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ECONOMIC PERSPECTIVES ON CROP DIVERSIFICATION: EVIDENCE FROM UDAIPUR AND BHILWARA DISTRICTS OF RAJASTHAN, INDIA

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ABSTRACT

India is one of the major players in the agriculture sector worldwide and it is the primary source of livelihood for around 55 percent of India's population. Agriculture is considered a risk portfolio in India. Because, there are many environmental reasons for this, and indeed, climate change and extreme events. Crop diversification is most important practices for maintain or higher return against adverse climate changes. The study was conducted in year 2023-24 and 2024-25 as a pilot project on crop diversification for overcome the adverse climate effect and shifting the farmers on pulses, oilseed and cereals from rice for reduce unseen losses due to lower water use efficient crops and emission of greenhouse gases in environment that have adverse effect on climate. The study conducted in Udaipur and Bhilwara district of Rajasthan as benchmark survey of rice in year 2023-24 and input interventions of crops viz, Maize, soybean and groundnut in kharif season 2024-25. For the study and input intervention distribution a sample of 60 farmers were selected from Udaipur district and 75 farmers were selected from Bhilwara district. The finding of the study (n=135) revealed that the participation of farmers in FPOs and cooperative societies was high and high adoption of Government schemes like PDS and crop insurance. The economic findings of the study stated that the total cost of cultivation was highest for rice at Rs. 27640.77, while soybean and maize have lower total costs at Rs. 23168.31 and Rs. 22681.64, respectively in Udaipur district of Rajasthan. Net income (profit after deducting costs), maize emerges as the most profitable crop with Rs. 19080.96, followed by soybean at Rs. 16819.71 and rice at Rs. 10731.06. The return per rupee invested is highest for maize (Rs. 1.84), meaning that for every rupee spent, farmers earn Rs. 1.84. Soybean follows with Rs. 1.72, while rice has comparatively the lowest return at Rs. 1.39 in Udaipur district of Rajasthan. In Bhilwara district the rice and ground nut were studied a comparatively which finding revealed that the total cost of cultivation is much higher for groundnut (Rs. 59352.14) compared to rice (Rs. 38772.74), primarily due to higher seed, rental, and fixed costs. Net income, with groundnut earning Rs. 59810.26, while rice remains at just Rs. 3016.06, indicating that rice barely covers its total cost. The return per rupee invested further emphasizes the difference in profitability groundnut yields Rs. 1.99 per rupee spent, whereas rice provides only Rs. 1.08, making groundnut a far superior choice in terms of financial returns. The study's findings indicate that maize, soybean, and groundnut were more profitable crops than rice in both districts. Therefore, crop diversification from rice to other crops (maize, soybean, and groundnut) was beneficial in the study or intervention area. Considering this, farmers are advised to adopt other pulse, oilseed, and cereal crops instead of rice.

Keywords **:** Crop diversification, pulses, oilseed, cost of cultivation, return per rupees, net return

Introduction

India is one of the major players in the agriculture sector worldwide and it is the primary source of livelihood for around 55 percent of India's population. According to second advance estimates, agriculture & allied sector share 17.60 percent in total GVA at current prices in year 2023-24 and the share of industry and service is 27.60 percent and 54.90 percent respectively (Agricultural Statistics at a Glance 2023).

Indian agriculture is predominantly a small and marginal peasant-based economy with approximately 85 percent of the operational holdings being below two hectares and at the same time, only 44.58 percent of the agricultural land is cultivated by them (Agriculture Census 2010-11, Government of India, 2010).

Agriculture is considered a risk portfolio in India (Paul *et al.* 2023). Because, there are many reasons for this, and indeed, climate change and extreme events (e.g., foods, cyclonic storms, droughts, extreme rainfall and temperature, etc.) are one of them (Pattanayak *et al.,* 2021). The negative association between climate change and agricultural output, as well as farm income in India, has already been established by various studies (Kumar and Pattanayak 2024; see Shaw *et al.,* 2022). Hence, adopting climate smart agriculture (CSA) practices is perceived as a solution in various policy documents released at international and country levels (Bahinipati *et al.,* 2024. Crop diversification is one of the most prominent CSA practices in India because it minimizes economic loss and damages occurred in terms of adverse effects on production due to climate change and extreme events (Shafril *et al.,* 2018; Birthal and Hazrana, 2019; Bahinipati *et al.,* 2021 and 2024; Datta and Behera, 2022).

Crop diversification is considered as a means to promote agricultural development while lowering its environmental implications. Diversified food production must substantially increase to fulfil the needs of food security and sustainability for the world's future population (Neogi and Ghosh, 2022). Crop diversification can provide a long-term solution to existing farming techniques, while also producing stable job opportunities and higher income, and taking into account the changing customer preferences (Kumar *et al.,* 2012). Crop diversification is the practice of reallocating inputs across crops based on comparative advantages (De and Chattopadhyay, 2010). However, in modern farming practices, crop diversification is in general a shift from traditional lower-value crops to high value crops. This is a vital alleyway for a holistic approach to agricultural development; it will boost farmers' adaptability to external shocks that would promote self-reliance and sustainability in agriculture (Neogi and Ghosh, 2022). Crop diversification is a crop-selection strategy that enables a farmer to cultivate a wide variety of crops in a limited area to increase production-related activities, while reducing the overall cultivation- and production-related risks (Kremen *et al.,* 2012, Neogi and Ghosh, 2022).

Materials and Methods

The present study was conducted in the Udaipur and Chittorgarh districts of Rajasthan. A benchmark survey of rice-growing fields and their cost components was carried out during the *Kharif* season of 2023-24. The intervention for crop diversification was implemented in the *Kharif* season of 2024-25. As part of this initiative, seeds were provided to promote diversification, with maize and soybean introduced in Udaipur district and groundnut in Bhilwara district. The study utilized the MPS tool to assess farmers' preferences for rice cultivation. A tabular analysis was conducted to examine various aspects of farming practices. For economic analysis, cost concepts and income measurement tools were employed.

Preference of farmer in rice cultivation

For measuring the preference of farmers, a preference index was developed and a score of "1" was assigned for each correct answer and "0" for each incorrect answer. Thus, the preference score was ready for administering to rice preference. The preference score for each farmers was calculated by using the following formula:

$$\text{MPS} = \frac{\text{Total preference scores possessed by the farmers}}{\text{Maximum possible obtainable score}} \text{ X } 100$$

Where, MPS = Mean Percentage Score

The minimum and maximum possible scores were obtained based on several questions. The mean and standard deviation of all these farmers were computed to classify the preference into different categories. Based on the mean score and standard deviation, three categories of preference of rice cultivation were formulated under low, medium, and high which are as follows:-

Category of preference of rice
Low knowledge = Score less than (mean-SD)
Medium knowledge = Score from (mean-SD)
to (mean + SD)
High knowledge = Score more than (mean + SD)
Where,
SD = Standard deviation

The standard cost concept used for calculation of cost of rice, maize soybean and groundnut. The income measure for the selected crop output, the following tools was used.

1. **Gross income:** It is the total value of main product as well as by–product.

$$GI = (Q_m \text{ x } P_m) + (Q_b \text{ x } P_b)$$

Where,

GI = Gross Income in Rupees

Qm = Quantity of main product

Pm = Price of main product

Qb = Quantity of by product

Pb = Price of by product

Here price of the by product was considered zero due to non-consideration of the quantity of the by product.

2. **Farm business income:** Gross income – Cost A_1 (Cost A_2 in case of tenant Operated land)
3. **Family labour income:** Gross income – Cost B_2
4. **Net income:** Gross income – Cost C_2
5. **Return to management** = Gross income – Cost C_3

6. **Return per rupee on Investment** $= \frac{\text{Gross Income (GI)}}{\text{Total Cost (Cost C2)}}$

1. **WUE (Kg. /Hectare/mm)** = Biomass or Crop Yield / Water Used
2. **Rice Equivalent Yield (REY)**

$$= \frac{(Yield\ of\ Non\ Rice\ Crop\ x\ Price\ of\ Non\ Rice\ Crop)}{Price\ of\ Rice\ Crop}$$

Result and Discussion

This section discusses the status of farmers in relation to organizations and government support, sources of irrigation, asset-holding patterns, farming activities and MPS of rice preference of farmers as in tabular analysis. Additionally, cost groups, income measures, water use efficiency, and rice equivalent yield of selected input crops are analyzed using relevant formulas.

Table 1 : Membership of farmers in organizations

S. No.	Particulars	Udaipur (n=60)		Bhilwara (n=75)		Total (n=135)	
	Membership of Organizations	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
1	Farmer Producer Organizations	60	0	75	0	135	0
2	Cooperative societies	33	27	71	4	104	31
3	Marketing societies	0	60	2	73	2	133
4	Shelf Help Groups	6	54	36	39	42	93

The table 1 presents the membership status of farmers in various organizations across Udaipur and Bhilwara districts. All surveyed farmers (100%) were members of Farmer Producer Organizations (FPOs) in both districts. Membership in cooperative societies was also significant, with 55 percent (33 out of 60) of farmers in Udaipur and 95 percent (71 out of 75) in Bhilwara being members, totaling 104 farmers across both districts. However, participation in marketing societies was minimal, with only two farmers from Bhilwara and none from Udaipur being members. In contrast, membership in Self-Help Groups (SHGs) was higher in Bhilwara (36 members) compared to Udaipur (6 members), bringing the total SHG membership to 42 farmers.

Table 2 : Benefits taken by farmers from government

S. No.	Particulars	Udaipur (n=60)		Bhilwara (n=75)		Total (n=135)	
	Benefits From Government	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
1	PM KISAN Scheme	13	47	75	0	88	47
2	PDS ration	59	1	75	0	134	1
3	Crop Insurance	56	4	75	0	131	4
4	Pension scheme	5	55	9	66	14	121

The table 2 highlights the benefits received by farmers from various government schemes in Udaipur and Bhilwara districts. The PM-KISAN Scheme had full coverage in Bhilwara (75 farmers), whereas only 13 farmers in Udaipur benefited, leaving 47 without access. Public Distribution System (PDS) ration had near-universal coverage, with 134 out of 135 farmers receiving benefits. Crop insurance was also widely availed, with 131 farmers covered 56 in Udaipur and all 75 in Bhilwara. However, participation in pension schemes was significantly lower, with only 14 farmers enrolled 5 in Udaipur and 9 in Bhilwara indicating a gap in social security support among farmers.

Table 3 : Source of irrigation used by farmers

S. No.	Particulars	Udaipur (n=60)		Bhilwara (n=75)		Total (n=135)	
	Source of Irrigation	Yes	No	Yes	No	Yes	No
1	Rainfed	58	2	74	1	132	3
2	Canal	0	60	75	0	75	60
3	Bore well	60	0	75	0	135	0

The data of table 3 illustrates the sources of irrigation used by farmers in Udaipur and Bhilwara districts. Rain fed irrigation was prevalent among the majority, with 132 out of 135 farmers relying on rainfall for cultivation. Bore wells were universally used, with all 135 farmers across both districts having access to this source. However, canal irrigation showed a stark contrast while all 75 farmers in Bhilwara had access to canal water, none of the farmers in Udaipur used it.

Table 4 : Asset holding pattern of farmers

S. No.	Particulars	Udaipur (n=60)		Bhilwara (n=75)		Total (n=135)	
	Asset Holding Pattern	Yes	No	Yes	No	Yes	No
1	Farm House	5	55	4	71	9	126
2	Tractor	9	51	16	59	25	110
3	Tiller	9	51	18	57	27	108
4	Cultivator	9	51	11	64	20	115
5	Weeder	9	51	10	65	19	116
6	Thresher	11	49	10	65	21	114
7	Rotovator	9	51	10	65	19	116
8	Sprayer	55	5	75	0	130	5

The table 4 provides insights into the asset-holding patterns of farmers in Udaipur and Bhilwara districts. Farmhouses were owned by only 9 out of 135 farmers, indicating that most farmers do not have separate farm dwellings. Ownership of tractors (25 farmers), tillers (27 farmers), cultivators (20 farmers), weeders (19 farmers), threshers (21 farmers), and rotovators (19 farmers) was relatively low, suggesting a limited adoption of mechanized farming equipment. However, sprayers were widely owned, with 130 out of 135 farmers having access to them, highlighting the importance of plant protection measures in both districts.

Table 5 : Activities performed by farmers at farm

S. No.	Particulars		Udaipur (n=60)		Bhilwara (n=75)		Total (n=135)	
	Farm Activity		Yes	No	Yes	No	Yes	No
1	Diversified cropping	Aware	60	0	75	0	135	0
		Adopted	58	2	75	0	133	2
2	Inter cropping	Aware	31	29	74	1	105	30
		Adopted	10	50	26	49	36	99
3	Crop rotation	Aware	59	1	73	2	132	3
		Adopted	57	3	72	3	129	6
4	Buffer stock of crops	Aware	16	44	74	1	90	45
		Adopted	1	59	4	70	5	129
5	Adoption of HYV	Aware	55	5	75	0	130	5
		Adopted	55	5	75	0	130	5
6	Custom hiring center	Aware	60	0	75	0	135	0
		Adopted	6	54	3	72	9	126
7	Crop insurance	Aware	60	0	75	0	135	0
		Adopted	59	1	74	1	133	2

The table 5 presents a comparative analysis of awareness and adoption of various farm activities among farmers in Udaipur and Bhilwara districts. Almost all farmers in both districts are aware of

diversified cropping, crop rotation, adoption of high-yielding varieties (HYV), custom hiring centers, and crop insurance. However, adoption rates vary across practices. While diversified cropping and crop rotation show high adoption rates (98.5% and 95.5%, respectively), intercropping has a much lower adoption (25.9%) despite significant awareness. Similarly, while 66.70 percent of farmers are aware of buffer stock management, only 3.7 percent adopt it. Custom hiring centers also see very low adoption (6.7%), indicating potential barriers despite widespread awareness. Crop insurance has a high adoption rate of 98.5 percent, suggesting strong acceptance.

Table 6 : Mean percent score on rice cultivation preference by farmers

S.No.	Why farmers prefer rice cultivation	Udaipur (n=60)		Bhilwara (n=75)	
		MPS	Rank	MPS	Rank
1	Rice shorter crop duration	100.00	1	99.11	1
2	Rice is more responsive to fertilizer and water than other crops	99.44	2	60.00	7
3	Sufficient availability of water	98.33	3	50.22	8
4	Soil is suitable/support other crops to cultivate	55.00	9	36.44	11
5	Attack of wild animals in other crops	65.00	8	98.22	3
6	Rice straw for animal feeding is necessary	50.00	11	49.78	9
7	Assured price for rice and procurement	51.11	10	81.53	4
8	High yielding varieties available	87.22	6	99.12	2
9	Advance mechanization available	66.67	7	40.8	10
10	Well established value chain	95.00	5	63.55	6
11	Required for home consumption/food habit	97.22	4	64.44	5

The data of table 6 highlights the reasons why farmers in Udaipur and Bhilwara prefer rice cultivation, ranked based on the Mean Percentage Score (MPS). In Udaipur, the top three reasons were shorter crop duration (MPS 100.00, Rank 1), high responsiveness to fertilizers and water (MPS 99.44, Rank 2), and sufficient water availability (MPS 98.33, Rank 3). Other significant factors included home consumption needs (MPS 97.22, Rank 4) and a well-established value chain (MPS 95.00, Rank 5). In Bhilwara, the most preferred reason was also shorter crop duration (MPS 99.11, Rank 1), followed by availability of high-yielding varieties (MPS 99.12, Rank 2) and protection against wild animal attacks (MPS 98.22, Rank 3). Other notable factors were assured procurement prices (MPS 81.53, Rank 4) and home consumption needs (MPS 64.44, Rank 5).

A comparison between districts shows that while Udaipur farmers emphasized water availability and responsiveness to fertilizers, Bhilwara farmers prioritized protection from wild animals and assured pricing. Mechanization and value chain factors were more influential in Udaipur, whereas Bhilwara farmers rated them lower.

Table 7 : Input utilization pattern of farmers in Udaipur district of Rajasthan (n=60)

S. No.	Particulars	Rice	Soybean	Maize
1	Human Labour (Man Days)	36.82	22.59	32.42
i	Family Labour (Man Days)	30.89	20.56	30.8
ii	Hired Labor (Man Days)	5.93	2.03	1.62
2	Machine Labour and Bull lock labour (Hours)	8.96	4.23	4.96
3	Seed rate for nursery (Kg)	26.32	90.6	19.35
4	Fertilizer (Kg)	192.57	68.4	95.23
5	Manure tones	5.6	2.76	3.4
6	PPC (litter)	0.91	0.76	0.8

The table 7 presents the input utilization for three major crops Rice, Soybean, and Maize across different resource categories. Rice has the highest human labor requirement at 36.82 man-days, with family labor contributing a significant portion (30.89 man-days) and hired labor accounting for only 5.93 man-days. Maize follows closely with 32.42 man-days, where family labor (30.8 man-days) again dominates, and hired labor is minimal (1.62 man-days). Soybean has the lowest human labor requirement at 22.59 man-days, primarily dependent on family labor (20.56 man-days) with just 2.03 man-days of hired labor. In terms of machine and

bullock labor, rice requires the most (8.96 hours), while maize and soybean require 4.96 hours and 4.23 hours, respectively. The seed requirement varies significantly, with soybean requiring the highest quantity (90.6 kg), followed by rice for nursery (26.32 kg) and maize (19.35 kg). Fertilizer application is the highest in rice cultivation (192.57 kg), whereas maize and soybean require 95.23 kg and 68.4 kg, respectively. The application of manure is also the highest in rice (5.6 tones), followed by maize (3.4 tones) and soybean (2.76 tones). Similarly, the use of plant protection chemicals (PPC) is slightly higher in rice (0.91 litter), compared to maize (0.8 litter) and soybean (0.76 litter).

Table 8 : Component wise cost of crops in Udaipur district of Rajasthan (n=60)

S. No	Particulars	Rice (Rs.)	Soybean (Rs.)	Maize (Rs.)
1	Human Labour	5523.00	3388.50	4863.00
i	Family Labour	4633.50	3084.00	4620.00
ii	Hired Labor	889.50	304.5	243
2	Machine Labour and Bull lock labour	5555.2	2622.6	3075.2
3	Seed	1105.44	7066.8	3870
4	Fertilizer	2854.25	1013.688	1411.309
5	Manure tones	4368.00	2152.80	2652.00
6	PPC	681.59	592.80	612.00
7	Interest on working capital	1406.124	1178.603	1153.846
A	Total Variable Cost	21493.6	18015.79	17637.35
8	Rental Value of own land	3837.18	3998.80	4176.26
9	Interest on fixed capital	614.72	515.25	504.43
10	Depreciation	1695.27	638.46	363.60
B	Total Fixed cost	6147.17	5152.52	5044.28
A+B	Total Cost	27640.77	23168.31	22681.64

The cost structure (Table 8) for cultivating Rice, Soybean, and Maize is divided into variable and fixed costs, highlighting differences in input expenses. Among variable costs, human labor is the highest for rice at Rs. 5523, followed by maize at Rs. 4863 and soybean at Rs. 3388.50. Family labor constitutes the bulk of this cost across all crops, with hired labor being significantly lower Rs. 889.50 for rice, Rs. 304.50 for soybean, and Rs. 243 for maize. Machine and bullock labor expenses are also the highest for rice (Rs. 5555.2), whereas soybean has the lowest requirement (Rs. 2622.6). Seed costs vary substantially, with soybean requiring the highest investment at Rs. 7066.8, while maize and rice incur costs of Rs. 3870 and Rs. 1105.44, respectively. Fertilizer expenses are highest for rice (Rs. 2854.25), whereas maize and soybean require Rs. 1411.31 and Rs. 1013.69, respectively. Similarly, the cost of manure is the highest for rice (Rs. 4368), followed by maize (Rs. 2652) and soybean (Rs. 2152.8). The use of plant protection chemicals (PPC) remains relatively similar across crops, with rice at Rs. 681.59, maize at Rs. 612, and soybean at Rs. 592.80. Interest on working capital is slightly higher for rice (Rs. 1406.12), compared to soybean (Rs. 1178.60) and maize (Rs. 1153.85), contributing to a total variable cost of Rs. 21493.6 for rice, Rs. 18015.79 for soybean, and Rs. 17637.35 for maize.

In terms of fixed costs, the rental value of land is highest for maize (Rs. 4176.26), followed by soybean (Rs. 3998.80) and rice (Rs. 3837.18). Interest on fixed capital is relatively lower across all crops, with rice at Rs. 614.72, soybean at Rs. 515.25, and maize at Rs. 504.43. Depreciation costs are highest for rice (Rs. 1695.27), followed by soybean (Rs. 638.46) and maize (Rs. 363.60). As a result, the total fixed cost stands at Rs. 6147.17 for rice, Rs. 5152.52 for soybean, and Rs. 5044.28 for maize. Combining both variable and fixed costs, the total cost of cultivation was highest for rice at Rs. 27640.77, while soybean and maize have lower total costs at Rs. 23168.31 and Rs. 22681.64, respectively. This analysis indicates that rice cultivation is the most resource-intensive among the three crops, with higher costs in both labor and input utilization.

Table 9 : Returns from the cultivation of crops in Udaipur district of Rajasthan (n=60)

S No.	Particulars	Rice	Soybean	Maize
1	Main Product (Quintal)	14.78	7.91	18.04
2	By product (Quintal)	42.86	19.78	54.12
3	Gross Income through Main Product (Rs.)	35028.60	39391.80	39327.20
4	Gross Income through by product (Rs.)	3343.23	596.21	2435.40
5	Gross Income (Rs.)	38371.84	39988.02	41762.60
6	Net Income (Rs.)	10731.06	16819.71	19080.96
7	Return Per Rupees (Rs.)	1.39	1.72	1.84
8	Farm Business Income (Rs.)	19816.46	24417.76	28381.65
9	Family Labour Income (Rs.)	15364.56	19903.71	23700.96

The table 9 presents the income and profitability metrics for Rice, Soybean, and Maize, highlighting variations in yield, revenue, and overall returns. Among the main products, maize yields the highest at 18.04 quintals, followed by rice at 14.78 quintals and soybean at 7.91 quintals. The by-product yield follows a similar pattern, with maize producing 54.12 quintals, rice 42.86 quintals, and soybean 19.78 quintals. The gross income through main product was highest (Rs. 39391.80) from soybean due high price followed by maize (Rs. 39327.20) and rice (Rs. 35028.60). The return form by product was highest from rice Rs. 3343.23 followed by maize (Rs. 2435.40) (Verma *et al.* 2022) and soybean (Rs. 596.21) due to lowest price and less use in tribal area (Udaipur).

Despite having the lowest main product yield, soybean generates the highest gross income (Rs. 39988.02), slightly surpassing maize (Rs. 41762.60) and rice (Rs. 38371.84). This is due to soybean's higher market price per quintal. However, when considering net income (profit after deducting costs), maize emerges as the most profitable crop with Rs. 19080.96, followed by soybean at Rs. 16819.71 and rice at Rs. 10731.06. The return per rupee invested is highest for maize (Rs. 1.84), meaning that for every rupee spent, farmers earn Rs. 1.84 (Verma *et al.* 2022). Soybean follows with Rs. 1.72, while rice has the lowest return at Rs. 1.39. Similarly, farm business income, which accounts for variable costs, is highest for maize at Rs. 28381.65, followed by soybean (Rs. 24417.76) and rice (Rs. 19816.46). Family labor income, which deducts rental value and other fixed costs, also favors maize at Rs. 23700.96, with soybean at Rs. 19903.71 and rice at Rs. 15364.56.

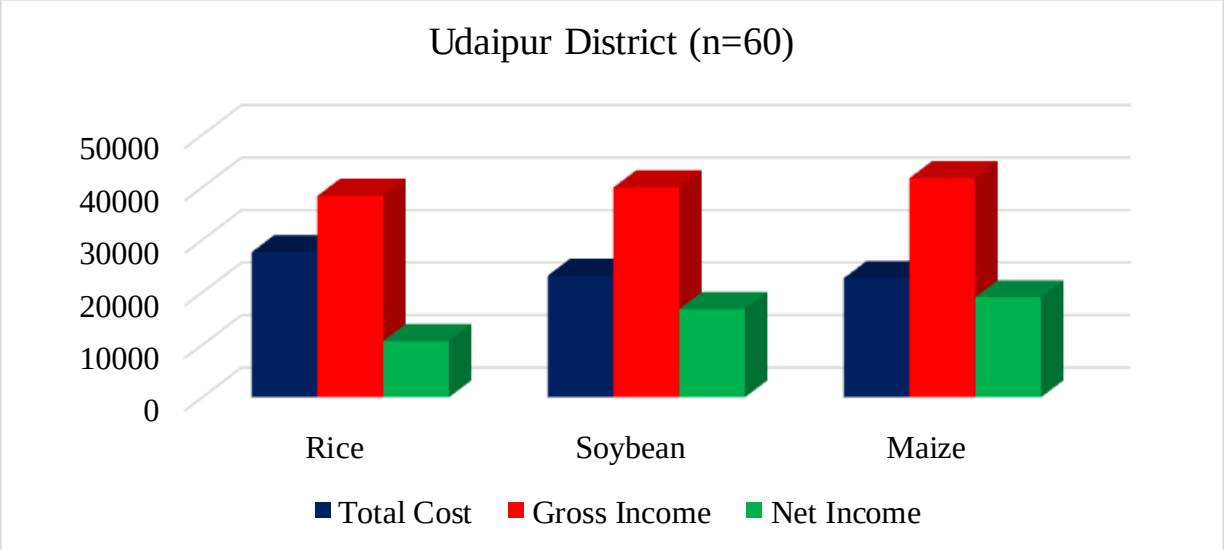

Fig. 1 : Total cost, gross income and net come in Udaipur district

Table 10 : Cost groups in cultivation of crops in Udaipur district of Rajasthan (n=60)

S. No.	Cost Groups	Rice (Rs.)	Soybean (Rs.)	Maize (Rs.)
1	Cost A_1	18555.37	15570.25	13380.95
2	Cost A_2	18555.37	15570.25	13380.95
3	Cost B_1	19170.09	16085.51	13885.38
4	Cost B_2	23007.27	20084.31	18061.64
5	Cost C_1	23803.59	19169.51	18505.38
6	Cost C_2	27640.77	23168.31	22681.64
7	Cost C_3	30404.85	25485.14	24949.80

The table 10 categorizes costs into different cost groups A_1, A_2, B_1, B2, C_1, C_2, and C_3 for Rice, Soybean, and Maize, reflecting various levels of cost inclusion from basic operational costs to total production expenses. Cost A_1 and A_2, which include direct costs like hired labor, seeds, fertilizers, and other input expenses, are the lowest across all cost groups. Rice has the highest Cost A_1 (Rs. 18555.37), followed by soybean (Rs. 15570.25) and maize (Rs. 13380.95), indicating that maize has the lowest initial production costs. Cost B_1, which includes Cost A_1 plus interest on fixed capital, is slightly higher, with rice at Rs. 19170.09, soybean at Rs. 16085.51, and maize at Rs. 13885.38. When adding the rental value of owned land to arrive at Cost B_2, the costs rise, with rice (Rs. 23007.27) being the highest, followed by soybean (Rs. 20084.31) and maize (Rs. 18061.64).

Cost C_1, which accounts for Cost B_1 plus family labor, shows that rice requires Rs. 23803.59, soybean Rs. 19169.51, and maize Rs. 18505.38, reflecting higher dependency on family labor in rice cultivation. Cost C_2, which further includes the rental value of owned land, represents the total cost of cultivation Rs. 27640.77 for rice, Rs. 23168.31 for soybean, and Rs. 22681.64 for maize. Finally, Cost C_3, which factors in managerial costs (10% of Cost C_2), represents the highest overall cost. Rice (Rs. 30404.85) remains the most expensive to cultivate, followed by soybean (Rs. 25485.14) and maize (Rs. 24949.80). Thus, maize has the lowest cost of cultivation across all cost groups, making it the most cost-efficient crop. Soybean falls in between, while rice is the most expensive to cultivate, driven by higher labor and input costs.

Table 11 : Input utilization pattern of farmers in Bhilwara district of Rajasthan (n=75)

S. No.	Particulars	Rice	Groundnut
1	Human Labour (Man Days)	39.59	34.92
i	Family Labour (Man Days)	33.41	33.09
ii	Hired Labor (Man Days)	6.18	1.83
2	Machine Labour and Bull lock labour	9.16	5.89
3	Seed rate for nursery (Kg)	29.53	109.32
4	Fertilizer (Kg)	209.22	96.21
5	Manure tones	5.90	6.20
6	PPC (litter)	0.83	0.75

The table 11 compares input utilization between Rice and Groundnut, focusing on labor, machinery, and input application. Rice requires slightly higher human labor (39.59 man-days) compared to groundnut (34.92 man-days). However, family labor is nearly the same for both crops 33.41 man-days for rice and 33.09 man-days for groundnut. The key difference lies in hired labor, which is significantly higher for rice (6.18 man-days) compared to groundnut (1.83 man-days), indicating that rice cultivation relies more on external labor. In terms of machine and bullock labor, rice requires 9.16 hours, which is higher than groundnut's 5.89 hours, suggesting more mechanization in rice farming. The seed rate differs substantially groundnut requires a much higher seed input (109.32 kg) compared to rice (29.53 kg), reflecting the difference in sowing methods and crop characteristics. Fertilizer application is also higher for rice (209.22 kg) than groundnut (96.21 kg), likely due to rice's higher nutrient demand. However, manure application is slightly higher for groundnut (6.20 tons) than rice (5.90 tons), possibly due to groundnut's reliance on organic matter for soil fertility. The use of plant protection chemicals (PPC) is fairly similar, with rice requiring 0.83 liters, slightly more than groundnut's 0.75 liters.

Table 12 : Component wise cost of crops in Bhilwara district of Rajasthan (n=75)

S. No	Particulars in (Rs.)	Rice	Groundnut
1	Human Labour	8709.80	7682.40
i	Family Labour	7350.20	7279.80
ii	Hired Labor	1359.60	402.60
2	Machine Labour and Bull lock labour	7328.00	4712.00
3	Seed	1535.56	17491.20
4	Fertilizer	3519.08	1618.25
5	Manure tones	6265.80	6584.40
6	PPC	819.21	740.25
7	Interest on working capital	1972.42	2717.9
A	Total Variable Cost	30149.87	41546.50
8	Rental Value of own land	5014.66	14223.89
9	Interest on fixed capital	1293.43	2670.85
10	Depreciation	2314.78	910.91
B	Total Fixed cost	8622.86	17805.64
A+B	Total Cost	38772.74	59352.14

The cost analysis of rice and groundnut cultivation reveals significant differences in input expenses in table 12. Rice has a lower total variable cost (Rs. 30149.87) compared to groundnut (Rs. 41546.50), indicating that groundnut requires a higher investment in inputs. While human labor costs are slightly higher for rice (Rs. 8709.80) than groundnut (Rs. 7682.40), the difference is mainly due to the greater reliance on hired labor in rice (Rs. 1359.60) compared to groundnut (Rs. 402.60), as family labor costs remain almost equal. Machine and bullock labor expenses are also higher for rice (Rs. 7328.00) than groundnut (Rs. 4712.00), reflecting the increased mechanization in rice farming. A significant cost difference lies in the seed expense, which is much higher for groundnut (Rs. 17491.20) than rice (Rs. 1535.56), due to the larger seed rate required for groundnut cultivation. Similarly, fertilizer costs for rice (Rs. 3519.08) exceed those of groundnut (Rs. 1618.25), while manure costs are slightly higher for groundnut (Rs. 6584.40) compared to rice (Rs. 6265.80), suggesting a greater reliance on organic inputs in groundnut farming. The expenditure on plant protection chemicals (PPC) is comparable, with rice at Rs. 819.21 and groundnut at Rs. 740.25.

Interest on working capital is higher for groundnut (Rs. 2717.90) than rice (Rs. 1972.42), which contributes to its overall higher production cost. The fixed costs also vary significantly, with groundnut having a much higher rental value of owned land (Rs. 14223.89) compared to rice (Rs. 5014.66), which significantly impacts total costs. Additionally, depreciation and interest on fixed capital are greater for groundnut (Rs. 910.91 and Rs. 2670.85, respectively) than for rice (Rs. 2314.78 and Rs. 1293.43, respectively). As a result, the total cost of cultivation is much higher for groundnut (Rs. 59352.14) compared to rice (Rs. 38772.74), primarily due to higher seed, rental, and fixed costs. This suggests that while groundnut cultivation requires a greater financial investment, its profitability would depend on market price returns and yield advantages over rice.

Table 13 : Returns from the cultivation of crops in Bhilwara district of Rajasthan (n=75)

S No.	Particulars	Rice	Groundnut
1	Main Product (Quintal)	16.00	16.44
2	By product (Quintal)	49.60	49.32
3	Gross Income through Main Product (Rs.)	37920.00	113107.20
4	Gross Income through by product (Rs.)	3868.80	5425.20
5	Gross Income (Rs.)	41788.80	118532.40
6	Net Income (Rs.)	3016.06	59810.26
7	Return per rupees (Rs.	1.08	1.99
8	Farm Business Income (Rs.)	16674.35	83354.80
9	Family Labour Income (Rs.)	10366.26	66460.06

The income analysis for Rice and Groundnut (table 13) highlights significant differences in profitability despite similar yields. The main product yield is almost the same, with rice producing 16.00 quintals per hectare and groundnut slightly higher at 16.44 quintals. The by-product yield is also similar, with rice at 49.60 quintals and groundnut at 49.32 quintals. However, the major difference lies in revenue generation. Gross income from the main product is significantly higher for groundnut (Rs.113107.20) compared to rice (Rs. 37920.00), due to the higher market price of groundnut. Even when considering by-products, groundnut generates a much higher total gross income of Rs. 118532.40, compared to rice's Rs. 41788.80. This results in a massive difference in net income, with groundnut earning Rs. 59810.26, while rice remains at just Rs. 3016.06, indicating that rice barely covers its total cost.

The return per rupee invested further emphasizes the difference in profitability groundnut yields Rs. 1.99 per rupee spent, whereas rice provides only Rs. 1.08, making groundnut a far superior choice in terms of financial returns. Similarly, farm business income (total income minus variable costs) is much higher for groundnut (Rs. 83354.80) compared to rice (Rs. 16674.35), demonstrating the lower cost-effectiveness of rice cultivation. When factoring in all fixed costs, family labor income remains significantly higher for groundnut (Rs. 66460.06) than rice (Rs. 10366.26). Overall, groundnut is far more profitable than rice, primarily due to its higher market price, which offsets its higher production costs, making it a more lucrative option for farmers.

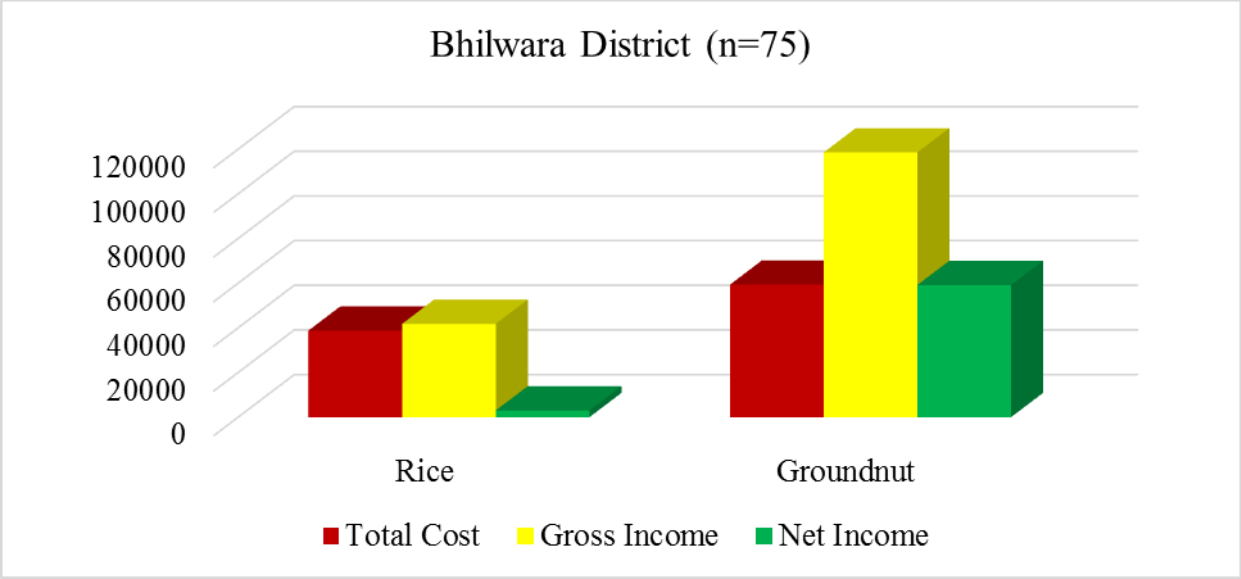

Fig. 2 : Total cost, gross income and net come in Bhilwara district

Table 14 : Cost groups in cultivation of crops in Bhilwara district of Rajasthan (n=75)

S. No.	Cost Groups	Rice (Rs.)	Groundnut (Rs.)
1	Cost A_1	25114.45	35177.6
2	Cost A_2	25114.45	35177.6
3	Cost B_1	26407.88	37848.45
4	Cost B_2	31422.54	52072.34
5	Cost C_1	33758.08	45128.25
6	Cost C_2	38772.74	59352.14
7	Cost C_3	42650.01	65287.35

The cost group table 14 analysis for Rice and Groundnut reveals a significant difference in expenses across different cost categories, with groundnut consistently having higher production costs. Cost A_1 and A_2, which include direct expenses such as hired labor, seeds, fertilizers, and other inputs, are Rs. 25114.45 for rice and Rs. 35177.60 for groundnut. This shows that groundnut requires a higher upfront investment in inputs compared to rice. As we move to Cost B_1, which adds interest on fixed capital to Cost

A_1, the costs increase to Rs. 26407.88 for rice and Rs. 37848.45 for groundnut. When the rental value of owned land is included (Cost B_2), the difference becomes even more pronounced, with rice at Rs. 31422.54 and groundnut at Rs. 52072.34, indicating that land costs are a major factor in groundnut cultivation expenses. (Kashyap *et al.* 2024 found nearby similar result).

Cost C_1, which accounts for family labor costs in addition to Cost B_1, further increases the expenses to Rs. 33758.08 for rice and Rs. 45128.25 for groundnut, reflecting the significant role of family labor in both crops. When all fixed costs, including the rental value of owned land, are considered in Cost C_2, the total cost of production rises to Rs. 38772.74 for rice and Rs. 59352.14 for groundnut. The Cost C_3, which incorporates managerial costs (10% of Cost C_2), represents the highest expense category. Rice's total cost under this category reaches Rs. 42650.01, while groundnut climbs to Rs. 65287.35, reinforcing the fact that groundnut cultivation is significantly more expensive than rice.

Table 15 : Rice equivalent yield and water use efficiency

S. No.	Particulars	Udaipur			Bhilwara	
	Crops	Rice	Soybean	Maize	Rice	Groundnut
1	Rice equivalent yield (Q)	14.78	16.62	16.59	16.00	47.72
2	Water Use Efficiency (Kg/Ha./mm)	3.10	2.65	7.20	2.70	8.40

The table 15 depict the rice equivalent yield of soybean, maize, and groundnut that is 16.62, 16.59 and 47.72 quintal respectively. Water Use Efficiency (Kg/Ha./mm) was 3.1 for rice and 2.65 and 7.2 for soybean and maize respectively in Udaipur district of Rajasthan. In Bhilwara district it was 2.7 rice and 8.4 for groundnut.

Conclusion

The present study of Udaipur and Bhilwara district conclude that participation of farmers among FPOs and cooperative societies was high, while participation in marketing societies was extremely low. Government schemes like PDS and crop insurance had high adoption, PM-KISAN and pension schemes showed disparities, especially in Udaipur. The irrigation sources indicates a strong dependence on bore wells and rainfall in Udaipur, whereas Bhilwara benefits from a mix of canal, bore well, and rain fed irrigation sources. The assets holding pattern indicates a strong reliance on smaller agricultural tools like sprayers, while ownership of larger machinery remains limited. The awareness and adoption of diversified cropping, crop rotation, HYVs, and crop insurance, intercropping, buffer stock storage, and custom hiring centers for all, farmers are generally aware of improved farming techniques, the actual adoption depends on factors such as accessibility, feasibility, and perceived benefits. Rice is a preferred crop in both districts, the underlying reasons for its preference vary based on local conditions and farming challenges.

The rice cultivation demands the highest input utilization in terms of labor, fertilizers, and manure, while soybean appears to be the least resource-intensive among the three crops in Udaipur district. This analysis of Udaipur district, indicates that rice cultivation require higher costs in both labor and input utilization. Maize proves to be the most profitable crop due to higher net income, return per rupee, and farm business income, making it a favorable option for farmers. Soybean, despite lower yield, remains highly competitive due to better pricing, while rice, although widely cultivated, incurs higher costs and lower profitability. Maize has the lowest cost of cultivation across all cost groups, making it the most cost-efficient crop. Soybean falls in between, while rice is the most expensive to cultivate, driven by higher labor and input costs. The productivity of soybean decrease in Udaipur district due to high rainfall in Udaipur throughout the crop growing period. In Bhilwara district, rice crop yield lower return as compare to Udaipur district, rice cultivation due to high price of labor and machinery or bullock cost. The diversified crop groundnut is most profitable cost as compare to rice in Bhilwara district. Return per rupees yield 1.99 Rs. per hectare in groundnut and its cultivation also yield highest labour return. Thus the study conclude that crop diversification from rice to other crops (maize, soybean, and groundnut) was beneficial in the study or intervention area. Considering this, farmers are advised to adopt other pulse, oilseed, and cereal crops instead of rice.

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Annexure

Table A.1 : Rate per unit of crops in Udaipur district of Rajasthan

S No.	Rate per unit (Rs.)	Rice	Soybean	Maize
1	Human Labour	150	150	150
2	Machine Labour and Bull lock labour	620	620	620
3	Seed	42	78	200
4	Fertilizer	14.82	14.82	14.82
5	Manure tones	780	780	780
6	PPC	749	780	765
7	Sale price of Main Product	2370	4980	2180

Table A.2 : Rate per unit of crops in Bhilwara district of Rajasthan

S. No.	Price per unit (Rs.)	Rice	Groundnut
1	Human Labour	220	220
2	Machine Labour and Bull lock labour	800	800
3	Seed	52	160
4	Fertilizer	16.82	16.82
5	Manure tones	1062	1062
6	PPC	987	987
7	Sale price of Main product	2370	6880