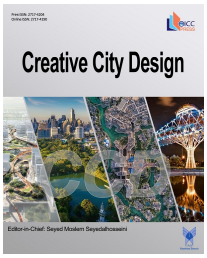

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Transformation of urban neighborhoods from the perspective of the public perception

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Abstract:

Aims: Urban neighborhoods continuously transform due to complex interactions among historical, demographic, socio-cultural, economic, and governance factors. Understanding these transformations is crucial for sustainable urban planning [1, 2]. This study examines the evolution of the Sisabad neighborhood in Mashhad, Iran, using urban complexity theory and a system dynamics approach. The research aims to explore the key drivers of neighborhood change and their interconnected feedback loops, focusing on public perceptions of these transformations.

Methodology: The study employs an extensive focus group discussion involving 850 participants, representing 20% of local families. This qualitative data collection method captures diverse perspectives on neighborhood changes. The analysis integrates public perception data with system dynamics modeling to identify key transformation patterns, including population growth, land use shifts, economic transitions, and governance influences.

Findings: The results indicate that increasing migration, informal housing development, and declining access to public services have significantly altered the socio-economic and spatial landscape of Sisabad. Weak governance, low public participation, and reduced institutional legitimacy have further exacerbated urban disparities. The study highlights the interconnection of demographic changes, economic transitions, and governance structures in shaping neighborhood evolution.

Conclusion: This research contributes methodologically by combining qualitative public perception analysis with system dynamics modeling, providing a holistic framework for understanding urban complexity. However, the findings are context-specific, and the absence of extensive quantitative modeling is a limitation. Future studies should conduct comparative analyses across different urban settings, integrate advanced geospatial and data-driven methods, and explore the role of climate resilience and governance innovations in urban transformation. The study underscores the necessity of inclusive, adaptive, and participatory urban planning strategies to foster sustainable neighborhood development.

Keywords: Urban complexity; System dynamics; Public perception; Neighborhood transformation; Governance; Land use change

1. Introduction

The complex approach to urban planning, originating in Britain during the 1960s, has been pivotal in shaping our understanding of cities and regions as intricate spatial entities comprising interconnected human settlements in a constant state of evolution [3]. Urban complexity theory asserts that planning within this context must be dynamic, responsive to probable changes, and cognizant of the internal dynamics inherent in urban areas [4].

Like other complex systems, cities exhibit internal dynamics influenced by the intricate processes of formation and change within the urban spatial and socio-economic landscape [5, 6]. Competitive behaviors of various actors seeking to optimize their interests play a pivotal role in shaping these dynamics, impacting stakeholders and relationships within the urban system [7]. The transformative effects of such actions are evident, for instance, in establishing a shopping center, influencing socio-economic patterns, traffic flows, and land values. Consequently, urban areas undergo

organic and spontaneous stages of adaptation, change, and evolution [8, 9].

A comprehensive literature review categorizes urban complexity into four fundamental aspects: Spatial, temporal, governance, and socioeconomic [[1, 10–13]. This categorization provides a framework for integrated analysis, enabling a conceptual understanding of the impacts of socioeconomic changes, demographic movements, and spatial transformations on urban areas. Shaw (2021) emphasizes the importance of this integrated perspective in addressing urban issues such as environmental impacts, climate change, urban poverty, and the consequences of urban sprawl [14].

As expounded by Alfeld (1995), systems thinking offers valuable approaches, tools, and techniques to understand urban complexity better [15]. The system dynamics approach, a systematic analytical perspective introduced by J. W. Forrester in his book "Urban Dynamics" in 1969, provides planners with a comprehensive and holistic viewpoint [16, 17]. Forrester (2009) argues that system dynamics, combining theories, methods, and philosophies, is essential for analyzing system behavior in management, environmental change, politics, and social trends [18]. This approach offers a general basis for understanding and analyzing how each urban system changes over time [16, 17].

In contemporary urban studies, the system dynamics (SD) approach addresses questions regarding urban dynamic tendencies as a complex system. This methodology extends beyond research on subsystems such as transportation, waste management, water management, land use, and environmental planning [19–23] to encompass various studies focusing on simulating and evaluating socio-economic changes like migration, urban poverty, social segregation, and employment dynamics [24, 25].

Cheng (2003) exemplifies applying the system dynamics model to elucidate the heterogeneity of components in three categories of urban complexity: Spatial, temporal, and decision-making complexity [10]. His work demonstrates how these categories' complex urban growth patterns depend on socio-economic and ecological circumstances. Similarly, Bottero et al. (2020) have described and applied an SD model to appraise the evolution of urban resilience [26].

Accordingly, understanding the dynamic nature of neighborhoods requires a multidimensional exploration that considers historical, demographic, and socio-cultural facets, particularly emphasizing public perceptions. Studies on the historical evolution of urban spaces provide a foundational understanding of how neighborhoods transform over time. Lynch (1964), in "The Image of the City," laid the groundwork for perceiving urban spaces as legible environments, emphasizing the role of perception in shaping individuals' interactions with their surroundings [27]. Sisabad, with its transition from a rural village to an urban neighborhood, aligns with Lynch's ideas, illustrating the transformative power of time on the built environment and the perceptions of its residents.

Moreover, the demographic composition of a neighborhood is a critical factor influencing its evolution. Sampson et al. (1997) explored the interconnectedness between social capital, crime rates, and neighborhood demographic shifts [28]. Sisabad's demographic profile, characterized by a significant youth population and a migrant community, resonates with Sampson et al.'s findings. This demographic dynamism adds a layer of complexity to the neighborhood's social fabric, necessitating an examination of how these demographics contribute to evolving public perceptions.

Additionally, the concept of social capital, as introduced by Weil & Putnam (1994) in "Making Democracy Work," emphasizes the role of community engagement in fostering a sense of belonging and collective efficacy [29]. Research by Lin (2019) further delves into the dimensions of social capital, highlighting its role in shaping neighborhood dynamics [30].

As the Local Development Office noted, Sisabad's active Neighborhood Social Council and the cohesive community align with these theories. Investigating how social capital manifests in public perceptions within Sisabad can provide insights into the neighborhood's evolving nature. Cultural factors also play a crucial role in shaping the identity of neighborhoods. Cooney & Jackson's (1987) seminal work, "Crabgrass Frontier," explores the historical and cultural forces that contribute to the development of suburbs [31]. Sisabad's historical roots and recent role as a pilgrimage destination introduce a rich tapestry of cultural influences. Researching how these cultural dynamics influence public perceptions can unveil the layers of complexity within the neighborhood. The literature on the perception of urban spaces is extensive, with seminal contributions from scholars like Appleyard (2021) and Canter (1997). Appleyard's "Livable Streets" investigates the impact of the physical environment on social interactions, while Canter's work delves into the psychology of place. Applying these frameworks to Sisabad, researchers can explore how the neighborhood's physical layout and cultural elements shape public perceptions and influence the evolving nature of the community [32, 33].

Economic factors often contribute significantly to neighborhood dynamics. Wilson William (1987) "The Truly Disadvantaged" discusses the impact of economic deprivation on urban communities [34]. While Sisabad's status as a destination for low-income migrants is a recent phenomenon, understanding how economic factors intersect with public perceptions can provide a nuanced understanding of the neighborhood's evolution.

In addition, recent trends in neighborhood studies focus on the intersectionality of various factors influencing urban spaces. Burgess and Park's (1925) classic concentric zone model has evolved into contemporary models that consider the interplay of socio-economic, cultural, and demographic factors [35]. Sisabad's unique blend of historical roots, demographic shifts, and cultural influences aligns with these trends, offering a contemporary lens to explore the evolving nature of neighborhoods.

Ultimately, a comprehensive literature review categorizes urban complexity into four fundamental aspects: Spatial, temporal, governance, and socioeconomic [10–13]. This categorization provides a framework for integrated analysis, enabling a conceptual understanding of the impacts of socioeconomic changes, demographic movements, and spatial

transformations on urban areas. Shaw (2021) emphasizes the importance of this integrated perspective in addressing urban issues such as environmental impacts, climate change, urban poverty, and the consequences of urban sprawl [14]. The main research concern of this study is how the evolution of neighborhoods in urban areas could develop further. The study is more precisely focused on the lens of public perception analysis. Therefore, the multidisciplinary nature of neighborhood studies and the importance of considering historical, demographic, socio-cultural, and economic factors are important in understanding the evolving nature of urban spaces. This research on Sisabad aims to contribute to this body of knowledge by examining how public perceptions intersect with these factors, unraveling the complexities inherent in the neighborhood's evolution based on the system's dynamic approach.

2. Methodology

In our pursuit of unraveling the intricate dynamics of the evolving Sisabad neighborhood, a comprehensive methodology was employed, combining a detailed focus group discussion with an analysis based on the system dynamic approach (SD). Rooted in the complex urban planning theory, this approach offers a holistic perspective on the interlinkages and intra-relationships of subsystems within complex urban systems.

Our investigation commenced with a comprehensive focus group discussion from September to November 2022 and March to May 2023, involving 850 participants, constituting approximately 20 percent of the neighborhood's resident families, totaling 4250 families. The primary objective of the discussion was to delve into public perceptions, examining various components identified in the existing literature. The topics of discussion were categorized into two sections. The first section focused on gathering general demographic information. In contrast, the second section consisted of specific issues related to the components shaping public perceptions, as delineated in the extensive literature review. To ensure a multidimensional understanding of the dynamic transitions within the neighborhood, the focus group discussions were conducted by a team of five experts from diverse academic backgrounds, including urban planning, psychology, economics, law, and sociology. This interdisciplinary approach aimed to encompass all facets of the evolving landscape. Participants were randomly assigned to different groups, each comprising a minimum of 8 and a maximum of 12 individuals. The circle time technique was employed between each group and the expert team to unveil the evolving processes within the neighborhood. The entire process, from conducting meetings to recording data, spanned six months.

Following the focus group discussion, we applied the system dynamic approach [36] to analyze the responses and provide an integrated understanding of the evolving nature of the Sisabad neighborhood. The SD model facilitated an in-depth examination, considering the principal components' relative effects and feedback concerning the research problem. This approach, grounded in systems thinking, provides tools and techniques to understand urban complexity better.

The SD model allowed us to trace the historical evolution of Sisabad, notably its transition from a rural village to an urban neighborhood. By incorporating the temporal dimension, we could discern the transformative power of time on the built environment and residents' perceptions.

Analyzing demographic data within the SD framework provided insights into the significant youth population and the presence of a migrant community, elucidating the layers of complexity in the social fabric.

The SD approach facilitated an examination of the manifestation of social capital in public perceptions, aligning with Putnam's emphasis on community engagement. The active Neighborhood Social Council and cohesive community dynamics were explored within this framework.

Cultural dynamics shaping public perceptions were analyzed using the SD model, drawing from Jackson's exploration of historical and cultural forces in the development of suburbs [37].

We used an integrated analysis to leverage the four fundamental aspects of urban complexity (spatial, temporal, governance, and socioeconomic). This approach allowed us to understand the impacts of socio-economic changes, demographic movements, and spatial transformations, aligning with the theoretical framework discussed in the literature.

The versatility of the SD approach was highlighted by showcasing its application beyond our study, emphasizing its relevance in researching subsystems such as transportation, waste management, water management, and land use, as well as its efficacy in simulating socio-economic changes.

To further illustrate the applicability of the SD approach, we referenced Cheng's expansion of a system dynamics model, explaining the heterogeneous behaviors of components in the context of urban complexity. Bottero et al. (2020) also applied an SD model to assess the evolution of urban resilience and highlighted the versatility of this methodology in diverse urban studies [10, 26].

To resume, the combined use of a comprehensive focus group discussion and the system dynamic approach provided a robust methodology for examining the evolving nature of the Sisabad neighborhood, grounded in public perceptions. This integrative approach allowed us to explore the feedback between local social, economic, and spatial variables, contributing to an enriched understanding of the complex dynamics inherent in urban spaces.

2.1 Focus group discussion participants

To ensure a representative sample, we targeted 20 percent of families in the Sisabad neighborhood, resulting in 850 participants. This strategic sampling approach aimed to capture diverse perspectives within the community (Table 1). It's important to note that participants who had lived in the neighborhood for less than 15 years were excluded from the discussion, ensuring that the responses reflected long-term residents deeply ingrained in the fabric of Sisabad.

2.2 Discussion description

Section 1: General demographic information

The first section of the discussion gathered essential demographic data to contextualize the responses received. Partici-

Table 1. General demographic information of participants.

Sample population	Gender ratio	Average years of the settlement	Participation ratio of age groups			
			25-34	35-44	45-54	55-64
850	50%	42 years	21.68%	28.41	31.27	18.64

pants were asked to provide their age, gender, and residency period in the Sisabad neighborhood. This information allowed us to identify trends and variations in perceptions across different demographic groups, contributing to a nuanced understanding of the community's dynamics.

Section 2: Components related to public perceptions

The second section of the discussion delved into specific components outlined in the literature, focusing on aspects that influence public perceptions within the urban environment.

1. Population Dynamics:

Participants were asked about their perceptions of changes in the neighborhood's population size, composition, and demographic characteristics over the years. Questions sought insights into how these changes influenced their sense of community, potential growth challenges, and the neighborhood's overall sustainability.

2. Peripheral Stimulation:

This section explored residents' perceptions regarding external factors such as building density and service accessibility. Participants were asked to share their experiences and opinions on how these factors significantly influenced their daily lives, satisfaction, and engagement within the neighborhood.

3. Land Use Changes and Accessibility to Services:

Topics in this category focused on residents' perceptions of changes in land use and accessibility to services. Participants were encouraged to express their views on how these changes influenced their satisfaction with the community and the impact of evolving spatial configurations on their daily lives.

4. Economic Transformation:

Participants were asked about their perceptions of economic changes within the neighborhood, particularly regarding job rates and overall socio-economic health. The discussion sought to uncover insights into residents' employment opportunities, income dynamics, and overall well-being concerning economic transformation.

5. Physical Environment of the Neighborhood:

This topic aimed to gauge residents' perceptions of changes in the physical environment, including the rate of building construction. Participants were encouraged to share their views on how these changes influenced the aesthetics, functionality, and overall satisfaction of their daily experiences.

6. Legitimacy and Legality of Local Governance:

This section explored residents' perceptions of the legitimacy and legality of local governance. Questions sought insights into how residents viewed governance structures, adherence to legal frameworks, and the impact of decision-making processes on the neighborhood's development.

7. Public Participation:

Participants were asked about their perceptions of opportunities for social demanding, claiming, and participation in decision-making processes-the discussion aimed to uncover insights into the inclusivity of decision-making processes, shaping community cohesion and engagement.

8. Local Employment Opportunities:

This set of questions focused on residents' perceptions of local employment opportunities. Participants were encouraged to share their satisfaction with job opportunities, the working environment, and the overall impact on the quality of life within the community.

9. Economic Disparities within the Community:

This category includes topics that sought insights into residents' perceptions of economic disparities within the community. The discussion aimed to understand variations in income, wealth, and access to resources among residents, shedding light on potential challenges related to social equity.

10. Composition of the Resident Population, Particularly Concerning Non-Indigenous Residents:

This section explored residents' perceptions of the demographic composition, focusing on non-indigenous residents. The topics aimed to uncover insights into social integration, cultural identity development, and community solidarity, acknowledging the importance of inclusivity and cultural diversity.

This comprehensive discussion is crucial in unraveling the complexities of the Sisabad neighborhood's evolution. By engaging 850 participants and delving into both general demographic information and specific components related to public perceptions, we aim to gain a nuanced understanding of community dynamics. The exclusion of residents with less than 15 years of residency ensures that our findings are grounded in the experiences of long-term community members. The collected data will provide valuable insights for urban planners and policymakers, enabling them to make informed decisions that cater to the diverse needs of the Sisabad community and foster sustainable development.

3. Case study

Sisabad emerges as an exemplary case study for investigating the intricate dynamics of a neighborhood's evolving nature, rooted in public perceptions. This neighborhood is located within the urban context of Mashhad, in the northern part of District Three of the Mashhad municipality (figure 1). It boasts a rich history of approximately 700 years, signifying a longstanding settlement with a unique socio-cultural landscape. The temporal transition from a rural village to a distinctive urban space until the late 1980s serves as a compelling backdrop, highlighting the complexity inherent in its transformation.

The demographic profile of Sisabad contributes significantly to its suitability as a case study (see Table 2). According to the 2021 census data meticulously collected by the Local Development and Facilitation Office, over 70% of the population falls within the age bracket of 20 to 55 years. Concurrently, around 20% comprises individuals aged 10 to 19 years. This demographic distribution underscores a youthful populace, constituting more than 70% of the neighborhood's inhabitants below 45. This demographic characteristic is a pivotal factor in understanding the evolving nature of the neighborhood, as the presence of a predominantly young population is likely to influence the cultural and social dynamics over time.

The social and cultural assets embedded in the fabric of Sisabad further enhance its suitability for research on the complexity of neighborhood evolution. The neighborhood's social foundation and inherent capacity, recognized by experienced professionals in the Local Development Office, offer valuable insights into the community's dynamics. The existence of a strong sense of community, evidenced by the active participation of social groups like the Neighborhood Social Council, highlights the neighborhood's potential as a microcosm of evolving social structures.

The historical context of Sisabad adds another layer of complexity to its evolving nature. Its transition from a rural setting and the notable presence of a migrant population, constituting approximately 14%, emphasize the neighborhood's multifaceted dimensions. The proximity to the religious center of Mashhad has further transformed Sisabad into a significant temporary residence for pilgrims and low-income migrants, introducing additional layers of diversity and complexity.

Public perceptions form the crux of understanding the evolving nature of any neighborhood, and Sisabad presents a dynamic canvas for such exploration. The juxtaposition of traditional rural roots with contemporary urban dynamics, coupled with the recent role as a destination for pilgrims and migrants, underscores the nuanced interplay of perceptions. Investigating how residents, newcomers, and external stakeholders perceive and interact with Sisabad provides a unique lens into the neighborhood's complexity.

In summary, Sisabad stands out as an ideal case study for research on the evolving nature of a neighborhood grounded in public perceptions. Its historical trajectory, demographic

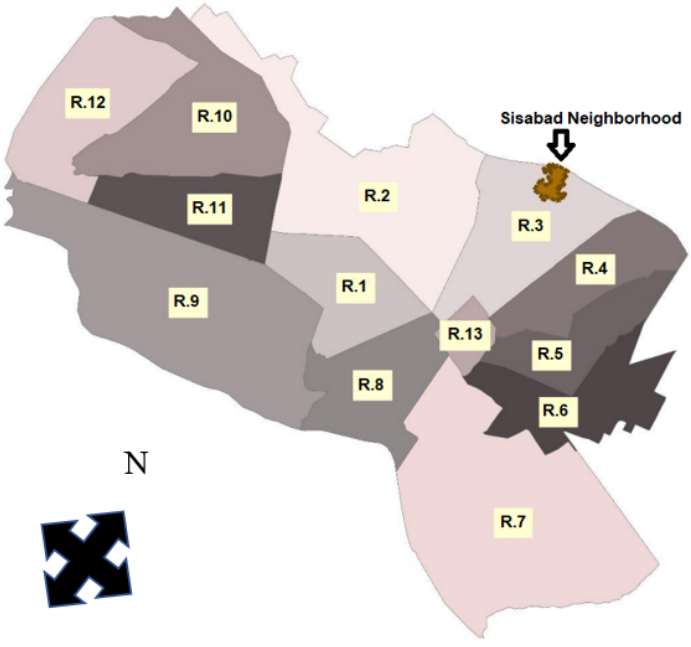

Figure 1. The location of the Sisabad Neighborhood in Mashhad (R = Urban Region).

Table 2. Sisabad demographic information based on 2021 census.

Population (number)	Gender ratio	Share of youth population (20 – 55 years old)	Share of immigrants population
10574	50%	71.56%	14%

(Source: Formal census, local development and facilitation office, 2021).

composition, social foundations, and diverse cultural influences converge to create a rich tapestry for exploration. By delving into the intricate interplay of factors that shape public perceptions within Sisabad, researchers can unravel the complexities inherent in the evolving nature of urban spaces, contributing valuable insights to the broader discourse on neighborhood studies.

4. Results and discussion

Participants shared insights into their perceptions of population dynamics within the neighborhood over the past decade. The focus encompassed changes in size, composition, and demographic characteristics, aiming to understand the impact of these transformations on community cohesion, potential challenges associated with growth, and the overall sustainability of the neighborhood.

Examining the feedback loops in the figure 2 unveils a reinforcing cycle tied to population changes. An upsurge in the total population triggers heightened housing demands. Consequently, increased housing construction follows suit, leading to a subsequent rise in the overall number of houses. This expanded housing availability can act as a magnet, drawing in more residents and perpetuating the cycle of population growth. As illustrated in the diagram, the contributing factors to this growth include the increase in natural population and the migration of low-income immigrants.

Another discernible loop in the diagram interconnects ′Local Land Use Changes′ (shifting from agricultural to residential), ′Housing building,′ and the ′Number of Houses.′ This interconnected cycle suggests that as more land undergoes conversion from agricultural to residential use, it prompts an increase in housing construction, thereby expanding the pool of available houses.

Additionally, the diagram sheds light on the relationship between ′Total Population′ and ′Number of inhabitants/families,′ forming a feedback loop with ′Natural growth.′ This indicates that the growth in the total population can influence the number of inhabitants or families, contributing to natural population growth.

In summary, participant insights and diagram analysis converge to illuminate the intricate dynamics of population changes within the neighborhood. The feedback loops outlined underscore the interconnected nature of demographic shifts, housing dynamics, and land use changes, providing a holistic understanding of how these elements collectively shape public perceptions of the evolving neighborhood.

Next, Participants were prompted to articulate their experiences and viewpoints on how the external factors, encompassing building density and accessibility to services, substantially influenced their daily lives, contentment, and involvement within the neighborhood.

The responses are presented in the figure 3, which articulates several discernible feedback loops and relationships within the intricate system of the Sisabad neighborhood:

1. The migration of low-income immigrants to Sisabad catalyzes an increase in the population.

2. The augmented population fosters a heightened inclination towards residency, further stimulating the influx of low-income immigrants to Sisabad. This forms a reinforcing feedback loop, potentially contributing to sustained population growth in the neighborhood.

3. With population growth, there is a concurrent surge in the demand for new services. However, a noteworthy inverse relationship emerges between the demand for new services and the accessibility to existing public services. This implies that as the demand for new services rises, the accessibility to existing public services diminishes.

4. The diminishing access to existing public services subsequently negatively impacts the inclination towards residency. Completing a balancing loop introduces a potential stabilizing factor for population growth. It does so by diminishing the neighborhood's allure for new residents due to decreased access to public services.

In essence, resident perceptions and the depicted diagram collaboratively elucidate the intricate dynamics surrounding external factors in the Sisabad neighborhood. The feedback loops outlined underscore the interplay between population growth, service demands, and accessibility, offering a comprehensive understanding of how these elements collectively shape residents' experiences and the evolving nature of the neighborhood.

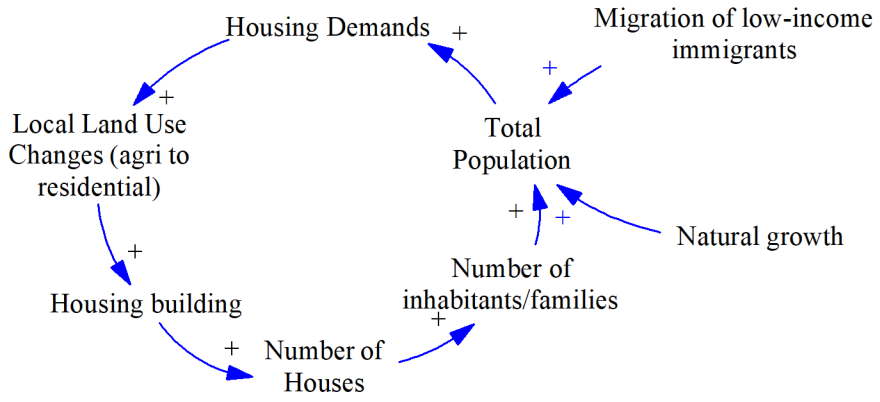

Figure 2. Population dynamics in Sisabad.

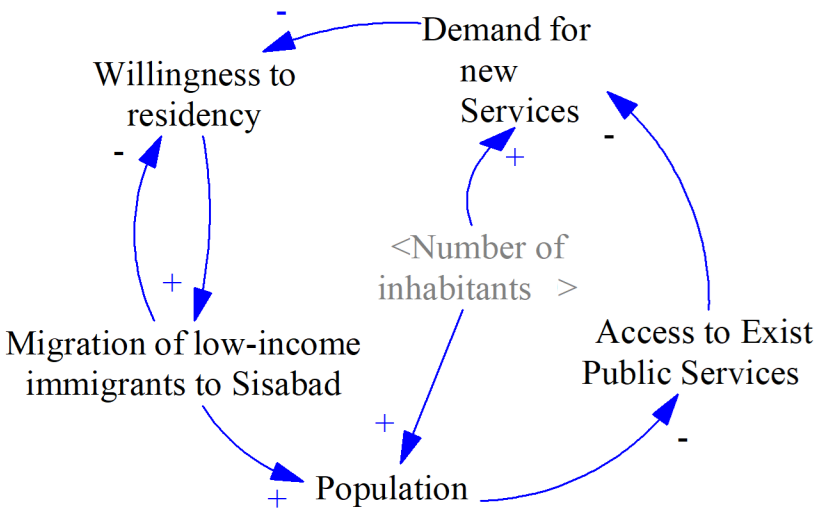

Figure 3. Peripheral stimulation feedback on Sisabad evolving process.

Afterward, the participants were encouraged to articulate how these changes impacted their satisfaction with the community and the ramifications of evolving spatial configurations in their daily lives. Additionally, participants were prompted to share their perceptions of economic transformations within the neighborhood, particularly concerning job rates and overall socio-economic well-being. The discussion aimed to unveil insights into residents' employment opportunities, income dynamics, and overall welfare in light of economic transformation.

Commencing from the dynamics of ′Local family's incomes,′ an escalation in income precipitates a rise in ′Local job opportunities,′ subsequently fostering an increase in ′Agricultural jobs′ as one facet of employment. This upswing in ′Agricultural jobs′ positively reverberates into the ′Proportion of Agriculture Land Area,′ signifying that as agricultural employment expands, so does the expanse of land dedicated to agriculture. Nevertheless, an intricate inverse relationship manifests between the ′Proportion of Agriculture Land Area′ and ′Local Land Use Changes′ (from agricultural to residential)(see figure 4). This intimates that when more land is utilized for agriculture, there is a decline in the conversion of agricultural land to residential use.

Further unfolding in the diagram, an upsurge in ′Local Land Use Changes′ (from agriculture to residential) instigates a surge in ′Housing Demand.′ The heightened ′Housing Demand′ positively influences the population, impacting the willingness to residency. ′Willingness to residency′ cyclically reinforces ′Local family's incomes.′ This feedback loop suggests that a greater willingness to reside in the area could attract more individuals or encourage current residents to stay, potentially bolstering local family incomes through a larger or more stable customer base or workforce. The diagram additionally intimates that an augmentation in 'Population' engenders an increase in ′Housing Demand,′ an anticipated relationship given that a burgeoning population naturally leads to heightened housing requirements.

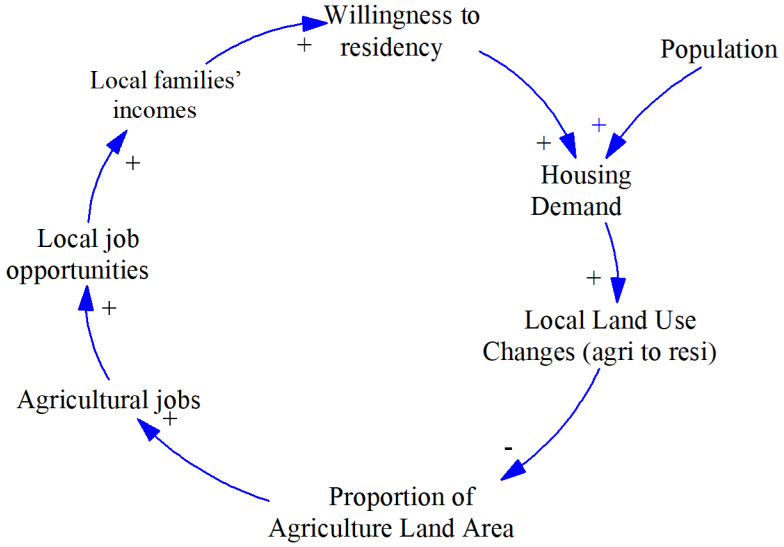

Figure 4. Economic transformation loop.

This interplay between ′Population′ and ′Housing Demand′ can form a reinforcing feedback loop capable of propelling further population growth and urbanization within the neighborhood.

Following a series of inquiries aimed to assess residents' perspectives on alterations in the physical environment, precisely the pace of building constructions. Participants were prompted to express their views on how these changes influenced the aesthetics, functionality, and overall satisfaction of their daily experiences.

Commencing with the dynamics of ′Population,′ an escalation in this factor instigates a rise in ′Housing Demand.′ This direct and anticipated relationship aligns with the notion that a larger population generally necessitates increased housing. The heightened ′Housing Demand′ subsequently triggers an increase in ′Informal builds,′ indicating that a growing demand for housing may lead to an upsurge in the construction of informal or non-regulated housing structures (see figure 5).

However, the figure 5 delineates that ′Informal builds′ negatively impact ′Environmental Qualities.′ This implies that an augmentation in informal housing may result in a deterioration of environmental conditions, potentially stemming from a lack of planning, infrastructure, or adherence to environmental regulations. Intriguingly, the diagram also suggests that a decrease in ′Environmental Qualities′ leads to an increase in ′Willingness to residency.′ This counterintuitive relationship prompts consideration, implying that despite environmental degradation, the willingness to reside might increase, possibly influenced by economic or social factors not explicitly represented in this diagram.

Concluding this interconnected scenario, 'Willingness to residency' positively influences 'Population,' thereby completing a feedback loop. This signifies that as more individuals express a willingness to reside in the area, the population experiences an uptick. This cyclical relationship could further intensify housing demand, potentially exacerbating informal builds and environmental quality issues.

The last segment delved into residents' perspectives on the legitimacy and legality of local governance, exploring their views on governance structures, adherence to legal frameworks, and the impact of decision-making processes on the neighborhood's development. The discussion inquired about residents' perceptions of opportunities for social demanding, claiming, and participation in decision-making processes, aiming to uncover insights into the inclusivity of decision-making processes that shape the level of community cohesion and engagement.

Figure 6 illustrates their perception through the intricate feedback loops involving governance, public engagement, housing, and environmental factors. An escalation in the ′Importance of Planning for providing public needs′ initiates a ′Need for Master Plan,′ subsequently enhancing ′Access to the Master Plan and Operational Instructions.′ Recognizing the importance of planning can lead to better access to planning documents, which is crucial for informed public participation and effective urban development.

′Access to the Master Plan and Operational Instructions′ positively influences the ′Legitimacy and Legality of Local municipality,′ fostering ′Public participation.′ This loop suggests that when the public perceives the local government as legitimate and legal, they are more likely to participate in civic processes. Increased ′Public participation′ contributes to better ′Public Monitoring,′ negatively impacting ′Informal builds,′ indicating that active civic engagement improves urban development oversight, reducing unregulated building occurrences.

A decline in ′Informal builds′ leads to an enhancement of ′Environmental Qualities,′ reinforcing the idea that more regulated and planned development preserves environmental standards. ′Environmental Qualities,′ in turn, positively influence the ′Importance of Planning for providing public needs,′ closing the loop by emphasizing the value of planning in meeting public needs.

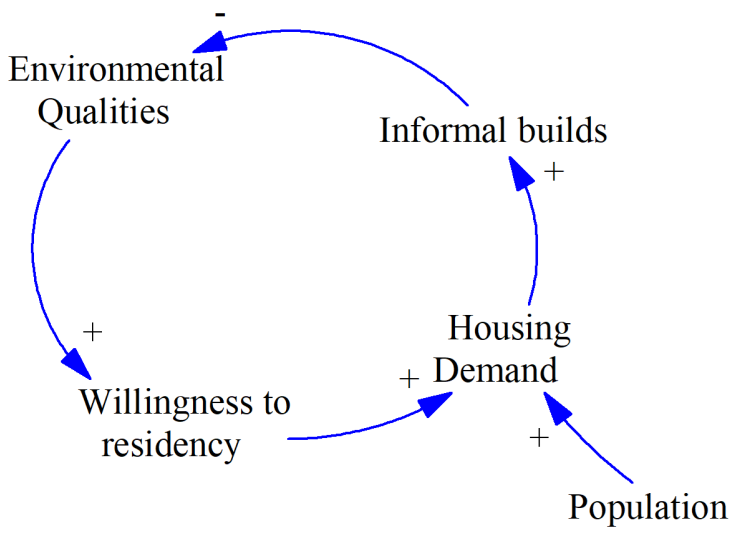

Figure 5. Dynamic impacts on the environment quality.

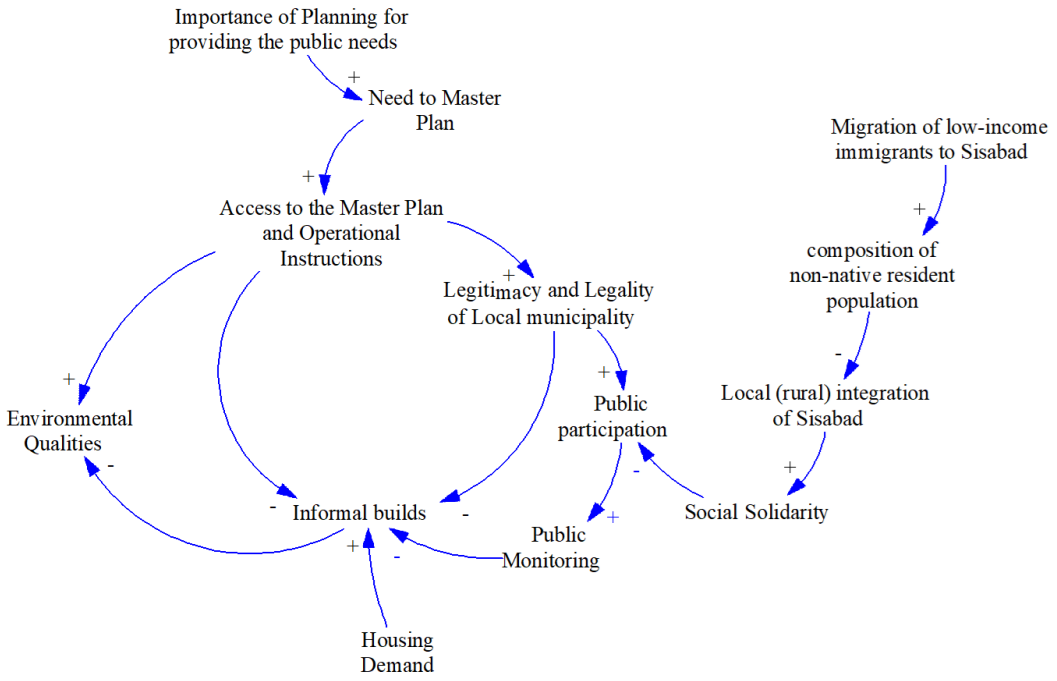

Figure 6. Feedback of the residents' perspectives on the legitimacy and legality of local governance.

Additional interactions are depicted, such as an increase in the 'Migration of low-income immigrants to Sisabad,' affecting the 'Composition of the non-native resident population,' which influences 'Local (rural) integration of Sisabad,' ultimately impacting 'Social Solidarity.' 'Social Solidarity' could influence 'Public participation' and 'Public Monitoring,' though these relationships are not directly drawn in the diagram.

The analysis of urban transition complexity in the Sisabad Neighborhood presents a comprehensive understanding of the interconnected components, impacts, and externalities across spatial, temporal, governance, and socio-economic aspects. The spatial element, characterized by peripheral stimulation, land use, migration streams, and building demand, has increased population and building density while decreasing the accessibility of services. This has resulted in a decrease in agricultural job opportunities and local families' income, impacting the socio-economic fabric of the neighborhood.

Temporally, the transition has seen a shift from agricultural jobs to increased inhabitants, leading to decreased quality of life. The governance aspect has been affected by a decrease in local municipality legitimacy and legality and a low rate of public participation, resulting in a lack of local monitoring and a reduction of local job opportunities. Additionally, an increase in the number of low-income immigrant families has been observed, impacting the social and economic dynamics of the neighborhood (see figure 7).

The findings underscore the complex and multifaceted nature of urban transition complexities, emphasizing the need for comprehensive understanding and strategic interventions to address the socio-economic, spatial, and governance challenges posed by urban development in the Sisabad Neighborhood (see Table 3). Holistic approaches that consider the diverse repercussions on population dynamics, economic growth, land use, and social cohesion are essential to foster sustainable and inclusive urban development in the area.

As illustrated in the table, the elements representing the four facets of urban complexity have been both influential and consequential, contributing to the formation of the present state of the Sisabad neighborhood.

5. Conclusion

This study provides a significant contribution to the understanding of urban transformation, particularly in the case of the Sisabad neighborhood, through the lens of urban complexity theory and the system dynamics approach. By integrating historical, demographic, socio-cultural, and economic dimensions, the research offers a holistic view of how neighborhoods evolve in response to internal and external factors. The study's findings reveal key insights into the intricate interconnections between population dynamics, economic transformations, land use changes, and governance structures, emphasizing the complexity of urban development.

One of the major contributions of this research lies in its methodological approach. The study employed an extensive focus group discussion involving 850 participants, representing 20% of Sisabad's families, ensuring a broad and representative sample of public perceptions. This participatory methodology allowed for an in-depth understanding of residents' viewpoints regarding changes in their living environment. The system dynamics approach further enhanced the research by enabling the identification of feedback loops within the urban system, demonstrating the interplay between various socio-economic and spatial variables.

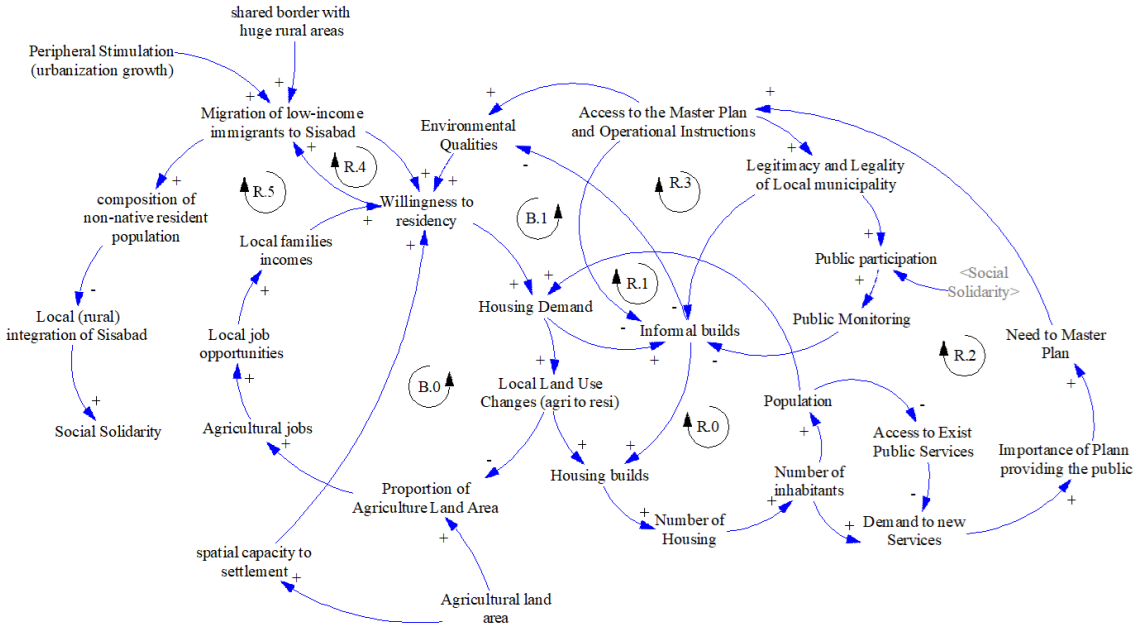

Figure 7. Dynamics of the complexity of the urban transition of the Sisabad.

Table 3. Urban transition complexity: Components, impacts, and externalities in the Sisabad Neighborhood based on public perception.

Aspect	Components	Variables	Impact	Externalities	Type of Externalities
Spatial	Peripheral stimulation	Migration stream	Increase the Population and Building density	Decrease the agricultural job opportunities and local families' income	Socio-Economic
		Building demand	Decrease the accessibility of the services (qualitative and quantitative)		
	Land use	LUNCH			
	Activity/Services	level of accessibility			
Temporal	Population	Growth rate	Increasing the rate of inhabitants	Decreasing the quality of life	Socio-Economic,
	Economic	Growth rate	Decreasing the rate of agricultural jobs		
	Physical	Growth rate	Increasing the rate of builds		Spatial
Governance	Legitimacy and Legality	Available plan	Decrease the level of local municipality legitimacy and legality	Increasing the rate of informal builds and Decreasing the environmental qualities	Spatial
	Social Demanding/ Claiming Cooperation of actors	Participation	Low rate of public involvement has caused the lack of local monitoring.		Socio-Economic
Socio-economic	Local Employment	Working-class composition	Decrease the local job opportunities	Increasing the rate of informal builds	Governance
	Migration	The compound of non-indigenous resident population	Decrease the social solidarity	Decreasing the rate of public participation	Spatial
	Income	family income level	Increase the number of low-income immigrant families		

The results highlight that population growth, economic shifts, and governance dynamics are deeply interconnected. The increase in low-income immigrant populations has contributed to the expansion of informal settlements, altering the social and spatial fabric of Sisabad. Changes in land use from agricultural to residential have triggered housing demand surges, exacerbating issues related to service accessibility, employment opportunities, and environmental quality. Furthermore, the study underscores the role of governance in shaping urban transformation. Weak public participation and declining trust in local governance have led to informal development patterns, reduced regulatory enforcement, and increased socio-economic disparities. These insights contribute to the broader discourse on urban transformation, emphasizing the need for governance structures that are more inclusive, transparent, and responsive to community needs.

However, despite its contributions, the study has several limitations. First, while the research successfully captures the perspectives of a large sample of Sisabad residents, the findings remain context-specific and may not be directly generalizable to other urban settings. The unique historical, cultural, and socio-economic characteristics of Sisabad may result in transformation processes that differ from those in other urban environments. Future research should explore similar methodologies in diverse urban contexts to validate and expand upon these findings.

Another limitation is related to data constraints. Although the study benefits from qualitative insights through focus group discussions, the lack of extensive quantitative data limits the ability to conduct predictive modeling or statistical validation of certain trends. Future research should incorporate a mixed-methods approach, integrating spatial analysis, census data, and economic modeling to strengthen the robustness of findings.

Additionally, the study does not deeply investigate the psychological and behavioral dimensions of public perception. While it acknowledges the impact of governance structures and economic conditions on community engagement, further research is needed to explore how cognitive and emotional factors influence residents' adaptation to urban change. Understanding these aspects could provide more nuanced insights into public attitudes toward transformation initiatives and policy interventions.

In terms of future research directions, several avenues emerge from this study. First, expanding the framework of analysis to include different urban neighborhoods with varying socio-economic profiles would provide comparative insights into urban transformation processes. Such comparative studies could help identify common patterns and unique local factors influencing urban change, contributing to a more generalized understanding of neighborhood evolution.

Second, there is a need to incorporate advanced technological tools into urban transformation research. Geographic Information System (GIS) mapping, artificial intelligence, and big data analytics could enhance the capacity to analyze spatial patterns, predict future urban changes, and design data-driven policy interventions. The integration of these technologies with the system dynamics approach could offer more precise and actionable insights for urban planners and policymakers.

Another crucial area for future research is the role of climate change and environmental sustainability in urban transformation. As cities worldwide face increasing challenges related to climate resilience, it is essential to examine how neighborhoods like Sisabad can adapt to environmental stressors such as rising temperatures, water scarcity, and extreme weather events. Investigating sustainable urban development strategies, green infrastructure implementation, and eco-friendly housing solutions could contribute to more resilient urban planning frameworks.

Moreover, future studies should delve deeper into governance innovations and participatory planning mechanisms. The findings of this research suggest that governance structures significantly impact the trajectory of urban transformation. Exploring models of community-based planning, digital participatory platforms, and decentralized decision-making could provide solutions to enhance public engagement and ensure more inclusive urban policies.

Finally, socio-economic mobility and social cohesion are critical dimensions that warrant further investigation. The increasing socio-economic disparities within Sisabad highlight the need for policies that promote equitable urban development. Research into affordable housing policies, local economic empowerment programs, and social integration strategies could help mitigate inequalities and foster more balanced neighborhood growth.

Overall, this study advances the academic discourse on urban complexity and neighborhood transformation by providing empirical evidence from Sisabad and applying a robust theoretical framework. The integration of public perceptions with system dynamics analysis offers a comprehensive perspective on how urban neighborhoods evolve in response to socio-economic, cultural, and governance factors. By identifying key challenges, limitations, and future research directions, this study lays the groundwork for further exploration of urban transformation processes, contributing to more effective and sustainable urban planning practices.

Moving forward, a more interdisciplinary approach that bridges urban studies, sociology, economics, and environmental science will be essential in tackling the multifaceted challenges of urban transformation. By fostering collaboration between researchers, policymakers, and local communities, future studies can develop innovative solutions that balance urban growth with social equity, economic vitality, and environmental sustainability.

In conclusion, the research on the Sisabad neighborhood underscores the complexity of urban transformation, highlighting the need for holistic, inclusive, and adaptive urban planning approaches. While the study provides valuable insights into public perceptions and systemic urban dynamics, continued exploration and innovation will be crucial in addressing the evolving challenges of urbanization. By building on the findings of this research, future studies can contribute to the development of more resilient, equitable, and livable urban environments.

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Authors contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interests
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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