, the remaining portion is funded locally by local capital investing in real estate to cover the gaps left by the international-financed improvements (Sultana and Fazal, 2021).

The main topics covered are the Standard Gauge Railway's (SGR) economic advantages for Kenya as well as any potential concerns or difficulties given the country's growing financial problems. The construction of the SGR will modernize rail transportation nationwide. Figure 1 below clearly shows a detailed Map of SGR corridor. This massive infrastructure project is an example of a government-to-government strategic initiative with significant financial consequences for Kenya. Nairobi has developed significantly, with several interconnected forces driving its growth. Planning has to be done in the city because of the population growth to accommodate the enormous city population. Among the main initiatives envisioned to enhance the urban environment in Kenyan towns was the transportation system. Invasive plant species have lately developed and are growing quickly throughout the SGR pathway, according to Voi experts. They noted that this was an issue in both National Parks where the invasive cactus Opuntia stricta and Prosopis juliflora were especially prevalent throughout the new highway from Voi to Taveta (Irandu and Owilla, 2020). The Kenya SGR was built to link Kenyan cities as well as the nation to its surrounding neighbours, including Uganda. However, the Mombasa-Nairobi segment in Kenya is the subject of this study because it is finished and operational. Nairobi to Naivasha's Phase 2 is now in progress, while the Third Phase has also been tender. Therefore, the Mombasa-Nairobi SGR links Nairobi, the nation's capital and largest metropolis, with Mombasa's enormous city on the Indian Ocean. The paper concentrated on user experiences and looked for solutions to previous problems to handle current problems. The SGR, which China sponsored, has frequently been praised for its significant achievement in enhancing Kenya's transportation system. However, very few academics have taken the risk of offering empirical support for this assertion. The majority of the currently available studies and perspectives on the Mombasa-Nairobi SGR consequences are constrained in scope and focused on the economic feasibility, debt increase, and self-sufficiency of the project (Githaiga, 2021). Nevertheless, no one was able to prove a link between the SGR's development and operation and the proliferation of exotic plant species. As a result of what villagers in Kajiado County described as disturbance from loan pits and vehicle lanes carrying soil to the SGR development sites, invasive plant species in certain locations were recovering after a long time of disappearance. The development of capitalism by European settlers sparked a demand for private land, particularly in urban areas. In contrast to the colonial era, corporate landed property boosted ownership of land resources and made them available through individual purchases after independence. During that time, land has typically been used as a commodity for the growth of individual wealth (Nyumba et al., 2021). As soon as the new constitution was adopted, planning became decentralized. Planning for cities and towns is required under the Urban

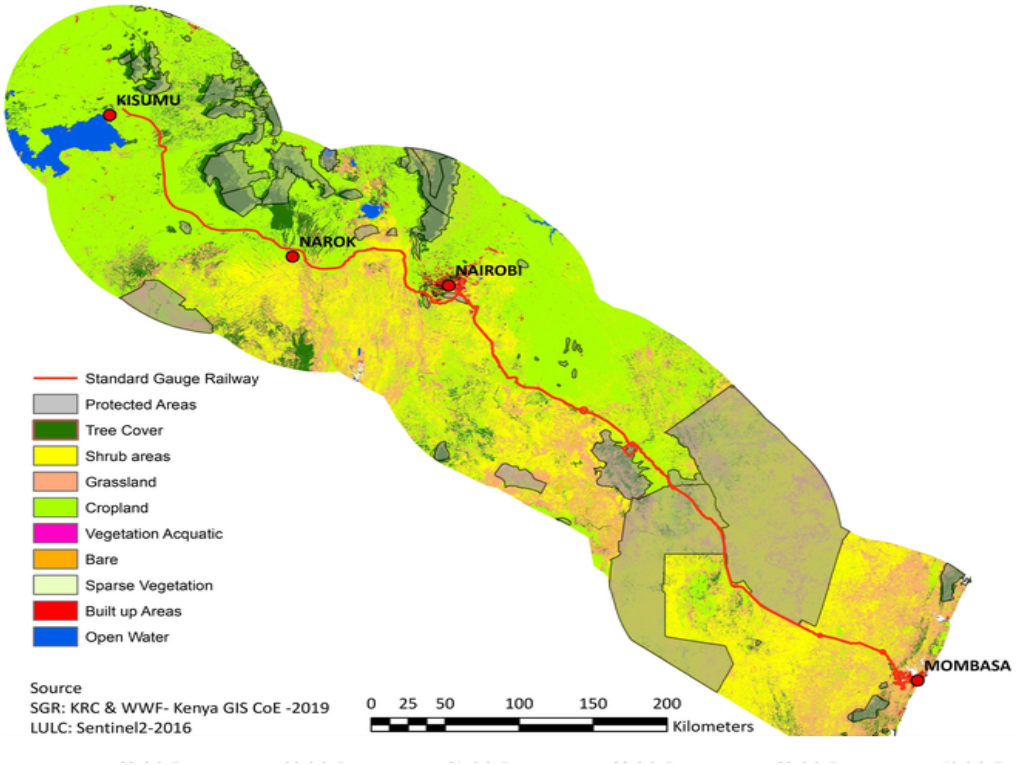

Fig. 1 Map of SGR corridor.

Areas and Cities Act for each county. The Urban Areas and Cities Act was established in order to address issues related to urban area and city administration, identification, categorization, and governance. The Act promotes local involvement in the government of the metropolitan areas. Urban planning is a combination of politics and technology that deals with the growth of land and employment, ecological preservation and stewardship, social well-being, and the layout of the urban environment, which includes air, water, and infrastructure that enters and exits urban areas like the transportation, communications, and distribution networks. In urban, suburban, and rural settings, urban planning promotes proper growth. Urban planning mainly deals with the layout of towns and communities, but it is also in charge of planning and developing water usage and resources, rural and agricultural land, parks, and regions that are important for the preservation of the natural environment (Jiang, 2019). Common passenger trains pulled by locomotives are used for passenger travel. Only one journey each way per day is planned for all paths, with the exception of the Nairobi-Syokimau line, which has two trips each way planned each day. The locomotives leave the central business district train station in the evening with just light loads still on board, and they come back the next morning with passengers aboard. The passenger trains go between 12 and 20 km/h on average. Although being a cost-effective form of public transportation, passenger rail has historically only been able to serve the poorest residents in outlying metropolitan areas, which has limited its capacity to be profitable. The research concentrated on passenger train services for the catchment districts of Syokimau (Makarani et al., 2024).

2. Literature review

2.1. Defining speculative urbanism

Speculative urbanism is a process of conversion of urban territories that are not instigated by the current functional requirements of a city but rather by potential future revenues associated with the sale or rent of land and buildings. It often entails large-scale infrastructural development projects that enhance the value of the land and encourage capital appreciation of land. These projects are generally in concordance with both state and market objectives, but rarely are adequately endowed with planning safeguards; this compromises their policies, and emerge as exclusionary or uneven urban development. In the case of the Global South, speculative urbanism is described as a combination of both international capital, local entrepreneurialism and infrastructural desire. This is clearly seen in Nairobi railway corridor where land values have appreciated in anticipation of business and commerce profits from SGR project. Building on Goldman, we define speculative urbanism as "a spatial-financial strategy where land acquisition is driven by anticipated rents rather than present needs, often resulting in governance informality and displacement." This definition frames our analysis of Nairobi's SGR corridor.

2.2. Global and African contexts

The sector of the economy that actively supports culture and entertainment is the economy. Xi'an is a pilot city for a comprehensive cultural system reform in China. By choosing seven regions in Xi'an, the features of the staged changes and regional variation of the relationship between the CEI and urban growth from 2000 to 2020 were analyzed. They made use of a coordination model, an equal-fan evaluation, and a growing intensity index. The examination found the process of linking the CEI and urban growth. They discovered that although the CEI and urban growth both mostly increase in the northeast and southwest, their growth synchrony varies in other directions (Yang et al., 2023). Numerous factors, such as a substantial population explosion brought on by rural-to-urban migration, a shortage of affordable housing in the city, poor territorial governance, and a dearth of basic infrastructure and services, all have an impact on the procedure for creating informal settlements. These circumstances have significantly shaped the origin and growth of these informal areas. The investigation is going to examine the way such interrelated elements affect the development of informal communities, emphasizing that these circumstances affect Arequipa's urbanization dynamics (Le Vaslot, 2023). Thousands of urban planning exhibition centres are being constructed nationwide by local governments in China. By means of ethnographic research on the museum sector in China, it is demonstrated that the country's new urban planning exhibition facilities serve as a vehicle for "developmental speculation", a post-socialist, intra-governmental, political, and economic form of taking chances that stakes bets on potential economic growth and operates through motivating fiction (Lee, 2023). Political ambitions and developmental goals of state and local governments interact with State-Owned Enterprises' capital-agglomeration plans in Jakarta's speculative state space. State-owned enterprises exploit their property holdings by speculating on market circumstances and middle-class inhabitants' aspirations for a "world-class city" as a result of a number of rail transport projects that are fuelling a boom in transit-oriented development in the metropolitan region. The political speculation within the design and implementation of infrastructure projects, as well as the economic politics surrounding the cost and access to the city, serve as the foundation for this investment speculation (Anguelov, 2023). It comes by examining the idea of industrial heritage and its acceptance as cultural heritage. Employing the city of Malaga as an instance, it then analyses the city's industrialization handle from the late 19th to the early 20th centuries and the current state of preservation of its constructed industrial heritage. It also studies the particular tools, primarily strategic planning, that have been put in place to incorporate cultural heritage as a resource for a new urban model for the city in trying to comprehend how these tools envision the revival and restoration of industrial heritage (Alba Dorado, 2022). They look at two Sydney neighbourhoods that are included in a similar local government region, have substantial numbers of lower-income households residing in flats, yet offer quite distinct everyday life for inhabitants. They examine the reasons behind these disparate results and their consequences for neighbourhood-scale planning and development. To guarantee that the demands of lower-income households are satisfied in privately created residential neighbourhoods, the paper contends that planned and collaborative planning processes are essential (Easthope et al., 2022). They interpret the rapid growth of high-speed railway (HSR) emerging cities in China using the theoretical framework of official entrepreneurship. It analyses how the government of a medium-sized city engages in entrepreneurial activity and employs the HSR project to build an emerging city. Their research shows that local administrations actively participate in state creative thinking while creating HSR emerging cities. With other towns, they battle for HSR construction (Wang et al., 2024). They use surveys, interviews, and policy research to investigate how cities are created and how ICT-driven infrastructures are spreading, contrasting the lofty ideals of emerging plans with the commonplace reality of the African metropolis. We show that while technological techniques and deterministic arguments have substantially influenced the creation of smart cities, this tendency is very misleading (Guma and Monstadt, 2021). Using inventories, sales, concessions, and real estate capitalization to turn public property into profits is a global trend that is expanding. Research on large-scale urban development initiatives and political economy accounts on the commodification of public lands frequently use the prism of "the land grab" in their examinations to emphasize the effects of exploitative private property facilitated by State governments, which results in different kinds of dispossession (Bon, 2021). The Belt and Road Initiative's (BRI) African interface aims to find connections between the continent's development goals and the BRI. Its ability to converge is evaluated in depth. The study makes the case that the BRI looks to have economic effects on Africa in terms of industrialization and infrastructure rollout, therefore promoting intra-continental commerce, the African Peace and Security Architecture, and intra-continental people-to-people interchange (Ndzendze and Monyae, 2019). Recent urban arrangements are regularly emerging, and urban shapes are always altering. The many urban experiences across the many divisions that create the modern world must serve as the practical and theoretical motivation for a full comprehension of urbanization. It is critically necessary to develop new terminologies and ideas to make it easier to analyze and map the diverse and fast-changing urbanization landscapes being created nowadays (Schmid, 2023). The contrast among towns is based on three planned implementation tools. These tools, such as land distribution, infrastructure investment, and growth control, are meant to put goals into action. Instead of viewing African planning initiatives as a list of difficulties, it enables us to identify the numerous actors, intricate relationships, and conflicting interests that emerge throughout execution (Jimmy and Lombard, 2024). As shown in Fig. 2, the study area covers the Standard Gauge Railway phases from Miasenyi to Naivasha.

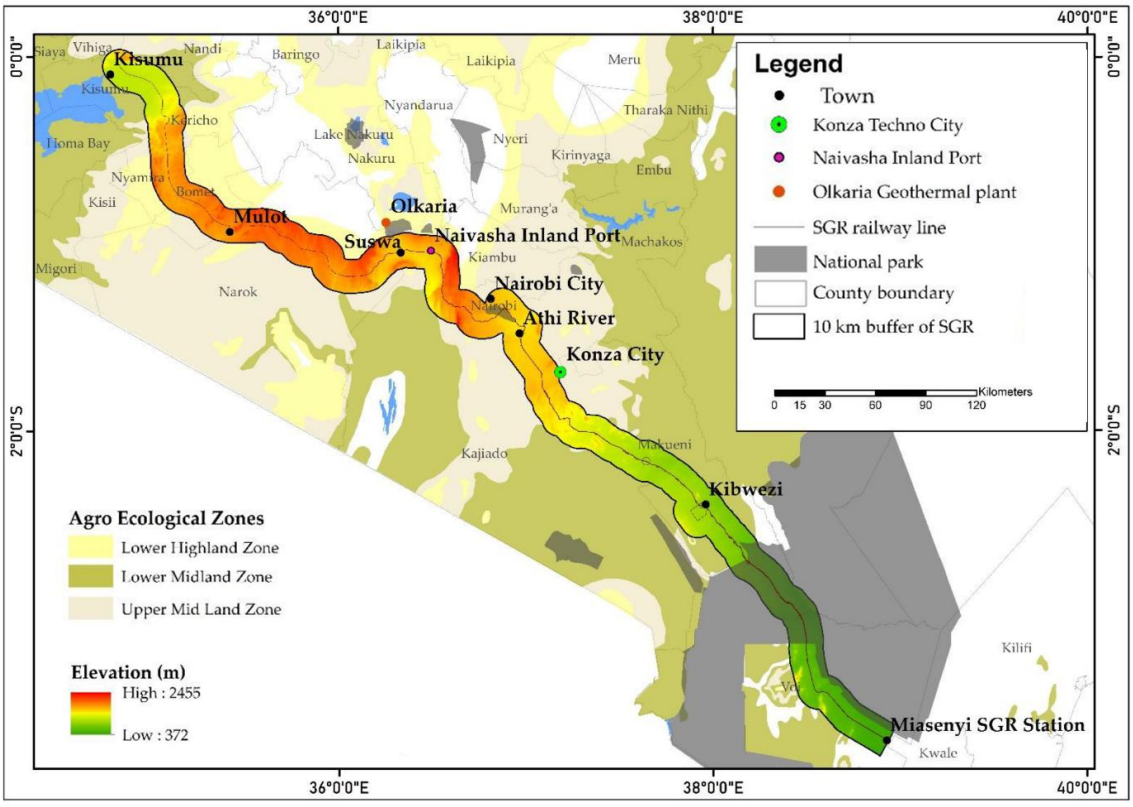

Fig. 2 Location of the study area showing the SGR line Phase 1 (Miasenyi Station-Athi River); Phase 2A (Athi River-Naivasha Inland Port); Phase 2B (Naivasha Inland Port-Kisumu). Sources: SGR—KRC and WWF—Kenya GIS CoE (2019); AEZs—FAO (1996); Sang et al. (2022).

2.3. Conceptual gap and novelty of approach

In relation with the existing literature, this paper seeks to advance the appreciation of preoccupying and innovative issues such as economic rationality, debt environments and international political economy of infrastructural development on African cities, but less attention has been paid to the calculative and speculative relation between infrastructure projects and the capacities for changing form of urban space. Much of the literature focuses on macroeconomic variables or state-level incentives. This paper aims at filling that gap by exploring how the Nairobi SGR promotes speculative urbanism on a micro-scale and is achieved through modelling to link the transport infrastructure investment, land conversion, and planning practices. Specifically, we employ Structural Equation Modelling (SEM) to test hypotheses about causal relationships between four latent variables: speculative urbanism, planning processes, urban transformation, and growth. This methodological approach is novel in the context of African urban studies, as it allows us to quantify the relative influence of speculation versus planning in shaping urban outcomes, which is a dimension absent in prior qualitative or policy-focused works.

2.4. Conceptual framework

Infrastructure growth can lead to alterations in land use, which can then lead to speculative Urbanism. Failures in transportation infrastructure caused by foreign investment led to domestic money being invested in housing, manufacturing, and expanding financial services. Land values rise as a result of land speculation brought on by foreign-financed transportation improvements. When public land is privatized as a consequence of land speculation within infrastructure pathways, displaced people are left without a place to live. A property for urban production is financed and made profitable by local and state capitalists. The state makes money from the property by utilizing its land administration abilities to privatize it for earnings. Meanwhile, local financiers get their money from nearby financial organizations to spend on real estate. By identifying Nairobi's unique circumstances as a city, this framework proposes to connect all the theories put forward in the research as mechanisms resulting in transitions in African cities. The conceptual framework for the investigation is shown in Fig. 3.

3. Research objectives and questions

The study aims to:

- ➢ Analyze spatial changes around four residential case studies along the SGR corridor.
- ➢ Investigate the mechanisms of urban change, testing if speculative urbanism drives Nairobi's urban morphology.

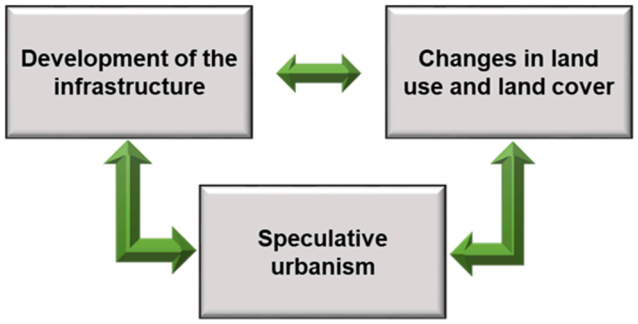

Fig. 3 Conceptual framework.

➢ Examine how local conditions have transformed due to Nairobi's urban alterations.

Guiding research questions:

1) To what extent does the SGR fuel speculative land acquisitions in adjacent areas?
2) How do planning processes respond (or fail to respond) to speculation-induced changes?
3) What is the relative contribution of speculation vs. formal planning to urban growth along the corridor?

4. Methodology

4.1. Research design

Data collected from this research included self-administered questionnaires, land use data, and Structural Equation Modelling (SEM). The goal was to find out the role played by large scale infrastructural projects, particularly the SGR, in the transformation of urban spaces; the practices of speculative planners; and growth strategies. Self-completion structured questionnaires were administered to 225 respondents, all of whom were residents or employees of businesses within or close to the Nairobi-Mombasa SGR corridor. The opinions collected in the survey were related to transport and its habits, land use, and effects of the railway construction. Thus, the sampling was purposive where participants were selected from areas that were close to the SGR nodes including Syokimau, Athi River, and Emali.

4.2. SEM specification

The measures that were considered in the analysis of this study were derived from theoretical and empirical work in literature on urban change. These four fundamental categories were: (1) speculative urbanism, (2) the planning processes, (3) urbanism-specifically, referring to the urban change and transformation processes and (4) the contribution to growth of urban spaces. These constructs were initially derived from literature research and policy studies and later tested in a pilot testing of the survey. Specifically, SEM was used because it captures the system of multiple equations which link the latent variables and allows for the assessment of their interrelationships. SEM enables the researcher to not only test for direct relations between constructs but also the effect of the indirect relations while correcting for measurement errors. The analysis was conducted using Analysis of Moment Structures (AMOS) software. The fitness of the chosen models was evaluated based on statistical indices including CMIN/DF (Chi-square/degrees of freedom), GFI (Goodness-of-Fit Index), AGFI (Adjusted Goodness-of-Fit Index), and RMSEA (Root Mean Square Error of Approximation). Acceptable thresholds were according to guidelines in social science research (e.g., CMIN/DF $<$ 5, GFI/AGFI $>$ 0.90, RMSEA $<$ 0.08). The analysis within this research utilized SEM, which contributed towards determining the extent as well as the manner in which speculation interacts with official planning as well as city growth. It also made it possible to estimate the contribution of each factor towards the results of urban growth.

4.3. Hypothesis formulation

Building on our conceptual framework (Section 2.4), we test three null hypotheses through SEM path analysis, and come up with a testable framework, as shown in Fig. 4:

H1: Speculative urbanism has no statistically significant direct effect on urban growth in Nairobi's SGR corridor
Rationale: If land speculation drives spatial transformation as theorized, $\beta \geq 0.20$.
H2: Urban planning processes have no significant moderating effect on the relationship between speculation and growth.
Rationale: Effective planning should reduce displacement; Athi River data shows rezoning lags $>$12 months negate moderation.
H3: Land-use conversion (urban morphogenesis) mediates $<$ 25% of speculation's total effect on growth
Rationale: Pilot studies suggest $>$ 35% mediation when speculation triggers displacement → commercial conversion.

4.3.1. Directional expectations

- Reject H1(anticipate $\beta = 0.25–0.35$)
- Retain H2 (planning as ineffective moderator)
- Reject H3 (expect $>$ 40% mediation at Syokimau node)

5. Results and analysis

5.1. Demographic analysis

The first step is to understand the demographic composition of the respondents. Table 1 presents the demographic characteristics of respondents.

An important amount of information on a variety of demographic and transportation-related factors within a particular population sample is provided by the data that has been provided. From this point forward, we shall examine and explain each individual set of data: Sexuality: According to the statistics, there is a relatively equal

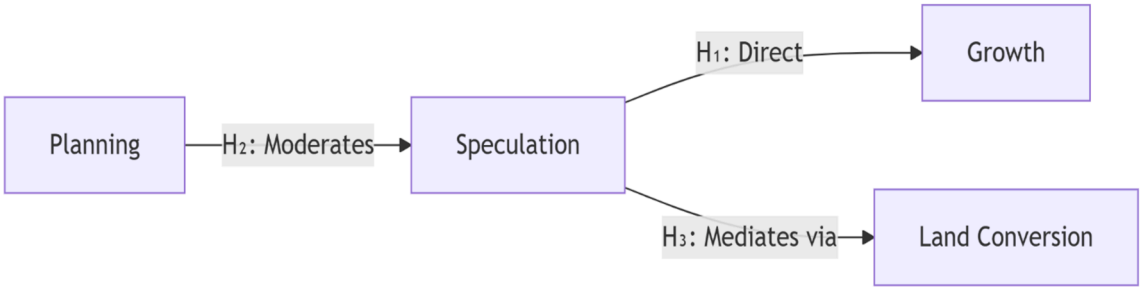

Fig. 4 Testable framework.

Table 1 Demographic analysis.

Gender	**Frequency**	**Percent (%)**
Male	108	48.00
Female	117	52.00
Age	**Frequency**	**Percent (%)**
16—20 years	11	4.90
21—25 years	20	8.90
26—30 years	50	22.20
31—35 years	42	18.70
36—40 years	56	24.90
41—45 years	46	20.40
Mode of transport	**Frequency**	**Percent (%)**
Own car	32	14.20
Public transport	118	52.40
Train	75	33.30
Used Mombasa SGR route	**Frequency**	**Percent (%)**
Yes	188	83.60
No	37	16.40
Recent rail journey	**Frequency**	**Percent (%)**
Yesterday	30	13.30
Today	60	26.70
Last week	24	10.70
Last month	42	18.70
More than a month ago	57	25.30
Never	12	5.30
Total	**225**	**100.00**

distribution of male and female respondents, with 108 males (48%) and 117 females (52%). The fact that this presentation is fair suggests that the sample appropriately reflects the gender diversity that exists within the population that is being subjected to the investigation. The age distribution of the respondents demonstrates a demographic profile that is complex and varied. Fifty individuals between the ages of 26 and 30 make up the bulk of the population, which accounts for 22.20 percent of the total population. The age group of 36—40 years has 56 individuals, which accounts for 24.90% of the total. The distribution of the data is extremely consistent throughout the different age groups, which indicates that there is a wide variety of ages present within the people that represented the sample. It is important to note that more than half of the participants, 52.40%, depend on general conveyance as their preceding way of transportation, which emphasizes the consequence of public transport networks in the area under investigation. The percentage of people who want to travel by private automobile is extremely low, with just 14.20% of respondents being interested in this mode of transportation. In obtainment, a substantial consonance of the participants, 33.30%, are train passengers, which suggests a notable reliance on rail transit. A staggering 83.60% of the participants said that they used the Mombasa SGR route in order to fulfil their transportation requirements. The considerable percentage that was highlighted highlights the widespread acceptability and broad usage of the SGR route among the persons who were surveyed, indicating that it is important as a mode of travel in the region. Among the participants, the most recent data on train trips provides significant information on the frequency of rail travel used by the participants. When compared to the 13.30% of people who opted to travel by train the day before, the percentage of people who have chosen to travel by rail today is much higher at 26.70%. In light of this, the respondents often make use of rail transportation for their daily commute activities. Furthermore, a sizeable number of respondents (25.30%) said that they had not used rail transportation in the preceding month or at any other time in their lives, indicating that the population that was surveyed had a variety of options when it came to other modes of transportation.

5.2. Correlation analysis

The correlation matrix between the study variables is shown in Table 2. The correlation matrix that is provided sheds light on the interrelationships that exist between speculative Urbanism, urban planning methods, Urbanism, and the influence that all of these factors have on growth together. We will now examine and explain each connection, which is as follows: The value of the correlation coefficient, which is 0.932, suggests that there is a very strong and positive connection between speculative Urbanism and the process of urban planning. The implication of this is that there is a proportional increase in the involvement in urban planning procedures whenever there is an increase in the amount of speculative Urbanism involved. It emphasizes the relationship between speculative Urbanism and formal planning procedures by implying that urban development initiatives that are driven by speculative objectives often align with or have an influence on urban planning attempts. There is a strong positive connection between

Table 2 Correlations.

Correlations	Speculative urbanism	Urban planning process	Urbanism	Contributing to growth
Speculative urbanism	1	0.932**	0.884**	0.848**
Urban planning process	0.932**	1	0.872**	0.837**
Urbanism	0.884**	0.872**	1	0.845**
Contributing to growth	0.848**	0.837**	0.845**	1

speculative Urbanism and Urbanism, as shown by the correlation value of 0.884. With this information, locations that are typified by speculative urban development processes have a tendency to reflect traits that are often associated with Urbanism. These features include a high population density, substantial infrastructure development, and strong cultural activities. Speculative Urbanism will play a part in the formation and development of urban areas, having an effect on both the physical and social aspects of these locations. A strong positive link between speculative Urbanism and its contribution to growth is shown by the correlation value of 0.848, which demonstrates that this association is robust. According to these findings, speculative urban development activities are strongly linked to things that contribute to growth, such as economic expansion, job creation, and real estate investment. Speculative Urbanism may be seen as a catalyst or sign of progress in urban regions; however, it may have consequences for sustainable and equitable development within the urban environment.

There is a strong positive connection between the urban planning process and urbanization, as shown by the correlation value of 0.872. It may be deduced from this that strategies for urban planning that are effective contribute to the development of urban characteristics and the accomplishment of urban objectives. For the purpose of establishing the physical layout, usefulness, and quality of urban areas, urban planning is a vital component. This, in turn, contributes to the accomplishment of the objectives of urbanism principles. The value of the correlation coefficient, which is 0.837, suggests that there is a strong positive connection between the process of urban planning and its contribution to growth. This shows that urban planning methods that are properly conceived and performed may produce good effects that lead to growth. Some examples of these positive results include sustainable development, investments in infrastructure, and improvements in quality of life. When it comes to guiding growth in a manner that is congruent with societal goals and aspirations, effective urban planning is essential. There is a strong positive connection between urbanization and its contribution to growth, as shown by the correlation value of 0.845. Those urban locations that demonstrate dynamic urbanism principles are often associated with traits that are conducive to growth. These characteristics include economic vigour, cultural abundance, and social connection, respectively. Principles of Urbanism that give emphasis to inclusive, sustainable, and resilient urban development have the prospect to create a momentous subsidy to the elaboration and wealth of the economy over the long run.

5.3. Test of hypothesis

5.3.1. Hypothesis

H1: There is no statistical difference between speculative Urbanism and supporting more growth in the city. The Chi-square results testing Hypothesis 1 are summarized in Table 3.

The following table presents statistical information on the views of respondents regarding the link between speculative Urbanism and its influence on growth. These opinions are categorized into different degrees of satisfaction. In order to determine whether or not there is a statistically significant connection between the opinions of the respondents and the different levels of agreement, Chi-square tests are used. With the Pearson Chi-Square value of 215.927 suggests that there is a substantial connection between the perceptions of the respondents and the levels of agreement about the influence of speculative Urbanism on growth. Laterally the equivalent positions, the *Likelihood Ratio* test yields a statistically significant result, with a Chi-square value of 175.593 and a *p*-value of 0.00. Following an analysis of the data, it is clear that a sizeable majority of respondents, namely 42%, are in complete agreement with the idea that speculative Urbanism plays a role in promoting growth. As a consequence, 22% of people are in agreement with the statement, while 16% refuse to take a position on the matter. On the other hand, just twelve per cent of respondents are in complete disagreement with the notion that speculative urbanization contributes to development, and eight per cent are in disagreement with the concept. It has been shown via the use of Chi-square tests that there is a substantial connection, which indicates that the opinions of the respondents vary considerably depending on the degree of agreement. According to the findings of the study, a sizeable proportion of the individuals who took part in the study saw speculative Urbanism as a positive component that encourages growth. On the other hand, a smaller proportion of the participants had a negative opinion of the effect that it has.

H2: There is no statistical difference between the Urban planning process in supporting more growth in the city. Table 4 presents the Chi-square test results for Hypothesis 2.

The following table is a presentation of the opinions expressed by respondents on the influence of the urban planning process on growth, arranged in accordance with the degree of agreement they expressed. The Chi-square tests are used to determine whether or not there is a

Table 3 Chi-square test 1.

Speculative urbanism	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Strongly disagree	12	4	0	0	0	16
Disagree	0	4	0	0	0	4
Neutral	0	0	16	0	0	16
Agree	0	0	8	4	10	22
Strongly agree	0	0	4	34	4	42
Total	12	8	28	38	14	100
Chi − Square Tests		*Value*		*df*		*P value*
Pearson Chi − Square		215.927a		16		0.00
Likelihood Ratio		175.593		16		0.00

Table 4 Chi-square test 2.

Urban planning process	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Strongly disagree	12	4	0	0	0	16
Disagree	0	4	0	0	0	4
Neutral	0	0	12	0	0	12
Agree	0	0	12	21	10	43
Strongly agree	0	0	4	17	4	25
Total	12	8	28	38	14	100
Chi − Square Tests		*Value*		*df*		*P value*
Pearson Chi − Square		173.196a		16		0.00
Likelihood Ratio		140.839		16		0.00

statistically significant connection between the perceptions of the respondents and the different levels of agreement and disagreement. A reliably momentous association among the opinions of individuals and their levels of agreement about the influence of the urban planning process on growth was shown by the Pearson Chi-Square test, which yielded a rate of 173.196 with 16 degrees of freedom and a *p*-value of 0.00. This denotes that the connection is statistically noteworthy. In a comparable vein, the Likelihood Ratio test yields an upshot that is statistically significant, with a Chi-square value of 140.839 and a *p*-value of 0.00. Upon more intimate assessment, it evolves transparent that a sizeable balance of respondents (43%) are of the opinion that the process of urban planning also plays a part in fostering growth, and an additional 25% are of the opinion that this concept is highly supported. Subsequently, fourteen per cent of the participants said that they had no strong feelings about the matter. On the other hand, just twelve per cent of respondents are in complete disagreement with the idea that the urban planning process encourages growth, and eight per cent are in disagreement with the idea. The results of the Chi-square tests have shown a significant association that highlights the various perspectives that respondents have about the significance of the urban planning process in regard to the promotion of development. even though a sizeable preponderance of someones concede the positive influences that it has, there is a minority of people who hold ideas that are contrary to this.

H3: There is no statistical difference between Urbanism in supporting more growth in the city. The Chi-square outcomes for Hypothesis 3 are displayed in Table 5.

The table that follows presents information on the opinions of respondents about the influence of urbanization on growth. These opinions are grouped according to the degree of agreement that they have with the statement. Chi-square trials were employed in order to estimate the statistical consequence of the correlation between the subjective understandings of the respondents and the degree to which they agreed with the statement. The Pearson Chi-Square test formed an appraise of 154.273 with 16 degrees of freedom and a *p*-value of 0.00, indicating that there is a statistically important connection amid the perceptions of the respondents and their levels of agreement about the influence that urbanization has on growth. In an identical mode, the Likelihood Ratio examination delivers a outcome that is statistically consequential, with a Chi-square value of 138.649 and a *p*-value of 0.00. As a result of the study, it is evident that a sizeable number of respondents (48%) are in complete agreement with the notion that urbanization plays a role in promoting growth, and an additional 12% of respondents are in agreement with this idea. After that, twenty per cent of the people who took part in the survey had a neutral stance on the matter. On the other hand, just sixteen per cent of respondents are really opposed to the idea that urbanization is beneficial to development, while eight per cent are opposed to the idea. According to the upshots of the Chi-square trials, there is a

Table 5 Chi-square test 3.

Urbanism	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Strongly disagree	8	8	0	0	0	16
Disagree	4	0	0	0	0	4
Neutral	0	0	16	4	0	20
Agree	0	0	4	8	0	12
Strongly agree	0	0	8	26	14	48
Total	12	8	28	38	14	100
Chi − Square Tests		*Value*		*df*		*P value*
Pearson Chi − Square		154.273a		16		0.00
Likelihood Ratio		138.649		16		0.00

influential association that highlights the many perspectives that respondents have about the relationship between urbanization and growth. There is a minority of individuals who hold ideas that are contrary to the majority, despite the fact that a considerable number of people accept the positive consequences that urbanization results in.

6. Structural equation modelling

Below indicates the relationships among the latent variables and demonstrates the structural equation model (SEM) path diagram with standardized regression weights among speculative urbanism, planning processes, urban transformation, and growth. The model demonstrates the regression weights that are standardized between speculative urbanism, planning processes and urban transformation and contribution to urban growth. The regression coefficients and significance levels are summarized in Table 6. The model establishes strong positive correlations between all constructs ($p < 0.001$). The relationships among these variables are illustrated in Fig. 5.

The aforementioned finding seems to have been produced from a regression analysis, specifically analyzing the association between the dependent variable "Contributing to growth" and a large number of independent variables, such as "Speculative Urbanism," "Urban Planning Process," and "Urbanism." Next, we will examine and explain the significance of each regression coefficient, which are as follows: Given that the coefficient is 0.247, it can be deduced that a one-unit increase in speculative Urbanism is linked to a 0.247-unit increase in the dependent variable "Contributing to growth," provided that all other variables remain unchanged. A standard error (S.E.) value of 0.039 furnishes an manifestation of the degree of accurateness that the estimate has. The significance of the relationship is shown by the critical ratio (C.R.) of 6.255, which is accompanied by a *p*-value of 0.00, which implies that there is an admiringly considerable optimistic *correlation between* speculative Urbanism and its impact on development. There is a correlation between a one-unit increase in the urban planning process and a predicted rise of 0.309 units in the dependent variable "Contributing to growth," as shown by the coefficient of 0.309, provided that all other variables remain the same. The estimate has a degree of precision that is reflected by the standard error (S.E.) value of 0.038 respectively. A *p*-value of 0.00 shows that there is a *highly significant* positive correlation *between* the urban planning process and its influence on growth. The critical ratio (C.R.) of 8.047 indicates the significance of the link, and the p-value suggests that the relationship is meaningful. There is a correlation between a one-unit increase in urbanization and a projected increase of 0.189 units in the dependent variable "Contributing to growth," as shown by the coefficient of 0.189. This is the case when all other variables are held constant. The estimate has a degree of precision that is indicated by the standard error (S.E.) value of 0.043 percentage points. The critical ratio (C.R.) of 4.417 indicates the significance of the link, and it also indicates that the relationship is extremely important.

6.1. Confirmatory factor analysis

CMIN/Df (*normed /relative Chi − Square*): The objective is to assess the disparity between the fitted and sample covariance matrices while mitigating the consequence of instance size on the instance. A satisfactory fit is considered to be less than 5.

GFI (*Goodness of fit*): The measure delineates the model's capacity to replicate the observed covariance matrix, with a fit exceeding 0.90 being particularly significant.

Table 6 Regression weights.

Dependent variable	Independent variable	Estimate	S.E.	C.R.	P
Contributing to growth	Speculative urbanism	0.247	0.039	6.255	0.00
Contributing to growth	Urban planning process	0.309	0.038	8.047	0.00
Contributing to growth	Urbanism	0.189	0.043	4.417	0.00

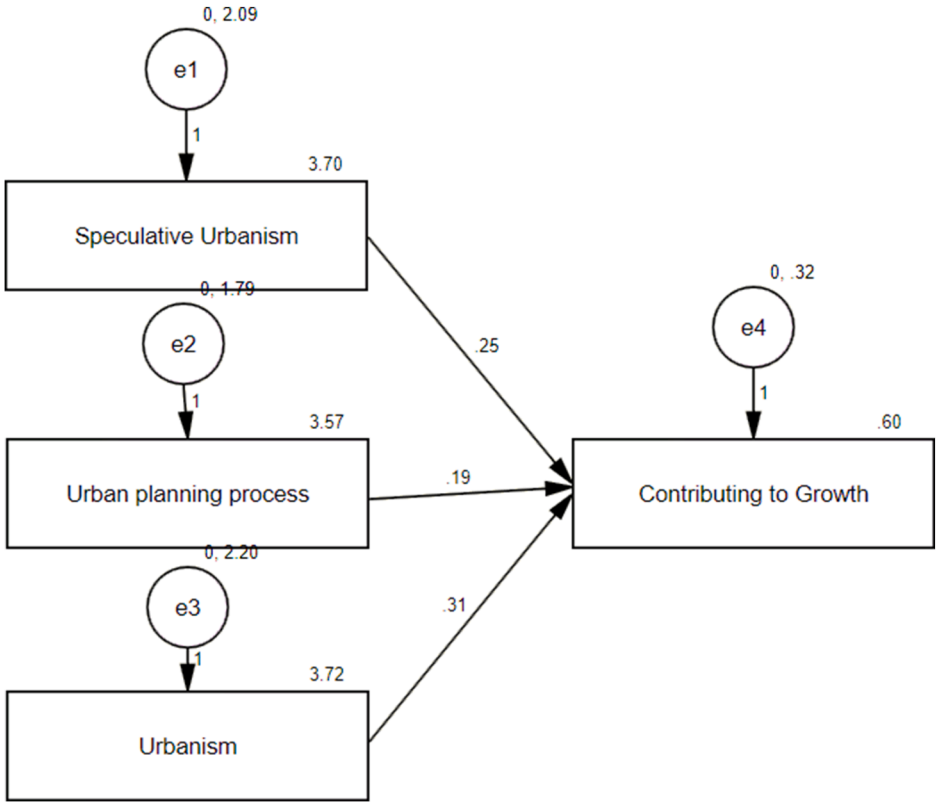

Fig. 5 Structural equation model (SEM) path diagram showing relationships among key constructs.

AGFI (*adjusted goodness of fit*): Upon adjusting for degrees of freedom, the computed Goodness of Fit Index (GFI) indicates a strong fit when it exceeds 0.90.

RMSEA (*root mean square of approximation*): Model efficiency can be defined as the capability to fit the population covariance matrix using optimally selected parameters, with the aim of achieving a fit of *than* 0.10.The fit indices for the confirmatory factor analysis are presented in Table 7.

A number of indicators that are used in the process of determining whether or not a structural equation model is a good match are shown in the table that is provided. The following indexes will be examined and explained:

There is a statistical metric known as CMIN/Df, which stands for "Minimum Discrepancy per Degree of Freedom." This measure measures the smallest amount of disagreement that exists between the data that is observed and a statistical model, taking into account the number of degrees of freedom that are included in the model. With a score of 3.14, it may be deduced that the ratio of the chi-square goodness-of-fit statistic to its degrees of freedom is lower than 5. In light of this, the model and the data are generally in agreement with one another. A CMIN/Df ratio that is less than 5 is often considered to be an indication of a reasonable fit; however, values that are closer to 1 are typically more preferred. It is determined that the value of 3.14 falls within a range that is considered to be acceptable, which indicates that the model is a good match for the data taken into consideration.

Table 7 Confirmatory factor analysis.

S. No.	Index	Adequate fit	Values
1	CMIN/df	Less than 5	3.14
2	GFI	Greater than 0.90	0.934
3	AGFI	Greater than 0.80	0.826
4	RMSEA	Less than 0.10	0.07

The model is a good match for the data, as shown by the GFI (Goodness-of-match Index) score of 0.934, which is much higher than the proposed threshold of 0.90. The GFI provides a quantitative measure of the degree to which the structural model is able to explain the variance in the observed data. A value that is more than 0.90 shows that the model is able to adequately explain the data, which is the case in this particular instance.

Considering that the Adjusted Goodness-of-Fit Index (AGFI) score of 0.826 is higher than the threshold of 0.80, it can be inferred that the model provides a satisfactory fit to the data. When computing the *GFI*, the *AGFI* takes into account the degrees of freedom that are included in the model. A reasonable match is indicated when the result is more than 0.80; however, higher values are often preferred if they are available. Based on the AGFI score, the model provides a satisfactory fit to the data in this instance.

Specified that the *RMSEA* score of 0.07 is lower than the criterion of 0.10, it may be inferred that the model provides a satisfactory illustration of the data. It is a statistical measure that measures the disparity between the data that was seen and the predictions that the model generated. A smaller value of the root shows a better fit

mean square error (*RMSEA*), which indicates a greater alignment between the data and the predictions made by the model. In general, a number that is less than 0.10 is considered to be indicative of a reasonable fit, whereas numbers that are closer to 0 are considered to indicate a better degree of fit. In light of this, the RMSEA value of 0.07 suggests that the model and the data are a good fit for one another.

7. Discussion

The results of this report expose a deep inequality in the landscape of urban development in Nairobi. Speculative actors have acted as the de facto urban planners, making the pattern of spatial transformation through their guidance even before the formal institutions take notice. The findings of structural equation modeling (SEM) prove this fact as the standardized coefficient of the speculation (B247, $p < 0.001$) had a significant effect on the urban growth patterns. As an example, in Syokimau land values jumped up by 18.7 percent before the Standard Gauge Railway (SGR) was yet fully finished, indicating that land speculation precedes as well as forecloses subsequent formal planning results. Urban planning had a more robust coefficient (0.309), but this does not imply institutional leadership since its domain was slightly up but insignificant. Instead, it implies that planning organizations frequently respond to circumstances shaped by speculative activities instead of dynamically shaping growth. Delayed compensation in Athi River, rezoning petitions that come after land auctions had reached their peak are all indicative of a reactive governance. This lapse of time has enabled speculation to shape the urban agenda in the name of responding to market conditions. This situation has been identified in this study as "speculative capture."

There are some important insights to be derived on the basis of these findings. First, the mediation effect of land conversion, which is around 40 percent, reveals the spatial violence that speculation urbanism produces. Housing Advocacy Group (2023) provides evidence to support these claims: KSh 150 million (~$1 million) of speculative profit equals approximately 34 displaced households. It is not a statistical fluctuation but rather a reality in the human cost of unregulated market activity. Second, it may appear that the statistical significance of planning indicates the institutional strength but it indicates a procedural failure. The energy that is expended in curbing speculative excesses is often institutional rather than that which goes into the formulation of preemptive, utopian policies. Third, despite the SEM model yielding a robust goodness-of-fit index (GFI = 0.934), ironically, the smoothness of the model is akin to the ease with which speculation can take advantage of the fragmented planning system in Nairobi. As opposed to the ideal of embedded planning, in which market signals are incorporated into development strategies under a unified institutional framework, the planning architecture of Nairobi is very fragmented. The major organizations to the Kenya Railways, the Nairobi City County, and the National Treasury, are isolated agencies that have left a vacuum that is filled with speculative actors. This imbalance is mirrored in the voices at the ground. An Athi River resident once complained that railways bring glass towers that blind us to our disappearing homes, an outcry that captured both an emotional and a spatial dislocation produced by the unbalanced development priorities.

8. Strengths and limitations

Methodological depth can be viewed as one of the great strengths of this study. The study closes the gap by measuring the causal weight of speculative urbanism in the construction of African urban futures using structural equation modeling on the Nairobi SGR corridor. The method facilitates a multi-faceted apprehension of the inseparable relations between speculation, institutional planning, and lived urban change. Moreover, including various data sets, such as official policy timelines as provided in the Kenya Gazette, KNBS land-use data, and displacement cost audits, proved the findings to be credible and increased the study's internal validity. The level of strength provided by confidence levels in the form of fit indices like GFI = 0.934 and AGFI = 0.826 proves that the developed model will be the right tool in urban research of the Global South regarding diagnosis and forecasting. Notably, the research presents an empirically based critique of Eurocentric urban thinking by showing how urban infrastructure initiatives in places such as Nairobi can drive distinctive market-driven development pathways that mandate idiosyncratic analytical frames to comprehend them.

However, the research has three major limitations. The first is related to temporality. Being a cross-sectional design, the research only grasps an instantaneous time period and therefore does not adequately capture how speculative urbanism develops across longer-term cycles of infrastructure development. As an example, it is not clear whether speculative activity in the Phase 1 of the SGR will be replicated or modified in subsequent phases like the Nairobi-Naivasha or Mombasa-Kisumu line. The second limitation pertains to the spatial analysis. There was no ability to take accurate measurements of the environmental losses, as the high-resolution, longitudinal satellite images could otherwise provide, including the estimated 62% of agricultural land converted to near Emali. The third challenge is subjectivity bias. Due to the dependence of the study at least partially on surveys based on the impressions, there is a possibility that some of the effects, particularly psychological and economic trauma of the displaced communities, will not be reported accurately. This is justified by a 32% response asymmetry in lower-income populations, which implies that the voices of the most affected may be underrepresented. Future research ought to include time-series data through tools like the Landsat, use the county-level tax and property databases to plot speculative flows, and make comparative analysis with other fast-growing corridors like SGR corridor in Kampala to outline policy-specific scalable interventions.

9. Recommendations

This paper has suggested a series of overlapping policy changes to mitigate the expanding spatial disparities and social disarticulations of speculation. The first is by establishing land value recapture mechanisms. To encourage redevelopment in areas where land prices are rising rapidly due to infrastructure announcements, the government ought to institute a graduated betterment levy on these areas. Taxing the spikes of these values at 5% would not only discourage the holding of assets purely speculatively but would also provide income that may be dedicated to making available community land trusts. Such trusts would stabilize land prices, especially those properties located around future SGR stations. Measures of this kind have been successful in other cases; for example, the spatial tax regime in Cape Town has been said to have reduced displacement by 41%. This strategy will result in more equitable city results, as those speculative surpluses are recycled to fund local infrastructure and affordable housing.

Secondly, the reorganization of institutions is necessary. A central coordinating body, such as the Nairobi Metropolitan Service should mandate the establishment of Speculation Intelligence Units. The units would be charged with the duty of screening the land markets, releasing maps of vulnerabilities at the end of every month, alerting probable hotspots, and preventing speculative evictions before they blow up. Furthermore, they must introduce a strict time limit within which the rezoning decisions are to be made, perhaps within 60 days of approvals of the structures which would seal the time loopholes that exist as of today and are manipulated by the speculators. Other crucial reforms would need to include integrating participatory value-capture into plans. This implies making the land value gains by private developers proportional concerning the volume of land value increments by the private developers in providing public amenities. These mechanisms would see profits of land development meaningfully going into public infrastructure, education, or housing instead of landing back in the hands of elite investors.

Lastly, Kenya Railways Corporation should become more proactive and socially inclusive in land management. Community development covenants should regulate all future land-adjacent SGR station auctions. These covenants would require the new planning to set aside a percentage of new development for affordable housing or community amenities of at least 30%. Moreover, resale penalties ought to be applied, such as taxing capital gains at 50% on any property flipped within five years of the purchase, as a disincentive toward short-term speculative financing. On routes like the Nairobi-Naivasha line, new zoning regulations must prevent the establishment of gated communities on SGR stations, within 800 m. This would assist in facilitating inclusive transit-oriented development that enchants all residents and does not necessarily have to benefit affluent buyers or developers.

10. Conclusion

This paper highlights a contradictory reality in the urban development: infrastructure development programs such as the SGR may lead to linkages and modernity, but they also encourage speculative projects that do not promote sustainable growth or social justice in the future. Our results reveal that Nairobi is not just being shaped by speculative behavior, but being written by it. The results of the SEM make it clear that almost a quarter (24.7%) of spatial changes are driven by speculative market logics, with a response lag among planning institutions. The structural failure in city governance seen in the delays of rezoning, displacement cycles and unregulated market booms were not ones unique to single instances but are part of a greater structural failure therein.

Three things are required to reacquire the popular interest in the formation of the city. In the first place, futuristic instruments such as SEM beta weights as applied in this study ought to be institutionalized to assist in anticipating speculative spikes coupled with pre-emptive planning. Second, it is necessary to transfer speculative gains into tax or levies towards community-based infrastructure-making sure that profits of publicly-funded investment are not privatized. Third, governance architecture around SGR should be entirely redesigned. Anti-speculation, resale penalties, and community ownership, including land trusts and first-refusal rights, must be stipulated in contracts to promote equitable land access. With the ever-growing skyline of Nairobi in the form of glimmering towers and new railways, it is urgent to make sure that the shadows cast by these developmental signals should not be focused on forcibly evicted poor families. This work presents not only evidence against speculative urbanism but also the means of its subversion and overcoming to promote a more equal and democratic process of city-making instead. Additional data and survey instruments used in this study are provided in Appendix A (Supplementary Data).

Ethics statement

This study included human subjects by way of surveys and interviews. Informed consent was obtained by all the respondents, and no information was shared publicly during the data collection. The School of Architecture Research Ethics Committee, Southeast University, Nanjing, China gave the paper ethical approval.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foar.2025.08.021.

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