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Cost and return analysis of organic and conventional farming systems in the Ganga River Basin, India

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Abstract

Conventional farming (CF) has significantly increased the aggregate supply of food grains and ensured food security for the growing population in India. However, it proved environmentally unsustainable due to its higher reliance on chemical inputs. Organic farming (OF) becomes an alternative approach that ensures the sustainability of the agricultural system. But, the transition from CF to OF can be a lengthy process, and farmers may experience income loss during its course. Farmers will switch only when they are convinced that the long-term benefits of OF are higher than those of CF. Therefore, a study on cost and return analysis can help policymakers take appropriate measures to promote the adoption of OF. The current study aims to examine the costs, returns, and profitability for three crops (sugarcane, wheat, and paddy) under OF and CF, using data collected through a primary survey of 600 farmers (300 organics and 300 conventional) for the crop year 2020-21 in two districts of the Ganga River Basin. The study finds OF less profitable than CF for all three crops. Further, the results of crop-wise economics of OF and CF show that sugarcane is the most profitable crop and paddy is the least remunerative crop among all the three crops in the study area under both farming systems. The findings suggest that the policy focus must be on raising productivity through reorientating R&D and extension services, establishing strong marketing networks, and institutionalizing the system of payments for ecosystem services for organic farmers.

Keywords: economic viability, profitability, primary survey, sustainability, system analysis

1 Introduction

Agriculture is the backbone of the Indian economy, employing more than one-third of India's workforce. Besides, it is crucial for the country's socio-economic development. The growth, driven by Green Revolution Technology (conventional farming), has significantly increased the aggregate supply of food grains, ensuring food security for the growing population. Fast forward to the 21^{st} century; however, it faces a severe challenge in terms of sustainability. The main problem faced by several states of India is the over-exploitation of scarce resources and overuse of chemical inputs. Hence, national and state governments introduced measures like sustainable agricultural practices, including organic farming (OF), to tackle these challenges. OF aims to protect the agricultural ecosystem and promote farming practices that benefit natural soil fertility, biodiversity and reduce or entirely refrain from using chemical products (Mäder *et al.*, 2002).

Literature suggests that OF is a system of farm management and food production that combines the best environmental practices, a high level of biodiversity, preservation of natural resources, and applications of high animal welfare. It has been proven as a more sustainable and long-lasting nutrient-providing system which is economically viable and ecologically balanced approach that ensures food security (Patil *et al.*, 2014; Srivastava *et al.*, 2016). The advantages of OF include conserving and improving soil and water resources and their quality, enhancing diversity, sustaining yield, producing quality products, reducing costs, and natural pest control with less environmental pollution. OF is also more climate-friendly than CF as the carbon footprint is lower in practicing it (Knudsen *et al.*, 2014).

India has a vast potential for producing different organic crops because of its varied agro-climatic conditions. The government of India has been promoting OF through vari-

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ous missions, schemes, and awareness programs, such as the National Programme for Organic Production (NPOP) (2001), Paramparagat Krishi Vikas Yojana (PKVY) (2015) and Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) (2015). Because of these policy initiatives, the cultivated area under OF has significantly increased from 43000 ha in 2004 to 2.65 million ha in 2021 (GoI, 2021). Similarly, the National Mission for Clean Ganga (NMCG) has been promoting zero-budget/natural/organic farming on 10 km on both sides of the river Ganga banks to maintain agricultural sustainability and reduce river pollution due to the criminalization of agriculture. PKVY and NMCG incentivize farmers to form OF clusters under the Participatory Guarantee System (PGS). Due to government policies and increased public awareness about its health and environmental benefits, the area under OF has been growing, yet it is still very low (Karki *et al.*, 2011; Priya & Singh, 2022).

Several factors affects the adoption of OF, out of which the economic viability of OF is one of the key factors (Koesling *et al.*, 2008). In their study, Sgroi *et al.* (2015) indicates that profitability is a crucial factor for a farmer in making a farming decision. The risk of having poor financial prospects keeps the farmers away from adopting OF (Yanakittkul & Aungvaravong, 2020; Siepmann & Nicholas, 2018). Existing literature shows that there are various studies which compare the profitability of OF and CF. Some studies show that the cost incurred in OF is higher than CF (Charyulu & Biswas, 2010; Tashi & Wangchuk, 2016; Uematsu & Mishra, 2012; Kumar *et al.*, 2017). The higher cost in OF has been linked to increased labour costs, given the greater demand for manual labour (Tashi & Wangchuk, 2016). On the other hand, Heinrichs *et al.* (2021), Kshirsagar (2006) and Sgroi *et al.* (2015), in their study find lower costs in OF due to the absence of chemical use.

Although the low costs of production have been observed in many studies in OF, the profitability is still low in most cases. Low profitability has been mainly attributed to the lower yields in OF (van Quyen & Sharma, 2003). However, in some cases, net revenue in OF was found to be higher than in CF (Kumar *et al.*, 2017; Mendoza *et al.*, 2001; Suwanmaneepong *et al.*, 2020). The main reason for higher returns in OF was the organic produce being priced at a 20 % higher rate than the conventional produce (Mendoza *et al.*, 2001), which points out that OF can be remunerative if the farmers receive the premium prices. In their study, Heinrichs *et al.* (2021) and Suwanmaneepong *et al.* (2020) also find a more significant price premium as the main reason behind higher profits in OF. Literature suggests that in the long run, OF can be more profitable or at par with CF (Delate *et al.*, 2003; Delbridge *et al.*, 2011).

Considering the social, ecological, and health benefits (positive externalities) of OF system, it becomes crucial to understand its economic viability as it would ultimately be a key aspect when a farmer decides to switch to OF. Hence, a cost and return analysis will help us understand its economics. Equally, a comparative analysis of OF with CF can help to explore why its adoption rate among farmers in the study is low. Although there is literature comparing the returns from the two farming systems, the dynamics of the study areas differ, and the results of one study cannot be generalized to other areas. Moreover, results vary across regions and crops for various reasons, including agroecological differences, crop types, water availability, time of practicing OF, farm sizes, market maturity, policy support, etc. Therefore, the diverse findings of the above studies inspire us to examine the costs, returns, and profitability under OF and CF in India. A study on cost and return analysis will help policymakers to understand the economics of OF. Also, a comparative analysis of CF with OF will also assist the stakeholders to take appropriate measures for the greater promotion and adoption of OF. Therefore, this study aims to analyse and compare the cost and returns of OF and CF in India.

2 Materials and methods

2.1 Study area, sample size, and data collection

The current study was conducted in the Ganga River basin in India. The Ganga River basin can be divided into three segments, namely, the Upper Ganga from Gaumukh to Haridwar, the Middle Ganga from Haridwar to Varanasi, and the Lower Ganga from Varanasi to Ganga Sagar (IITC, 2010). There are 53 districts alongside the mainstream of the Ganga River, located mainly in four states: Uttarakhand, Uttar Pradesh, Bihar, and West Bengal. Two districts from the Middle Ganga River basin, Haridwar (Uttarakhand) and Bulandshahr (Uttar Pradesh) have been selected for the current study. Haridwar is one of the first towns where the Ganga originates from the mountains to touch the plains, whereas Bulandshahr district is situated between the Ganga and Yamuna rivers. Further, the major crops grown in the area are sugarcane, wheat, and paddy, constituting about 80 % of the gross cropped area (GCA) in the Haridwar district and about 67 % of the GCA in Bulandshahr district. Therefore, these three crops have been selected for the current analysis.

Two development blocks and five villages from each district were selected for the primary survey. Thirty farmers, i.e., fifteen OF and fifteen CF farmers, were surveyed from each sample village. A total of 600 farmers were selected for the final survey, of which 300 were OF, and 300 were CF farmers, with 150 OF and 150 CF farmers from each district. The data for the current study was collected through structured questionnaires, where both exploratory and explanatory research designs were used. The questionnaire consists of two sections: the first contains questions related to demographic profile, which includes farm and farmer characteristics, and the second is based on cost and return data.

2.2 Data analysis

Cost and return analyses are done to study the economics of OF and CF systems. The manual on 'Cost of Cultivation Surveys' by the Commission for Agricultural Costs and Prices (CACP) has been used as a guide to collecting data and calculating the costs and returns from the primary data. The following concepts are considered to estimate costs and returns from different crops:

Cost A1 = Value of hired human labour + Value of hired bullock labour + Value of owned bullock labour + Value of owned machine labour + Hired machinery charges + Value of seed (both farms produced & purchased) + Value of insecticides and pesticides + Value of manure (owned and purchased) + Value of fertilisers + Irrigation charges + Depreciation of implements and farm buildings + Land revenue cesses and other taxes + Interest on working capital + Misc. expenses

Cost A2 = Cost A1 + Rent paid for leased in-land. Thus, Cost A2 includes all paid-out costs

Cost B1 = Cost A1 + Interest on value of owned fixed capital assets (excluding land)

Cost B2 = Cost B1 + Rental value of owned land (net of land revenue) and rent paid for leased-in land

Cost C1 = Cost B1 + Imputed value of family labour

Cost C2 = Cost B2 + Imputed value of family labour

Whereas the value of production (VOP) is calculated by adding the value of the main product (Rs. per hectare) and the value of the by-product (Rs. per hectare). Other concepts used to measure income and profit are as follows:

Farm Business Income (FBI) = VOP - Cost A2

Family Labour Income (FLI) = VOP - Cost B2

Further, the benefit-cost ratio (BCR) has been calculated on VOP to cost A1, cost B2 and cost C2, for analysing the benefits over the costs. The ratio less than one shows costs are higher than the benefits and farming is not viable and ratio greater than one indicates vice-versa (Murthy *et al.*, 2009). Lastly, an independent sample t-test has been conducted to check the significant difference between the mean values of costs and returns under OF and CF systems.

3 Results

3.1 Economics of OF and CF for sugarcane, wheat and paddy cultivation

Cost and return analyses have been conducted to study the economics of OF and CF for three major crops grown in the study area: sugarcane, wheat, and paddy. The average area under sugarcane is lesser in OF than in CF (Table 1). In the case of wheat and paddy, it is higher under OF than CF. Organic sugarcane producers produce 22,600 kilograms (kg) less output per hectare than their conventional counterparts. The average yields of wheat and paddy are also observed to be lower in OF than in CF in our study. However, along with lower yields, all the costs in OF for three crops are also lower compared to CF. The farm business income (FBI), farm labour income (FLI), and net profit are higher in CF than OF for all three crops. Further, the t-test results show a statistically significant difference between the costs and returns in all three crops, except FLI in paddy.

3.2 District-wise costs and returns in sugarcane, wheat and paddy cultivation

3.2.1 District-wise costs and returns in sugarcane cultivation

The district-wise comparison of the costs and returns in sugarcane under two farming systems (Table 2) shows that in the Haridwar district, the average area per farm under sugarcane is higher in OF (0.43 ha) than in CF (0.72 ha), whereas, in Bulandshahr district, it is almost the same. The average yield in OF is lower than in CF in both districts. Along with higher costs, the VOP is also higher in both farming systems in Bulandshahr. Also, FBI, FLI, and net profit are much higher in Bulandshahr than in the Haridwar district. However, OF provides relatively lower returns compared to CF. Low returns demotivate the farmers to adopt OF. The independent sample t-test shows significant differences between OF and CF systems in per hectare costs and returns in sugarcane in both districts, except for average area and Cost C2 in Bulandshahr.

3.2.2 District-wise costs and returns in wheat cultivation

The average area under wheat cultivation on our sample farms is almost equal under both farmings in the Haridwar

Table 1: *Costs and returns of sugarcane, wheat, and paddy cultivation (in Rs. per hectare).*

Various measures	*Sugarcane*			*Wheat*			*Paddy*		
	OF	*CF*	*t-value*	*OF*	*CF*	*t-value*	*OF*	*CF*	*t-value*
Avg. area (ha)	0.44	0.63	5.01*	0.36	0.28	-5.84*	0.36	0.29	-4.28*
Avg. yield (kg ha^{-1})	71800	94400	30.76*	3800	5000	47.02*	3500	5600	56.92*
Cost A1	114839	135051	10.68*	43532	47171	6.57*	38114	58884	25.06*
Cost A2	116358	141753	11.25*	44217	49342	6.84*	38585	60830	23.67*
Cost B2	178689	188397	4.77*	74671	86452	19.80*	70001	98391	32.73*
Cost C2	212325	218362	4.14*	85812	94715	18.99*	88202	111281	47.15*
VOP	239352	310390	27.10*	95468	115850	29.63*	80128	110333	21.42*
FBI	122994	168637	17.28*	51251	66508	15.97*	41543	49502	4.96*
FLI	60663	121993	29.96*	20797	29398	10.25*	10127	11941	1.10
Net profit	27027	92028	34.50*	9656	21135	15.49*	-8074	-948	4.81*

Source: Authors' own estimation. * Indicates significance at a 1 % level of significance. OF: organic farming; CF: conventional farming; Cost A1 = Value of hired human labour + Value of hired bullock labour + Value of owned bullock labour + Value of owned machine labour + Hired machinery charges + Value of seed (both farms produced & purchased) + Value of insecticides and pesticides + Value of manure (owned and purchased) + Value of fertilisers + Irrigation charges + Depreciation of implements and farm buildings + Land revenue cesses and other taxes + Interest on working capital + Misc. expenses. Cost A2 = Cost A1 + Rent paid for leased in-land. Thus, Cost A2 includes all paid-out costs. Cost B1 = Cost A1 + Interest on value of owned fixed capital assets (excluding land); Cost B2 = Cost B1 + Rental value of owned land (net of land revenue) and rent paid for leased-in land; Cost C1 = Cost B1 + Imputed value of family labour; Cost C2 = Cost B2 + Imputed value of family labour; VOP: value of production; FBI: Farm business income; FLI: Farm labour income.

Table 2: *District-wise per hectare costs and returns in sugarcane cultivation (in Rs.).*

Various measures	*Haridwar (Uttarakhand)*			*Bulandshahr (Uttar Pradesh)*		
	OF	*CF*	*t-test*	*OF*	*CF*	*t-test*
Av. area§	0.43	0.72	5.76*	0.49	0.47	−0.25
Av. yield†	71000	91300	22.91*	75700	99400	19.64*
Cost A1	114436	135104	9.57*	116820	134965	4.15*
Cost A2	116263	136402	8.42*	116820	150384	6.85*
Cost B2	177700	185936	3.50*	183561	192367	2.05**
Cost C2	210747	215196	2.46**	220098	223468	1.29
VOP	233329	299212	22.87*	269019	328421	14.38*
FBI	117066	162810	16.32*	152199	178037	5.50*
FLI	55630	113276	25.51*	85458	136054	16.42*
Net Profit	22582	84015	28.75*	48922	104952	21.05*

Source: Authors' estimation. §Av. area = average area in ha; †Av. yield = average yield in kg ha^{-1}; * and ** indicate significance at 1 % and 5 % levels of significance, respectively. For an explanation of abbreviations, see Table 1.

Table 3: *District-wise per hectare costs and returns in wheat cultivation (in Rs.).*

Various measures	*Haridwar (Uttarakhand)*			*Bulandshahr (Uttar Pradesh)*		
	OF	*CF*	*t-test*	*OF*	*CF*	*t-test*
Av. area§	0.28	0.30	0.69	0.42	0.26	-10.05*
Av. yield†)	3900	5000	32.51*	3900	5000	33.97*
Cost A1	43181	49527	7.50*	43872	45025	1.68
Cost A2	44071	49527	5.76*	44359	49178	4.206*
Cost B2	74275	88608	16.90*	75057	84489	11.72*
Cost C2	84033	97074	20.02*	87544	92567	8.45*
VOP	90390	115163	31.83*	100410	116478	16.62*
FBI	46319	65635	16.63*	78230	67299	8.11*
FLI	16116	26554	9.79*	25353	31988	5.83*
Net Profit	6358	18088	12.15*	12866	23910	10.97*

Source: Authors' estimation. §Av. area = average area in ha; †Av. yield = average yield in kg ha^{-1}; * indicate significance at 1 % levels of significance. For an explanation of abbreviations, see Table 1.

district. On the other hand, it is higher in OF in the Bulandshahr district, and the difference is also statistically significant (Table 3). The average yield in OF (3900 kg ha^{-1}) is much lower than in CF (5000 kg ha^{-1}). However, there is no difference in the yield across districts. As far as per hectare average costs are concerned, we observe that costs A1, A2, B1, B2, and C2 in OF are higher in Bulandshahr than in Haridwar District, while in the case of CF, these costs are higher in Haridwar district. The average yield per hectare of wheat is higher in Bulandshahr than in the Haridwar district under both farming systems. For instance, per kilograms (kg), realised wheat prices under OF and CF in Haridwar are estimated to be Rs 2318 and Rs.2303, respectively, while the corresponding figures in Bulandshahr are Rs 2575 and Rs 2330, respectively. We also estimate FBI, FLI, and net profit per hectare for wheat, which are much higher in Bulandshahr than in the Haridwar district under both farming systems. The independent sample t-test shows a statistically significant difference in costs and returns between OF and CF in both districts, except Cost A1 in Bulandshahr.

Table 4: *District-wise per hectare costs and returns in paddy cultivation (in Rs.).*

Various measures	Haridwar (Uttarakhand)			Bulandshahr (Uttar Pradesh)		
	OF	*CF*	*t-test*	*OF*	*CF*	*t-test*
Av. area[§]	0.33	0.28	-1.47	0.38	0.30	-4.12*
Av. yield[†]	3600	5600	33.09*	3600	5700	44.86*
Cost A1	40381	61224	15.09*	37243	56989	19.81*
Cost A2	40947	61224	13.81*	37678	60512	18.09*
Cost B2	72447	100620	19.50*	69055	96585	25.68*
Cost C2	86607	113225	33.25*	88812	109705	36.30*
VOP	69424	100522	18.30*	84145	118361	19.07*
FBI	28477	39297	5.68*	46484	57849	5.54*
FLI	-3023	-98.19	1.60	15090	21775	3.11*
Net Profit	-17183	-12703	2.74*	-4667	8656	6.91*

Source: Authors' estimation. [§]Av. area = average area in ha; [†]Av. yield = average yield in kg ha^{-1}; * indicate significance at 1 % levels of significance. For an explanation of abbreviations, see Table 1.

3.2.3 District-wise costs and returns in paddy cultivation

The average paddy yields in OF and CF are the same in both districts. All costs (A1, A2, B2, C2) are much lower in OF than in CF in both districts (Table 4). However, on average, the total cost (C2) of paddy cultivation is higher in Bulandshahr district than in the Haridwar district in both farming systems. Further, VOP is lower in OF than in CF in both districts but much lower in Haridwar (Rs 69424) than in Bulandshahr (Rs 84145). Overall, paddy is not a profitable crop in the Haridwar district as FLI and net profit are negative in both types of farming, whereas OF in paddy performed better in Bulandshahr than in the Haridwar district. Statistically significant t-values of various cost and return variables indicate that costs and returns significantly differ between OF and CF systems. The insignificant t-values in the case of the average area and FLI in Haridwar show no significant difference between the two farming systems in terms of area and Cost C2 in Haridwar and yield and VOP in the Bulandshahr district.

3.3 Costs and returns in sugarcane, wheat, and paddy by the size of landholdings

3.3.1 Costs and returns in sugarcane by the size of landholdings

Table 5 shows that most farmers in the study area cultivating sugarcane are either marginal or small, and the average landholding with marginal farmers is 0.62 ha for both OF and CF farmers. The results indicate that the per-hectare yield of organic sugarcane increases with farm size, showing a positive relationship between farm size and productivity. In the case of CF sugarcane, the yield is almost the same for all land sizes. Along with high yield, the costs are also higher in the case of larger land sizes in OF, which could be due to higher handling costs.

On the other hand, in CF, the average yield and costs are similar for all land sizes, which shows that the performance of CF is not affected by the farm size. The VOP is also higher for large organic farmers than for small and marginal farmers, and it is more or less the same for conventional farmers under different landholding categories. The FBI and FLI are lower in the case of OF, who own larger lands. This is because of the higher variable costs associated with larger land sizes. Similarly, the net profits are also higher in large farms under organic sugarcane. Further, the mean differences between OF and CF in all the cost and income measures of the two farming systems are statistically significant, except in C2 under marginal, A1, A2, and B2 under medium, and VOP under large categories of land holdings.

3.3.2 Costs and returns in wheat by the size of landholdings

The average yield for wheat in OF and CF is the same for all land sizes; however, the costs are higher for farmers with larger land sizes in OF (see Table 6). CF farmers incur similar costs for different land sizes. It shows that land sizes do not impact the economics of CF much. The cost of cultivation is higher for CF for all the land sizes than that incurred in OF. The VOP is higher in CF than in OF. In the case of organic wheat, VOP is higher on marginal and small farms than on medium and large farms.

In contrast, in the case of CF, VOP from wheat is highest on medium, followed by marginal and small farms. Organic farmers with large landholdings earn less FBI and FLI than small and marginal ones. Cost A2 rises with the increase in farm size mainly because of hired labour costs. Similarly, in the case of organic wheat, FLI in organic wheat is found to be inversely related to farm sizes. It is highest on marginal farms and lowest on large farms. The net profit from organic wheat on marginal farms is higher than that of small, medium, and large organic farms, resulting from the lower costs.

3.3.3 Costs and returns in paddy by the size of landholdings

In the case of paddy, the study does not find any significant difference in the per-hectare productivity across farm sizes in both farming systems. However, a significant difference exists between OF and CF in paddy productivity. The per-hectare yields in OF are lower than in CF (Table 7). In the case of OF paddy, all cultivation costs (A1, A2, B2, C2) are positively associated with the farm sizes. In contrast, in CF, these costs do not vary substantially across farm sizes,

Table 5: *Cost & return in sugarcane by size of landholdings.*

Various measures	Marginal			Small			Medium			Large		
	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value
Av. area§	0.62	0.62	0.18	1.27	1.18	−2.14**	1.75	2.67	0.65	5.67	7.0	2.69**
Av. yield†	69500	93900	22.18*	72400	95900	19.50***	72800	92000	12.29***	75900	93500	0.05
Cost A1	103267	142205	13.62*	114699	131861	6.44*	119597	123187	−1.16	137678	130893	−9.91*
Cost A2	104418	142205	11.65*	116606	143796	7.39*	121310	131243	0.24	137678	130892	−9.92*
Cost B2	168361	185455	5.78*	178950	193814	4.91*	182862	188632	−0.21	199011	195892	−16.65*
Cost C2	210709	213276	1.78	213268	225944	5.70*	213058	224400	3.79*	214292	228292	−10.15*
VOP	230077	309064	20.56*	243091	315147	16.45*	243393	301905	11.05*	253204	306275	-0.52
FBI	125660	166859	10.59*	126485	171351	9.78*	122083	170662	9.62*	115526	175382	8.18*
FLI	61716	123608	22.66*	64141	121333	14.35*	60531	113273	11.31*	54193	110382	12.21*
Net profit	19368	95787	30.67*	29823	89202	17.16*	30335	77505	9.75*	38912	77982	3.50**

Source: Authors' estimation. §Av. area = average area in ha; †Av. yield = average yield in kg ha^{-1}; * and ** indicate significance at 1 % and 5 % levels of significance, respectively. For an explanation of abbreviations, see Table 1.

Table 6: *Cost & return in wheat by size of landholdings.*

Various measures	Marginal			Small			Medium			Large		
	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value
Av. area§	0.63	0.57	-2.37**	1.29	1.18	−3.22*	2.57	2.67	0.74	5.37	7	4.15*
Av. yield†	3900	5000	30.67*	3900	4900	25.92*	3900	5000	14.58***	3900	4900	15.65*
Cost A1	41825	46652	5.79*	42735	47677	5.68*	47399	50041	1.42	48726	48122	−0.62
Cost A2	42119	48029	6.04*	43495	51227	5.50*	48765	53930	1.76	48726	48121	−0.62
Cost B2	73046	85567	14.10*	73927	87768	15.86*	78461	89069	5.08*	78908	90621	11.63
Cost C2	85633	94398	12.97*	85654	95216	13.71*	86675	95672	4.52*	84880	93861	16.14
VOP	96928	116278	17.91*	95470	114690	16.65*	93228	117135	11.27*	93315	112489	7.96
FBI	54809	68248	9.82*	51976	63462	6.66*	44464	63204	5.99*	44589	64367	9.52
FLI	23882	30710	5.48*	21544	26920	4.02*	14767	28065	4.01*	14407	21867	3.45
Net profit	11295	21879	9.95*	9817	19472	7.82*	6554	21462	4.37*	8435	18627	4.53

Source: Authors' estimation. §Av. area = average area in ha; †Av. yield = average yield in kg ha^{-1}; * and ** indicate significance at 1 % and 5 % levels of significance, respectively. For an explanation of abbreviations, see Table 1.

implying that land sizes do not play any role in deciding the costs. FBI, FLI, and net profits in an organic paddy on medium and large farms are lower than on marginal and small farms.

Table 7: *Cost & return in paddy by size of landholdings.*

Various measures	Marginal			Small			Medium			Large		
	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value	OF	CF	t-value
Av. area§	0.63	0.59	−1.49	1.27	1.18	−2.36**	2.60	2.67	0.49	5.02	7	3.98*
Av. yield†	3600	5600	43.76*	3600	5700	31.10*	3600	5600	14.28*	3600	5700	21.19*
Cost A1	33233	58589	22.70*	38831	59243	15.93*	44611	59844	8.11*	49689	61619	5.42*
Cost A2	33233	60135	22.40*	39176	61601	15.10*	46680	63733	5.83**	49689	61619	5.42*
Cost B2	65196	97721	28.14*	70607	99551	21.42*	76594	99010	10.52*	81832	104119	10.50*
Cost C2	87795	111248	34.89*	88343	111775	30.29*	88607	109461	11.29*	88708	109042	32.14*
VOP	81056	112634	15.32*	80261	107797	11.97*	77659	101267	5.69*	79688	108111	8.55*
FBI	47823	52498	1.96**	41085	46195	2.13**	30979	37533	1.56	29999	46492	4.95*
FLI	15859	14912	−0.38	9654	8245	−0.54	1066	2255	0.25	−2144	3992	1.71
Net profit	−6740	1385	3.72*	−8082	−3978	1.75**	−10947	−8193	0.58	−9021	931	2.71**

Source: Authors' estimation. §Av. area = average area in ha; †Av. yield = average yield in kg ha^{-1}; * and ** indicate significance at 1 % and 5 % levels of significance, respectively. For an explanation of abbreviations, see Table 1.

Along with higher costs, a higher level of hired labour in OF resulted in such a pattern. The negative values here are also the result of accounting for the imputed value of family labour, which is not included in costs A1, A2, B1, and B2 (variable and fixed costs). The t-value of FLI in all landholding categories is not statistically significant in paddy cultivation, showing no difference between the two farming systems. Further, the net profit under both farming systems is negative or very low.

3.4 The benefit-cost ratios (BCR) of the three crops

After analysing the costs and returns in the two farming systems, the ratio of gross returns over the total costs gives a clearer picture of actual benefits and costs under OF vis-a-vis CF. Table 8 shows the BCR of the three major crops for OF and CF in the study area. The BCR of VOP to cost A1 (variable costs) is greater than one and higher for CF in sugarcane and wheat. In contrast, it is greater for OF in paddy cultivation. Similarly, the ratios of VOP to cost B2 and cost C2 are higher under CF for sugarcane and wheat cultivation. The results show that sugarcane cultivation is more profitable than other crops, irrespective of farming systems. However, farmers who opted for CF achieve more profit than those who adopt OF. In the case of paddy cultivation, the BCR under OF is better than in CF.

Table 8: *Benefit-cost ratio (BCR) of sugarcane, wheat, and paddy crops under two farming systems.*

Various measures	*Sugarcane*		*Wheat*		*Paddy*	
	OF	*CF*	*OF*	*CF*	*OF*	*CF*
The ratio of VOP to:						
Cost A1	2.08	2.29	2.19	2.45	2.10	1.87
Cost B2	1.34	1.65	1.28	1.34	1.14	1.12
Cost C2	1.13	1.42	1.11	1.22	0.91	0.99

Source: Authors' estimation. For an explanation of abbreviations, see Table 1.

4 Discussion

The current study analyses the costs and returns of OF and CF systems in the Ganga River basin India. The study's findings provide valuable insights towards the actual benefits and costs associated with OF and CF. The average yield of sugarcane, wheat, and paddy under OF is much lower than that in CF in the study area. These findings align with earlier studies (Mäder *et al.*, 2002; Uematsu & Mishra, 2012; van Quyen & Sharma, 2003). A lower yield in OF might be because farmers in the study area have been practicing OF for 3 to 5 years, which is still the conversion period for organic farmers. The findings from various literature indicate that the yield under OF decreases in the initial periods when they convert from CF to OF (Aulakh & Ravisankar, 2017; Digal & Placencia, 2019; Padel, 2001; Priya & Singh, 2022; Singh *et al.*, 2023). All costs associated with producing three major crops under OF are also lower than CF because of the cheaper and mostly internal inputs, like bio-pesticides (or "Jeevamrit"). This result aligns with several studies (Kshrirsagar, 2008; Heinrichs *et al.*, 2021; Sgroi *et al.*, 2015). However, Uematsu & Mishra (2012) and Kumar *et al.* (2017), in their studies, found a higher cost of cultivation in OF than CF due to high opportunity costs under OF. Although our findings show that costs associated with OF are lesser than CF, the overall returns under OF are also lower than CF. The primary reasons for lower profitability in OF can be attributed to the substantial productivity gaps between the two farm systems and the lack of premium prices for organic produces, which is further associated with a lack of proper marketing structure (Bayramoglu & Gundogmus, 2008). Therefore, in order to enhance the productivity of OF, focus should be given for reorientating research and development (R&D), premium price coupled with developing organic market channels.

The district-wise comparison of cost and cultivation of OF and CF shows higher returns in Bulandshahr than in Haridwar for all three crops. The net returns in sugarcane earned by CF farmers in Bulandshahr are more than two times that of OF farmers. The reason may be due to the well-established supply chain for CF sugarcane and the high proximity to sugar mills in Bulandshahr, and CF farmers can easily sell their produce at competitive prices in Bulandshahr. The existing literature also shows that the market size directly correlates with agricultural profitability (Bandanaa *et al.*, 2021; Levi *et al.*, 2020). Similarly, in the case of wheat cultivation, costs and returns in OF are lesser than in CF in both districts, which shows wheat cultivation under OF is more cost-effective than CF in the study area. Moreover, paddy is the least remunerative crop among all the crops in both farming systems, showing that the region is less suitable for paddy cultivation. Our results are consistent with the study conducted by (2014) in the region and prove that the area is less suitable for paddy cultivation.

Likewise, the findings show that landholding size affects OF's costs, returns, and yields, while it does not make much difference in CF. The yield of all three crops is less under OF for all land sizes. In organic sugarcane, per hectare yield increases with landholding size. These results align with the study conducted by Kshirsagar (2008), where he found that OF in sugarcane cultivation gives better output on larger landholdings in Maharashtra, India. Farm size does not play a significant role in costs and returns in the case of wheat and paddy crops under both farming systems. However, the cost under OF for wheat and paddy cultivation is less than the CF, regardless of farm size. Sudheer (2013) also shows that cost and returns are generally lower in OF than CF, irrespective of crops and size of landholding in India.

The BCR ratio of VOP to cost A1 (variable costs) is higher for CF in sugarcane and wheat, indicating that these crops are less remunerative under OF than CF in the study area. Our results are consistent with the findings of Bayramoglu & Gundogmus (2008), which reveal that OF is comparatively less cost-efficient than CF. Conversely, Kumar *et al.* (2017) and Suwanmaneepong *et al.* (2020) find that the returns (or BCR) under OF are higher than CF. As discussed above, the lower returns in the current study might be due to the transition period of conversion from CF to OF. Therefore, the government should adopt policies focusing on input subsidies and price premiums to make OF more efficient. Similarly, the ratios of VOP to A1 and VOP to Cost B2 are greater for the OF in paddy, which shows that even though the region is less suitable for paddy cultivation, the comparative returns are higher under OF than CF. Therefore, for paddy cultivation in the area, the focus should be on its cultivation under OF. Further, during the field survey, it was observed that although the situation regarding marketing is similar in the case of all crops, most OF wheat farmers could fetch a premium price for their products because of their network with the consumers. In contrast, in the case of sugarcane and paddy, organic producers' networks could not work to provide better prices as these products do not directly cater to the final consumers' demands. Therefore, the initial drop in crop yield and poor marketing infrastructure for organic products are deterrents to scaling up OF in the study area; hence, policy should be focused on price guarantees and market access for organic products.

The lack of a bio-input market and knowledge deficit among farmers also affect the productivity and profitability of these crops under OF. Primarily, bio-fertilisers and bio-pesticides are prepared by farmers themselves. Therefore, farmers' training and awareness programs can improve their performance. It is also observed that farmers practice OF only on the part of their lands, and therefore, a separate cluster of OF could not be formed, raising the risk of crop contamination. The lack of availability of inputs, the initial drop in yields, and poor marketing infrastructure for organic products are deterrents in scaling up OF in the study area. Moreover, the assessment of costs, returns, and profitability in the two farming systems is based only on private costs and returns, excluding external costs and benefits (ignoring externalities). If both negative and positive externalities are internalized, then the real profitability of the two farming systems would change. The existing literature suggests that the CF system has been a significant cause of soil degradation and fertility loss, pollution of water bodies, and natural resource depletion (Biswas, 2016; Imran *et al.*, 2018). OF is considered more environmentally sustainable than CF; however, its scale in the study largely depends on its economic and social sustainability (Dasgupta *et al.*, 2021; Knudsen *et al.*, 2014; Tashi & Wangchuk, 2016), which calls for a stable policy and institutional support.

5 Conclusion

The comprehensive examination of the costs and returns associated with OF and CF systems for sugarcane, wheat, and rice crops in the Ganga River basin in India gives essential insights into the economic dynamics of both farming practices. The study found that, on average, OF yields lower outputs for sugarcane, wheat, and paddy than CF, which is consistent with previous studies on the initial yield drop during the CF to OF transition phase. Despite lower production costs in OF, the total returns in OF are shown to be lower than those in CF. This profit difference is primarily due to significant production disparities, a lack of premium prices for organic goods, and insufficient marketing infrastructure. District-level comparisons reveal various degrees of profitability, with Bulandshahr outperforming Haridwar in all three crops, highlighting the importance of well-established supply linkages and market proximity. The study also examines the influence of landholding size on OF costs, returns, and yields, stressing the beneficial relationship between landholding size and organic sugarcane output. Despite mixed results for farm size and profitability, the findings highlight the need for policy interventions to improve the economic viability of OF. The lack of bio-input markets, insufficient marketing infrastructure, and the requirement for farmer training programs to bridge knowledge gaps are some challenges for OF adoption. Hence, to reduce the profitability gap between OF and CF, policies should focus on establishing organic market channels, premium prices, and R&D initiatives.

6 Policy implications

A comparative analysis of costs and returns in the two farming systems indicates that OF is less profitable than CF, mainly due to lower productivity and a lack of premium prices. Therefore, the policy must focus on increasing productivity by orienting R&D and extension services towards

OF and ensuring premium prices. OF can be an economically viable option in the study area with strong marketing networks, farmers' linkages to processors and distributors, an easy certification process, removal of knowledge deficit through training and capacity-building programs, and farmers' risk minimisation by institutionalizing the ecosystem services' payment system. The problem of up-scaling of organic production can be addressed through farmers' collectives, contract farming, and FPOs. In addition to the PGS certification, a common branding of organic products would help consumers believe in the products' authenticity and pay a premium for the same.

Although OF is incentivised to be practiced in clusters, OF farmers allocate a part of their lands to OF and practice CF farming in the rest of the area, raising the risk of contamination and defeating the cluster approach's purpose in OF. In practice, OF groups are not formed on a cluster basis. Farmer members in the group have their land scattered, not in one place. The study suggests that a cluster of organic growers should be formed continuously to promote collective production and marketing.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the authorship, research, and publication.

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