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The role of rural–urban linkages in perceived environmental effects of farmers for participation in sustainable food security plans

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Abstract

Background: This study examines the rural–urban linkages about the perceived farmers' environmental effects of food security plans to participate in these plans in Iran's rural areas. We have also considered the mediating role of farmers' empowerment as the capacity of rural–urban linkages in this field. In the past, increasing food production and supply in the short term for urban and rural areas was concerned with food security. However, over time, in sustainable food security, instead of emphasizing increasing production and maximizing resource pressure, empowering farmers to become more involved in food security plans is essential. Therefore, using the capacity of rural–urban linkages and directing them towards empowering farmers reduces the negative consequences of food security plans.

Methods: The present research is quantitative and has been done by the descriptive-analytical method. Statistical methods in this study were performed by correlation analysis and regression using software (SPSS). In addition, the structural equation model (SEM) was performed using the least-squares method (PLS) and software (SMART PLS 3).

Results: The results showed that rural–urban linkages have a positive effect on empowering farmers. Empowerment of farmers affected by rural–urban linkages is effective on the environmental effects perceived of food security plans. Perceived environmental–ecological and political–cultural effects of farmers from implementing food security plans are not effective in their participation. However, socio-economic effects provide the basis for farmers' participation in the process of sustainable food security. In general, empowerment affected by rural–urban linkages in farmers' participation is effective for investment in diversifying products, improving agricultural and non-agricultural production infrastructure, and processing products.

Conclusions: Rural–urban linkages through the empowerment of urban specialists in formal and informal organizations are an essential step towards improving the farmers' perceived effects of implementing food security plans. This issue creates the context for increasing the participation of farmers in such plans. Thus, with increasing attention to empowering farmers in implementing sustainable food security plans, their perceived environmental effects of implementing these projects will increase. It also provides the basis for their participation in these plans.

Keywords: Accessing resources, Capacity of spatial flows, Dimensions of sustainable food security, Knowledge and skills, Training

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Introduction

For a long time, the city and the countryside have interacted as two human settlements. Of course, in recent decades, planners have emphasized the capacity of rural–urban linkages and "reciprocal interaction" [1] to take advantage of each other's capacities. In this regard, formal and informal urban organizations improve sustainable food security infrastructure by performing empowerment work in each of the spatial and sectoral flows. The World Food Summit also emphasized the importance of eradicating poverty by empowering farmers as the potential of rural–urban linkages to participate in sustainable food security [2]. In this regard, factors such as education and awareness of farmers, utilizing their indigenous knowledge and skills, empowerment in access to resources, learning new skills in agriculture, industry, and services for their participation, and improving sustainable food security and newer products emphasized [3]. Various studies have examined farmers' empowerment affected by rural–urban linkages [4–9]. In addition, many research types have also examined the effects of empowerment on sustainable food security [10–16]. However, few studies have examined the relationship between improving farmers' empowerment affected by rural–urban linkages based on perceived environmental impacts from food security plans and participation. This study aims to identify rural–urban linkages' role in empowering farmers and improving the perceived environmental dimensions of food security plans to participate in sustainable food security.

Therefore, the research's main issue is that empowerment affected by rural–urban linkages influences farmers' participation in sustainable food security plans?

In line with the main issue, the sub-questions are presented in Table 1.

Eight hypotheses were tested to answer the questions. However, before formulating research hypotheses, the present article examines the literature and research background related to rural–urban linkages and farmers' empowerment for participation in sustainable food security plans. On this foundation, questions, hypotheses, and the conceptual framework of the research formed.

Literature review and research background

Rural–urban linkages and empowerment of farmers

In recent years, in different countries, attention to rural–urban linkages' capacity, the integrated rural–urban policy has dramatically helped to empower farmers [17]. In analyzing rural–urban linkages in different countries, one of the fundamental factors is to pay attention to rural–urban linkages' capacity and improve farmers' empowerment. Spatial flows empower farmers in their various dimensions if guided in a proper process [18]. Of course, in infrastructure, institutional constraints, and trade barriers, some challenges have made it hard to communicate between urban and rural areas. It also hinders the improvement of farmers' empowerment and economic development measures [4]. As one of the effective strategies in rural–urban linkages, a participatory approach can address critical concerns about improving sustainable development dimensions [19]. In the meantime, rural–urban NGOs' role is crucial for local stakeholders' empowerment and participation and strengthening its linkages [5]. In this regard, civil society organizations' potential to create direct linkages such as finance, consumption, and production or indirect participation can be considered [20]. Empowered farmers who participate in associations are more inclined to improve sustainable food security dimensions [18]. By participating in NGOs, farmers can increase their income, education, awareness, and skills by gaining socio-economic

Table 1 Sub-questions

Number	Sub-questions
1	Are rural–urban linkages effective in empowering farmers?
2	Does empowering farmers affected by rural–urban linkages influence their perceived environmental–ecological impacts from sustainable food security plans?
3	Does empowering farmers affected by rural–urban linkages influence their perceived political–cultural impacts from sustainable food security plans?
4	Does empowering farmers affected by rural–urban linkages influence their perceived socio-economic impacts from sustainable food security plans?
5	Are farmers' perceived environmental–ecological effects of food security plans influential in their participation in these plans?
6	Are farmers' perceived political–cultural effects of food security plans influential in their participation in these plans?
7	Are farmers' perceived socio-economic effects of food security plans influential in their participation in these plans?
8	Does empowering farmers affected by rural–urban linkages affect their participation in food security plans?

Source: Research findings, 2020

independence. Having a higher socio-economic status in more cases, they can support agriculture and other socio-economic activities in their village. However, their powerlessness and dependence on the government make it less possible for them to participate in various socio-economic activities in rural and agricultural areas. Therefore, it is essential to empower agriculture to access socio-economic development opportunities and potentials resulting from linkages [21].

Policymakers can also be aware of the importance of linking rural–urban linkages and empowering and involving farmers. Develop policies and strategies tailored to the needs of all residents in the area [22]. Empowerment of rural communities is part of decentralization, redistribution of government functions to lower government levels, moving towards good governance, and increasing community participation in decision-making [23]. For the formation of agricultural ideals in developing countries, effective links at the local, national and global levels can empower farmers. Innovative farming methods can be used with the flow of innovation and utilize farmers' potential to participate in this field [24, 25]. In addition, by improving rural–urban linkages and utilizing their capacity, the context for increasing access to markets, access to tangible and intangible resources (including water, land, new types of products, innovation, services, and education) will be provided farmers [5, 17].

Definitions and dimensions of food security

There are multiple definitions of food security that have evolved over the years [26]. Food security is not a new idea and has a relatively long history. Its intellectual origins go back to the world food crisis in the early 1970s or earlier to the United Nations Declaration of Human Rights in 1948. In the early 1970s, the world faced a food crisis in which food production, especially in developing countries, became unstable and declining sharply. To prevent the consequences of this crisis, the World Food Conference was convened at the United Nations initiative in 1974, and the issue of food security was first seriously addressed at this conference and defined globally and nationally [27–29]. In this regard, the World Food Conference addressed food security with the following definition: availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices. The term "food security" was initially used as a synonym of "food self-sufficiency" at the national or even global level, implying that the country or the world had access to enough food to meet the nutrition requirements of the population [30]. This definition emphasizes the supply side of the food equation, either by domestic means, through local agricultural production, or from food imports, through the international market. The former considers the local resource production capacity, resource constraints, productivity, and the operation of the agro-food supply chain, while the latter assumes that the country has sufficient foreign exchange to finance its food imports [31]. Global experience in the 1970s showed that improving supply using new technology did not solve malnutrition. In the 1980s, with further experience and research, extensive theoretical developments in food security occurred. The definition of food security has been extended to include access to food and available resources for vulnerable people. In 1983, the FAO extended the concept of food security to "ensuring access to supply for vulnerable people" and showed that attention in the food security equation must be balanced between supply and demand and provided the following definition: "Ensuring that all people at all times have both physical and economic access to the basic food that they need" [32–34]. The World Food Summit in 1996 redefined food security as follows.

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." [30, 35, 36]. Four main dimensions of food security can be identified that also constitute the means to measure food security:

Availability. This dimension describes the supply side of the food–population equation and is determined by the quantity of domestic food production and net trade.

Access. This dimension pays attention to consumption and the demand side at the household and individual levels. It examines the economic and physical access to food, emphasizing the access by vulnerable people to food.

Utilization. This dimension looks at food utilization in an adequate diet, considering important non-food factors for households and individuals to attain food security.

Stability. This dimension examines whether vulnerable households or individuals have access to food at all times [31, 37–40] (Fig. 1).

Sustainable food security indicators

Sustainable food security is defined as "when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life without compromising the productive capacity of natural resources, the integrity of biological systems, or environmental quality". The 1996 Rome Declaration on Food Security and the World Food Summit Plan of Action recognized that although the availability

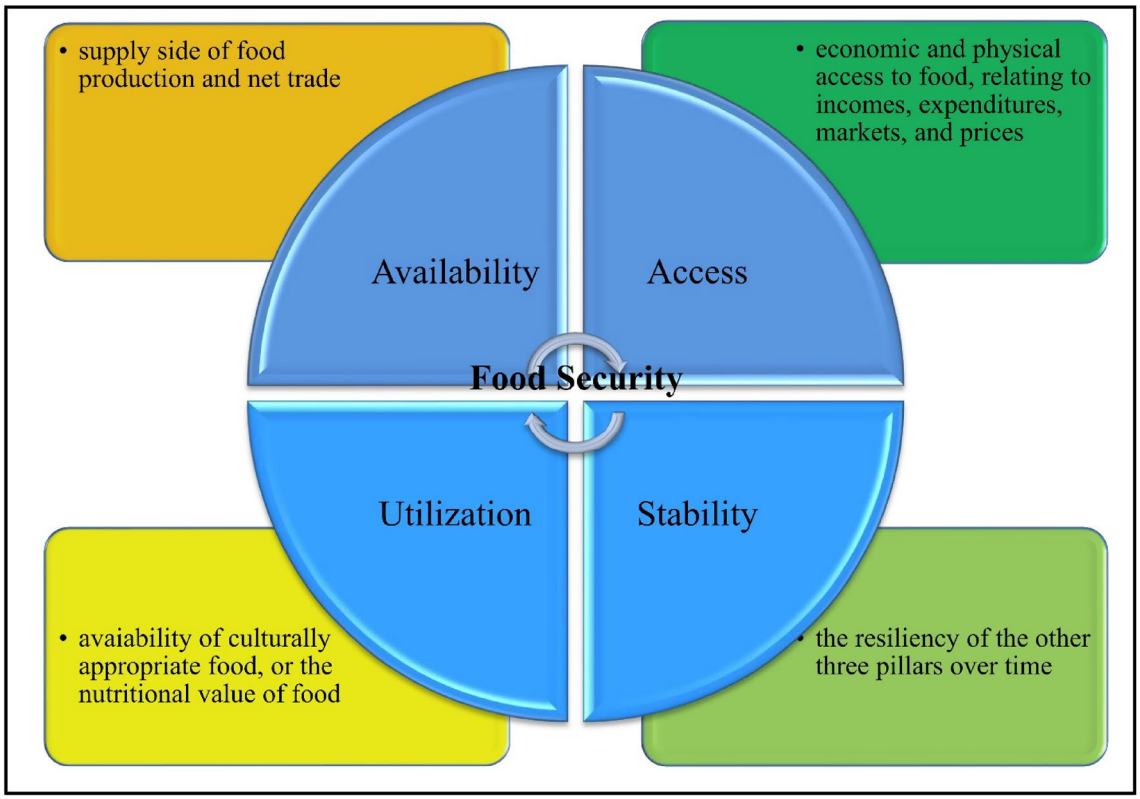

Fig. 1 Four pillars of food security. Source: [100]

of food has increased substantially during past decades, serious constraints in access to food, coupled with the continuing inability of households to purchase food, the instability of supply and demand and natural and human-induced disasters, prevent many people from fulfilling their basic food needs [41]. In this context, the 1996 World Food Summit reiterated the importance of poverty eradication through women and men's full participation to achieve sustainable food security for all [2]. A state has food security and sustainable development only when it has enough available food and agricultural products to provide nutrition for all its inhabitants while ensuring forage for animals and water in case of natural disasters, crises, war [42]. In sustainable food security, one of the main goals is to maintain production factors' stability and present healthy food products to the market. Therefore, sustainable food security by maintaining and improving production factors and increasing the supply of healthy products by increasing productivity can increase production in the long run.

Over the past years, there has been increasing agreement that sustainability is very relevant to food security. Food security is one of the sustainable development goals. Various studies have examined food security in the context of sustainable development [43–46].

In recent years, FAO, the International Fund for Agricultural Development, and the World Food Programme have proposed various food security indicators. Several indicators describe each food security dimension. Efforts are also underway to summarize these indicators into aggregated indices. Many other indices are available, and the topic has recently been summarized by other researchers, criticized, and queried. However, of all the different food security measures, the FAO suite is the only one to include stability in the index. Table 2 (left side) summarizes indicators selected by FAO as best representing the dimensions of food security at present. These were chosen from numerous different indicators based on their relevance, availability, and frequency of measurement. Universal indicators for sustainability have yet to be established; they need to be widely accepted as correct and reasonably objective. Ideally, there must also be reliable, periodically collected, and reported data to support their use for a wide range of countries [46].

Therefore, in this study, the leading indicators of food security, availability, access, utilization, and stability in the context of the dimensions of sustainable development have been explained (Table 3). Based on this, the diversity of environmental–ecological, socio-economic, political–cultural, and infrastructural dimensions in food security indicators is as follows:

Environmental-ecological sustainability: in the availability index, factors such as improving soil condition, suitable cultivated lands, water resources, and infrastructure and its proper utilization, planting of plant species, native seeds, and products compatible with the region, as well as protection of resources against environmental pollution determines this indicator in this dimension. The access index includes access to natural, fresh, healthy (organic) food and reliable health and food preparation levels. In the utilization index, the consumption of seeds and seedlings suitable for growing crops and the quantity and quality of agricultural lands, gardens, and farms can be explained. In the stability index, stability in the proper use of soil and water resources, the safety of resources and food, the reduction of threatening environmental pollutants, and stability in the harvest at the right time are considered [48–51].

Socio-economic sustainability: This dimension is also in the availability index, with the efficiency of production and availability of food needed by households, providing facilities, seeds, fertilizers and the appropriateness of quantity and quality of food, providing services and facilities for producers and exploitation systems for developing agricultural production is associated. In the index of access, access to food, markets for the sale of products, and fair prices in the distribution of products. In the utilization index, household savings to buy food in emergencies, the vulnerability of food consumption needed in economic fluctuations is considered. In the stability index, stability is in the low fluctuations of food prices consumed and the provision of facilities, seeds, fertilizers, and various insurance types [3, 14–16, 52–54].

Political–cultural sustainability: this dimension in the availability index is incentive policies to improve planting technology, maintenance, harvesting, new methods and techniques suitable for livestock and poultry management, policy-making, and planning to price agricultural products and cultivation patterns suitable for each region. Increasing the level of nutritional literacy, achieving product packaging, and appropriate long-term maintenance and self-reliance methods in producing essential goods and soil maintenance and improvement are considered in the access index. The utilization index increases local products with quality and low range of food products and proper diet of family members and has a proper diet plan. In the stability index, stability in consuming various food items needed by the household throughout the year and stability in low food price fluctuations [3, 48, 49].

Infrastructure sustainability: In the availability index, access to agricultural lands in micro-lands and equipping and renovating farms and gardens, and creating and empowering centers for storage, packaging, and transfer of products. In the access index, production efficiency through integration, access to greenhouse inputs, and appropriate machinery. The utilization index, storage, processing, distribution, and transportation status is awareness of the quality of food consumed. The stability index also includes stability in food supply centers and natural resource management and equipping and renovating farms and gardens. Therefore, the dimensions of sustainability by maintaining the capacity of natural, human, and infrastructure systems will significantly impact the realization of the pillars of food security [55–58].

Empowerment affected by rural–urban linkages and perceived environmental impacts of food security plans

The city provides services to rural centers, and on the other side of the flows, the village has conditions that can provide facilities to the city. It is essential is to increase farmers' power and ability to offer various high-quality products based on their ability. Urban empowerment measures such as providing specialized and skills training, raising awareness, and improving farmers' and villagers' knowledge and skills increase their ability to access resources and make optimal use of them. On the other hand, they improve farmers' perceptions and knowledge of environmental effects (environmental–ecological, political–cultural and socio-economic) implementation of agricultural plans in the direction of food security [66]. In other words, one of the basic principles in the capacity of rural–urban linkages is the empowerment of the urban through the implementation of educational plans, investment in the field of agriculture, and food security. These measures raise farmers' awareness of the various environmental effects of the implemented plans. Improving the perception of the positive effects of the implementation of agricultural plans and food security by formal and informal urban organizations provides the basis for farmers to establish a constructive relationship with the environment and participate in food security plans [67]. Agriculture plays an essential role in economic growth and development [68] and the potential to improve food security indicators and reduce food costs for all consumers. However, it faces several challenges until 2050.

Therefore, empowering farmers increase production efficiency in line with food security. In this regard, according to Delano's 2017 [65] research, empowering farmers can have significant benefits in agricultural production in 2050. The role and participation of farmers in food supply and food production are essential for household food security. The role of farmers includes food processing activities, food marketing, agricultural activities, and farm work. These roles are primarily influenced by empowerment actions by urban organizations and their training [48]. Improving farmers' ability at their lowest level through education leads to communities' participation and involvement in future changes. It increases their control through awareness of the individual, social and environmental resources, and related issues [69]. Since most people in developing countries live in rural areas and there are the highest poverty and hunger in these areas, it can be concluded that empowerment and education are good tools to improve national food security. A significant relationship has been observed between increasing food insecurity and farmers' low education level in different periods [70, 71]. According to Nwokolo [72], in South Africa, education has played a fundamental role in increasing income and the overall economic dimension of food security. Green's [73] research in Kenya showed that education affected farmers' food security plans [3]. In such a way, trained and knowledgeable farmers, with a correct understanding of the environment and responding to the upcoming agricultural development projects, try to manage and benefit from the living environment in line with their goals. In Nigeria, research findings have shown that formal and informal training by rural–urban professionals and special skills learning have effectively improved farmers' environmental perceptions of food security plans. In Tanzania, empowerment in various socio-economic, political, and cultural contexts has been directly related to food security plans' perceived environmental impacts [74]. In addition, other research findings showed that farmers' empowerment and increasing the productivity of agricultural products in improving their environmental perception (in three environmental dimensions) have been effective in sustainable food security plans [14, 52]. In Bangladesh, the empowerment of farmers by professionals has improved their knowledge and skills, access to resources, institutionalization, and organization, and encouraged them in production and marketing to earn a living and ensure nutritional status to improve the dimensions of sustainable food security [15]. In Bangladesh, the empowerment of farmers by professionals has

Table 2 A compilation of indicators from the FAO, together with those incorporating sustainability as the long-term time dimension to the domains of food security

Food security domain Level	FAO suite of indicators for food security	Additional indicators for sustainability
Availability	- Average dietary energy supply	Environment
Regional	Adequacy	
	- Average value of food production	
	- Share of dietary energy supply derived from cereals, roots and tubers	
	- Average protein supply	
	- Average supply of protein of animal origin	
Accessibility	- Percentage of paved roads	Economy
Household	- Road density	
	- Rail lines density	
	- Domestic food price index	
	- Prevalence of undernourishment	
Utilization	- Access to water sources	Nutrition and health
Individual	- Access to sanitation facilities	
	- Child (under-5) anthropometry	
Stability	- Cereal import dependency ratio	
Exposure/	- Percentage of arable land equipped for irrigation	
Vulnerability	- Value of food imports over total merchandise exports	
Stability	- Political stability and absence ofviolence/terrorism	
Shock	- Variability in the domestic food price level index	
	- Variability in per capita food supply	

Source: [46, 47]

Table 3 Sustainable food security variables

Variable	The main dimensions	Index	
Sustainable food security	Environmental–ecological	Availability	- Suitable soil and suitable lands for growing crops
			- Water resources and infrastructure for proper and sustainable use and transfer of water
			- Favorable climate for crops
			- Plant species, native seeds, and local produce
			- Water and soil resources are not protected
			-Reasonable exploitation without maintaining the quality of resources
			-Improper cultivation with the ecological environment of the region
			- Farmers' awareness of the principles of sustainability
			-Protecting resources from environmental pollution
		Access	- Access to natural and healthy food (organic)
			- Access to fresh food
			-Access to food hygiene
			- Access to local food consistent with people's tastes
			- Access to products by the principles of regional sustainability
		Utilization	- Utilization of healthy and organic foods
			- Utilization of seeds and seedlings suitable for growing crops
			- Improvement in the quantity and quality of agricultural lands
			- Progress in the amount and quality of gardens and farms
			- Controlling and managing land use conservation
			- Improper use of fertilizers and chemical toxins
		Stability	- Stability in the proper use of resources
			- Stability in reducing the threatening environmental pollution
			- Stability in resource and food safety
			- Stability in increasing the level of environmental health
			- Stability in harvesting at the right time
			- Stability in the optimal use of fertilizers and chemical pesticides

Table 3 (continued)

Variable	The main dimensions	Index	
			- Stability in controlling and managing land use conservation
			- Stability in the proper use of resources
			- Stability in reducing the threatening environmental pollution
			- Stability in resource and food safety
			- Stability in increasing the level of environmental health
			- Stability in harvesting at the right time
			- Stability in the optimal use of fertilizers and chemical pesticides
			- Stability in controlling and managing land use conservation
	Socio-Economic	Availability	- Adequate quantity and quality of available food
			- Availability to improve production efficiency
			- Facilities, seeds, and fertilizers
			-Availability to provide insurance and compensation
			- Availability to provide services and facilities for manufacturers to create, upgrade and empower production
			- Availability to upgrade manufacturers' confidence to have a good consumer market
			-Availability to improve the exploitation system to develop the production of products for domestic and foreign markets
		Access	- Low cost of access to food
			- Sufficient household income to buy the food needed
			- Decreasing production costs
			- Access markets to sell products
			- Reduce local production
			- Access to conversion industries
			- Access to fair prices in the distribution of products
			- Access to eliminate items such as food hoarding
			- Social participation to change the systems of exploitation from traditional to new systems
		Utilization	- Low fluctuations in food prices
			- Adequate household savings to buy food in case of emergency
			- Quantitative and qualitative development of horticultural, agricultural, and livestock products

Table 3 (continued)

Variable	The main dimensions	Index	
			- Low vulnerability to food consumption required in economic fluctuations during the year
		Stability	- Stability in low fluctuations in food prices
			- Stability in increasing production efficiency
			- Stability in the availability of food needed by the household
			- Stability in the provision of facilities, seeds, and fertilizers
			- Stability in increasing local production
	Political-Cultural	Availability	- Policy-making and planning to increase support from urban centers
			- Implementation of policies and support programs for insurance, marketing, advertising, branding, financial facilities
			- Incentive policies to promote planting, holding, and harvesting technologies
			- Implementation of transportation programs for agricultural products to national and global levels
			- Planning to increase the efficiency of food supply centers
			- Food diversity and innovative initiatives in agriculture, horticulture, animal husbandry, and aquaculture
			- Use of appropriate technologies for food production
			- Livestock and poultry management using modern methods
			- Education and awareness of the local community and stakeholders in the direction of environmental sustainability
			- Preservation and promotion of indigenous knowledge
			- Entrepreneurship and sustainable employment policies in the field of agriculture and related to agriculture
			- Implementation of policies to increase territorial justice to achieve food products
			- Policy-making and planning to price agricultural products considering the interests of producer and consumer groups
			- Implementation of policies to remove intermediaries and dealers from the process of marketing products
			- Crop cultivation pattern suitable for each region and by market needs
		Access	- Access to research and educational services to farmers
			- Access to increase nutritional literacy levels
			- Access to improve product packaging
			- Access to improve product branding
			- Access to self-reliance in the production of essential goods
			- Access to food without suffering mental and physical harm
			- Sense of social justice in access to food among the people
			- Access to proper methods of long-term storage of products

Table 3 (continued)

Variable	The main dimensions	Index	
		Utilization	- Food culture and local products
			- Increase in local production
			- Knowledge about the quality of food consumed
			- Low waste of food products
			- The proper diet of family members
			- Awareness of the various benefits of food
			- Appropriate diet plan for family members to consume during the week
		Stability	- Stability consumption of a variety of foods needed by households throughout the year
			- Stability in incentive policies to upgrade machinery and equipment technology
			- Stability in livestock management using modern methods
			- Stability in soil maintenance and improvement after production
			- Stability in low fluctuations in food prices
	Infrastructure	Availability	- Sufficient food supply centers
			- Availability to enhance the situation of agricultural lands in micro-lands
			- Availability to improve resource management (water, soil)
			- Availability to the improvement of production infrastructure
			- Availability to improve the quantity and quality of agricultural and non-agricultural lands
			- Availability to improve product storage centers
			- Product packaging centers
			- Availability to upgrade product transfer centers
			- Access to agricultural, horticultural, livestock, and aquaculture inputs
		Access	- Access to improve production efficiency through integration
			- Access to greenhouse inputs
			- Access to cultivation patterns appropriate to available water resources, production capacities, and climatic conditions
			- Access to proper machinery
			- Accessibility to improve access to food
		Utilization	- Utilization to improve storage, processing, distribution, and transportation
			-Knowledge about the quality of food consumed
		Stability	- Stability in the adequacy of food supply centers
			- Stability in equipping and renovating farms and gardens
			- Stability in improving natural resource management
			- Stability in access to production inputs

Source: [A review of the related literature, 2020, 3, 14–16, 48–65]

improved their knowledge and skills, access to resources, institutionalization, and organization, and encouraged them in production and marketing to earn a living and ensure nutritional status to improve the dimensions of sustainable food security [16].

Empowerment affected by rural–urban linkages and participation in sustainable food security projects

Empowerment of farmers affected by rural–urban links and empowerment flows by formal (governmental) and informal organizations (NGOs) and urban professionals in various socio-economic life fields effectively encourage them to participate in various activities [75]. Individual and group empowerment by increasing individuals' capabilities and delegating authority, and giving them the freedom to act to manage and control affairs has been the focus of many governments [76]. Improving farmers' power levels in the productive empowerment process, according to Roland [77], in addition to increasing their control over life and democratic participation in their socio-economic activities, encourages them to provide solutions to overcome the challenges of agricultural production [77]. Power is the limiting or motivating factor for participating in various activities [77, 78]. Sustainable food security plans and initiatives should increase farmers' active participation and provide interactive, functional, and optimal partnerships to create efficiency, effectiveness, and accountability to ensure plans' sustainability [79]. Improving farmers' empowerment by urban organizations leads to participation and improving management quality at the local level in sustainable food security. In such a way, capacity building, participatory learning, and empowerment resulting from farmers' cooperation within themselves and with urban experts are operated and analyzed cyclically [80]. Participation can be effective when each farmer is satisfied with their participation level [81]. For meaningful participation, farmers can set their own goals and track their progress; they can learn from change and suggest corrective action [80, 82]. Collaborative learning and the exchange of farmers' experience and urban organizations allow their cooperation to be considered for sustainability and effective implementation of decisions [83]. In Ghana, retail farmers' empowerment has been through active participation in urban organizations' agricultural plans [84]. More participation has been considered an essential prerequisite for the sustainable management of natural resources. Empowering and engaging farmers provides a platform for dialogue and consultation between them and many others' views [85]. Therefore, attention to farmers' empowerment and participation is considered a fundamental aspect in the survival of villagers and the local community. Without farmers' productive and active participation in agricultural and food security plans and projects implemented by urban organizations, food security projects will not be successful in practice [86, 87].

Perceived environmental effects of farmers' implementation of sustainable food security plans and participation in them

The implementation of food security plans has numerous positive and negative environmental effects such as environmental–ecological, political–cultural, and socio-economic on farmers' perception and well-being. When farmers realize the benefits of implementing food security plans through empowerment and training, they try to increase sustainability and improve agricultural products' quantity and quality by participating in food security plans [88, 89]. In this regard, it is necessary to assess farmers' perceived environmental effects to prevent the reduction of local agricultural products and explain the real effects of plans in agriculture and food security [90, 91]. Improving farmers' perceived environmental effects from implementing food security plans improves agricultural products' quantity and quality [92]. In this regard, education in agricultural innovation and natural resources is among the other factors that increase agricultural farmers' participation. This issue has been addressed in researches in recent years [93]. Underdeveloped agriculture, lack of proper market access, pests in crops, and lack of production infrastructure, challenge sustainable food security. In addition, it affected farmers' environmental perception. It reduces their participation in agricultural production projects and food security and increases food insecurity in agricultural centers [94]. Increasing use of pesticides and chemicals, deforestation, soil erosion, degradation, and destruction of ecosystems cause water and soil pollution. Therefore, if food security schemes are carried out without considering their environmental effects, it will affect farmers' environmental perception and cause them to be dissatisfied with the current situation [95, 96]. The positive economic effects of market expansion affect production and farmers' main actors and encourage them to be more involved. Accordingly, the perceived environmental–ecological, political–cultural, and socio-economic effects of implementing food security plans need special attention from the institutions involved in this field. Governments can improve farmers' perceived environmental impacts, especially in poorer countries such as Africa and Asia, by adopting appropriate policies for areas facing more significant food insecurity challenges [97].

Hypothesis 1: Rural–urban linkages have a positive effect on farmers' empowerment.

Hypothesis 2: Farmers' empowerment affected by rural–urban linkages positively influences the perceived environmental–ecological effects of implementing sustainable food security plans.

Hypothesis 3: Farmers' empowerment affected by rural–urban linkages positively influences the perceived political–cultural effects of implementing sustainable food security plans.

Hypothesis 4: Farmers' empowerment affected by rural–urban flows and linkages positively affects the perceived socio-economic effects of implementing sustainable food security plans.

Hypothesis 5: Perceived environmental–ecological effects on farmers' food security plans positively affect their participation in these plans.

Hypothesis 6: Perceived political–cultural effects on farmers' food security plans positively affect their participation in these plans.

Hypothesis 7: Perceived socio-economic effects on farmers' food security plans positively affect their participation in these plans.

Hypothesis 8: Farmers' empowerment affected by rural–urban linkages affects their participation in sustainable food security.

Conceptual framework

To investigate the role of rural–urban linkages in improving their participation in sustainable food security plans based on the perceived environmental–ecological, political–cultural and socio-economic effects of these plans and the mediating role of farmers' empowerment by reviewing the literature and background as the general framework for determining the relationships between variables of the research was modeled in Fig. 2. The number of each hypothesis is indicated by the letter H in a conceptual framework.

Methodology

The present research is quantitative and has been done by the descriptive-analytical method. Statistical methods in this study were performed by correlation analysis and regression using software (SPSS). In addition, the structural equation model (SEM) was performed using the least-squares method (PLS) and software (SMART PLS 3).

The present study's statistical population comprises 163 villages with active agriculture in the study area. Based on the central limit theorem and the number of samples more extensive than and equal to 30, the number of random samples for this statistical population of 37 villages was determined. Thus, we selected 37 random sample villages by multi-stage cluster sampling method, which according to the statistics of 2018, had 3127 households operating in agriculture, horticulture, and livestock. Using the multi-stage sampling method, first, one section of each city was randomly selected. One village was randomly selected in each section, and finally, about ten villages with the cultivated area were randomly selected from each village. In the next step, using the "Probability Proportional to size" method based on the number of farmers, the desired number of samples in each village was obtained. In the final step, according to the number of farmers in 37 villages (3127 farming families), the desired number of samples for questioning was obtained through Cochran's formula with a specific statistical population of 342 random samples. For better sample coverage in 37 studied villages, the number of random samples was increased to 400 samples. A questionnaire was used to collect field data. Different studies based on the conditions and situation of Iranian society were used to design the questionnaire. In this regard, according to Table 4, various researchers' studies about the subject were used to measure the empowerment affected by rural–urban linkages. To assess the perceived environmental effects of farmers from the implementation of food security plans and initiatives to participate in the process of sustainable food security was evaluated according to Table 5. To ensure the compatibility of the questions taken from previous studies with the research variables in the host community and determine the face validity of these indicators and their compliance with Iran's conditions and the villages of the study area, the importance of research indicators was as follows.

Twelve related university lecturers and researchers were surveyed in different universities in Iran. In addition, ten managers and experts of related organizations and institutions, including the Agricultural Jihad Organization, Agricultural Jihad Service Centers, Institute for Economic Research, and Rural Development of the Ministry of Agriculture Jihad, were assessed. After receiving their comments, corrective actions were taken in the questionnaire, and several unimportant questions were removed. Final variables and indicators of rural–urban linkages and farmers' empowerment (Table 4) as independent variables and the effect of farmers' empowerment on their participation in sustainable food security plans (Table 5) based on farmers' perceived environmental effects in rural settlements are presented. The indicators were measured as Likert spectral ranking options from a very low value of 1 to a very high value of 5.

Various organizations involved in food security in Iran and are the leading players in this field have implemented various empowerment plans in food security in the study area (Table 6). Therefore, it is necessary to analyze these organizations' performance in improving farmers' empowerment to participate in sustainable

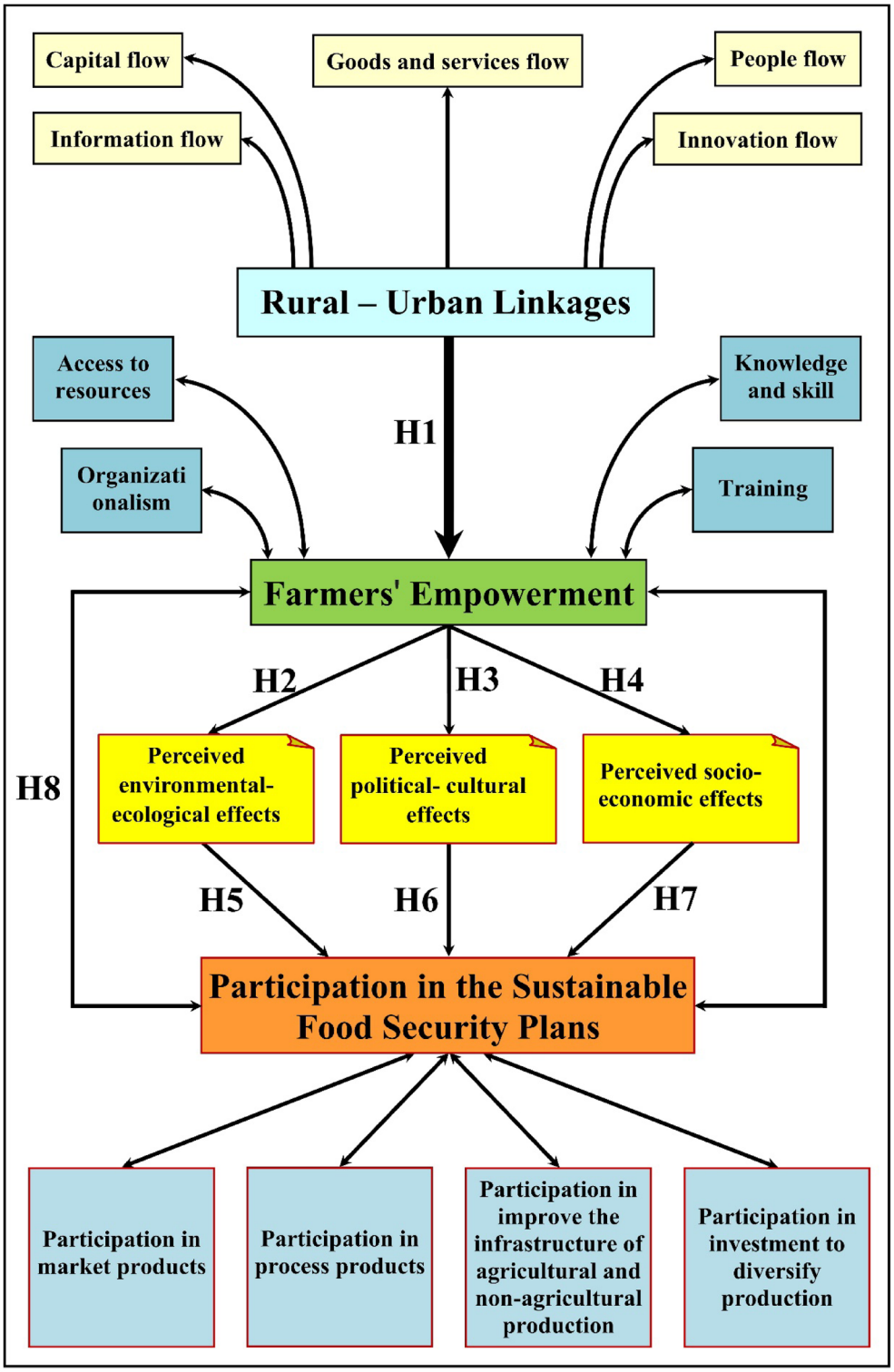

Fig. 2 Conceptual framework of the effective and affected components and indicators of research. Source: Authors

Table 4 Latent and observed variables of the empowerment process affected by rural–urban linkages

Effective component (Latent variable)		Observed variables	Symbol	Researches
People flow		An urban and rural specialist workforce	AQ1	Tacoli et al. (2013) [17] Moa (2013) [15]
		Targeting institutionalism		
Goods and services flow		Agricultural services and production support	AQ2	Burchi and De Muro (2007) [70]; Nwokolo (2015) [72]; Echebiri et al. (2017) [3] Douglass (1998) [1] Balakrishnan (2005) [2]
		Transportation of products		
Innovation flow		Innovation in production	AQ3	
		Branding and marketing		
		Innovation in product supply		
Information flow		workshops	AQ4	
		ICT		
Capital flow		Investing in formal and informal resources	AQ5	
		Production and service investment		
		Economic organizations and enterprises and microcredit		
Empowerment	Training	Specialized training in promoting the production of new and higher quality products	BQ1	Akkoyunlu (2015) [4]; Fahsbender et al. (2020) [16]; Galièa et al. (2019) [74]; Diiro et al. (2018) [14] Ramos and Prideaux (2014) [69]; Rowlands (1995) [77]
		Productive and non-productive training to improve the knowledge and scientific and technical skills of farmers	BQ2	
		Holding training courses to turn traditional and subsistence agriculture into industrial and competitive and informing them	BQ3	
	Knowledge and skills	Knowledge and information and skills relating to agricultural and non-agricultural production	CQ1	
		Knowledge and information and skills related to production and service activities	CQ2	
	Accessing resources	Accessing to environmental resources such as water, fertile soil and suitable land	DQ1	
		Accessing to formal and informal financial resources	DQ2	
		Accessing to local organizations and institutions, social networks to offer products and exchange information	DQ3	
		Accessing to product transportation networks	DQ4	
	Institutionalism	Urban organizations in connecting to villages	EQ1	
		Formal and informal urban institutions interacting with rural and agricultural institutions	EQ2	
		Integrating land management through a partnership with legal organizations	EQ3	

Source: A review of the related literature, 2020

food security plans. Thus, in recent years, the issue of empowerment affected by rural–urban linkages and farmers' participation in existing and leading production and economic challenges have been widely discussed in the community and academia, and agricultural organizations in Iran.

Based on this necessity, the present study's researchers have paid attention to the organizations' contribution and implemented empowerment work for farmers (which was done to improve their ability to participate in sustainable food security plans). Rural–urban linkages were also explored to improve their participation

Table 5 Process of indexing the concept of perceived environmental impacts, farmers' participation, and sustainable food security

Latent variable	Observed variables	PLS	Researches
Perceived environmental–ecological effects	Improving the soil, suitable cultivated lands, water resources and suitable transmission and utilization infrastructure	GQ1	Echebiri et al. (2017) [3]; Moa (2013) [15]; Sharaunga et al. (2016) [52]; Diiro et al. (2018) [14]; Fahsbender et al. (2020) [16]; Chi et al. (2007) [92]
	Improving the growing of plant species, native seeds, and products compatible with the region	GQ2	
	Improving access to natural, fresh, healthy (organic) food	GQ3	
	Improving the safety of resources and food and reducing environmental pollutants	GQ4	
perceived political–cultural effects	Improving incentive policies to promote planting technology, harvesting and food diversity, and innovative initiatives in this area	HQ1	
	Improving policy-making in line with the cultivation pattern of each region and adjusted to market needs	HQ2	
	Achieving an increased level of nutritional literacy	HQ3	
	Achieving product packaging and appropriate methods of long-term storage of products	HQ4	
	Achieving self-reliance in the production of basic goods and maintaining and improving the soil after production	HQ5	
	Stability in low food price fluctuations	HQ6	
Perceived socio-economic effects	Providing facilities, seeds, fertilizers and the appropriate quantity and quality of available food	IQ1	
	Exploitation systems to develop the production of agricultural products for domestic and foreign markets	IQ2	
	Activities of rural organizations and cooperatives to create new mechanized agricultural systems	IQ3	
	Social participation to change traditional operating systems to new ones	IQ4	
	Stability in low price fluctuations in food consumption and increase production efficiency	IQ5	
Participation in sustainable food security plans	Participation in investment to diversify production	JQ1	Thilmany et al. (2013)[88] Yahaya et al. (2017) [94] Zbinden and Lee (2005) [93] Eugenio et al. (2017) [91] Hilhorst and Guijt (2006) [80] Hiemstra (2012) [84]
	Participation in improve the infrastructure of agricultural and non-agricultural production	JQ2	
	Participation in process products	JQ3	
	Participation to market products	JQ4	

Source: A review of the related literature, 2020

in sustainable food security plans based on improving farmers' perceived environmental effects.

Location of the study area

This study has selected rural settlements in the southeastern part of Tehran province in the Varamin plain area (including Varamin, Pishva, Pakdasht, and Qarchak) in Iran (Fig. 3). The capital of this province is the city of Tehran, which is the capital of Iran. We have selected the villages of this area for the following reasons.

Most rural centers in Iran have located on the periphery of a metropolitan center or a vast city with a high demographic and economic focus in its 32 provinces. Varamin plain has been the center of agriculture and animal husbandry in Tehran province due to its fertile soil with desirable and abundant agricultural and livestock products. Moreover, since ancient times, it has been considered by various ethnic groups. Water and land suitable for agriculture and settlement of villages in flatlands are among their other potentials for production

Table 6 Summary of the plans made by formal and informal organizations and urban experts on empowering farmers for food security

Name of organization		Plans and actions are taken to empower farmers for food security
Ministry of Agriculture Jihad and Agricultural Engineering Organization	Herbal products	Setting up training plan workshops in the field of greenhouse products, medicinal plants and production of aloe vera, etc Training plan on how to produce a healthy product and cultivate quinoa (vegetable caviar) Training plan in the production of rosewater, saffron, herbal medicines, cultivation of flowers and medicinal oils Implementing several other projects in this regard
	Rural industries	Training plan to expand the agricultural conversion and complementary industries and turn traditional greenhouses into semi-industrial and industrial ones Training plan for the promotion and development of the poultry industry; Plans for converting of traditional greenhouses to semi-industrial and industrial; Etc
	Agricultural promotion	Training plans in the field of agricultural mechanization, pest and plant disease control plan, livestock and poultry diseases Training and promotion in various agricultural, horticultural, livestock projects Training and promotion of various mushroom, bee, saffron, and greenhouse cultivation projects Training and promotion of the plan to create and expand micro-funds for rural men and women, Etc
	Agriculture and horticulture	Training plan for producing various vegetables and summer crops, flowers and ornamental plants and greenhouses Plan for providing a special pistachio harvesting machine in a mechanized way to support and increase pistachio production and teach how to use it Training plan to prevent the decline in crop yields in times of drought crisis, with proper implementation of mechanization operations Etc
	Preserve plants	Training plan for grain pest control (Spraying wheat and barley infected fields with the recommended pesticides, control of pests and weeds) Training plan to use a hygrometer and thermometer for products Etc
Ministry of Interior (State secretary and Governorate	–	Plan to provide facilities and training for the opening of edible mushroom breeding units Construction of carpet weaving workshops and recruitment of trainees; Etc
Technical and Vocational Education	–	Providing free training in technical, service and agricultural fields; Public training centers in the fields of agricultural workshops, construction industries, leather goods production, business management, and handicrafts Etc

Source: Research findings, 2020

and diversification of agricultural and non-agricultural activities. As a result, the study area is significant in Tehran province and Iran's food security. The proximity of the area to the metropolises of Tehran, Karaj, Qom, and numerous large cities adjacent to it has created a unique feature in terms of economic sales of agricultural products for the consumer market. This proximity has led to extensive spatial flows and interactions between towns and villages in the area. Therefore, with the responsible organizations' plans in this field, extensive changes have occurred in this area's agricultural centers' environmental–ecological, political–cultural, and socio-economic dimensions.

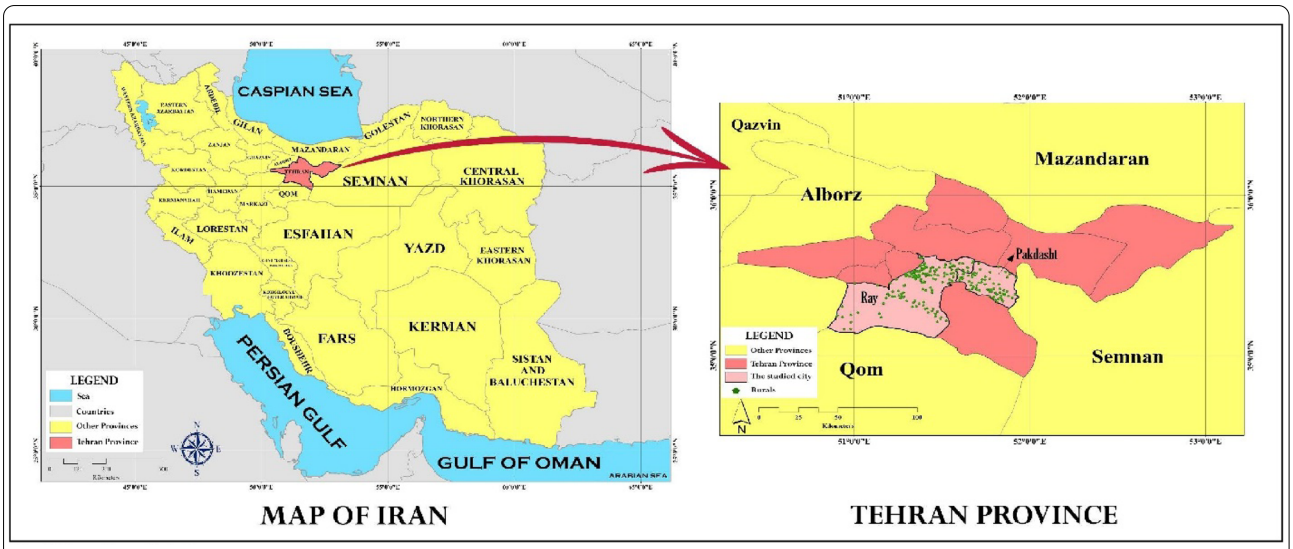

Fig. 3 Location of the study area

Results and discussion

Distribution of respondents according to individual characteristics

Out of 400 questionnaires completed by agricultural and horticultural farmers, 61.3% of the respondents were male, and about 38.8% were female. According to the information obtained, 37.8% were single, and 62.3% were married. In addition, 14.8% of the rural respondents were illiterate, 28% had primary education, 24.5% had middle school, 10% had a high school, 15.3% had a diploma, 3% had a master 5% had a bachelor's degree. According to the information obtained, among the three age groups, 19.8% were under 35 years, 71.8% were in the age group of 35–55 years, and 8.4% were over 55 years (Table 7).

The mean and standard deviation of the studied indicators

To evaluate rural–urban linkage indicators, empowerment affected by rural–urban linkages, perceived environmental effects of farmers, and participation in food security projects in the studied villages, the average and standard deviation have been used. Each of the indicators in the questionnaire was evaluated based on the Likert scale from 1 to 5. The average was obtained based on the score that each of them gave to the indicators. Table 8 shows that in Iran, especially the villages studied in the four indicators of the study, the situation is not ideal, and the averages are around 2.5. Therefore, there is a need to improve the level of indicators of this research in the region. The respondents' perceptual effects were not enough to reach the highest level of the average number. This issue may work differently in other countries. Any country that does more to strengthen rural–urban linkages to empower farmers to enhance their food security plans' participation will increase the study population's perceptual effects. The average number will be higher. The average of all rural–urban linkages is 2.40, the ratio of the mean among the various dimensions of the variables is close. While the flow of innovation has the highest intensity of responses, the flow of goods and services has the lowest respondents' responses. The innovation in the production and supply of products and branding and marketing in the region is better than other indicators. However, it is not a good position in training workshops for empowering farmers and effective use of information and communication technology in this field. This issue can have economic consequences if it continues. In addition, the average of total empowerment affected by rural–urban linkages is 2.52, and the average of the indicators is close to each other. Organizations and institutions responsible for agriculture and food security have performed better than other region indicators in providing educational services. If these trainings are provided with principled planning and advancing each department's policies and strategies, it will significantly help the production process. In addition, the average perceived environmental impact is 2.53. The average participation in sustainable food security plans is 2.32.

Table 7 Distribution of respondents based on personal characteristics

Variable		Percentage		Variable	Percentage
Gender	Male	61.3	Education	Illiterate	14.8
	Female	38.8		Primary education	28.0
	Total	100		Middle school	24.5
				High school	10
				Diploma	15.3
				Master	3.0
				Bachelor	5.0
Marital status	Single	37.8		Total	100
	Married	62.3	Age (years)	Under 35	19.8
	Total	100		35–55	71.8
				Over 55	8.4
				Total	100

Source: Research findings, 2020

Table 8 Mean and standard deviation of the studied indicators

	Dimensions and main indicators	Mean	Standard deviation
Rural–urban linkages	People flow	2.48	0.950
	Goods and services flow	2.47	1.117
	Innovation flow	2.48	0.949
	Information flow	2.53	1.064
	Capital flow	2.51	1.101
	Total	2.40	0.760
Empowerment affected by rural–urban linkages	Training	2.68	1.207
	Knowledge and skills	2.67	1.191
	Accessing resources	2.36	1.168
	Institutionalism	2.63	1.286
	Total	2.52	0.898
Perceived environmental impacts	Perceived environmental–ecological effects	2.50	0.847
	Perceived political–cultural effects	2.35	0.938
	Perceived socio-economic effects	2.26	0.993
	Total	2.53	0.886
Participation in sustainable food security plans	Participation in investment to diversify production	2.22	1.130
	Participation in improve the infrastructure of agricultural and non-agricultural production	2.32	1.174
	Participation in process products	2.18	1.159
	Participation in market products	2.39	1.194
	Total	2.32	1.089

Source: Research findings, 2020

Correlation relationship between indicators

Due to the non-normality of the indices, non-parametric statistics of Kendall-Taubi were used to determine. The statistical test results showed that the rural–urban linkages have a direct and positive relationship with empowerment variables. The relationship between empowerment indicators affected by rural–urban linkages with indicators of perceived environmental effects of food security based on the Kendall-Taubi test results shows a significant level ($p = 0.000$). There is a significant and positive relationship at the level of 1% with a 99% confidence interval between these two variables in the studied population centers (Table 9). So that by improving each of the practical components of education, knowledge, and skills, access to resources and organization of perceived environmental effects of food security are improved. In addition, perceived

Table 9 Relationship between indicators

Indicators		Kendall's tau_b test		Existence of a relationship
		The correlation coefficient	Significance level (sig)	
People flow	Empowerment	0.128	0.003	Accept
Goods and services flow		0.158	0.000	Accept
Innovation flow		0.173	0.000	Accept
Information flow		0.147	0.04	Accept
Capital flow		0.180	0.000	Accept
Training	Perceived environmental impacts	0.454	0.000	Accept
Knowledge and skills		0.492	0.000	Accept
Accessing resources		0.522	0.000	Accept
Institutionalism		0.459	0.000	Accept
Perceived environmental–ecological effects	Participation in sustainable food security plans	0.284	0.000	Accept
perceived political–cultural effects		0.376	0.000	Accept
Perceived socio-economic effects		0.789	0.000	Accept

Source: Research findings, 2020

environmental–ecological, political–cultural, and socio-economic effects are significantly associated with sustainable food security plans.

Multivariate linear regression analysis to explain the empowerment of farmers affected by rural–urban linkages on participation

To investigate farmers' empowerment affected by rural–urban linkages on farmers' participation in food security plans, we have used multivariate linear regression in a stepwise manner. The stepwise regression model of independent variables to explain the participation shows that in the model (1), this model could predict 45.8% of the participation in the region after the variable of participation in investing in diversifying products. Models 2 and 3 shows that it has increased by about 51.7% and 53.4% with participation in improving agricultural and non-agricultural production infrastructure and product processing participation, respectively (Table 10). Table 11 shows the effect coefficients of the final model of independent variables explaining the participation. Of the four variables included in the regression equation, except for the variable participation in marketing products, the rest of the variables remain in the equation. The effect of all variables on the variable variation is positive.

In this research, modeling was done in two stages; the first stage: evaluating the measurement model. The second stage evaluates the structural model by estimating the path between the variables and determining the model fit indices.

First step: evaluate the measurement model

Two index reliability and concurrent validity criteria were used [98]. The reliability was measured by two criteria (Cronbach's alpha, Combined Reliability (CR)). According to Table10, Cronbach's alpha index for all structures was calculated higher than 0.7. Combined Reliability (CR) was also higher than 0.7. Therefore, the reliability of the structures was confirmed. Convergence validity is the second criterion used to fit measurement models in the partial least squares' method. Fornell and Larker [99] expressed that the mean criterion for measuring convergent validity is 0.5. This issue means that the mean value of variance extracted above 0.5 indicates acceptable convergent validity. According to the above and Table 12 of the mean extracted variance index (AVE), all studied structures have a mean extracted variance higher than 0.5. Therefore, the model presented has an appropriate convergence validity.

Step 2: evaluate the structural model

The structural equation model was used to test the research hypotheses. This method is a technical method for data analysis designed to evaluate the relationship between two types of variables (observed and latent). The values of fit indices showed the confirmation of measurement patterns in the conceptual model of the research. This issue suggests that measurement indices of detected variables can reliably measure hidden variables. According to Figs. 4 and 5, the research's external measurement model shows the relationships between obvious and hidden variables in standard coefficient estimation and the case of significant coefficients. In the structural equation model, the coefficients between the

Table 10 Regression model to explain the effect of empowerment of farmers affected by rural–urban linkages on participation

Model	Variables	Multiple correlation coefficient (*R*)	The coefficient of determination (R^2)	The adjusted coefficient of determination	ANOVA (*F*)	Sig
1	Participation in investment to diversify production	0.458	0.210	0.208	105.297	0.000
2	Participation in improve infrastructure of agricultural and non-agricultural production	0.517	0.267	0.263	71.988	0.000
3	Participation in process products	0.534	0.285	0.280	52.429	0.000

Source: Research findings, 2020

Table 11 Impact coefficients of the final model of independent variables on the diversification of activities

The final model	Variables	Non-standard coefficient		Standard coefficient	*T*	Sig
		B	Std	Beta		
	Participation in investment to diversify production	0.365	0.036	0.458	10.261	0.000
	Participation to improve the infrastructure of agricultural and non-agricultural production	0.209	0.038	0.274	5.547	0.000
	Participation in process products	0.139	0.044	0.179	3.166	0.002

Source: Research findings, 2020

Table 12 Convergent validity indicators and reliability of research variables

Hidden variables	Cronbach's Alpha	rho_A	Composite reliability (CR)	AVE	R^2
Training	0.768	0.812	0.863	0.679	0.054
Knowledge and skills	0.757	0.791	0.890	0.802	0.829
Accessing to resources	0.866	0.874	0.909	0.715	0.461
Institutionalism	0.772	0.834	0.865	0.684	0.091
Empowerment affected by rural–urban linkages	0.853	0.857	0.901	0.696	0.538
Perceived environmental–ecological effects from the plans	0.735	0.745	0.834	0.558	0.114
Perceived political–cultural effects from the plans	0.810	0.849	0.859	0.511	0.576
Perceived socio-economic effects from the plans	0.910	0.910	0.933	0.735	0.713
Participation in the sustainable food security plans	0.820	0.824	0.881	0.649	0.558

Source: Research findings, 2020

latent or latent variables (circular) and the observable or explicit variables (rectangular) are the external loads (external weights), which are determined in the model for measuring the relationships between the obvious and latent variables. Numbers inside circles or hidden variables represent the coefficient of determination (percentage of changes in the influential or endogenous variable by the influential and exogenous variables Coefficients between latent variables (the relationship between circular variables of shape) are included in the research hypotheses. According to the coefficient of determination, "knowledge and skills" have the highest impact on farmers' empowerment, and that "institutionalism" has the lowest impact on farmers' empowerment. The results also showed that farmers' perceived socio-economic effects from implementing sustainable food security plans with a coefficient of 0.713, the highest impact, and environmental–ecological effects with a coefficient of 0.114 have the lowest impact on farmers' participation.

Figure 5 shows the external model in a significant state of the coefficients (*t* value). According to this model, the 95% confidence level's path coefficient is significant, because the *t*-statistic value is greater than 1.96.

Testing hypotheses

Table 13 shows the path coefficients (beta), *t*-statistic, significance, and the result of research hypotheses.

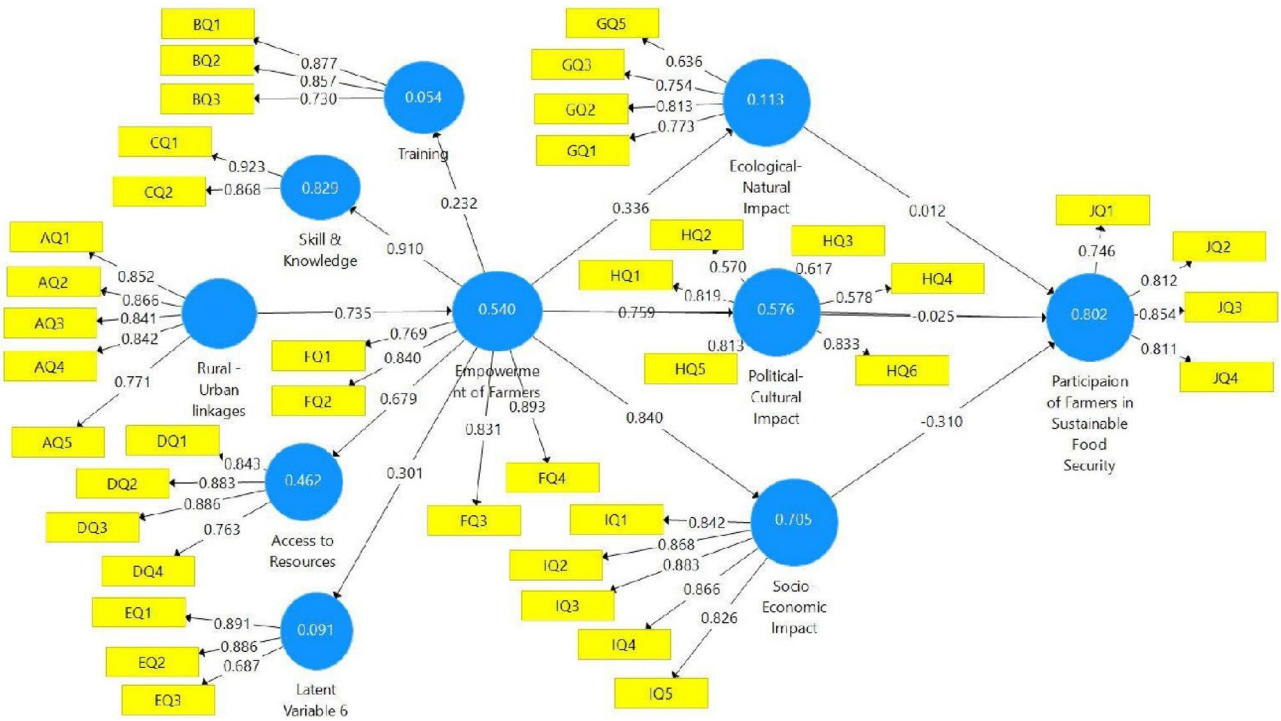

Fig. 4 Standardized coefficient model. Source: Research Findings, 2020

According to the results obtained from the values of path coefficients and *t*-statistics, a positive and significant relationship between rural–urban linkages and farmers' empowerment was confirmed. Empowerment of farmers by rural–urban linkages with their perceived political–cultural and socio-economic effects of food security plans was also confirmed. As we can see in Table 13, the first hypothesis is the impact of rural–urban linkages on farmers' empowerment. The second, third, fourth hypotheses that the effect of farmers' empowerment on by rural–urban linkages on environmental–ecological, political–cultural and socio-economic effects perceived by food security plans were confirmed. In all these hypotheses, the value of the *t*-statistic is more than 1.96, and the significance level is equal to $p = 0.000$. Therefore, there is a direct positive and significant relationship between farmers' empowerment and their perceived environmental–ecological, political–cultural and socio-economic effects of food security plans. Moreover, the results obtained from farmers' perceived environmental–ecological, socio-cultural, and economic effects on their participation in sustainable food security plans showed no significant relationship between farmers' perceived environmental–ecological and political–cultural effects participation in sustainable food security plans. Because the value of the *t*-statistic is less than 1.96, and their significance level is $p > 0.609$ and $p > 0.497$, respectively. Based on this, the fifth and sixth hypotheses were not confirmed. However, in this regard, there is a positive and significant relationship between the perceived socio-economic impact of farmers on sustainable food security plans and their participation in these plans, because the value of the *t*-statistical is more than 1.96, and the level of significance is equal to $p = 0.000$. On this basis, Hypothesis Seven was confirmed. In the eighth hypothesis, the relationships between farmers' empowerment affected by rural–urban linkages on their participation in sustainable food security plans were examined. The path coefficient and *t* test on the effects of the empowerment variable on participation in sustainable food security plans revealed an indirect relationship between farmers' empowerment and their participation in sustainable food security plans. Therefore, the eighth hypothesis was confirmed.

Rural–urban linkages in urban specialists' empowerment measures in rural areas improve farmers' empowerment and improve their perceived environmental effects (environmental–ecological, political–cultural and socio-economic) of food security plans. This issue provides sustainable food security for their participation in plans. The literature and research background were reviewed, and finally, the theoretical framework of the research was presented. In this regard, eight hypotheses were tested based on the assumed relationships in the

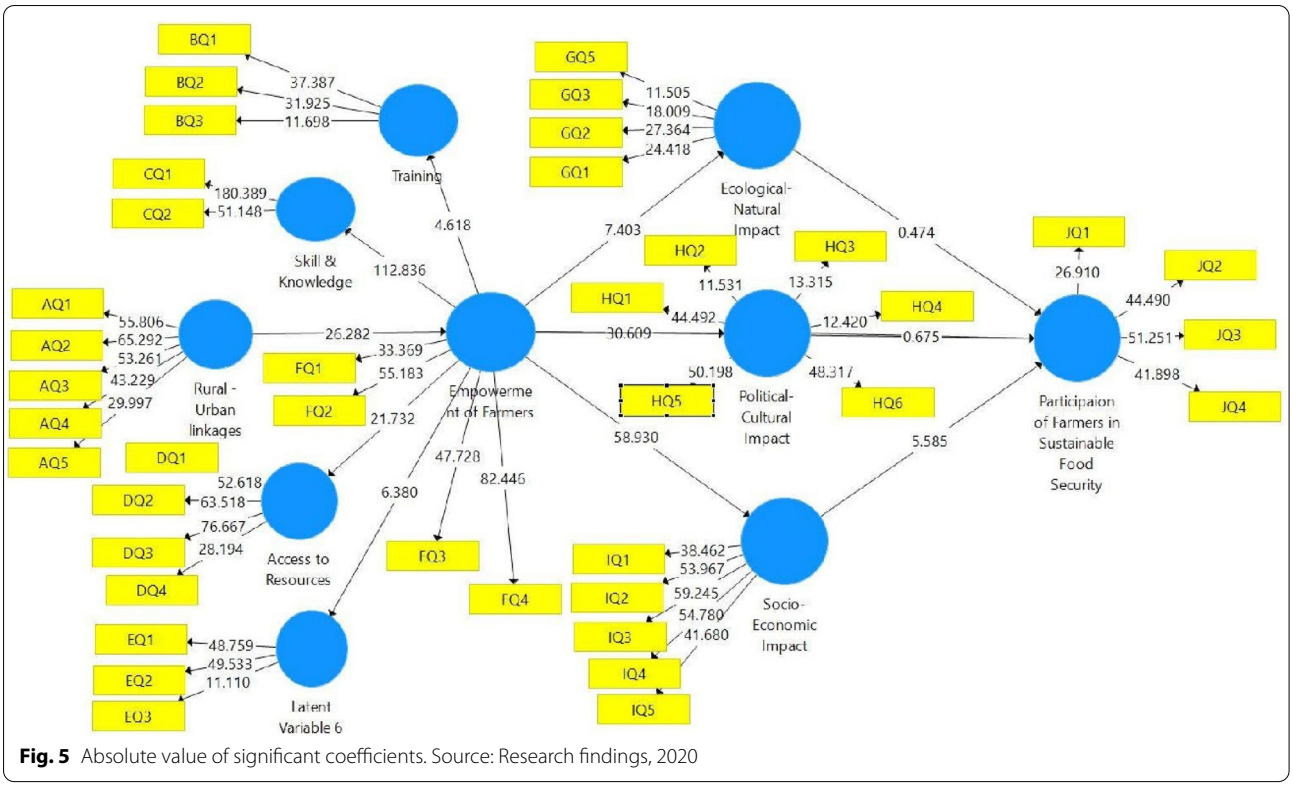

Fig. 5 Absolute value of significant coefficients. Source: Research findings, 2020

Table 13 Path coefficients (beta), *t*-statistic, coefficient of determination, and result of research hypotheses

Direct hypotheses	Beta coefficients	*T* value	*P* value	Result
Rural–urban flows and linkages- > Empowerment of farmers	0.735	27.728	0.000	Accept
Empowerment of farmers affected by rural–urban flows and linkages- > Perceived environmental–ecological effects of sustainable food security plans	0.336	7.214	0.000	Accept
Empowerment of farmers affected by rural–urban flows and linkages- > Perceived political–cultural effects of sustainable food security plans	0.759	33.183	0.000	Accept
Empowerment of farmers affected by rural–urban flows and linkages- > Perceived socio-economic effects of sustainable food security plans	0.840	54.001	0.000	Accept
Perceived environmental–ecological effects by farmers on the implementation of food security plans- > Their participation in sustainable food security plans	0.012	0.512	0.609	Reject
Perceived political–cultural effects by farmers on the implementation of food security plans—> Their participation in sustainable food security plans	− 0.025	0.680	0.497	Reject
Perceived socioeconomic effects by farmers on the implementation of food security plans—> Their participation in sustainable food security plans	− 0.310	5.628	0.000	Accept
Empowerment affected by rural–urban linkages—> Participation in sustainable food security	1.155	21.626	0.000	Accept

Source: Research findings, 2020

sample. In the first hypothesis, the effect of rural–urban linkages on farmers' empowerment was measured, which results indicate a positive relationship between the two categories. Therefore, it is in line with the research results [5, 17, 18]. In the second to fourth hypotheses, the relationship between empowerment and their perceived environmental–ecological, political–cultural and socio-economic effects of food security plans was examined (Table 13). The results showed a positive relationship between farmers' empowerment affected by rural–urban linkages and their perceived environmental–ecological, political–cultural and socio-economic effects of food security plans. Therefore, the present study's findings are consistent with researchers' results

[14, 16, 52]. It is also consistent with the findings of Muigua [67]. He believes that urban professionals' empowering actions by implementing training plans, investment in agriculture, and food security raise farmers' awareness of the implemented plans' various environmental effects. In addition, it is consistent with the Green [73] study in Kenya, which showed that training, as one of the indicators of empowerment, has impacted farmers' perceived environmental effects of food security plans. Finally, the empowerment of farmers affected by rural–urban linkages on the perceived socio-economic effects of food security plans is consistent with the findings of Galièa et al. [74]. In the fifth to seventh hypotheses, the relationship between environmental–ecological, political–cultural, and socio-economic effects of farmers' perceived food security plans and their participation in these plans was measured (Table 13). Findings showed a direct positive and significant relationship between farmers' perceived socio-economic effects on food security plans and their participation in these plans. However, there is no direct positive and significant relationship between environmental–ecological and political–cultural effects of food security plans and their participation in these plans. In this regard, it is not consistent with the findings of Yahaya et al. [94]. They believe that all three perceived environmental dimensions of farmers effectively implement food security plans in their participation in these plans. In addition, it is not consistent with the findings of Thilmany et al. [88]. However, it is in line with the research results of Chi et al. [92]. They said that improving the perceived environmental impact of farmers' food security plans improves agricultural products' quantity and quality. The present study also equates with the results Lal, 2009; Stoate et al. [95, 96], who said that the more farmers' satisfaction with implementing food security plans in its various dimensions affects their environmental perception and participation these plans will reduce. Finally, in the eighth hypothesis, the mediating effects of the empowerment variable on participation in sustainable food security plans revealed that the indirect relationship between farmers' empowerment and their participation in sustainable food security plans was measured (Table 13). This study is in line with the findings of Park and Kim [75]. They believe that farmers' involvement and involvement in various rural and agricultural challenges can affect various aspects of their lives and food security plans.

Conclusions

This study explains rural–urban linkages' effect on farmers' empowerment in food security plans' perceived environmental effects. Therefore, this article uses the essential effective indicators in empowerment affected by rural–urban linkages to improve farmers' participation in sustainable food security plans in rural settlements around Tehran's metropolis (Iran's capital). Finally, the findings confirm the positive effect of rural–urban linkages on farmers' empowerment. Empowerment of farmers affected by rural–urban linkages is also effective on their perceived effects on the environmental–ecological, political–cultural and socio-economic dimensions of sustainable food security plans. By promoting environmental perceptions, farmers' participation in sustainable food security plans will improve. Of course, there is no significant relationship between farmers' perceived environmental–ecological and political–cultural effects and their participation in sustainable food security plans. However, in this regard, there is a positive and significant relationship between the perceived socio-economic impact of farmers on sustainable food security plans and their participation in these plans. Past studies have examined rural–urban linkages in participation or empowerment or food security. However, this study's superiority over other studies is studying these three components about each other. The new way of thinking presented in this research is to change the approaches in strengthening rural–urban linkages towards empowering farmers and their greater participation in sustainable food security plans. Of course, we have faced limitations in the research path. This research with a new approach examines several essential parameters about each other. This research required detailed interviews and expert opinions from experts and specialists in these fields, making it challenging to coordinate and arrange meetings for interviews with experts and the heads of the responsible organizations. The results of the present study can be generalized to the villages around the metropolis. If it needs to be generalized to other rural areas, be done with sufficient caution and knowledge. This research was conducted in 37 sample villages in the southeastern villages of Tehran province. It is better to repeat the research process in future research with a larger sample size. To fill the research gap in this area, other researchers in other countries need to examine the role of rural–urban linkages in empowering farmers to participate in sustainable food security plans to understand the results better. This research area is located around Tehran's metropolis (the capital of Iran) and on the edge of the desert. It is suggested that this research be done for other regions with other geographical features. For example, it should be done in border villages so that a single model can be designed for villages with the same geographical features [59–64].

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