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Assessment of the social, economic, and environmental sustainability of garden cities surrounding Zanjan City, Iran

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ABSTRACT

Urban agriculture, as a sustainable and innovative approach to resource management, focuses on the optimal use of available spaces within and around cities for agricultural production and on strengthening the connection between citizens and nature. Accordingly, the main objective of this study was to assess the sustainability of garden cities surrounding Zanjan City, Iran with an emphasis on social, economic, and environmental dimensions. The statistical population of the study consisted of the owners of garden cities around Zanjan City (N = 4,896). The sample size was determined to be 253 individuals using Cochran's formula and was selected using proportionate stratified random sampling. Data were collected using a researcher-made questionnaire, the validity of which was confirmed by a panel of experts. To examine the reliability of the research instrument, Cronbach's alpha was used, yielding acceptable values ranging from 0.926 to 0.947 for different sections of the questionnaire. The results of the analysis indicated that in the garden cities surrounding Zanjan City, social sustainability was at a high level, while economic sustainability and environmental sustainability were at a moderate level.

Keywords: Garden city; sustainability; sustainable development; Zanjan City; urban agriculture.
Article type: Research Article.

INTRODUCTION

In classical urban planning literature, the term "Garden City" refers to the model proposed by Ebenezer Howard, which emphasizes planned and self-contained urban settlements integrating urban and rural functions. However, in the context of this study, the term does not refer to the Howardian planning model. Instead, it denotes small-scale peri-urban garden plots in Zanjan that are privately owned and mainly used for recreational, subsistence, or semi-commercial agricultural activities. Therefore, the concept is operationalized here as peri-urban garden holdings rather than formally designed urban settlements. The present century is the century of cities and urbanization. The phenomenon of urbanization has very extensive economic and social impacts and consequences (Maleki-Nejad *et al.* 2020). Undoubtedly, with the expansion of cities and the growth of the urban population, demand for food has increased (Darikvand *et al.* 2021). According to assessments of the global urbanization outlook in 2016, the world's urban population increased from 0.57 billion (29.4% of the world's population) in 1950 to 4.21 billion (55.3%) in 2018, and it is expected to reach 6.25 billion (67.2%) by 2050. The decline in rural populations and the growth of urban populations have caused a large share of the world's producing population to turn into consumers. Over the course of the present century, due to the disruption of this balance, food crises have become one of the major challenges of urbanization (United Nations, 2018). In this context, societies face reduced production—mainly carried out by rural populations, which leads to the spread of food insecurity (Poulsen *et al.* 2015). Agriculture has always been the primary provider of human food and has ensured food security for societies. Moreover, scholars consider strengthening the relationship between urban residents and nature, a relationship that has been partially severed in urban life, as one of the main ways to address the problems of urbanization (Maleki-Nejad *et al.* 2020). Today, given rapid population growth, urbanization, food insecurity, and climate change, urban agriculture can be used to support the economic, social, and environmental sustainability of cities (Azunre *et al.* 2019; Cheng *et al.* 2022; Mutambisi *et al.* 2022; Fanfani *et al.* 2022; Benedetti *et al.* 2023). Urban agriculture is expanding worldwide and can provide numerous quantitative and qualitative benefits for urban residents (Valipoor *et al.* 2013). The aim of urban agriculture is the cultivation of edible plants and fruit trees on urban farms (Cheng *et al.* 2022) and in peri-urban areas (Zezza *et al.* 2010; Zasada 2011; FAO 2020; Gustavsen *et al.* 2021). The development of peri-urban agriculture plays an important role in enhancing socio-economic benefits, providing food for local residents, and preserving urban ecosystems, which are conceived both as a "resource" and a "protective element" (La Rosa *et al.* 2014; Huang *et al.* 2018). Urban agriculture, as one of the approaches to green city development, can play a fundamental role in sustainable urban development. It represents a system in which, through proper management of natural resource use within cities, citizens' food needs can be met while maintaining environmental quality and preventing the degradation of natural reserves (Rahimi *et al.* 2022). Establishing a rational and sustainable relationship among humans, the city, and nature, an interpretation of the concept of sustainable development from an urban-environmental design perspective, is one of the ways to combat urban pollution (Azani *et al.* 2012). Thus, sustainable urban development is based on the rational use of natural resources, considering environmental, economic, and social dimensions simultaneously (Cahya 2016). From the environmental perspective of sustainable development, urban agriculture provides benefits such as improving climatic conditions (Mendes *et al.* 2008; Azunre *et al.* 2019; Payen *et al.* 2022), responding to global threats including environmental crises (Mendes *et al.* 2008; Rahimi *et al.* 2022), protecting land and preventing soil erosion, lowering air temperatures (Wahab *et al.* 2023), reducing air pollution (Mendes *et al.* 2008; Saleem *et al.* 2022), conserving urban biodiversity (Lin *et al.* 2017; Ministry of Interior Research Office 2021; Rahimi *et al.* 2022), mitigating the urban heat island effect (Mendes *et al.* 2008; Barthel &Isendahl 2013; Kazemi *et al.* 2022), recycling waste and organic materials (Mendes *et al.* 2008; Timouri *et al.* 2019), saving energy (Mendes *et al.* 2008; Ministry of Interior Research Office 2021), utilizing unused water and soil resources, improving water management (Mendes *et al.* 2008; Barthel & Isendahl 2013; Richman, 2015; Vyawahare 2016), and creating pleasant landscapes (Mendes *et al.* 2008). From the social dimension of sustainable development, urban agriculture can also play a significant role by extension and improving environmental justice in marginal and poorer areas, fostering a sense of attachment through plant cultivation between space and people (Rahimi *et al.* 2022), extension social cohesion (Angotti 2015; Langemeyer *et al.* 2021), increasing participation (Timouri *et al.* 2019), enhancing social welfare and social capital (Hamidi *et al.* 2015; Ebadi *et al.* 2021), and improving food security (Angotti 2015; Opitz *et al.* 2016; Kazemi *et al.* 2018; Sarker *et al.* 2019; Lai 2020; Steenkamp *et al.* 2021; Payen *et al.* 2022; Rahimi *et al.* 2022). From an economic perspective, urban agriculture can contribute to sustainability through job creation (Kazemi *et al.* 2018; Hosseinpour *et al.* 2018; Timouri *et al.* 2019; Lai 2020; Rahimi *et al.* 2022), the development of new professions (Pourjavid *et al.* 2011; Hamidi *et al.* 2015; Ministry of Interior Research Office 2021), poverty reduction, increased household income (Van Tuijl *et al.* 2018; Azunre *et al.* 2019; Lai 2020), energy efficiency (Gill *et al.* 2007; Guo-yu *et al.* 2013), production of goods and services, filling gaps in food marketing and distribution, and reducing transportation and transit costs of food products (Pourjavid *et al.* 2011; Rahimi *et al.* 2022). In recent years, numerous studies have been conducted inside and outside the country in this field. Rahimi & Dehri (2022) concluded that urban agriculture has various ecological and economic functions and that preserving and developing it is essential for achieving sustainable urban development. Darikvand *et al.* (2021) identified economic investment, infrastructure development, innovation, empowerment, and institutional development as key factors in sustainable urban and peri-urban agriculture. Ebadi & Mohabi (2021) showed that urban gardening projects increase social interaction, participation, and family cohesion. Yadavari *et al.* (2020) found that urban agriculture positively affects perceptions of agriculture's role in cities and improves quality-of-life indicators. Timouri & Shami (2019) emphasized the feasibility of urban agriculture across all urban contexts with minimal investment. Hosseinpour & Kazemi (2018) highlighted its role in strengthening human–nature relationships and providing new recreational opportunities. Other studies have similarly demonstrated the social, economic, and environmental benefits of urban agriculture, including enhanced livelihoods, resilience, participation, and sustainable food production (e.g., Barthel & Isendahl 2013; Azunre *et al.* 2019; Tang *et al.* 2020; Payne *et al.* 2022). In Iran, urban agriculture can serve as a complementary strategy to reduce urban poverty and enhance environmental management while improving food security and local economic development, particularly by engaging women and marginalized groups (Maleki-Nejad *et al.* 2020). However, unlike some countries, interest and knowledge regarding urban agriculture in Iran remain limited, and many urban planners oppose it due to concerns about pollution, lack of knowledge, or economic reasons (Hosseinpour *et al.* 2022). In Zanjan City, despite relatively stable population growth between 1996 and 2016, the proportion of the city's population relative to the total provincial population has increased significantly (Yargholi *et al.* 2018). Between 1984 and 2011, approximately 4,329 hectares of peri-urban land around Zanjan experienced land-use change due to urban expansion into agricultural lands and orchards. Residential areas expanded from 4,662 hectares in 2011 to 5,550 hectares in 2020 (Malakarmi *et al.* 2024). Agricultural lands in the peri-urban areas of Zanjan face critical water resource conditions, requiring special protective measures to prevent land-use change (Ahadnejad Reveshty, 2011). One potential response is the purposeful integration of agriculture into the urban landscape (Sharghi *et al.* 2016). According to statistics from the Zanjan Provincial Agricultural Organization, 53 garden cities have been identified in Zanjan Province, 47 of which are located around Zanjan City, comprising 5,413 plots on agricultural land. It is widely believed that in these garden cities, basic resources such as water and soil are used unsustainably and that they are in an unstable economic, social, and environmental condition. Therefore, the present study aims to evaluate the social, economic, and environmental sustainability of peri-urban garden plots in Zanjan. Unlike classical interpretations of garden cities, this research focuses on small-scale peri-urban agricultural holdings in a semi-arid context. This study contributes to the limited empirical evidence on sustainability assessment of peri-urban garden plots in semi-arid Iranian cities. Accordingly, this study seeks to address the question of the sustainability status of existing garden cities. For the first time, this research evaluates the sustainability of Zanjan's garden cities by focusing on the 47 peri-urban garden cities and demonstrates how urban agriculture can serve as a tool to counter land-use change in Iran; an aspect largely neglected in previous studies.

MATERIALS AND METHODS

The present study is quantitative in nature. In terms of data collection and analysis, it is a non-experimental survey research, and with regard to its objective, it is considered an applied study. The statistical population consisted of the owners of garden cities in Zanjan County (N = 4,896). The sample size was calculated as 253 individuals using Cochran's formula; however, to increase the confidence level, the sample size was increased to 279 respondents. The participants were selected using proportionate stratified random sampling. The strata were defined based on the location of the garden cities (urban fringe or sphere of influence).

To assess the face validity of the research instrument, interviews were conducted with a number of individuals from the statistical population, and based on their feedback, modifications were made to the appearance and wording of the questionnaire items. Data were collected using a researcher-made questionnaire, and its content validity was confirmed by a panel of experts in the relevant field. To determine the reliability of the questionnaire, Cronbach's alpha coefficient was used, which exceeded 0.90 for all sections of the questionnaire (Table 1), indicating good reliability for measuring the research variables.

Table 1. Results of reliability assessment of the data collection instrument.

No.	Variables	Number of items	Cronbach's Alpha
1	Social Sustainability Index	17	0.944
2	Economic Sustainability Index	23	0.947
3	Environmental Sustainability Index	20	0.926

The questionnaire consisted of several sections, including individual characteristics, social sustainability, economic sustainability, and environmental sustainability indicators. These variables were measured using a Likert scale (Table 2). Data processing and analysis were conducted in two stages—descriptive and inferential statistics—using SPSS software (version 26).

Table 2. Components of the Research Questionnaire.

Section	Number of Items	Scale	Sources
Individual Characteristics	Gender, age, place of birth, plot area, farming or gardening experience, level of familiarity with gardening, education level	Nominal – Interval – Ordinal	Maleki-Nejad *et al.* 2020; Teymouri *et al.* 2019; Khodadadian & Shahedi 2021

	, occupation, name of the garden city, place of residence in the city, Number of household guests in the garden city production compared to other farmers, economic yield of the garden city		
Social Sustainability Indicators	1. Provision of space and opportunities for leisure activities for family, relatives, and friends; 2. Increased capacity in agricultural knowledge (types of crops, production methods, etc.); 3. Creation of a calming environment for physical and sports activities (e.g., walking); 4. Strengthening social gatherings and local and indigenous culture (customs, games, etc.); 5. Greater sense of security for families compared to external green spaces and gardens around the city; 6. Increased satisfaction, mental peace, and psychological well-being for individuals and their families; 7. Reduction of stress and anxiety caused by urban life; 8. Increased sense of self-worth and self-confidence; 9. Extension of creative thinking and creativity; 10. Increased interaction with local and rural communities; 11. Enhanced sense of belonging, mutual trust, and social cohesion; 12. Provision of space and opportunities for interaction and cultural exchange; 13. Increased participation, social responsibility, and cooperation; 14. Organization of social and ceremonial events; 15. Provision of an appropriate environment for active aging and physical and mental health; 16. Provision of agricultural tourism services based on crop-harvesting experiences; 17. Increased interest and curiosity in acquiring knowledge about healthy agricultural product	Ordinal	Hamilton *et al.* 2013; Walker, 2015; Peng *et al.* 2015; Azunre 2019; Grahn & Stigsdotter 2003; Hynes & Howe 2004; Brown & Jameton 2000; Hamidi *et al.* 2015; Hosseinpour *et al.* 2022; Ebadi *et al.* 2021; Nazemi-Rafi *et al.* 2020
Economic Sustainability Indicators	1. Creation of local markets for selling garden city products; 2. Potential for establishing agricultural greenhouses in the future; 3. Production of processed products (e.g., jam, raisins, dried fruits); 4. Provision of temporary employment for skilled workers and laborers (agricultural, construction, etc.); 5. Supplying surplus agricultural products to urban markets and sales centers; 6. Reduction of travel-related costs by meeting family recreational needs through the garden city; 7. Shortening the distance between production and consumption (reduced transportation costs); 8. Reduced need for storage due to fresh consumption of agricultural and horticultural products; 9. Reduction in household expenses due to self-production; 10. Economic justification of production in the garden city; 11. Reduction of gardening labor costs through family labor; 12. Economic and efficient use of inputs (fertilizers, pesticides, etc.); 13. Use of modern methods in garden management; 14. Economic and efficient irrigation practices; 15. Economic and efficient fertilization management; 16. Economic and efficient pest and disease control; 17. Economic and efficient harvesting and marketing of garden city products; 18. Use of soil test results in garden management; 19. Assurance of producing and consuming healthy products (with minimal chemical inputs); 20.	Ordinal	Mendes *et al.* 2008; Deelstra & Girardet 2000; Lai 2020; Azunre 2019; Cahya 2016; Angotti 2015; Hynes & Howe 2004; Brown & Jameton 2000; Ellis & Sumberg 1998; Zezza & Tasciotti 2010; Badami & Ramankutty 2015; Golden 2013; Draper & Freedman 2010; Kulak *et al.* 2013; Rajan & Duncan 2013; Pourjavid *et al.* 2011; How & Wheeler 1999; Prain & Lee-Smith 2010; Kazemi *et al.* 2018; Hamidi *et al.* 2015; Teymouri *et al.* 2019; Ministry of Interior 2021; Rahimi *et al.* 2022; Hosseinpour *et al.* 2018

	Provision of space for cultivating medicinal plants; 21. Distribution of surplus agricultural products among people in need; 22. Improvement of irrigation systems to reduce consumption and increase efficiency		
Environmental Sustainability Indicators	1. Enhancement of environmental responsibility; 2. Increased awareness, education, and learning about environmental protection; 3. Gaining practical and personal experience in environmental conservation; 4. Cooperation with individuals and organizations for environmental protection; 5. Improved waste management, including separation of dry and wet waste and recycling hazardous waste (e.g., pesticide containers); 6. Production and use of compost from garden-generated waste; 7. Use of solar panels or other renewable energy sources; 8. Reduction of air pollution by preventing dust sources around the city; 9. Reduced use of chemical pesticides and adoption of sustainable production methods; 10. Use of environmentally friendly construction materials; 11. Reduced use of single-use materials; 12. Reuse of wash water in the garden; 13. Use of rainwater harvesting systems for irrigation; 14. Regular maintenance of irrigation systems to prevent leakage and water loss; 15. Building insulation to reduce energy demand; 16. Use of smart technologies for managing and controlling energy consumption; 17. Use of electrical appliances with high energy-efficiency ratings; 18. Increased interaction with nature and the environment; 19. Increased environmental knowledge and awareness; 20. Enhanced connection with nature and experience of seasonal natural changes; 21. Development of green belts and green spaces around the city	Ordinal	Beilin & Hunter 2011; Camps-Calvet *et al.* 2016; Schreinemachers *et al.* 2019; Langemeyer *et al.* 2018; Mendes *et al.* 2008; Deelstra & Girardet 2000; Greafe 2019; Lai 2020; Ackerman *et al.* 2014; Azunre 2019; Gill *et al.* 2007; Voiland 2010; Guo-yu *et al.* 2013; Buehler & Junge 2016; Close & Lam 2006; Woodford 2018; Grahn & Stigsdotter 2003; Hynes & Howe 2004; Brown & Jameton 2000; Maleki-Nejad *et al.* 2020; Teymouri *et al.* 2019; Khodadadian & Shahedi 2021; Ministry of Interior 2021; Hosseinpour *et al.* 2018; Nazemi-Rafi *et al.* 2020

Note: Six-point Likert scale: None (0), Very Low (1), Low (2), Moderate (3), High (4), Very High (5).

RESULTS AND DISCUSSION

Demographic characteristics of the study population

The study population of garden city owners was 25.4% female, with the remainder being male. The 41–60 age group was most frequent (61.4%), with ages ranging from 21 to 80 years (Table 5). In terms of place of birth, 90% of the garden city owners were born in urban areas. The plot area of the garden cities for the majority of owners (91.4%) ranged between 1,000 and 2,000 m^2. A total of 167 owners (59.9%) had no prior experience in farming or gardening. Gardening familiarity was highest among 45.5% of respondents (127 individuals). All respondents were literate, with approximately 79% holding university degrees. Government employees comprised 34.8% of owners (97 individuals), followed by retirees at 27.2%. Additionally, 57.4% of the studied garden cities were located in urban fringe areas (Table 12). Regarding residence, 50.8% of owners lived in apartments, and 2.2% (6 individuals) lived in residential complexes (Table 13). Excluding the owner, the garden city households ranged from 0 to 30, with 1–5 households being most common (57.3%; Table 14). Furthermore, 51.6% of owners felt garden city production costs were higher than those of other farmers, while 29.4% considered the economic return to be moderate. Garden city ownership and management are predominantly male, with middle-aged individuals comprising the largest user demographic, suggesting a primarily urban rather than rural utilization. Garden plots typically range from 1,000–2,000 m^2, indicating small, often recreational, gardens managed by inexperienced individuals. Over half of garden owners lack prior farming experience, emphasizing the non-productive nature of these spaces. Economically, most respondents found production costs higher compared to other farms, with only 29.4% reporting moderate economic returns. This suggests weak economic viability and limited perception of garden cities as sustainable production areas, likely due to the high costs associated with small plots (averaging 1,377 m^2), a challenge previously noted by Kazemi *et al.* (2018) regarding small-scale urban agriculture. The garden city owners were highly educated, with all being literate and most holding university degrees. They were primarily salaried employees or retirees. Over half were affiliated with urban residential environments, suggesting garden cities serve as spaces for family and collective gatherings in addition to their individual functions. Spatially, over half were located on the urban fringe, highlighting their increasing recreational and residential roles within urban life due to their proximity to the city.

Table 3. Frequency distribution of the garden city owners based on individual characteristics (n = 279).

Variable	Category/Group	Frequency	Valid (%)	Cumulative (%)	Other Statistics
Gender of garden city owner	Male	208	74.6	—	—
	Female	71	25.4	100	—
Age of garden city owner	21–40	63	22.7	22.7	Mean = 48.8, SD = 11.1, Mode = 50
	41–60	170	61.4	84.1	—
	61–80	44	15.9	100	—
Place of birth	Rural	28	10	10	—
	Urban	251	90	100	—
Plot area (m²)	<1000	8	2.9	2.9	Mean = 1377.47, SD = 816.89, Mode = 1000
	1000–2000	255	91.4	94.3	—
	>2000	16	5.7	100	—
Agricultural experience	Yes	112	40.1	40.1	—
	No	167	59.9	100	—
Familiarity with gardening	None	24	8.6	8.6	—
	Very Low	29	10.4	19	—
	Low	51	18.3	37.3	—
	Medium	127	45.5	82.8	—
	High	37	13.3	96.1	—
	Very High	11	3.9	100	—
Education level	Illiterate	0	0	0	—
	Basic Literacy	2	0.7	0.7	—
	Secondary School	8	2.9	3.6	—
	High School Diploma	49	17.6	21.2	—
	Associate Degree	31	11.1	32.3	—
	Bachelor's Degree	108	38.7	71	—
	Master's Degree	57	20.4	91.4	—
	PhD	24	8.6	100	—
Occupation	Employee	97	34.8	34.8	—
	Private Sector	34	12.2	47	—
	Merchant	20	7.2	54.2	—
	Self-employed	52	18.6	72.8	—
	Retired	76	27.2	100	—
Location of garden city	Urban Fringe	160	57.4	57.4	—
	Urban Influence Area	119	42.6	100	—
Residence type	Apartment	142	50.8	50.8	—
	Villa	131	47	97.8	—
	Residential Complex	6	2.2	100	—
Number of households using garden (excluding owner)	None	15	5.4	5.4	Mean = 5.6, SD = 7.5, Mode = 5
	1–5	160	57.3	62.7	—
	6–10	74	26.5	89.2	—
	>10	30	10.8	100	—
Production cost compared to other farmers	Higher	144	51.6	51.6	—
	Same	58	20.8	72.4	—
	Lower	77	27.6	100	—
Economic return of garden city	None	61	21.8	21.8	—
	Very Low	50	17.9	39.7	—
	Low	65	23.3	63	—
	Medium	82	29.4	92.4	—
	High	18	6.5	98.9	—
	Very High	3	1.1	100	—

Prioritization of items related to sustainability indicators

As shown in the results presented in Table 4, within the social dimension, greater feelings of family safety compared to outdoor green spaces and gardens around the city, increased satisfaction, mental and psychological calm for individuals and their families, and the reduction of stress and anxiety caused by urban life were identified as the most important indicators of social sustainability. Economically, ensuring confidence in the production and consumption of healthy products (with minimal use of chemical fertilizers and pesticides) and reducing travel-related costs by meeting family recreational needs through garden cities were reported as the most important indicators of economic sustainability. Environmentally, increased interaction with nature, enhanced connection with the natural environment, and experiencing natural changes throughout the year were identified as the highest-ranked indicators of environmental sustainability. From the perspective of garden city owners, the social sustainability of garden cities, with a mean value of 3.56, was assessed as moderate to high. The mean score of items related to the economic sustainability indicator was 1.41, indicating that the economic sustainability of the studied garden cities is perceived as very low to low. Meanwhile, the environmental sustainability indicator, with a mean value of 2.94, was evaluated as being at a moderate level. An assessment of sustainability indicators in garden cities reveals varying conditions across the three main dimensions: social, economic, and environmental. Social sustainability indicators, including family safety in green spaces, increased satisfaction, psychological comfort, and reduced urban stress, were particularly notable. This suggests that garden cities effectively enhance residents' social and psychological well-being. A mean value of 3.56 indicates a moderate to high level of social sustainability from the respondents' perspective. Economic sustainability received low ratings. While strengths included healthy product production with minimal chemicals and reduced recreational travel costs, a mean value of 1.41 reveals a very low to low level of sustainability. Thus, the economic dimension of garden cities needs focused policies and significant support for improvement. Garden cities foster human-nature connections, scoring moderately (2.94) on environmental sustainability. While positive, improvements are needed in resource conservation and reducing environmental pressures. Garden cities excel socially, reducing psychological stress and enhancing well-being. However, weaknesses in the economic dimension, coupled with the moderate environmental performance, necessitate supportive policies, especially to bolster economic sustainability, for holistic sustainable development.

Table 4. Descriptive results of sustainability indicators.

Dimension	Item	Mean*	SD	Rank
Social	Family security compared to external green spaces and surrounding gardens	4.35	0.863	1
	Increased satisfaction and psychological well-being of self and family	4.19	0.963	2
	Reduction of stress and anxiety caused by urban life	4.15	0.963	3
	Increased sense of self-worth and self-confidence	4.0	0.956	4
	Provision of space and opportunity for family/friends leisure	3.92	1.113	5
	Creation of a relaxing environment for physical and sports activities (e.g., walking)	3.91	1.108	6
	Provision of appropriate environment for active aging and physical/mental health	3.84	1.232	7
	Strengthening social gatherings and local cultural traditions	3.79	1.179	8
	Encouraging creative thinking and innovation	3.67	1.057	9
	Enhancement of agricultural skills (types of products, production methods, etc.)	3.42	1.116	10
	Increasing social participation, responsibility, and cooperation	3.4	1.149	11
	Strengthening belonging and mutual trust in the community	3.38	1.112	12
	Fostering interest in learning about healthy agricultural products	3.26	1.292	13
	Providing space for cultural exchange and interaction	3.24	1.254	14
	Organizing social and ceremonial events	2.98	1.314	15
	Increasing connections with local and rural communities	2.94	1.423	16
	Offering agri-tourism services based on harvest experiences	2.16	1.487	17
Economic	Ensuring safe production and consumption of products (minimal chemical fertilizers/pesticides)	3.56	1.374	1
	Reducing travel-related costs through garden-based recreation	3.22	1.374	2
	Improving irrigation methods to reduce consumption and increase efficiency	3.1	1.429	3
	Distributing surplus agricultural products to the needy	3.07	1.506	4
	Reducing household expenses by replacing purchased products	3.04	1.421	5
	Reducing storage needs due to fresh consumption	2.94	1.582	6
	Providing temporary employment for skilled workers	2.9	1.429	7
	Using modern management techniques in the garden	2.94	1.293	8
	Economic and efficient use of inputs (fertilizers, pesticides, etc.)	2.87	1.237	9
	Producing processed products (jam, dried fruits, etc.)	2.82	1.528	10
	Efficient pest and disease management	2.81	1.208	11
	Reducing labor costs through family workforce	2.75	1.494	12

	Efficient irrigation management	2.74	1.295	13
	Reducing the distance between production and consumption	2.73	1.455	14
	Efficient fertilization management	2.62	1.223	15
	Economic justification for garden production	2.38	1.515	16
	Efficient harvesting and selling of products	2.37	1.318	17
	Providing space for medicinal plant cultivation	2.3	1.549	18
	Potential establishment of greenhouses	2.13	1.566	19
	Marketing surplus products to urban markets	2.07	1.548	20
	Using soil test results for garden management	1.68	1.334	21
	Establishing local markets for garden products	1.64	1.462	22
	Increasing interaction with nature and environment	4.1	0.991	1
	Enhancing connection with nature and experiencing seasonal changes	3.99	0.950	2
	Regular maintenance of irrigation systems to prevent leakage and water loss	3.8	1.502	3
	Reducing air pollution by preventing dust hotspots	3.8	1.595	4
	Increasing environmental knowledge and awareness	3.61	1.171	5
	Gaining practical personal experience in environmental conservation	3.55	1.261	6
	Promoting environmental responsibility	3.48	1.126	7
	Environmental education and learning	3.44	1.273	8
	Developing green belts around the city	3.32	1.032	9
	Improved waste management (sorting and recycling hazardous waste)	3.18	1.501	10
Environmental	Reduced use of chemical pesticides and sustainable production methods	3.03	1.415	11
	Collaboration with organizations and individuals for environmental protection	2.82	1.432	12
	Use of smart technologies for energy management	2.82	1.461	13
	Building insulation to reduce energy needs	2.65	1.428	14
	Using environmentally friendly construction materials	2.41	1.574	15
	Compost production and use from garden waste	2.3	1.513	16
	Use of high-efficiency electrical appliances	2.25	1.333	17
	Reduced use of single-use materials	2.14	1.506	18
	Reuse of wash water in the garden	2.14	1.531	19
	Rainwater harvesting and reuse for irrigation	1.55	1.599	20
	Use of solar panels or other renewable energy sources	1.43	1.531	21

*Measured using a 6-point Likert scale: None (0), Very Low (1), Low (2), Moderate (3), High (4), Very High (5)

Leveling of garden city sustainability

According to the results of the sustainability leveling of the studied garden cities (Table 5), more than two-thirds (69.2%) of them exhibit high social sustainability. Over half of the garden cities (57.3%) have moderate economic sustainability. Additionally, more than two-thirds (60.9%) of the garden cities demonstrate moderate environmental sustainability.

Table 5. Sustainability leveling of the studied garden cities.

Variable	Level	Frequency	Valid (%)	Cumulative (%)
	Low	5	1.8	1.8
Social	Medium	81	29.2	30.0
	High	193	69.2	100.0
	Low	44	15.8	15.8
Economic	Medium	160	57.3	73.1
	High	75	26.9	100.0
	Low	26	9.4	9.4
Environmental	Medium	170	60.9	70.3
	High	83	29.7	100.0
	Low	12	4.3	4.3
Overall Sustainability	Medium	158	56.1	60.4
	High	109	39.6	100.0

Correlation analysis of individual characteristics with sustainability indicators

Table 6 shows a significant positive correlation between views on social sustainability and guest households, gardening experience, and economic return, with gardening experience exhibiting the strongest correlation. Age, plot size, and education level showed no significant relationship with social sustainability. Economic sustainability is positively correlated with gardening experience, economic return, and the number of guest households, but negatively correlated with age. Economic return showed the strongest correlation with economic sustainability. Plot size and education level were not significantly related to economic sustainability. In the case of environmental sustainability, there was a significant and positive correlation with gardening experience, economic return, and the number of guest households. Based on the correlation coefficients, the economic return of garden cities had the highest correlation with the environmental sustainability indicator. Other individual characteristics examined, including age, plot size, and education level, did not show a significant correlation with environmental sustainability. Finally, regarding overall garden city sustainability, there was a significant and positive correlation with gardening experience, economic return, and the number of guest households. The economic return of the garden city exhibited the highest correlation with the overall sustainability indicator. Other individual characteristics, including education level, plot size, and age, did not show a significant relationship with overall sustainability.

Table 6. Correlation results between social sustainability indicator and individual characteristics.

Variable indicator	Age	Plot Size	Gardening experience	Education level	Number of guest households	Economic return of garden city
Social	-0.047	-0.005	0.254	-0.072	0.213	0.253
Sig	0.432	0.927	0.000	0.229	0.000	0.000
Economic	-0.131	0.099	0.301	-0.010	0.124	0.511
Sig	0.030	1.000	0.000	0.862	0.039	0.000
Environmental	-0.074	-0.077	0.233	-0.020	0.121	0.368
Sig	0.222	0.202	0.000	0.738	0.043	0.000

indicates significance at the 1% level ($p < 0.01$, 99% confidence).
indicates significance at the 5% level ($p < 0.05$, 95% confidence).

Analysing the utility of different dimensions of garden city sustainability

To examine and analyze the various dimensions of sustainability in the studied garden cities, a one-sample t-test was employed. In this process, the survey items were first grouped into three categories: social, economic, and environmental, and their averages were calculated. Then, using the one-sample t-test and considering a numerical desirability value of 2.5 based on the Likert scale, the evaluation was conducted in SPSS v.26. This approach allowed for determining the mean values of each sustainability dimension at the level of the garden cities under study. The analysis of the mean values of the different sustainability dimensions, based on the one-sample t-test, indicates that social and environmental sustainability are high at the level of the studied garden cities. As shown in Table 7, considering the range of the dimensions (0–5 on the Likert scale), the only dimension with a mean below the medium threshold (2.5) was economic sustainability economic sustainability.

Table 7. One-sample t-test results for different dimensions of garden city sustainability.

Test value (desirability threshold): 2.5							
Indicator	Mean	t-Statistic	Degrees of Freedom	Significance Level (p-value)	Difference from Desired Level	95% Confidence Interval	
						Lower Bound	Upper Bound
Social	3.5635	7.943	16	0.000	1.06353	0.7797	1.3474
Economic	1.4106	−44.000	21	0.000	−1.08936	−1.1409	−1.0379
Environmental	2.9386	2.551	20	0.019	0.43857	0.0800	0.7972

this table shows that social and environmental sustainability exceed the desired level, while economic sustainability falls below the desired threshold.

Social sustainability

The numerical analysis of the social sustainability dimension, with a mean of 3.5653, indicates that garden cities exhibit high social sustainability, exceeding the medium threshold of 2.5. This demonstrates that these garden cities are socially sustainable. Key factors contributing to social sustainability include: increased family security compared to urban green spaces and peripheral gardens, enhanced satisfaction, mental and psychological well-being of family members, reduced urban stress and anxiety, heightened self-worth and confidence, provision of spaces for family and social recreation, creation of areas for physical activities such as walking, support for active aging and physical and mental health, reinforcement of local and cultural gatherings (rituals, games, etc.), extension of creative thinking, increased agricultural knowledge and skills, enhanced social participation, responsibility, and cooperation, greater sense of belonging and trust within the community, facilitation of cultural exchange, hosting social and cultural events, and strengthening ties with local and rural communities.

Economic sustainability

The analysis of the economic sustainability dimension, with a mean of 1.4106, indicates that garden cities exhibit low economic sustainability, below the medium threshold (2.5). Contributing factors include low economic justification for production, suboptimal efficiency in harvesting and selling garden city products, limited areas for medicinal plant cultivation, future potential for greenhouse development, limited market access for surplus products, suboptimal use of soil analysis for garden management, and restricted development of local markets for garden products.

Environmental sustainability

The analysis of environmental sustainability, with a mean of 2.9386, suggests that garden cities are moderately to highly sustainable in this dimension. Key factors include increased interaction with nature, experiencing seasonal changes, regular maintenance of irrigation systems to prevent water loss, reduction of air pollution by preventing dust accumulation, increased environmental knowledge and awareness, practical experience in environmental conservation, enhanced environmental responsibility, education and learning about environmental protection, expansion of green belts around the city, improved waste management (sorting dry and wet waste, recycling hazardous materials), reduced chemical usage, adoption of sustainable agricultural methods, collaboration with organizations for environmental protection, smart energy management, and energy-efficient building practices.

DISCUSSION

Descriptive results for the sustainability indicators indicate that respondents rated social sustainability with a mean of 3.56 (medium to high), economic sustainability at 1.41 (very low to low), and environmental sustainability at 2.94 (medium). According to the classification of garden cities based on these indicators, 69.2% exhibited high social sustainability, 57.3% moderate economic sustainability, and 60.9% moderate environmental sustainability. Overall, 56.6% of garden cities showed medium overall sustainability. Comparison of different groups regarding environmental sustainability did not reveal significant differences. However, social and economic sustainability, as well as overall garden city sustainability, were significantly related to agricultural experience. Other individual variables, including gender, plot size, and education, were not significant. This aligns with Adeoti *et al.* (2012), where gender did not significantly impact economic sustainability. Agricultural experience emerged as a key factor influencing social, economic, and overall sustainability. This strong link with agriculture enhances social cohesion, local connections, and economic sustainability. Policymakers and planners can leverage these findings to promote sustainable agriculture and preserve local agricultural identity, ultimately improving residents' quality of life and environmental conservation. This result is consistent with Pretty & Smith (2004), Barthel & Isendahl (2013) and Naazie *et al.* (2024). Occupation also plays a vital role in social sustainability by strengthening social cohesion, enhancing quality of life, and promoting local participation. Sustainable and locally appropriate jobs improve economic welfare, reinforce social networks, preserve local identity, and reduce social inequality. Therefore, developing sustainable employment can be a key strategy for enhancing social sustainability in garden cities, consistent with Nigus *et al.* (2024). Correlation analysis showed a significant positive relationship between social sustainability and the variables number of guest households, agricultural experience, and economic return of the garden city, with agricultural experience exhibiting the strongest correlation. This suggests that garden city residents with more agricultural experience tend to act more sustainably socially, fostering community attachment and facilitating social and economic interactions. Similarly, guest households and economic returns directly enhance social sustainability by promoting participation and local interaction. These findings align with studies by Pretty & Smith (2004), Tonhayi & Mafakher (2015), Ilieve *et al.* (2016), Rabiei Dastjerdi *et al*. (2016), Yadavar (2020), Ebadi & Mohibi (2021), Derikvand *et al.* (2021). Economic sustainability was significantly and positively associated with agricultural experience, economic returns, and number of guest households, and negatively with age. Economic return showed the strongest correlation, highlighting its critical role in economic sustainability. Guest household participation and agricultural experience further reinforce economic resources and productivity. The inverse relationship with age indicates that older participants may have reduced economic output due to physical or managerial limitations. These results align with Tiraieyari *et al.* (2019) and Payen *et al.* (2022).

Environmental sustainability and overall garden city sustainability were positively correlated with agricultural experience, economic return, and guest household participation, with economic return showing the strongest relationship. This indicates that improved financial resources enable sustainable management of natural resources, reducing environmental pressures. Agricultural experience promotes efficient and sustainable resource use, while guest household involvement fosters environmental awareness. These findings are consistent with Tittonell (2014).

CONCLUSION

The study revealed that garden cities around Zanjan, as a form of peri-urban agriculture, have high social sustainability but face challenges in economic and environmental dimensions. Social sustainability (69.2%) is driven by enhanced family security, reduced urban stress, and strengthened local interactions. Economic sustainability is low (mean 1.41), while environmental sustainability is moderate (mean 2.94). More than half of the garden cities (56.6%) have medium overall sustainability. Agricultural experience, economic returns, and guest household participation are key factors for improving all dimensions of sustainability. These findings fill a research gap in assessing garden city sustainability in Iran and indicate that peri-urban agriculture can effectively combat land-use change while improving urban quality of life.

Recommendations for enhancing Garden City sustainability:

Transform garden cities into small-scale production and distribution centers for local products;

develop processing and packaging industries to boost economic efficiency and create jobs.

Improve connections to urban and regional markets via transport and digital marketing networks to enhance profitability.

Provide regular technical and managerial training for garden city owners to improve productivity, reduce waste, and enhance economic and environmental sustainability.

Adopt modern agricultural methods (e.g., ecological or conservation agriculture) to improve resource efficiency and reduce environmental impacts.

Encourage household participation in local social and economic activities to strengthen social sustainability.

Create spaces for guest households to participate in gardening and establish family gardens to extension agricultural culture and social cohesion.

Implement efficient irrigation systems (e.g., drip or smart irrigation) and renewable energy sources like solar power to reduce resource consumption and environmental impacts.

Extension the use of organic fertilizers and agricultural waste recycling systems to maintain soil health and reduce environmental pollution.

These strategies can enhance economic, social, and environmental sustainability, improve residents' quality of life, and protect natural resources in garden cities.

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