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HUMAN RESOURCE DEMAND AND DETERMINANTS IN ENVIRONMENT-FRIENDLY AGRICULTURE: A CASE STUDY OF SUSTAINABLE FARMING IN TAIWAN

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ABSTRACT

The transformation of agriculture toward sustainable and environmentally friendly practices has created a growing demand for a specialized workforce capable of integrating traditional farming knowledge with modern agricultural technologies. This study investigates the human resource needs and influencing factors within Taiwan's environment-friendly farming sector. Drawing on a comprehensive survey of 391 farmers, the research examines current workforce structures, recruitment challenges, talent retention issues, and future labor requirements across seven functional categories, including production, marketing, and R&D. The findings highlight that talent demand is shaped by a combination of policy support, market trends, and internal farm management factors. Key constraints include low salary levels, a lack of specialized training, and limited attractiveness of agricultural careers to younger generations. To bridge these gaps, the study recommends strategic investments in human capital development, enhanced policy incentives, adoption of smart farming technologies, and improvement of rural infrastructure. These insights offer a foundation for shaping agricultural workforce strategies and ensuring the resilience of eco-friendly agriculture in Taiwan.

Keywords: Environment-Friendly Farming; Sustainable Agriculture; Agricultural Human Resources; Talent Demand; Workforce Retention; Smart Farming; Policy Incentives; Taiwan Agriculture; Agricultural Labor Market; Rural Development

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

1. INTRODUCTION

Taiwan's agricultural sector is currently facing significant challenges, particularly the decline and aging of its workforce. Over the past 25 years, there has been a substantial reduction in the agricultural labor force, accompanied by a marked increase in the average age of farmers. This demographic shift has led to a pressing need for effective human resource policies to rejuvenate the sector. In response, the Ministry of Agriculture in Taiwan (MOA) has implemented various measures, including the establishment of specialized units for human resource management, the development of diverse labor resources, and the improvement of employment conditions to attract younger individuals to agricultural professions.

Moreover, the advancement of precision agriculture and smart farming technologies has introduced new dynamics into the agricultural labor market. The integration of information and communication technologies into traditional farming practices necessitates a workforce proficient in these modern tools. However, the high initial costs and the existing knowledge gap among farmers pose significant barriers to the widespread adoption of smart agriculture. These developments underscore the need to conduct a comprehensive analysis of the current human resource demands within Taiwan's environment-friendly farming sector.

Given these trends and challenges, this study aims to identify the factors influencing labor requirements and availability in the sector, and to propose actionable recommendations for bridging existing gaps and preparing for future workforce needs. By addressing these issues, this research contributes to the sustainable development of Taiwan's agriculture, ensuring it remains resilient and competitive in the face of evolving global challenges.

2. LITERATURE REVIEW

2.1 Sustainable Agriculture and Its Relevance

Sustainable agriculture focuses on optimizing resource utilization while preserving ecological balance. Hamilton (1990) and Keeney (1991) emphasized the dual goals of improving productivity and maintaining ecological harmony. Recent advancements have expanded these principles to include socio-economic sustainability, aiming for a balance between economic viability and environmental stewardship. Studies on Taiwan's agricultural practices have underscored the urgent need for a workforce capable of integrating traditional knowledge with modern technologies (Lin et al., 2019).

Further studies, such as those by the National Development Council (2021), highlight how sustainable agriculture is increasingly being viewed as a solution to global challenges such as climate change and food security, emphasizing its role in creating resilient farming communities.

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

2.2 Principles and Practices of Environment-Friendly Farming

Environment-friendly farming encompasses practices that prioritize ecological integrity, such as minimizing chemical use, enhancing biodiversity, and promoting soil and water conservation. Popular models include:

- KKF Natural Farming: Employing localized microbial decomposition for soil enrichment.
- Permaculture: Designing agricultural systems modeled after natural ecosystems.
- Shumei Farming: Avoiding all synthetic inputs to rely on the natural vitality of soil and plants.
- MOA Green Label Standards: Promoting zero chemical input and fostering habitats for diverse organisms (Chen & Liu, 2021).

In Taiwan, the "Friendly Environment Farming Certification Measures" have been implemented to encourage farmers to adopt organic and sustainable practices. This policy aims to reduce environmental impacts while enhancing the market competitiveness of eco-friendly products (Ministry of Agriculture, 2023).

2.3 Challenges in Human Resource Management

Labor shortages, aging workforces, and a lack of specialized training are recurring themes in the literature on sustainable agriculture (Wang, 2015; Chen, 2017). Studies also highlight difficulties in recruiting and retaining skilled professionals due to low wages and the physically demanding nature of agricultural work. Additionally, seasonal fluctuations in labor demand exacerbate workforce management challenges.

Ho (2022) discusses how Taiwan’s agricultural sector faces significant demographic challenges, with younger generations less inclined to pursue careers in farming. Proposed solutions include leveraging foreign labor and providing enhanced incentives to attract local talent.

2.4 Factors Influencing Human Resources Demand

Key factors shaping human resource demand include:

- Policy Environment: Incentives like subsidies, green payment programs, and certification initiatives.
- Market Trends: Rising consumer demand for organic and eco-friendly products.
- Technological Innovations: Adoption of automation and precision farming tools, including remote monitoring systems.
- Societal Shifts: Growing interest in sustainability among younger generations.

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

The National Development Council's 2021 report highlights how policy frameworks, combined with technological advancements, have the potential to reshape labor demands in Taiwan's agricultural sector. These changes, however, require robust training programs and infrastructure development to support their effective implementation.

2.5 Human Resource Demand in Environment-Friendly Farming

2.5.1 Research on Human Resource Demand in Environment-Friendly Farming

Existing literature on the demand for human resources in environment-friendly farming is relatively scarce. However, some studies have explored the age, educational background, and job classifications of agricultural workers.

Shen, Yang, & Tsai (2013) found through an agricultural census that the average age of farm managers was 57.3 years, which is 4.5 years younger than the average for the entire agricultural sector. Moreover, 41.6% of farm managers had at least a high school education, indicating a trend of younger and more educated farm managers. Additionally, 5.3% of farm managers were engaged in leisure agriculture, while 9.8% were involved in agricultural processing.

Liao & Chang (2000) classified professional competencies in precision agriculture into eight categories based on expert surveys: customer service and marketing; business management; advertising and planning; production and manufacturing; quality assurance and safety; research and development; financial accounting; information management and legal affairs;

Tung (2011) examined the demand for precision agriculture professionals and identified the five most significant talent gaps: precision farm management personnel; inspection engineers; agricultural materials research and development engineers; agricultural biotechnology product development engineers; product marketing and business management specialists.

2.5.2 Value Chain and Talent Demand in Environment-Friendly Farming

The demand for human resources in environment-friendly farming can be analyzed from the perspective of the value chain, which includes technology research and development, production and maintenance, processing and logistics, brand establishment, and sales. The required expertise at each stage includes:

Technology Research and Development (Breeding specialists; Pest control researchers; Organic fertilizer developers; Agricultural materials research personnel); Production and Maintenance (Crop production personnel; Agricultural, forestry, fishery, and animal husbandry technicians; Farm maintenance workers; Harvesting personnel); Processing and Logistics (Quality control specialists; Agricultural product processing personnel; Grading and packaging workers; Storage

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

and transportation managers); Brand Establishment and Sales (Market research analysts; Brand marketing specialists; Sales and trade specialists; Customer service representatives).

Based on data from 1111 Job Bank and 104 Job Bank, job vacancies in environment-friendly farming can be classified into seven categories (as shown in Table 2):

Table 2: Professional Competencies in Environment-Friendly Farming

Category	Job Responsibilities
Research and Quality Control	Innovation and improvement of products, technology, processes, and services, as well as green energy and biotechnology applications.
Production and Cultivation	Seedling cultivation, land preparation, sowing, field management, harvesting, and maintenance of production materials and facilities.
Processing and Logistics	Post-harvest processing, grading, processing, certification, packaging, storage, transportation, and distribution.
Business Management	Farm planning, analysis, decision-making, financial allocation, and risk management.
Marketing and Sales	Market research, brand marketing, promotional planning, event organization, sales and trade, and customer service.
Administrative Support	Farm record management, administrative documentation, accounting, procurement, human resources, and facility maintenance.
Information Technology	Design, use, and maintenance of information systems, computer equipment, and website management.

Source: This study

2.5.3 The Impact of Policy and Market Trends on Talent Demand

2.5.3.1. Policy Support:

According to the Council of Agriculture (2023), the government has implemented the Environment-Friendly Farming Certification Measures, providing subsidies and policy support to encourage farmers to adopt organic and sustainable farming techniques.

The National Development Council (2021) reported that policy subsidies, such as green payment programs, are essential for promoting sustainable agriculture but require additional efforts to cultivate and support relevant talent.

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

2.5.3.2. Increasing Market Demand:

Jones & Lee (2020) highlighted the growing global demand for organic and environment-friendly agricultural products, prompting businesses to seek professionals in marketing and brand management to enhance product value.

Smith, Adams & Clark (2021) emphasized that climate change and rising environmental awareness are pushing agricultural entrepreneurs to adopt smart farming and sustainable technologies, which will increase the demand for professionals in agricultural technology and digital solutions.

2.5.4 Talent Development and Future Trends

2.5.4.1. Strengthening Education and Training

Establish partnerships with universities to develop environment-friendly farming talent cultivation programs, focusing on production management, agricultural technology, marketing, and business management. Promote government-enterprise collaborations to offer on-the-job training in agricultural technology, business management, and marketing.

2.5.4.2. Promoting Digitization and Smart Agriculture

Develop a Smart Agriculture Technology Talent Training Program to enhance workers' skills in IoT, data analysis, and automation technologies. Expand the application of digital farm management systems to improve operational efficiency and sustainability.

2.5.4.3. Improving Agricultural Working Conditions to Attract Young Talent

Provide entrepreneurial incentives for young farmers to encourage youth participation in sustainable agriculture. Improve rural infrastructure, including transportation, healthcare, and community development, to make agricultural professions more attractive.

The demand for human resources in environment-friendly farming encompasses multiple fields, including technology research and development, production and maintenance, processing and sales. This demand is influenced by policy support, technological advancements, and market trends. Future development should focus on talent cultivation, smart agriculture applications, and enhancing the attractiveness of agricultural professions to ensure the sustainable growth of the sector.

3. RESEARCH DESIGN

3.1 Research Framework

This study is based on the theoretical literature presented in the previous chapters and derives the research framework accordingly. The primary focus of this study is to explore whether there is a

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

significant impact among environment-friendly farming, farmers' perceptions of talent demand, and influencing factors. The research subjects consist of environment-friendly farmers in Taiwan, as illustrated in Figure 3-1.

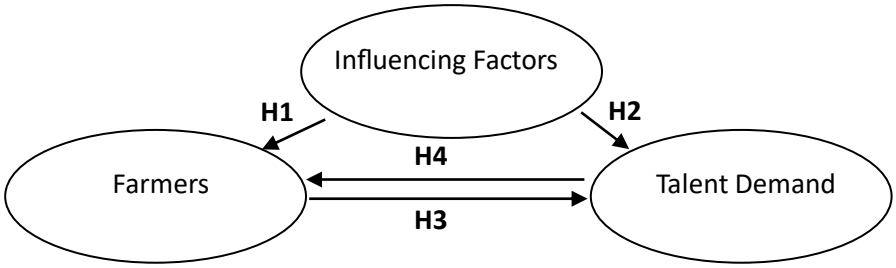

Figure 3-1: Research Framework

Source: this study

3.2 Research Hypotheses

Based on the literature review, research framework, and study objectives, the following hypotheses are proposed and will be tested through empirical analysis:

H1: The factors influencing environment-friendly farming have a significant positive impact on farmers.

H2: The factors influencing environment-friendly farming have a significant positive impact on talent demand.

H3: Farmers' perceptions of talent demand for environment-friendly farming have a significant positive impact on overall talent demand.

H4: The demand for talent in environment-friendly farming has a significant association with farmers' operational success.

3.3 Questionnaire Design

To enhance measurement reliability and instrument validity, the questionnaire was refined through a two-phase process. A pilot study with 50 respondents was conducted to pretest item clarity and internal consistency. Based on the pilot results, items with low item-total correlations were revised or eliminated. Exploratory factor analysis (EFA) was applied to assess construct dimensionality.

To understand the talent demand and influencing factors for environment-friendly farming, a questionnaire was developed as the primary research tool. The questionnaire consists of four main sections:

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

Basic Information of Farmers: Includes questions about major crops cultivated, years of farming experience, farm size, number of employees, annual revenue, and regional characteristics of the farm.

Current Talent Structure: Focuses on the workforce composition in seven categories: management, R&D and quality control, production and cultivation, processing and logistics, marketing, administrative support, and IT. Data on employment type (full-time/part-time), tenure, nationality, age, education, and retention factors for key personnel are collected.

Future Talent Demand: Examines the priority rankings for future talent needs in the seven categories and explores willingness to pay salaries based on candidates' educational backgrounds and practical experience.

Factors Influencing Talent Demand: Investigates the main challenges in recruitment, key factors for retaining talent, and external and internal environmental factors affecting talent demand.

3.4 Sampling

Population: The study focuses on farmers engaged in environment-friendly farming as identified by the Taiwan Organic Agriculture Information Network (2018).

Sampling: Stratified proportional sampling is used to ensure representation across regions. The sampling frame includes certified environment-friendly farming groups and their partner farms. Questionnaires are distributed to selected farmers, explained in detail, and collected upon completion.

Sample Size: Using the formula for determining sample size with a 95% confidence interval. The minimum sample size is calculated as 385. To account for potential non-responses, 400 questionnaires were distributed, proportionally allocated as follows: Northern of Taiwan 88; Central of Taiwan 65; Southern of Taiwan 122; Eastern of Taiwan 124; Offshore Islands: 1.

3.5 Data Analysis Methods

In addition to descriptive statistics and chi-square tests, the following multivariate techniques were employed:

- Exploratory Factor Analysis (EFA) to validate the underlying structure of key constructs.
- Multiple Regression Analysis to examine how influencing factors (policy, market, internal practices) predict perceived talent demand.
- Logistic Regression to evaluate how demographic characteristics (e.g., gender, migrant status) affect likelihood of retention or recruitment.
- Reliability was assessed using Cronbach's alpha, with a threshold of 0.70 as the benchmark

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

for internal consistency. Adjustments were made to improve subscale scores based on pilot data.

Statistical analyses were conducted using SPSS 22.0. The following methods were employed: Reliability Analysis; Descriptive Statistics; Chi-Square Tests etc.

This comprehensive research design ensures robust data collection and analysis, providing insights into the talent demand and influencing factors in Taiwan's environment-friendly farming sector.

4. EMPIRICAL ANALYSIS

4.1 Reliability Analysis

A total of 391 valid responses were obtained, resulting in a valid response rate of 97.75%. The study measured two main constructs: influencing factors and talent demand. Cronbach's α was used to assess the internal consistency of the questionnaire. the Cronbach's α coefficients for the influencing factors and talent demand were 0.642 and 0.516, respectively, with an overall α value of 0.617 for all constructs. These results indicate an acceptable level of reliability for the research instrument.

4.2 Farmers' Demographic Data Analysis

This section provides an overview of the demographic data of farmers engaged in environment-friendly farming, categorized by crop type, years of experience, farm size, number of employees (full-time and part-time), annual revenue, and geographic location. Descriptive statistics for these variables were analyzed as follows:

Crop Types: The vegetables were the most commonly cultivated crop, accounting for 38.3% of the farms, followed by fruits at 27.8%, other crops (e.g., grains and specialty crops) at 15.5%, rice at 12.3%, and tea at 6.1%.

Years of Experience: The majority of respondents had been farming for over 10 years, reflecting a predominantly experienced farming population.

Farm Size: Farms varied widely in size, with smaller farms dominating the sample, a reflection of Taiwan's fragmented land ownership. It can be seen that in the planting of friendly environment

In terms of the proportion of full-time employees, the largest number of full-time employees is less than 3, accounting for 44.0%; The second is 4-6 people, accounting for 25.3%; followed by 7-9 people, accounting for 16.4% Minimum number of full-time employees. Those with more than 10 people accounted for 14.3%.

Employee Structure: Analysis of the workforce revealed that most farms employed a mix of full-time and part-time staff, with part-time employment peaking during peak farming seasons.

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

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Annual Revenue: A significant portion of farms reported annual revenues within a mid-range bracket, indicating financial sustainability but also highlighting potential growth opportunities. It can be seen that in the cultivation of friendly environment in terms of annual turnover, the largest proportion is 310,000-600,000 NTD, accounting for 29.2%; 610,000-900,000 NTD, accounting for 21.0%%; followed by less than 300,000 NTD, accounting for 16.4%; 910,000-1.2 million NTD; 13.8% 1.21-1.50-million-yuan 10.5% Minimum annual turnover is 1.51 million yuan or more 9.2.

Geographic Distribution: Farms were distributed across Taiwan, with representation from northern, central, southern, and eastern regions, as well as offshore islands.

4.3. Current situation of farm talent structure

The number of staff involved in the current talent structure of friendly farming is the largest among production and cultivation personnel, with an average of about 1.90 people per friendly farming farm; followed by management personnel, with an average of about 1.24 people per friendly farming farm; and The largest number of workers are in the processing, storage and transportation category, with an average of 0.59 people per environmentally friendly farming farm; the others are in the marketing business category, R&D and quality control category, administrative affairs category, information technology category and others.

From this, we can see that the current talent structure of environmentally friendly farming is mainly composed of production and cultivation personnel, business management personnel, and processing and storage personnel, while there are fewer marketing and business, R&D and quality control, administrative and general affairs, and information technology personnel. The possible reason is that currently friendly environment farming is still the primary and secondary industries are the main industries, so the talents needed for friendly environment farming are still production and cultivation, business management and, mainly business management, processing, storage and transportation.

4.4. Main factors causing difficulty in recruiting talents

Farmers who work in a friendly environment believe that the top five factors that make it difficult to recruit talent are that job seekers cannot adapt to the job, accounting for 13.3%; followed by the environment, the lack of industry attractiveness, accounting for 13.1%, the small number of applicants, accounting for 10.1%, and other factors accounting for less than 10%. The main reasons

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

are inability to coordinate working hours, disparity in salary and benefits, and insufficient understanding of the industry.

4.5. Main factors affecting the retention of key talents

Farmers who farm in an environment-friendly manner believe that the top three factors affecting the retention of key personnel are salary (16.9%), work atmosphere (14.7%), and matching the right person to the right job (13.5%). The last three are farm prospects, farm culture, and farm image, which are less likely to retain talent.

4.6. Influencing Factors in Talent Demand

The analysis identified key factors influencing talent demand in environment-friendly farming, categorized into macro-environmental, industry-specific, and internal factors. These include:

Macro-Environmental Factors: Policies, technological advancements, and consumer trends emerged as critical determinants.

Industry-Specific Factors: Seasonal labor shortages, recruitment challenges, and competition for skilled workers were significant.

Internal Factors: Farm management practices, employee retention strategies, and operational efficiency were highlighted.

4.7 Talent Demand for Future Development

This study also examined the future talent needs of the environment-friendly farming sector, with farmers prioritizing roles such as production and cultivation expert, management personnel, and marketing experts. Educational background and practical experience were deemed essential qualifications, with farmers expressing willingness to offer competitive salaries for skilled candidates.

4.8 Challenges in Recruitment and Retention

The major challenges identified in recruitment included a limited talent pool, high training costs, and the physically demanding nature of farming work. Retention was influenced by factors such as salary competitiveness, work environment, and job satisfaction.

5. CONCLUSION AND RECOMMENDATIONS

In addressing the multifaceted challenges of human resources in environment-friendly farming, this study has highlighted several critical insights and proposed actionable strategies to drive sustainable development. The following conclusions and recommendations are presented:

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

5.1 Key Findings

5.1.1. The gap between salary and ideal:

Through the chi-square test, the main factor affecting the difficulty of recruiting friendly talents is the "gap between salary and ideal", 37.6% of the farms are willing to pay a monthly salary of NT$28,101-33,100, followed by 36.3% of the farms willing to pay a monthly salary of NT$28,101-33,100. The salary is between NT$23,101 and NT$28,100, which is still generally low considering Taiwan's living standards. The study confirmed that Taiwan's agricultural sector faces huge demographic challenges, especially the aging population and the declining labor force participation rate. Younger generations have limited interest in agricultural careers due to low pay and poor working conditions.

5.1.2. The industry lacks a talent certification mechanism, making it difficult to identify talent:

There is a clear gap in professional training programs for environment-friendly agriculture and smart farming technologies. Farmers lack continuous learning opportunities to integrate traditional knowledge with modern agricultural practices.

5.1.3. Main factors affecting the retention of key talents in farm image:

Technological advances such as precision agriculture and digital tools have the potential to reshape labor dynamics but require significant upfront investment and upskilling. Policy incentives such as subsidies and certification play a key role in encouraging sustainable practices and addressing workforce challenges.

5.2 Recommendations

5.2.1. Investing in Human Capital:

Collaborate with educational institutions to create specialized curricula in sustainable agriculture, focusing on agroecology, smart farming technologies, and environmental stewardship. Offer targeted training programs and workshops to bridge existing skill gaps, ensuring farmers and agricultural workers are well-equipped for emerging challenges.

5.2.2. Enhancing Policy Support:

Introduce comprehensive workforce development incentives, such as wage subsidies, housing benefits, and tax exemptions, to attract and retain talent in agriculture. Strengthen policies promoting environment-friendly certifications and provide financial support for farmers adopting sustainable practices.

ISSN: 2455-6939

Volume: 11, Issue: 03 "May-June 2025"

5.2.3. Facilitating Technology Adoption:

Promote the use of automation, robotics, and remote monitoring systems to enhance efficiency and reduce physical labor requirements. Establish public-private partnerships to lower the financial barriers to adopting smart agricultural technologies.

5.2.4. Improving Rural Infrastructure:

Develop essential rural amenities, such as transportation, healthcare, and education, to make farming communities more attractive to younger generations. Encourage community-building initiatives to foster a sense of belonging and pride in agricultural professions.

5.2.5. Building Market Competitiveness:

Launch awareness campaigns emphasizing the health and environmental benefits of eco-friendly farming, creating a stronger market demand for sustainable products. Support farmers in accessing domestic and international markets through digital platforms and marketing resources.

5.2.6. Promoting Collaborative Ecosystems:

Foster collaboration between government, academia, and industry stakeholders to develop a cohesive framework for sustainable agricultural development. Establish platforms for international knowledge exchange to learn from global best practices and innovations in sustainable farming. By addressing these areas, this research aims to contribute to the resilience and competitiveness of Taiwan's environment-friendly farming sector, ensuring its sustainability in the face of evolving global challenges.

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Volume: 11, Issue: 03 "May-June 2025"

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