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Growing Green: A Cross-Regional Comparison Of Ecological Farming In Europe And Pakistan

Farah Yaseen[1], Muhammad Adeel[2], Salih Gücel[3], Özge Özden[4]
[1,2,3,4]Faculty of Agriculture, Near East University, Nicosia, North Cyprus.

Abstract
The study compares European Union ecological farming systems with agricultural practices in Pakistan, focusing on the future of ecological farming. The research used a mixed method approach, involving survey questionnaires and interviews with 100 farmers. The study found that sustainable farming strategies such as integrated pest management, agroforestry, cover crops, and crop rotation are crucial for overcoming challenges like water scarcity and pest pressure. Similar to farms in Europe, Pakistani eco-farms are dedicated to sustainable practices, but they lack institutional support and technological advancement. To develop Pakistan's ecological farming and food systems, the study suggests improving education, gender equity, funding R&D, availability of markets, regulatory measures, and applying sustainable land management approaches.
Keywords: *Ecological farming, sustainability, biodiversity, water management.*

INTRODUCTION

Despite being a widely used system, conventional farming is criticized for its unsustainable farming methods and detrimental effects on biodiversity, soil, and climate. Because it is heavily relying on chemical inputs, monocultures, and mechanization, which is eventually affecting the environment globally. Agriculture is facing numerous sustainability difficulties since increased food production is necessary to feed the increasing world population, current systems are depleting natural resources and polluting ecosystems at unsustainable rates (Boschiero et al., 2023). Agricultural sector release substantial amounts of greenhouse gases, such as methane, nitrous oxide, and carbon dioxide (Chataut et al., 2023). In the EU, agriculture sector is responsible for 45% of greenhouse gas emissions (Mielcarek-Bocheńska & Rzeźnik, 2021). While in Pakistan, the agricultural sector is responsible for about 28% of the total greenhouse gas emissions (Mir et al., 2017). According to Ali et al. (2022) tomato tunnel farming in Pakistan emits a significant amount of greenhouse gases, mostly from fertilizers. It is estimated that livestock production and irrigation use over 70% of the freshwater on Earth (Foley et al., 2011). Similarly, unsustainable farming methods in Pakistan's Indus Plains have caused groundwater depletion, which has resulted in issues with the ecology and economy (Watto & Mugera, 2016). Approaches to ecological farming provide viable ways to solve agricultural environmental issues while maintaining food security. Ecological farming is required as a more secure and sustainable alternative for industrialized agriculture that relies heavily on chemicals (Nicolopoulou-Stamati et al., 2016). Similarly, by using techniques like polyculture, crop diversification, and integrated pest control, agro ecological systems can help address important global concerns include climate change, biodiversity loss, and food security (Vikas & Ranjan, 2024). In Europe, ecological farming especially agro ecology is getting more widely accepted as a possible remedy for agricultural problems. It provides sustainable food systems, increased farmer incomes, and environmental benefits (Van der Ploeg et al., 2019; Wezel et al., 2018). Agro-ecology is being promoted by training facilities in Belgium, France, and Spain using a "community frame" founded on environmental charity (Schnyder, 2022). However, Pakistan is dealing with a number of issues, including overuse of pesticides, soil degradation, climate change, and water scarcity (Ishaque et al., 2023; Qureshi & Perry, 2021). Adopting sustainable ecological agricultural practices is crucial to resolve these problems. These practices include conserving water, reducing reliance on chemicals, boosting biodiversity, and assisting small farmers with financial aid and cutting-edge technical training. Ecological farming is extremely important for the Pakistan because the agriculture sector of Pakistan is facing several challenges like climate change, underground water depletion, soil salinization, land degradation and loss of biodiversity (Qureshi & Perry, 2021; Ranjan, 2019; Syed et al., 2022). Organic agriculture is increasingly recognized as a viable solution to boost yields while reducing environmental impacts. Organic farming is presently accounts for less than 2% of global agricultural land, but its growth has been remarkable, reaching over

773 million hectares as of now, compared to 15 million hectares in the year 2000 (Board, 2022). Because, genetically modified seeds, toxic pesticides, and herbicides are rejected in organic agriculture with the goal of improving the quality of the soil and water in particular (Larsen et al., 2024). EU is working on several projects to enhance the ecological farming in the region like the "Common Agricultural Policy" (CAP) encourages sustainable strategies to counteract climate change and preserve natural resources (Thompson et al., 2024). Similarly, EU's Farm to Fork Plan and California's push for carbon neutrality (Board, 2022). This study is important in understanding the comparison between Europe and Pakistan, including what practices the EU and Pakistan are following and how we can improve existing ecological farming system to overcome issues such as food security, environmental pressures, and farm income, particularly for small farmers. Hence, the objective of the study was to do comparative analysis of the ecological farming practices, opportunities, difficulties, and commonalities in European Union (EU) and Pakistan. The study emphases on ecological farming methods that incorporate integrated pest management, crop rotation, cover crops, and agroforestry to increase biodiversity, improve soil health, and use less chemical inputs. Survey questionnaires were distributed to 100 ecological farmers in Pakistan in order to better understand their experiences and methods. The acquired data was analyzed using descriptive statistics, while thematic analysis was used to identify important themes and patterns in the qualitative data from the interviews. By examining the advanced ecological farming systems in EU in comparison with Pakistan the study identifies the critical gaps and opportunities that how to make Pakistani ecological farming more sustainable.

The following research questions are intended to be addressed in this article:

1. Which ecological farming methods are most frequently employed by Pakistani and European farmers?
2. How do ecological farmers in Pakistan and Europe handle diseases, pests, water supplies, and soil fertility?
3. What difficulties do ecological farmers face in Pakistan and Europe, and are there any differences between the two regions?

MATERIAL AND METHODS

The survey-based methodology was used in this study to collect comprehensive data on ecological farming systems in Pakistan, with an emphasis on contrasting them to the European ecological farming systems. Figure 1 illustrates the study's coverage of Pakistan's Punjab province, which includes the districts of Multan, Muzaffargarh, and Bahawalpur as well as the surrounding villages of Vehari, Lodhran, and Khanewal. The area is well known for growing a variety of crops, such as sugarcane, wheat, cotton, mangoes, citrus fruits, and vegetables. Within this diverse agricultural environment, progressive farmers integrate modern agricultural technologies alongside traditional practices such as crop rotation and smart irrigation techniques. The purposive sampling technique was used to do the sampling. Using structured questionnaires, farmers were picked from both academic and non-academic groups that practice ecological farming systems in Multan and the surrounding areas, such as Bahawalpur, Muzaffargarh, Vehari, Lodhran, and Khanewal. The informative data was collected from 100 farmers that were involved in ecological farming. Numerous aspects of ecological farming, such as farming practices, land management tactics, disease and pest management, and soil and water conservation techniques, were covered in this questionnaire. Additionally, some farmers who may have limited access to technology and prefer face-to-face communication were interviewed in-person. A more complete comprehension of the survey responses was made possible by the in-person interviews, which allowed for clarification of the responses and deeper discussion. A comparative analysis, which is a methodical side-by-side comparison that emphasizes the similarities and contrasts between two or more items, was used to analyze the data (Kumar et al., 2023).

Figure 1. Map showing the selected districts used in the study (Comersis, n.d.).

RESULTS

3.1. Demographics

Results for demographics are presented in Table 1. Table shows the percentage and frequency of the respondents. The survey sample consisted mostly of male respondents (70%), with female respondents making up 29%, and 1% of participants did not provide a response. Age groups were categorized as 18-30, 30-40, 40-50, and over 50 to capture a broad range of ages of the respondents, 65% were aged 18-30, 20% were 30-40, 10% were 40-50, and 5% were over 50. Occupations were categorized into four groups: (FTF) full-time farmers (65%), (PTF) part-time farmers (20%), (AC) agricultural consultants (10%), and others (5%). The majority of respondents were full-time farmers, while part-time farmers, agricultural consultants, and others made up smaller portions of the sample.

Table 1: Age, gender and occupation of participants (%).

Age	Occupation	%	Male	Female
18-30	FTF	65	50	15
30-40	PTF	20	11	9
40-50	AC	10	6	4
Over 50	Other	5	3	1
Total		100	70	29

3.2. Education of Farmers

By displaying the frequency and percentage of farmers in each educational group, Table 2 offers an extensive overview of the respondents' educational backgrounds within the agricultural community. The various educational levels were represented by four categories. "no formal education," "primary education," "secondary education," and "higher secondary education." According to 50% of the sample, they have never participated in formal education. In the meantime, 30% of the sample has completed their primary education. Of those surveyed, 15% had finished their secondary education. Furthermore, 5% of the sample has finished their higher secondary education.

Table 2: Education of the farmers (%).

Education of Farmers	Frequency	Percentage
No formal education	50	50
Primary education	30	30
Secondary education	15	15
Higher secondary education	5	5
Total	100	100

3.3. Experience in Ecological Farming

The duration of ecological farming, as well as the frequency and proportion of participants in each time period, are displayed in Table 3. Less than a year, one to five years, five to ten years, and more than ten years were the options for responses. From individuals with significant long-term experience to those who were new, these groups were chosen to reflect a range of experiences. The findings showed that 40% of the entire group had been engaged in ecological farming for less than a year. One- to five-year ecological farming experience is reported by 30% of the sample. For five to ten years, 18% of the respondents have been engaged in ecological farming. Additionally, 12 percent of the total participants has accumulated over a decade.

Table 3: Participants' replies to the question "How long have you been practicing ecological framing?"

Duration	Frequency	Percentage
Less than 1 year	40	40
1-5 years	30	30
5-10 years	18	18
More than 10 years	12	12
Total	100	100

3.4. Total Area Under Ecological Farming

Table 4 shows the sharing of participant responses about the total land area utilized for ecological farming, together with the frequency and percentage of each area type. Respondents were given the following choices when asked the scale of their ecological farming enterprises. "Under one acre," "One to five acres," "Six to ten acres," and "Over ten acres." Forty-five people, or 45% of the sample as a whole, cultivate less than one acre of land for ecological farming, whereas 25% of respondents manage farms with one to five acres. While 20% of respondents committed six to ten acres to ecological agricultural activities, just 10% of respondents overall cultivate more than 10 acres.

Table 4: Participants' responses to the question "What is the total area of the farm dedicated for ecological farming?" (%)

Areas	Frequency	Percentage
Less than 1 acre	45	45
1-5 acres	25	25
6-10 acres	20	20
More than 10 acres	10	10
Total	100	100

3.5. Source of Irrigation

Participants' answers regarding the water sources they utilize for irrigation systems are included in Table 5, along with the frequency and percentage of each type of water supply. Using the terms "groundwater," "rainwater harvesting," "municipal water supply," or "canal water," the framers chose their responses. The statistics show that 40 people, or 40% of the sample overall, rely mostly on groundwater sources for their irrigation water. Furthermore, thirty people, or thirty percent of the sample, collect rainwater. Twenty percent of the participants use government water supply for their irrigation. Ten people, or ten percent of the farmers, use canal water.

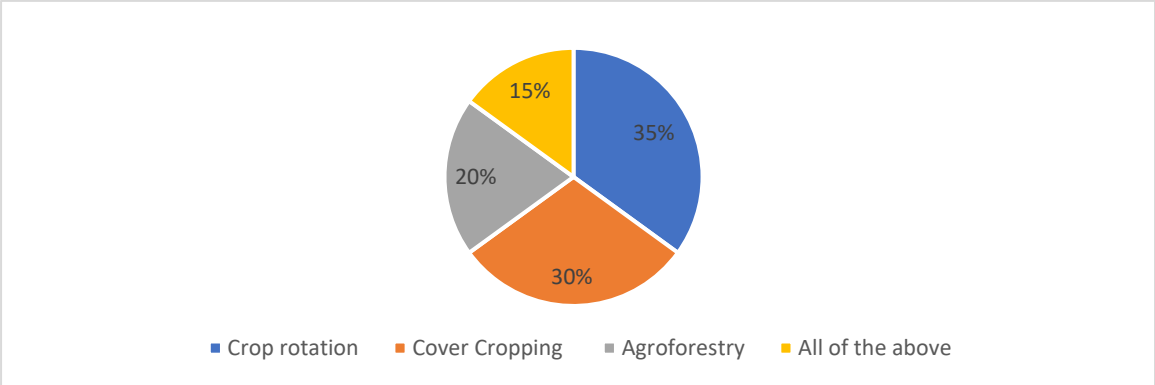
Table 5: Participants' responses to the question "What are the water sources for your irrigation systems?" (%)

Water sources	Frequency	Percentage
Groundwater	40	40
Rainwater Harvesting	30	30
Municipal water supply	20	20
Canal water	10	10
Total	100	100

3.6. Ecological Farming Methods

Graph 1 provides a summary of the main ecological farming methods used by the respondents on their farms, along with the percentage of each practice type. The primary ecological farming strategies chosen by respondents were "crop rotation," "cover cropping," "agroforestry," and "all of the above." According to the findings, 35% of the sample's respondents used crop rotation as a key ecological farming strategy, 30% used cover crops, 20% used agroforestry, and 15% used all of the previously mentioned techniques on their farms.

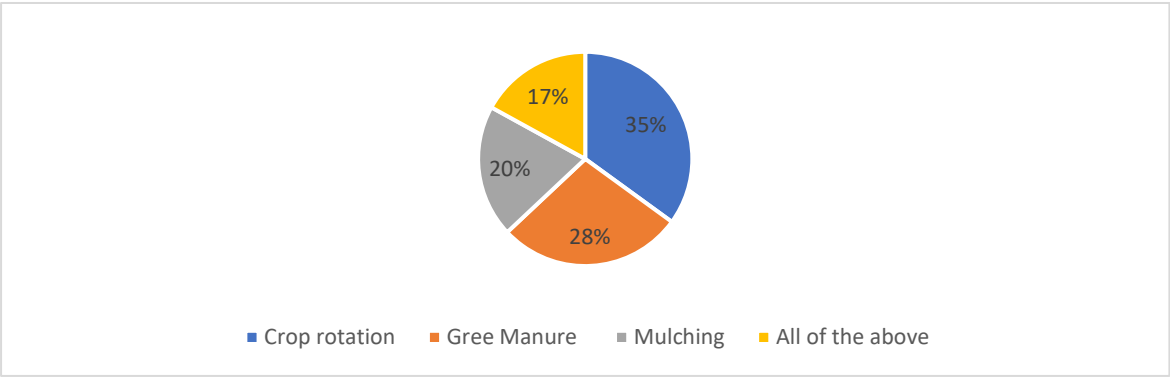
Graph1: Responses from participants to "could you please describe the main ecological farming practices you implement on your ecological farm"



3.7. Soil Management

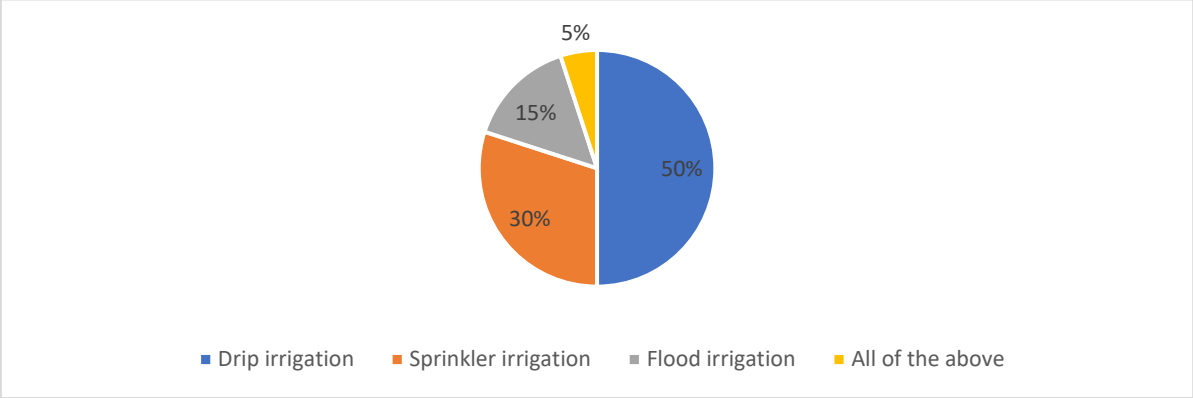
Graph 2 displays the proportion of participants who responded to each management category regarding how they maintain the fertility and health of the soils on their ecological farms. When asked what methods they employ, participants answered with "mulching," "green manure," "crop rotation," or any combination of these methods. According to the data, 35% of the sample as a whole uses crop rotation as a method of soil management. Additionally, 28% of farmers apply green manure, whereas 20% apply mulch. Furthermore, 17% of farmers maintain the soil on their ecological farms healthy and productive by utilizing all of the previously mentioned methods.

Graph 2: Respondents answer the question, "How do you manage soil fertility and health on your ecological farm?" %**3.8. Irrigation Techniques**



Graph 3 presents the percentage of the question regarding the irrigation techniques they employ on their ecological farms. When questioned about how they give water, the participants selected between "flood irrigation," "sprinkler irrigation," "drip irrigation," and “all of above”. According to the data, 50% farmers, utilize drip irrigation system as their primary irrigation technique of irrigation. Additionally, 30% of the farmers, apply sprinkler irrigation, while 15 % use flood irrigation and 5% of the farmers utilize all of the above-mentioned irrigation techniques to irrigates their fields on their ecological farms.

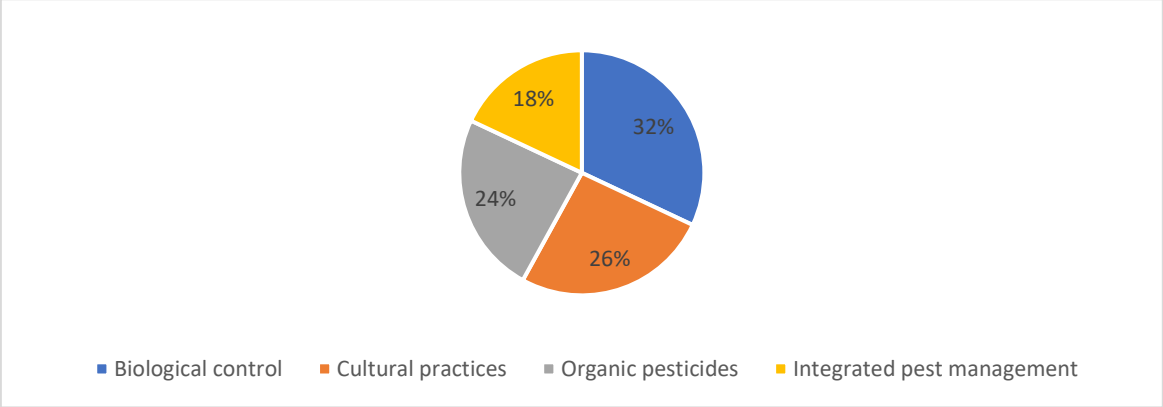
Graph 3: Participants' answers to the question, "what irrigation systems do you use in your ecological "farm?" (%)



3.9. Insect Pest Management

Graph 4 gives a summary of the methods used by the respondents to manage diseases and insect pests on their ecological farms. It also depicts the percentage of each management strategy. The options for answering questions about pest management techniques were "integrated pest management," "biological control," "cultural practices," and "organic pesticides." 32% of farmers, according to the data, primarily employ biological management methods to manage pests. Additionally, 18% of the sample employ integrated pest control tactics, 26% of farmers use cultural practices, and 24% use organic insecticides.

Graph 4: Responses from participants to the question "How do you manage insect, pests, and disease on your ecological farm?" (%)



DISCUSSION

In the study area, 70% of respondents were male and 29% were female farmers employed with ecological farming methods in Punjab Pakistan. The discrepancy between male and female participation demonstrates that men have a significant role in Pakistan's agriculture economy. However, increasing women's participation could promote ecological farming to a wider range of perspectives (Rao & Moharaj, 2023). According to our findings, the ecological farming methods used by the study participants such as crop rotation, mulching and cover crops are very successful because they promote biodiversity, improve soil health, and reduce the need for chemical inputs. It was discovered that agroforestry methods, which use trees and bushes as part of the agricultural system, are also very beneficial for increasing biodiversity. The findings of our study are also supported by the previous studies that shows that ecological farming is beneficial for biodiversity, it improves soil health, enhance carbon sequestration and also help in mitigation of problems caused by the climate change (Li et al., 2023; Pantera et al., 2021; Vermeire et al., 2024).

One crucial element of the agricultural production system is irrigation. Water is a limited resource, and fresh water supplies are being depleted globally as a result of population growth, poor water management, and climate change (Famiglietti & Ferguson, 2021; Gleick & Cooley, 2021; Lall et al., 2020). Forty percent of our respondents use ground water for irrigation, and since ground water is running out quickly, it is urgently necessary to switch to other sources, such as rainwater harvesting which is both beneficial and prevents waste. Drip irrigation systems are used by 50% of our respondents since they conserve resources while minimizing a water loss. In order to address the problem of water waste, other farmers should concentrate on using modern irrigation systems. Regarding pest management, only 18% of respondents employed integrated pest management. IPM strategies help to control insect pests and diseases without the use of pesticides by employing biological controls and cultural methods (El-Shafie, 2018; Sarwar, 2013; Tiwari, 2024). Farmers found mulching to be an efficient weed control strategy since it reduces the need of chemical sprays, which helps to increase biodiversity; however, cultural weed removal methods require a large number of workers and are not realistic for large farms. Therefore, mulching could be the sustainable way of reducing weeds in the ecological farming. Overall results of this comparison study signify that the ecological farming of Pakistan have the potential, particularly for soil fertility, biodiversity, minimizing chemical inputs, and sustainable use of water. Nonetheless, as compared with the existing ecological farming practices in the EU, it is obvious that Pakistan is still far behind in terms of institutional support, farmer education, access to technologies and policies. Thus, we conclude that the process of ecological farming in Pakistan still needs to improve government should play its role to spread information about ecological farming and support existing farmers with the technological innovations.

CONCLUSION

This research illustrates that there is a great potential for the growth and sustainability of ecological agriculture in Punjab, Pakistan. Because ecological farming techniques address the challenges that the agriculture industry faces, such as water scarcity, excessive chemical usage, land degradation, and climate change. Therefore, practices like crop rotation, integrated pest management, and agroforestry are being adopted by the farmers and translating into better soil health and biodiversity. However, some of the significant issues like water scarcity, pest management, and lack of organic inputs still remain. There is an urgent need to invest more in smart irrigation systems, production of organic inputs locally, and education of the farmers to enhance ecological farming. The government support in the form of financing, policy reform, and incentives will also be a key determinant for the sector. As infrastructure, training, and market access get better, ecological farming can be a profitable and sustainable system. Future technologies like precision farming and regenerative practices will further make this sector more robust. Tight coordination between farmers, government, and organizations is necessary for long term success. Ecological farming in Pakistan, in general, has a good future if significant challenges are addressed effectively.

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