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**Original Article**

# Development of Impactful Scenarios for Smart Village Approaches on the Sustainability of Peri-Urban Settlements of the Metropolis of Tehran (Case Study: Villages of Islamshahr County)

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## Abstract

**Purpose-** The "Smart Village" approach includes long-term social, economic, and environmental activities of the rural community that involve widespread participation in local governance processes, promoting entrepreneurship, preserving the rural environment and, ultimately, sustainable development of rural areas. Therefore, the development of scenarios that facilitate the realization of the smart village approach in the peri-urban settlements of the metropolis of Tehran should be emphasized.

**Design/methodology/approach-**This research is a descriptive-analytical study from the perspective of its objectives it is applied. Data and information were collected through library research, documentary studies, and survey methods (interviews). By reviewing scientific sources and conducting interviews with experts, 57 influencing factors of the smart village approach on the sustainability of peri-urban settlements were identified, categorized into 5 dimensions, and a total of 35 people, including managers of relevant organizations and university experts, were interviewed. The analysis of data was based on futures studies techniques, including structural analysis and mutual effects analysis (done using Micmac and Scenario Wizard software).

**Finding-** The research findings show that there are a very large number of possible scenarios for the impact of the smart village on the sustainability of peri-urban settlements in the metropolis of Tehran within the range of Islamshahr County. Among them, 14 scenarios have weak compatibility and only 1 scenario is in a state of strong and sustainable compatibility (zero incompatibility). The first scenario, which is a positive one, has a mutual effect score of 733 and a compatibility value of 13, while the second scenario, which indicates unfavorable conditions for the future impact of the smart village on sustainable development, has a mutual effect score of -144 and a compatibility value of 5. The third scenario also has a compatibility value of -2 and with a mutual effect score of 63, it can be one of the impactful scenarios for the smart village on the sustainability of peri-urban settlements in the metropolis of Tehran. At the end of the research, operational suggestions are presented to enhance the indices of a smart village to achieve sustainable development in the rural settlements of the studied area.

**Originality/Value -** For the first time in Iran, scenarios have been developed on the impact of smart villages on the sustainability of peri-urban settlements, and from this perspective, it is innovative and among the first research in the field.

**Keywords -** Futures studies, Key drivers, Smart village, Peri-urban settlements, Scenario writing.

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## 1. Introduction

The development of rural areas involves organizational processes that are a response to growing social and economic inequalities, spatial inequalities, backwardness, poverty, social exclusion, etc. (Somwanshi et al., 2016) based on the concept of endogenous development, the development of rural areas is based on institutional capacity building to ensure the mobilization of internal resources and recovery of external forces. Building partnerships requires that everyone involved in the building process embrace empathy and equal participation. Strategies and methods for deeper community involvement are needed to address these issues (Guinjoan et al., 2019). The concept of intelligent development and subsequent smart city has been proposed globally as a possible and practical answer to the challenges resulting from increasing urbanization (Arbab & Fasihi, 2019). It should be noted that we are now at the beginning of a revolution (the fourth industrial revolution) that affects the way of life, work, and everything related to these two, and is based on the digital revolution (Ahlawat, 2017). In fact, intelligentization is not a new concept (Anabastani & Javanshiri, 2015) and it varies from one region to another (Gerli & et al, 2022). Through the use of advanced technologies of information and communication technology, the intelligentization of all aspects of life, including activities, transportation, etc., and due to its various dimensions, it includes various economic, social, physical, and environmental benefits (Kamal et al., 2016)

The smart village provides long-term social, economic and welfare and environmental activities for the village community, which enables widespread participation in local governance processes and promotes entrepreneurship. At the same time, a "smart village" benefits from proper health facilities, proper education, better infrastructure, clean drinking water, sanitary facilities, environmental protection, resource efficiency, waste management, renewable energy, etc. In fact, technology acts as a facilitator to develop, empower and increase local job opportunities. It can also improve health and well-being and strengthen the interactions of village residents (Sutriadi, 2018). Smart village, self-sufficient rural, and spiritual empowerment of human resources (especially rural youth) through the use of available resources and appropriate rural technologies, leading to the promotion of decentralized management and employment creation with the help of governmental and non-governmental organizations. This framework can be implemented in all villages. By improving water availability, cropping patterns, livestock management and local employment prospects should be adapted to conserve natural resources (Ramachandra et al, 2015). Smart villages are made up of rural people who take the initiative to discover practical solutions to solve fundamental challenges and gain new opportunities. Rural communities do this in a variety of ways. Many of them use new digital technologies; But this is only one of the tools available. There are also many social innovations in rural services, new relationships with urban areas, and activities that enhance the role of villages in transitioning to a greener, healthier, and healthier society. It has proven itself to benefit mankind in various fields. The focus of smart villages should be based on the advantages/problems/challenges of different types of villages and provide targeted solutions for them. As some researchers have stated in their research, smart village research should be considered more from the perspective of problem solving. Problem solving seeks to identify problems in rural areas and provide a way to circumvent them by referring to ICT1 (Visvizi & D Lytras, 2018).

The combination of the two concepts of development and sustainability formed a new theory that caused a change of attitude in many programs and behavior of governments and people, both at the micro level and at the global level, (Hall et al., 2000) on the one hand, the need for improvement and Progress in any society is sustainable development as a process. The process that is the basis of the improvement of the situation and is considered to be the mediator of the socio-cultural shortcomings of the advanced societies, therefore it should be the driving engine of balanced, proportional and harmonious economic and cultural progress of all societies, especially developing countries. (Beg, 2018). Sustainable development is building the future based on the

1 Information and communication technology

current state of the land, identity, needs, resources, and opportunities. Creating any development plan should always be based on acknowledging who we are and where we come from, even if the present or the near future is unclear. not clear Sustainable development requires looking into the future, and in order to do so, it is necessary to use the tools that allow us to approach it. While technological advances have transformed urban areas, rural communities often struggle to keep up with the digital revolution. Bridging this gap is critical to ensuring equal access to educational resources, health care services, and economic opportunities.

Preoccupation with the present and trying to solve existing problems prevents managers and decision-makers from thinking about the future. However, current problems are the most important reason to think about the future. It goes without saying that today's crises are the forced result of not addressing the obstacles and problems before they appear in the form of a crisis. Another factor that makes addressing the future inevitable is the speed of evolution in this environment full of change, instability, and uncertainties, and the only approach and policy that is likely to achieve more success is the architecture of the future (Anabestani et al., 2023). In fact, future research allows decision makers to solve ambiguous problems by focusing on key drivers in the decision-making process about issues with high complexity and high uncertainties come. Futuristic research is the knowledge that opens the eyes of the people of the city and society to possible future events, opportunities and challenges, and by reducing the ambiguity and corrosive doubts, increases the ability of people and society to make smart choices and allows everyone to know that Where can they go or where should they go? (Ziari & Ehsanifard, 2022). The goals and applications of future research could include understanding and addressing the emerging issues of human society, as well as developing long-term and short-term plans to prevent the harmful consequences of unforeseen events. The preparation and regulation of rules and frameworks for future developments and research on the growth of technology and its use in the future have been mentioned (Abtahi et al., 2011).

In the peri-urban rural areas of Iran, due to their unique conditions and geographical location, it has led to the creation of both capabilities and obstacles. In fact, it can be stated that the unplanned growth of the population of peri-urban villages, the unplanned physical expansion of rural settlements, and the indiscriminate use of the rural environment in recent decades have caused challenges such as land use and social security issues. Additionally, population growth, agricultural natural hazards, unstable policies, and poor decision-making have had significant effects on the sustainable development of villages in the study area (Heydarpour et al., 2019). The statistics of illegal rural-urban migrations and the problems that migrants bring with them to their migration destinations highlight the consequences of neglecting villages, which are the main challenges facing managers and planners. Therefore, studying the development and sustainability of villages, particularly peri-urban settlements, requires more in-depth and comprehensive research. The smart village approach has the potential to provide a solution to the instability facing peri-urban settlements.

Islamshahr County in the near of Tehran metropolis has been a destination for many immigrants from near and far due to its relatively affordable housing and short distance from the capital, combined with a high population growth rate. However, there is a limited number of studies on the smart village approach in this field, and future research should aim to explore the effective scenarios of this approach on the sustainability of peri-urban settlements in Tehran metropolis by 2033 (the horizon of the research). In conclusion, the research question for future research is: What are the scenarios for the impact of the smart village approach on the sustainability of peri-urban rural settlements in Tehran metropolis (Islamshahr County) in the horizon of 2033?

## 2. Research Theoretical Literature

The concept of the smart village has emerged as a sophisticated development paradigm for rural areas in India, building upon the established smart city model and aimed at integrating technology into the fabric of remote locales. The primary purpose of this initiative is to tackle multifaceted rural challenges through the adoption of Information and Communication Technology (ICT) and Geographic Information System (GIS) tools. This endeavor strives for sustainability and aligns with the broader goals of sustainable development. The smart village framework is predicated on the

inclusive principle of "access to information for all," wherein ICT services become readily accessible to the rural populace via dedicated applications (Adamowicz & Zwolińska-Ligaj, 2020; Zavratnik et al, 2018; Tregear & Cooper, 2016). The conceptualization proposed by Viswanadham and Vedola (2020) of the smart village ecosystem encapsulates four cardinal aspects: institutional structures, resource utilization, service chains, and the technologies facilitating service delivery. Moreover, seven pivotal dimensions underpin the smart village architecture: the economy, ICT, human resources, governance, the environment, lifestyle, and energy. This model's inception is a direct consequence of recognizing the role of ICT as a potent instrument for catalyzing local economic development. Corresponding to notions of smart growth and smart development, smart villages embody a transformative vision for rural livelihoods, advocating for sustainable practicability across various domains (Somwanshi et al., 2016; Holmes & Thomas, 2015). Further, by interweaving elements from the Smart City framework into rural contexts, smart villages harness advancements in sustainable agriculture, energy efficiency, health, education, and digital communication. Leveraging technologies such as ICT, the Internet of Things (IoT), and other innovations, smart villages endeavor to equip rural communities with the requisite capabilities to flourish in an era of incessant change (Ella & Andari, 2018). The objectives of smart village initiatives are manifold:

- Combating rural population decline: Smart villages represent a rural development strategy that can prevent or reverse the process of migration from rural to urban areas, thereby preserving rural populations by improving local quality of life and economic prospects.
- Improving agricultural practices: Precision agriculture, with digital technologies such as IoT sensors, satellite imagery, and data analysis, can increase the efficiency and sustainability of agricultural practices in these communities.
-Adoption of renewable energy: Smart villages often incorporate renewable energy solutions such as solar panels and wind turbines, which promote energy self-sufficiency and reduce carbon footprints.
-Digital connectivity and education: High-speed Internet access enables e-learning, telemedicine services, and global market connectivity for local businesses, artisans, and farmers.
- Social integration and governance: Smart village initiatives promote participatory governance, ensuring that the benefits of technology are accessible to all members of society, including vulnerable groups (Beg, 2018; Singh & Patel, 2019).

In the quest to elevate the quality of human settlements and embrace the smart village concept, it is critical to acknowledge the regional planning principles and the intrinsic characteristics of the target locale. This perspective underpins the belief that all regions whether they are technologically advanced or not—possess the innate potential and a diverse array of capabilities, from economic robustness to knowledge and innovation capacity, to embark on the path toward actualizing the smart village paradigm:

To this end, a substantial body of research executed in the past decade, encompassing both domestic and international studies, has contributed to our understanding of this developmental approach. Anabastani et al. (2022) illustrate how the attributes of what constitutes smart growth diverge considerably across different societies. Broadly, smart growth endeavors to rejuvenate rural zones and neglected urban fabrics through strategic investment of time and resources. Cowie et al. (2020) expounds upon the concept of the fourth industrial revolution—encompassing a suite of technological innovations posited to transmute society as profoundly as the prior industrial upheavals—by pinpointing a disproportionate emphasis on urban centers in these discussions, leaving rural landscapes at a perceptible disadvantage. There is a discernible need to deepen our understanding of how technological advancements can be effectively assimilated within rural contexts, thereby facilitating a seamless transition to a smart, rural future. Complementing this, Zavaratnik et al. (2020) synergize the fundamental aspects of society - encompassing village, city, and sustainability- and critically examine the interconnections among these elements. Their research posits a holistic developmental strategy that underscores that a sustainable existence transcends mere technological interventions. The study probes into the triad of energy, mobility, and waste management as dimensions of intelligent living, analyzed through the lens of rural-urban dynamics

and the pivotal role played by information and communication technology in fostering such an ecosystem.

According to Aziza and Susanto (2020), rural zones grapple with perennial issues like poverty, a low educational threshold, and limited technological access. Within this framework, they proffer a smart village archetype, envisaged as a blueprint for rural advancement towards a more promising future. This model is explicated in six dimensions: governance, technology, resources, village services, lifestyle, and tourism, setting a holistic standard for rural development. Anabestani and Kalate-Meymari (2020) further elucidate that the proliferation of higher education within rural inhabitants and the subsequent retention of these educated individuals—coupled with collaborative industrial activities like tourism, food, and cultural production—are pivotal drivers of smart village evolution. Entwining the broader context of development, Visvizi & Lytras (2018) advocate for twenty novel approaches to underscore the proposition that sustainable living extends beyond technological fixes, placing significant emphasis on surmounting the barrier of limited technological access in rural environs. They posit that information and communication technology (ICT) is a cardinal element in any development schema, whether it pertains to smart cities or villages. An exploratory study by Anabestani & Javanshiri (2018) deduces that among the myriad factors, the dynamic duo of rural creative economy and human capital—alongside economic indicators—exert the most substantial influence upon smart rural development. This research also unpacks the less favorable conditions pertaining to physical and environmental benchmarks in relation to smart evolution. In parallel discourse, Guzal-Dec (2018) postulates that the smart village concept emerges as a panacea in the quest for sustainable development modalities. Within sustainable development's ambit, challenges like resistance to change within rural communities, innovation deficits, insubstantial social capital levels, local market limitations, and infrastructural inadequacies in transportation and communication networks are identified as significant impediments. Complementary insights from Zavaratnik et al. (2018) underscore the social and economic upheavals faced by rural and urban communities in recent decades. They avow that the panacea to these challenges often lies within the realm of technological and digital innovation. The researchers also assert that given the heterogeneity of rural regions, smart rural development must be implemented in concert with a place-based approach, tailored to the unique characteristics and needs of each community.

Anabastani et al. (2023) findings reveal that prioritizing key drivers of smart growth as cornerstones for sustainable rural development could alleviate the detriments associated with rural decline. Implementing strategic and actionable planning toward an envisioned optimal scenario of smart growth is deemed a facilitator of sustainable rural development processes. Research by Emolifar et al. (2020) delves into the fourth industrial revolution and the pervasive connectivity offered by the internet, encompassing objects, individuals, services, and energy networks. This interconnectedness has demonstrable repercussions for public transportation, energy use reduction, health and medical management, and enhancements in interpersonal communications within urban settings. Bahadori Amjaz et al. (2022) posits that villages with larger populations exhibit superior performance in harnessing the benefits of smart growth indicators. Consequently, the enhancement and proliferation of such indicators inherently foster the sustainable development of rural settlements. In the projection of smart rural development by 2031, Anabistani and Kalate-Meymari (2021) argue that reducing service provision costs and infrastructure expenses through intensified development, augmenting residential space per capita (specifically within new, expansive units), and boosting the allocated green space and parks are pivotal. Furthermore, they advocate for a heightened populace and household density in rural service domains and pursuing equilibrium in the engagement of public and private sectors in rural construction endeavors. Anabestani (2021) research ranks the constituents of smart dynamics as preeminent, with a weightage of 28.4%, followed by the facets of a smart economy, which stand at 23.8% according to survey respondents. In contrast, Nowrozi (2020) study diagnoses the economic dimension as the zenith of potential smart village development within scrutinized rural landscapes, while institutional aspects lag behind, with service and planning indices highlighting the best and worst

conditions, respectively. The study by Babaei et al. (2021) conveys that the examined villages present unsatisfactory conditions for smart growth. They conceptualize an eclipse of rural development by mere rural growth, where ecological indicators are markedly deficient compared to other dimensions, reflecting the overarching challenges faced by the sustainable development paradigm postulated at the Rio and Brundtland Conferences. Complementing this narrative, Anabestani et al. (2021) research corroborates that, concerning smart rural growth indices, transportation and communication, coupled with the enhancement of the physical fabric, are the most critical in the target villages. Furthermore, earlier studies by Anabestani & Kalate-Meymari (2019) and Anabestani & Javanshiri (2015) illustrate that economic and physical indicators command a significant influence in the orchestration of smart rural development.

Consequently, the evolution of the smart village paradigm posits longevity, leading to sustainable development within rural communities (Beg, 2018). This evolution becomes the cornerstone for the enhancement of quality of life, as well as the socioeconomic prosperity of those regions (Singh & Patel, 2019). Focusing future inquiry on the quintessential drivers of the smart village ethos can facilitate strategic planning for the sustainable development of rural settlements. The conception of future research is multifaceted and bears varied interpretations. A comprehensive synthesis denotes that future research constitutes a methodical endeavor to project long-term outcomes across diverse sectors such as knowledge, technology, economics, environment, and society. The principal objective is discerning emergent opportunities, nascent technologies, and investments potentially yielding higher returns (Taghilu et al., 2015). Alternatively, it is postulated as a foresight activity, aligning the utilization of present resources with prevailing values and objectives (Sardar, 2010).

Ultimately, the current inquiry represents one of the pioneering domestic investigations into the scenario development regarding the impact of the smart village approach on the sustainability of peri-urban settlements. By assimilating insights from extant literature and studies concerning smart attributes (smart growth, smart rural development, smart villages) and their bearing on sustainable rural progress, this research extrapolates the importance of facets such as access, infrastructure, transportation, communication, innovation, and knowledge dissemination. Therein, it discerns pivotal drivers and constructs scenarios to gauge the influence of the smart village approach on the enduring development of peri-urban rural settlements in the Tehran metropolitan area.

## 3. Research Methodology

### *3.1 Geographical Scope of the Research*

The area under study in this research is suburban settlements in Islamshahr city. Islamshahr city, in the center of Islamshahr city with 992 meters above sea level in a plain, relatively flat and semi-arid climate at 35 degrees and 17 minutes north latitude and 51 degrees and 21 minutes east longitude, 17 kilometers southwest of Tehran and 24 kilometers It is located west of Shahreri. It is limited to Tehran city from the north, Rei city from the south, Shahriar and Rabat Karim cities from the west, and Tehran city from the east. This city has three parts named Marzari, Chahardangeh and Ahmedabad Mostofi. According to the statistics provided by Iran Statistics Center in 2015, the whole city of Islamshahr has a population of 548,620 people and 168,228 households, of which 512,156 people with 158,106 households live in urban areas and 36,439 people (6.6 percent) with 10,162 households live in rural parts of the city. are (Iranian Statistical Center, 2015).

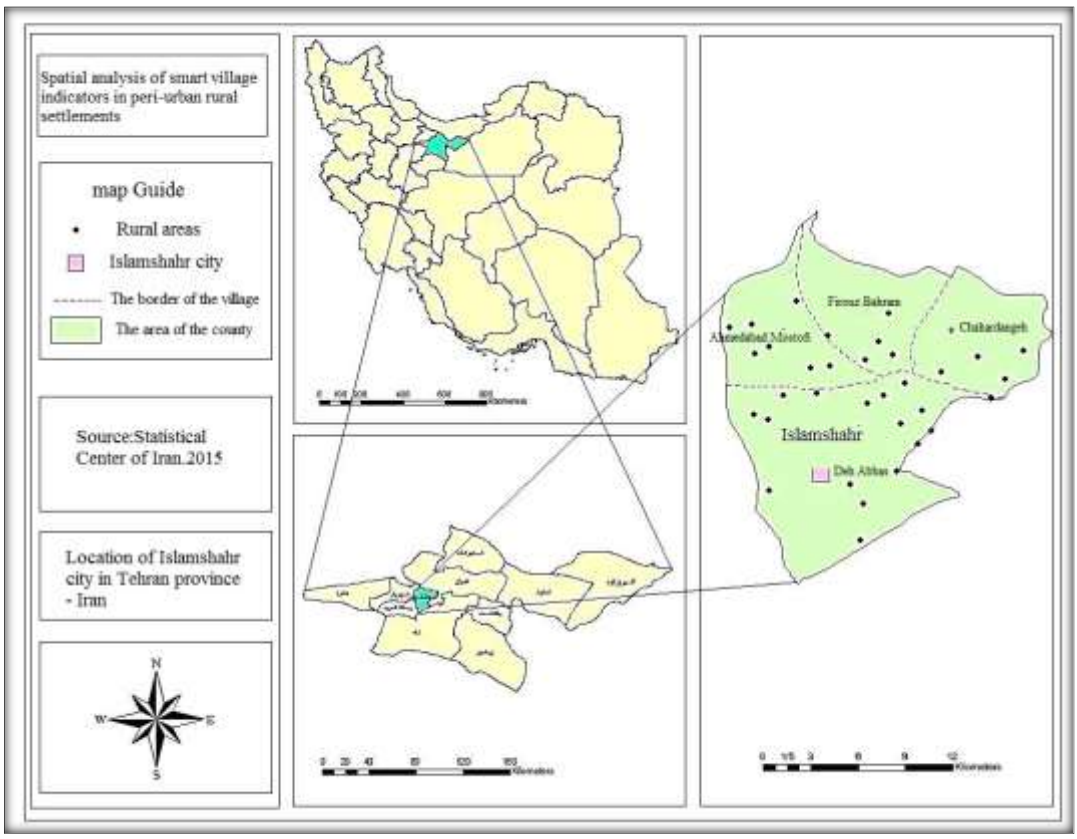



**Figure 1. Location of the studied area**

### *3.2. Research method*

In pursuit of examining the ramifications of the smart village approach on the sustainability of peri-urban settlements within the context of the Tehran metropolis, the present research adopts an applied orientation, being prescriptive in intent and descriptive-analytical by methodology. This blend allows for the synthesis of data through documentary and field research, supplemented by comprehensive literary review. Furthermore, the study adopts a scenario-writing framework to discern the influential factors pertaining to the smart village approach of peri-urban rural settlements and to formulate potential future scenarios for these communities, thereby employing a fusion of quantitative and qualitative research techniques. The research can be characterized as normative-analytical, distinguishing itself through a reliance on qualitative methods of futures research to address complex problems. The French prospective method informs the adopted research methodology (Godet & Durance, 2011). Regional foresight implementation encompasses various methodologies, classified according to their theoretical underpinnings. This particular research proceeded by amalgamating interaction analysis with scenario construction methods.

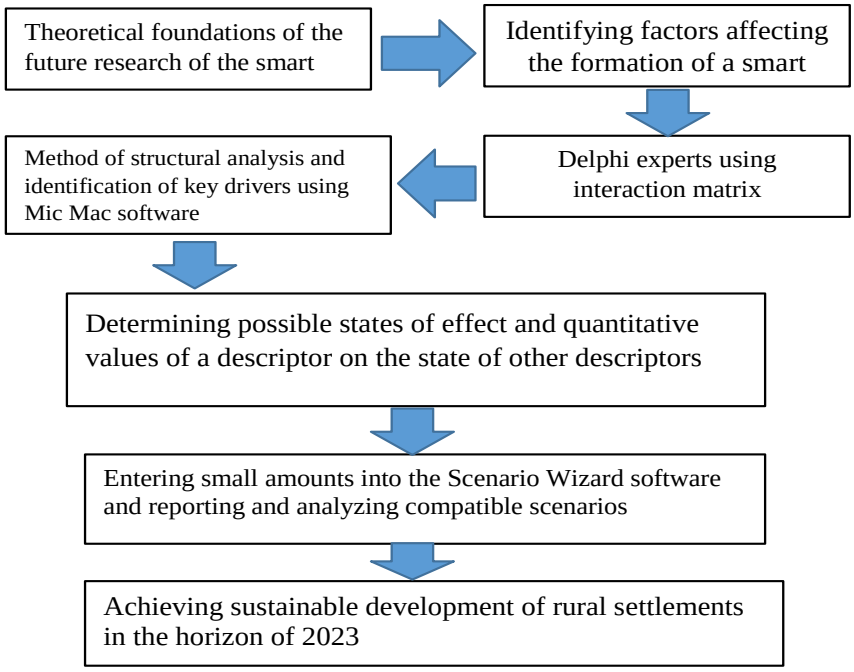



**Figure 2. Conceptual model of research**

The required data was collected by examining scientific and documentary sources and through interviews and expert meetings. Figure 2 shows the flowchart of the research.

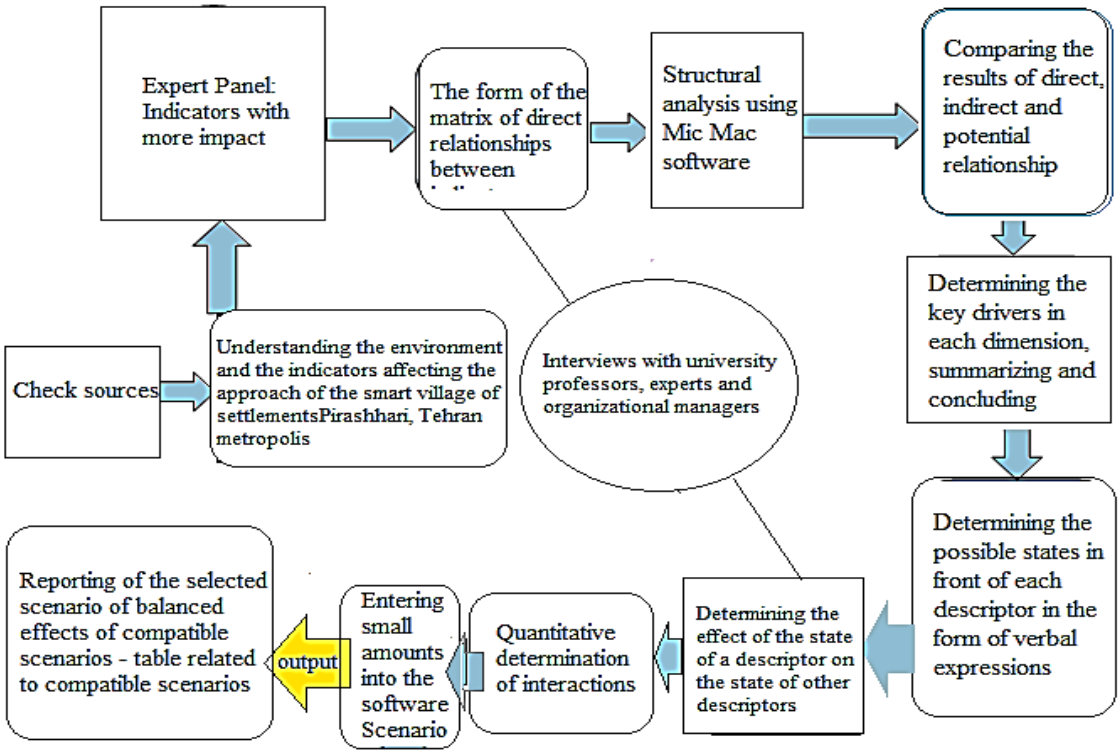



**Figure 3. Flow chart of research implementation**

To ascertain the factors influencing the smart village approach for peri-urban rural settlements of Tehran's expansive metropolitan area, we commenced by extracting pertinent elements from

an array of prior studies focused on 'smart' attributes. Subsequently, these factors were presented to experts to assess their significance. The experts were also solicited for insights regarding any factors that might not have been encompassed within the initial aggregation. This was achieved by first compiling a list of sub-indices based on the thorough examination of both domestic and international literature. These sub-indices were then categorized into five dimensions by the consensus of the research authors. The initial gamut of determinants was prioritized by the expert panel, from which 57 items emerged as salient. The selection of experts, including practitioners from government and executive organizations, academic scholars, and officials from Islamshahr County's municipality and governorate, adhered to the snowball sampling technique. For the operational definition of the smart village concept's theoretical construct, ten constituent components were identified, and their application facilitated by questionnaires and impact matrices (refer to Table 1). To achieve the research objectives, collaboration was sought from academics and doctoral candidates affiliated with prominent academic institutions such as Shahid Beheshti University, Tehran University, Birjand University, among others, alongside senior organizational executives, all of whom held a minimum educational qualification of a bachelor's degree.

**Table 1. Factors affecting the sustainability of peri-urban rural settlements through the smart village approach**

| Component | Indicators |
|---|---|
| **Economic factors** | (1) Access to suitable jobs in the village and surrounding cities and create diverse job opportunities in the future (2) Access to various and reliable financial resources in order to take advantage of the competitive advantage of the region (3) Increase intra-local financial exchanges by strengthening rural-urban flows and links (4) Diversification of income sources of rural households with the aim of creating savings (5) Appropriate access to support facilities for economic activities in villages (6) Optimum use of the Internet in line with identity and branding to strengthen the economy, especially in tourism (7) Increasing innovation in Economic activities (new marketing, etc.) (8) Increasing investment in the process of innovative businesses in the village (9) Increasing the spirit of entrepreneurship, launching and promoting new local businesses (10) Improving the ability to save and increasing investment opportunities in the village (11) Improving The process of reducing poverty among rural households (12) increasing access to smart systems to perform economic activities (13) increasing skill transfer and economic capacity building through the digital divide (the number of workers employed in the sector (ICT). |
| **Socio-cultural factors** | (1) Increasing the process of protecting agricultural lands and village gardens by people and local managers (2) Creating and strengthening sewage disposal lines in order to reduce the level of pollution (water and soil) in the village environment (3) The process of increasing access to purified and potable water In villages (4) increasing the use of smart irrigation methods and remote control in the agricultural sector in order to reduce the consumption of water resources (5) increasing the use of technology and electronic marketing and selling agricultural products (6) increasing the use of agricultural information systems in the compilation The pattern of crop cultivation (7) reducing the consumption of chemicals and using compost to protect the land. water and soil in the villages (8) increasing the trend of using clean (green) and renewable energy in the villages (9) increasing attention to the management of optimal fuel and energy consumption in the villages (10) increasing the protection of historical and cultural relics and monuments in the villages (11) Extensive efforts to increase the use of clean transportation |
| **Environmental factors** | (1) increasing the process of protecting agricultural lands and village gardens by people and local administrators (2) creating and strengthening sewage disposal lines in order to reduce the level of pollution (water and soil) in the village environment (3) increasing the access to purified and usable water drinking in villages (4) increasing the use of smart irrigation methods and in the agricultural sector to reduce the consumption of water resources (5) increasing the use of technology and electronic marketing and selling agricultural products (6) increasing the use of agricultural information systems in developing crop cultivation patterns (7) Reducing the consumption of chemicals and using compost to protect the land. water and soil in the villages (8) increasing the trend of using clean (green) and renewable energy in the villages (9) increasing attention to the management of optimal fuel and energy consumption in the villages (10) increasing the protection of historical and cultural relics and monuments in the villages ( 11) Extensive efforts to increase the use of clean transportation |
| **Physical-spatial factors** | (1) Creating a suitable platform to increase the access of residential units to fixed internet in the village (2) Creating and increasing communication infrastructure in order to increase access and reduce transportation and communication costs (3) Increasing access to electronic payment systems in order to facilitate services banking and commercial (4) Paying attention to the development of information and communication technology (ICT) infrastructure in order to develop Internet-based services (5) Using the appropriate bandwidth to benefit from suitable platforms for virtual communication (6) Improving road connections, sidewalks and transportation routes The |

| Component | Indicators |
|---|---|
| | importance of rural settlements (7) Increasing the amount of intensive activity (agricultural and non-agricultural) in rural settlements (8) Trying to reduce the distance between residence, work, education and meeting daily needs (9) Development of residential units outside the approved scope of the village head plan (10) Increasing mixed uses and developing access to services at the settlement level (11) Increasing village social access to information, to search in databases such as job advertisements and government services |
| **Keyinstitutional -management factors** | (1) Creating a suitable platform to increase the access of residential units to fixed internet in the village (2) Creating and increasing communication infrastructure in order to increase access and reduce transportation and communication costs (3) Increasing access to electronic payment systems in order to facilitate services banking and commercial (4) Paying attention to the development of information and communication technology (ICT) infrastructure in order to develop Internet-based services (5) Using the appropriate bandwidth to benefit from suitable platforms for virtual communication (6) Improving road connections, sidewalks and transportation routes The importance of rural settlements (7) Increasing the amount of intensive activity (agricultural and non-agricultural) in rural settlements (8) Trying to reduce the distance between residence, work, education and meeting daily needs (9) Development of residential units outside the approved scope of the village head plan (10) Increasing mixed uses and developing access to services at the settlement level (11) Increasing village social access to information, to search in databases such as job advertisements and government services |
| Source: Anabistani & Kalate-Meymari, 2022; Anabestani & Javanshiri, 2015; 2018; Anabestani & Meymari, 2020; Adesipo & et al, 2020; Gerli & et al, 2022; Kalinowski et al., 2022; Kurniawan et al., 2022; Asri et al., 2022; Srivastava, 2022; Maja et al., 2020; Vignesh & Priyan, 2018 | |

The methodology of this study commenced with the collation of data through a documentary approach and conducting Delphi method-based interviews with domain experts. The process was structured in three waves to distill the variables influencing the formation of the smart village approach. Subsequent to these rounds, the provisional factors were subjected to rigorous scrutiny by experts for reaffirmation. Following this reconfirmation, a questionnaire was meticulously crafted, and its validity and reliability were initially tested through a preliminary distribution to a select cohort of experts, consisting of university faculty and domain specialists. Seven copies of the preliminary questionnaire were disseminated, and refinements were integrated based on the feedback obtained. Ultimately, to delineate the principal drivers underpinning the impact of the smart village approach on the sustainability of peri-urban settlements, the study leveraged the descriptive and inferential insights garnered from the expert questionnaires. Vital variables, including influential and bidimensional risk factors, were elicited applying the structural analysis methodology. To facilitate this procedure, Micmac software was employed. Structural analysis within this research unfolded in three discrete phases: First, the Delphi method was utilized to extract relevant variables and factors. Second, inter-variable relationships were mapped and defined. The third phase was dedicated to the identification of pivotal variables. Subsequently, the Balanced Interaction Analysis method, alongside the Scenario Wizard software, constituted the tools for crafting the impact scenarios of the smart village approach on peri-urban settlement sustainability. It is pertinent to note that the foundation of the Scenario Wizard software employs Cross-Impact Balance (CIB) matrices. These matrices serve a critical function—capturing expert opinions regarding the probabilistic effects of one descriptor state on another. Verbal expressions were used to record these impacts, and through the computation of direct and indirect effects between states, coherent scenarios for the subject system were distilled and extrapolated.

## 4. Research Findings

### *4.1. The key variables of shaping the scenarios of the impact of the smart village approach on the sustainability of peri-urban settlements in Tehran metropolis.*

According to the materials obtained from field and library studies, the main factors influencing the approach of the smart village in the rural settlements of Tehran metropolis were identified. These indicators are in 5 dimensions "social-cultural index", "economic index", "physical-physical index", "management-institutional index" and "environmental index". According to the descriptive and inferential results obtained from the expert questionnaires and structural equations, the drivers of each of the key factors in 5 dimensions were prepared and presented. They will

be of fundamental use to determine the logic of the scenario. The factors included in (Table 2) have the most impact; therefore, they are considered among the drivers.

**Table 2. The influence of the drivers of the smart village approach in rural settlements based on the opinions of experts and Mikmak software.**

| Row | Propulsion | indirect effect | Direct effect |
|---|---|---|---|
| 1 | Increasing skill transfer and economic capacity building through the digital divide (the number of workers employed in the (ICT) sector). | 5208+ | 10+ |
| 2 | Access to various and reliable financial resources in order to take advantage of the competitive advantage of the region | 624+ | 1+ |
| 3 | Diversification of rural household income sources with the aim of creating savings | 5.2+ | 1+ |
| 4 | Increasing investment in the process of innovative businesses in the village | 645+ | 0 |
| 5 | Educational classes benefit from electronic and internet facilities to use virtual and distance education | 1370+ | 5+ |
| 6 | Increasing access to the smart health system in order to innovate in providing healthcare services to villagers | 408+ | 0 |
| 7 | Facilitating access to higher education institutions in order to train specialized human resources | 1807 | 6- |
| 8 | Improving satisfaction with livability in rural settlements | 652 | 2- |
| 9 | Creating a suitable platform to increase the access of residential units to fixed internet in the village | 4744+ | 9+ |
| 10 | Increasing mixed uses and developing access to services at the settlement level | 1371+ | 3+ |
| 11 | Increasing access to electronic payment systems to facilitate banking and business services | 998+ | 2+ |
| 12 | Improving road connections, sidewalks and important transportation routes of rural settlements | 483- | -1 |
| 13 | Increasing attention to management of optimal consumption of fuel and energy in villages | 1799+ | 5+ |
| 14 | Increasing protection of historical and cultural works and monuments in villages | 1141+ | 3+ |
| 15 | Increasing the participation of villagers in decision-making, implementation and maintenance of projects by local managers | 3162+ | 8+ |
| 16 | Application of information and communication technology in providing services for easy access of villagers to administrative services | 1298+ | 3+ |
| 17 | Increasing villagers' trust in local administrators and rural planners | 407+ | 1+ |

After identifying the driving factors, it is time to formulate the scenario. At this stage, if we want to involve all the driving factors in the scenario, it will cause the number of scenarios to be too wide and the managers will be more confused to use these scenarios in planning and policy making; Therefore, the main challenge at this stage is how to structurally expand the driving factors, which includes all the driving factors in a regular structural format, and presents a number of viable and logical scenarios for managers to exploit. For this purpose, a step called the development of scenario logic must be completed for the structural expansion of driving factors. At this stage, creativity and perception play the most important role.

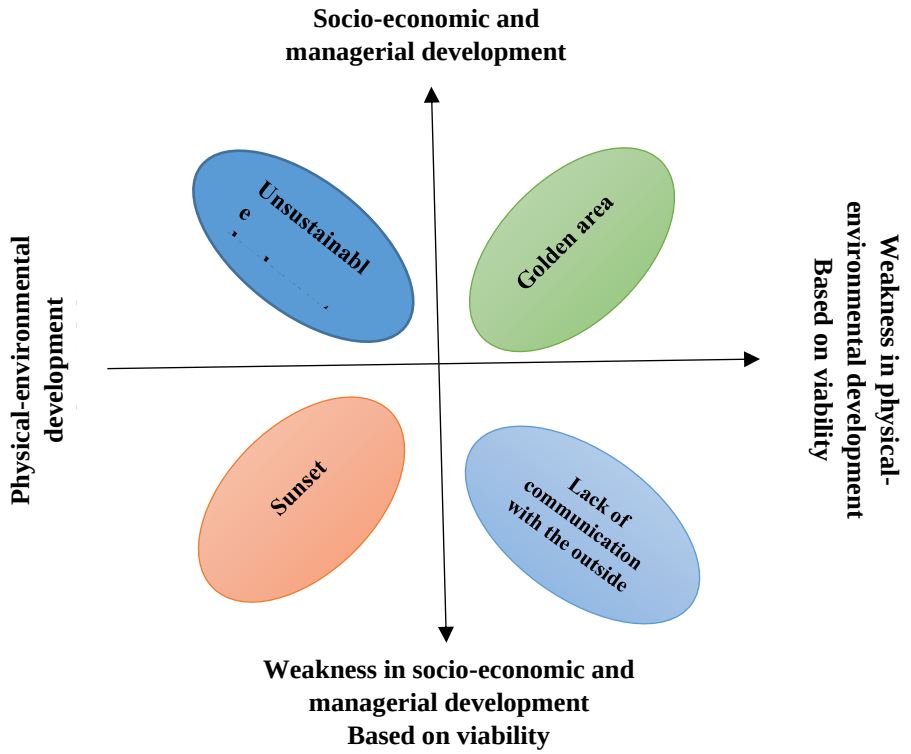



**Figure 4. The formation of scenario logic with two dimensions in the context of the network**

In this research, the inductive method was chosen as the scenario logic formulation method due to the wide range and variety of drivers and after interviewing experts. The logic of the scenario in this research has the following two dimensions:

- The level of socio-economic development based on livability in line with the formation of a smart village
- The amount of physical-environmental development based on livability in line with the formation of a smart village

After consulting with experts, these two dimensions were chosen as the holder and shaper of the logic of the scenario. It should be noted that these two holders are determined in such a way that they contain all the critical drivers of the scenario. These two dimensions are shown in figure (4). In fact, drivers play a role in each of the four quadrants created by the combination of two dimensions and develop the desired scenario. It should be noted that at this stage the scenarios are named through a survey of experts.

***4.2. Creating an analysis structure (drivers and their possible assumptions)***

From determining the key factors of the research, for each of the factors, all the possible states (scenarios facing the factor) of the effect of the smart village on the sustainable development of rural settlements in the complex around the metropolis of Tehran in the horizon of 2033 in three favorable, semi-favorable and unfavorable situations with Paying attention to the opinions of experts, in total, 17 drivers and 51 possible hypotheses were prepared along with their characteristics. It is important to point out that the drivers and their possible assumptions all have uncertainty in terms of occurrence.

**Table 3. Key factors influencing the smart village approach and possible future states for each factor in the horizon of 2033**

| Code | Factor | scenario type | Possible modes |
|---|---|---|---|
| A1 | kill transfer and economic capacity building through digital technologies | Optimal | Paying special attention to creating the necessary platforms for increasing skill transfer and economic capacity building through digital technologies and increasing the number of workers working in the sector (ICT). |
| A2 | | static | Limited access to digital platforms for skill transfer and the low number of workforces working in the sector (ICT) |
| A3 | | Undesirable | The lack of access to digital platforms for skill transfer and the lack of workforce in the sector (ICT) |
| B1 | Funds | Optimal | Creating simple and appropriate access mechanisms to access various businesses and financial institutions for rural comprehensive access to various and reliable financial resources and benefit from the competitive advantage of the region |
| B2 | | static | Limited access to financial resources and relatively high interest of facilities and relative attention to the competitive advantage of the region |
| B3 | | Undesirable | Lack of access to financial resources and the existence of strict banking rules and neglecting the competitive advantage of the region |
| C1 | sources of income | Optimal | Planning and paying special attention to different economic sectors (handicrafts, tourism, etc.) and diversifying the income sources of rural households with the aim of creating savings |
| C2 | | static | Relatively low attention to non-agricultural sectors (handicrafts, tourism, etc.) and little attention to diversification of rural household income sources |
| C3 | | Undesirable | Being a single product and depending on the rural economy on agriculture, the rural household economy was fragile |
| D1 | Investment in business process Electronic facilities of educational classes | Optimal | Special attention and strengthening of start-ups and rural knowledge-based companies with the aim of increasing investment in the process of innovative businesses in the village |
| D2 | | static | Relative existence of administrative and legal obstacles in the way of investing knowledge-based and innovative businesses in the village |
| D3 | | Undesirable | Distrust and lack of investment in the process of innovative businesses in villages |
| E1 | | Optimal | Equipping educational classes with various electronic facilities and high-speed internet to use virtual and distance education |
| E2 | | static | The limited and relative electronic facilities of classrooms and low internet speed, limited access to virtual and distance education |
| E3 | | Undesirable | Absence of any electronic facilities in classrooms and lack of access to the Internet, lack of use of virtual and distance education |
| F1 | Smart health system | Optimal | Creating electronic health records and creating and strengthening access to smart health systems in order to innovate in providing health and treatment services to villagers |
| F2 | | static | Limited access to the smart health system and the existence of disruptions in the smart systems of providing healthcare services to the villagers |
| F3 | | Undesirable | Absence of smart health system and lack of electronic platform in providing healthcare services to villagers |
| G1 | Access to higher education institutions | Optimal | Establishing educational institutions and facilitating access to higher education institutions in order to train specialized human resources in villages |
| G2 | | static | Limited access and long distance to higher education institutions and difficult conditions for the presence of specialized manpower in the villages |
| G3 | | Undesirable | Lack of infrastructure and deposits necessary for construction and lack of access to higher education institutions and lack of specialized human resources in the village |
| H1 | Livability | Optimal | paying special attention to improving the level of satisfaction with livability in rural settlements |

| Code | Factor | scenario type | Possible modes |
|---|---|---|---|
| H2 | | static | Relative attention to improving the level of satisfaction of villagers with livability in rural settlements |
| H3 | | Undesirable | Failure to pay attention to improving the level of villagers' satisfaction with livability in rural settlements |
| I1 | Fixed internet for residential units | Optimal | Creating and strengthening suitable platforms to increase the access of residential units to high-speed and desirable fixed internet in the village |
| I2 | | static | Limited access and low-quality fixed internet speed of residential units in villages |
| I3 | | Undesirable | Lack of a suitable platform for residential units to access the desired fixed internet in the villages |
| J1 | Mixed uses | Optimal | Special attention to the increase of mixed uses and the development of access to services at the level of rural settlements |
| J2 | | static | Relative attention to mixed uses and development of access to services at the settlement level |
| J3 | | Undesirable | Neglecting mixed uses and developing access to services at the settlement level |
| K1 | Electronic payment systems | Optimal | Strengthening electronic banking, platform creation and training to facilitate access to electronic payment systems and perform banking and commercial services |
| K2 | | static | Low and unfavorable access to electronic payment systems and emphasis on face-to-face banking and commercial services |
| K3 | | Undesirable | Absence of electronic payment systems in the village and the need to go to urban areas to perform banking and commercial services |
| L1 | Road connections, transportation routes | Optimal | Paying special attention to the role of road connections and spending the necessary money for the continuous maintenance and reconstruction of roads, sidewalks and important transportation routes in rural settlements. |
| L2 | | static | Relative attention to road connections, sidewalks and important transportation routes in rural settlements |
| L3 | | Undesirable | Neglect of local managers and planners to road connections, sidewalks and important transportation routes of rural settlements. |
| M1 | Fuel and energy consumption | Optimal | A special look at alternative and clean fuels in order to manage optimal fuel and energy consumption in villages |
| M2 | | static | Neglecting the management of optimal fuel and energy consumption in villages |
| M3 | | Undesirable | Increasing consumption of fossil fuels and energy in villages and environmental destruction |
| N1 | Historical and cultural monuments | Optimal | Cultivation and effort in the protection of historical and cultural works and monuments in the villages |
| N2 | | static | Relative attention to the protection of historical and cultural works and monuments in villages |
| N3 | | Undesirable | Neglecting the protection of historical and cultural monuments and their destruction |
| O1 | Participation of villagers | Optimal | Creating the necessary platform for the formation and strengthening of non-governmental organizations in order to increase the participation of villagers in decision-making, implementation and maintenance of projects by local managers. |
| O2 | | static | Low attention to participatory mechanisms and institutions in decision-making, implementation and maintenance of projects by local managers |
| O3 | | Undesirable | Neglecting the participation of villagers in decision-making, implementation and maintenance of projects by local managers |
| P1 | Applying IT technology in providing management services | Optimal | Creating and strengthening smart systems and using information and communication technology in providing services for easy access of villagers to management services. |
| P2 | | static | Low quality and speed of smart systems in villages to provide management services |
| P3 | | Undesirable | Neglect and lack of intelligent systems for villages to provide management services |
| Q1 | Trust in local managers and planners | Optimal | Creation and special attention to increase villagers' trust in local managers and rural planners |
| Q2 | | static | Ignoring public trust in the way villagers view local administrators and rural planners |
| Q3 | | Undesirable | Distrust of villagers towards local administrators and rural planners |

After determining all the possible states in front of the research drivers, by applying the matrix method of the first interaction effects of all the possible states with the opinion of the experts, all the scenarios in the form of cells, groups and parts in the spectrum of the strong strengthening effect (+3) to the limiting effect severe (-3) were compared. In the next step, by entering the collected data into the software environment (Scenario Wizard), the analysis of the collected data resulting from the opinion of experts and the identification of the scenario facing the smart village in the peri-urban settlements of Tehran metropolis, Daragaf 1412, have been done. The results of the research showed that out of a total of 2448 cell judgments, 60 cells 2.45 (percent) have reciprocal effects -3, 176 cells 7.19 (percent) have reciprocal effects -2, 363 cells 14.83 (percent) have reciprocal effects -1 428 cells 17.48 (percent) have no mutual effect on each other, 625 cells 25.53 (percent) have 1+ mutual effects and 561 cells 22.92 (percent) have 3+ mutual effects.

### *4.3. Identification of the future scenarios of the impact of the smart village on the sustainable development of rural settlements in the area around the metropolis of Tehran in the horizon of 2033*

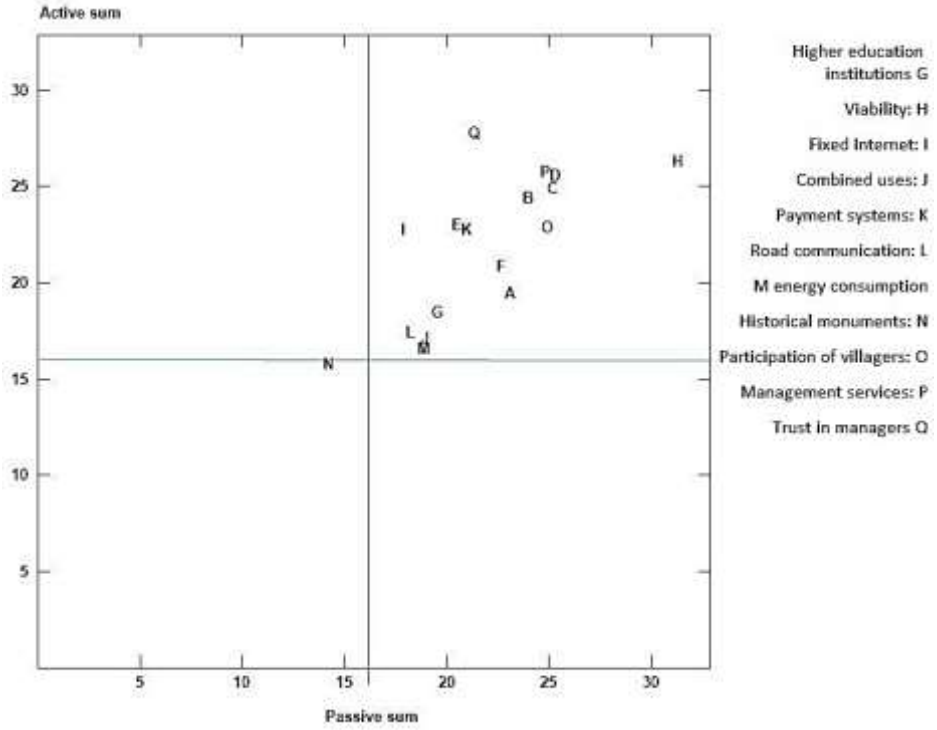
In order to extract the desired scenarios, the compatibility of the scenarios must be evaluated; Therefore, first the strong compatibility of the scenarios and then their weak compatibility were identified. In total, the results of the research showed that there are a very large number of possible scenarios for the impact of the smart village approach on the sustainability of peri-urban settlements in Islamshahr County, out of which there are 14 scenarios with weak adaptation and only 1 scenario with strong and stable adaptation (zero incompatibility) is located, so the scenario is a best scenario for the smart village of rural settlements in Islamshahr city. Scenario 2 and 3 are also presented with a maximum incompatibility of one, to show the extent of the futures facing the smart village of rural settlements in Islamshahr County.

**Table 4. Scenarios of the impact of the smart village approach on the stability of peri-urban settlements of Tehran metropolis in the horizon of 2033**

| Propulsion/descriptor | First scenario (Golden) | | Second scenario (disaster) | | Third scenario (silver) | |
|---|---|---|---|---|---|---|
| | state of | *Compatibility* value | state of | Compatibility value | state of | Compatibility value |
| Skill transfer | Optimal | 15 | Undesirable | 10 | Undesirable | 3 |
| Funds | Optimal | 15 | Undesirable | 9 | static | -2 |
| source of income | Optimal | 14 | Undesirable | 7 | Optimal | -2 |
| Business | Optimal | 14 | Undesirable | 11 | Undesirable | 0 |
| Training classes | Optimal | 14 | Undesirable | 8 | Optimal | 1 |
| the health | Optimal | 16 | Undesirable | 9 | Undesirable | -1 |
| Higher education institutions | Optimal | 15 | Undesirable | 8 | static | 0 |
| Livability | Optimal | 13 | Undesirable | 12 | Undesirable | 3 |
| Fixed internet | Optimal | 15 | Undesirable | 8 | Optimal | -1 |
| Mixed uses | Optimal | 13 | Undesirable | 11 | Undesirable | -1 |
| Payment systems | Optimal | 14 | Undesirable | 11 | Undesirable | 0 |
| Road communication | Optimal | 16 | Undesirable | 5 | Optimal | 2 |
| energy consumption | Optimal | 14 | Undesirable | 10 | Optimal | -1 |
| Cultural monuments | Optimal | 15 | Undesirable | 12 | Undesirable | 0 |
| Participation of villagers | Optimal | 13 | Undesirable | 9 | Optimal | 1 |
| Management services | Optimal | 15 | Undesirable | 10 | Optimal | 1 |
| Trust in managers | Optimal | 14 | Undesirable | 8 | Undesirable | -2 |
| The compatibility value of the whole scenario | Compatibility value | 13 | Compatibility value | 5 | Compatibility value | -2 |
| Total interaction effect score (CIB) | CIB | 733 | CIB | -144 | CIB | 63 |

Within the framework of this study, three scenarios delineate the potential impact of the smart village approach on the sustainability of peri-urban settlements in the Tehran metropolis, each with distinct interaction effects and compatibility values. The first scenario, indicative of a positive trajectory, boasts a total interaction effect score of 733 and a high compatibility value of 13. This 'golden scenario,' posits an idealized future in the 1412 horizon where the smart village approach robustly underpins the sustainability of peri-urban settlements in the area surrounding the Tehran metropolis. Here, all 17 drivers operate at peak efficacy. The realization of this scenario lays the groundwork for enhanced skill transfer and capacity building in the digital economic sphere, thereby bolstering the information and communication technology (ICT) sector's workforce. Access mechanisms to diverse and credible financial resources will be streamlined for companies and financial institutions, catering to various economic sectors like handicrafts and tourism. Consequently, this diversification will cultivate additional income streams for rural households and savings opportunities.

Further, the incantation and fortification of start-ups and knowledge-based rural companies will catalyze investment in innovative village enterprises. Infrastructure enhancements will ensure augmented access to fixed internet for residences, alongside the development of mixed-use spaces and service accessibility at the heart of rural settlements. The establishment of intelligent health systems and electronic health records are set to reinforce health and medical service provision to villagers. Concomitantly, the creation of educational institutions, coupled with the facilitation of access to higher educational bodies, will forge pathways for the cultivation of specialized human resources within village confines, subsequently uplifting livability satisfaction levels among rural residents. Electronic banking infrastructures will be strengthened, and educational initiatives will simplify electronic payment systems, thus easing banking and commercial services. The reinforcement of road connections and consistent financial allocation for maintenance and refurbishment of crucial transportation networks will streamline village connectivity. Efforts to manage optimal fuel and energy consumption, alongside the promotion of alternative and cleaner fuel sources, will resonate positively with the rural environmental milieu. Historical and cultural assets within villages will garner protective measures through cultural valorization. The establishment and amplification of non-governmental organizations, led by local stakeholders, will amalgamate villager participation in decision-making, project execution, and ongoing operations. Intelligent service delivery systems will alleviate villagers' access to management services, thereby fostering trust in local governance and planning, which is integral to realizing the aspirational future of smart village sustainability.




**(Figure 5). Network system of research descriptors**

**Forming a network system -** Within the ambit of this research, a network system is pivotal in illustrating the interplay of descriptors and their impact on system dynamics, which is crucial for the authentic construction of scenarios. To forge such a network system, it is imperative to compute the totality of influences that each descriptor exerts on its counterparts (active sum), along with the aggregate of influences it receives from them (passive sum). Plotting the passive sum results on the x-axis against the active sum products on the y-axis facilitates the formation of a network system diagram (Figure 5)

The analytical outcomes derived from the grid system underscore that descriptor such as "management services," "trade," "source of income," "financial resources," "payment systems," "villagers' participation," "educational classes," "health," "skill transfer," and "managers' trust" operate within a mode of concurrent influence and susceptibility. In essence, these elements exert influence upon, as well as are influenced by, other descriptors in the system (as depicted in Figure 5). In particular, the livability descriptor stands out for its pronounced efficacy compared to others, highlighting its critical importance due to its potential to exert significant positive or negative oscillations on alternate scenarios pertaining to the smart village concept in rural Islamshahr settlements. Additionally, the descriptor detailing the presence of fixed internet occupies a strategic inflection point, bridging the right and left sectors of the impact spectrum, consequently wielding substantial influence. These mentioned variables constitute the primary agents of change in advancing the smart village agenda within the rural settlements of Islamshahr County. They exhibit notable degrees of influence, albeit varying in magnitude. The network system analysis further reveals that descriptor such as "skill transfer," "higher education institutions," "mixed uses," "road communication," and "energy consumption" straddle the boundary between two distinctive influence domains, positioning them as potential target variables. Through strategic manipulation and alterations to these variables, one can catalyze the evolutionary trajectory of the program system, thus advancing towards the intended objective.

**Table 5. Balance calculation page of the effect of the first scenario of the smart village approach on the sustainability of peri-urban settlements**

| code | Propeller/descriptor | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Skill transfer | - | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 2 |
| B | Funds | 3 | - | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| C | source of income | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| D | Business | 3 | 3 | 3 | - | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| E | Training classes | 3 | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 2 |
| F | the health | 3 | 3 | 2 | 3 | 3 | - | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| G | Higher education institutions | 3 | 3 | 3 | 3 | 3 | 3 | - | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| H | Livability | 3 | 3 | 3 | 3 | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| I | Fixed internet | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | - | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 2 |
| J | Mixed uses | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | - | 2 | 3 | 3 | 3 | 3 | 2 | 2 |
| K | Payment systems | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | - | 3 | 3 | 2 | 3 | 3 | 2 |
| L | Road communication | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 3 | - | 3 | 3 | 2 | 2 | 2 |
| M | energy consumption | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | - | 2 | 3 | 2 | 2 |
| N | Cultural monuments | 2 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 1 | 3 | 1 | 3 | 2 | - | 3 | 3 | 3 |
| O | Participation of villagers | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | - | 2 | 3 |
| P | Management services | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | - | 2 |
| Q | Trust in managers | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 2 | 2 | 3 | 3 | - |
| Balance effect | favorable assumption | 44 | 47 | 46 | 46 | 42 | 45 | 42 | 48 | 40 | 39 | 43 | 42 | 42 | 35 | 47 | 44 | 41 |
| | Semioptimal assumption | 29 | 32 | 32 | 32 | 28 | 29 | 27 | 35 | 25 | 26 | 29 | 26 | 28 | 20 | 34 | 29 | 27 |
| | Unfavorable assumption | 19 | 19 | 23 | 23 | 17 | 19 | 18 | 31 | 13 | 15 | 19 | 15 | 15 | 12 | 20 | 22 | 17 |

In scrutinizing the equilibrium effect within the 'golden scenario' for the impact of the smart village paradigm on the sustainability of peri-urban settlements, the scenarios' articulation acknowledges that driving forces interact with divergent coefficients of influence and, in certain instances, some may exert negligible or zero influence on others. Consequently, this study section investigates the mutual reinforcement and validation among the driving forces undergirding the primary scenario. Employing the mutual effect balance method, the internal consistency of a scenario is gauged through its effect balance, an To check the compatibility status of the first scenario, that is, the scenario:

SW1= [A1 B1 C1 D1 E1 F1 G1 H1 I1 J1 K1 L1 M1 N1 O1 P1 Q1]

Analysis of the balanced interaction matrix within the confines of the 'golden scenario' indicates that all catalysts possess preponderant weight and exhibit a high degree of equilibrium effect under the favorable condition. When juxtaposing the equilibrium values associated with this condition evaluation made possible by assimilating scenario assumptions within the interaction matrix. Thereby, any potential inconsistencies among the scenario assumptions are uncovered. In the absence of such discordance, the scenario can be appraised for its internal constancy. Table (5) enumerates the compatibility status of the primary research scenario across three qualifying assumptions favorable, static, and unfavorable. Herein, each element's mutual impacts are assessed and juxtaposed against each driver's alternative suppositions.

against alternative suppositions -static and unfavorable- the data implies that these latter assumptions yield a diminished equilibrium effect relative to the favorable condition. Consequently, the favorable assumption is adjudged as internally consistent for all descriptors, as delineated in Table 5. The mutuality of effects amongst various elements within the primary scenario was subjected to meticulous evaluation, and these outcomes were systematically contrasted with substitutive

postulations for each influencing factor. The balanced interaction matrix revealed the following compatibility values: for the descriptor 'skill transfer,' 44 in the favorable state, 29 in the semi-favorable state, and 19 in the unfavorable state; for 'financial resources,' 47 in the favorable state, 29 in the semi-favorable, and 19 in the unfavorable; and for 'source of income,' 46 in the favorable state, 32 in the semi-favorable, and 23 in the unfavorable. Noticeably, the equilibrium effect values for the semi-optimal and unfavorable states are significantly lesser than those of the optimal condition for the descriptors. Subsequent to the identification of variables that substantiate the scenario, the compatibility status of these elements was scrutinized.

In the first scenario, the equilibrium effect is most pronounced in the drivers of "viability (45)," "villagers' participation (46)," "financial resources (46)," "income sources (47)," "trade (47)," and "health (48)." These elements showcased the highest balancing impact. Conversely, "cultural monuments (39)" and "mixed uses (35)" emerged as the drivers with the least balancing effect within the ensemble of the first scenario. In the exemplified 'golden scenario,' each driver ideally maximizes its weight and equilibrium effect under the favorable assumption. A comparative analysis of the equilibrium values vis-à-vis the favorable assumption confirms that the alternative scenarios (semi-favorable and unfavorable) deliver substantially lower equilibrium effects. Therefore, it is established that the favorable assumption is compatible and can be upheld as consistent across all descriptors.

## 5. Discussion and Conclusion

Neglecting technological advancements, a cornerstone of the smart village paradigm, can result in diminished efficiency of rural settlements. This is particularly detrimental for the village's educated populace, precipitating an increase in their migration due to technology-related constraints in employment opportunities. Such limitations undermine the economic and welfare aspects of rural life, exacerbating spatiotemporal constraints. The concept of a "Smart Village" embodies a holistic approach to fostering long-term social, economic, welfare, and environmental initiatives within the village community. It facilitates widespread participation in local governance and promotes entrepreneurial activities. An efficacious implementation of smart village indicators correlates positively with the performance of villagers in sustainable development endeavors. Conversely, their diminished effectiveness compromises sustainable rural development.

Thus, the identification and examination of optimal scenarios impacting the efficacy of the smart village approach is critical for sustainable rural development. By addressing the pivotal drivers of the smart village construct as foundational to sustainable rural development, the adverse implications linked to this segment may be mitigated. Additionally, strategic and operational planning geared towards realizing the 'golden scenario' can substantially contribute to sustainable rural development. In this regard, the development of scenarios that lay the groundwork for actualizing the smart village approach in peri-urban settlements of the Tehran metropolis merits attention. Literature review and empirical findings of this research underscore the bidirectional relationship between smart villages and sustainable rural development. This interdependence underscores the vital need for integrating the smart village approach within sustainable rural development strategies. Utilizing insights from expert questionnaires and key variables—both influential and of dual-faceted risk drawn from structural equations (Micmac analysis)—has enabled the delineation of drivers across the five sustainability dimensions of rural settlements, informed by the smart village approach.

Subsequent to pinpointing the pivotal factors of the study, potential states (scenarios) of each factor were devised based on expert insights. These characterized the influence of the smart village on the sustainability of peri-urban settlements in the Tehran metropolis with a projection towards the 2033 horizon. This process culminated in three qualitative strata: favorable, semi-favorable, and unfavorable. Altogether, 17 drivers and 51 prospective assumptions were devised, with attributes assigned accordingly. Preliminary compatibility was ascertained via the Monte Carlo method (default iteration of 50,000 runs). The research revealed a vast array of possible scenarios for the smart village in rural Islamshahr settlements, among which 14 scenarios exhibited marginal compatibility and a single scenario demonstrated robust and stable compatibility (zero

incompatibility)–a scenario that emerged as the most propitious for rural Islamshahr's smart village. Scenarios two and three, although indicative of some inconsistencies, delineate the spectrum of potential futures for the smart village in rural Islamshahr. The first scenario, exemplifying a positive direction, garnered a total interaction effect score of 733 with a compatibility value of 13. The second scenario, reflecting a less favorable prognosis for the impact of the smart village on sustainable development, posted a total interaction effect score of -144 and a compatibility value of 5. The third scenario, while presenting minor inconsistencies with a compatibility value of -2 and an overall score of 63, remains a plausible future for the impact of the smart village on the sustainable development of Tehran's peri-urban settlements.

The research findings, analyzed in conjunction with the work of other scholars, reinforce the pivotal role of technological integration within rural landscapes. Notably, the studies by Anabastani and Kalate-Meymari (2020, 2022) as well as Anabastani & Javanshiri (2018, 2015) align with our results, highlighting higher education prevalence and the propensity of educated individuals to reside locally. These studies also underscore synergistic industrial activities such as tourism, food services, and cultural production as crucial drivers propelling smart rural development. Conversely, Zavaratnik et al., (2020), Aziza and Susanto (2020), and Visvizi & Lytras (2018) postulate that the pursuit of sustainable living transcends mere technological innovations, asserting that accessibility to information and communication technology (ICT) stands as a fundamental challenge in both urban and rural locales. The work of Guzal-Dec (2018), Anabestani et al. (2023), and Emli Far et al. point toward inhibitions to the adoption of sustainable development concepts, such as resistance to change within rural communities, limited local market capacity, geographical remoteness, and underdeveloped transport and communication networks. These observations coincide with the studies by Anabastani et al., (2022) and McGuire et al., (2022), who advocate that enhancing the livability of rural settlements, fostering sustainable economic growth, diversifying housing options, and maintaining ecological, social, and economic balance are imperative for rural community revitalization.

Synthesizing the evidence, the smart village approach embeds potential multifaceted impacts on the future sustainability of suburban settlements. The projected effects are manifold:

1. Enhancing quality of life by integrating high-speed Internet, smart housing, and health technologies, thereby advancing service accessibility and societal connectivity.
2. Augmenting economic opportunities through digital platforms and innovative agricultural technologies, fostering job creation and business growth within local economies.
3. Advancing environmental sustainability by adopting green technologies, integrating smart energy solutions, and promoting responsible waste management and sustainable transportation systems.
4. Significantly investing in infrastructure, incorporating sustainable transportation networks, renewable energy sources, and water management systems fortified with smart technologies.
5. Encouraging participatory governance models, digitizing decision-making processes to promote community involvement, and addressing social justice and inclusion through bridging digital divides.
6. Enriching educational landscapes with e-learning platforms and digital resources, positioning residents for future workforce integration.
7. Expanding healthcare accessibility with telemedicine and health monitoring technologies, particularly crucial for underrepresented peri-urban regions.
8. Raising climate change and disaster resilience by leveraging technology for predictive management and responsive strategies.

The fruition of these initiatives hinges on the synergistic blend of technical, economic, and social innovations, buttressed by policy support and sustainable practice investments. Consequently, the future of smart villages in peri-urban territories is intimately linked to communal adeptness in leveraging smart technology potentials and adapting to the dynamic tapestry of environmental, social, and economic shifts.

Concluding with policy implications, the paper posits several recommendations for macro and micro-level planning authorities:

- Elevate existing digital infrastructures within peri-urban rural districts, addressing development

challenges through a unified regional and local development strategy.
- Enhance bandwidth provisions, offering expanded access to high-speed Internet for peripheral rural regions.
- Elevate rural decision-makers' comprehension of smart technology applications, cultivating the political resolve to pursue smart village constructs.
- Implement telemedical services for managing chronic conditions and spearheading preventive health initiatives.
- Foster the adoption and production of renewable energy sources, advocating for their widespread use within the peri-urban rural populace.
- Prioritize enhancing digital literacy across rural demographics, with a tailored focus on the "digital proficiency" requisite for the aging population in these communities.

The presented propositions offer a roadmap to actualize the smart village vision, fostering an inclusive, sustainable, and technologically integrated future for peri-urban settlements.

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**Authors' contributions**

The authors equally contributed to the preparation of this article.

**Conflict of interest**

The authors declare no conflict of interest.

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# تدوین سناریوهای اثرگذاری رهیافت روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری کلانشهر تهران (مطالعه موردی: روستاهای شهرستان اسلامشهر)

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## چکیده مبسوط

### ۱. مقدمه

روستای هوشمند از جمله راهبردهایی است که زمینه‌ساز بستر پایداری روستاها در قالب نظریه توسعه پایدار است. رهیافت روستای هوشمند میتواند مسیری را برای برون رفت از ناپایداری برای پایداری سکونتگاههای پیراشهری فراهم نماید. در پایان می‌توان گفت محدوده اسلامشهر، مقصد خیل مهاجران از نقاط دور و نزدیک پایتخت بوده است. قیمت نسبتاً ارزان مسکن و اجاره خانه و کم بودن فاصله از کلان‌شهر در کنار نرخ بالای رشد جمعیت بدان نقش خوابگاهی داده است این امر در کنار انجام فعالیت های اقتصادی (کشاورزی و فعالیت‌های صنعتی ، ..) وجه غالب و نکته مشترک این عرصه‌ها به شمار می‌رود. با توجه به محدود بودن مطالعات صورت گرفته در زمینه روستای هوشمند، در پژوهش پیش رو با رویکرد آینده پژوهانه نسبت به تبیین سناریوهای اثرگذار رهیافت روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری است. بنابراین پژوهش حاضر در پی پاسخ گویی به این پرسش است که سناریوهای پیش روی اثرگذاری رهیافت روستای هوشمند بر پایداری سکونتگاه‌های روستایی پیراشهری کلان‌شهر تهران (شهرستان اسلامشهر) در افق ۱۴۱۲ کدام است؟

### ۲. مبانی نظری و ادبیات پژوهش

روستای هوشمند یکی از مفاهیم روستاهای توسعه‌یافته در هند بود. یک مدل دهکده هوشمند از یک مدل از شهر هوشمند پیروی کردکه به‌عنوان تأثیر فناوری یکپار چه در مناطق دورافتاده اجرا می‌شود. هدف روستای هوشمند کمک به حل همه مشکلات از طریق اجرای فناوری اطلاعات و ارتباطات و سیستم اطلاعات جغرافیایی بود. یک روستای هوشمند جامعه‌ای در مناطق روستایی است که از ارتباطات دیجیتالی،راه‌حل‌ها و منابع برای توسعه و تحول خود در جهت دستیابی به اهداف توسعه پایدار استفاده می‌کند. مدل روستای هوشمند مبتنی بر مفهوم "دسترسی به اطلاعات برای همه" که در آن خدمات فناوری اطلاعات و ارتباطات (فناوری اطلاعات و ارتباطات) به‌راحتی توسط روستاییان از طریق برنامه قابل‌دسترسی بود. مدل روستای هوشمند توسعه‌یافته توسط ویزوانادهام و ودولابه‌عنوان اکوسیستم روستای هوشمند نامیده شد که ۴ جنبه را پوشش می‌دهد. ۱) موسسه ۲) منابع ۲) زنجیره خدمات ۴) فناوری‌ها و مکانیسم ارائه خدمات. علاوه بر این، ۷ محور اصلی در روستای هوشمند شامل اقتصاد،فناوری اطلاعات و ارتباطات،مردم، حکومت، محیط‌زیست، زندگی و انرژی وجود داشت. روستای هوشمند به دلیل آگاهی از فناوری اطلاعات و ارتباطات وجود داشت که می‌تواند به‌عنوان ابزاری برای توسعه اقتصادی محلی مورداستفاده قرار گیرد.

### ۳. روش تحقیق

روش تحقیق در این پژوهش مجموعه ای از روش های توصیفی-تحلیلی است. از جنبه هدف، این پژوهش کاربردی است و به سبب اینکه با ابزار سناریونویسی در پی شناسایی عوامل بررسی اثرگذاری رهیافت روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری کلان‌شهر تهران است روش تحقیق را می توان ترکیبی از روش های

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کمی و کیفی دانست. در این پژوهش نیز به‌منظور رسیدن به اهداف تحقیق و دستیابی به رهیافت روستای هوشمند در سکونتگاه‌های پیراشهری محقق نیازمند جمع‌آوری اطلاعات از جامعه دانشگاهی و سازمانی و اداری بود. بنابراین، جامعه آماری این پژوهش برای ارزیابی و اولویت‌بندی عوامل کلیدی اثرگذاری رهیافت روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری متخصصان آگاه به موضوع تحقیق در دانشگاه شهید بهشتی، دانشگاه تهران، راه و شهرسازی، شهرداری، فرمانداری و بنیاد مسکن انقلاب اسلامی بود. مؤلفه‌های مؤثر بر رشد هوشمند سکونتگاه‌های روستایی، که از پژوهش‌های پیشین استخراج‌شده بود، برای تعیین میزان اهمیت آن‌ها در اختیار اعضای خبرگان قرار گرفت. همچنین از آنان خواسته شد ایده‌های خود را درباره عواملی که در این فهرست قرار ندارد ارائه کنند. بنابراین، با مطالعه پیشینه داخلی و خارجی پژوهش ابتدا فهرستی از زیر شاخص‌ها تهیه شد و سپس با نظر نگارندگان این زیر شاخص‌ها در ۵ بعد قرار گرفت. مجموعه عواملی (۵۷ عامل) که در گام اول پیشنهادشده بود برای تعیین میزان اهمیت در اختیار نخبگان قرار گرفت. برای این منظور تعداد ۳۵ نفر از متخصصان با روش گلوله برفی انتخاب شدند. به‌منظور عملیاتی کردن مفهوم نظری متغیر از ۵۷ گویه رشد هوشمند سکونتگاه‌های روستایی استفاده شد که از طریق پرسشنامه از استادان و کارشناسان در قالب پرسشنامه و ماتریس‌های تأثیرگذاری میک مک تکمیل و استخراج و در مرحلهٔ بعد برای تنظیم سناریوهای اثرگذاری رهیافت رشد هوشمند بر پایداری سکونتگاه‌های پیراشهری از روش تحلیل تأثیر متقابل متعادل و نرم افزار سناریوویزارد استفاده شد.

## ۴. یافته‌های پژوهش

نتایج تحقیق نشان داد تعداد خیلی زیاد سناریوی ممکن پیش روی اثرگذاری روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری کلان‌شهر تهران در محدوده شهرستان اسلامشهر وجود دارد که از بین آن‌ها، تعداد ۱۴ سناریو با سازگاری ضعیف و تنها ۱ سناریو در حالت سازگاری قوی و پایدار (ناسازگاری صفر) قرار دارد. سناریوی اول که یک سناریو با جهت مثبت است، دارای مجموع امتیاز اثر متقابل ۷۳۳ و ارزش سازگاری ۱۳ است، درحالی‌که سناریوی دوم که گویای شرایط نامطلوب برای آینده برای اثرگذاری روستای هوشمند بر توسعه پایدار است، دارای مجموع امتیاز اثر متقابل ۱۴۴-و ارزش سازگاری ۵ است. سناریو سوم نیز دارای ارزش سازگاری -۲ بوده و با امتیاز مجموع اثر متقابل ۶۳ می‌تواند از سناریوهای اثرگذاری روستای هوشمند بر پایداری سکونتگاه‌های پیراشهری کلان‌شهر تهران محسوب گردد.

## ۵. بحث و نتیجه‌گیری

بی‌توجهی به تغییرات فناوری که یکی از ارکان روستای هوشمند محسوب می‌شود کارایی یک سکونتگاه روستایی را برای اقشار ساکن روستا به‌ویژه قشر تحصیل‌کرده در نازل‌ترین درجه قرار می‌دهد و موجب مهاجرت بیشتر آن‌ها می‌شود .محدودیت در زمینه فناوری، اشتغال. اقتصاد و رفاه ساکنان روستایی را تحت تاثیرمنفی قرار می‌دهد و محدودیت زمانی و مکانی را بیشتر می‌کند. روستای هوشمند" فعالیت‌های طولانی‌مدت اجتماعی ، اقتصادی و رفاهی و زیست‌محیطی را برای جامعه روستا فراهم می‌کند که باعث می‌شود مشارکت گسترده در فرآیندهای حاکمیت محلی و ارتقاء کارآفرینی فراهم شود. هر چه میزان اثر گذاری شاخص های روستای هوشمند افزایش یابد ، میزان اثرات ابعاد محیطی - اکولوژیک، اجتماعی، اقتصادی و فیزیکی افزایش یافته و درنتیجه عملکرد روستاییان در زمینه توسعه پایدار افزایش یافته ودر مقابل با کاهش میزان اثرگذاری شاخص ها روستای هوشمند، میزان عملکرد روستاییان در فرآیند توسعه پایدار روستایی نیز کاهش خواهدیافت. بنابراین بهبود و ارتقاء وضعیت شاخص های روستای هوشمند میتواند زمینه توسعه پایدار روستایی را فراهم کند.

**کلیدواژه‌ها:** آینده‌پژوهی، پیشران‌ها، روستای هوشمند، سکونتگاه‌های پیراشهری، سناریونویسی.

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