

Examining the Possibility of Agriculture Diversification amidst the Groundwater Crisis in Punjab

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The study examines the cropping pattern in Punjab's agriculture using secondary data sources from different periods. The results revealed that, following the adoption of new agricultural technology in the 1960s, the cropping pattern in Punjab underwent significant changes, leading to the emergence of a paddy-wheat monoculture cropping system. However, this static cropping pattern had severe implications for the state's agroecology, resulting in excessive pressure on the state's natural resources, especially underground water resources. This highlights the need for policy interventions to diversify cropping patterns, potentially replacing the area under paddy with alternative crops to promote sustainable agriculture. The study examines the significance of the horticulture sector as a diversification option in the state of Punjab.

1. Introduction

Punjab, a pioneer in the Green Revolution, has earned the reputation as India's food bowl. To achieve food security in the country around the 1950s and 1960s, the introduction of new farm technology, popularly known as the Green Revolution, ushered in a wave of adoption of new farming methods and technologies in the state, leading to a groundbreaking increase in the production and yield of food grains. However, the increase was largely limited to wheat and paddy crops, which gained immense importance after the 1970s, especially paddy cultivation. Paddy,

which received negligible importance in the pre-green revolution era, became one of the most significant cash crops since the 1970s. Only in the short span from 1966 to 74, rice production grew at an exceptional rate of 18 per cent (Murgai, 2008). The dominance of these two crops has made Punjab a significant contributor to the centre's food security pool over the last several decades. In 2021-22, Punjab contributed around 20 per cent to the central pool of rice managed by the FCI and around 53 per cent of wheat in 2022.

Though this cropping pattern was instrumental in achieving food security in the country, it has resulted in several long-term challenges for the state. In just two decades of adopting new agricultural technology, its positive impact began to fade, and it gave way to what is popularly known as agrarian distress. After the 1980s, both agricultural production and yields began to stagnate. Over the coming years, the rising cost of production due to expensive and market-oriented seeds, fertilisers, chemicals, and machinery has placed farmers, especially small and marginal ones, at the mercy of market forces (Singh et al., 2012). The stagnation and fall in incomes of the farming community, along with the increased cost of cultivation, have led to an increased debt burden and, thus, growing suicides among farmers (Gill, 2005)

Not only that, it has also led to severe environmental challenges in the state, particularly groundwater depletion. The paddy cultivation, which requires high amounts of water for irrigation purposes, has resulted in the unsustainable extraction of groundwater, far exceeding the natural recharge rate in the state. Thus, the role and need for irrigation water gained significant importance with the adoption of high-yielding varieties of paddy and wheat, which require extensive irrigation. However, in the post-green revolution era, in the decades following the 1960s, groundwater became the primary source of irrigation, especially in the central and north-western regions of the state, where it meets more than 92 per cent of irrigation demand (GoP, 2018). In 1970-71, the share of irrigation by the canal was around 44.53 per cent, which declined to 21 per cent in 2022-23. However, out of the total cropped area of 7,826 thousand hectares, nearly 7,879 thousand hectares were under irrigation, constituting 99.8 per cent of the gross cropped area; however, greater reliance was placed on underground water. This has led to a dramatic fall in the water table, with more than 76 per cent of blocks categorised as over-exploited (Dynamic Groundwater Resource Assessment report, 2023). The current groundwater exploitation stage, which indicates

groundwater utilisation relative to its recharge rate, was 163.76 per cent in 2022-23, indicating a high level of groundwater depletion.

Thus, to address the problem of a falling water table and environmental degradation, there is a need to devise a strategy to diversify the cropping pattern away from these crops towards alternative crops that are less water-intensive and of higher value. The horticulture sector can act as an effective and promising alternative to this diversification strategy. India is currently the world's second-largest producer of fruits and vegetables; this sector is increasingly recognised as a sunrise sector in the country. Horticulture crops have greater productivity than food grains, and thus have huge potential to increase farm income, generate employment opportunities, and enhance export potential (Singh et al., 2022; Tiwari et al., 2021).

Punjab has great potential for growing fruits, vegetables, flowers, and other high-value horticultural commodities due to its ideal climate, rich soil, and well-established irrigation system. By reducing the state's dependency on water-intensive crops, such as paddy, the cultivation of horticultural crops can help address the pressing problem of groundwater depletion.

2. Methodology

The study primarily relies on secondary data. The data were largely compiled from various issues of the Statistical Abstracts of Punjab, Agriculture Statistics at a Glance, several Central Ground Water Board (CGWB) reports, and numerous published and unpublished sources.

3. Results and Discussion

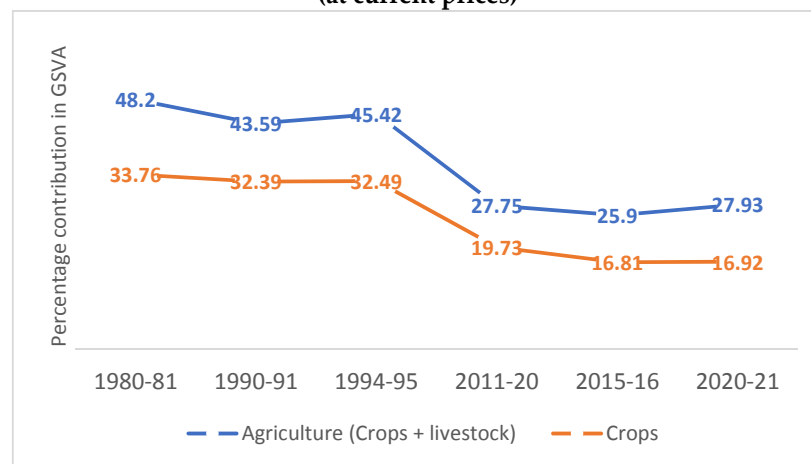
3.1 Overall trends in the agriculture sector of Punjab

3.1.1 Agriculture sector contribution to GVA

The contribution of agriculture to Gross State Value Added (GVA) in Punjab has been continuously declining over the period. It was 48.2 per cent in 1980-81, which declined to 45.43 per cent in 1994-95 and further decreased to 27.93 per cent in 2020-21. This highlights the structural changes in Punjab's economy, where the relative share of other sectors has increased significantly (Gill, 2005). However, it also highlights the diminishing role of agriculture in Punjab, despite its foundation as an agrarian economy, underscoring the low value generated in the sector

despite the highly input-intensive farming practices. The percentage contribution of agriculture to total net state income at constant (2011-12) prices has also declined from 20.96% in 2011-12 to 15.30% in 2020-21.

Figure 1
Share of the agriculture sector in gross state value added
(at current prices)

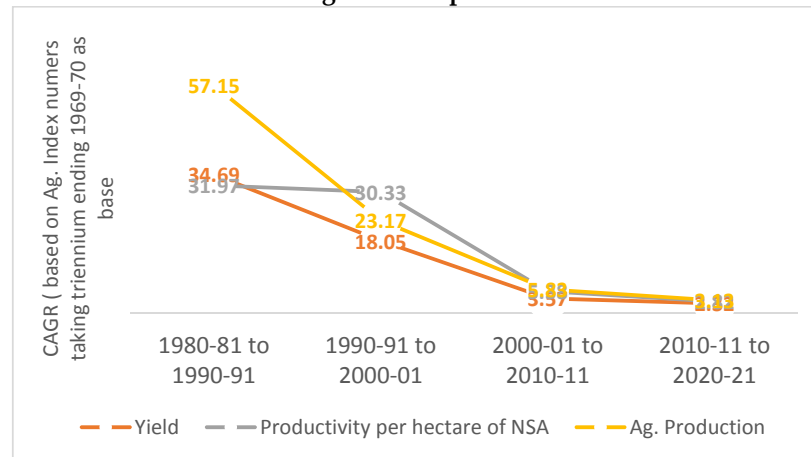


Source: Statistical Abstract of Punjab, various issues.

3.1.2 Growth rate of yield, productivity per hectare and agricultural production

The green revolution, which enabled the state to make great strides in production and productivity in the initial years, however, lost its charm in subsequent decades, especially after the 1980s, as the initial increase in yield and production was not sustainable and after the 1980's there was a steep decline, especially in agricultural production and yield (Mann, 2017). Though there was an increase in yield in absolute numbers, the compound annual growth rate declined from 34.69 per cent in 1980-90 to 18.05 per cent in 1990-2000, declining further to a meagre 2.32 per cent in the decade of 2010-2020. The decline in agricultural production was much faster, from a growth rate of as high as 57.15 per cent in 1990-2000 to just 3.33 per cent in 2010-20. However, in the case of productivity per hectare of NSA, the value became fairly constant starting from the 1980s and then declined.

Figure 2
Growth rate of yield, productivity per hectare,
and agricultural production

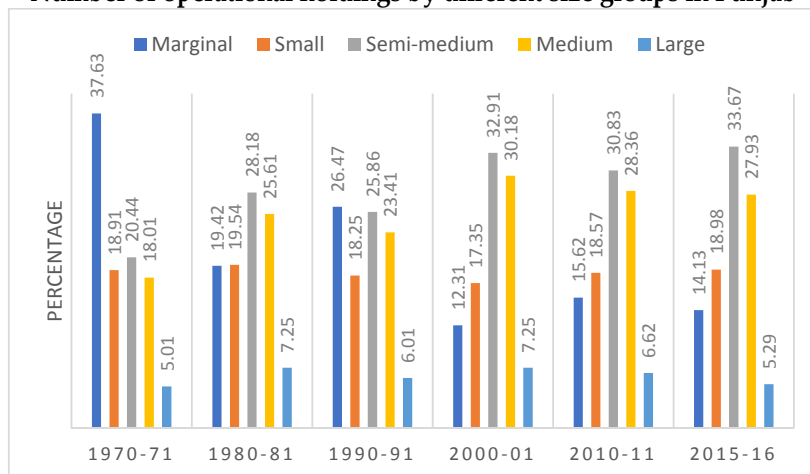


Source: Author calculation based on data from various issues of the Statistical Abstract of Punjab.

3.1.3 Number of operational holdings by different size groups in Punjab

It is not merely enough to examine the agricultural sector's contribution to the state's GDP; rather, analysing the division of land among various categories is equally important to understand the composition of farms and cropping patterns. Since 1970-71, the share of marginal landholders (>1 ha) has significantly declined from 37.63 per cent to 14.13 per cent, which depicts that the marginal farmers were unable to bear the increased cost of cultivation ushered in due to the adoption of this new technology in terms of HYV seeds, fertilisers, chemicals, etc. The proportion of small and large farmers has remained almost similar to the 1970s level. In contrast, the percentage of semi-medium and medium farmers has increased by approximately 13% and 10%, respectively. This suggests that the gains earned by the Green Revolution have not been equitably distributed, with marginal and small farmers bearing the major brunt. They also highlight that marginal farmers cannot keep up with the necessity of adopting modern technology and other expensive inputs, given the increasing pressure on land for higher output per unit area, and are rapidly becoming unviable (Sidhu, 2005).

Figure 3
Number of operational holdings by different size groups in Punjab



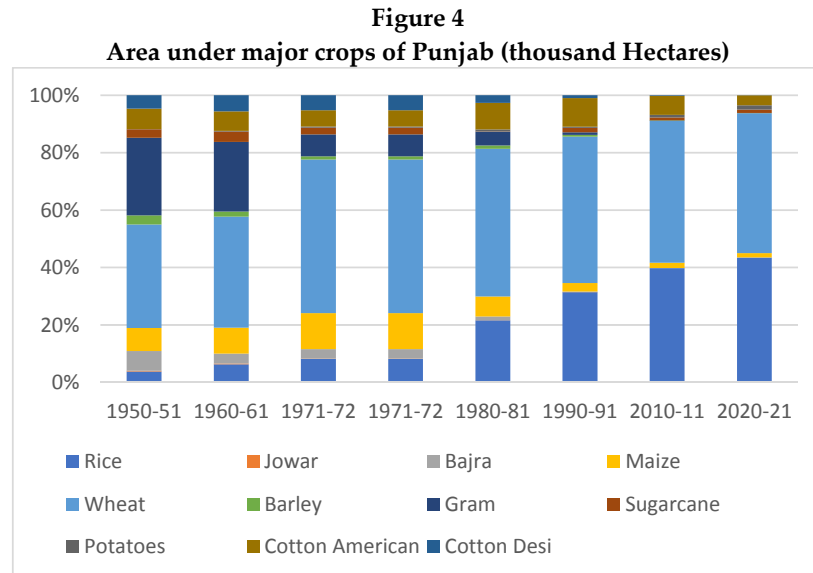
Source: Statistical Abstract of Punjab, Various Issues.

3.2 Cropping Pattern over the years

Since the 1960s, following the adoption of new farming technologies and methods, significant changes have been observed in Punjab in terms of crop area, production, yield, and cropping patterns (Dhindsa & Sharma, 1995).

3.2.1 Area under major crops

Before the Green Revolution, the cropping pattern in Punjab was fairly diversified, with crops such as maize, bajra, and cotton occupying significant areas. In 1950-60, cereals and pulses accounted for 45.95 per cent and 19.08 per cent of the total cropped area, respectively. However, in 2020-21, wheat and paddy constituted as high as 85.29 per cent of the total cropped area. Over the years, Punjab agriculture has developed a monocropping characteristic. Therefore, the post-green revolution era has seen a decline in crop diversity, with the majority of farmers in the state preferring to cultivate paddy and wheat. In contrast, during the pre-green revolution period, farmers followed different cropping patterns, such as maize-wheat or sugarcane-maize-wheat patterns (Sangha, 2014).



Source: Statistical Abstract of Punjab, various issues.

The paddy crop, which was limited to just 11 per cent of the net sown area (NSA) during the 1971–72 kharif season, expanded to 76.3 per cent of NSA by 2020–21, marking a massive jump of more than six times over 50 years, illustrating the severity of the crop rotation between paddy and wheat. This increasing trend in the area under paddy had a severe, detrimental effect on other traditional crops sown in the state during the kharif season. Similarly, wheat, which accounted for 57.3 per cent of NSA in 1971–72, likewise replaced other rabi season crops over the following five decades, reaching 85.4 per cent of NSA in 2020–21. Paddy-wheat monoculture, which accounted for less than 50 per cent of GCA overall in the 1970s, surpassed the 50 per cent GCA threshold in the 1980s and continued on an upward trend, with the most recent relative share reaching 85.29 per cent in 2020–21.

Table 1
Share of rice and wheat as net sown area and gross cultivated area

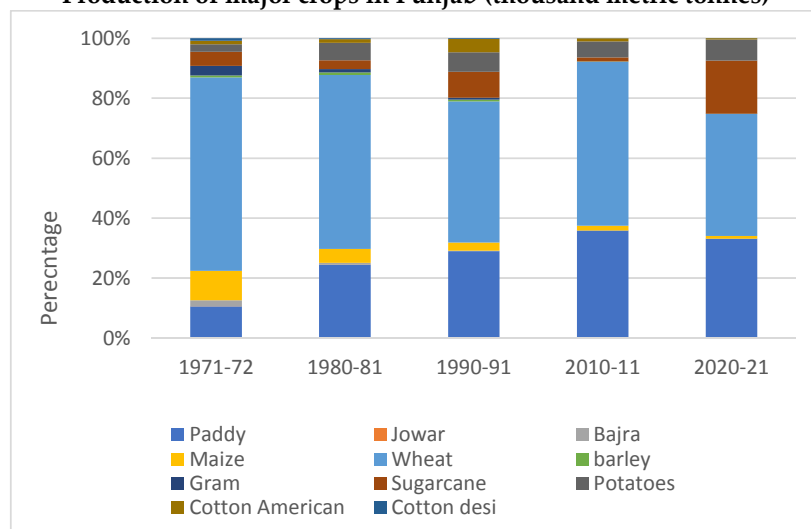
Year	Paddy area as a percentage of NSA	Wheat area as a percentage of NSA	Area under wheat and rice as a percentage of GCA
1971-72	11.0	57.3	48.7
1975-76	13.6	58.7	48.1
1980-81	28.2	67.1	59.1
1985-86	40.8	74.1	67.4
1990-91	47.8	77.6	70.5
1995-96	52.8	77.9	70.1
2000-01	61.5	80.2	75.8
2005-06	63.5	83.1	77.7
2010-11	68.0	84.4	80.4
2015-16	71.8	84.6	82.3
2020-21	76.30	85.4	85.29

Source: The author's calculation is based on data from various issues of the Statistical Abstract of Punjab.

3.2.2 Production of Major Crops

There has been a tremendous jump in the output of both paddy and wheat since the 1970s. The CAGR of growth in paddy output between 1970-71 and 2020-21 was 46.66 per cent, whereas for wheat it was 18.15 per cent. The greater output can be attributed to both an increase in yield due to the use of better variety seeds, advanced technology, and increased use of chemicals, as well as the expansion of the area under cultivation of these crops, as depicted by a vast amount of existing literature (Mann, 2017; Singh et al., 2021). However, the increase in output for wheat was mainly due to the yield effect, whereas in the case of paddy, it was due to both the yield and area effects (Singh et al., 2021).

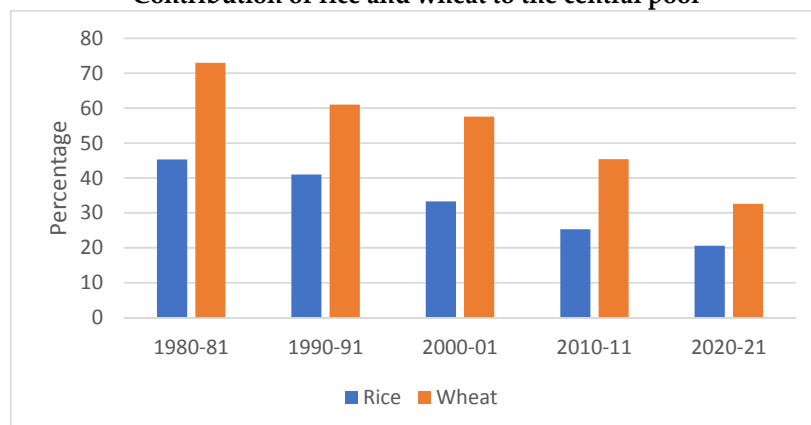
Figure 5
Production of major crops in Punjab (thousand metric tonnes)



Source: Statistical Abstract of Punjab, various issues.

With the rise in output of rice and wheat, Punjab became a significant contributor to the nation's food security. The contribution of wheat to central pool has increased in absolute numbers, from 25.2 lakh tonnes in 1980-81 to 135.89 lakh tonnes in 2020-21 for rice and from 42.8 lakh tonnes to 127.14 lakh tonnes for wheat, however, the percentage contribution has declined (45.3 to 20.62 for rice and 73 to 32.61 for wheat) due to greater contribution by other states (Kaur & Kaur, 2012).

Figure 6
Contribution of rice and wheat to the central pool

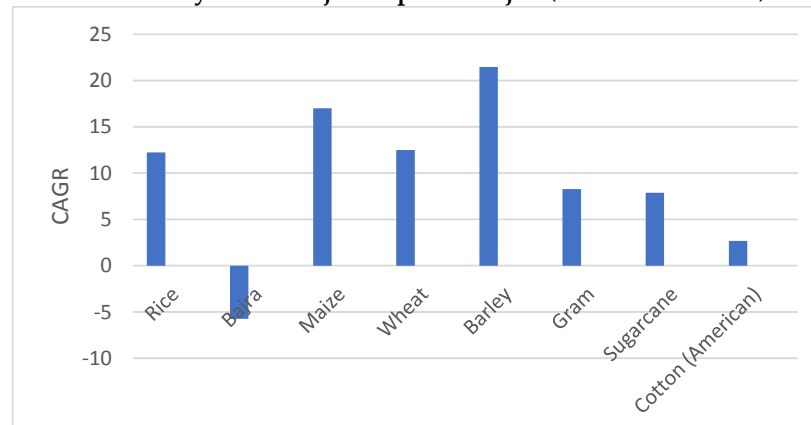


Source: Statistical Abstract of Punjab, various issues.

3.2.3 Yield of major crops

Comparing the annual average growth rate of yield of major crops for the period 1971-72 to 2020-21, the yield of barley saw the greatest increase, with a staggering growth of 21.47 percent, representing a threefold increase from its yield in 1971-72. The rate of growth in the yield of maize around 17percent was also quite high, followed by rice and wheat. (Mann, 2017). The yield of rice was 1765 Kg/ha in 1971-72, which increased to 4443 kg/ha in 2020-21, which was approximately 2.5 times. The yield of wheat, which was 2406 Kg/ha in 1971-72, reached 4868 Kg/ha in 2020-21, becoming almost double. The significant increase in yield of these crops can be attributed to the new technology and methods of production. Though the yield growth rate of other crops like sugarcane, barley, and maize has also increased tremendously, the area and production of these crops have not increased in the same proportion.

Figure 7
Growth in yield of major crops in Punjab (1971-72 to 2020-21)



Source: Author's own calculation on the basis of data from various issues of the Statistical Abstract of Punjab.

Even though there has been an increase in yields of other crops during this time period, the cropping pattern shifted in favour of paddy-wheat cultivation only as the share of both in GCA grew tremendously. This can mainly be attributed to the state policies over this period, which favoured the cultivation of these crops. The policies of both the central and state governments, which included assured procurement through minimum support prices, subsidised inputs such as fertilisers, chemicals, and especially power subsidies, significantly favoured the cultivation of these crops (Chhatre et al., 2016; Kumar & Kaur, 2022).

Looking at the effective minimum support price (MSP) policy and assured procurement regulations of the state, it is seen that the procurement rate of Paddy, which was just 48.9 per cent in 1970-71, has reached to 92.4 per cent in 2021-22. A similar case was observed with wheat procurement, where the procurement-to-production ratio was around 90 per cent in 2021-22. For farmers, as compared to other crops, growing these crops is the safest and most lucrative production model due to the guaranteed purchase and support price (Chhatre et al., 2016).

Table 2
Procurement of paddy and wheat as a percentage of production

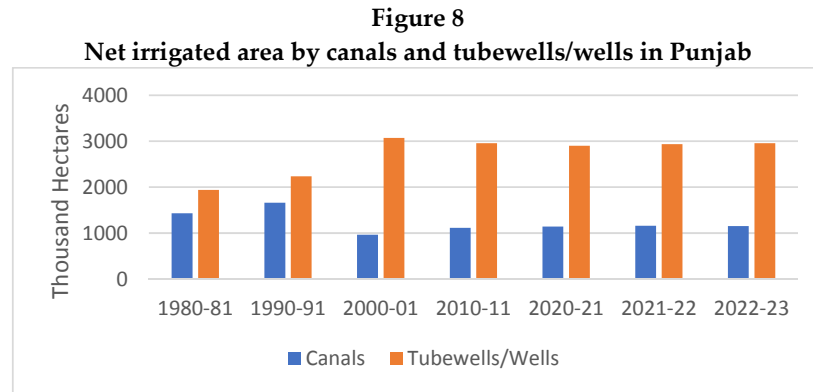
Year	Procurement as per cent of Production	
	Paddy	Wheat
1970-71	48.9	48.8
1980-81	91.4	55.6
1990-91	80.5	62.4
2000-01	80.5	62.4
2010-11	81.3	62.4
2020-21	97.6	74.3
2021-22	92.4	88.9

Source: Statistical Abstract of Punjab, various issues.

Not only that, although there has been increase in the minimum support price for many other crops like cotton, gram, arhar (tur), moong, mustard, sunflower, and ground- nut which was even higher than the increase in the MSP of wheat and paddy for the same period but the area under these crops have increased scarcely, and the farmers have meagre interest in cultivating these crops. This is mostly because of their lower yield levels and the absence of marketing of these crops (Mann, 2017).

3.2.4 Irrigation

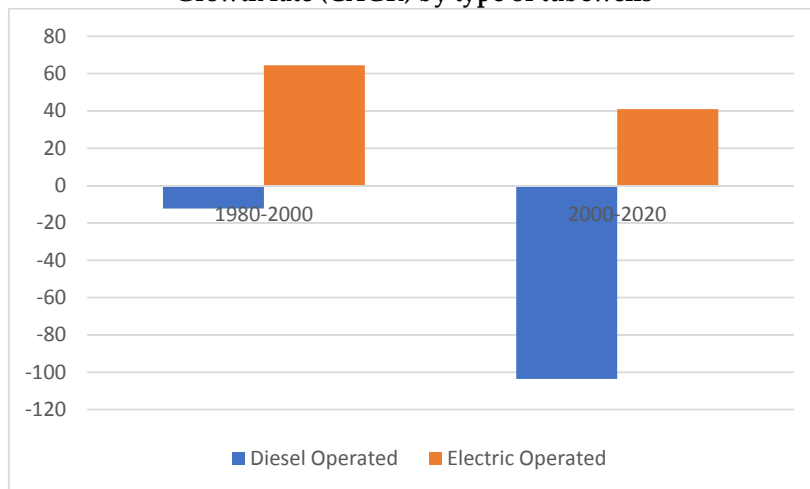
The hybrid varieties of these highly water-intensive crops required assured availability of irrigation water. The recommended water requirement for paddy is quite high, around 165 hectare meters, with 22 irrigations, which is four times higher than that of wheat (Kaur & Kaur, 2012). Therefore, the increase in the area under these crops since the 1970s was made possible only because of the expansion of irrigation areas. In 2020-21, out of the total cropped area of 7,826 thousand hectares, nearly 7,879 thousand hectares were under irrigation, which constituted 99.8% of the gross cropped area. However, examining the source of irrigation reveals that there have been significant changes in the source of irrigation over time.



Source: Statistical Abstract of Punjab (various issues)

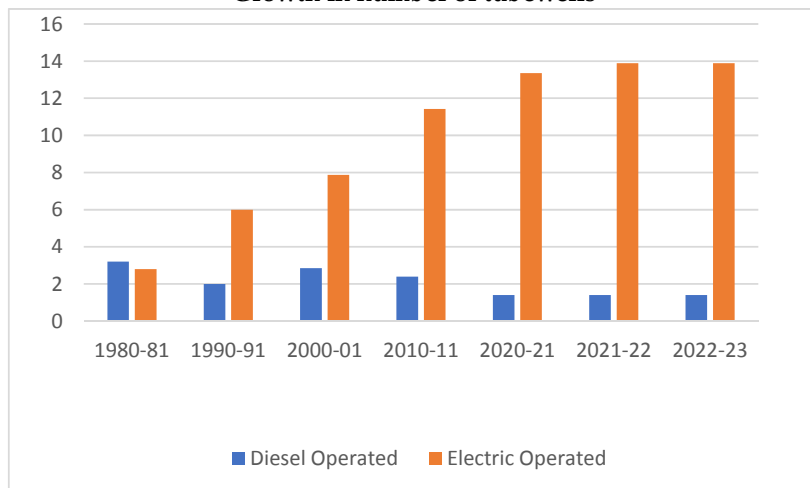
In Punjab, groundwater from tube wells and surface water from canals have been the most common sources of irrigation. However, in the years following the Green Revolution and policy changes aimed at boosting Punjab's output and productivity, greater emphasis was placed on tubewell irrigation rather than canal irrigation (Bhardwaj & Dutta, 2024). The irrigated area under canals in the state has declined from 14.30 lakh ha in 1980-81 to 11.53 lakh ha in 2022-23. The decline in surface water availability and poor maintenance of the canal system have contributed to this trend in the state, with the central region of Punjab being particularly affected in terms of depleting water resources (Kaur, 2015). On the other hand, the area under irrigation has increased tremendously from 19.39 lakh ha in 1980-81 to 29.55 lakh ha in 2022-23. However, the greater reliance on tubewells and, consequently, underground water for cultivating these water-intensive crops has led to the immense depletion of groundwater.

Figure 9
Growth rate (CAGR) by type of tubewells



Source: Statistical Abstract of Punjab, various issues.

Figure 10
Growth in number of tubewells



Source: Statistical Abstract of Punjab, various issues.

The figures above indicate a significant increase in electrically operated tubewells, whereas diesel-operated tubewells have experienced

a decline over time. The highest CAGR for electric tubewells was registered from 1980 to 2000, at around 64.46 per cent, whereas the highest decline in diesel-operated tubewells was registered in the period from 2000 to 2020, at as high as 103.54 per cent. This is mainly due to state policies of subsidised, later free, power to agriculture, which makes electrically operated tubewells cheaper than diesel-operated ones.

3.2.5 Power Subsidy

Over the considered time period, the power supply to the farm sector has either been subsidised or provided free of charge, which has been a point of contention among various experts. With the increased cultivation of water-intensive crops, such as paddy, and the rising demand for irrigation water, the subsidy in the form of free power has improved the affordability of farmers, making the extensive use of electric tube wells possible for irrigation. This ensures a timely water supply without worrying about high electricity bills. However, this has also been readily blamed for causing an immense decline in the water table due to increased irrigation hours and a steep rise in the number of tubewells without any cost to farmers, but a high cost to society. This has resulted in a power subsidy of 14,717 per sown hectare in 2019–20, up from 2,129 in 1996–97, indicating an annual growth rate of about 9.5 per cent year over year (Singh et al., 2021). This has led to an immense burden on the state, with the debt-to-GSDP ratio reaching 49.3 per cent in 2021-22.

3.3 Groundwater Status in Punjab

From the above discussion, it is clear that the dominance of the paddy-wheat cultivation system, which promoted food self-sufficiency in India, is one of the primary reasons for Punjab's growing agricultural water problems and increased groundwater exploitation. Punjab is currently the largest extractor of groundwater in the country, and 97 per cent of it is used for irrigation, with paddy cultivation accounting for a major share (Ground Water Estimation report, 2020). Not only has there been excessive use of pesticides and chemicals for farming, which has led to a significant decline in water quality (Kaur & Kaur, 2017).

The state is experiencing a severe water crisis due to existing agricultural practices that over-rely on groundwater (Bhogal & Vatta, 2021). The following table shows the stage of Groundwater extraction in Punjab, which depicts the rate of water extraction relative to the recharge

rate over the years, reaching an alarming rate of 163.76 per cent in 2023. This is also the highest among all the states of India.

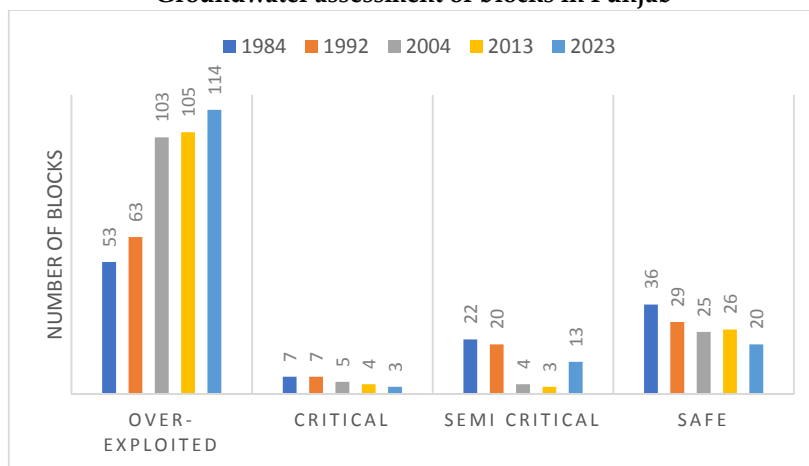
Table 3
Stage of groundwater extraction in Punjab over the years

Year	2004	2011	2013	2017	2020	2022	2023	Percentage Change (per cent) 2004-2023
Stage of Water Extraction	145	172	149	166	164.42	165.99	163.76	12.93

Source: Central Ground Water Board, India, various reports

Of the total 150 blocks in Punjab, the groundwater resource is overexploited in 111 blocks, critical in 3 blocks, and semi-critical in 13 blocks, thus indicating an alarming groundwater situation. There has been a continuous decline in the number of safe blocks over the years. Therefore, highlighting the immediate need to address this situation.

Figure 11
Groundwater assessment of blocks in Punjab



Source: Central Ground Water Board (India), various reports.

3.4 Crop Diversification:

Crop diversification has been viewed as a promising remedy to the water crisis in Punjab, which aims to replace water-guzzling paddy, now grown on more than 76 per cent of the net sown area, with less water-intensive crops (Rani & Sahoo, 2023). Several studies have shown that diversification in cropping patterns offers several advantages, including the efficient use of water and, thus, the preservation of groundwater, improvement of soil health through the production of nitrogen-fixing crops, increased yields, resource efficiency, ecological benefits, and greater employment opportunities. (Weinberger and Lumpkin, 2006).

Diversification has attained various meanings over time. Typically, it is understood in terms of a shift of resources from the farm to the non-farm sector, or the utilisation of resources in a diverse mix of activities within the agricultural sector, and a shift in resources to high-value-added crops from less lucrative traditional crops (Joshi et al., 2004). The horticulture sector, being an emerging sector, can act as a viable alternative for crop diversification in Punjab. These crops are known to have greater productivity than food grains, and thus have huge potential to increase farm income, generate employment opportunities, and enhance export potential (Singh et al., 2022; Tiwari et al., 2021). Moreover, in recent years, increasing wages, growing health consciousness, and shifting consumption habits have created a demand for fruits and vegetables, thereby providing a market and potential areas for diversification to the farming community in Punjab.

3.4.1 Area and Production of various horticulture crops in Punjab

In 2022-23, a total of 477.01 thousand hectares of area was cultivated by various horticulture crops. Among the horticulture crops, the highest area (66 per cent/316580 ha) was devoted to the cultivation of vegetables, followed by fruits (23 per cent/109880 ha) and spices (7 per cent/34860 ha). The remaining share was under other crops, which constituted 4 per cent. In terms of production, the total production was approximately 9,092 thousand metric tons, with vegetables contributing the major share of 6,509 thousand metric tons, followed by fruits at around 2,412 thousand metric tons.

Table 4
Production and area under horticulture crops in Punjab (2023)

Crops	Fruits	Vegetables	Aromatics & Medicinal	Flowers	Spices	Honey	Total
Production (Th MT)	2412.26 (26.53)	6509 (71.58)	3.02 (0.03)	14.45 (0.15)	133.42 (1.46)	20 (0.21)	9092.15 (100)
Area (Th Ha)	109.88 (23.03)	316 (66.24)	13.37 (2.81)	2.32 (0.48)	34.86 (7.31)	-	477.01 (100)

Source: Agriculture Statistics at a Glance, 2023.

The area under vegetables has increased consistently from 54.614 Th. Ha in 1990-91 to 86.798 Th. Ha in 2021-22. The average annual growth rate for overall vegetables was 9.73% from 1990-91 to 2021-22. Among vegetables, the largest area was under potatoes, which grew at an annual rate of 13.5% during the year. In the case of potatoes, Punjab contributed 5 per cent of the national output in 2022-23. The area under onions and summer vegetables saw a decline over this period.

In the case of fruits, the area under cultivation also increased, with a CAGR of 18.34 per cent. The areas under Kinnow, Guava, and Lithchi grew at an annual rate of more than 30 percent.

Table 5
Area under different vegetables in Punjab (in Ha)

Year	Potato	Onion	Other vegetables		Total vegetables
			Winter	Summer	
1990-91	23107	646	14412	16354	54612
2000-01	99602	1973	24837	23893	110316
2010-11	64397	1522	20561	16413	102893
2020-21	70282	951	18852	32969	110512
2021-22	51860	402	18242	15408	86798
Percentage Change (1990-91 to 2021-22)	124.43	-37.77	26.57	-5.78	58.93
CAGR	13.520	-15.45	1.97	2.04	9.72

Source: Statistical abstract, various issues.

Table 6
Area under different fruits in Punjab (in Ha)

Year	<u>Kinnow</u>	Orange & Malta	Mangoes	Litchi	Guava	Pear	Peach	Grapes	Total Fruits (in Ha)
1990-91	21718	10987	11581	1386	4015	7427	3137	2187	68835
2000-01	11434	3317	5608	1146	4358	2147	1101	1378	34309
2010-11	41207	2886	6509	1628	7840	2665	1526	457	69813
2020-21	44752	2788	7987	3142	9730	3336	1801	230	93615
2021-22	46841	3800	8897	3653	12173	4335	2623	224	96686
Percentage change (1990-91 to 2021-22)	115.67	-65.41	-23.17	163.56	203.18	-41.63	-16.38	-89.75	40.46
CAGR	33.67	-20.52	-1.72	34.27	35.27	-6.16	1.35	-46.99	18.33

Source: Statistical abstract, various issues.

3.4.2 Pathways for diversification toward horticulture crops

The development of the horticulture sector requires robust state support and market mechanisms. The first and foremost step for the development of the horticulture sector would be enforcing efficient and assured public procurement at predetermined rates and guaranteeing remunerative prices, or MSP, which would promote the cultivation of these crops. Currently, only the procurement of paddy and wheat in the state can be considered satisfactory, which is one of the main reasons for its widespread cultivation. However, there is a lack of infrastructure for procuring other crops, especially fruits and vegetables, which are perishable. This makes farmers vulnerable to high price volatility and distress sales, posing a significant risk of loss and discouraging them from cultivating these crops. Therefore, a proper market needs to be developed along with storage facilities for these crops, as a lack of proper marketing facilities leads to high marketing expenses. The primary causes of high marketing expenses were found to be transportation expenses and wholesalers, as well as retailers' marketing margins, which negatively

impact the profitability of these crops (Kumar & Arora, 1999). There is a need on the part of the state government to establish organised supply chains directly between producers and consumers, thus eliminating middlemen.

Notably, given the water-intensive nature of paddy cultivation, a shift away from it would result in positive externalities that can be attributed to water and electricity savings. These savings can be further distributed to farmers in the form of financial incentives or subsidies for switching to horticulture crops (Sidhu et al, 2010). The market significantly influences the pattern and rate of diversification, favouring high-value crops. In this regard, the establishment of processing and other auxiliary businesses by creating better linkages for fruits and vegetables can create an additional market for these products, in addition to the consumer market.

Conclusion

Since the 1970s, Punjab's agricultural landscape has undergone significant evolution, characterised by a dominance of paddy-wheat cropping patterns. With over 80 per cent of its land used for farming, Punjab has witnessed tremendous growth in agricultural production and yield, driven by factors such as mechanisation and improved irrigation. However, over time, the monocropping pattern (paddy-wheat cycle) of cultivation, which came into being as a result of this new farming practice, has led to a decline in crop diversification, with both paddy and wheat collectively accounting for 85.29 per cent of GCA. Although this growth contributed to making the nation self-sufficient in food grain production, it had a detrimental effect on the landscape of Punjab, leading to the alarming exploitation of natural resources, especially underground water resources, given the irrigation intensity requirements of these crops. To address this issue, it is imperative to shift towards alternative crops which are less water-intensive. In this case, the horticulture sector appears as a viable alternative with lower water requirements and the potential to generate high-value crops, thereby benefiting both the state and the farming community. However, the development and shift towards horticulture crops require robust state support, assured procurement policy and market infrastructure. With a focus on this sector, in long run, Punjab can transform towards a more diversified agrarian cropping pattern and sustainable agriculture.

Acknowledgement

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