frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 16 April 2025
DOI 10.3389/fsufs.2025.1539777

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OPEN ACCESS

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RECEIVED 04 December 2024
ACCEPTED 31 March 2025
PUBLISHED 16 April 2025

CITATION
Rezaei A, Fatemi M and Shennan C (2025) Healthy agricultural production: a socio-psychological and environmental approach to sustainable food systems in Fars province, Iran.
Front. Sustain. Food Syst. 9:1539777.
doi: 10.3389/fsufs.2025.1539777

Healthy agricultural production: a socio-psychological and environmental approach to sustainable food systems in Fars province, Iran

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Introduction: Concerns about health and food security related to the food production chain and environmental degradation have increased the demand for sustainable agricultural development and a reduction in the harmful effects of conventional agriculture. Consumers are increasingly inclined to choose healthy food due to the environmental and health risks posed by products contaminated with chemical inputs.

Methods: This study aims to identify the determinants of healthy and sustainable agricultural production based on Diffusion of Innovations (DOI) and Farm Structure (FS) models, combined with a socio-psychological and environmentally-oriented approach. The study also seeks to propose recommendations for extension services to promote such production among summer crop farmers in Iran. Data were collected from 260 farmers using a survey and stratified random sampling method. The data were analyzed with $SPSS_{26}$ and $AMOS_{24}$.

Results and discussion: The analysis of the research model demonstrated that the greatest influence on healthy and sustainable agricultural production is attributed to the emphasis on the importance of marketing. Environmental identity and attitudes toward healthy and sustainable agricultural production are of secondary importance. Access to extension services indirectly affects healthy and sustainable agricultural production through environmentally responsible behavior. Information access directly influences healthy and sustainable agricultural production. Furthermore, information beneficiaries also indirectly affect healthy and sustainable agricultural production by enhancing farmers' knowledge and attitudes toward producing such products. Specific production and marketing relations should be established for these products. Additionally, various organizations should focus on extending, training, and informing farmers about healthy and sustainable agricultural production, while also creating the necessary infrastructure to make this a public demand among both consumers and producers.

KEYWORDS

healthy product, adoption, sustainable agriculture, socio-psychologic, environmentally-oriented, diffusion of innovations model, farm structure model

1 Introduction

Agro-industrial production began in the early 1960s, marking the transition from traditional subsistence farming to industrial and commercial agriculture, known as the Green Revolution. While this shift aimed to enhance global food production, it also led to significant environmental challenges, including water pollution, soil degradation, ecological imbalances,

10.3389/fsufs.2025.1539777

and the emergence of new pests and diseases (Fatemi et al., 2018). The excessive use of chemical fertilizers and pesticides has caused long-term damage to natural resources, disrupting food production and natural cycles (Fanelli, 2020). Rapid economic growth has further intensified environmental threats, such as land degradation and water scarcity (Kopteva et al., 2019).

Iran, particularly Fars province, faces alarming health risks due to the widespread use of chemical inputs in agriculture. However, the toxicity levels and persistence of residues differ significantly between fertilizers and pesticides. While synthetic fertilizers primarily contribute to environmental pollution—such as nitrate leaching into groundwater and eutrophication—they generally pose lower direct toxicity risks to human health compared to pesticides (EFSA, 2023). In contrast, excessive pesticide application, including 34 carcinogenic types, has been linked to increased risks of gastrointestinal cancers, hormonal disruptions, and neurological disorders (NICRS, 2023; Burns, 2023). Many pesticides, particularly persistent organic pollutants (POPs), remain in the environment for extended periods, accumulating in food chains and posing long-term health threats (EFSA, 2023). Furthermore, unsafe pesticide storage and application practices heighten exposure risks for both farmers and consumers (Ebrahimi and Manian, 2007; Kalachian et al., 2011).

Given these challenges, exploring sustainable agricultural models becomes imperative. The following section delves into the theoretical foundations of agroecology and sustainable agriculture, highlighting key frameworks that support environmentally responsible farming practices. Additionally, it reviews innovation adoption models to better understand the factors influencing farmers' transition toward sustainable agricultural methods, with a focus on promoting healthy and sustainable agricultural production.

1.1 Theoretical background

1.1.1 Agroecology and sustainable agriculture

Sustainable agriculture, rooted in the principles of the Brundtland Commission, seeks to balance productivity with environmental responsibility (Fatemi et al., 2018; Rose et al., 2019). By reducing reliance on harmful chemicals and implementing eco-friendly technologies, it promotes food security, soil preservation, and optimal agricultural performance (Trigo et al., 2021). Growing awareness of the dangers posed by agricultural chemical inputs, such as pesticides and synthetic fertilizers, has shifted consumer demand toward healthier, sustainably produced food (Rezaei-Moghaddam et al., 2023). Organic farming and Good Agricultural Practices (GAP) provide sustainable solutions by prioritizing environmental conservation, soil health, and consumer well-being (Sharma and Singhvi, 2018). GAP encompasses a set of principles, regulations, and technical guidelines designed to ensure the sustainability, safety, and quality of agricultural production. It focuses on optimizing resource management, minimizing environmental impact, ensuring food safety, and enhancing the economic and social sustainability of farming. Key elements of GAP include soil and water management, biodiversity conservation, integrated pest and nutrient management, worker health and safety, and traceability of agricultural practices. Institutionalized as GLOBALGAP in 2007, GAP is recognized globally as a standard for responsible and sustainable farming practices (Sabir et al., 2010). While organic farming adheres to strict international standards, Iran lacks a comprehensive regulatory framework aligned with these norms (Ghorbani et al., 2009). Instead, some producers achieve national certifications by reducing chemical inputs and adopting environmentally friendly practices, producing "healthy and sustainable products" that serve as a transitional step toward organic farming (Fatemi et al., 2018). These products follow stricter input management but do not yet meet full organic certification criteria. In addition to organic farming, agroecology offers a broader, more integrated approach to sustainable agriculture, blending ecological principles with social and economic dimensions to promote biodiversity, resource efficiency, and resilient food systems (Röös et al., 2022). By embracing agroecological practices, Iran's agricultural production can move beyond input reduction and develop a more holistic and sustainable farming model.

A promising approach to promoting agroecology and sustainable agriculture is the development of biodistricts, or ecological districts, which are territorial areas where farmers, local authorities, and other stakeholders collaborate to implement agroecological principles (Stefanovic and Agbolosoo-Mensah, 2023). Biodistricts foster local economies by encouraging short food supply chains, organic production, and environmentally friendly farming practices while strengthening rural development and community engagement (Lamine et al., 2023). By integrating agricultural, social, and economic policies, biodistricts serve as models for sustainable territorial development, demonstrating how coordinated efforts can enhance the viability and adoption of agroecological practices (Gava et al., 2025). Despite the recognized benefits of agroecology, its adoption remains limited due to significant barriers, including farmers' risk perceptions, lack of technical knowledge, economic constraints, and insufficient policy support. Understanding and addressing these challenges is crucial to promoting a widespread transition toward sustainable agricultural practices.

1.1.2 Innovation adoption models

The *Diffusion of Innovations (DOI)* Model, introduced by Rogers and Shoemaker (1971), provides a framework for understanding how new ideas and technologies spread within social systems. It identifies the stages of adoption: acquiring knowledge, forming attitudes, deciding to adopt, implementing, and confirming effectiveness. Key factors influencing the diffusion process include perceived benefits, compatibility with existing practices, ease of use, trialability, and the visibility of results. Social networks, opinion leaders, and communication channels also play crucial roles. Although widely applied across various fields, recent research has expanded the DOI model by incorporating cultural and socio-economic barriers (Rogers, 2003).

DOI has been instrumental in understanding the adoption of organic farming, which typically follows an S-shaped diffusion curve. Early adopters play a key role in influencing broader adoption, often motivated by environmental awareness, market incentives, and peer influence (Padel, 2001; Kamua et al., 2024). Organic farming distinguishes itself from conventional agriculture by prioritizing sustainability over immediate productivity. Research highlights the importance of farmers' attitudes toward environmental protection, resource conservation, and the health of humans and animals in shaping their adoption decisions (Fatemi et al., 2018). Educational efforts in organic farming focus on sustainable crop production, soil fertility management, water conservation, biological pest control, and environmentally friendly weed management (Monfared et al., 2019).

In response to critiques of the DOI model in the 1970s, the *Farm Structure (FS)* Model emerged, focusing on how farm organization and management affect productivity (Jones et al., 2017). FS examines the role of factors such as farm size, resource allocation, and technological adoption in shaping agricultural output. Recent studies indicate that transitioning from smallholder to mechanized farming significantly boosts productivity (Wang et al., 2024). The FS model also emphasizes profitability and economic incentives, addressing challenges like limited land, low income, restricted access to extension services, and market barriers (Fatemi and Atefatdoost, 2020).

Ecological benefits of organic agriculture have also been explored, with studies indicating that organic inputs improve soil health and biodiversity (Qian et al., 2020), and organic waste enhances CO_2 levels in greenhouses, benefiting crop production (Hao et al., 2020). Extension services play an essential role in educating farmers about organic farming, marketing, certification, and the transition process (Alotaibi et al., 2019). However, inadequate infrastructure and marketing systems continue to hinder the widespread adoption of organic products (Gökkür and Sinav, 2020). Additionally, consumer trust, pricing, and awareness are critical factors in shaping market demand for healthy products (Firoozzare et al., 2024).

Pro-environmental behavior involves actions that minimize environmental harm or actively contribute to sustainability (Pradhananga et al., 2017). Studies suggest that attitudes and beliefs alone do not directly translate into environmental behavior; social influences play a vital role in shaping individual choices (Steg and Vlek, 2009). Environmental sociology explores these interactions, integrating social, cultural, and ecological dimensions (Rezaei-Moghaddam et al., 2005; Rezaei-Moghaddam and Karami, 2008). Expanding traditional adoption models, Rezaei-Moghaddam and Fatemi (2013) introduced a framework incorporating environmental knowledge, social norms, and behavioral control, offering a comprehensive analysis of pro-environmental behaviors. Farmers' environmental awareness, moral obligations, and perceived behavioral control strongly influence their willingness to adopt green technologies, such as organic farming (Padel, 2001; Lei et al., 2023). Studies in China demonstrate that government policies, long-term yield benefits, and ecological concerns encourage sustainable practices (Lei et al., 2023). Psychological and social factors, such as pro-environmental responsibility, awareness of conventional agriculture's negative impacts, and social norms, also drive the adoption of organic methods (Fatemi and Rezaei-Moghaddam, 2020). Recent research emphasizes the importance of education in fostering environmental values and promoting responsible farming practices, especially among experienced farmers (Wang et al., 2023).

Iran's agricultural sector is vital for the country's economic development, yet excessive pesticide and chemical fertilizer use, driven by increasing food demands, poses significant environmental and health risks (Asadollahpour et al., 2020). Achieving sustainable food production is crucial for environmental conservation, economic stability, and public health (Niu et al., 2024). Given Iran's growing population, rapid urbanization, and climate challenges, prioritizing food safety and sustainable agricultural practices is essential, with farmers playing a key role in this transition. Official statistics indicate that a relatively small percentage of farmers in Iran engage in organic farming. Although Iran has the capacity to participate in global markets, its current share remains limited. The most recent data reports slightly over 30,000 hectares of organic farming in the country (Fatemi et al., 2021). This suggests a need for Iran to explore the potential for expanding sustainable agricultural practices. However, achieving this transition requires the involvement of various stakeholders.

This study aims to identify the key determinants of adopting healthy and sustainable agricultural practices, integrating the DOI and FS models with a socio-psychological and environmentally-oriented approach. Specifically, the research will focus on summer crop farmers in Fars province, Iran, exploring the factors influencing their adoption behaviors. The study will compare various characteristics of farmers, including individual factors (e.g., age, educational level, agricultural background), structural-economic factors (e.g., annual income and farm size) and environmentally oriented factors (e.g., knowledge about sustainable agricultural production and attitudes toward healthy farming practices). The study will identify the determinants of healthy and sustainable agricultural production behaviors and propose targeted strategies, such as educational programs, financial incentives, and policy recommendations, to encourage the broader implementation of these practices.

The paper begins with a review of the theoretical framework, outlining the DOI and FS models and their application to organic agriculture. It then presents the methodology, describing the study's design, data collection process, and analysis approach. The results section provides a detailed comparison of different groups of farmers based on characteristics such as farm size, experience, education level, and attitudes toward sustainable farming practices. This section identifies the key factors influencing the adoption of healthy and sustainable agricultural production among summer crop farmers in Fars province. Finally, the paper concludes with a discussion of the findings, offering insights and policy recommendations to support the advancement of sustainable farming initiatives in Iran.

1.2 Study area

Abadeh County, with Abadeh as its central city, covers an area of 6,800 square kilometers, accounting for 4.6% of the total land area of Fars province, located in southern Iran. As one of the high-altitude regions of the province, the county is geographically positioned between 51°51′ to 53°13′ east longitude and 30°48′ to 31°42′ north latitude. It shares borders with Isfahan Province to the north, Eqlid County to the south, Yazd Province to the east, and Kohgiluyeh and Boyer-Ahmad Province to the west. According to the latest national administrative divisions (2012), Abadeh County consists of two districts and five urban areas (Abadeh, Bahman, Soghad, Izadkhast, and Surmaq) as well as five rural districts (Khosrowshirin, Bahman, Bidek, Izadkhast, and Surmaq), encompassing a total of 272 villages. The distance from the county's center to the provincial capital (Shiraz) is 275 km (Fars Agricultural Jihad Organization, 2023). The county's water resources primarily include seasonal rivers and groundwater sources (wells and qanats). According to the local synoptic meteorological station, Abadeh has a cold and arid climate, with a long-term average annual precipitation of 136 mm and an average annual temperature of 14.4°C (Ghasemi et al., 2020).

Based on the 2016 national census, the population of Abadeh County was 100,831 (50,991 males and 49,840 females), representing

2.14% of the total population of Fars province. The employed population in the county was 29,243, of which 5,620 individuals (19.2%) were engaged in the agricultural sector. The main economic activities in the agricultural sector include crop production, horticulture, livestock farming, and poultry farming (Ministry of Agricultural Jihad, 2024). Out of the 186,000 hectares of total land in the county, approximately 74,000 hectares are arable, with 57,000 hectares cultivated annually for various crops and orchards. The predominant agricultural products include grains, legumes, summer crops, apples, apricots, almonds, and grapes. Summer crop production plays a significant role in the county's agriculture, covering a substantial portion of farmlands and supplying a notable share of the provincial market. The major vegetables cultivated in Abadeh include potatoes, onions, tomatoes, and cucumbers. In terms of livestock production, the county is a major producer of both red and white meat, ranking second and third in the province, respectively (Ministry of Agricultural Jihad, 2024).

2 Research method

2.1 Research methodology flowchart: process and procedures

Figure 1 illustrates the research methodology, outlining the key steps in the study. The process begins with problem identification, highlighting the degradation of natural resources and health issues, which emphasizes the need for healthy and sustainable agricultural practices. The literature review phase involves searching and analyzing relevant studies, from which research variables are extracted to form the conceptual framework. The research aims to identify the factors influencing the adoption of healthy and sustainable agricultural production among summer crop farmers in Fars province, Iran. To address this aim, the study investigates various characteristics of farmers, such as individual, structural-economic, and environmentally oriented factors. Questionnaire design included reviewing literature, using relevant questionnaires and standard indicators, and conducting informal interviews with experts. Quality criteria were ensured by confirming the face and content validity of the questionnaire through a panel of experts, including professors from the School of Agriculture at Shiraz University and specialists from the Fars Organization of Jihad Agriculture, to ensure the use of the most relevant and effective questions for assessing each research variable. A pilot study, conducted with a sample separate from the main study, was performed to calculate Cronbach's Alpha and assess the reliability of the questionnaire. Sampling was done through stratified random sampling, estimating 260 farmers from 42 villages in Abadeh County. Data collection involved field visits to the villages, with data entry into statistical software. Data analysis used SPSS for descriptive statistics and AMOS21 for structural equation modeling (SEM). Lastly, interpreting the results involved comparing them with previous studies, followed by report preparation.

2.2 Research design and data collection instrument

Data were collected using a survey and a questionnaire consisting of a set of open and closed questions derived from previous studies and adapted to the conditions of this study. The face and content validity of the questionnaire was confirmed by a panel of professors from the School of Agriculture at Shiraz University. Next, the reliability of the questionnaire was confirmed through a pilot study and by computing the Cronbach's alpha coefficients in a sample outside the main one, specifically among summer crop farmers in Eqlid County. Cronbach's alpha is a measure of internal consistency, which evaluates how closely related a set of items are as a group. It is widely used to assess the reliability of a questionnaire, with higher values indicating better consistency (Taber, 2018). A Cronbach's alpha value above 0.70 is generally considered acceptable (Zandazar et al., 2025), and all variables in this study had Cronbach's alpha values exceeding this threshold. Table 1 shows the Cronbach's alpha coefficients for the variables along with their conceptual and operational definitions. Finally, the collected data were analyzed using $SPSS_{26}$ and $AMOS_{21}$ software.

2.3 Sampling method

The study focused on summer crop farmers in Abadeh, Fars province, Iran. According to the Ministry of Agricultural Jihad (2024), the total number of summer crop farmers in Abadeh during the study was 770. To ensure a representative sample and account for the diversity in farm size, socio-economic characteristics, and other relevant factors, a stratified random sampling method was employed. Stratified random sampling is a technique that divides the population into distinct subgroups, or strata, that share certain characteristics (Glasgow, 2005). In this case, the strata were based on variables such as farm size, farming experience, and geographic location within the 42 villages of Abadeh. This approach ensures that each subgroup is appropriately represented in the final sample. Stratified sampling enhances the precision of the results by ensuring that key segments of the population are adequately represented, particularly when there is significant variability across different strata (Makwana et al., 2023). Once the strata were identified, a random sampling technique was applied within each subgroup to select participants. A total of 260 farmers were chosen from the 770 summer crop farmers. The sample size was determined using the standard formula for sample size calculation (Fowler, 2009), which takes into account the total population size, desired confidence level, and margin of error. This method ensures that the sample is statistically representative of the larger population, with sufficient power to detect meaningful differences between groups.

The stratified random sampling method not only improves the representativeness of the sample but also allows for a more granular analysis of the factors affecting the adoption of healthy and sustainable agricultural practices among different subgroups of farmers in Abadeh. By incorporating these varied strata, the study is able to account for potential differences across farmers based on farm characteristics, geographic location, and other relevant demographic and socio-economic factors. This ensured a balanced and diverse representation of the farming population, providing the necessary data to explore the key factors influencing the adoption of sustainable agricultural practices in this region.

$$n = N\,\delta^2 / \left(N-1\right) D + \delta^2$$

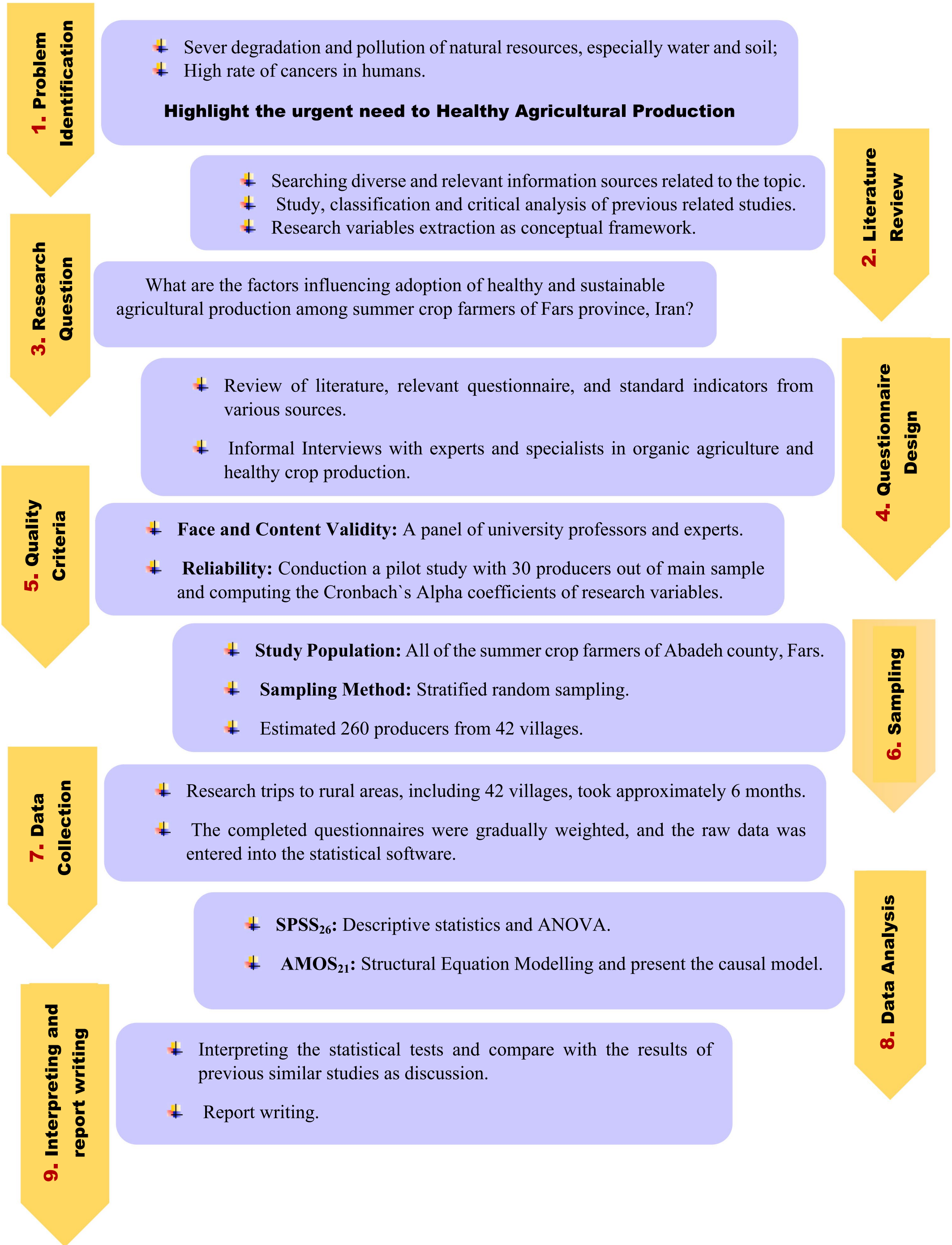

FIGURE 1
Flowchart of research methodology.

$$n = (770)(95.6)/(769)(0.25) + (95.6) = 255.56 \cong 260$$

$$D = B^2/4 = (1)^2/4 = 0.25.$$

N = Total number of summer crop farmers of Abadeh County; n = Sample Size; δ^2 = Variance of the sample (based on pilot study); B = Probable error (considering 1 in this study).

2.4 Analysis methods

Path Analysis and SEM are advanced statistical techniques used to explore complex relationships among observed and latent variables. In this study, path analysis was applied to quantify the direct effects of socio-psychological and environmental factors on the adoption of healthy and sustainable agricultural practices. It estimates the strength and direction of effects of variables through path coefficients. SEM, which includes both observed and latent variables, allows for modeling

TABLE 1 Definitions of research variables and the Cronbach's alpha coefficients.

Variables	Items	Definition	Cronbach's alpha
Awareness about the consequences of conventional agriculture	11	This variable identifies the respondents' awareness level about the weaknesses, shortcomings, and negative effects of the methods applied in conventional agriculture and determine whether the negative implications of the conventional method are understood by the respondents or not. The variable was assessed using questions about the effects of conventional agriculture on various forms of pollution, including water, soil, and air contamination. It also considered the impact on the destruction of rangeland and forest cover, as well as the harmful effects on human health and other living organisms due to excessive use of chemical inputs.	0.70
Environmental identity	6	This variable indicates the internal and mental connection with the natural and non-human factors in the surrounding environment, which is based on the historical records, emotional dependencies, and similarities influencing the method of behaving with the surrounding environment by humans. Based on the environmental identity, human belongs to the environment and nature is a part of human. The variable was measured through items related to emotional connection with nature, concerns and worries about environmental degradation, feelings of dependence and attachment to nature, a respectful attitude toward the environment, and guilt from causing harm to natural resources.	0.90
Access to information sources	4	The ability to receive information depends highly on the access to the information sources. Information channels spread awareness about new ideas and techniques, as well as encouraging the farmers in this regard. This variable determines the channels and information sources of farmers regarding healthy and sustainable agricultural production. The variable was assessed by the farmers gather the required information from various sources, including expert agricultural extension agents in the region, agricultural input vendors in villages, experienced local friends and acquaintances, and interactions with plant protection clinics.	0.74
Marketing of healthy products	6	This variable is utilized to investigate marketing-related factors including obtaining the necessary licenses and certificates for healthy products, packaging and branding, pricing and creating a culture for buying such products, and the like.	0.73
Social norms	7	This variable identifies the rules and regulations which direct people's behavior, as well as determining to what extent the respondents' protective behaviors towards the environment are influenced by social pressures and expectations. The variable was evaluated through questions addressing the individual's perception of the importance of receiving encouragement from various social connections. These included family members, relatives, neighbors, fellow farmers within the village, regional agricultural experts, and agricultural input vendors. The emphasis was on how such support and recognition might influence their decision to adopt healthy crop production practices. This highlights the role of social validation in motivating environmentally conscious agricultural behavior.	0.84
Perceived behavioral control	7	This variable identifies access to all kinds of inputs, instruments, and machines at the disposal of farmers (owned or leased) to perform their various agricultural activities in line with healthy and sustainable agricultural production. In fact, this variable refers to the level of controllability of the respondents' environmental behaviors in this field. The variable was assessed through questions regarding the ability to produce healthy crops under various conditions, including the availability of improved seeds, organic fertilizers, and non-chemical nutrients. It also examined the feasibility of using biological pest control, mechanical weed management methods, and the ability to cover the costs associated with producing healthy crops. This highlights the practical and financial factors that influence farmers' ability to adopt sustainable agricultural practices.	0.89
Attitude towards healthy and sustainable agricultural production	7	This variable seeks the positive or negative evaluation of the farmer towards methods of healthy and sustainable agricultural production, studies the respondents' opinion regarding the various techniques of such production as an alternative to conventional methods, and reviews the level of farmers' concern towards natural resources and environmental preservation during agricultural activities, as well as the significance, and concern which they have for their health, family members, and other members in the social system. The variable, analyses whether the farmers pay attention to the negative consequences of using chemicals on their health and those around during agricultural activities in the short and long term or not.	0.74

(Continued)

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TABLE 1 (Continued)

Variables	Items	Definition	Cronbach's alpha
Environmentally responsible behavior	9	Responsible behavior refers to the feeling of commitment and accepting the consequences of individual actions in performing agricultural activities. Here, responsible behavior means accepting the consequences of the respondents' agricultural activities on nature and their efforts to reduce negative environmental implications. This variable was measured using items related to the importance of crop selection to minimize environmental damage, the sense of responsibility towards soil health and water conservation, accountability for family and community well-being, and concerns about producing healthy crops for the nation.	0.70
Healthy and sustainable agricultural production	19	This variable applies various methods of healthy and sustainable agricultural production during planting, growing, and harvesting (including organic crop production as well as using Good Agricultural Practices (GAP)), and also utilizing non-chemical methods for pests and diseases control (Integrated Pests Management (IPM)). The respondents were scored based on the level of applying different methods of agricultural production. Then, they were divided into different groups, compared, and analysed.	0.93
Access to extension services	11	This variable discusses the communication of the farmer with agricultural extension institutions at the level of the village, county and province, as well as other private institutions. The variable assesses the extent of the farmer's access to such institutions, relevant experts, and other specialists, as well as the quality and influence of such communication. The respondents were asked to mention how many times they go to these centers, monthly is some direct questions.	-
Knowledge about healthy and sustainable agricultural production	14	This variable evaluates the level of respondent's knowledge. First, the level of farmers' knowledge and their familiarity with the method of healthy and sustainable agricultural production were measured. Then, the level of their knowledge about the types of methods available in healthy and sustainable agricultural production was examined. This recognition refers to production requirements, planting method, maintenance status, differences from other conventional products, and the type of usable or mandatory standards in the healthy and sustainable agricultural production. The level of respondents' familiarity with the advantages and benefits of applying healthy and sustainable agricultural production methods plays a critical role in this regard. The variable investigates the awareness about the relative advantage of healthy and sustainable agricultural production as an innovation for summer crop farmers. The Good Agricultural Practices (GAP) method was employed to achieve the objective of this variable.	0.87

Ajzen (1991); Malek-Saeidi et al. (2012); Rezaei-Moghaddam and Fatemi (2013); Rodrigues and de la Riva (2014); Bayona et al. (2015); Secretario (2017); Chiamjinnawat and Garnevska (2018); Fatemi et al. (2018); Innocent and Vasanthakaalam (2018); Irianto et al. (2019); Joshi et al. (2019); Fatemi and Rezaei-Moghaddam (2020); Hansmann et al. (2020); Kwapong et al. (2020).
All of the variables except "access to extension service" were computed with 5-point Likert scale.

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multiple equations simultaneously, capturing the complex interactions between these factors (Almeida, 2024). SEM offers a comprehensive understanding of both direct and indirect effects on the adoption of organic farming practices.

Standardized total effects provide a summary of both direct and indirect effects, indicating the total influence of one variable on another. Direct effects are the immediate impacts of one variable on another, while indirect effects are mediated through other variables (Lleras, 2005). These effects are calculated by summing the direct and indirect effects and then standardizing them, making the results comparable across studies. In this study, $AMOS_{21}$ software was used to compute the standardized total effects, which were then interpreted based on their strength: effects under 0.10 indicate weak relationships, 0.10–0.30 represent moderate effects, and those over 0.50 show strong effects (Gignac and Szodorai, 2016; Fatemi et al., 2021). This analysis provides valuable insights into the factors most influencing farmers' adoption of healthy and sustainable agricultural practices.

3 Results and discussion

Based on the results, most respondents (52%) were aged 30–45 years. A significant proportion, 66.2% (172 individuals), had education up to the diploma level, while 28.5% (74 individuals) had university degrees. Regarding household size, 47.3% (123 individuals) had fewer than three members, 7.3% (19 individuals) had more than five members, and 45.4% had between three and five members. In terms of agricultural experience, 38.5% (100 individuals each) had less than 15 years and 15–25 years of experience, while 60 respondents had more than 25 years of agricultural background.

3.1 The comparison of summer crop farmers with different levels of activities in healthy crop production

Since farmers exhibit a range of behaviors regarding healthy and sustainable agricultural production and the use of related techniques, it was not possible to categorize them simply into "users" and "non-users." Therefore, as indicated in the conceptual and operational definitions of the variables in Table 1, the variable of healthy and sustainable agricultural production was measured using 19 questions on a Likert scale, ranging from 0 to 76. To obtain a qualitative description of the healthy and sustainable agricultural production variable and classify respondents among summer crop farmers, the Interval Standard Deviation from Mean (ISDM) method was used. This method is a popular choice for qualitative description of research variables (Amir et al., 2020). In the ISDM method, the scores obtained are divided into three levels, as shown in Table 2. The results indicated that the rate of healthy and sustainable agricultural production was low for 14.2% of summer crop farmers, moderate for 47.3%, and high for 38.5%.

TABLE 2 Classifying the extent of healthy and sustainable agricultural production of summer crop farmers.

A < Mean-SD	A < 22.3	Low	14.2%
Mean-SD < B < Mean	22.3 < B < 31.24	Moderate	47.3%
Mean < C	C > 31.24	High	38.5%

3.1.1 Farmers' comparison: individual factors

Table 3 presents the results of a one-way ANOVA comparing three groups of summer crop farmers with varying levels of activity in healthy and sustainable agricultural production. Significant differences were found among the groups for education level ($p = 0.0001$, $F = 10.53$) and environmental identity ($p = 0.0001$, $F = 10.42$). The high-activity group had a significantly higher average education level (13.69), indicating greater awareness and knowledge in healthy product cultivation. Additionally, the environmental identity score was notably higher in the high-activity group (24.77), suggesting stronger environmental awareness compared to the low and medium activity groups. Kılıç et al. (2020) found that education level is crucial for adopting appropriate agricultural practices among farmers in Bafra, Turkey.

3.1.2 Farmers' comparison: structural-economic factors

Table 4 presents the results of a one-way ANOVA comparing three groups of summer crop farmers with varying levels of activity in healthy and sustainable agricultural production, focusing on structural-economic factors. Significant differences were observed for income from non-agricultural work ($p = 0.0001$, $F = 19.13$) and the importance of product marketing ($p = 0.0001$, $F = 376.40$). The high-activity group had a significantly higher mean income from non-agricultural work (37.95) and placed more emphasis on product marketing (18.34) compared to the other two groups. This suggests that the high-activity group's focus on healthy and sustainable agricultural production and involvement in various activities drives their greater attention to marketing. Hansmann et al. (2020) suggested that a sufficient income level and economic justification are key reasons for adopting organic products. Kılıç et al. (2020) also reported a significant relationship between non-agricultural income and healthy and sustainable agricultural production, while Gökkür and Sinav (2020) highlighted the often-overlooked importance of marketing healthy products.

Additionally, significant differences were found for access to extension services ($p = 0.03$, $F = 3.34$) and access to information sources ($p = 0.0001$, $F = 62.11$). The high-activity group had significantly better access to both extension services (81.82) and information sources (17.72) than the other groups. This suggests that increased use of information sources to improve crop productivity and health is linked to better utilization of extension services. These findings emphasize the need for the Agriculture Jihad Organization to adequately support the other groups, while also teaching all farmers the methods for utilizing communication channels with relevant experts. These results align with Irianto et al. (2019), who found that greater access to information sources leads to increased awareness and encourages healthy product production. Furthermore, Alotaibi et al. (2021) showed that better access to information strengthens social capital and provides insight into production challenges.

TABLE 3 One-way ANOVA results of summer crop farmers in triple groups of healthy and sustainable agricultural productions activities in terms of individual factors.

Variables	Low		Moderate		High		F	Sig.
	Mean	SD	Mean	SD	Mean	SD		
Age	38.76	10.007	41.99	9.81	41.42	9.87	1.54	0.216
Household size	3.41	1.23	3.68	1.30	3.56	1.25	0.74	0.477
Educational level	12.38[a]	1.75	12.26[a]	2.58	13.69[b]	2.36	10.53	0.0001
Agricultural background	18.76	10.007	21.99	9.81	20.75	10.04	1.58	0.207
Environmental identity	23.39[a]	2.60	24.57[a]	1.87	24.77[b]	2.15	10.42	0.0001

There is no significance difference at 0.05 level between the means with similar letters.
Environmental Identity: 6–30.

TABLE 4 One-way ANOVA results of summer crop farmers in triple groups of healthy and sustainable agricultural productions activities in terms of structural-economic factors.

Variables	Low		Moderate		High		F	Sig.
	Mean	SD	Mean	SD	Mean	SD		
Agricultural annual income	85.97	63.46	98.92	67.30	97.83	64.89	0.56	0.572
Farm size	3.56	1.11	3.84	1.45	3.65	1.29	0.89	0.412
Non-farm activities' income	10.81[a]	20.05	15.98[a]	24.98	37.95[b]	37.11	19.13	0.0001
Marketing of healthy products	10.68[a]	2.08	11.23[a]	2.33	18.34[b]	1.68	376.40	0.0001
Access to extension service	70.30[a]	30.97	74.11[a]	28.91	81.82[b]	26.81	3.34	0.037
Access to information sources	15.57[a]	1.95	14.98[a]	1.98	17.72[b]	1.64	62.11	0.0001

There is no significance difference at 0.05 level between the means with similar letters.
Marketing of healthy products: 6–30; Access to information sources: 4–20.

3.1.3 Farmers' comparison: environmentally-oriented factors

Table 5 presents the results of a one-way ANOVA comparing three groups of summer crop farmers with varying levels of activity in healthy and sustainable agricultural production, focusing on environmentally-oriented factors. Significant differences were found in awareness of conventional agricultural consequences ($p = 0.0001$, $F = 176.68$), knowledge about healthy and sustainable agricultural production ($p = 0.0001$, $F = 100.23$), social norms ($p = 0.0001$, $F = 18.08$), attitude towards healthy and sustainable agricultural production ($p = 0.0001$, $F = 152.44$), and perceived behavioral control ($p = 0.0001$, $F = 104.92$). The high-activity group demonstrated significantly greater awareness of conventional agriculture's negative impacts (36.99), followed by the medium (30.31) and low (28.54) activity groups. This suggests that those engaged in higher levels of healthy and sustainable agricultural production are more informed about the drawbacks of conventional practices. Training programs and showcasing successful socio-economic examples could help raise awareness in the other groups.

Moreover, the high-activity group also had significantly more knowledge about healthy and sustainable agricultural production (43.98), indicating a stronger commitment to improving product quality. In terms of social norms, the high-activity group (26.43) displayed greater alignment with environmental protective behaviors compared to the medium (25.37) and low (24.68) activity groups. This suggests that the high-activity group is more influenced by social pressures to engage in environmentally responsible practices. Expanding healthy and sustainable agricultural practices in the region could encourage similar behaviors among the other groups. Regarding attitude towards healthy and sustainable agricultural production, the low-activity group (17.22) exhibited the least favorable attitude, suggesting the need for coordinated training and continuous implementation to improve this attitude. Additionally, the high-activity group (20.58) reported greater perceived behavioral control over their environmental practices, reflecting their ability to manage both product quality and environmental impact. Asadollahpour et al. (2020) identified lack of knowledge and concerns about future outcomes as key challenges in adopting healthy and sustainable agricultural practices. Fatemi and Rezaei-Moghaddam (2020) highlighted the importance of environmentally responsible behavior, environmental identity, perceived behavioral control, moral and social norms, and farmers' awareness of organic farming methods as critical factors for adopting healthy and sustainable agricultural production.

TABLE 5 One-way ANOVA results of summer crop farmers in triple groups of healthy and sustainable agricultural productions activities in terms of environmentally-oriented factors.

Variables	Low		Moderate		High		F	Sig.
	Mean	SD	Mean	SD	Mean	SD		
Awareness of consequences of conventional agriculture	28.54[a]	2.31	30.31[b]	2.74	36.99[c]	3.48	176.68	0.0001
Knowledge about healthy and sustainable agricultural production	35.68[a]	5.77	35.75[a]	4.96	43.98[b]	3.42	100.23	0.0001
Social norms	24.68[a]	1.95	25.37[b]	1.95	26.43[c]	1.21	18.08	0.0001
Environmentally responsible behavior	27.14	3.03	26.24	3.12	26.37	3.40	1.12	0.326
Attitude toward healthy and sustainable agricultural production	17.22[a]	1.62	20.92[b]	2.35	21.37[b]	1.79	152.44	0.0001
Perceived behavioral control	15.97[a]	2.26	16.54[a]	2.12	20.58[b]	2.43	104.92	0.0001

There is no significance difference at 0.05 level between the means with similar letters.
Awareness of consequences of conventional agriculture: 11–55; Knowledge about healthy and sustainable agricultural production: 0–70; Social norms: 7–35; Environmentally responsible behavior: 0–36; Attitude toward healthy and sustainable agricultural production: 7–35; Perceived behavioral control: 7–35.

3.2 Causal analysis of factors affecting healthy and sustainable agricultural production

Analyzing the variables of the DOI and FS models through a socio-psychological and environmentally-oriented lens provides a deeper understanding of the adoption process for healthy crop production practices. Figure 2 presents the conceptual framework outlining the key factors influencing healthy and sustainable agricultural production, which will be tested through path analysis in this section. This framework serves as the foundation for exploring the relationships between these factors and their impact on farmers' adoption of healthy and sustainable practices. Figure 3 displays the results of the path analysis, illustrating how these factors interact and influence each other in the context of healthy and sustainable agricultural production among summer crop farmers. The analysis was conducted using $AMOS_{21}$ software, and standard path coefficients were obtained. Table 6 provides the indices for data-model fitting, confirming the optimal fit of the causal model.

TABLE 6 Goodness of fit measures of structural equation model of healthy products of summer crop farmers.

Index	Expected	Computed
Chi-square	–	216.420
df	–	72
Chi-square/df	5≥	3
GFI	0.9≤	1
NFI	0.9≤	0.96
CFI	0.9≤	0.95
RMSEA	0.06≥	0.025

3.2.1 Causal effects of variables on environmentally-oriented factors

3.2.1.1 Knowledge about healthy and sustainable agricultural production

As shown in Table 7 and Figure 3, healthy product marketing has the most direct and significant effect on knowledge about healthy and sustainable agricultural production ($p = 0.0001$, $\beta = 0.482$). Increased focus on marketing healthy products and educating farmers about these issues enhances their knowledge. Additionally, environmental identity has a positive effect on knowledge about healthy and sustainable agricultural production ($p = 0.01$, $\beta = 0.126$). Farmers with a strong connection to their environment tend to seek out more information on sustainable agricultural practices. Access to information sources also positively influences knowledge ($p = 0.02$, $\beta = 0.119$), with more information leading to better production knowledge.

Both agricultural ($\beta = 0.111$) and non-agricultural ($\beta = 0.101$) incomes directly influence knowledge about healthy and sustainable agricultural production. Conversely, the agricultural background negatively affects knowledge ($p = 0.03$, $\beta = -0.111$), indicating that older, more experienced farmers tend to have less knowledge in this area. Fatemi and Rezaei-Moghaddam (2020) highlighted the role of environmental identity and perceived behavioral control in farmers' understanding and adoption of organic practices, which aligns with these findings. Moreover, Razzaghi-Burkhani and Mohammadi (2019) noted that a lack of communication channels and information sources hinders farmers' progress, consistent with this study's results. Hansmann et al. (2020) emphasized that more information and sufficient income are crucial for adopting environmentally friendly agricultural practices, further supporting these findings.

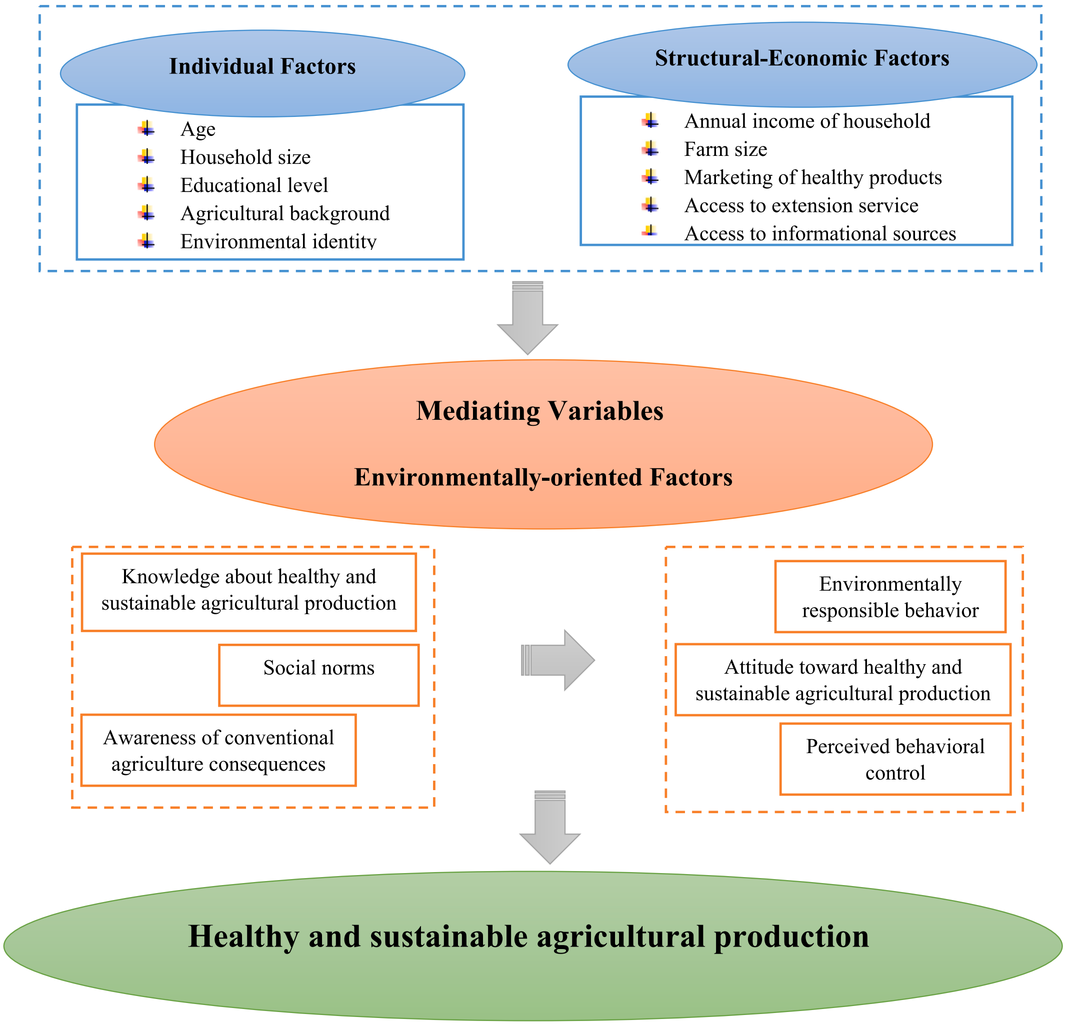

FIGURE 2
Conceptual framework of the study based on an integrated model combining DOI, FS and environmentally-oriented factors.

3.2.1.2 Awareness of conventional agriculture consequences

Table 7 and Figure 3 illustrate the causal effects of various variables on awareness of the consequences of conventional agriculture. The results show that the healthy product marketing has a direct and positive effect on awareness (p = 0.0001, β = 0.584). Farmers who prioritize marketing healthy products and related issues are more aware of the negative impacts of conventional agriculture. Access to information sources also significantly enhances awareness (p = 0.001, β = 0.152), providing specialized knowledge about the harmful consequences of conventional agricultural practices. Non-agricultural income positively influences awareness (p = 0.004, β = 0.135), suggesting that farmers who recognize the environmental damage caused by conventional farming often seek additional non-agricultural work to ease the strain on natural resources. The agricultural background also contributes positively to awareness (p = 0.01, β = 0.113), indicating that more experienced farmers tend to be more aware of these consequences. Alotaibi et al. (2019) emphasized the importance of marketing organic products as a critical source of knowledge in transitioning from conventional to sustainable farming. Similarly, Gökkür and Sinav (2020) pointed out that the lack of proper infrastructure and marketing management systems for healthy products disrupts the production-to-consumption chain. Dos Santos and Ahmad (2020) highlighted family income and non-agricultural employment as key factors influencing sustainable agriculture in their study of 28 EU countries. Fatemi and Rezaei-Moghaddam (2020) also found that awareness of organic farming methods and their environmental impact plays a significant role in adopting healthy planting practices. These findings align with the results from the current study's causal model.

3.2.1.3 Social norms

Table 7 and Figure 3 illustrate the causal effects of various variables on social norms. The results indicate that attention to market significance directly and positively influences social norms (p = 0.0001, β = 0.224). Focusing on the market networks of healthy products helps shape social norms related to their production through encouragement and persuasion from different sectors of society. Additionally, environmental identity has a direct positive effect on social norms (p = 0.004, β = 0.164), with a high level of environmental concern leading to stronger societal alignment with environmental preservation. Non-agricultural income also positively influences social

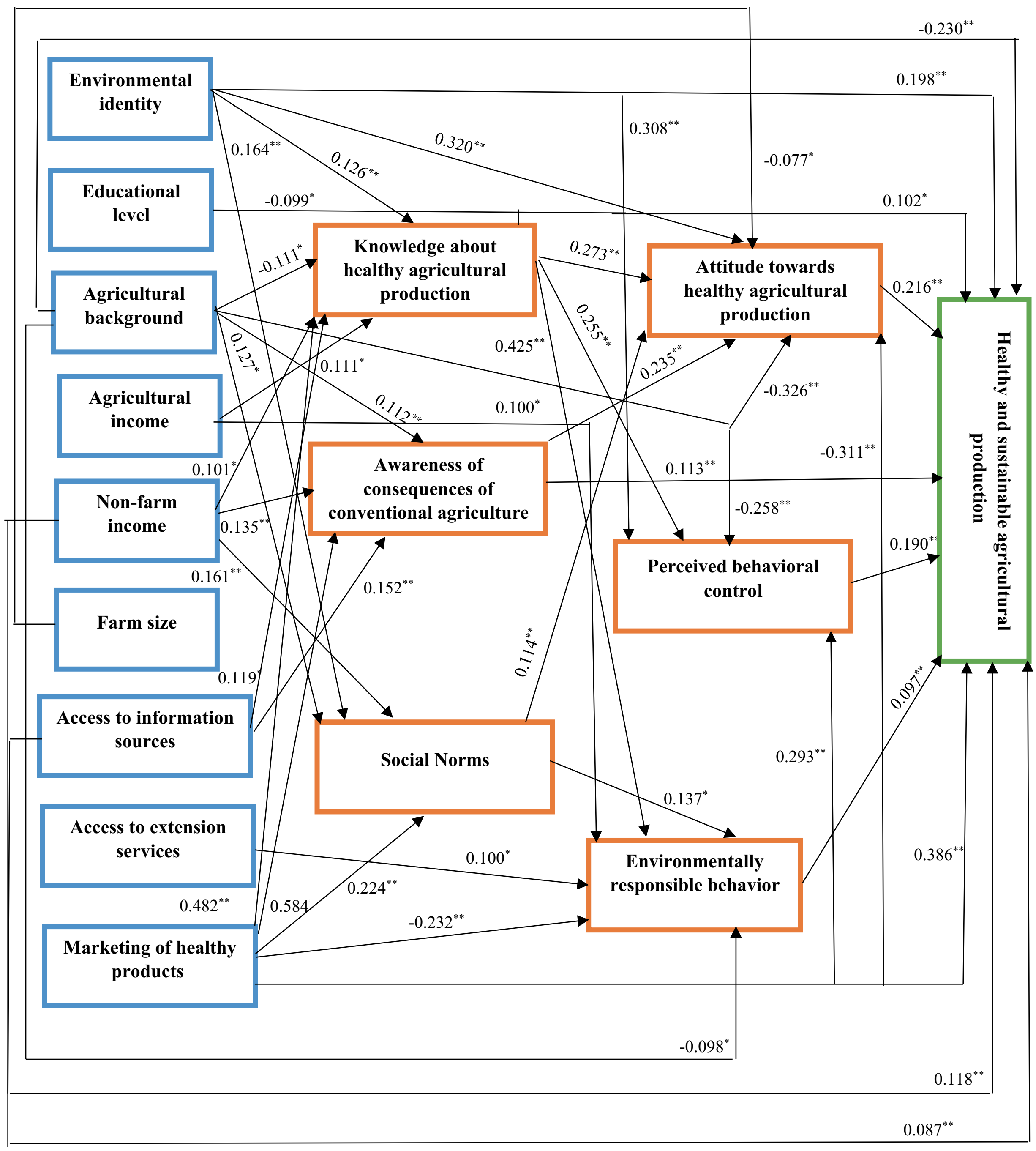

FIGURE 3
Causal model factors affecting the healthy and sustainable agricultural production.

norms (p = 0.005, β = 0.161). Furthermore, the agricultural background plays a significant role in shaping social norms related to healthy and sustainable agricultural production (p = 0.02, β = 0.127), suggesting that experienced farmers serve as key influencers in rural communities, guiding the adoption or rejection of healthy production methods. Li et al. (2016) examined 34 neighborhoods in New York City and found that interventions aimed at social norms through marketing and reliable models can increase the social acceptance of healthy product consumption. Bertoldo and Castro (2016) argued that the effect of environmental identity on social norms is stronger in group settings than in individual ones, with cognitive norms having a greater influence when they are direct and well-established.

3.2.1.4 Attitude towards healthy and sustainable agricultural production

As shown in Table 7, environmental identity has the most direct effect on attitudes towards healthy and sustainable agricultural production (p = 0.0001, β = 0.320). This emphasizes the importance of enhancing summer crop farmers' environmental identity to improve their attitudes towards healthy and sustainable agricultural

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production. Farmers who are more engaged with and have a stronger connection to the environment tend to exhibit more favorable attitudes toward producing healthy products. Social norms also directly and positively influence farmers' attitudes towards healthy and sustainable agricultural production ($p = 0.009$, $\beta = 0.114$). The influence of peers, particularly those who excel in healthy and sustainable agricultural practices, plays a critical role in shaping attitudes. Moreover, knowledge about healthy and sustainable agricultural production has a direct and positive impact on attitudes ($p = 0.0001$, $\beta = 0.273$). Training programs that increase farmers' knowledge about healthy products can significantly improve their attitudes toward producing such products.

Awareness of the consequences of conventional agriculture also positively and significantly affects attitudes towards healthy and sustainable agricultural production ($p = 0.0001$, $\beta = 0.235$). Educating farmers about the negative impacts of conventional agriculture strengthens their commitment to adopting healthier production methods. On the other hand, a background in conventional agricultural practices negatively affects attitudes ($p = 0.0001$, $\beta = -0.326$). Older, more experienced farmers, who have used conventional methods for a long time, often show resistance to adopting new practices such as healthy and sustainable agricultural production. Additionally, the size of agricultural land negatively influences attitudes towards healthy and sustainable agricultural production. Farmers with larger landholdings tend to prefer conventional methods, which are perceived to be more efficient and profitable, as opposed to the lower yield and profitability associated with healthy and sustainable agricultural practices. Williams and Chawla (2015) examined informal environmental education programs and found that social education theory strengthens attitudes by improving environmental identity, which aligns with our findings. Ranjbar Shams and Omidi Najafabadi (2014) reported that knowledge, environmental concerns, and social norms influence attitudes toward using organic products. Hansmann et al. (2020) asserted that economic and social justification for using conventional food products affects attitudes and social norms towards organic products. Furthermore, Fatemi and Rezaei-Moghaddam (2020) highlighted that farmers' attitudes towards organic methods, their environmental concerns, and opinions from reference groups significantly impact the adoption and implementation of organic farming practices.

3.2.1.5 Environmentally responsible behavior

As indicated in Table 7, knowledge of healthy and sustainable agricultural production has the most direct effect on environmentally responsible behavior ($p = 0.0001$, $\beta = 0.425$). This emphasizes the importance of enhancing summer crop farmers' knowledge about healthy and sustainable agricultural practices. Improving this knowledge increases their sense of responsibility towards responsible agricultural production, which is crucial for encouraging related behaviors. Additionally, social norms positively influence responsible behavior in healthy and sustainable agricultural production ($p = 0.020$, $\beta = 0.137$). Societal norms and customs play a significant role in shaping individuals' sense of responsibility, as people tend to align their actions with societal expectations. Access to appropriate extension services related to healthy and sustainable agricultural production also plays a critical role in fostering responsible behavior. Extension services directly impact responsible behavior in healthy and sustainable agricultural production ($p = 0.032$, $\beta = 0.100$). These trainings are most effective when farmers have adequate agricultural income to cover the associated costs.

Agricultural income significantly influences responsible behavior in healthy and sustainable agricultural production ($p = 0.04$, $\beta = 0.100$). However, the results also indicate that an excessive focus on market and economic issues related to healthy products negatively affects farmers' sense of responsibility ($p = 0.002$, $\beta = -0.232$). Overemphasis on economic aspects and market sales can prevent farmers from prioritizing environmentally responsible actions to preserve natural resources. Furthermore, the background of conventional agricultural practices negatively affects farmers' environmental responsibility in healthy and sustainable agricultural production ($p = 0.03$, $\beta = -0.098$). Older and more experienced farmers tend to exhibit a lower sense of environmental responsibility in healthy and sustainable agricultural practices. Rezaei-Moghaddam and Fatemi (2013) found that environmental responsibility, social effects, awareness, social norms, and environmental identity are key factors influencing environmental behavior. Badani (2021) also suggested that the willingness to adopt organic farming, combined with environmental identity, responsibility, and ethical norms, plays a crucial role in promoting the behavior of producing organic products.

3.2.1.6 Perceived behavioral control

As shown in Table 7, environmental identity has the most direct effect on perceived behavioral control ($p = 0.0001$, $\beta = 0.308$). Farmers with a stronger sense of connection to the environment and natural resources exert more effort to acquire the tools needed for healthy product production, granting them better access to and control over these resources.

Marketing healthy products also has a significant positive impact on perceived behavioral control ($p = 0.0001$, $\beta = 0.293$). The market and its components significantly influence the improvement of farmers' activities, especially in healthy product production. Furthermore, knowledge about healthy and sustainable agricultural production positively affects perceived behavioral control ($p = 0.0001$, $\beta = 0.255$). As farmers gain more knowledge about healthy product production, their control over their activities increases.

In contrast, the background in conventional agriculture has a significant negative effect on perceived behavioral control in healthy and sustainable agricultural production ($p = 0.0001$, $\beta = -0.258$). This suggests that farmers with conventional agriculture experience face limitations in accessing and controlling the necessary resources and inputs for healthy crop cultivation, likely due to support structures favoring conventional practices. Xu et al. (2020) found that ecological perceived behavior among local people and tourists is related to proper education, with a positive and significant effect on ecological behavior and environmental identity. Similarly, Prati et al. (2017) highlighted the role of environmental behaviors, social identity, and the ecological context, noting that perceived environmental behavior largely predicts environmental behavior habits. Tartaro (2017) reported that perceived behavioral control, coupled with a positive attitude, plays a key role in protecting natural resources and meeting environmental expectations.

3.2.2 Causal effects of variables on healthy and sustainable agricultural production

As shown in Table 8, the healthy products market has the most significant direct and positive effect on the activities of healthy and

TABLE 7 **Total and direct effects of research variables on environmentally-oriented factors.**

Variables	Knowledge about healthy and sustainable agricultural production		Awareness of consequences of conventional agriculture		Social norms		Attitude towards healthy and sustainable agricultural production				Environmentally responsible behavior				Perceived behavioral control			
	Direct effect	Sig.	Direct effect	Sig.	Direct effect	Sig.	Total effect	Direct effect	Indirect effect	Sig.	Total effect	Direct effect	Indirect effect	Sig.	Total effect	Direct effect	Indirect effect	Sig.
Environmental identity	0.126	0.015	0.037	0.439	0.164	0.004	0.296	0.32	−0.024	0.0001	0.115	0.086	0.029	0.124	0.351	0.308	0.043	0.0001
Educational level	−0.01	0.854	−0.061	0.199	−0.079	0.166	0.03	0.022	0.008	0.586	−0.021	−0.031	0.01	0.568	−0.11	−0.099	−0.011	0.02
Agricultural background	−0.111	0.032	0.113	0.018	0.127	0.026	−0.284	−0.326	0.042	0.0001	−0.122	−0.098	−0.023	0.03	−0.302	−0.258	−0.044	0.0001
Agricultural income	0.111	0.034	0.076	0.113	0.075	0.191	0.021	0.06	−0.039	0.14	0.133	0.1	0.032	0.04	0.068	0.03	0.038	0.49
Non-farm income	0.101	0.04	0.135	0.004	0.161	0.005	−0.02	0.021	−0.041	0.608	0.012	−0.001	0.013	0.987	0.092	0.047	0.044	0.283
Fam size	−0.065	0.209	0.033	0.494	−0.062	0.282	−0.074	−0.077	0.003	0.04	−0.045	−0.024	−0.021	0.667	−0.083	−0.066	−0.017	0.12
Access to information sources	0.119	0.022	0.152	0.001	0.05	0.387	−0.089	−0.027	−0.062	0.517	0.108	0.073	0.035	0.195	0.087	0.042	0.045	0.335
Access to extension service	0.056	0.277	0.035	0.465	0.079	0.167	−0.042	−0.027	−0.015	0.499	0.111	0.1	0.011	0.032	0.033	0.012	0.021	0.773
Marketing of healthy products	0.482	0.0001	0.584	0.0001	0.224	0.0001	−0.555	−0.311	−0.243	0.0001	−0.092	−0.232	0.141	0.002	0.447	0.293	0.181	0.0001
Knowledge about healthy and sustainable agricultural production	–	–	–	–	–	–	0.273	0.273	–	0.0001	0.425	0.425	–	0.0001	0.255	0.255	–	0.0001
Awareness of consequences of conventional agriculture	–	–	–	–	–	–	0.235	0.235	–	0.0001	−0.057	−0.057	–	0.419	0.082	0.082	–	0.141
Social norms	–	–	–	–	–	–	0.114	0.114	–	0.009	0.137	0.137	–	0.02	0.048	0.048	–	0.292

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TABLE 8 Total, direct and indirect effects of research variables on healthy and sustainable agricultural production behavior.

Variables	Standardized total effects	Standardized direct effects	Standardized indirect effects	Sig.
Environmental identity	0.203	0.198	0.006	0.0001
Educational level	0.005	0.037	−0.032	0.242
Agricultural background	−0.236	−0.230	−0.006	0.0001
Agricultural income	0.048	0.034	0.014	0.299
Non-farm income	0.129	0.087	0.043	0.008
Fam size	0.024	0.022	0.003	0.492
Access to information sources	0.172	0.118	0.054	0.0001
Access to extension service	0.042	0.029	0.013	0.352
Marketing of healthy products	0.716	0.386	0.330	0.0001
Knowledge about healthy and sustainable agricultural production	0.168	0.102	0.066	0.021
Awareness of consequences of conventional agriculture	0.185	0.113	0.072	0.008
Social norms	−0.022	−0.020	−0.002	0.571
Attitude towards healthy and sustainable agricultural production	0.216	0.216	–	0.0001
Perceived behavioral control	0.190	0.190	–	0.0001
Environmentally responsible behavior	0.097	0.097	–	0.007

sustainable agricultural production ($p = 0.0001, \beta = 0.386$). A well-established market plays a crucial role in promoting healthy and sustainable agricultural production. Additionally, perceived behavioral control significantly healthy and sustainable agricultural production. The results reveal that perceived behavioral control directly and positively affects these activities ($p = 0.0001, \beta = 0.190$). Access to resources and support is essential for summer crop farmers to engage in healthy and sustainable agricultural production. Farmers with supplementary income sources beyond agriculture are better equipped to produce healthy products. The model indicates that non-agricultural income significantly affects the behaviors related to healthy and sustainable agricultural production ($p = 0.008, \beta = 0.087$). Access to information sources is also vital in increasing farmers' awareness of the consequences of conventional agriculture and improving their knowledge of healthy and sustainable agricultural practices. These factors, along with perceived behavioral control, directly and significantly affect healthy and sustainable agricultural production, with coefficients of 0.118, 0.113, and 0.102, respectively.

Fostering farmers' environmental identity is critical, as it directly and positively influences healthy and sustainable agricultural production ($p = 0.0001, \beta = 0.198$). Training programs that strengthen environmental responsibility and commitment to producing healthy products can have a profound impact. Furthermore, the attitude towards healthy and sustainable agricultural production positively and significantly affects these activities ($p = 0.0001, \beta = 0.216$), as does the farmers' sense of responsibility ($p = 0.007, \beta = 0.097$). However, the model also highlights the negative effect of the farmers' background in conventional agricultural practices ($p = 0.0001, \beta = -0.230$). Older, more experienced farmers are less likely to engage in healthy and sustainable agricultural production behaviors.

Since age and household size showed no significant differences across the groups and had no significant effect on the dependent variable in the causal model, they were excluded from the path analysis. Some variables influence healthy and sustainable agricultural production both directly and indirectly through mediator variables. Environmental identity, agricultural and non-agricultural incomes, access to information sources, extension services, and the significance of marketing all affect healthy and sustainable agricultural production in these ways. Knowledge about healthy and sustainable agricultural production influences activities directly and indirectly by shaping attitudes towards healthy products, perceived behavioral control, and environmentally responsible behavior. Awareness of the consequences of conventional agriculture improves healthy and sustainable agricultural production by positively shaping attitudes and promoting necessary improvements. Additionally, social norms indirectly enhance healthy and sustainable agricultural production by influencing attitudes and fostering environmental responsibility. Asadollahpour et al. (2020) developed a model of farmers' behavior in organic agriculture, finding that attitudes and abstract norms positively influenced rice farmers' willingness to engage in organic agricultural practices, which aligns with the findings of this study.

4 Conclusion

This study aimed to understand the factors influencing the adoption of healthy and sustainable agricultural practices in Fars province, Iran, by integrating the DOI model, FS model, and environmental perspectives. The findings highlight the intricate link between agricultural production, environmental responsibility, and farmers' decision-making regarding healthy and sustainable practices. By examining both economic and social drivers, this research offers valuable insights into the necessary steps for promoting sustainable farming in the region.

The transition from conventional to sustainable agriculture requires a concerted effort to enhance farmers' awareness, improve access to information, and expand targeted extension services. Policymakers should prioritize specialized support for farmers already practicing sustainable agriculture, as they serve as key influencers in their communities. Their role in knowledge dissemination can accelerate the adoption process, making it crucial to establish effective communication channels between experienced sustainable farmers and others. Additionally, the study emphasizes the influence of socio-cultural norms on agricultural behavior. Farmers engaged in healthy and sustainable practices tend to adhere to stronger social norms supporting environmental responsibility, while others may lack motivation or confidence in sustainable methods. Addressing these disparities calls for cultural education initiatives, engagement of community opinion leaders, and the implementation of regulatory frameworks to reinforce environmental commitments. Economic and policy incentives are fundamental to shaping farmers' perspectives on sustainability. This research advocates for the introduction of financial and cultural incentives, demonstration farms, and comparative studies to highlight the economic benefits of healthy and sustainable practices over conventional ones. Strengthening infrastructure for the sale and distribution of healthy and sustainable agricultural products, along with expanding market access, can help alleviate financial concerns and encourage wider adoption of sustainable farming.

Environmental identity and emotional bonds with nature emerged as significant drivers of sustainable agricultural behaviors. Enhancing these connections through educational programs and community-based initiatives can reinforce farmers' commitment to environmental stewardship. Moreover, leveraging modern communication technologies, such as digital platforms and mobile applications, can facilitate broader awareness of sustainable agriculture's benefits and the environmental risks of conventional methods. A key challenge identified in this study is the lack of coordination among institutions. To address this, a collaborative effort between agricultural, environmental, and health organizations is necessary to create a unified platform for educating both consumers and producers. This synergy should focus on increasing awareness, fostering consumer demand for healthy and sustainable products, and cultivating a sustainability-oriented agricultural culture.

Ultimately, adopting healthy and sustainable agricultural practices in Fars province requires a multifaceted approach that addresses both the knowledge gaps and structural challenges facing farmers. Through targeted policies, improved access to resources, and a stronger cultural emphasis on sustainability, Iran's agricultural sector can move toward a more sustainable future, benefiting both the environment and public health. It is recommended that policymakers strengthen extension services, particularly for farmers already involved in sustainable practices, while also promoting cultural education and legal mechanisms to elevate social norms around sustainability. Financial and economic incentives, coupled with improved market access for sustainable products, can help overcome adoption barriers. Furthermore, fostering emotional connections to the environment and leveraging modern communication technologies can enhance awareness and drive sustainable farming behaviors. Finally, greater inter-institutional coordination is essential to create a unified approach for supporting the transition to healthier, more sustainable agricultural practices, benefiting both farmers and consumers alike.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Higher Education Committee at School and University level. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. MF: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CS: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. Some of the research costs were funded by Shiraz University through a research grant for a student thesis, covering expenses related to research trips and data collection.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T

Almeida, F. (2024). Editorial: performing a structural equation modeling (SEM) in innovation science studies. *Int. J. Innov. Sci.* 16, 1005–1011. doi: 10.1108/IJIS-12-2024-289

Alotaibi, B. A., Yoder, E., Brennan, M. A., and Kassem, H. S. (2019). Training needs of extension agents' regarding organic agriculture in Saudi Arabia. *Eval. Program Plann.* 77:101711. doi: 10.1016/j.evalprogplan.2019.101711

Alotaibi, B. A., Yodera, E., Brennana, M. A., and Kassemc, H. S. (2021). Perception of organic farmers towards organic agriculture and extension services. *Saudi J. Biol. Sci.* 28, 2980–2986. doi: 10.1016/j.sjbs.2021.02.037

Amir, L. R., Tanti, I., Maharani, D. A., Wimardhani, S. Y., Julia, V., Sulijaya, B., et al. (2020). Student perspective of classroom and distance learning during COVID-19 pandemic in the undergraduate dental study program Universitas Indonesia. *BMC Med. Educ.* 20:392. doi: 10.1186/s12909-020-02312-0

Asadollahpour, A., Omidi Najafabadi, M., and Farajollah Hosseini, S. J. (2020). Transition barriers to organic farming among paddy farmers in Mazandaran province. *Iranian Agric. Ext. Educ. J.* 16, 235–246. doi: 10.22034/iaeej.2020.205833.1469

Badani, M. (2021). Investigation of promotional and sociological factors affecting organic agriculture in Iran. *Int. J. Farm. Allied Sci.* 10, 22–35.

Bayona, J. A., Caballer, A., and Peiró, J. M. (2015). The work design questionnaire: Spanish version and validation. *Revista de Psicología del Trabajo y de las Organizaciones* 31, 187–200. doi: 10.1016/j.rpto.2015.06.001

Bertoldo, R., and Castro, P. (2016). The outer influence inside us: exploring the relation between social and personal norms. *Resour. Conserv. Recycl.* 112, 45–53. doi: 10.1016/j.resconrec.2016.03.020

Burns, C. J. (2023). Farmers, pesticides, and cancer: a global perspective on exposure and health risks. *Pesticide Facts*. Retrieved from https://pesticidefacts.org

Chiamjinnawat, B., and Garnevska, E. (2018). Effects of farmers' goals on strategic marketing decisions: a study of fruit farmers in Chanthaburi province of Thailand. *Asian Adm. Manage. Rev.* 1, 123–137.

Dos Santos, M. J. P. L., and Ahmad, N. (2020). Sustainability of European agricultural holdings. *J. Saudi Soc. Agric. Sci.* 19, 358–364. doi: 10.1016/j.jssas.2020.04.001

Ebrahimi, N., and Manian, F. (2007). The impact of pesticides on agricultural land in Fars province, Iran: carcinogenic risks and hormonal effects. *J. Environ. Health* 26, 65–71.

EFSA. (2023). *The 2021 European Union report on pesticide residues in food*. Available online at: https://www.efsa.europa.eu/en/efsajournal/pub/7939

Fanelli, R. M. (2020). The spatial and temporal variability of the effects of agricultural practices on the environment. *Environments* 7, 1–18. doi: 10.3390/environments7040033

Fars Agricultural Jihad Organization. (2023). *Abadeh county agricultural statistical yearbook*. Department of Statistics, Technology, and Information.

Fatemi, M., and Atefatdoost, A. (2020). The alternative model to predict adoption behavior of agricultural technologies. *J. Saudi Soc. Agric. Sci.* 19, 383–390. doi: 10.1016/j.jssas.2020.04.003

Fatemi, M., and Rezaei-Moghaddam, K. (2020). Sociological factors influencing the performance of organic activities in Iran. *Life Sci. Soc. Policy* 16, 1–16. doi: 10.1186/s40504-020-00098-z

Fatemi, M., Rezaei-Moghaddam, K., Karami, E., Hayati, D., and Wackernagel, M. (2021). An integrated approach of ecological footprint (EF) and analytical hierarchy process (AHP) in human ecology: a base for planning toward sustainability. *PLoS One* 16, 1–31. doi: 10.1371/journal.pone.0250167

Fatemi, M., Rezaei-Moghaddam, K., Monfared, N., and Moghaddas-Farimani, S. (2018). Factors affecting behavioral change toward organic agriculture (the case of farmers of Bushehr province). *Iranian J. Agric. Econ. Dev. Res.* 2-49, 779–796. doi: 10.22059/ijaedr.2018.245092.668515

Firoozzare, A., Boccia, F., Yousefian, N., Ghazanfari, S., and Pakook, S. (2024). Understanding the role of awareness and trust in consumer purchase decisions for healthy food and products. *Food Qual. Prefer.* 121:105275. doi: 10.1016/j.foodqual.2024.105275

Fowler, F. J. (2009) in Survey research methods. Applied social research method series. eds. L. Bickman and D. J. Rog (Thousand Oaks, CA: SAGE).

Gava, O., Vanni, F., Schwarz, G., Guisepelli, E., Vincent, A., Prazan, J., et al. (2025). Governance networks for agroecology transitions in rural Europe. *J. Rural. Stud.* 114:103482. doi: 10.1016/j.jrurstud.2024.103482

Ghasemi, M. M., Sahraeiyan Jahromi, H., Pakparvar, M., Kooshafar, S., and Rezaei, A. (2020). *Agricultural atlas and planted area of strategic crop- maps of Abadeh county.* Fars Agricultural Jihad Organization, Office of New Technologies. Shiraz: Iran-e-Kabir Publications.

Ghorbani, R., Koocheki, A. R., Jahan, M., Nassiri Mahallati, M., and Rezvani-Moghadam, P. (2009). National organic standards for Iran: concepts, principles and aims of organic production and standards for agronomic and horticultural products. *J. Agroecol.* 1, 129–142. doi: 10.22067/jag.v1i1.2660

Gignac, G. E., and Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personal. Individ. Differ.* 102, 74–78. doi: 10.1016/j.paid.2016.06.069

Glasgow, G. (2005). Stratified sampling types. *Encycl. Soc. Meas.*, 3, 683–688. doi: 10.1016/B0-12-369398-5/00066-9

Gökkür, S., and Sinav, E. (2020). Sustainable agriculture and new food marketing management system. *Eurasian J. Agric. Res.* 4, 45–55.

Hansmann, R., Baur, I., and Binder, C. R. (2020). Increasing organic food consumption: an integrating model of drivers and barriers. *J. Clean. Prod.* 275:123058. doi: 10.1016/j.jclepro.2020.123058

Hao, P. F., Qiu, C. W., Ding, G., Vincze, E., Zhang, G., Zhang, Y., et al. (2020). Agriculture organic wastes fermentation CO2 enrichment in greenhouse and the fermentation residues improve growth, yield and fruit quality in tomato. *J. Clean. Prod.* 275:123885. doi: 10.1016/j.jclepro.2020.123885

Innocent, M., and Vasanthakaalam, H. (2018). Success story of implementing the self-sustaining agricultural extension system in Rwanda. *J. Agric. Ext. Rural Dev.* 10, 175–185. doi: 10.5897/JAERD2018.0981

Irianto, H., Qonita, A., and Riptanti, E. W. (2019). Socio-economic characteristics of farmers on the existence of floating-rice cultivation demonstration plots in flood prone area in Bojonegoro, East Java. *IOP Conf. Series Earth Environ. Sci.* 314:012048. doi: 10.1088/1755-1315/314/1/012048

Jones, J. W., Antle, J. M., Basso, B., Boote, K. J., Conant, R. T., Foster, I., et al. (2017). Brief history of agricultural systems modeling. *Agric. Syst.* 155, 240–254. doi: 10.1016/j.agsy.2016.05.014

Joshi, A., Kalauni, D., and Tiwari, U. (2019). Determinants of awareness of good agricultural practices (GAP) among banana growers in Chitwan, Nepal. *J. Agric. Food Res.* 1:100010. doi: 10.1016/j.jafr.2019.100010

Kalachian, T., Ebrahimipour, S., and Lankarani, A. (2011). Industrial pesticides and associated risks in agricultural regions of Iran: a focus on Fars province. *Adv. Life Sci.* 13, 157–162.

Kamua, C., Prinsen, L., and Thaldar, D. (2024). Benefit-sharing with human participants in health research in South Africa: A call for clarity. *Dev. World Bioeth.* 10:1–10. doi: 10.1111/dewb.12456

Kılıç, O., Boz, İ., and Eryılmaz, G. A. (2020). Comparison of conventional and good agricultural practices farms: a socio-economic and technical perspective. *J. Clean. Prod.* 258:120666. doi: 10.1016/j.jclepro.2020.120666

Kopteva, L., Shabalina, L., and Kashirina, E. (2019). "Ecological aspects of the world food security" in E3S web of conferences (vol. 91) (France: EDP Sciences), 06011. doi: 10.1051/e3sconf/20199106011

Kwapong, N. A., Ankrah, D. A., Boateng-Gyambiby, D., Asenso-Agyemang, J., and Fening, L. O. (2020). Assessment of agricultural advisory messages from farmer-to-farmer in making a case for scaling up production: a qualitative study. *Qual. Rep.* 25, 2011–2025. doi: 10.46743/2160-3715/2020.4241

Lamine, C., Pugliese, P., Barataud, F., Berti, G., and Rossi, A. (2023). Italian biodistricts and French territorial food projects: how science-policy-experience interplays shape the framings of transitions towards sustainable territorial food systems. *Front. Sustain. Food Syst.* 7:1223270. doi: 10.3389/fsufs.2023.1223270

Lei, S., Qiao, Q., Gao, X., Feng, J., Wen, Y., and Han, Y. (2023). Ecological awareness, policy perception, and green production behaviors of farmers living in or near protected areas. *Forests* 14:1339. doi: 10.3390/f14071339

Li, Y., Zhang, D., and Pagán, J. A. (2016). Social norms and the consumption of fruits and vegetables across New York City neighborhoods. *J. Urban Health* 93, 244–255. doi: 10.1007/s11524-016-0028-y

Lleras, L. (2005). Path analysis. *Encycl. Soc. Meas.* 25:30. doi: 10.1016/B0-12-369398-5/00483-7

Makwana, D., Engineer, P., Dabhi, A., and Chudasama, H. (2023). Sampling methods in research: a review. *Int. J. Trend Sci. Res. Dev.* 7, 762–768.

Malek-Saeidi, H., Rezaei-Moghaddam, K., and Ajili, A. (2012). Professionals' attitudes towards organic farming: the case of Iran. *J. Agric. Sci. Technol.* 14, 37–50. Available online at: https://jast.modares.ac.ir/article-23-2119-en.html

Ministry of Agricultural Jihad. (2024). *Comprehensive system of zoning and agricultural data management*. Available online at: https://poud.maj.ir/login/login.php

Monfared, N., Fatemi, M., Rezaei-Moghaddam, K., Moghaddas Farimani, S., Bayat, P., and Khalafloo, A. M. (2019). Need assessment of the skill training sessions of organic farming for the farmers of Bushehr province. *Agric. Educ. Admin. Res.* 51, 83–108. doi: 10.22092/jaear.2020.128818.1675

NICRS. (2023). *Cancer incidence in Iran: Current trends and regional variations*. Available online at: https://ncii.ir

Niu, H., Li, Z., Zhang, C., and Li, M. (2024). Sustainable food systems under environmental footprints: the delicate balance from farm to table. *Sci. Total Environ.* 954:176761. doi: 10.1016/j.scitotenv.2024.176761

Padel, S. (2001). Conversion to organic farming: a typical example of the diffusion of an innovation? *Sociol. Rural.* 40, 285–299. doi: 10.1111/1467-9523.00149

Pradhananga, A. K., Davenport, M. A., Fulton, D. C., Maruyama, G. M., and Current, D. (2017). An integrated moral obligation model for landowner conservation norms. *Soc. Nat. Resour.* 30, 212–227. doi: 10.1080/08941920.2016.1239289

Prati, G., Albanesi, C., and Pietrantoni, L. (2017). The interplay among environmental attitudes, pro-environmental behavior, social identity, and pro-environmental institutional climate. A longitudinal study. *Environ. Educ. Res.* 23, 176–191. doi: 10.1080/13504622.2015.1118752

Qian, X., Ma, J., Weng, L., Chen, Y., Ren, Z., and Li, Y. (2020). Influence of agricultural organic inputs and their aging on the transport of ferrihydrite nanoparticles: from enhancement to inhibition. *Sci. Total Environ.* 719:137440. doi: 10.1016/j.scitotenv.2020.137440

Ranjbar Shams, H., and Omidi Najafabadi, M. (2014). Factors affecting the attitude towards agricultural organic productions in Tehran. *Ext. Res. Agric. Educ.* 7, 51–62.

Razzaghi-Burkhani, F. R., and Mohammadi, Y. (2019). Perceived outcomes of good agricultural practices (GAPs) technologies adoption in citrus farms of Iran (reflection of environment-friendly technologies). *Environ. Sci. Pollut. Res.* 26, 6829–6838. doi: 10.1007/s11356-018-04083-0

Rezaei-Moghaddam, K., and Fatemi, M. (2013). Towards an environment-sociologic model for prediction of environmental behaviors and investigation of strategic policy alternatives. *J. Agric. Technol.* 9, 1381–1397.

Rezaei-Moghaddam, K., Fatemi, M., and Monfared, N. (2023). Sustainable food security. Shiraz, Iran: Mrajaeelm.

Rezaei-Moghaddam, K., and Karami, E. (2008). A multiple criteria evaluation of sustainable agricultural development models using AHP. *Environ. Dev. Sustain.* 10, 407–426. doi: 10.1007/s10668-006-9072-1

Rezaei-Moghaddam, K., Karami, E., and Gibson, J. (2005). Conceptualizing sustainable agriculture: Iran as an illustrative case. *J. Sustain. Agric.* 27, 25–56. doi: 10.1300/J064v27n03_04

Rodrigues, M., and de la Riva, J. (2014). An insight into machine-learning algorithms to model human-caused wildfire occurrence. *Environ. Model Softw.* 57, 192–201. doi: 10.1016/j.envsoft.2014.03.003

Rogers, E. M. (2003). Diffusion of innovations. *5th* Edn. New York, U.S.A: Free Press.

Rogers, E. M., and Shoemaker, F. F. (1971). Communication of innovations: A cross-cultural approach. New York, U.S.A: Free Press.

Röös, E., Mayer, A., Muller, A., Kalt, G., Ferguson, S., Erb, K. K., et al. (2022). Agroecological practices in combination with healthy diets can help meet EU food system policy targets. *Sci. Total Environ.* 847:157612. doi: 10.1016/j.scitotenv.2022.157612

Rose, D. C., Sutherland, W. J., Barnes, A. P., Borthwick, F., Ffoulkes, C., Hall, C., et al. (2019). Integrated farm management for sustainable agriculture: lessons for knowledge exchange and policy. *Land Use Policy* 81, 834–842. doi: 10.1016/j.landusepol.2018.11.001

Sabir, N., Singh, B., Hasan, M., Sumitha, R., Deka, S., Tanwar, R. K., et al. (2010). Good agricultural practices (GAP) for IPM in protected cultivation. *Tech. Bull.* 23, 1–14.

Secretario, S. (2017). *Revisiting the adoption of the Philippine good agricultural practices (PhilGAP) certification Programme: A case study of Cavendish banana plantations. A thesis prepared in partial fulfillment of the requirements for the degree of master of AgriScience at Massey University, New Zealand* (Doctoral dissertation, Massey University).

Sharma, N., and Singhvi, R. (2018). Consumers perception and behavior towards organic food: a systematic review of literature. *J. Pharmacogn. Phytochem.* 7, 2152–2155.

Stefanovic, L., and Agbolosoo-Mensah, O. A. (2023). Biodistricts as a tool to revitalize rural territories and communities: insights from the biodistrict Cilento. *Front. Sustain. Food Syst.* 7:1267985. doi: 10.3389/fsufs.2023.1267985

Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behavior: an integrative review and research agenda. *J. Environ. Psychol.* 29, 309–317. doi: 10.1016/j.jenvp.2008.10.004

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res. Sci. Educ.* 48, 1273–1296. doi: 10.1007/s11165-016-9602-2

Tartaro, A. (2017). *Turning off the lights at the end of the world: An examination of hope, environmental identity and pro-environmental behavior* (doctoral dissertation). USA: Haverford College.

Trigo, A., Marta-Costa, A., and Fragoso, R. (2021). Principles of sustainable agriculture: defining standardized reference points. *Sustain. For.* 13, 1–20. doi: 10.3390/su13084086

Xu, F., Huang, L., and Whitmarsh, L. (2020). Home and away: Cross-contextual consistency in tourists pro-environmental behavior. *J. Sustain. Tour.*, 28, 1443–1459. doi: 10.1080/09669582.2020.1741596

Wang, P. C., Liu, F. C., Lee, D. C., and Lin, M. Y. (2023). Environmental knowledge, values, and responsibilities help to enhance organic farming intentions: a case study of Yunlin County, Taiwan. *Agriculture* 13:1476. doi: 10.3390/agriculture13081476

Wang, M., Zhang, X., and Guo, Z. (2024). The impact of farm structure on agricultural growth in China. *Land* 13:1494. doi: 10.3390/land13091494

Williams, C. C., and Chawla, L. (2015). Environmental identity formation in non-formal environmental education programs. *Environ. Educ. Res.* 22, 978–1001. doi: 10.1080/13504622.2015.1055553

Zandazar, S., Fatemi, M., and Rezaei-Moghaddam, K. (2025). Psychological capital of knowledge-based companies in science and technology park incubators of Fars province, Iran *Journal of Strategy & Innovation*, 36:200531. doi: 10.1016/j.jsinno.2025.200531