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Empowerment and spatial justice through urban acupuncture: testing a participatory model in the informal settlement of Shahid Bahonar, Mashhad

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Abstract

Rapid urbanization in developing countries has expanded informal settlements as a manifestation of spatial inequality, demonstrating the need for practical and low-cost intervention strategies. This study aims to design and validate an operational model for implementing "Urban Acupuncture" to foster community empowerment and achieve spatial justice in the Shahid Bahonar neighborhood of Mashhad, through an applied, mixed-methods study. Data were collected from 375 residents (via cluster sampling) and 20 experts (via purposive sampling) using a questionnaire (reliability: 0.87), interviews, and focus group discussions. Data analysis was performed by integrating AHP-TOPSIS methods and inferential statistics. The findings indicated that the AHP-TOPSIS model, which prioritized problem density (0.42), is an effective tool for prioritizing critical intervention points. A strong and significant relationship was found between the physical-environmental condition and the perception of spatial justice (r = 0.73), with the physical indicator identified as the strongest predictor of spatial justice (β = 0.52). Furthermore, the neighborhood's relatively strong social capital (mean= 3.65) and its positive correlation with the willingness to participate (r = 0.55) provided a suitable foundation for participatory interventions. Finally, low-cost and participatory operational plans were designed for the prioritized points. The findings suggested that urban acupuncture, within the framework of a scientific-participatory model, can act as a catalytic strategy to initiate the empowerment process and advance toward spatial justice in such contexts.

Keywords

Empowerment
Informal Settlement
Mashhad
Small-Scale Interventions
Shahid Bahonar Neighborhood
Spatial Justice
Urban Acupuncture

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1. Introduction

Rapid urbanization, as a central feature of the 21st century, has created complex challenges for sustainability and justice in urban spaces, alongside new opportunities (UN-Habitat, 2022; Rybski & González, 2022). This trend peaked in 2007 when the urban population surpassed the rural population. It is projected that by 2050, 68% of the world's population will reside in cities, with approximately 90% of this growth expected to occur in Asia and Africa (Shand & Ndezi, 2025; Dodman et al., 2018). One of the most tangible manifestations of this uneven growth and a reflection of structural inequalities is the phenomenon of informal settlements (Bettencourt & Marchio, 2025). Estimates indicate that approximately one billion people currently reside in these settlements, which may increase to three billion by 2050 (Agyabeng et al., 2022; World Bank, 2022; Atkinson, 2024). These settlements are formed primarily due to rapid urbanization, a shortage of affordable housing, the inability of planning systems, and poverty-driven migration, turning them into a persistent and challenging part of the urban landscape, especially in developing countries (Aghajani et al., 2024; Olubodun & Aluko, 2022; Tellman et al., 2022; Simon & Ngereja, 2024; Ewnetu & Seo, 2025; Matamanda, 2020; Zhang et al., 2020).

Understanding and managing these complex challenges requires a perspective beyond conventional analytical approaches and the adoption of novel strategies. In this context, macro-scale approaches like urban regeneration often face significant practical obstacles due to financial constraints, tenure complexities, institutional weaknesses, and difficulties in securing broad stakeholder participation (Sharif Zadegan & Safavi, 2023). Consequently, small-scale, pragmatic approaches, such as "urban acupuncture," which emphasize small, low-cost, precise, and high-impact interventions in sensitive urban points, have gained importance (Lo, 2024). The success of these interventions hinges on the simultaneous achievement of two interconnected goals: spatial justice (emphasizing a more equitable distribution of resources and access) and social empowerment (through strengthening social capital and local institutions) (Fainstein, 2010; Hashempour et al., 2022).

In Iran, with an urbanization rate of approximately 77%, informal settlements have become an inevitable feature of metropolises (Statistical Center of Iran, 2025; Jalili Sadrabad & Eskandari Dorbati, 2023). The metropolis of Mashhad, as the country's second most populous city, is a telling example of this reality, where the high population density in low-quality residential fabrics poses a serious urban management challenge (Baghban & Minaei, 2023). Past experiences have shown that large-scale regeneration plans in these areas, due to the aforementioned limitations, have often failed to yield tangible and sustainable results (Deputy of Planning and Human Capital Development, Mashhad Municipality, 2021). The urban acupuncture approach can be a practical and efficient strategy for gradual regeneration and empowerment.

Despite numerous studies on informal settlements in Mashhad, a significant research gap exists regarding the provision and testing of an integrated operational framework that directly links urban acupuncture with the dual goals of local community empowerment and the realization of spatial justice in a specific neighborhood. Domestic research has less frequently addressed the design of hybrid decision-making models (such as AHP-TOPSIS) for scientific identification of optimal "acupuncture points" and simultaneous assessment of relationships between physical, social components, and perceptions of justice in these contexts. The primary contribution and objective of this study are to fill this gap by designing, validating, and implementing a hybrid model in the Shahid Bahonar neighborhood of Mashhad. This research aims to demonstrate how an evidence-based, small-scale, and participatory operational strategy for gradual regeneration can be implemented by integrating multi-criteria decision-making methods (AHP-TOPSIS) to prioritize intervention points, combined with survey and participatory approaches for assessing social variables. The central question is whether the targeted implementation of urban acupuncture projects in selected critical points can simultaneously enhance the perception of spatial justice and strengthen social empowerment (including willingness to participate) among residents of an informal neighborhood. Furthermore, the relationship between objective physical-environmental indicators and subjective socio-economic indicators is explored. From this perspective, urban acupuncture in this study is regarded not as an isolated action but as a catalytic strategy for gradual institutional and physical change toward sustainability and justice.

2. Theoretical foundations

2.1. The city as a complex system and living organism

Understanding and managing contemporary urban complexities necessitates a perspective beyond conventional analytical views. The approach of "the city as a complex adaptive system" or a "living organism" (Rybski & González, 2022; Abujder Ochoa et al., 2024; GholipourDomye et al., 2025) views the city as a dynamic entity whose seemingly separate components create a whole and emergent behaviors through continuous interaction (Zarei, 2021; Kirwan & Zhiyong, 2020). This biological metaphor provides a suitable theoretical basis for devising "targeted" and "place-sensitive" therapeutic approaches in the city (Chu et al., 2020). Within this macro framework, urban regeneration is known as a "holistic treatment," aiming to simultaneously revitalize the physical, economic, social, and environmental dimensions of deteriorated and unstable urban fabrics (Khaing et al., 2025; Mokari et al., 2024).

2.2. Informal settlements: From a physical problem to a social process

Informal settlements, as the most tangible manifestation of urban poverty and spatial inequality, have been at the center of development and urban planning studies for over six decades. The conceptual roots of this phenomenon date back to the 1960s and 1970s with pioneering research that considered their formation a sign of a structural gap between formal housing supply and increasing demand of low-income groups in developing countries (Fouad & Abbas, 2021; Atkinson, 2024). This initial view emphasized the inability of governments and the lack of infrastructure (Akirso, 2021; Mohamed et al., 2024). Over time, the perspective on these settlements shifted from the negative concept of "slum" focused on physical deprivation to "informal settlement," emphasizing social agency and self-organization of residents (UN-HABITAT, 2025; Dovey et al., 2020). This paradigmatic shift introduces the informal settlement not merely as a place but as a dynamic social process in the production of space that operates outside formal frameworks of land control and ownership (Dovey, 2019; Kamalipour, 2023; Alene, 2022). From a structural characteristics perspective, three key indicators are accepted for identifying these settlements: 1) Non-compliance with formal land and construction regulations, 2) Inadequate access to basic urban services (water, electricity, sanitation), and 3) Lack of land tenure security (UN-Habitat, 2017; World Bank, 2022). These conditions often lead to locating in unsuitable and hazardous land, increasing vulnerability to disasters (Hailu et al., 2024; Ampofo et al., 2024; Shand & Ndezi, 2025). In response to this phenomenon, two opposing policy approaches have emerged: the eviction/coercive approach, which, emphasizing health and physical threats, pursues a policy of demolition and displacement (Atkinson, 2024), and the in-situ upgrading approach, which considers these settlements a dynamic part of the urban ecosystem and emphasizes gradual improvement of living conditions through resident participation (Cirolia, 2017; Collier et al., 2019; UN-Habitat, 2017). The latter approach forms the basis for concepts such as regeneration and empowerment.

2.3. Urban regeneration: The macro framework for intervention

Urban regeneration emerged as a comprehensive and multi-dimensional concept in response to the inefficiency of purely physical urban renewal approaches. This approach is an interventionist, dynamic, and long-term process that seeks the simultaneous revitalization of the physical-environmental, economic, and socio-cultural dimensions of deteriorated and unstable fabrics (Khaing et al., 2025; Kowkabi, 2021). The nature of regeneration is inherently participatory and multi-stakeholder, necessitating interaction and negotiation among the public, private, and civil society sectors (Sharif Zadegan & Safavi, 2023). Its ultimate goal is to achieve endogenous sustainable development that, while enhancing quality of life and spatial justice, relies on strengthening social capital and local capacities (Mokari et al., 2024). Urban regeneration is a way to prevent the spread of decay to the entire urban system (Jahed et al., 2023). In the context of informal settlements, urban regeneration can lead to improved social security, reduced vulnerabilities, enhanced skills and dignity of residents, strengthened sense of belonging, and the creation of a healthy and sustainable environment (Sedaghati et al., 2025). In other words, sustainable urban regeneration builds a bridge between informal settlements and the formal urban fabric (Sedaghati et al., 2025). However, the successful implementation of large-scale regeneration plans in informal contexts often faces major obstacles: Financial resource limitations, tenure complexity, weak local institutions, and significant challenges in

securing genuine and sustained resident participation (Sharif Zadegan & Safavi, 2023). These limitations highlight the necessity of employing small-scale, pragmatic, and catalytic strategies within the broader regeneration framework.

2.4. Urban acupuncture: The small-scale and catalytic strategy

In response to the limitations of macro-scale approaches, "urban acupuncture" has emerged as a "catalytic spot treatment" (Lerner, 2014). Urban acupuncture, as a pragmatic theory and strategy, is inspired by the "city-as-organism" metaphor and concepts from traditional Chinese medicine. This approach views the city as a living and complex system where small-scale, precise, low-cost, and high-impact interventions in sensitive points or critical nodes can stimulate and activate positive social, economic, and physical flows on a larger scale (Lerner, 2014; Salman & Hussein, 2021). These interventions, like needles in the body, by stimulating key points (such as a vacant lot, a problematic intersection, or a symbolic dilapidated building), can create widespread effects in their surrounding fabric and gradually initiate positive processes of social, physical, and economic revitalization (Lo, 2024; Zarei, 2021). Their effects extend beyond the physical boundaries of the project and act as a catalyst (Zarei, 2021). Therefore, urban acupuncture can be considered a practical laboratory for testing regeneration ideas on a micro-scale with community participation, paving the way for broader changes (Carlotti, 2024; CASPRINI et al., 2026). Given its recent popularity, this approach is often celebrated as "social urbanism," architectural achievements, and a "solution" to various urban problems (Lo, 2024, p. 1). It is a response to financial constraints, heavy bureaucracies, and the inefficiency of large-scale projects. This approach essentially reflects the same spirit of urban regeneration on a micro and dynamic scale, where revival begins not from the top down, but from within forgotten spaces and through the collective energy of citizens (Salman & Hussein, 2021; Sherafati et al., 2024). Its key principles include focusing on sensitive points with latent energy or problematic potential, emphasizing social capital and public participation, rapid implementation, avoiding lengthy bureaucracies, flexibility, and context-sensitivity (Salman & Hussein, 2021). From this perspective, urban acupuncture can be viewed as a "practical laboratory" or a "pre-motor" for urban regeneration, preparing the ground for broader and institutionalized changes (Carlotti, 2024).

Table 1. Principles of the urban acupuncture approach, Source: Salman & Hussein, 2021; Lerner, 2014; Zarei, 2021; Hoogduyn, 2014

Principle	Description
Holistic approach	Analysis of all economic, social, environmental, and cultural information for planning
Citizen participation	Utilizing local knowledge and community participation for intervention success
Small-scale intervention	Quick, low-cost, and impactful actions on the whole system
Identifying sensitive points	Identifying key urban points (ailing, with latent energy, urban nodes)
Rapid performance	Immediate implementation of plans without long bureaucracy
Place-making	Liberating and utilizing the existing potential in places
Scenario-building	Developing plans and visions to attract participation and collective decision-making
Catalytic characteristic	Impact beyond the physical boundary and stimulating widespread changes

Global experiences indicate that the origin of this approach is Spain, the city of Barcelona, but its foundational thinking relates to Chinese acupuncture. Thus, most implemented actions in this field are related to China. Successful examples of urban acupuncture worldwide show positive impacts on neighborhood revitalization, regeneration of forgotten spaces, and strengthening social capital. Reviewing these experiences confirms key lessons, such as the necessity of genuine resident participation, flexibility in design, attention to local identity, and the use of local resources. Looking broadly at the experiences of different countries, one can conclude that good urban acupuncture possesses seven principles: Minimalism, value-based, flexibility, context-sensitivity, participatory, multi-dimensional, and emphasis on gradual improvement (Mahdianpoor et al., 2019, p. 35). A critique of this approach is that without linkage

to larger programs, it carries the risk of "islanding" successes, dependence on specific local leaders, and an inability to solve macrostructural issues (such as the land market and housing policies) (Lo, 2024). Therefore, its application should occur within an integrated strategy and with awareness of these limitations.

2.5. Social empowerment: The human dimension of development

Empowerment is a paradigm positioned against top-down, authoritarian approaches, emphasizing the increase of authority, capacity, and control of individuals and local communities over their lives and environment (Hashempour et al., 2022; Kheiroddin & Salahimoghadam, 2021). This process has three complementary dimensions: Economic (increasing income and job opportunities), social (strengthening social capital, networks, and sense of belonging), and political (increasing participation in effective decision-making) (Kohfeldt et al., 2011; Ma et al., 2021; Maleki & Mosavi, 2021; Kiani Salmi et al., 2020; Hashempour et al., 2022). In informal contexts, empowerment is recognized as the most efficient organizing approach because, by relying on the internal assets and capacities of the community, it increases sustainability and sense of ownership of development projects (Beidi Gharaghyeh & Arbabi, 2022).

2.6. Spatial justice: The ultimate horizon of planning

Spatial justice is a theoretical framework emphasizing the equitable distribution of urban resources, services, and opportunities among different social groups and various urban areas (Soja, 2010). As a central concept in urban planning, spatial justice emphasizes the equitable distribution of basic needs, facilities, and urban services among different urban areas (Saeedi Monfared et al., 2020). This concept has two dimensions: Distributive justice (equality in access to facilities) and procedural justice (fairness in decision-making processes and the possibility of genuine participation for all) (Fainstein, 2010). Informal settlements are the tangible embodiment of spatial injustice. From this perspective, any development intervention in these contexts should lead to a reduction of these inequalities (Marnane & Greenop, 2023).

2.7. Integrated conceptual framework of the research: Linking concepts

Based on the above theoretical foundations, the conceptual framework of this research is based on the proposition that urban acupuncture can be positioned as an operational strategy within the macro framework of urban regeneration. The success of this strategy depends on designing interventions that simultaneously and dialectically achieve social empowerment of residents (through genuine participation and strengthening social capital) and enhance spatial justice (through a more equitable distribution of resources and improved access). These two goals reinforce each other: An empowered community can better demand justice, and justice-oriented interventions, in turn, increase the sense of empowerment and belonging. This triple linkage (regeneration-acupuncture, empowerment, spatial justice) fills the existing theoretical gap and provides a framework for analysis and action. (The redesigned conceptual model will schematically show this relationship.)

2.8. Research background: Gaps and the position of this study

A systematic review of previous studies on informal settlements and intervention approaches indicates a paradigmatic shift from macro-scale, physically-oriented solutions towards small-scale, community-based, and multi-dimensional strategies. In general, although extensive literature has separately addressed the concepts of urban regeneration, social empowerment, and spatial justice, and emphasized the importance of participatory and context-sensitive approaches, an operationally tested link between urban acupuncture as a micro executive strategy and the dual goals of empowerment and spatial justice in a single field study has been less realized. This gap is evident in both international and domestic research.

International studies on urban acupuncture can be traced along three main trajectories. First, the stream of theorization and conceptualization, which deals with the philosophical foundations and operational frameworks of this approach. For example, pioneering works like Lerner (2014) and Casagrande (2010) provided the theoretical justification for this approach by expanding the "city-as-organism" metaphor. Subsequently, studies such as Salman & Hussein

(2021) and Zarei (2021) systematically formulated its principles and implementation stages. The second stream focuses on methodology and objectifying the point selection process, attempting to move beyond pure intuition. In this direction, Tortosa et al. (2010) took steps to quantify and algorithmize the identification of "hotspots" by presenting a "neural network model," and Nassar (2021) by designing "filtering frameworks." The third and very important stream is the critical analysis and contextualization of the socio-political consequences of this approach. The critical study by Lo (2024) warned that urban acupuncture can be co-opted by power institutions and reduced to a tool for "isolated beautification" and a form of aesthetic governance, without addressing the structural issues of poverty and inequality. In contrast, studies like Carlotti (2024) and CASPRINI et al. (2026) emphasized the potential of this approach in strengthening social cohesion and stimulating local innovations in crisis-ridden contexts, which was also reflected in field works like Tousi et al. (2022) in Greece and Dikmak et al. (2024) in Beirut.

In comparison, domestic studies are mostly in the stage of introducing, adapting, and preliminary testing of this concept in Iranian contexts, often focusing on identifying intervention regions or explaining general principles (such as Roofi & Shieh, 2023; Sherafati et al., 2024) or explaining its general principles and mechanisms (such as Salavati et al., 2025). Innovations such as extending its application to the supra-urban scale and macro issues like climate change are also observed (Zarnegarzade Shirazi, 2024). However, a noticeable deficiency in most of these studies is the relative neglect of analyzing dimensions of power, institution, and political economy, which is addressed in the critical stream of international studies. On the other hand, in the domestic literature related to informal settlements, although the importance of social capital, sense of belonging, and perception of justice is emphasized, the focal point of these studies is often either solely on empowerment or presents spatial justice as a general theoretical framework, without testing a specific micro-scale executive strategy (like urban acupuncture) as a bridge between physical intervention and the realization of these social goals.

A comparative and critical examination of the above background reveals the main research gap of this study: The lack of an integrated and field-tested framework that simultaneously and systematically links urban acupuncture as a pragmatic strategy directly to both ultimate goals of social empowerment and the realization of spatial justice in the context of Iran's informal settlements, and evaluates the entire process from the participatory and scientific identification of points using multi-criteria decision-making tools (like AHP-TOPSIS), to the implementation of the micro-project, and then the assessment of its impacts on subjective (perception of justice, willingness to participate) and objective indicators. Furthermore, insufficient attention to the catalytic mechanisms of impact and institutional-political obstacles (emphasized in studies like Lo (2024)) when implementing such projects in the Iranian context is another gap that this research seeks to address. The contribution and innovation of this research lie in filling these gaps through the design, implementation, and validation of a neighborhood-based action model. In the conceptual model of this research, urban acupuncture is defined not as an end, but as a "transition channel" or "catalytic lever." This lever, by activating an impactful triad consisting of "targeted physical intervention + strengthening the perception of spatial justice + participatory empowerment process," ultimately acts to stimulate the dynamism of the entire neighborhood system and move towards sustainability. Therefore, this study, by combining a critical perspective (with awareness of limitations and the risk of co-optation) and a pragmatic one (by providing and testing a hybrid methodological model), aims to contribute to the theoretical and practical literature of organizing informal settlements in Iran.

2.9. Conceptual model of the research

The presented conceptual model outlines a systematic and multi-level framework for analysis and action in the context of informal settlements. This model begins by adopting the perspective of the "city as a living organism" or a complex adaptive system. Within this macro framework, informal settlements are considered not as isolated phenomena but as "disease nodes" or the tangible embodiment of spatial injustice and structural deprivation in the city's body. To address this disorder, sustainable urban regeneration is chosen as the overarching philosophy and macro intervention strategy. This comprehensive approach aims for simultaneous and balanced revitalization of physical, economic, and socio-cultural dimensions. However, the successful implementation of this macro strategy in complex informal contexts often faces practical

obstacles, including resource limitations, tenure complexity, and weak local institutions. To overcome this challenge, the present model proposes "urban acupuncture" as the operational and catalytic strategy within the regeneration framework. This strategy relies on small-scale, targeted, low-cost, and participatory interventions in "sensitive points" that have the highest potential to impact the entire local system.

The distinguishing feature of this model lies in detailing the systematic pathways of impact for this operational strategy. The model shows that urban acupuncture operates through three parallel and interconnected mechanisms: First, the physical-environmental mechanism, which provides the physical groundwork for justice by improving accessibility, enhancing quality of public spaces, and limited renewal; second, the social mechanism, which supplies the fuel and legitimacy for the intervention by stimulating genuine resident participation, strengthening social capital, and increasing the sense of place belonging; and third, the economic-institutional mechanism, which ensures the economic and institutional sustainability of the change by creating micro-employment opportunities, improving livelihoods, and strengthening local institutions. It is the interaction and synergy of these three mechanisms that create an "integrated catalytic effect" and exponentially expand the scope of the initial intervention's impact. The output of this catalytic process is the simultaneous achievement of two interconnected ultimate goals: Spatial justice and social empowerment. Spatial justice itself has two dimensions: Distributive (more equitable distribution of resources and access) and procedural (equal opportunity for participation in spatial decision-making processes). Social empowerment also encompasses political (increased agency and activism), economic (improved livelihood base), and social (increased collective capacity) dimensions. These two goals are in a dialectical relationship, each reinforcing and complementing the other. A more just experience of space increases the sense of empowerment and belonging, and conversely, an empowered community pursues and safeguards the realization of spatial justice.

Achieving these goals at the neighborhood scale leads to the restoration of dynamism and health to the urban system, manifested in indicators such as increased resilience to shocks, the realization of local sustainability, and the facilitation of endogenous development. This desirable outcome creates a positive feedback loop in the entire system, reinforcing corrective cycles. Finally, in line with the critical perspective of the reviewers, the present model, with full insight into the inherent limitations of this path, also enumerates the challenges and obstacles ahead. These include the risk of the approach being co-opted by power institutions and turned into superficial beautification operations ineffective on inequality structures, the existence of serious institutional-political obstacles, dependence of success on specific local leaders, and ultimately the risk of "islanding" successes without the ability to impact macro urban problems. The operational validity of the model depends on identifying, managing, and mitigating these limitations in the planning and execution process.

In summary, this conceptual model introduces urban acupuncture not as an isolated action but as an "intelligent transition channel" or "catalytic lever" that, by systematically activating physical, social, and economic mechanisms, builds an operational bridge between the macro ideals of regeneration and achieving the ultimate goals of justice and empowerment at the local scale. This framework provides both a roadmap for the present research and a model for urban planners and activists.

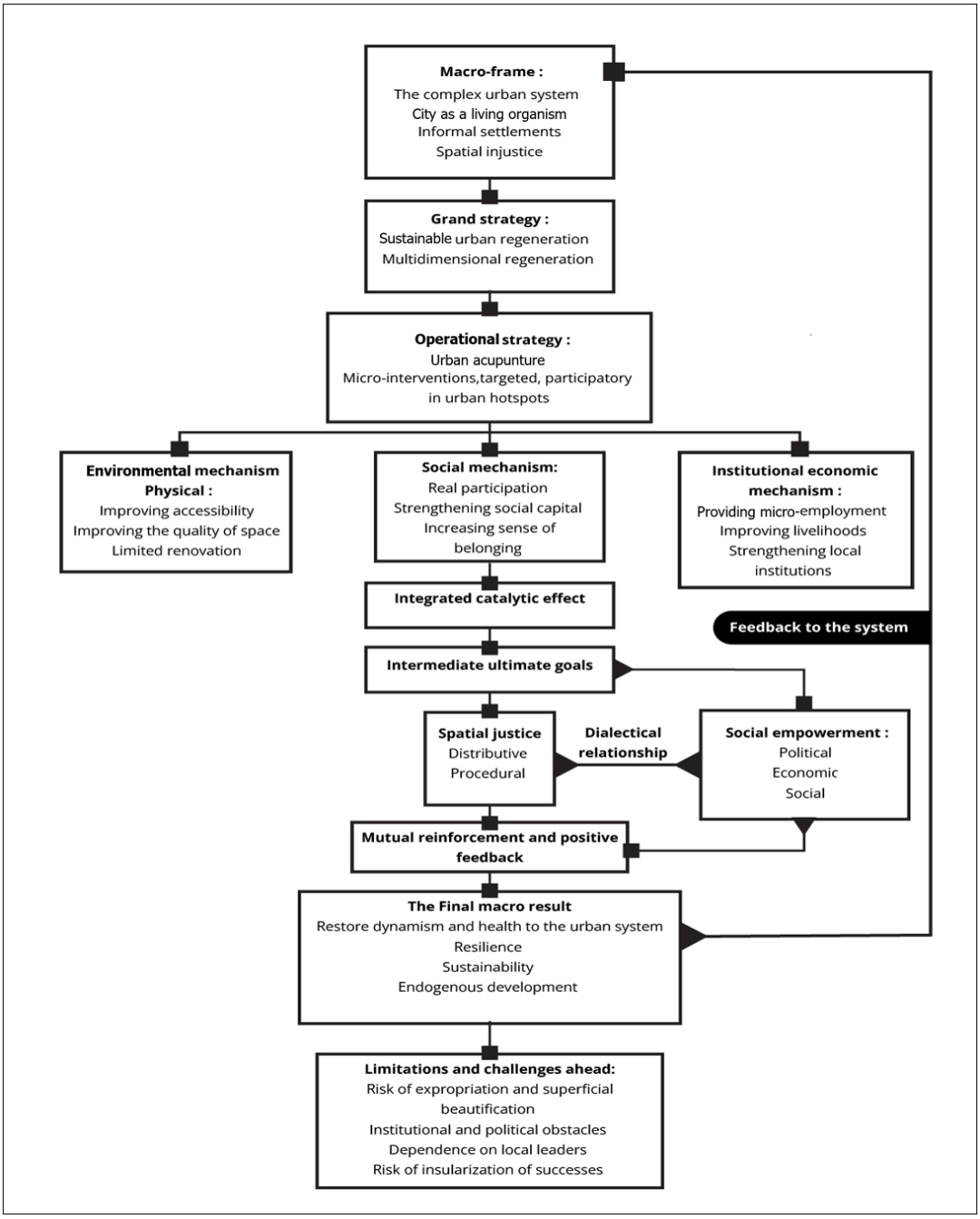

Figure 1. Conceptual model of the research

3. Materials and methods

This research is applied-developmental in purpose and descriptive-analytical in nature. Due to the complexity of the problem and the need to combine qualitative depth with quantitative generalizability, a sequential mixed-methods approach was used in three phases: 1) Qualitative phase (identification and prioritization of critical intervention points), 2) Quantitative phase (assessment of the current status of indicators), and 3) Qualitative phase (design and validation of interventions). The study population consisted of all residents of the Shahid Bahonar neighborhood in Mashhad (approximately 34,000 people) and urban specialists and experts, including planners, executive managers, university professors, and social facilitators. The sample size for the resident population was estimated using Cochran's formula, resulting in 375 individuals, selected via multi-stage cluster random sampling. The neighborhood was first divided into 8 homogeneous areas (clusters), then two residential blocks from each cluster and 25 households from each block were systematically selected.

Sampling of experts was performed using purposive-judgmental sampling based on the theoretical saturation criterion. Entry criteria included a minimum of 5 years of relevant professional experience, organizational affiliation with urban management institutions, universities, or active NGOs in the study domain, and willingness to participate in the interview. The interview process began with 15 individuals, and theoretical saturation appeared after the 18th interview, when no new themes or perspectives emerged. For further assurance, two additional interviews were conducted, and ultimately, data from all 20 interviews were analyzed.

For data collection, the triangulation method was employed: 1) Documentary studies (review of comprehensive and detailed plans); 2) Systematic field observation using a researcher-made checklist, which led to the initial identification of 7 critical points with the recording of geographical coordinates (GPS), photographs, and descriptions; 3) A researcher-made questionnaire for measuring quantitative indicators. All main indicators (spatial justice, social empowerment, social capital, and willingness to participate) were measured using a 5-point Likert scale (from 1=Very Low to 5=Very High). For transparency, a sample of key items for each indicator is provided in Table 2. The score for each indicator was calculated from the average of its related items; 4) Semi-structured interviews with 20 experts; and 5) Conducting two focus group sessions with 8 residents (using the snowball method) for participatory intervention design. The questionnaire's validity (face and content) was reviewed and revised based on feedback from 15 experts. Its reliability was confirmed by calculating Cronbach's alpha in a preliminary study (30 questionnaires) (α = 0.82). For qualitative data (interviews and focus groups), reliability was ensured through dual coding by two independent researchers and member checking. The thematic content analysis process was conducted using MAXQDA software (version 2020). To ensure qualitative reliability, after independent coding by two researchers, the inter-coder agreement was measured using Cohen's Kappa coefficient, the value of which (0.87) indicated strong agreement.

Data analysis was conducted along three main axes. In the qualitative analysis related to the first and third phases, interview and focus group data were analyzed using thematic content analysis; the stages of this analysis included data transcription, open coding, categorization of codes, and final extraction of themes, and a matrix of the extracted codes and themes was presented. For prioritizing critical points, a combination of two multi-criteria decision-making techniques, AHP and TOPSIS, was used. The criteria for point selection (including problem density, accessibility, and impact potential) were first extracted from the literature and initial qualitative analysis and then weighted using the AHP technique in Expert Choice software (the inconsistency ratio for all pairwise comparisons was less than 0.1). The operationalization and scoring of each point in these criteria were performed as follows:

Problem density: Based on the count and classification of problems recorded in the field checklist (e.g., waste, insecurity, deterioration) on a scale of 1 (lowest) to 5 (highest).

Accessibility: Based on distance from main routes and high-traffic passages, and the ease of access for residents on a scale of 1 (very difficult access) to 5 (very easy access).

Impact potential: Based on expert judgment (expert panel) regarding the point's potential to create positive chain changes in the surrounding fabric, on a scale of 1 (lowest potential) to 5 (highest potential).

This scoring was first performed by the researchers based on observations and secondary data and then reviewed and finalized in an expert session with 5 specialists.

In the next step, the 7 identified points were finally prioritized using the TOPSIS technique in Excel software. Analysis of quantitative questionnaire data in the second phase was performed using SPSS software. Before conducting parametric tests, the normality of data distribution was checked and confirmed using the Kolmogorov-Smirnov test. Subsequently, descriptive statistics, a one-sample T-test for assessing the status of indicators, a Pearson correlation coefficient for examining relationships between variables, and multiple linear regression for analyzing the influence of variables were used. Before running the regression, its assumptions, including the absence of autocorrelation (with the Durbin-Watson test: DW = 1.92) and the absence of multicollinearity (by examining the Variance Inflation Factor or VIF indicator – all VIF values were between 1.08 and 1.84, which is below the threshold of 5), were controlled and confirmed. Regarding ethical considerations, the principles of obtaining informed consent from participants, maintaining confidentiality of information, and reflecting the results to neighborhood residents were observed throughout the research process.

Table 2. Sample of key questionnaire items

Indicator (number of items)	Sample key items (based on a 5-point Likert scale: 1=Very Low to 5=Very High)
Physical-environmental empowerment (6 items)	1. The quality of streets and alleys in the neighborhood is satisfactory. 2. Lighting of streets and public spaces at night is sufficient. 3. The neighborhood has a satisfactory status in terms of cleanliness and hygienic waste disposal. 4. Access to basic urban services (water, electricity, telephone) in the neighborhood is good. 5. The safety and stability of residential buildings in the neighborhood are adequate. 6. Green spaces and recreational places accessible to residents exist.
Social empowerment (6 items)	7. In times of need, neighbors help each other. 8. I trust local institutions and leaders (neighborhood council, elders). 9. I feel a sense of belonging and attachment to the neighborhood. 10. If neighborhood improvement projects are implemented, I am willing to participate financially. 11. If neighborhood improvement projects are implemented, I am willing to participate intellectually and through labor. 12. People in the neighborhood cooperate to solve common problems.
Economic empowerment (4 items)	13. Construction and urban improvement projects in the neighborhood have created new job opportunities. 14. Economic activity and business prosperity in the neighborhood have increased in recent years. 15. My household income is sufficient to meet basic life needs. 16. Educational and skill-enhancement programs for improving the economic status of residents exist.
Spatial justice (4 items)	17. Public facilities and services are distributed fairly in the neighborhood. 18. Benefits from urban improvement and renovation projects are distributed equally among residents. 19. In decision-making processes related to the neighborhood, the opinions of all residents are considered. 20. Access to job and educational opportunities in the neighborhood is equal for all groups.

The metropolis of Mashhad, as the center of Razavi Khorasan Province and the second most populous city in the country, with a population exceeding 3,715,000 (Statistical Center of Iran, 2025), is a clear example of the informal settlement challenge. With 3,894 hectares of informal settlement area (equivalent to 10% of the city's area), it hosts about 30% of its urban population in these fabrics (Baghban & Minaei, 2023; Aghajani et al., 2024). Its national pilgrimage status and its position as the primary hub for absorbing migrants in the east of the country, from Sistan to North Khorasan, have significantly contributed to the rapid and unplanned growth of these settlements. Over the past three decades, the city's area has expanded about 11 times, and its population has more than doubled, with currently over one million people residing in these fabrics (Aghajani et al., 2024; Deputy of Planning and Human Capital Development, Mashhad Municipality, 2021). Region 6 of Mashhad, with over 70% informal settlement, is considered the main center of this phenomenon (Ghasemi & Gharaee, 2021). The present study was conducted in Shahid Bahonar Town (Ghal'eh Khiaban), located in District 4 of Region 6 in Mashhad. This town, with an area of 161 hectares and a population of 33,937 (Mashhad Statistical Yearbook, 2023), is situated at the eastern extremity of the Mashhad metropolis, adjacent to the Mashhad-Sarakhs axis (Konavist Road). The initial core of this settlement, known as "Khoderbig," was in the not-too-distant past recognized as endowed agricultural lands of the Astan Quds Razavi and a resting place for farm animals (Alikhani et al., 2022). Its main growth occurred in the 1970s, with its gradual transformation into a rural settlement, and following population increase and physical expansion, agricultural lands were converted to residential construction.

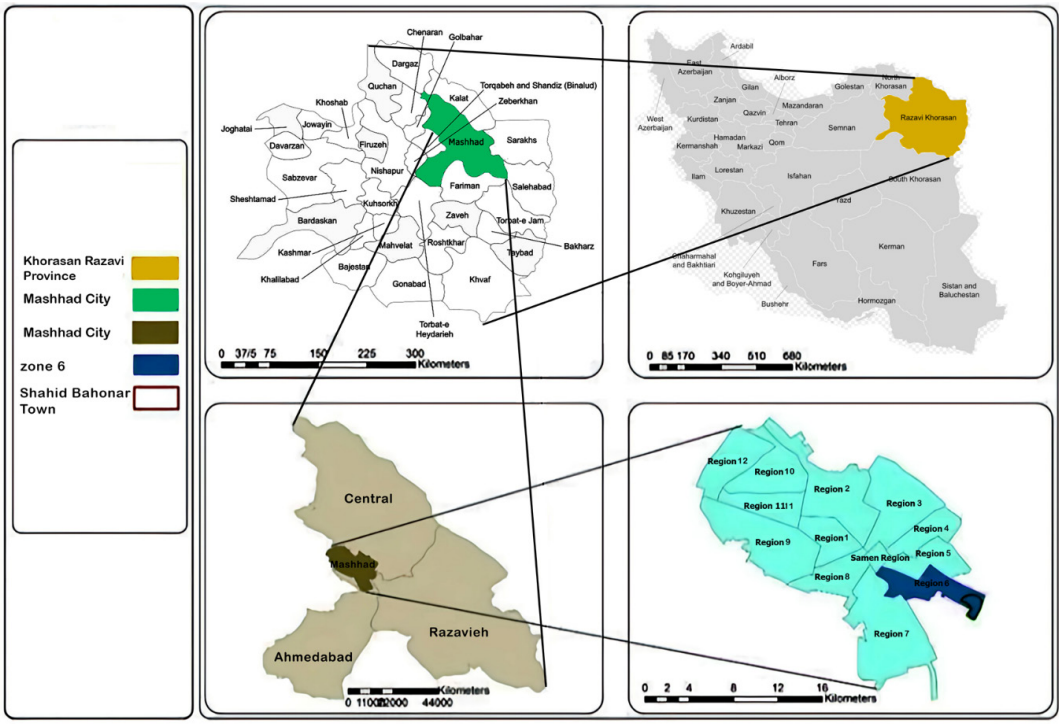

Figure 2. Political divisions of region 6 and Shahid Bahonar town in Mashhad

The mentioned area is bounded to the north by agricultural lands of Astan Quds Razavi, to the west by Shahid Rajaei Town, to the south by Toroq Town, and to the east by the Toroq Canal, Shariati Power Plant, and Sarakhs Road (Aliakbari et al., 2022). Until 2009, this fabric was known as one of the peripheral villages of Mashhad and, upon annexation to the city, was renamed “Shahid Bahonar Town.” Key characteristics of this fabric include high migrant acceptance (with the presence of various ethnic groups and Afghan immigrants), a weak economy, physical instability, severe shortage of urban services (such as clinics and libraries), and religious-cultural heterogeneity (Montazeri et al., 2020; Ghasemi & Gharaee, 2021). Nonetheless, potentials such as a rural background, the possibility of urban agriculture development, and tourism capabilities near Sarakhs Road, along with a considerable level of resident participation, provide the opportunity to employ local empowerment strategies.

4. Findings

Following the implementation of the research phases described in the previous section, this section presents the findings from all three phases of the study (point identification, quantitative and qualitative analyses). First, the results related to the identification and prioritization of critical intervention points based on field analyses and multi-criteria decision-making are presented, followed by the findings from the field survey and hypothesis testing. Based on systematic field observation using a researcher-made checklist, seven critical points in the Shahid Bahonar neighborhood were identified, along with their geographical coordinates, and assessed in terms of existing problems and intervention potential. These points are ranked based on the preliminary expert assessment in Table 3.

Table 3. Analysis and preliminary prioritization of intervention points in Shahid Bahonar neighborhood, Mashhad

Preliminary priority	Point	Coordinates	Description of current status and negative consequences	Intervention potential	Preliminary intervention idea (based on urban acupuncture)
1	4- Dilapidated building	36.2463, 59.7152	A haven for delinquency, creating a severe sense of insecurity	Very High	Security wall + creating a participatory garden
2	1- Dirt road	36.2478, 59.7156	Damage to vehicles, dust infiltration into houses	High	Cold asphalt for critical sections
3	2- Lack of lighting	36.2469, 59.7141	Nighttime insecurity, limitation of social activities	Very High	Installation of solar lights
4	7- Unused vacant land	36.2475, 59.7161	Undesirable gatherings, lack of social interaction	High	Participatory brainstorming for future use
5	5- Absence of trash bins	36.2481, 59.7143	Littering in passages, environmental pollution	High	Installation of bins designed by the youth
6	3- Open-air waste accumulation	36.2472, 59.7138	Pests, unpleasant odor	Medium	Creating a designed waste collection station
7	6- Narrow dead-end alley	36.2458, 59.7147	Feeling of suffocation, insecurity, and lack of emergency access	Medium	Wall painting + Artistic lighting

This preliminary ranking, based on field observations and expert judgment, indicated that the dilapidated building (Point 4) was the top priority due to creating a severe sense of insecurity and having very high potential for transformation into a positive public space. This preliminary assessment provided the necessary input for a more scientific analysis using multi-criteria decision-making techniques.

To move from subjective judgment to weighted evaluation, three main criteria for prioritizing points were extracted: Problem density (A), Accessibility (B), and Impact potential (C). The relative importance of these criteria was determined using the AHP technique through completing pairwise comparison matrices by five experts in urban planning and sociology. The varying perspectives of the experts are reflected in Table 4.

Table 4. Pairwise comparison matrix for each expert

Expert	Evaluation approach	Relative priority of criteria
1	Priority to problem density	A > C > B
2	Priority to impact	C > A > B
3	Balanced approach	A ≈ C > B
4	Priority to accessibility	B > A > C
5	Pragmatic approach	A > B ≈ C

This table clearly shows how the different perspectives of the experts influenced the evaluation of the criteria. For example, Expert 1, with a “Priority to problem density” approach, gave a higher score to problem density, while Expert 4, with a “Priority to accessibility” approach, placed more importance on accessibility.

After aggregating the opinions and calculations in Expert Choice software, the final weights and the inconsistency ratio (IR) were calculated. The overall inconsistency ratio of the matrices was 0.04, which is below the standard threshold (0.1), indicating consistent judgments. The final weights of the criteria are presented in Table 5.

Table 5. Calculation of final criteria weights

Criterion	Final weight	Interpretation
Problem density (A)	0.42	Most important criterion from the experts' viewpoint
Impact potential (C)	0.35	Second most important criterion
Accessibility (B)	0.23	Least important criterion

The AHP results indicate that, from the experts' perspective, focusing on points with high problem density (weight 0.42) is the top priority. This suggests that intervening in critical hotspots that impose the greatest burden of problems on the neighborhood can lead to faster and more tangible improvements. Impact potential also holds significant importance with a weight of 0.35, reflecting attention to the points' capacity to create catalytic and widespread changes post-intervention.

Using the weights obtained from AHP, the seven identified points were evaluated and finally ranked using the TOPSIS technique. Initial scoring of each point for each criterion (scale 1 to 5) was based on field checklists and expert assessment. The TOPSIS computational process was carried out in four steps (forming the decision matrix, weighted normalization, calculating ideal and anti-ideal solutions, and calculating the relative closeness indicator). The relative closeness indicator (Ci), which is a number between zero and one, indicates each point's proximity to the ideal condition. The final ranking results are presented in Table 6.

Table 6. Final ranking of intervention points

Final rank	Point	Final TOPSIS score	Intervention priority	Interpretation
1	1- Dirt road	0.67	Very High Priority	Highest proximity to the ideal solution
2	4- Dilapidated building	0.63	High Priority	
3	5- Absence of trash bins	0.63	High Priority	
4	2- Lack of lighting	0.57	Medium-High Priority	
5	7- Unused vacant land	0.47	Medium Priority	
6	3- Waste accumulation	0.39	Medium-Low Priority	
7	6- Narrow dead-end alley	0.11	Low Priority	Lowest proximity to the ideal solution

The final results from the TOPSIS technique show that Point 1, with a score of 0.67, ranks first in intervention priority. This point, having the highest relative closeness score, is identified as a point with "Very High Priority" for intervention. Points 4 and 5, with scores of 0.63, are in the "High Priority" category. This final ranking provides a scientific and documented basis for planning and implementing interventions in the neighborhood.

Comparative analysis and mechanism of effect: Comparing the final TOPSIS results (Table 6) with the initial qualitative ranking (Table 3) reveals an important change: the "Dirt road (point 1)" has surpassed the 'Dilapidated building" to become the top intervention priority. This change stems from the scientific weighting mechanism in TOPSIS. Given the high weight of the "Problem density" criterion (0.42), point 1, which scored highly on this criterion (5 out of 5) and also had a better status in the "Accessibility" criterion (with a weight of 0.23), could achieve a superior aggregate score. This highlights the importance of multi-criteria analysis because it shows that even if a point (like the dilapidated building) is very strong in one characteristic (impact potential), the density and daily accessibility to problems can be more decisive in the final prioritization. This result aligns with the views of the experts who prioritized problem density in the AHP and indicates that intervening in problems that directly and repeatedly affect residents' daily lives (such as damaged roads) can lead to a quicker increase in the perception of justice and satisfaction.

In the quantitative phase of the research, to accurately

measure the study indicators in the Shahid Bahonar neighborhood before any intervention, a researcher-made questionnaire was distributed among 375 residents. In the first step, the validity and reliability of the research instrument were examined, the results of which indicated the satisfactory quality of the questionnaire. The researcher-made questionnaire had acceptable content validity (CVI=0.89) and good reliability (α=0.87), confirming its capability for measuring the research variables. Demographic analysis of the 375 respondents shows that the sample was balanced in terms of gender (Male: 53.6%, Female: 46.4%) and was predominantly middle-aged in terms of age (49.9% in the 21-40 age range). Nearly half (48.5%) resided in the neighborhood for over 10 years, indicating relative population stability and the potential for rooted social capital. The education level was predominantly high school diploma or lower (60.3%), and home ownership was mainly through property deed (73.1%), providing a picture of a local community with relative ties but limited educational and economic levels. The mean of the main indicators on a scale of 1 to 5 provides an illustrative picture of the neighborhood's status (Table 7).

Table 7. Status of main research indicators in Shahid Bahonar neighborhood

Indicator	Number of items	Mean	Standard deviation	Relative status	Key points
Physical-environmental empowerment	6	2.45	0.72	Unsatisfactory	Acute problems: Road quality (2.10), lighting (2.15), and cleanliness (2.20) Relative strength: Access to basic services (4.25)
Social empowerment	6	3.65	0.68	Relatively satisfactory	Strengths: Mutual neighborly help (4.10), sense of belonging (3.80), and willingness to participate (3.70) Weakness: Trust in local institutions (2.40)
Economic empowerment	4	2.15	0.74	Very unsatisfactory	All components (job creation, business prosperity, and income adequacy) at low levels
Spatial justice	4	2.30	0.70	Unsatisfactory	Lowest score related to "equitable distribution of improvement benefits" (1.90), very intense perception of injustice in benefit distribution
Overall questionnaire mean	20	2.64	0.58	Unsatisfactory	-

The aggregate results of the research indicators show that the social indicator, with a mean of 3.65, received the highest score, suggesting the existence of relatively favorable social capital in the neighborhood. In contrast, the economic and spatial justice indicators, with means of 2.15 and 2.30, respectively, received the lowest scores, indicating structural problems in these areas. The physical-environmental indicator, with a mean of 2.45, also shows an unsatisfactory status, confirming the findings of the previous qualitative phase. In the fourth step and for deeper data analysis, various inferential tests, including a one-sample T-test, correlation analysis, and multiple regression, were performed.

Table 8. Results of the one-sample T-Test for main indicators

Indicator	Mean	Std. deviation	t-value	df	Significance (p-value)	Result
Physical-environmental	2.45	0.72	-15.27	374	0.001	Significant - Unsatisfactory status
Social	3.65	0.68	9.42	374	0.001	Significant - Satisfactory status
Economic	2.15	0.74	-21.62	374	0.001	Significant - Unsatisfactory status
Spatial justice	2.30	0.70	-18.75	374	0.001	Significant - Unsatisfactory status
Overall mean	2.64	0.58	-11.72	374	0.001	Significant - Unsatisfactory status

The results of the one-sample T-test, conducted assuming a midpoint of average (μ=3), show that all indicators except the social indicator were significantly below the average. The social indicator, with a positive

t-value (9.42) and a significance level of 0.001, shows a more favorable status compared to the other indicators. These findings reveal a key apparent paradox: The Shahid Bahonar neighborhood has relatively strong social capital and willingness to participate, but this social potential exists within a context of severe physical deprivation, economic hardship, and a perception of injustice.

Pearson correlation analysis (Table 9) and multiple regression reveal systematic relationships between the indicators and pathways of influence.

Table 9. Correlation matrix and summary of regression analysis for predicting spatial justice

Relationship between indicators	Correlation coefficient (r)	Significance level	Strength and interpretation
Physical-environmental ↔ spatial justice	0.73	0.001	Strong and positive; Strongest relationship in the model
Physical-environmental ↔ economic	0.68	0.001	Moderately positive; Physical improvement accompanies economic improvement.
Economic ↔ spatial justice	0.61	0.001	Moderately positive
Social ↔ other indicators	0.28 to 0.42	0.001	Weak to moderately positive; Social capital is the foundation, but is not sufficient alone.

Pearson correlation analysis shows that all indicators have a positive and significant relationship with each other. The strongest relationship was observed between the physical-environmental and spatial justice indicators, with a correlation coefficient of 0.73, highlighting a close connection between these two indicators. This suggests that improving physical-environmental conditions can directly influence the realization of spatial justice in the neighborhood. To determine the contribution of each indicator in explaining the perception of spatial justice, a multiple regression analysis was performed (Table 10).

Table 10. Results of multiple regression analysis for predicting spatial justice

Variable	Regression coefficient (β)	Standard error	t-value	significance level
Constant	0.45	0.12	3.75	0.001
Physical-environmental	0.52	0.08	6.50	0.001
Social	0.15	0.06	2.50	0.013
Economic	0.23	0.07	3.29	0.001
Model summary				
Coefficient of determination (R^2)	0.62			
Adjusted R^2	0.61			
F Statistic	85.34			
Significance of F	0.001			

Multiple regression analysis was conducted to predict spatial justice based on physical-environmental, social, and economic indicators. As observed in Table 10, the final model had a very good fit and was significantly capable of predicting spatial justice ($R^2 = 0.62$, $F=85.34$, $p<0.001$), meaning that 62% of the variation in the spatial justice indicator could be explained by the other three indicators. The final standardized coefficients show that the physical-environmental indicator was the strongest predictor of spatial justice.

The regression equation is as follows: Spatial Justice = 0.45 + 0.52(Physical-Environmental) + 0.23(Economic) + 0.15(Social)

Interpretation of the mechanism of effect: The regression analysis clearly shows that the physical-environmental indicator (β=0.52) is the strongest predictor of spatial justice. This finding is important from two perspectives:

1. Theoretical: It supports theories emphasizing the material and physical dimension of justice (especially

in severely deprived contexts). Tangible and daily physical improvements (roads, lighting, and cleanliness) have the greatest impact on residents' perception of fairness and benefit.

2. Functional (policy): For planners and executives, this result provides a pragmatic strategy. Targeted physical-environmental interventions (urban acupuncture) not only improve the physical condition but also represent the most direct and efficient path to increase the perception of justice and, consequently, create a foundation of trust for subsequent participatory initiatives. Although social and economic indicators are effective, they have a more subdued effect at this stage.

Summary of the quantitative phase: The quantitative findings confirm the necessity of adopting a "gradual empowerment approach with a physical starting point." The neighborhood possesses the necessary social potential to accept participatory interventions, but this participation must be organized around solving tangible and objective physical problems to both improve living conditions and strengthen the positive cycle of empowerment by increasing the perception of justice.

In the final phase, through conducting focus group sessions, residents' ideas for the three priority points (Points 1, 2, and 4) were gathered and incorporated into the intervention designs. Analysis of these sessions revealed a practical and realistic willingness to participate (ranging from relative financial contribution to providing labor). Accordingly, three intervention options were designed for each point, spanning a range of social, functional, and artistic uses (such as a participatory garden, children's creativity house, cold asphalt combined with local art, and artistic solar lights). The designed options were validated by 10 experts using the Delphi method in terms of feasibility, cost-effectiveness, sustainability, and participatory potential. The results (Table 11) led to the selection of one superior option for each point, which had the highest total score and the best profile.

Table 11. Final selected options for urban acupuncture interventions and reasons for selection

Critical point	Selected option	Total score (out of 5)	Key strengths and selection rationale
4- Dilapidated building	Therapeutic participatory garden	4.45	- Highest participatory potential (4.8): Maximally engaging women and families - Direct psycho-social effects: Reducing insecurity and creating local pride - Potential for gradual expansion and modeling
1- Dirt road	Cold asphalt + local art	4.35	- Quick and low-cost implementation - Functional and identity-building fusion: Improving access + strengthening sense of belonging through local symbols - Divisible into small phases
2- Lack of lighting	Artistic solar lights	4.45	- Highest feasibility (4.6): Independent from the power grid and quick installation - Safety and identity-building: Increasing nighttime security + creating a visual symbol for the neighborhood

For the implementation of the selected interventions, a detailed and operational execution roadmap was developed, based on which the projects will be implemented in four separate phases, with the active participation of residents and related institutions. This roadmap was designed to respond to the objective needs of the neighborhood and create maximum effectiveness. Details of phasing, scheduling, responsibilities, and resource estimates are provided in Tables 12 and 13.

Table 12. Detailed execution roadmap and institutional mechanism

Phase	Key Activities	Duration (Weeks)	Main Responsible	Collaborating Institutions and Their Roles	Deliverable Outputs
Phase 1: Preparation & empowerment	Signing a social contract and a memorandum of understanding Holding awareness workshops and teaching simple skills for residents Obtaining technical and administrative permits Preliminary resource mobilization	3	Neighborhood Dispute Resolution Council (as community intermediary)	Mashhad Region Municipality: Issuing permits, supplying part of the basic material Housing Foundation of the Islamic Revolution: Technical support and feasibility Local NGO: Facilitation and training	Signed MoU Established community execution teams Necessary permits obtained 30% of initial financial resources secured
Phase 2: Pilot execution (point 2)	Purchase, construction, and installation of 20 designed solar lights Holding a local festival for participatory installation and naming Training maintenance for volunteer teams	4	Neighborhood Youth Committee (under the supervision of Neighborhood Council)	Regional Electric Company: Technical supervision of installation Ferdowsi University of Mashhad (Design Group): Artistic consultation Residents: Volunteer labor and protection	20 artistic solar lights installed and operational Noticeable increase in nighttime security on the passage New visual symbol created for the neighborhood
Phase 3: Main Project Execution (point 1)	Site preparation and cold asphalt for the road Execution of mural and local paintings with participation of artists and residents Installation of neighborhood identification elements	5	Local Micro-Contractor (under supervision of Neighborhood Council)	Local elders and trusted figures: Resolving potential disputes Local artists: Design and execution of artworks Men of the neighborhood: Participation in physical work	350 meters of dirt road improved Visual identity and sense of belonging strengthened Resident access facilitated
Phase 4: Completion & institutionalization (point 4)	Wall construction and securing the dilapidated building Establishing 10 therapeutic participatory gardens Setting up a drip irrigation system 4. Establishing a women's cooperative for garden management	8	Neighborhood Women's Committee	Department of Environment: Supplying saplings and cultivation consultation Agriculture Jihad: Training in urban agriculture Resident families: Utilization and maintenance	Insecure space transformed into a participatory garden Creation of a small income source for women Local institution for green space management established

Table 13. Cost estimate and required resources

Project	Total estimated cost (million Tomans)	Financing model (percentage)	Explanation
Artistic solar lights (pilot)	150	Municipality (50%) + public participation (30% cash/in-kind) + private sector support (20%)	Low cost; immediate and observable effect; best option for starting and building trust
Cold asphalt + local art	320	Housing Foundation (40%) + Municipality (30%) + resident participation (30% as labor)	Relatively high cost but reducible through role division and the use of local labor
Therapeutic participatory garden	120	Department of Environment (30%) + family participation (50% cash/in-kind) + charitable aid (20%)	Cost mainly for initial materials; labor and maintenance are fully participatory

Emphasis on pilot implementation: Due to the limitations of the research, practical execution of the projects during the study was not feasible. However, implementing the pilot project "Artistic solar lights" is seriously recommended. This project, due to its relatively low cost (150 million Tomans), short execution time (4 weeks), immediate and tangible effect (security), and simplicity of participation, is the best option for initiating the process, testing the designed participatory mechanisms, and creating the necessary social capital for larger subsequent projects. For evaluating the effects of the interventions, multiple quantitative and qualitative indicators are considered. We suggest the final evaluation be conducted as a quasi-experimental design with a control group at two time intervals: 6 months and one year after project completion, by the Provincial Management and Planning Organization. These indicators are presented in Table 14.

Table 14. Monitoring and evaluation indicators

Indicator	Measurement method	Measurement time	Goal
Physical-environmental	Standardized questionnaire	Before, during, after	35% improvement in score
Sense of security	Local survey	Monthly	50% increase
Social participation	Attendance registration	Weekly	Participation of 60% of households
Satisfaction	Qualitative interview	End of each phase	80% satisfaction

Testing research hypotheses

The quantitative and qualitative findings collectively confirmed all four research hypotheses (Table 15).

Table 15. Summary of research hypothesis testing results

Hypothesis	Hypothesis statement	Test method	Result and key finding
1	There is a positive and significant relationship between physical-environmental status and spatial justice in informal settlements	Pearson Correlation & Regression	Confirmed; strongest relationship (r=0.73); physical indicator, the strongest predictor of justice (β=0.52)
2	The combined AHP-TOPSIS model is suitable for prioritizing intervention points in informal settlements	Multi-Criteria Decision Analysis	Confirmed; logical weights (Density: 0.42); different and evidence-based prioritization (priority of point 1 over 4)
3	Social capital positively affects the willingness to participate in local projects	Pearson Correlation	Confirmed; positive and significant relationship (r=0.55); the necessary context is provided with relative social capital
4	There is a significant relationship between the density of physical-environmental problems and the level of economic deprivation	Pearson Correlation	Confirmed; strong and bidirectional relationship (r=0.68); emphasis on the structural linkage of deprivations

Final summary of findings: The present research, by combining quantitative and qualitative methods, succeeded in: 1) Using a combined AHP-TOPSIS model to prioritize intervention points not based on intuition but on scientifically weighted criteria; 2) revealing the paradoxical status of the neighborhood: relatively strong social capital and willingness to participate within a context of severe physical-economic deprivation and a deep perception of injustice; 3) demonstrating that in such a context, the physical pathway is the most direct and effective lever for increasing the perception of justice and creating initial trust; and 4) designing and validating feasible, low-cost, and implementable participatory operational plans for the three priority points. These findings complete the theoretical-practical action cycle proposed in the conceptual model: Scientific point identification → Analysis of current status → Participatory design of physical-social interventions → Provision of an execution roadmap. This cycle offers a practical solution to the primary research question of how to apply urban acupuncture for empowerment and spatial justice.

5. Discussion and conclusion

5.1. Discussion

This section analyzes and interprets the findings within the theoretical framework of the study, primarily to compare the obtained results with the existing literature, explain potential causes, and extract their theoretical and practical implications for the planning and management of informal settlements. The findings of this research demonstrate the efficacy of a systematic framework for applying urban acupuncture in empowering the Shahid Bahonar informal settlement.

- Priority of the physical pathway: Explaining a key mechanism for spatial justice

One of the most prominent findings of this study is the existence of a strong structural relationship between physical-environmental indicators and the perception of spatial justice (r = 0.73). In the regression model, the physical-environmental indicator also has the highest standardized coefficient (β = 0.52), meaning that among the variables entered into the model, this indicator is the strongest predictor (though not necessarily the cause) of spatial justice. This result highlights the material and immediate dimension of justice in highly deprived contexts. While studies such as Casperini et al. (2026), in contexts with relatively established infrastructure, emphasize social innovation as a driver of justice, the present finding indicates that in contexts like Shahid Bahonar, which face tangible basic deficiencies (damaged pathways, lack of lighting), targeted physical interventions represent the most direct and effective pathway associated with increasing the perception of fairness and a more equitable distribution of amenities. This finding localizes the spatial justice theories of Harvey (2008) and Soja (2010) within the context of developing societies, demonstrating that the "right to the city" for residents of these neighborhoods begins, first and foremost, with the right to access basic services and a healthy physical environment.

- Objectifying point selection: Addressing a methodological demand

The successful application of the combined AHP-TOPSIS model in prioritizing points is a step towards objectifying a process often reliant on intuition. The weighting of criteria (problem density: 0.42, impact potential: 0.35, accessibility: 0.23) not only makes the selections transparent but also reveals the inherent priority of planners and experts for solving "Tangible and recurring problems" (problem density) over "Future-oriented potentials." This finding, on one hand, aligns with Lou's (2024) warning about the necessity of moving beyond the realm of subjective beautification and relying on objective criteria. On the other hand, it addresses the existing methodological gap in domestic studies (e.g., Roufi & Shia, 1401 [2022]), which often lack such weighting mechanisms. However, the advantage of this model compared to more complex ones like the "Neural Network Model" of Tortosa et al. (2010) lies in its simplicity, comprehensibility for non-expert stakeholders, and compatibility with conditions of limited data in the Iranian context.

- Analyzing a paradox: Strong social capital in a context of deprivation

The confirmation of a positive relationship between social capital and willingness to participate (r = 0.55) and its relatively high average score (3.65), alongside severe physical-economic deprivation, reveals an apparent paradox. This situation may indicate the existence of "survival-oriented" social capital, where, in response to harsh conditions, networks of mutual aid and in-group trust are strengthened to facilitate adaptation and resilience. In contrast, "progress-oriented" social capital, necessary for creating structural change, depends on vertical trust in institutions and access to external resources. The low score for "Trust in local institutions" (2.40) supports this interpretation. Therefore, successful interventions must be able to identify this existing social capital and guide it from a passive-adaptive state towards an active-change-making one.

- A note on causal relationship and the limitation of cross-sectional data

As mentioned earlier, although the physical-environmental indicator appeared as the strongest predictor of spatial justice in the regression model, the cross-sectional nature of this study does not allow for definitive inference of a causal relationship (causality). While theoretically, physical improvement can lead to increased perception of spatial justice, the reverse relationship or the existence of a common third factor (such as macro-urban policymaking or the level of regional development) that influences both the physical condition and the perception of justice is also plausible. This consideration highlights the necessity for longitudinal studies and experimental research designs to more precisely discover and confirm the direction and mechanisms of causality.

- Inherent challenges of the urban acupuncture approach: Beyond partial successes

Although this research demonstrates the positive potential of the approach, the findings also highlight its inherent limitations, which are addressed in studies such as Lou (2024). They include:

1. Risk of appropriation and superficial beautification: Interventions such as "cold asphalt + local art," if merely reduced to changing the appearance of pathways and do not address structural issues, like tenure security or employment, are at risk of being appropriated by power institutions for demonstrative purposes. The participatory model and justice-oriented criteria of this research (such as prioritizing "problem density") steer clear of such risks by placing the real needs of the community at the center.
2. Risk of insularity: The success of micro-projects at three points does not necessarily mean the transformation of the entire neighborhood. Without linking these points to a comprehensive regeneration plan and a strong local governance system, these successes may remain as islands of prosperity in a sea of deprivation.
3. Dependence on local leaders and instability: The implementation of projects often depends on the motivation and effort of a few local community leaders. The lack of institutionalized mechanisms for continuity can endanger the entire project upon their departure.
4. Inability to solve macro structural issues: The urban acupuncture approach, by design, cannot solve macro issues such as the land market, macro housing policies, or regional inequalities, which are the root causes of informal settlement problems. Its role is primarily catalytic and facilitative at the local level.

- Proposed model and general framework for applying urban acupuncture in informal settlements

Based on the findings of this research, a general three-stage framework for the targeted application of urban acupuncture in other informal settlements is proposed: 1) Scientific identification of critical points: Using a combination of qualitative (observation, interview) and quantitative methods (such as AHP-TOPSIS) with combined criteria of problem density, catalytic impact potential, and accessibility for prioritization; 2) Context and goal assessment: Simultaneous evaluation of social capital (as the context for participation) and spatial justice indicators (as the ultimate goal) through a neighborhood survey, for designing context-aware interventions; and 3) Participatory design, implementation, and monitoring: Designing low-cost, multi-functional interventions with active resident participation, and establishing a combined (quantitative-qualitative) monitoring system to track the chain effects of the project on physical, social, and perceived justice indicators. This framework has the necessary flexibility to adapt to the specific conditions of each neighborhood.

5.2. Conclusion

This research showed that urban acupuncture, when placed within a scientific-participatory model framework, can act as a catalytic and pragmatic strategy for initiating the process of empowerment and pursuit of justice in informal settlements. The innovative core of this model is the effective integration of the triad: "scientific identification of points (AHP-TOPSIS) + targeted physical-social intervention + spatial justice-based evaluation," which closes the loop between theory and practice. While specifying the cross-sectional nature of the data, the findings indicate a strong structural association and an effective predictive pathway: improvement of physical-environmental conditions is the strongest factor associated with increased perception of spatial justice in this deprived context. This finding clarifies the priority pathway for practical action, although definitive determination of the causal relationship requires future longitudinal research.

The main point is that in contexts with multi-dimensional deprivation but relative social capital (like Shahid Bahonar neighborhood), the optimal starting point is small-scale, quickly achievable, and participatory physical interventions. These interventions, by tangibly improving quality of life, simultaneously advance two goals: strengthening the perception of justice and consolidating social capital through the participatory process. This positive cycle provides the necessary foundation of trust and institutional capacity for accepting more complex socio-economic interventions in subsequent stages.

This research moved beyond the stage of theoretical design by presenting a detailed action plan (including phasing, scheduling, cost estimation, and clear allocation of institutional-community responsibilities). Accordingly, the immediate and feasible practical step for policymakers and implementers is to execute the pilot project "Artistic solar lights." This project, with a relatively low cost (approximately 150 million Tomans), short implementation time (about 4 weeks), and immediate impact on neighborhood safety and

symbolism, provides the best opportunity for practically testing the proposed participatory framework, building initial trust, and creating a tangible model for attracting broader resources. The success of this pilot will be a practical validation of the efficacy of the urban acupuncture strategy in Iranian contexts.

The limitations of the research include its cross-sectional nature, focus on a specific neighborhood, partial dependence of data on self-reporting, and the inability to practically implement interventions within the timeframe of this study. Additionally, insufficient analysis of institutional-political obstacles and the role of power conflicts in the participatory process is considered a limitation of this study.

For future research, it is suggested: 1) Longitudinal studies to assess the sustainability of urban acupuncture project effects (especially after pilot implementation); 2) ethnographic research for deeper analysis of decision-making processes, conflicts, and power dynamics during participatory implementation; 3) comparative international studies to compare the application of this approach in contexts with different governance systems; and 4) integration of environmental impact assessment indicators in project evaluation.

Finally, as a framework for generalization, the proposed model of this research for applying urban acupuncture in other informal settlements can be summarized in three key steps: 1) Identifying critical points with combined criteria of problem density/impact/accessibility; 2) quantitatively assessing social capital and justice indicators as context and goal; and 3) designing and implementing low-cost participatory interventions based on a transparent operational roadmap with the capability to monitor chain effects. Urban acupuncture is not a "miracle," but an intelligent participatory planning tool. Its success depends on collective wisdom in point selection, institutional honesty in dividing responsibilities and resources, and sustained accompaniment with the local community from the design stage to long-term monitoring.

Authors' Contributions

All authors contributed to the preparation and development of the article. The share of contribution is as follows: First author: Study design, data collection, analysis, and drafting the manuscript (70%). Second author: Reviewing and editing scientific content and final review (30%).

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Conflict of Interest

According to the authors' statements, there is no conflict of interest related to this article.

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