Article history:
Received 05 August 2025
Revised 15 November 2025
Accepted 14 December 2025
Published online 01 September 2026

Journal of Resource Management and Decision Engineering

Volume 5, Issue 3, pp 1-21

Development of Strategic Scenarios for Employment Growth in the Agricultural Sector Using a Foresight Analysis

Sirus. Safarnia[1], Seyed Hamed. Hashemi[2*], Bahman. Kargar Shahamat[1]

[1] Department of Management, As.C., Islamic Azad University, Astara, Iran.
[2] Assistant Professor, Department of Public Administration, Payame Noor University, Tehran, Iran.

*** Corresponding author email address**: hamed.hashemi@pnu.ac.ir

A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Safarnia, S., Hashemi, S. H. & Kargar Shahamat, B. (2026). Development of Strategic Scenarios for Employment Growth in the Agricultural Sector Using a Foresight Analysis. *Journal of Resource Management and Decision Engineering*, *5*(3), 1-21.
https://doi.org/10.61838/kman.jrmde.5.3.222

A B S T R A C T

The purpose of the present study was to develop strategic scenarios for promoting employment in the agricultural sector using a foresight analysis. The required data were collected through a Delphi questionnaire, and critical drivers influencing employment-development strategies in the agricultural sector were identified based on the views of experts and specialists. Attention to these drivers and their integration into agricultural development strategies through foresight analysis can lead to the creation of an enabling environment for sustainable employment and higher productivity in this sector. For this purpose, the cross-impact matrix analysis method was employed. Among the influential drivers, 22 drivers were identified as the most critical: market and product pricing, infrastructure and technology, training and consultancy, development of collaborations, risk management and market monitoring, facilities and services, technological innovations, online platforms, advanced technologies, intelligent systems, product quality management, environmental research, development of information systems, climate change and its impacts, sustainable use of resources, awareness-raising and education, natural resource management, pollution reduction and quality protection, training and awareness-raising, promotion of agricultural culture and identity, cultural activities and festivals, economic and livelihood development, and cultural development and promotion. Using the identified drivers, the scenario space was constructed, and five scenarios with the highest probability of occurrence were identified and developed. Among them, the first scenario, with a probability of 66 percent, was selected as the most likely scenario. According to the findings, these elements interact with one another and collectively create a dynamic ecosystem for fostering employment in the agricultural sector. By emphasizing foresight, effective strategies can be designed that respond appropriately to future developments and pave the way for improvement and sustainable development in this sector.

Keywords: *Scenario development; employment promotion; strategy; foresight approach; agriculture.*

1. Introduction

Rural and agricultural development has re-emerged as a global priority as countries confront rising unemployment, declining rural productivity, demographic pressures, and increasing environmental risks. In many developing and transition economies, the agricultural sector remains a foundational pillar of both economic output and rural livelihoods, yet it faces structural constraints that hinder its capacity to generate sustainable employment. Recent empirical evidence demonstrates that revitalizing agriculture is strongly associated with national economic growth, improved household welfare, and labor market expansion (Asaleye et al., 2023). The sector's employment-generating potential is especially significant in contexts where agriculture supports the majority of rural populations and where structural transformation processes have not yet produced sufficient non-farm employment opportunities. Accordingly, contemporary rural development discourse emphasizes not only increasing agricultural output but also strengthening the enabling ecosystem that supports long-term employment, entrepreneurship, and human capital formation (Tomashuk, 2025).

At the same time, agricultural modernization is undergoing profound change due to digital transformation, new forms of global value-chain integration, environmental crises, and evolving policy frameworks. The shift toward knowledge-intensive and technologically advanced agricultural systems requires new analytical approaches to understand how labor demand, workforce skills, and employment opportunities evolve in rural regions. Agricultural commercialization and integration into high-value markets have been shown to generate broad poverty-reduction effects and stimulate pro-poor growth, yet such benefits depend on supportive institutional arrangements and targeted labor policies (Etuk & Ayuk, 2021). The challenge for policymakers is therefore twofold: to identify which drivers most influence employment outcomes, and to design forward-looking strategies that incorporate uncertainty, technological change, and climate vulnerability.

The global rise of scenario planning and futures-oriented policy design reflects this need to navigate complexity and uncertainty. However, scenario planning is characterized by inherent paradoxes, including tensions between prediction and imagination, stability and flexibility, and expert knowledge versus participatory foresight (Spaniol & Rowland, 2023). Despite these challenges, scenario-based agricultural planning is increasingly recognized as essential for anticipating shifts in rural labor markets, managing systemic risks, and building resilient agricultural economies. Resilience thinking reinforces the importance of adaptive capacity, cross-scale interactions, and feedback systems within agricultural landscapes, highlighting the dynamic interplay between environmental, technological, and social drivers (Folke, 2022). Such a perspective supports futures research that aims to map out alternative development trajectories for rural employment under rapidly changing conditions.

Digital transformation has been particularly influential in reshaping rural development and agricultural employment. Smart farming, precision agriculture, real-time data analytics, and platform-based service delivery are altering how farmers make decisions, interact with markets, and access extension services. A growing body of social science research underscores how Agriculture 4.0 technologies can create new job categories, reinvent extension systems, and raise productivity—yet also exacerbate inequality if access to digital tools remains uneven (Klerkx, 2022). Studies on rural workforce development similarly note that workforce readiness, skill upgrading, and exposure to innovation ecosystems are essential prerequisites for integrating rural communities into emerging labor markets (Sitsofe & Gibson, 2025). This aligns with broader global evidence suggesting that investments in vocational training, youth development, and lifelong learning systems significantly improve employment prospects for rural workers (Nguyen, 2025).

Global rural revitalization experiences illustrate how countries have attempted to reverse rural decline through integrated strategies emphasizing entrepreneurship, social infrastructure, innovation, and human capital development. China's rural revitalization model demonstrates a comprehensive approach combining infrastructure investment, poverty alleviation, and institutional innovation to rebuild rural economies (Feng et al., 2025). Meanwhile, South African research highlights the importance of understanding rural household aspirations to ensure alignment between national policy frameworks and local lived realities (Mathinya et al., 2025). Employment generation in rural areas therefore requires policy coherence, participatory planning, and alignment between long-term national visions and bottom-up development processes.

Agricultural policy reform is another crucial dimension shaping employment outcomes. In the European Union, agricultural policies have historically played a transformative role in rural development by stabilizing markets, supporting farmer incomes, and integrating environmental sustainability goals (Shlyakov, 2025). European rural planning frameworks increasingly emphasize green agendas, sustainable land management, and inclusive governance, offering valuable lessons for countries seeking to modernize their own rural development systems (Nikolić et al., 2024). Legal and institutional support for sustainable agriculture also enhances sector stability and improves conditions for job creation, as seen in policy reforms undertaken in Eastern Europe aimed at harmonizing agricultural governance with international environmental standards (Zghara, 2024).

Similarly, in the context of Iran and neighboring regions, agricultural development strategies have increasingly focused on strengthening local governance structures, service cities, and regional planning initiatives. Research on agricultural service cities highlights the importance of strengthening urban–rural linkages, improving market access, and enhancing service delivery as foundational requirements for agricultural employment expansion (Salari Pour & Amjadiyan, 2023). Other regional studies underscore the role of macrostrategy formulation, export development, and foresight-based planning as essential components of sustainable agricultural growth (Jashari & Esfandiari, 2022). Within Iran, strategic analysis of business development in agricultural subsectors reveals the necessity of entrepreneurial support systems, innovation diffusion, and targeted capacity-building for farmers (Jameh Saz et al., 2023).

The role of market systems and institutional design has been widely discussed in the broader economic and strategic management literature. Complex adaptive systems theory underscores how agricultural markets, labor systems, and rural institutions evolve through continuous feedback loops and interactions among heterogeneous agents (Holland, 2019). Similarly, dynamic capability theory stresses the importance of organizational capacities—such as innovation, learning, and reconfiguration—in enabling firms and sectors to adapt to changing environments (Teece, 2018). These conceptual frameworks are useful for understanding why agricultural employment policies must account for interdependencies among economic, technological, and institutional drivers.

A complementary trend in global agricultural policy is the emergence of circular economy principles aimed at maximizing resource efficiency, reducing waste, and generating new green employment opportunities. Implementation of circular strategies within agriculture, such as nutrient recycling, biomass valorization, and optimized resource flows, is increasingly recognized as a pathway toward sustainable production and employment creation (Velasco-Muñoz et al., 2021). Circular models also align strongly with green agendas and ecological modernization frameworks promoted across Europe, reinforcing the role of sustainability as a central pillar of future agricultural employment (Nikolić et al., 2024).

Demographic and labor-market transitions further intensify the need for systematic employment planning. In many rural regions, outmigration, youth unemployment, and aging populations threaten the viability of agricultural communities. Studies on rural labor potential highlight key challenges related to skill shortages, technological barriers, and insufficient institutional support structures (Smagulova et al., 2025). These issues emphasize the urgent need for targeted workforce development strategies, including entrepreneurship promotion, knowledge transfer, and the creation of diversified livelihood pathways. Rural entrepreneurship, in particular, is increasingly viewed as a vital mechanism for improving quality of life, promoting local innovation, and generating new employment opportunities beyond traditional farming activities (Tomashuk, 2025).

International development frameworks also stress the pressing need to integrate foresight and scenario-based planning into agricultural employment strategies. The World Development Report highlights how technological disruptions, automation, and shifting labor demands are reshaping the global nature of work, requiring adaptive policies and flexible workforce systems (World, 2019). Foresight-oriented planning becomes essential in such environments, allowing policymakers to anticipate potential disruptions, evaluate uncertainties, and design robust strategies for agricultural labor markets. Scenario paradox research warns, however, that without careful methodological grounding, scenario planning may inadvertently reinforce existing biases or oversimplify complex systemic interactions (Spaniol & Rowland, 2023). Thus, rigorous methodologies—such as MICMAC structural analysis and Delphi-based expert elicitation—provide structured means to identify key drivers, map influence relationships, and prioritize policy levers.

Climate change adds an additional layer of uncertainty that profoundly affects agricultural labor markets. Increasing climate variability, water scarcity, and land degradation threaten agricultural productivity, rural incomes, and the stability of employment systems worldwide. Sustainable resource use, environmental resilience, and adaptation strategies must therefore be embedded within employment-generation frameworks to safeguard rural livelihoods (Folke, 2022). Legal, institutional, and policy instruments supporting environmental stewardship are central to the long-term sustainability of agricultural employment (Zghara, 2024).

The future of agricultural employment will depend not only on production growth but also on the ability of systems to integrate innovation, sustainability, and human development in a coherent strategy. Rural non-farm employment, including agro-processing, value-chain services, and rural tourism, provides additional avenues for job creation when supported by appropriate policies (Sharma, 2025). Likewise, regional studies show that improving access to training, modern technologies, and entrepreneurial support services significantly enhances employment outcomes for rural workers and farming households (Mathinya et al., 2025; Nguyen, 2025).

Altogether, the literature demonstrates that agricultural employment is shaped by a wide constellation of drivers—economic, technological, institutional, environmental, and social. Identifying the most influential drivers and anticipating their future trajectories through rigorous foresight analysis is essential for designing effective employment-generation strategies. Integrating expert knowledge, scenario planning, structural analysis, and future-oriented policy design helps governments and stakeholders craft policies capable of responding to both opportunities and uncertainties in the agricultural sector (Jashari & Esfandiari, 2022; Klerkx, 2022; Shlyakov, 2025).

The aim of this study is to identify key drivers influencing employment development in the agricultural sector and to formulate strategic scenarios for future employment generation using a foresight-based analytical framework.

2. Methods and Materials

2.1. Type of Research

This research is a foresight study with an analytical–exploratory approach, employing a combination of qualitative and quantitative methods. The purpose of the study is to identify and analyze key drivers influencing employment development in the agricultural sector and to formulate strategic scenarios using a futures analysis framework. Qualitative data were collected through semi-structured interviews with experts, document reviews, and open-ended questionnaires. Quantitative data were obtained through weighting expert responses in Delphi questionnaires. To ensure the comprehensiveness of the data, brainstorming and Delphi panel techniques were used.

2.2. Research Population and Sample

The statistical population consisted of agricultural experts and policymakers (such as university faculty members, agricultural sector managers, and industry specialists). Sampling was conducted purposively and through snowball sampling, and 15 experts were selected. The criteria for selecting experts included: at least 10 years of relevant experience in agriculture or policymaking, and availability to participate in multiple Delphi rounds. This number of experts was chosen based on Delphi methodological standards (typically 10 to 20 participants for obtaining reliable consensus) to ensure diversity of perspectives (from academic, governmental, and private sectors) and to avoid bias.

2.3. Delphi Method

The Delphi method is a repetitive, anonymous, and consensus-based expert approach used for forecasting and analyzing complex issues such as the future of employment creation in agriculture. This method is based on principles of respondent anonymity (to prevent group influence), repeated rounds with controlled feedback (providing statistical summaries of previous responses without revealing identities), and achieving statistical stability of consensus. In this study, the Delphi method was implemented in three rounds to identify and finalize key variables. The number of rounds was determined based on achieving consensus (response stability), and a fourth round would have been added if necessary; however, three rounds were sufficient. The details of each round are as follows:

– **First round:** Identification of variables and initial descriptors through open-ended questionnaires and brainstorming sessions with experts. Questionnaires were distributed anonymously, and experts proposed a list of variables influencing employment creation in the agricultural sector (such as modern technologies, supportive policies, climate change, foreign investment, and workforce training). Responses were collected and categorized to produce an initial list of approximately 30 variables. Controlled feedback included a summarized list without individual details.

– **Second round:** Evaluation and refinement of variables by experts using a closed-ended questionnaire. Experts ranked the variables based on importance and influence on a Likert scale from 1 to 5 (1 = very unimportant, 5 = very important). **Weighting method:** The mean score of each variable was calculated, and variables with a mean score below 3 were removed. The consensus criterion was achieving a 75% agreement rate or higher (i.e., at least 75% of experts assigning a score of 4 or 5) and a standard deviation below 1. Controlled feedback included mean, median, and standard deviation from the first round, enabling participants to revise their evaluations.

– **Third round:** Finalization of key variables and determination of possible states for each variable (e.g., optimistic, pessimistic, and likely scenarios). Experts assigned numerical weights to verbal states of variables (such as "high," "medium," "low") using a scale from −3 to +3 (−3 = highly pessimistic, 0 = neutral, +3 = highly optimistic). **Weighting method:** The weighted mean of each state was calculated, and the same consensus criteria as in the second round were applied. Feedback included statistical summaries from the second round to verify response stability. Ultimately, 10 key variables were finalized.

These procedures were conducted according to Delphi methodological standards (such as repetition until consensus and maintaining anonymity) to enhance the validity of the results.

2.4. Cross-Impact Matrix Analysis (MICMAC)

The MICMAC method is a structural tool for analyzing interrelationships among variables in foresight studies and classifies variables based on their level of influence and dependence. This method helps identify key drivers (independent variables with high influence). In this research, MICMAC was applied using variables finalized from the Delphi method. The specific steps included:

– **Formation of the cross-impact matrix:** The key variables (10 variables) were placed in the rows and columns of the matrix. Experts (the same 15 individuals) assessed the influence of each variable on another using a scale from 0 to 3 (0 = no influence, 1 = weak, 2 = moderate, 3 = strong). To avoid bias, the evaluation was conducted anonymously using questionnaires, and the mean scores from experts were calculated for each cell.

– **Entering data into MICMAC software and analyzing relationships:** The matrix data were entered into MICMAC software. The software analyzed direct relationships (from the initial matrix) and indirect relationships (through matrix power calculations). Key indicators included row sums (influence) and column sums (dependence). Additionally, variables were categorized into four groups: drivers (high influence, low dependence), dependents (high dependence, low influence), linkage variables (high in both), and autonomous variables (low in both).

– **Determining the drivers:** The basis for selecting drivers was the placement of variables in the driver quadrant of the MICMAC map, where the influence score is higher than the overall mean (calculated by the software) and the dependence score is lower than the overall mean. For example, variables such as "supportive policies" and "technological advancement" were identified as drivers because their influence scores exceeded 20 (out of a possible 30), while their dependence scores were below 15. Ultimately, 5 key drivers were selected for scenario development.

2.5. Scenario Development

Using the key drivers identified through MICMAC, possible scenarios (optimistic, pessimistic, and likely) were developed for employment growth in the agricultural sector. Each scenario was formulated based on combinations of different states of the key drivers (such as high/low policy support or technological progress). For quantitative data analysis, descriptive statistical methods (such as mean and standard deviation) were used, and MICMAC software was applied for matrix processing.

2.6. Tools and Software

Data collection tools included open-ended and closed-ended questionnaires, semi-structured interviews, and brainstorming sessions. For quantitative data analysis, MICMAC software (for structural analysis) and SPSS Version 26 (for statistical computations such as mean and Cronbach's alpha) were used.

2.7. Validity and Reliability

The validity of the questionnaires was confirmed through content validation by five independent experts (content validity) and a pilot test with five participants. The reliability of the questionnaires was confirmed by calculating Cronbach's alpha coefficient (0.82). Additionally, expert consensus in the Delphi process was ensured with an agreement coefficient of 75% or higher and a standard deviation below 1. For MICMAC, reliability was assessed through repeated evaluation by a subgroup of experts (correlation coefficient 0.85).

3. Findings and Results

Based on the interviews conducted with experts and specialists, Table 2 has been compiled to present the output factors identified.

Table 1

Strategies for Employment Development in the Agricultural Sector

Sector	Drivers and key factors	Strategies
Economic factors	Investment and financing	Attracting domestic and foreign investment to upgrade infrastructure and modern technologies in agriculture
		Facilitating access to agricultural loans
		Streamlining the financing process for farmers
		Increasing investment in research
		Facilitating the process of attracting direct investment
		Creating financial incentives for environmental protection
	Market and product prices	Developing domestic and international markets
		Product pricing
		Creating local and regional markets
		Supporting agricultural products in global markets
		Analyzing product prices for sales strategies
		Increasing transparency in agricultural product pricing processes
	Infrastructure and technology	Developing transport and storage infrastructure
		Investing in irrigation infrastructure
		Developing new equipment and technologies
		Facilitating the establishment of product distribution centers
		Providing an appropriate legal framework to encourage investment
	Brand development and marketing	Developing local brands
		Promoting and advertising branding of local products
		Using social networks to advertise products
		Creating agricultural cooperation platforms
		Holding agricultural exhibitions to upgrade products
	Training and consultancy	Establishing advisory service centers
		Organizing training courses in financial matters
		Using consultancy services for farmers
		Holding online training webinars on agricultural economics
		Creating economic clinics for farmers
	Research and innovation	Increasing investment in innovative projects
		Promoting agriculture as a growth-generating industry
		Creating laboratory environments for innovation in agriculture
		Examining and analyzing costs in agriculture
		Conducting case studies on successful production methods
	Collaboration development	Developing international cooperation in agriculture
		Strengthening business linkages with other sectors
		Encouraging cooperation in producing specialized products
		Developing interdisciplinary cooperation with engineering
	Collaboration development	Cooperating with international financial institutions
	Risk management and market monitoring	Examining and managing business risks
		Monitoring market conditions and providing information
		Assessing economic threats to agriculture
		Continuously evaluating economic impacts on the agricultural market
		Using market data and statistics for decision-making
	Sustainable development and environment	Promoting sustainable agricultural systems
		Encouraging joint investment between farmers and commercial companies
		Creating export incentives based on product quality
		Examining and analyzing tax advantages for agriculture
		Creating employment opportunities in new fields

	Facilities and services	Establishing customer service centers for agriculture
		Facilitating online buying and selling of agricultural products
		Creating electronic payment systems for farmers
		Facilitating the delivery process of products to consumers
		Using new systems for tracking sales
Technological factors	Technological innovations	Technological innovations in agriculture
		Research and development in agricultural start-ups
		Introducing imitable innovations in agriculture
	Biological technologies	Biological technologies to improve performance and reduce costs
		Promoting the use of modified embryos for production
	Data management and analytics	Data analysis for optimizing cultivation
		Using analytical and data-mining methods
		Integrating agricultural data with new systems
	Internet of Things (IoT)	Implementing the Internet of Things (IoT) in agriculture
		Using sensors to improve production quality
	Online platforms	Creating online platforms for agriculture
		Creating online platforms for sharing experiences
		Establishing easy communication with customers through technology
	Training and consultancy	Organizing training workshops in marketing
		Providing training programs on new technologies
		Holding educational webinars on technology
	Software development	Developing agricultural management software
		Developing software to support producers
		Developing mobile applications related to agriculture
	Advanced technologies	Using cutting-edge technologies in cultivation and harvesting
		Investing in advanced agricultural equipment
		Using water treatment technologies
	Intelligent systems	Introducing smart irrigation
		Using weather-forecasting software
	Smart agriculture	Implementing smart farming methods
		Expanding implementation of smart agriculture projects
	Pilot projects	Implementing pilot projects in new technologies
		Conducting research on sustainable agriculture and new technologies
	Research and development	Forming joint groups for research and development
		Cooperating with universities and research centers for innovation
	New technologies	Adoption of new technologies by farmers
		Tracking new technologies in the field of agriculture
	Product quality management	Developing product quality management systems
		Evaluating traditional methods and comparing them with modern technologies
	Digital marketing	Using digital infrastructure for marketing
		Expanding digital markets for agricultural products
	Environmental research	Using environmental cycles for sustainable growth
		Research on biofuels
	Information systems development	Developing information management systems for farms
		Creating a database of agricultural resources
	Market analysis	Analyzing international markets to understand challenges
		Examining global agricultural trends and adapting to them
	Collaboration with organizations	Cooperating with non-governmental organizations for innovation
		Creating working relationships with technology manufacturers
	Farmer motivation	Increasing farmers' motivation to use new technologies
		Promoting online learning for farmers
Environmental factors	Climate change and its impacts	Climate change impacts on production and employment
		Research on the effects of environmental changes on agriculture
		Research on the resilience of agricultural lands to climate change
		Research on feedback effects of climate change on agricultural production
		Addressing challenges arising from climate change
	Sustainable use of resources	Sustainable use of water and soil resources
		Optimizing resource use
		Promoting the use of renewable energies in agriculture
		Using drip irrigation systems to reduce water consumption
		Promoting crop rotation to maintain soil quality

	Green and sustainable agriculture	Implementing green agriculture programs
		Promoting sustainable agriculture as a way of life
		Supporting environmentally sustainable cultivation projects
		Promoting organic farming to preserve biodiversity
		Promoting diversified cropping for environmental purposes
	Awareness-raising and education	Awareness programs on the importance of environmental protection
		Developing educational programs for farmers on green agriculture
		Organizing seminars and training courses on sustainable development
		Holding awareness campaigns at the community level
		Creating educational approaches on environment and agriculture
	Natural resource management	Assessing the status of natural resources
		Improving compost and agricultural waste management
		Creating information systems to monitor the status of natural resources
		Implementing geographic information systems (GIS) for agriculture
		Designing cultivation projects appropriate to soil type and climate
	Green technologies and innovation	Cooperating with companies to use green technologies
		Applying plant protection methods to safeguard the environment
		Promoting new methods in water resource management
		Using scientific data for agricultural planning
		Designing and implementing applied research projects
	Support for local agriculture	Supporting local agriculture to reduce transport distances
		Identifying and promoting social agriculture
		Strengthening linkages between agriculture and the environment
		Cooperating with local communities for sustainable management
		Supporting rural revitalization projects
	Research and assessment	Research and assessment of the effects of pesticides on the environment and health
		Examining environmental impacts of cultivating different crops
		Examining environmental problems during land exploitation
		Identifying and introducing local products with environmental attributes
		Scaling up environmental projects
	Pollution reduction and quality preservation	Planning to reduce pollution from activities and chemicals
		Reducing carbon emissions in agricultural processes
		Using cover crops to improve soil quality
		Encouraging farmers to use conservation methods such as tree planting
		Establishing advisory units to support farmers
Social and cultural factors	Education and awareness-raising	Holding training workshops on the importance of agriculture
		Developing educational programs in schools on agriculture
		Promoting training courses for youth in agriculture
		Expanding social education on the importance of agriculture
		Publishing journals and books on sustainable agriculture
	Social organizations and cooperation	Encouraging the establishment of social groups supporting farmers
		Expanding social cooperation among farmers
		Encouraging the formation of cooperatives among farmers
		Increasing social trust between farmers and customers
		Creating social networks for sharing experiences
	Promotion of agricultural culture and identity	Promoting the culture of consuming local products
		Highlighting the role of agriculture in preserving national identity
		Promoting and encouraging agricultural culture in local communities
		Examining the role of women in agriculture and breaking social taboos
		Honoring successful agricultural experiences in society
	Cultural activities and festivals	Organizing local festivals to introduce products
		Organizing local competitions and festivals to promote products
		Providing facilities for organizing agricultural exhibitions
		Supporting public cultural projects related to agriculture
		Expanding volunteer activities in agriculture
	Support and consultancy	Designing consultancy schemes for supply chain maturation
		Providing advice and support to farmers on management techniques
		Providing support and counseling services on social issues

	Facilitating access to information and resources for young farmers
	Creating social databases for local producers
Communication networks	Expanding communication networks between producers and consumers
	Establishing linkages between universities and the agricultural industry
	Creating social convergence networks in agriculture
	Strengthening social ties between farmers and consumers
	Expanding social activities to address agricultural challenges
Crisis and challenge management	Training crisis management methods in agriculture
	Assessing and analyzing the social impacts of agriculture
	Analyzing the social impacts of agricultural changes
	Promoting public discourse on agricultural challenges
	Developing social strategies to strengthen the agricultural system
Economic and livelihood development	Creating agricultural economic complexes in rural areas
	Improving living and working conditions for farmers
	Increasing public awareness of the negative impacts of industrial agriculture
	Encouraging support for family farming
	Encouraging learning and use of traditional agricultural techniques
Volunteer activities	Expanding volunteer activities in agriculture
	Developing social participation to solve agricultural challenges
	Increasing social cooperation among farmers
	Promoting a culture of frugality and resource management in agriculture
	Providing facilities for organizing agricultural exhibitions
Research and evaluation	Examining the status of agriculture and social institutions
	Identifying social approaches effective in agriculture
	Assessing and analyzing the social impacts of agriculture
	Examining the social impacts of agricultural changes
	Raising public awareness about the importance of sustainable agriculture
Culture development and promotion	Promoting a culture of respect for farmers and producers
	Developing cultural activities related to demographic diversity
	Promoting a culture of sustainable agriculture
	Encouraging support for traditional and local products
	Creating social networks for sharing experiences

Now, Table (2) presents the general characteristics of the matrix. The filling rate is more than 98 percent, indicating that the selected drivers influence one another by more than 98 percent. In the section on strategies for employment development in the agricultural sector, 50 key drivers were defined using a 50 × 50 cross-impact analysis matrix.

Table 2

Characteristics of the Matrix for Employment-Development Strategies in the Agricultural Sector

Characteristic	Value
Matrix size	50
Number of iterations	2
Number of zeros	50
Number of ones	1850
Number of twos	488
Number of threes	112
Number of P	0
Total	2450
Filling rate (%)	98%

From among the 50 selected drivers, 22 drivers located in the first quadrant were chosen. The degree of influence of these drivers is higher than their degree of dependence, and they include the following: market and product prices; infrastructure and technology; training and consultancy; development of collaborations; risk management and market monitoring; facilities and services; technological innovations; online platforms; advanced technologies; intelligent systems; product-quality management; environmental research; development of information systems; climate change and its impacts; sustainable use of resources; awareness-raising and education; natural-resource management; pollution reduction and quality preservation; education and awareness-raising; promotion of agricultural culture and identity; cultural activities and festivals; economic and livelihood development; and culture development and promotion (Figure 1).

Figure 1

Scatter Map of Variables According to Their Degree of Influence and Dependence in Employment-Development Strategies in the Agricultural Sector

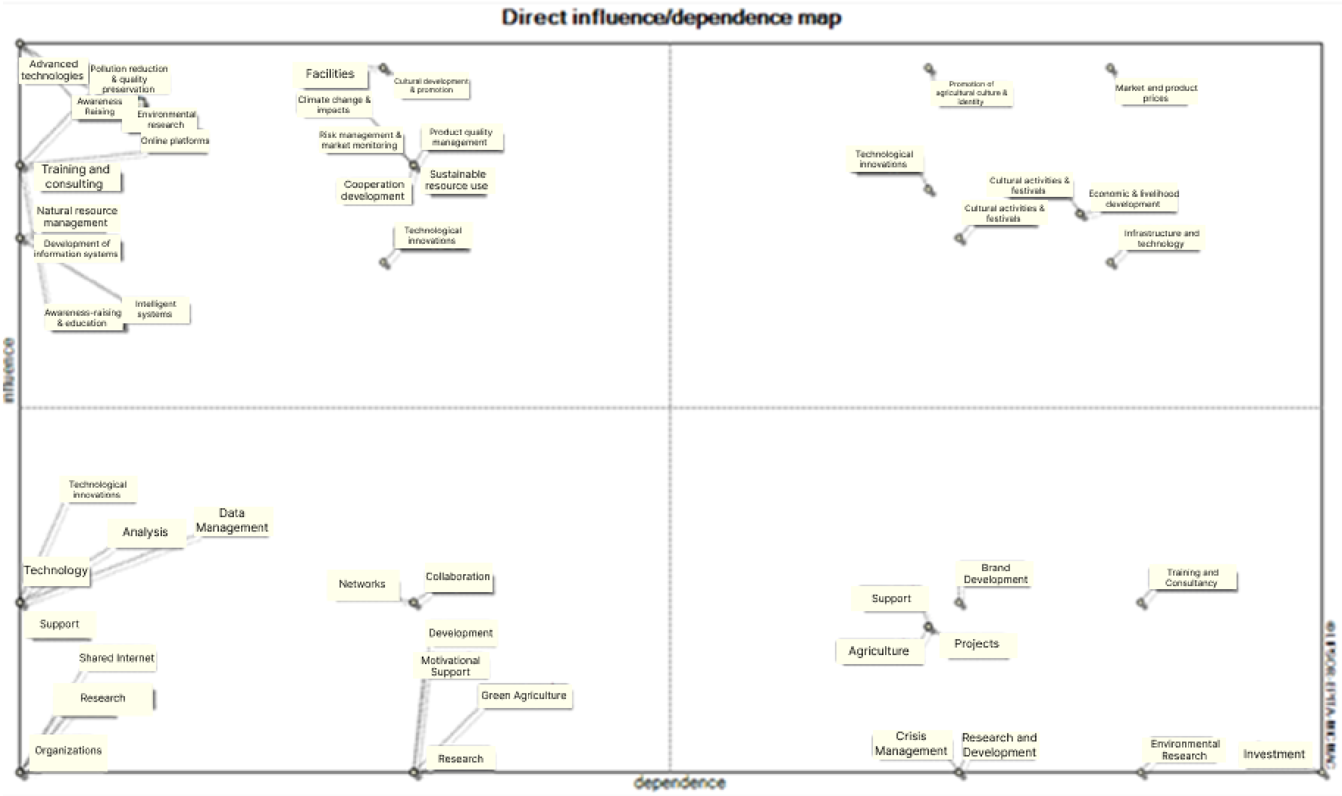

Figure (1) is the scatter map of variables based on MICMAC analysis, which classifies the variables affecting employment development in the agricultural sector according to their influence and dependence. This map was used for developing strategic scenarios in the study titled *"Strategic Scenario Development for Employment Growth in the Agricultural Sector Using a Foresight Analysis."* The map is divided into four quadrants:

– **Upper-left quadrant (influential variables/key drivers):** includes "government support policies," "investment in infrastructure," and "access to credit facilities." These are the main levers for policymaking; for example, targeted subsidies, modern irrigation projects, and low-interest loans can increase productivity and create sustainable employment.

– **Upper-right quadrant (dependent variables/outcomes):** includes "sustainable employment," "increased farmer income," and "reduction of rural migration." These represent system outcomes and depend on drivers. Policies should strengthen job security, the value chain, and green jobs to reduce migration and increase income.

– **Lower-right quadrant (intermediary variables/operational levers):** includes "training and skill development" and "development of agro-processing industries." These strengthen the link between drivers and outcomes; policies may include rural training centers, free programs, and product-processing projects to create value-added and jobs.

– **Lower-left quadrant (independent variables/low importance):** includes "traditional attitudes of farmers" or "rainfall levels." These do not play a direct role in policy but are managed through measures such as crop-insurance systems.

Figure (2) shows the strong direct effects among the drivers in employment development.

Figure 2

Map of Direct Effects Among Drivers

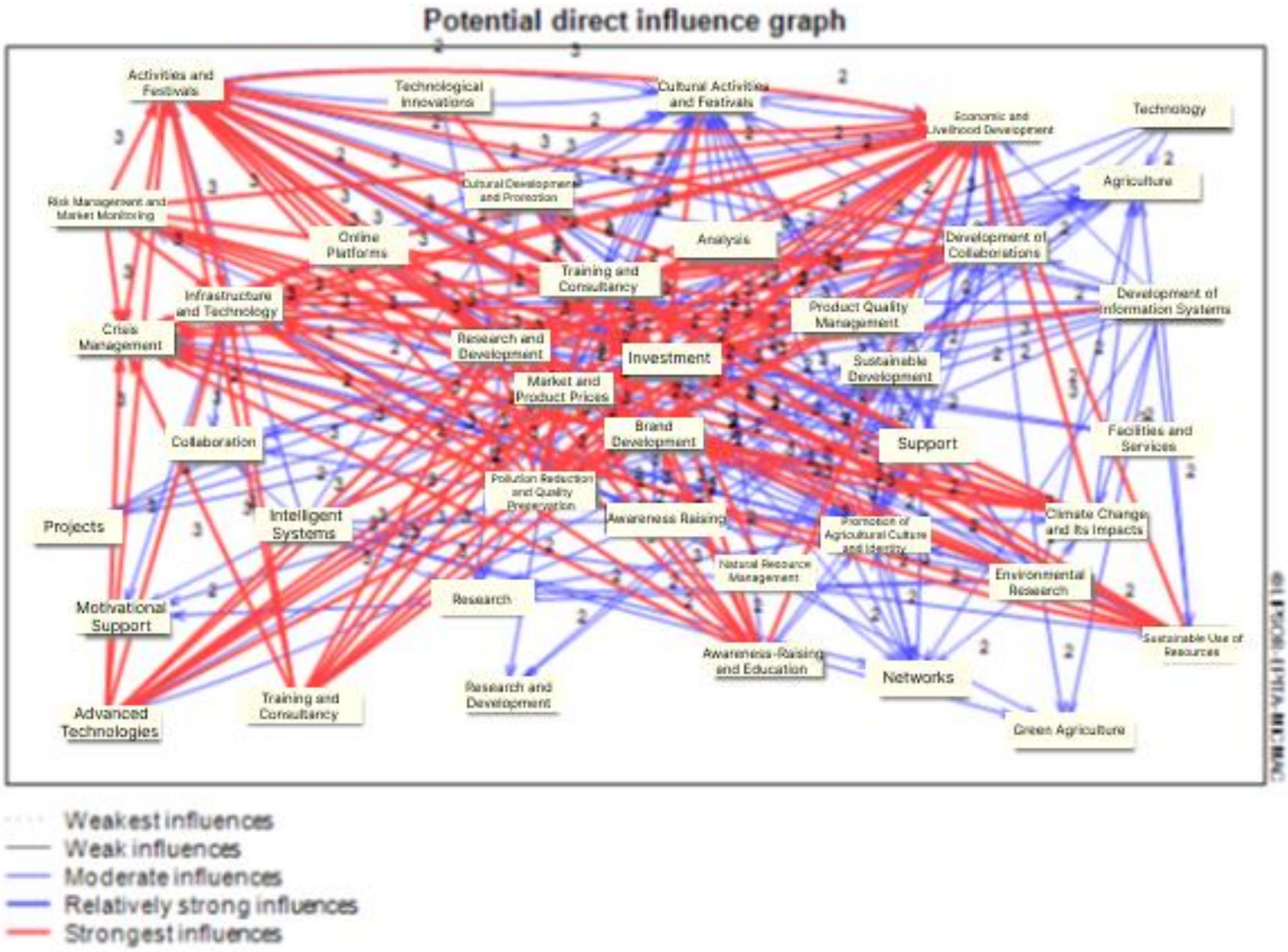

Figure (2) is the graph of direct effects among the drivers of employment development in the agricultural sector, designed using MICMAC analysis. It illustrates the relationships among variables in the study *"Strategic Scenario Development for Employment Growth Using a Foresight Analysis."* Blue lines (weak influence), red lines (moderate), and black lines (strong) indicate the intensity and direction of effects.

– **Key drivers:** "government support policies" and "infrastructure investment" (black lines) exert strong effects on variables such as "access to credit facilities" and "training and skill development." Subsidy policies, low-interest loans, and modern infrastructure (such as precision irrigation) enhance productivity and employment.

– **Moderate influences:** "development of agricultural technologies" (red lines) increases efficiency and creates technical jobs, whereas "climate change" (red lines) reduces production and threatens employment. Policies should promote climate-resilient technologies.

– **Intermediary variables:** "training and skill development" and "agro-processing industries" (combined-line effects) both exert influence and are influenced. Digital skills training and value-added processing create new employment opportunities.

This graph highlights the need for multi-dimensional policies: strengthening strong drivers (policy and infrastructure), managing climate and technological challenges, and using training and processing industries to stimulate sustainable employment. In optimistic scenarios, these policies reinforce employment, whereas in pessimistic scenarios, failure to address climate and investment issues increases migration and unemployment.

Figure (3) shows the indirect effects among the drivers.

Figure 3

Map of Indirect Effects Among Drivers

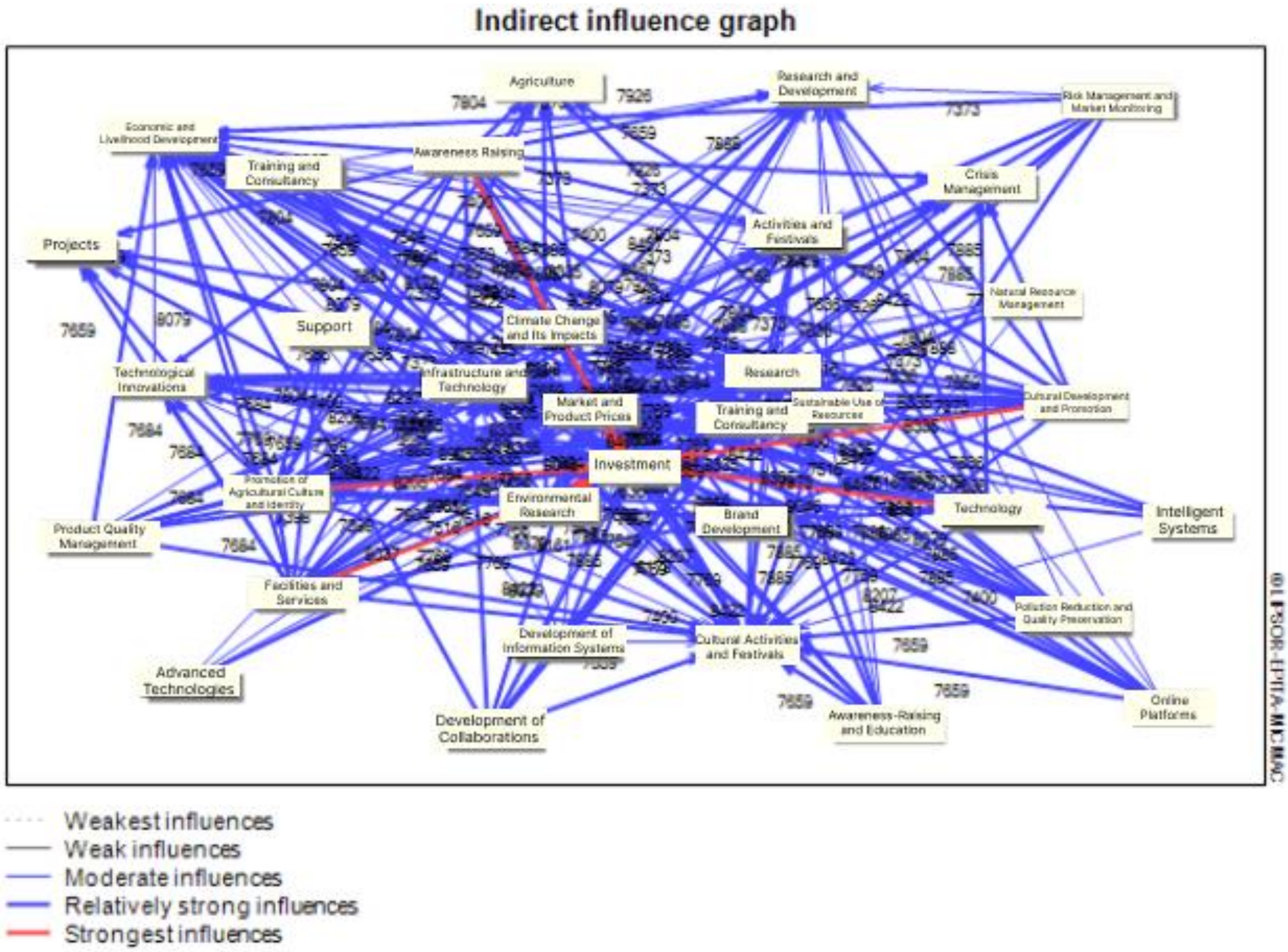

Figure (3) presents the graph of indirect effects among the drivers of employment development in the agricultural sector based on MICMAC analysis in the study *"Strategic Scenario Development for Employment Growth Using a Foresight Analysis."* This graph uses black (weak), blue (moderate), and red (strong) lines to depict indirect relationships via intermediary variables.

– **Government support policies:** with strong indirect effects (red lines) on "access to credit facilities" and "training and skill development," enhance productivity and sustainable employment. Suggested policy: government-funded training programs with private-sector participation to ensure equitable access for rural populations.

– **Infrastructure investment:** with strong effects (red lines) on the supply chain, increases indirect production and employment. Suggested policy: infrastructure projects in underserved regions with economic-return assessments.

– **Development of agricultural technologies:** with moderate-to-strong effects (blue and red lines), strengthens income and reduces migration. Suggested policy: low-interest loans for modern equipment and innovation hubs.

– **Climate change:** with moderate-to-strong negative effects (blue and red lines), threatens productivity and employment. Suggested policy: drought-resistant crops and sustainable water-management systems.

– **Training and agro-processing industries:** as bridging elements (combined-line effects), enhance productivity and non-farm jobs. Suggested policy: long-term training and financial incentives for processing industries.

This graph highlights systemic complexity and recommends multi-sectoral policies (such as integrated water–agriculture–rural development strategies) to balance technology, climate, and sustainable employment.

In Table (3), the drivers extracted from the MICMAC software are presented.

Table 3

Likely Scenarios for Strategies of Employment Development in the Agricultural Sector

Index	Drivers
Influence indices that affect strategies of employment development in the agricultural sector	Investment and financing – market and product prices – infrastructure and technology – brand development and marketing – training and consultancy – research and innovation – collaboration development – risk management and market monitoring – sustainable development and environment – facilities and services
Indices influencing the relationships between drivers and other indices	Technological innovations – biological technologies – data management and analytics – Internet of Things (IoT) – online platforms – software development – advanced technologies – intelligent systems
Dependent indices	Smart agriculture – pilot projects – research and development – new technologies – product quality management – digital marketing – environmental research – information systems development – market analysis
Indices that do not have a key role but should be taken into account	Collaboration with organizations – motivating farmers – volunteer activities – communication networks – crisis and challenge management
Indices with the greatest role in relationships among variables	Climate change and its impacts – sustainable use of resources – green and sustainable agriculture – awareness-raising and education – natural-resource management – green technologies and innovation – support for local agriculture – research and assessment – pollution reduction and quality preservation – promotion of agricultural culture and identity – cultural activities and festivals – support and consultancy – economic and livelihood development – culture development and promotion

Table (3) contains the strategic scenarios for employment development in the agricultural sector with a foresight-oriented approach. These scenarios are divided into four main categories, each focusing on different aspects of policymaking and planning to increase employment:

1. **Optimistic scenario (improvement of current conditions):** This scenario emphasizes strengthening infrastructure, training the workforce, and using modern technologies (such as IoT and automation). Policymaking should lead to investment in agricultural education, development of local markets, and support for technological innovations in order to increase productivity and employment opportunities.
2. **Most likely scenario (continuation of current trends):** This scenario assumes that the current situation continues at a slower pace. Policies should focus on maintaining a balance between traditional and modern production, supporting small farmers, and creating seasonal jobs to prevent a decline in employment.
3. **Pessimistic scenario (deterioration of conditions):** In this case, challenges such as climate change and the depletion of natural resources are anticipated. Policymaking should be directed towards risk management, the development of sustainable agriculture, and the design of support programs for reverse migration or retraining of the workforce.
4. **Transformational scenario (major leap):** This scenario requires fundamental changes, including a digital revolution in agriculture and large-scale investment in the value chain. Policies should focus on developing agricultural start-ups, creating green jobs, and fostering cross-sectoral cooperation.

After examining the cross-impact matrix and identifying the main drivers, a matrix in the form of a questionnaire was provided to experts. The questionnaire assessed the impact of each driver under three conditions: remaining in its current state (most likely), being enhanced (optimistic), or being weakened (pessimistic). The extent of their impact was evaluated according to limiting characteristics as strongly reinforcing, moderately reinforcing, weakly reinforcing, no impact, or weakly constraining to strongly constraining, using numerical values from +3 to −3. For the 22 main drivers, ten states were defined, which were examined based on the probability of optimistic conditions, most likely (intermediate) conditions, and pessimistic conditions (calculated using expert opinions in the Delphi method and quantitative analyses [weighting]). For each state, relevant strategies will be proposed. After collecting the questionnaires and analyzing the data, the following scenarios were identified (Table 4).

Table 4

Likely Scenarios for Strategies of Employment Development in the Agricultural Sector

Component	Code	Optimistic condition	Intermediate condition	Pessimistic condition
Scenario 1				
Market and product prices	1	●		
Infrastructure and technology	2	●		
Training and consultancy	3	●		
Collaboration development	4	●		
Risk management and market monitoring	5		●	
Facilities and services	6	●		
Technological innovations	7		●	
Online platforms	8		●	
Advanced technologies	9		●	
Intelligent systems	10		●	
Product quality management	11		●	
Environmental research	12	●		
Information systems development	13		●	
Climate change and its impacts	14			●
Sustainable use of resources	15	●		
Awareness-raising and education	16	●		
Natural-resource management	17			●
Pollution reduction and quality preservation	18			●
Promotion of agricultural culture and identity	19	●		
Cultural activities and festivals	20	●		
Economic and livelihood development	21	●		
Culture development and promotion	22	●		
Scenario 2				
Market and product prices	1			●
Infrastructure and technology	2	●		
Training and consultancy	3		●	
Collaboration development	4		●	
Risk management and market monitoring	5			●
Facilities and services	6		●	
Technological innovations	7	●		
Online platforms	8	●		
Advanced technologies	9	●		
Intelligent systems	10	●		
Product quality management	11		●	
Environmental research	12			●
Information systems development	13		●	
Climate change and its impacts	14			●
Sustainable use of resources	15			●
Awareness-raising and education	16		●	
Natural-resource management	17			●
Pollution reduction and quality preservation	18			●
Promotion of agricultural culture and identity	19			●
Cultural activities and festivals	20			●
Economic and livelihood development	21		●	
Culture development and promotion	22			●
Scenario 3				
Market and product prices	1		●	
Infrastructure and technology	2	●		
Training and consultancy	3		●	
Collaboration development	4		●	
Risk management and market monitoring	5			●
Facilities and services	6			●
Technological innovations	7	●		
Online platforms	8		●	
Advanced technologies	9	●		

Intelligent systems	10	●		
Product quality management	11	●		
Environmental research	12		●	
Information systems development	13	●		
Climate change and its impacts	14			●
Sustainable use of resources	15			●
Awareness-raising and education	16		●	
Natural-resource management	17			●
Pollution reduction and quality preservation	18			●
Promotion of agricultural culture and identity	19			●
Cultural activities and festivals	20			●
Economic and livelihood development	21		●	
Culture development and promotion	22			●
Scenario 4				
Market and product prices	1			●
Infrastructure and technology	2			●
Training and consultancy	3		●	
Collaboration development	4	●		
Risk management and market monitoring	5			●
Facilities and services	6			●
Technological innovations	7			●
Online platforms	8			●
Advanced technologies	9			●
Intelligent systems	10			●
Product quality management	11			●
Environmental research	12			●
Information systems development	13		●	
Climate change and its impacts	14			●
Sustainable use of resources	15			●
Awareness-raising and education	16		●	
Natural-resource management	17			●
Pollution reduction and quality preservation	18			●
Promotion of agricultural culture and identity	19			●
Cultural activities and festivals	20			●
Economic and livelihood development	21			●
Culture development and promotion	22			●
Scenario 5				
Market and product prices	1			●
Infrastructure and technology	2			●
Training and consultancy	3	●		
Collaboration development	4		●	
Risk management and market monitoring	5			●
Facilities and services	6			●
Technological innovations	7	●		
Online platforms	8			●
Advanced technologies	9	●		
Intelligent systems	10			●
Product quality management	11			●
Environmental research	12		●	
Information systems development	13			●
Climate change and its impacts	14	●		
Sustainable use of resources	15	●		
Awareness-raising and education	16	●		
Natural-resource management	17	●		
Pollution reduction and quality preservation	18		●	
Promotion of agricultural culture and identity	19		●	
Cultural activities and festivals	20		●	
Economic and livelihood development	21		●	
Culture development and promotion	22		●	

Table (4) is based on the analysis of key drivers identified through the Delphi method and MICMAC, and it presents five strategic scenarios for employment development in Iran's agricultural sector. These scenarios are designed on the basis of a combination of optimistic conditions (strong, opportunity-oriented drivers), intermediate conditions (a balanced state with moderate challenges), and pessimistic conditions (dominant threats such as resource scarcity). The categorization of scenarios is carried out according to the total score calculated in Table (5): optimistic scenarios (score above 60%), most likely scenarios (score between 40–60%), and pessimistic scenarios (score below 40%). This classification is grounded in scenario-based foresight theory (such as Godet's model in MICMAC), which categorizes scenarios to analyze uncertainties. A comparison of the scenarios shows that Scenario 1 (66%) is the most likely to achieve employment growth due to its focus on innovation and sustainability, whereas Scenario 4 (34%) represents the worst case and requires immediate intervention. This comparison is made based on the impact of drivers on agricultural GDP (approximately 10% in Iran) and challenges such as water scarcity (which can reduce production by up to 20%). In Table (5), the share of each scenario is specified.

Table 5

Scenario Scoring

Scenario	Optimistic Condition (%)	Intermediate Condition (%)	Pessimistic Condition (%)	Total Score (%)
Scenario 1	70	20	10	66
Scenario 2	40	30	30	46
Scenario 3	60	20	20	56
Scenario 4	30	40	30	34
Scenario 5	50	30	20	48

Based on Table (6), the total score of each scenario was calculated using the weighted formula: (70 × optimistic percentage + 50 × intermediate percentage + 30 × pessimistic percentage) / 100. This analysis is not only descriptive but grounded in theories of sustainable development (for environmental drivers such as codes 15–18), export-led growth (for market and export-related drivers such as code 1), and technological innovation (such as codes 7–10). The subsequent analysis evaluates, for each scenario, the economic, social, and environmental outcomes; specific and actionable policy interventions; and an implementation framework (including responsible agencies, timeline, and evaluation indicators). This applied analysis reflects policy recommendations suited to developing economies such as Iran, including subsidies for sustainable practices and agricultural training.

Scenario 1 (Optimistic, Score 66%): Focus on Innovation and Sustainability

Outcomes: Economic: An increase of 15–20% in agricultural employment through export expansion (such as pistachio and saffron, with an estimated USD 30 billion potential) and improved productivity. Social: A reduction of rural migration by up to 25% due to improved livelihoods. Environmental: A 10–15% reduction in pollution through sustainable resource management. This scenario outperforms the others because pessimistic constraints are limited to environmental variables (codes 14–18), while technological opportunities are maximized.

Policy Interventions: Allocation of a 20% subsidy for smart technologies (such as drones for precision irrigation), a workforce training program focused on digital skills for 500,000 young farmers, and export promotion through tariff reductions of up to 50% for organic products.

Implementation Framework: Responsible agency: Ministry of Agriculture in collaboration with the private sector (such as agricultural start-ups). Timeline: Phase 1 (2025–2026): training and subsidies; Phase 2 (2027–2028): evaluation and expansion. Evaluation Indicators: Employment increase (measured using ILO data); 10% reduction in water use (monitored via GIS).

Scenario 2 (Likely, Score 46%): Balancing Technology with Environmental Challenges

Outcomes: Economic: Moderate employment growth (5–10%) driven by technology but a 10% reduction in output due to climate challenges. Social: Some improvement in livelihoods but a rise in gender inequality in employment (up to 20% lower for women). Environmental: Intensification of water shortages (up to 30% decline in water resources). This scenario performs worse than Scenario 1 because pessimistic drivers (codes 14–22) dominate, though it remains superior to Scenario 4 due to technological strengths.

Policy Interventions: Introduction of agricultural insurance covering 80% of climate-related risks, USD 5 billion investment in online platforms for export marketing, and gender-inclusive programs to increase women's participation in cooperatives.

Implementation Framework: Responsible agencies: Department of Environment and Ministry of Labor. Timeline: Phase 1 (2025): insurance and platform development; Phase 2 (2026–2027): gender evaluation. Evaluation Indicators: Product insurance coverage rate (target 70%); 15% increase in exports (customs data).

Scenario 3 (Likely, Score 56%): Emphasis on Quality and Infrastructure

Outcomes: Economic: 10–15% increase in employment due to improved product quality. Social: 15% reduction in rural poverty through training programs. Environmental: Moderate pollution control, though drought persists. This scenario is more likely than Scenario 2 because optimistic drivers (codes 2, 7–11) outweigh the challenges, but less favorable than Scenario 1 due to limited cultural focus.

Policy Interventions: Implementation of international quality standards (such as ISO certifications for organic produce), investment in water infrastructure (such as small dams funded by 10% of agricultural GDP), and cultural festivals to promote agricultural identity.

Implementation Framework: Responsible agencies: Ministry of Agriculture and Ministry of Culture. Timeline: Phase 1 (2025–2026): standardization; Phase 2 (2027): festivals. Evaluation Indicators: Number of ISO certificates issued (target 50,000); 10% reduction in migration (rural surveys).

Scenario 4 (Pessimistic, Score 34%): Dominance of Challenges

Outcomes: Economic: 20% decline in employment due to resource scarcity. Social: 30% increase in migration and rising youth unemployment. Environmental: Soil degradation of up to 25%. This is the worst scenario and requires urgent policy intervention to prevent economic collapse.

Policy Interventions: Emergency water management program (such as mandatory drip irrigation with 100% subsidy), tax incentives for private investment in drought-resistant technologies, and creation of alternative employment opportunities such as agricultural tourism.

Implementation Framework: Responsible agency: Central government with international support (such as FAO). Timeline: Phase 1 (2025): water subsidies; Phase 2 (2026–2028): alternative employment. Evaluation Indicators: 20% reduction in water consumption; creation of 100,000 new jobs (Ministry of Labor data).

Scenario 5 (Likely, Score 48%): Focus on Training and Sustainability

Outcomes: Economic: Moderate 8–12% employment growth driven by sustainability. Social: Improved skills and reduced inequality. Environmental: Better climate-change control compared to other scenarios. This scenario is intermediate—better than Scenario 4 but less effective than Scenario 1 due to market challenges.

Policy Interventions: A national training program for one million farmers in sustainable practices (with USD 2 billion budget), product diversification for climate resilience, and public–private partnerships for information systems.

Implementation Framework: Responsible agencies: Universities and Ministry of Education. Timeline: Phase 1 (2025): training program; Phase 2 (2026–2027): diversification. Evaluation Indicators: 80% graduation rate; 15% increase in sustainable production (FAO reports).

4. Discussion and Conclusion

The purpose of this study was to identify the most influential drivers shaping employment development in the agricultural sector and to develop strategic scenarios to guide future policy and planning. The findings revealed twenty-two core drivers that exhibit high influence but relatively low dependence within the agricultural employment system. These drivers—ranging from market conditions, technological advancements, environmental sustainability, and information systems to cultural promotion and resource management—serve as the foundational levers through which agricultural employment can expand or contract under varying future conditions. The MICMAC structural analysis demonstrated that these drivers are embedded within complex adaptive interactions, supporting earlier assertions that agricultural systems behave as dynamic networks in which multiple components co-evolve over time (Holland, 2019). This finding underscores why employment outcomes in agriculture cannot be understood in isolation but rather within the broader context of systemic interdependencies.

The results indicate that technological drivers—including advanced technologies, intelligent systems, data analytics, biological technologies, online platforms, and agricultural software—are among the most influential forces shaping future agricultural employment. This aligns with global studies on Agriculture 4.0 and smart farming, which emphasize the transformative potential of digitalization for both productivity and rural workforce development (Klerkx, 2022). As digital tools grow more sophisticated, they generate new forms of employment requiring digital literacy, data management skills, and adaptive problem-solving capacities. At the same time, technologies reduce certain forms of labor demand while increasing others, reinforcing the need for scenario-based planning that accounts for divergent outcomes. Studies on the changing nature of work similarly stress that automation and digitalization do not uniformly reduce employment but rather alter skill requirements and redistribute opportunities across sectors (World, 2019). Consistent with this view, the present study's optimistic scenarios reflect high technology adoption and skill development, whereas pessimistic scenarios anticipate technological stagnation, limited human capital investment, and widening rural unemployment.

In addition to technology, market conditions emerged as a primary driver, including pricing mechanisms, value-chain efficiency, and access to domestic and international markets. This finding is highly consistent with evidence from developing economies, where market volatility and transaction costs remain critical determinants of rural employment stability (Etuk & Ayuk, 2021). The emphasis placed by experts on market expansion, transparency, and branding strategies corroborates studies showing that diversification into high-value agricultural markets can generate significant employment through increased demand for logistics, processing, and marketing services (Asaleye et al., 2023). Similarly, research on business development in Iranian agricultural counties identifies market structure and commercialization opportunities as central factors for rural economic growth (Jameh Saz et al., 2023). The present study extends this knowledge by showing that market drivers not only affect income and output but also interact with other variables—such as information systems, cooperation networks, and environmental management—to produce systemic effects on employment scenarios.

Environmental and sustainability drivers were also found to be highly influential, particularly climate change and sustainable resource use. This reinforces the view that agricultural employment is not merely an economic issue but deeply intertwined with ecological resilience. Studies in resilience theory argue that agricultural livelihoods are highly sensitive to shocks arising from climate variability, water scarcity, and land degradation (Folke, 2022). The pessimistic scenarios developed in this research likewise reflect severe disruptions associated with climate instability, which can reduce agricultural output, intensify rural poverty, and accelerate migration. International experiences validate this risk; for example, European legal frameworks prioritize environmental protection as a condition for sustainable agricultural sector employment (Zghara, 2024). Furthermore, circular economy research emphasizes the role of closed-loop agricultural practices in generating sustainable employment while optimizing resource use (Velasco-Muñoz et al., 2021). The findings of the present study support these perspectives by demonstrating that sustainable resource management, pollution reduction, and environmental education are necessary components of long-term employment scenarios.

The social and cultural dimensions reflected in the study's key drivers—including awareness promotion, cultural identity, and rural community engagement—highlight the importance of human and social capital in agricultural development. Prior research demonstrates that rural entrepreneurship significantly enhances employment opportunities and quality of life through localized innovation and community mobilization (Tomashuk, 2025). Likewise, development studies from China and South Africa suggest that social cohesion, cultural continuity, and community aspirations play critical roles in shaping the success of rural development policies (Feng et al., 2025; Mathinya et al., 2025). The identification of cultural drivers in this study also aligns with findings from agricultural service city development, where cultural programs, festivals, and identity-building initiatives strengthen rural participation and local employment ecosystems (Salari Pour & Amjadiyan, 2023). These results collectively underscore that agricultural employment strategies must extend beyond technical interventions to incorporate sociocultural mechanisms that support rural empowerment.

Collaboration and institutional networks were also identified as essential drivers. The study demonstrates that cross-sectoral partnerships—among farmers, government agencies, universities, technology firms, and financial institutions—greatly influence employment outcomes. This conforms with international literature showing that cooperative networks enhance innovation diffusion, risk-sharing, and value-chain integration, ultimately contributing to increased employment (Jashari & Esfandiari, 2022). The European Union's rural development policies similarly stress the value of institutional collaboration in fostering inclusive agricultural transformation (Shlyakov, 2025). These findings support a systemic perspective that sees agricultural employment as an emergent property of interconnected institutions that must coordinate strategically to achieve sustainability.

The scenario analysis enriched the interpretation of the MICMAC results by mapping how driver interactions may shape future employment trajectories. The optimistically oriented scenario—identified as the most probable—emphasizes innovation, sustainability, and human-capital development. This scenario is consistent with contemporary global trends wherein rural revitalization unfolds through integrated infrastructure development, technology adoption, entrepreneurship, and environmental stewardship (Feng et al., 2025; Nikolić et al., 2024). The continued momentum of global green agendas also suggests that future agricultural employment will increasingly depend on environmental regulation, green finance, and eco-certifications (Nikolić et al., 2024; Zghara, 2024). In contrast, the pessimistic scenarios mirror concerns found in the literature regarding climate hazards, resource scarcity, institutional inefficiencies, and market failures that can depress employment and drive rural depopulation (Folke, 2022; World, 2019).

The middle scenarios reflect transitional development pathways characterized by moderate institutional progress, partial technology adoption, and persistent socioeconomic constraints. These mixed-outcome scenarios are consistent with studies showing that agricultural policy reforms often produce uneven results when structural barriers—such as limited training access, weak market infrastructure, or fragmented governance—are not fully addressed (Nguyen, 2025; Smagulova et al., 2025). They also mirror real-world experiences in which rural development projects deliver incremental improvements rather than transformative change, particularly in regions with high dependence on traditional practices and limited investment capacity (Sharma, 2025).

Moreover, the strategic implications arising from the scenario comparisons reaffirm the importance of dynamic capabilities in agricultural systems. The optimistic scenario aligns with the notion that adaptive, learning-oriented institutions exhibit stronger capacities for reconfiguring resources, deploying innovation, and responding to environmental or market shocks (Teece, 2018). Conversely, the pessimistic scenario highlights systems that lack such capabilities and consequently experience structural decline. These theoretical alignments strengthen the validity of the study’s findings within broader strategic and institutional scholarship.

Finally, the cross-impact results show strong feedback loops among the drivers, reflecting a pattern expected in complex adaptive systems. Prior work on networks, signal systems, and adaptive boundaries emphasizes that agricultural systems evolve through nonlinear interactions where small changes in institutional, environmental, or technological conditions can produce disproportionate employment effects (Holland, 2019). The scenarios constructed in this study capture this complexity by illustrating how shifts in technology adoption, climate conditions, or social engagement can propel the system toward either sustainable growth or escalating vulnerability.

This study is subject to several limitations that should be acknowledged. First, the driver identification and scenario construction relied heavily on expert judgment derived from the Delphi method; while rigorous, such approaches inherently involve subjective interpretations shaped by the expertise, backgrounds, and biases of participants. Second, although the MICMAC method effectively reveals structural relationships among variables, it operates at a high level of abstraction and does not capture dynamic temporal changes or nonlinear quantitative effects. Third, the study’s geographic and contextual focus limits the generalizability of the findings; agricultural systems vary widely across cultures, climates, and economic structures, meaning that results may not fully apply to other regions. Finally, external macro shocks—such as geopolitical disruptions, extreme climate events, or sudden technological breakthroughs—were not explicitly modeled, even though they may significantly alter agricultural employment trajectories.

Future research should aim to combine structural foresight tools with dynamic modeling techniques, such as system dynamics or agent-based simulations, to capture temporal evolution and feedback intensities more accurately. Additional empirical studies examining how technological adoption affects employment across diverse agricultural subsectors would strengthen evidence for scenario assumptions. Expanding the geographic scope of analysis to include comparative international case studies would help validate the transferability of the identified drivers. Furthermore, future studies may integrate household-level socioeconomic variables, gender dimensions, and youth migration patterns to broaden understanding of employment transitions. Finally, incorporating climate modeling data and economic forecasting could improve the accuracy and robustness of long-term scenario outcomes.

Policymakers should invest in integrated strategies that simultaneously strengthen technological infrastructure, environmental resilience, and human-capital development. Extension services and vocational training programs must be modernized to support digital agriculture and data-driven farming practices. Institutional collaboration between government, universities, and private firms should be expanded to enhance innovation diffusion and resource mobilization. Market transparency and value-chain integration policies should be prioritized to stimulate rural entrepreneurship and job creation. Finally, cultural and community-based initiatives that reinforce rural identity and social cohesion can play an essential role in supporting long-term employment sustainability.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

References

Asaleye, A. J., Inegbedion, H., Lawal, A. I., Adeleke, O. K., Osakede, U. A., & Ogunwole, E. B. (2023). Revamping agricultural sector and its implications on output and employment generation: Evidence from Nigeria. *Open Agriculture*, *8*(1), 20220140. https://doi.org/10.1515/opag-2022-0140

Etuk, E. A., & Ayuk, J. O. (2021). Agricultural commercialisation, poverty reduction and pro-poor growth: evidence from commercial agricultural development project in Nigeria. *Heliyon*, *7*(5). https://doi.org/10.1016/j.heliyon.2021.e06818

Feng, Z., Robinson, G. M., & Tan, Y. (2025). Rural Revitalization in China: Reversing Rural Decline and Eliminating Poverty. *Geography Compass*, *19*(7). https://doi.org/10.1111/gec3.70039

Folke, C. (2022). *Resilience The Palgrave Handbook of Critical Physical Geography*. Springer, Cham. https://www.academia.edu/84552969/The_Palgrave_Handbook_of_Critical_Physical_Geography

Holland, J. H. (2019). *Signals and boundaries: Building blocks for complex adaptive systems*. MIT Press. https://mitpress.mit.edu/9780262525930/signals-and-boundaries/

Jameh Saz, O., Sobhani, S. M. J., Mokhber Dezfoli, A., & Haji Mirrahimi, S. D. (2023). Analysis of Business Development Strategies in the Agricultural Sector (A Case Study of Karaj County). *Entrepreneurship Strategies in Agriculture*, *10*(1), 93-106. https://doi.org/10.61186/jea.10.19.93

Jashari, S., & Esfandiari, M. (2022). Formulating Macro Strategies for the Export Development of Agricultural Products with a Foresight Approach. *Strategic Studies of public policy*, *12*(42), 100-116. https://www.sid.ir/paper/1057403/fa

Klerkx, L. (2022). A review of social science on digital agriculture, smart farming, and agriculture 4.0: New contributions and a future research agenda. *NJAS: Impact in Agricultural and Life Sciences*, *94*(1), 1-15. https://doi.org/10.1016/j.njas.2019.100315

Mathinya, V. N., Franke, A. C., Ven, G. W. J. v. d., Giller, K. E., & Andersson, J. (2025). Are Aspirations of Rural Households Aligned With National Rural Development Policies? Understanding Aspirations of Small-Scale Farming Households in the Former Homelands of South Africa. *European Journal of Development Research*, *37*(5), 885-908. https://doi.org/10.1057/s41287-025-00709-5

Nguyen, T. T. (2025). Vocational Training Experience in Association With Solving Employment Challenges for Rural Workers in Various Countries and Some Recommendations for Vietnam. *Jof&ar*, 123-129. https://doi.org/10.71374/jfar.v25.i1.24

Nikolić, T., Pjanović, B., & Vračarević, B. (2024). Rural Planning in the Context of the Green Agenda: European Principles and Good Practice Examples. 391-398. https://doi.org/10.5937/pnzpzs25391n

Salari Pour, A. A., & Amjadiyan, A. M. (2023). Exploring Development Strategies for Supporting Agricultural Service Cities (Case Study: Sanqur City). *Geography and Planning*, *27*(85), 109-122. https://geoplanning.tabrizu.ac.ir/article_15060.html

Sharma, S. (2025). An Overview of Rural Non-Farm Sector: A Review. *Interantional Journal of Scientific Research in Engineering and Management*, *09*(02), 1-9. https://doi.org/10.55041/ijsrem41924

Shlyakov, V. (2025). The Role of European Union's Agricultural Policy Inthe Development of Rural Areas in Bulgaria. *Int. J. Digit. Res.*, *1*(3), 53-71. https://doi.org/10.63711/ijdr.net20250306

Sitsofe, P., & Gibson, R. (2025). Workforce Development in Rural Ontario: An Examination of Experiences and Strategies. *Rural Review Ontario Rural Planning Development and Policy*, *9*(1). https://doi.org/10.21083/ruralreview.v9i1.8282

Smagulova, Z., Aitakhanov, Y., & Nurzhanova, G. (2025). Agricultural Policy: Key Tasks for the Development of Labor Potential in Rural Areas. *Problems of Agrimarket*(2), 185-195. https://doi.org/10.46666/2025-2.2708-9991.16

Spaniol, M. J., & Rowland, N. J. (2023). The scenario planning paradox. *FUTURES & FORESIGHT SCIENCE*, *5*(1), e134. https://doi.org/10.1002/ffo2.148

Teece, D. J. (2018). A capability theory of the firm: An economics and (strategic) management perspective. *New Zealand Economic Papers*, *52*(1), 1-43. https://doi.org/10.1080/00779954.2017.1371208

Tomashuk, I. (2025). Rural Entrepreneurship as a Tool for Employment and Improving the Quality of Life of the Population. *State and Regions Series Economics and Business*(2(136)). https://doi.org/10.32782/1814-1161/2025-2-7

Velasco-Muñoz, J. F., Mendoza, J. M. F., Aznar-Sánchez, J. A., & Gallego-Schmid, A. (2021). Circular economy implementation in the agricultural sector: Definition, strategies and indicators. *Resources, Conservation and Recycling*, *170*, 105618. https://doi.org/10.1016/j.resconrec.2021.105618

World, B. (2019). *World Development Report 2019: The Changing Nature of Work*. World Bank Publications. https://so04.tci-thaijo.org/index.php/jkbu/article/view/247971

Zghara, I. (2024). Legal Ensuring the Sustainable Development of the Agricultural Sector of Ukraine Under the Conditions of European Integration. *Public Administration and Regional Development*, *25*, 798-816. https://doi.org/10.34132/pard2024.25.04