



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(4): 302-308
Received: 08-01-2026
Accepted: 12-02-2026

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Cropping pattern and sustainability concerns in the wheat–paddy system of Punjab: A study of selected villages

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4Sd.5411>

Abstract

The present study was conducted to examine the existing cropping pattern and associated sustainability concerns in selected villages of Punjab. The study was carried out in ten villages namely Bajheri, Deh Kalan, Mehmoodpur, Mandlan, Karimpura, Kalaundi, Dugri, Kotli, Dhalon Majra, and Dumna. A total of 60 farmers were selected randomly, and primary data were collected through structured interviews covering cropping pattern, resource use, and agronomic practices.

The results revealed that the wheat–paddy cropping system is the dominant cropping pattern in the study area, with more than 80 percent of farmers cultivating wheat and about 70 percent cultivating paddy. Limited diversification was observed, as only a small proportion of farmers cultivated crops such as maize, fodder, and vegetables. The study further indicated excessive dependence on groundwater irrigation, high use of chemical fertilizers, and limited adoption of sustainable practices.

The findings highlight that although the wheat–paddy system provides economic stability to farmers, it has led to serious sustainability concerns including groundwater depletion, soil degradation, and reduced crop diversification. Therefore, there is a need to promote diversified cropping systems and sustainable agricultural practices to ensure long-term productivity and environmental balance.

Keywords: Cropping pattern, wheat–paddy system, sustainability, Punjab agriculture, groundwater depletion, crop diversification

1. Introduction

By making a major contribution to food security, employment, and rural livelihoods, agriculture is essential to the Indian economy. Agriculture is the primary source of income for almost half of India's population, and a significant percentage of the country's people are directly or indirectly dependent on it for their survival. The continued significance of agriculture and associated industries in India's economic stability and rural development is underscored by its contribution of roughly 16% to the country's GDP in FY24(Of & Future, 2024) ^[1] (Government of India, 2025).

Since the Green Revolution, Punjab, also known as the "Food Bowl of India," has made a significant contribution to the nation's food grain output. Despite having a limited geographical area, the state makes a significant contribution to the nation's wheat and rice production because of its rich soils, irrigation systems, and use of contemporary agricultural technologies (Gdp, 2026) ^[2].

But these quick advancements in agriculture have also brought about substantial shifts in crop patterns. The wheat–paddy cropping system has gradually gained popularity in Punjab because of its economic viability, guaranteed procurement, and policy support. Research suggests that this system has resulted in a significant rise in water demand and cropping intensity, making agriculture extremely input-intensive (Bhardwaj & Dutta, 2024) ^[3].

The wheat-paddy system has persisted, even with its economic advantages, resulting in significant sustainability issues. Overuse of groundwater irrigation has caused a considerable drop in water table levels, with long-term research showing groundwater depletion of many

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meters throughout the state and an average annual decrease in many areas. In addition, over 75% of Punjab's administrative blocks are categorized as overexploited, which indicates significant stress on groundwater resources.

Soil deterioration and environmental problems have been exacerbated by the imbalance in fertilizer usage and the overreliance on chemical inputs. According to studies, the groundwater depletion and resource stress in the state has been exacerbated by input-intensive agricultural methods and policy incentives (Chatterjee *et al.*, 2024) ^[4].

A comparable pattern is seen at the district level in areas like Rupnagar, Fatehgarh Sahib, and Sahibzada Ajit Singh Nagar (Mohali), where the cropping system is dominated by wheat and rice. Tube wells are a common source of irrigation, indicating significant groundwater use. Nevertheless, as a result of rising worries about water scarcity and sustainability, certain farmers are gradually switching to alternative crops like maize, pulses, and vegetables.

The wheat–paddy system, which is now the dominant system, has helped guarantee food security and farmer income stability, but it has also posed significant long-term sustainability challenges. To ensure sustainable agricultural development, it is necessary to evaluate cropping patterns, encourage diversification, and promote resource-efficient methods.

2. Literature Review

The wheat–paddy cropping system has become the dominant agricultural system in Punjab due to assured procurement, higher returns, and policy support. However, this system has led to serious sustainability concerns. A study by (Pandey, 2014) ^[8] reported that continuous cultivation of rice and wheat has resulted in excessive extraction of groundwater, leading to declining water table levels and increased cost of irrigation. The study emphasized the need for diversification towards less water-intensive crops to ensure long-term sustainability.

Groundwater depletion is one of the most critical issues associated with the wheat–paddy system. (Srivastava *et al.*, 2017) ^[9] found that intensive irrigation practices and free electricity for tube wells have accelerated groundwater depletion in Punjab. The study highlighted that continued dependence on groundwater may negatively impact farm income and agricultural productivity in the future.

In addition to water stress, soil health degradation has also emerged as a major concern. (Baweja, 2018) ^[10] reported that excessive use of chemical fertilizers and monocropping has led to nutrient imbalance and decline in soil fertility in Punjab. The study suggested the adoption of integrated nutrient management practices to restore soil health and improve sustainability.

Furthermore, (Amarasinghe *et al.*, 2010) ^[11] observed that the rice–wheat system has reduced crop diversification and increased environmental pressure in Punjab. The study pointed out that diversification towards alternative crops such as maize, pulses, and oilseeds is essential to reduce pressure on natural resources and improve farm resilience.

Objectives

Objectives of the Study

1. To examine the existing cropping pattern followed by farmers in selected villages of Punjab.
2. To assess the dominance of the wheat–paddy cropping system in the study area.
3. To analyze the extent of crop diversification among farmers.
4. To evaluate the sustainability concerns associated with the current cropping system.

3. Materials and Methods

The current study was carried out in a few Punjab villages, including Bajheri, Deh Kalan, Mehmoodpur, Mandlan, Karimpura, Kalaundi, Dugri, Kotli, Dhalon Majra, and Dumna. The districts of Sahibzada Ajit Singh Nagar (Mohali), Fatehgarh Sahib, and Rupnagar are home to these villages.

The study included 60 farmers chosen at random. Personal interviews utilizing a structured questionnaire were the method of gathering primary data. The survey covered topics such as cropping patterns, resource utilization, and the agronomic methods used by the farmers.

Basic statistical techniques like percentages and averages were used to organize, categorize, and analyze the collected data. For easier understanding and interpretation, the findings were presented in tabular form. (Kothari, 2004; FAO, 2017) ^[6, 7].

3.1 Cropping Pattern

3.1.1 Distribution of Major Crops

The dominance of the wheat–paddy cropping system in the research region is evident in the selected villages' cropping pattern, which is shown in Table 1. The majority of farmers depend on this two-crop system for their income, as evidenced by the fact that 81.7% of them produced wheat and 63.3% of them cultivated paddy. This cropping pattern has become widely adopted because of guaranteed procurement under the Minimum Support Price (MSP), the availability of high-yielding cultivars, and well-established growing methods.

3.1.2 Extent of Crop Diversification

Compared to other crops like maize and feed, cultivation was far less. Only 27.5% of farmers cultivated maize, while 44.2% grew fodder crops, primarily to sustain livestock production. The incorporation of crop–livestock systems in the area is indicated by the somewhat greater ratio of fodder crops. Nevertheless, vegetable farming was quite restricted (12.5%), suggesting little diversification toward lucrative crops.

3.1.3 Implications of Cropping Pattern

The study area showed a consistent reliance on the wheat–paddy system, as evidenced by the little diversity in crop patterns among villages. Farmers may be more susceptible to market changes, pest infestations, and climate unpredictability because of this lack of variety, which could endanger the long-term viability of agriculture.

Table 1: Cropping Pattern

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Wheat	84.6	80	80	80	80	83.3	83.3	83.3	80	75	81.7
2	Paddy	69.2	60	60	60	60	66.7	66.7	66.7	60	50	63.3
3	Maize	30.8	20	20	20	20	33.3	33.3	33.3	20	25	27.5
4	Fodder	46.2	40	40	40	40	50	50	50	40	50	44.2
5	Vegetables	15.4	20	0	20	0	16.7	16.7	16.7	20	0	12.5

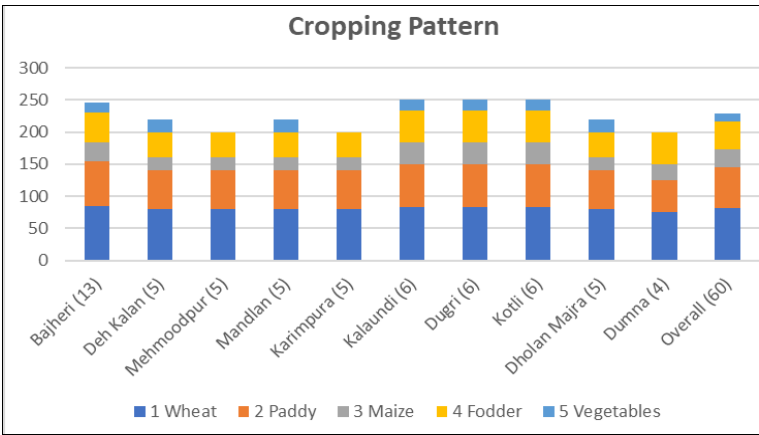


Fig 1: Cropping Pattern

3.2 Nutrient Management

3.2.1 Types of Nutrient Management Practices

Table 2 illustrates the nutrient management practices that farmers have implemented. The majority of farmers (81.7%) use a combination of organic and inorganic fertilizers, indicating that they are using an integrated approach. Farmers are only somewhat conscious of the need to mix nutritional inputs in order to sustain soil fertility, as seen by this.3.2.2 Imbalance in Fertilizer Use

A detailed analysis reveals that the use of organic fertilizers alone is very limited (5.0%), while 13.3 percent of farmers

depend exclusively on inorganic fertilizers. This indicates a continued reliance on chemical inputs for crop production.

3.2.2 Lack of Scientific Nutrient Management

A major deficiency in scientific agriculture is that none of the farmers were discovered to be using soil test-based nutrient management methods. The fact that soil testing is not done indicates that the use of fertilizer is mainly based on established methods and farmers' expertise rather than scientific advice. This frequently causes an uneven nutrient application, which eventually causes soil erosion and a decrease in production.

Table 2: Nutrient Management

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Madlan (5)	Karimpur (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Org+Inorg	84.6	80	80	80	80	83.3	83.3	83.3	80	75	81.7
2	Organic only	7.7	0	0	0	0	8.3	8.3	8.3	0	0	5
3	Inorganic only	7.7	20	20	20	20	8.3	8.3	8.3	20	25	13.3
4	Soil test	0	0	0	0	0	0	0	0	0	0	0

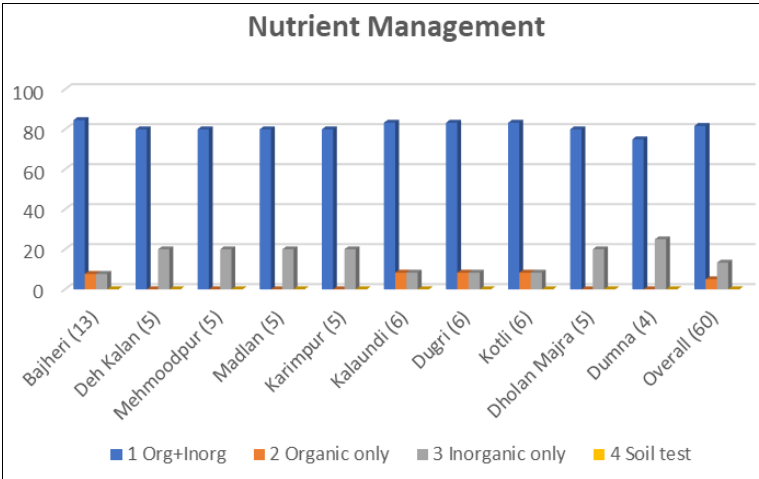


Fig 2: Nutrient Management

3.3 Weed Management Practices

3.3.1 Methods of Weed Control

Table 3's weed management practices demonstrate a significant reliance on chemical approaches for weed control. In order to control weeds in both wheat and paddy fields, a large percentage of farmers (83.3%) employed herbicides.

3.3.2 Role of Traditional and Mechanical Methods

With 55.0% of farmers using manual weeding, it's clear that conventional approaches are still being used. Reflecting the

restricted usage of mechanized weed control, only 27.5 percent of farmers employed mechanical techniques.

3.3.3 Sustainability Concerns

The excessive usage of herbicides raises concerns about environmental contamination, the emergence of herbicide resistance, and possible health risks. Integrated weed management methods must be promoted for sustainable agriculture.

Table 3: Weed Management

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Chemical	92.3	80	80	80	80	83.3	83.3	83.3	80	75	83.3
2	Manual	53.8	60	60	60	60	50	50	50	60	50	55
3	Mechanical	30.8	20	20	20	20	33.3	33.3	33.3	20	25	27.5

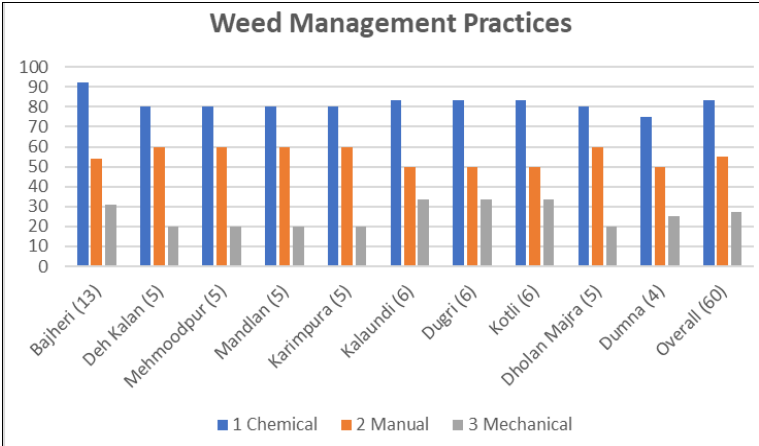


Fig 3: Weed Management Practices

3.4 Major Pests Observed

3.4.1 Prevalence of Major Pests

Table 4's data on the distribution of significant pests in the research region reveals that borers were the most common pests, impacting 63.3% of farmers. Plant hoppers made up 26.7% of the observed insects, while aphids made up 45.0%.

3.4.2 Causes of Pest Incidence

The continuous cultivation of wheat and paddy, which fosters

the accumulation of these pests, is directly related to their presence. This issue is made worse by the absence of crop diversity.

3.4.3 Pest Management Implications

Farmers primarily relied on chemical pesticides, which increases the cost of cultivation and environmental risks. Adoption of integrated pest management practices is necessary to ensure sustainable crop protection.

Table 4: Major Pests

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Borers	69.2	60	60	60	60	66.7	66.7	66.7	60	50	63.3
2	Aphids	46.2	40	40	40	40	50	50	50	40	50	45
3	Hoppers	23.1	20	20	20	20	33.3	33.3	33.3	20	25	26.7

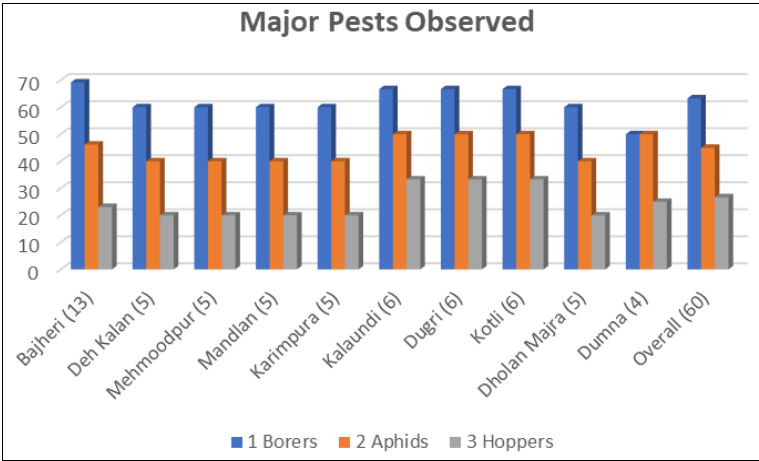


Fig 4: Major Pests Observed

3.5 Source of Irrigation

3.5.1 Distribution of Irrigation Sources

The data in Table 6 clearly shows that tube wells are the main source of irrigation in the research region. The great bulk of farmers (98.3%) depended on tube well irrigation, while just

1.7% of farmers used canal water for irrigation.

3.5.2 Dependence on Groundwater

According to the data collected from villages, the majority of farmers rely only on groundwater through tube wells. The

paucity of surface irrigation sources like canals in the research region is demonstrated by this. Because tube wells are dependable, accessible, and allow farmers to manage irrigation schedules, they are more popular.

3.5.3 Sustainability Implications

Overreliance on groundwater for irrigation poses a significant

risk to long-term sustainability. Constant groundwater extraction without sufficient replenishment might result in aquifer depletion, higher irrigation expenses, and a decrease in future water supplies. As a result, alternative irrigation sources and water-saving technologies must be encouraged.

Table 5: Source of Irrigation

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Tube well	92.3	100	100	100	100	100	100	100	100	100	98.3
2	Canal	7.7	0	0	0	0	0	0	0	0	0	1.7

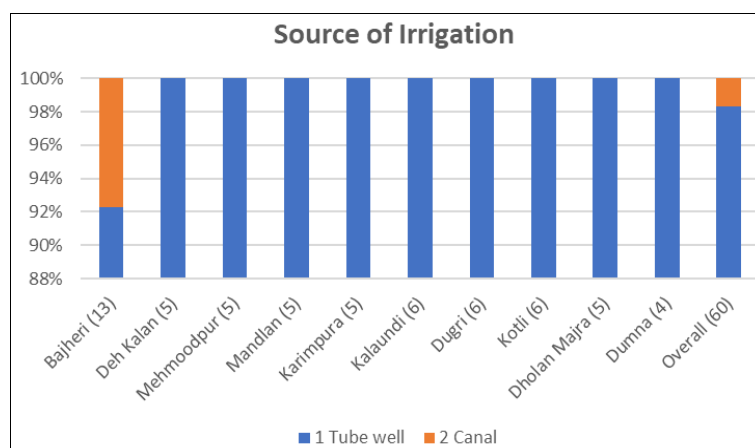


Fig 5: Source of Irrigation

3.6 Source of Seed

3.6.1 Types of Seed Used

According to the information in Table 7, the great majority of farmers (80%) utilized certified seeds for growing crops, while 20% of farmers used their own stored seeds.

3.6.2 Adoption of Improved Varieties

A high degree of acceptance of better crop types among farmers is indicated by the increased use of licensed seeds. Certified seeds provide enhanced germination, increased yield potential,

and resistance to pests and diseases, all of which help to enhance crop productivity.

3.6.3 Constraints in Seed Adoption

Despite the higher adoption rate, a section of farmers still depends on their own seeds, which may be due to factors such as cost considerations, lack of awareness, or traditional practices. The use of non-certified seeds may affect crop yield and uniformity.

Table 6: Source of Seed

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Certified Seed	76.9	80	80	80	80	83.3	83.3	83.3	80	75	80
2	Own Seed	23.1	20	20	20	20	16.7	16.7	16.7	20	25	20

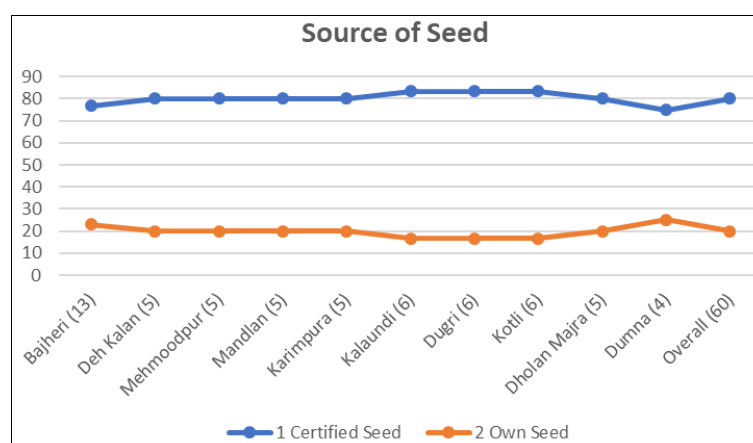


Fig 6: Source of Seed

3.7 Farm Machinery Ownership

3.7.1 Level of Mechanization

The data presented in Table 8 shows that a considerable proportion of farmers have adopted farm mechanization. About 62.0 percent of farmers owned tractors, while 45.0 percent owned seed drills.

3.7.2 Use of Harvesting Machinery

A large majority of farmers (81.7%) reported the use of combine harvesters, either through ownership or hiring services. This

indicates a high level of mechanization in harvesting operations across the study area.

3.7.3 Implications of Mechanization

The adoption of farm machinery has helped in reducing labor dependency, improving operational efficiency, and ensuring timely agricultural operations. However, small and marginal farmers may face constraints in owning machinery due to high costs, leading to dependence on custom hiring services.

Table 7: Machinery Ownership

Sr No	Item	Bajheri (13)	Deh Kalan (5)	Mehmoodpur (5)	Mandlan (5)	Karimpura (5)	Kalaundi (6)	Dugri (6)	Kotli (6)	Dholan Majra (5)	Dumna (4)	Overall (60)
1	Tractor	61.5	60	60	60	60	66.7	66.7	66.7	60	50	62
2	Seed Drill	46.2	40	40	40	40	50	50	50	40	50	45
3	Combine Harvester	84.6	80	80	80	80	83.3	83.3	83.3	80	75	81.7

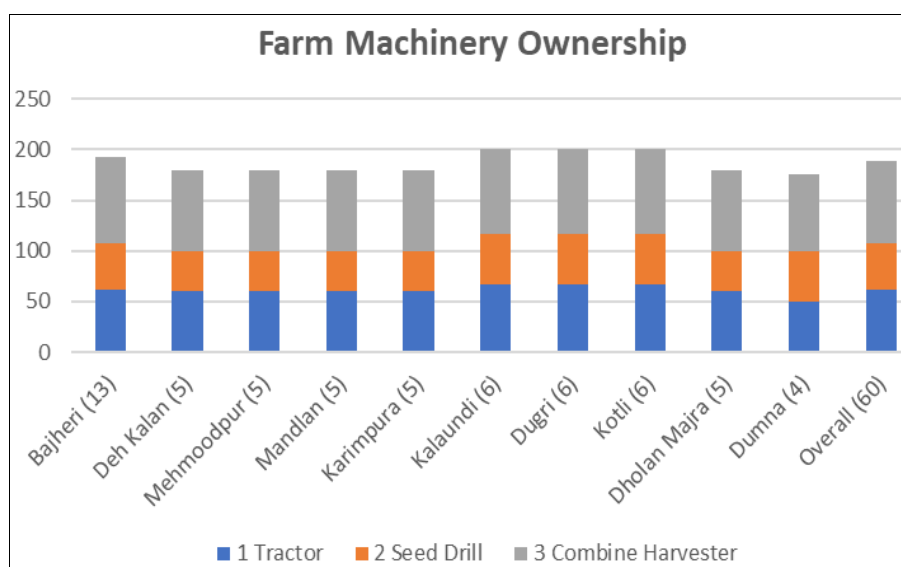


Fig 7: Farm Machinery Ownership

3.8 Yield of Major Crops

3.8.1 Yield Distribution of Wheat

The wheat yield performance shows that the majority of farmers (61.7%) produced yields between 15 and 20 quintals per acre, while 38.3% of farmers attained higher yields, exceeding 20 quintals per acre.

3.8.2 Yield Distribution of Paddy

With 47.5% of farmers reporting yields over 25 quintals per

acre, paddy yields were somewhat higher. Furthermore, 34.2% of farmers harvested between 21 and 25 quintals per acre.

3.8.3 Sustainability of Yield Levels

Intensive use of inputs like fertilizers, irrigation, and pesticides can account for the higher yields. However, these behaviors raise worries about long-term sustainability because they cause environmental damage and resource depletion.

Table 8: Yield of Major Crops

Crop	Range	Bajheri	Deh Kalan	Mehmoodpur	Mandlan	Karimpura	Kalaundi	Dugri	Kotli	Dholan Majra	Dumna	Overall
Wheat	15-20	61.5	60	60	60	60	66.7	66.7	66.7	60	50	61.7
Wheat	21-25	23.1	20	20	20	20	16.7	16.7	16.7	20	25	20
Wheat	>25	15.4	20	20	20	20	16.7	16.7	16.7	20	25	18.3
Paddy	15-20	15.4	20	20	20	20	16.7	16.7	16.7	20	25	18.3
Paddy	21-25	30.8	40	40	40	40	33.3	33.3	33.3	40	25	34.2
Paddy	>25	53.8	40	40	40	40	50	50	50	40	50	47.5

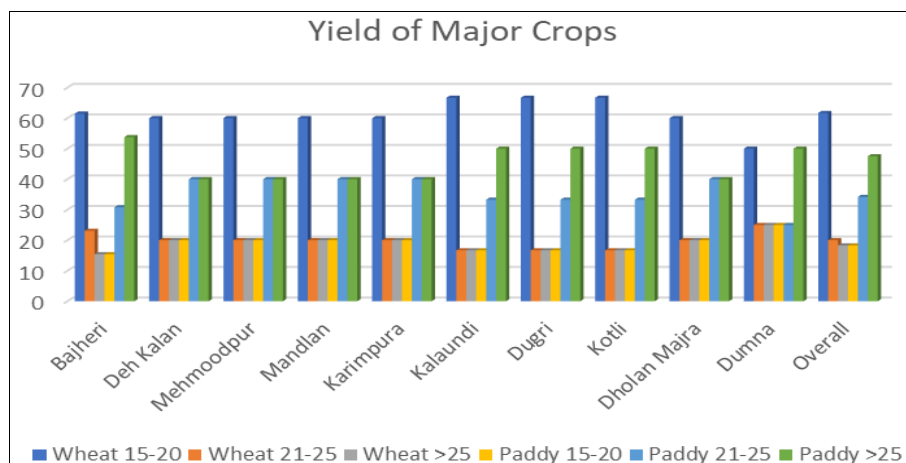


Fig 8: Yield of Major Crops

4. Conclusion

The current study emphasizes that the wheat–paddy cropping system is the most prevalent farming practice in the sampled towns of Punjab. Because of its guaranteed returns, well-established procedures, and access to market support, a large number of farmers rely on this system. Nevertheless, the research demonstrates conclusively that this dominance has resulted in a number of environmental issues.

Significant problems seen in the study region include an overreliance on groundwater for irrigation, an unbalanced usage of chemical fertilizers, and a strong reliance on chemical methods for controlling weeds and pests. These problems are also made worse by the lack of crop diversity, which increases the farm system's susceptibility to environmental and economic dangers.

Despite farmers' adoption of contemporary agricultural technology and achievement of adequate yield levels, the system's long-term sustainability is still a worry. It is thus imperative to encourage balanced nutrient management, diverse cropping systems, and the productive use of water resources. Raising farmers' understanding of sustainable agricultural methods and boosting extension services may significantly contribute to enhancing the general resilience and productivity of the agricultural sector in the area.

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