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Profitability Analysis of Major Crops in Punjab: Some Evidence from Cost of Cultivation Survey Data*

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ABSTRACT

During the past half century, the Punjab state achieved exemplary growth in food grain production. Consolidation of landholdings, reclamation of new agricultural lands, development of irrigation, use of biochemical inputs comprising high yielding variety seeds, chemical fertilizers, insecticides and mechanical inputs were among the important factors which helped agriculture in the state in making rapid strides The fast shift in the area from traditional diversified crops to mono-culture of rice wheat system was driven by forces such as price policy, technological change, market infrastructure and low cost of irrigation. The underground water is being used indiscriminately and due to over exploitation of water resource, the sustainability of existing crop systems is becoming doubtful creating critical second generation problem. Evidently, the state agriculture has reached at a stage of stagnation whereas the social cost is increasing due to environmental degradation. Though the economic evaluation of social cost is a cumbersome process, an attempt has been made to access the performance of different crops and cropping pattern in the state of Punjab using alternative scenarios like market prices, economic prices (without subsidies) and natural resource valuation (NRV) considering environmental benefits like biological nitrogen fixation and greenhouse gas costs. The results revealed that on the basis of market prices, basmati and paddy common generated net returns of ₹54289/ha and ₹45360/ha respectively as the net returns from other crops were less. The basmati remains the most remunerative crop with net returns of ₹41633/ha at economic prices and for paddy common net returns at economic prices were ₹33191/ha. The net returns from basmati and paddy common were estimated to be ₹33951/ha and ₹31733/ha on the basis of NRV. The results also brought out that alternative crops gave lower returns ascompared with paddy. The present set of marketing infrastructure and agricultural technological know-how, the rice-wheat cropping pattern is likely to produce the highest and more stable income. The sustainability of natural resources can be achieved only if same platform of technology-market-Govt. assurance for other alternative crops will be provided to the farmers Market incentives for other crops should be explored so that farmers could move away from thirsty crops such as rice.

Keywords
Groundwater, profitability, subsidies, technology

JEL Codes
Q15, Q16, Q18

INTRODUCTION

During the past half century, the Punjab state achieved exemplary growth in food grain production. The state particularly known as the *Granary of India* is contributing 18.37 per cent of wheat, 10.55 per cent rice and 4.09 per cent cotton of the country's total output (Anonymous, 2014) apart from sizeable share in the production of various other crops. It is well documented, that the state has witnessed tremendous increase in the agricultural production during the Green Revolution period, supported by a mix of institutional and technological factor A total of 85 per cent of the area in the state is under agriculture. The area sown more than once has increased by 250 per cent since the late sixties. Consolidation of landholdings, reclamation of new agricultural lands, development of irrigation, use of biochemical inputs comprising high yielding variety seeds, chemical fertilisers, insecticides and mechanical inputs were among the important factors which helped agriculture in the state in making rapid strides. Thus, by exploiting high potential agriculture of the state, the country which was in the grip of serious food shortage till 1960s' has now been

*The paper is drawn from the ongoing ICAR-NIAP network project on Regional Crop Planning for Improving Resource Use Efficiency and Sustainability.

able to generate, even surpluses apart from meeting the needs of its rapidly growing population. The fast shift in the area from traditional diversified crops to mono-culture of rice wheat system was driven by forces such as price policy, technological change, market infrastructure and low cost of irrigation. The underground water is being used indiscriminately and due to over exploitation of water resource, the sustainability of existing crop systems is becoming doubtful creating critical second generation problem. Evidently, the state agriculture has reached at a stage of stagnation whereas the social cost is increasing due to environmental degradation. Though the economic evaluation of social cost is a cumbersome process, an attempt has been made to access the performance of various crops and crop sequence in the state of Punjab in terms of market prices, economic prices and natural resource valuation which will help gain insight into the suitability of various crops in Punjab from long term prospects of society. Against this backdrop, the present study was undertaken:

i. toexamine the cropping pattern , irrigation pattern and crop-wise fertilizer consumption pattern in Punjab,
ii. to analyze the crop-wise groundwater extraction and usage in Punjab, and
iii. to estimate the profitability of different crops using market prices, economic prices and natural resource valuation technologies

METHODOLOGY

The study is primarily based on plot-level data collected under "Comprehensive Scheme for Cost of Cultivation of Principal Crops" of Directorate of Economics and Statistics (DES), Ministry of Agriculture. In the Cost of Cultivation Scheme (CCS), each sample household is surveyed consecutively for three years and the latest available data pertains to the period 2008-09 to 2010-11 (block year ending 2010-11). The plot-wise data were collected from the 300 representative households of 30 tehsils during each year of the block period (2008-09 to 2010-11). From three agro-climatic zones of the state, farmers were selected using three-stage stratified sampling technique, with tehsil as stage one, a village or cluster of villages as stage two and operational holdings within the cluster as stage three. From each cluster, a sample of 10 operational holdings, two each from the five size-classes, *viz*. marginal (< 1 ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-6 ha) and large (> 6 ha), were selected randomly. Secondary data for subsidy rate on fertilizers and electricity were procured from Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India and Punjab State Electricity Regulatory Commission (*website: http://www.pserc.nic.in/*). The data on district wise ground water depth of observation wells for the three years 2008, 2009 and 2010 was taken from Central Ground Water Board (CGWB, 2014), Ministry of Water Resources, Government of India. Statistical Abstract of Punjab, (Various issues) has been used to retain data on various cropping and irrigation parameters of Punjab agriculture. The volume of total groundwater for irrigating major crops in Punjab was estimated as the product of irrigation hours and per hour groundwater draft (cum/hr). The irrigation hours (hrs/ha) for each crop were taken from plot-wise CCS data. As CCS does not collect information on groundwaterdraft, it was estimated using the following formula (Srivastava *et al*., 2014)

$$\text{Groundwater draft lit/sec} = \frac{\text{Hp} \quad 75 \quad \text{Pump efficiency}}{\text{Total head (m)}}$$

Where HP- Horse power (Hp) of the pumps owned by the farmers

The crop-wise groundwater footprints (cum/kg) was estimated by dividing total groundwater use with the respective crop yield. Similarly, groundwater productivity (`/cum) was estimated by dividing value of output (main + by product) with the groundwater use. The net returns under alternative scenarios were compared as under

(i) **Net Returns at Market Prices:** Net returns at market prices can be defined as the gross return (value of main product and by product) less variable costs (Cost A1 + imputed value of family labour) at market prices actually paid and received by the farmer or imputed in some cases

$$NR_{MP} = GR - VC \ldots\ldots\ldots (i)$$

Where, NR MP – Net returns at market prices; GR- Gross Returns; and VC- Variable Costs

(ii**) Net Returns at Economic Prices:** Net return at economic prices (NR_{EP}) can be defined as the difference between net return or income at market prices and subsidies on inputs like fertilizers and irrigation used in crop production

$$NR_{EP} = NR_{MP} - Subsidy \ldots\ldots\ldots\ldots (ii)$$

Thus, subsidy component has internalized into the model, by covering two aspects viz., fertilizer subsidy and irrigation subsidy. Fertilizer subsidy consists of subsidy on nitrogen (N) and combination of Phosphorous (P) and Potassium (K). The total irrigation subsidy includes canal, electricity and diesel subsidy and has been distributed over selected crops based on area under irrigation of each crop.

(iii) Net Returns using Natural Resource Valuation Technique

Net return based on Natural Resource Valuation (NRV) technique has been used taken care of nitrogen fixation by legume crops and Green House Gas (GHG) emission from crop production. As such *NRNRV* is computed as by adding value of nitrogen fixation by legume crops at economic price of nitrogen (Value of N) and deducting the imputed value of increase in GHG emission cost to the atmosphere

$$i.e.\ NRN_{RV} = NR_{EP} + (Value\ of\ N - Cost\ of\ GHG). \ (iii)$$

As such, the economic valuation has been done by taking into account the positive externality of legume crops by biological nitrogen fixation and the negative externality of GHG emissions. The data on contribution

of pulses by biological nitrogen fixation and emission of different crops were collected from various published scientific literature, (Peoples *et al*., 1995, IIPR, 2003; Anonymous, 2014a). The value of GHG emissions in terms of CO_2Kg equivalent was taken at the rate of 10 US dollar per tonne. Biological nitrogen fixation for various crops has been calculated by taking the average value of nitrogen fixed by various legumes and then multiplied with the economic price of nitrogen prevailed in the TE 2010-11.

RESULTS AND DISCUSSION

Changes in Cropping Pattern in Punjab

The cropping pattern in the state is shown in Table 1. The results revealed that in the TE 2013-14, nearly 82 per cent of the gross cropped area was under the cereal crops. Wheat is the principal crop of Punjab which alone had 44.59 per cent of the gross cropped area followed by rice (35.88 per cent area) and cotton (6.25 per cent area). Thus, wheat and rice taken together occupied nearly 81 per cent of the area. Rice is not a historical crop of Punjab. The area under paddy was just 7.15 per cent of the gross cropped area in the TE 1973-74 which increased to 35.88 per cent in the TE 2013-14. The major factors responsible for increase are high and stable yield compared to other Kharif crops, assured minimum support price and public procurement. Since the net returns to the farmers from paddy crop are high *vis-à-vis* other competing Kharif crops. So paddy was replaced Kharif pulses and oilseeds on a large scale in the last decades. Increasing area under wheat has also replaced rabi pulses particularly gram and oilseed crops. This crop has high and stable yield, assured price and public procurement as compared to other rabi crops. It is also a staple food of Punjabis. Wheat Bhusa, the by-product of wheat is used on a very large scale by the farmers to feed dairy animals.

The share of cereals like bajra and maize has declined sharply. As the share of maize in gross cropped area has declined from 9.76 per cent in the TE 1973-74 to 2.56 per cent in the TE 1993-94 and further to 1.68 per cent in the TE 2012-13. Maize infact is replaced by the paddy crop. Although the MSP is announced for maize crop every year but there is no effective public procurements. Therefore, to avoid price risk, the Punjab farmers particularly of the central zone shifted from maize to paddy on a large scale during Kharif season. The area under pulses and oilseeds has recorded a sharp decline.

Table 1: Changes in cropping pattern in Punjab during 1970-71 to 2013-14

(Per cent)

Crop	TE 1973-74	TE 1993-94	TE 2013-14
Paddy	7.15	26.74	35.88
Wheat	40.57	43.52	44.59
Bajra	3.37	0.14	0.04
Maize	9.76	2.56	1.68
Total Cereals	60.85	72.96	82.19
Pulses	7.17	1.53	0.18
Oilseeds	5.41	1.61	0.50
Sugarcane	2.27	1.40	0.98
Cotton	7.64	9.51	6.25
GCA ('000 ha)	5589	7473	7887

The pulses share in area dropped from 7.17 per cent in the TE 1973-74 to 1.53 per cent in the TE 1993-94 and further to 0.18 per cent in the TE 2013-14. Similarly area share of oilseeds fell from 5.41 to 0.50 per cent per year over the period of forty year Thus expansion of area under paddy cultivation has been mainly at the cost of maize, groundnut millets and cotton while the wheat gained from area under gram, rapeseed and mustard, barley etc. The area under commercial crops also declined drastically. Therefore, cultivation of cereals, particularly rice and wheat, not only enjoyed productivity advantages but also ensured stable and assured economic returns which raised their relative profitability. Consequently, there was a large shift in land and other resources towards cultivation of these two cereal crops. The combination of technological breakthroughs and strong policy support has served the important purpose of achieving food security for the country. Consequently wheat-rice crop rotation has come to dominate the cropping pattern in the state.

Changes in Irrigation Pattern in Punjab

The state has well developed surface and groundwater irrigation infrastructure. The surface irrigation distribution network comprises 1,45,000 km of canals including branch canals and minor distributories and one lakh km of field channel or water courses. The canal irrigation system irrigated about 27.37 per cent of the net irrigated area in the state and the share of canal irrigation has declined sharply from 46.50 per cent in the TE 1970-71 to 39.94 per cent in the TE 1990-91 and further to 27.37

Table 2: Changes in irrigation pattern in Punjab during TE 1970-71 to TE 2011-12

Particulars	TE 1970-71	TE 1980-81	TE 1990-91	TE 2000-01	TE 2011-12
Net irrigated area ('000 ha)	2691.67	3389.00	3868.33	3990.67	4068.33
Irrigated (% to net area sown)	69.33	81.00	92.00	94.33	97.73
Irrigation coverage					
Surface water (per cent)	46.56	42.85	39.94	25.97	27.37
Ground water (per cent)	53.44	57.15	60.06	74.03	72.63
No. of pumps (in Lakh)	0.64	5.73	7.69	10.12	13.8
Electric (per cent)	47.40	45.06	73.73	77.51	82.23
Diesel (per cent)	52.60	54.94	26.27	22.49	17.77

per cent in the TE 2011-12 (Table 2). On the other hand, the groundwater irrigation (tubewell irrigation) particularly in the Central and Northern regions of Punjab has been on the increase. During 1970□s irrigation done by using groundwater accounted for 53.44 per cent which has jumped to 72.63 per cent in 2011-12.

The important reason behind such increase in the use of groundwater resource is phenomenal increase in the growth of groundwater abstraction structures (tubewells) due to their technical feasibility (groundwater is sweet) and economic viability (electricity to pump out water for irrigation is free) backed by huge investment in generation and distribution of power to farm sector and good quality seeds and use of chemical fertilizers There has been sharp increase in the total number of tubewells from 0.64 lakh in TE 1970-71 to 7.69 lakh in the TE 1990-91 and then to 13.80 lakh in the TE 2011-12 in the state. The share of electric operated tubewells in the total number of tubewells increased from 47.48 per cent in the TE 1970-71 to 82.23 per cent in the TE 2011-12 while the share of diesel operated tubewells during the same period has declined from 52.60 per cent to 17.77 per cent. The density of tubewells per thousand hectare of net sown area (NSA) for the state was 66 in 1980- 81, which rose to 287 in 2012-13. This clearly explains the extent of ground water exploitation in Punjab (Kaur *et al.*, 2015) Subsidized power to agriculture lead to installation of more and more electric-tubewells and consequent greater withdrawal of groundwater than ever before.

Crop-wise Consumption of Fertilizers in Punjab

The crop wise fertilizer consumption was estimated using the unit level COC data of Punjab for the TE 2010-11. Nitrogen has emerged as the major component in fertilizer consumption across all crops in the state. The average fertilizer use per hectare for wheat and paddy was 282.93 kg and 249.48 kg respectively compared to 550.32 kg, 368.53 kg, 343.75 kg and 218.11 kg for potato, sugarcane (planted), sugarcane (Ratoon) and cotton respectively. Vegetables were applied 316.23 kg/ha fertilizers while for maize fertilizer usage was 261.03 kg/ha. However, potato, sugarcane and vegetables have been found to be the higher consumers of macro nutrients (Table 3).

Table 3: Crop-wise consumption of fertilizers in Punjab, TE 2010-11

(Kg/ha)

Crops	N	P	K	NPK
Wheat	172.15	68.71	42.08	282.93
Paddy	158.01	49.09	42.38	249.48
Basmati	105.72	46.10	43.16	194.99
Maize	136.86	64.17	60.00	261.03
Potato	264.59	186.05	99.67	550.32
Sugarcane	248.51	85.65	34.37	368.53
Sugarcane ratton	287.28	56.47	0.00	343.75
Rapeseed & Mustard	101.95	50.98	15.00	167.93
Cotton	126.89	48.98	42.23	218.11
Vegetables	121.69	107.04	87.50	316.23
Fodder	128.01	59.27	32.47	219.75
Arhar	85.52	28.75	-	114.27
Barley	132.46	69.83	-	202.29
Groundnut	15.00	38.33	-	53.33
Gram	18.00	46.00	-	64.00
Oilseeds	143.75	-	-	143.75
Mesta	74.73	38.38	-	113.11
Moong	60.00	27.49	-	87.49
Pea	149.68	107.40	8.46	265.54
Sunflower	134.05	58.44	-	192.49
Urad	35.16	23.00	-	58.16

Groundwater Extraction and Use in Punjab

Crop-wise ground water extraction

The largest component of ground water use is the water extracted for irrigation. The main means of irrigation in the state are canals and tube-wells. Of these sources, ground water constitutes the largest share. Over the years, there has been a decrease in surface water use and a continuous increase in ground water utilization for irrigation. The practice of providing power subsidies for agriculture has played a major role in decline of water levels the state.

The extent of groundwater use varies across different crops depending upon the pumping hours and average yield (cubic meter/hour) of the pumps. Pattern of groundwater extraction in Punjab is presented in Table 4. It was found that Punjab farmers run tubewells for 252.46 hours to cultivate one hectare of paddy followed by 179.07 hours for sugarcane, 52.92 hours for wheat, 34.92 hours for maize and 33.25 hours for cotton. The pump-wise decomposition further revealed that about 50 per cent of the groundwater irrigation is given using submersible pumps except for cotton and sugarcane. The dominance of submersible pumps for major crops indicates a deeper water table in large part of the state. For cotton cultivation, submersible pumps are not used primarily because the crop is grown in water logging and salinity affected south-western part of the state. Due to salinity problems farmers prefer canal irrigation and use groundwater as a supplementary irrigation

Crop-wise groundwater usage

The perusal of Table 5 reveals that among major crops, paddy was found to be the most water guzzling crop with the groundwater use of 11097.51 cum/ha during 2010-11. The groundwater use for cultivation of other crops was 9.29 (for maize) 40.34 (for cotton) and 83.47 (for sugarcane) per cent of the groundwater use in paddy depending upon the crop duration and water requirements. On an average, production of one kilogram of paddy in Punjab required 1702.77 litres groundwater and the estimated groundwater foot prints for other crops (except cotton) were much less than for paddy. Due to substantially high groundwater use, groundwater productivity (₹/cum) of paddy was also much less than

Table 4: Crop-wise groundwater extraction in Punjab, TE 2010-11

Crops	Ground water irrigation hours (Hr/ha)				Share in total irrigation hours (Per cent)		
	Diesel	Electrical	Electric	Total	Diesel	Electrical	Electric
Wheat	3.94	19.32	29.66	52.92	7.45	36.51	56.04
Paddy	16.90	110.01	125.55	252.46	6.69	43.58	49.73
Basmati	9.50	77.08	178.80	265.39	3.58	29.05	67.37
Cotton	23.58	6.84	2.83	33.25	70.93	20.56	8.50
Maize	5.86	12.11	16.94	34.92	16.79	34.69	48.52
Sugarcane	28.36	64.45	86.27	179.07	15.84	35.99	48.18
Sugarcane ratton	19.42	151.54	54.46	225.43	8.62	67.22	24.16
Potato	16.03	39.88	66.00	121.90	13.15	32.71	54.14
Rapeseed	2.68	21.15	11.66	35.49	7.54	59.59	32.87
Fodder	6.82	33.23	61.89	101.94	6.69	32.60	60.71
Vegetables	-	25.70	99.58	125.28	-	20.51	79.49
Barley	2.04	13.10	42.51	57.65	3.54	22.72	73.74
Pea	0.15	9.36	40.20	49.71	0.30	18.83	80.87
Gram	22.50	0.00	17.50	40.00	56.25	0.00	43.75
Moong	19.83	0.00	16.19	36.02	55.05	0.00	44.95
Urad	6.66	7.08	17.50	31.24	21.32	22.66	56.02
Groundnut	23.33	56.25	0.00	79.58	29.32	70.68	0.00
Sunflower	35.04	38.40	25.66	99.10	35.36	38.75	25.89
Mesta	4.27	159.70	0.00	163.97	2.60	97.40	0.00
Arhar	10.95	65.06	42.46	118.47	9.24	54.92	35.84
Oilseeds	0.00	0.00	111.29	111.29	0.00	0.00	100.00

Table 5: Crop wise groundwater use in Punjab, TE 2010-11

Crops	Groundwater draft (Cum/ha)	Crop yield (kg/ha)	Groundwater footprints (*l*/kg)	Gross returns (₹/ha)	Groundwater productivity (₹/cum)
Wheat	3009.42	4263.67	705.82	54167.63	18
Paddy common	11097.51	6517.33	1702.77	69000.55	6.22
Basmati	11031.71	3696.00	2984.77	79485.44	7.21
Cotton	4477.43	2137.00	2095.19	72267.03	16.14
Maize	1031.29	3647.67	282.726	34678.48	33.63
Sugarcane	9263.47	72044	128.581	152480.07	16.46
Sugarcane (ratton)	9288.26	74131.00	125.29	154101.16	16.59
Potato	3974.10	25164,00	157.92	71389.05	17.96
Rapeseed	1467.38	3837.67	382.36	31388.42	21.39
Fodder	5196.98	63294.67	82.10	37836.70	7.28
Vegetables	3222.64	11525.67	279.60	74532.16	23.13
Barley	2321.18	3745.00	619.81	40968.83	17.65
Groundnut	1609.23	692.00	2325.48	24375.00	15.15
Gram	2134.97	900.00	2372.19	34200.00	16.02
Moong	1322.41	736.00	1796.75	23344.90	17.65
Pea	1125.00	4945.00	227.50	71483.81	63.54
Urad	1293.60	441.00	2933.33	14511.66	11.22
Sunflower	2655.97	1786.00	1487.11	35042.01	13.19
Mesta	7426.13	5422.00	1369.63	47787.49	6.44
Arhar	4789.91	11300.00	423.89	37685.33	7.87
Oilseeds	2963.56	730.00	4059.67	37125.00	12.53

Cum: Cubic metre

other crops. Thus paddy a dominant crop in the existing cropping pattern is ecologically not suitable for Punjab and thus resulting in rapid decline of water table in the state. It was also found that in terms of per unit production, basmati variety consumed 2984.770 litres/kg volume of groundwater than the paddy-non basmati (1702.71 *l*/kg) due to substantially lower yield in the year 2010-11. Inspite of lower yield, large price differential made basmati variety more remunerative than thepaddy non-basmati. Therefore, it is imperative to say that replacement of paddy non-basmati with basmati variety, may improve the farmers' income but with reducing the pressure on depleting groundwater resources in the state. Thus paddy (common) was found to be the most water intensive crop with groundwater use of 11097.51 cum/ha followed by paddy basmati (11031.71 cum/ha). Sugarcane (ratoon) consumed 9288.26 cum/ha groundwater. Wheat consumed lesser water (3009.42 cum/ha) compared to paddy but higher than rapeseed (1467.38). and maize (1021.29 cum/ha). The widespread paddy cultivation in the state is found to be the main cause of large scale depletion of groundwater. Thus, cropping pattern is needed to be diversified to curb the depletion of groundwater in the state.

Profitability of different Crops using Market Prices (MP), Economic Prices (EP) and Natural Resource Valuation (NRV)

Crop-wise net returns using market prices in Punjab

The comparative return or profitability is affected by the factors like yield levels, input use in production and their respective prices and output prices. The comparative returns at market prices along with the variable cost for various crops in Punjab are presented in Table 6. The variable costs included the cost incurred on different inputs such as feed fertilizer, manure insecticides, human labour (including family labour), machine labour and irrigation. During the TE 2010-11, the variable cost was found the highest in sugarcane, planted (₹57825.50) followed by potato (₹43541.16) and the lowest for wheat (₹17291.49), rapeseed (₹17776.74) and maize (₹19669.89). The variable costs in the production of cotton were ₹30192.96 while it was ₹23639.97 and ₹25196.89 for paddy non-basmati and basmati respectively. In the case of pulses, the variable costs were found the highest in the cultivation of peas (₹29267.07) while forurad, it was found lowest (₹12159.96). Among oilseeds, the variable costs incurred on the production of sunflower were ₹17568.01/ ha while in the case of sesamum it was ₹9811.85/ha.

The returns depend upon the cost of cultivation as well as the productivity of crop and its price. Among the crops, sugarcane (ratton) accrued the highest net returns (₹120536.53/ha) over the variable cost. As the crop occupies land for the whole year therefore, its net returns need to be compared with crop rotation or crop sequence in the year like paddy-wheat. The results brought out that net returns from sugarcane at market-prices turned out to be higher even when compared with the sum of net returns from paddy and wheat. The wheat-paddy (common) combination generated net returns of ₹82236.6 per ha which is lower than that of sugarcane. However, lack of marketing infrastructure for crops, other than wheat and rice, high transport cost and inadequate agro-processing units in the rural areas are the constraints to the spread of sugarcane cultivation in the state. The combination of wheat and paddy (basmati) due to its lower costs of cultivation turn out to be the best combination as the net profit from other combinations are less i.e. from wheat-maize (₹51884.65/ha) and wheat-cotton (₹78950.22/ha). The wheat-cotton combination yields less profit due to high cost of cultivation and italso involves higher risk due to price instability of cotton. On the other than in Kharif crops, pea gave the highest net returns of ₹42216.94 per hectare. Potato yielded net returns of ₹27847.90/ha. Thus it may be concluded that the wheat-rice (basmati) provided higher financial returns with relatively low risks. From the comparative cost and returns analysis for different crops in Punjab in the year 2010-11, sugarcane and paddy-basmati have emerged to be the most efficient crops in financial aspects. As such the wheat rice cropping pattern offers the best returns to the farmers in the given framework of productivity and marketing criteria

Table 6: Net returns from different crops using market prices in Punjab, TE 2010-11

(₹/ha)

Crop	Variable cost (A1+family labour)	Gross returns	Net returns at market prices
Wheat	17291.49	54167.64	36876.15
Paddy (common)	23639.97	69000.55	45360.58
Basmati	25196.09	79485.44	54289.35
Cotton	30192.96	72267.04	42074.07
Maize	19669.98	34678.48	15008.50
Rapeseed	17776.74	31388.42	13611.68
Potato	43541.16	71389.06	27847.90
Sugarcane	57825.50	152480.08	94654.58
Sugarcane ratton	33564.63	154101.16	120536.53
Fodder	37468.87	37836.71	367.84
Vegetables	33888.85	74532.17	40643.32
Barley	16610.88	40968.83	24357.95
Groundnut	21533.25	24375.00	2841.75
Moong	13732.79	23344.90	9612.11
Pea	29267.07	71483.81	42216.74
Urad	12159.96	14511.66	2351.70
Sunflower	17568.01	35042.01	17474.00
Sesamum	9811.89	20256.25	10444.36
Mesta	11462.70	47787.49	36324.79
Arhar	15368.44	37685.33	22316.89
Oilseeds	15537.81	37125.00	21587.19
Gram	16105.51	34200.00	18094.49

Crop-wise net returns using economic prices in Punjab

Net returns for different crops based on economic prices are presented in Table 7. The net returns at economic prices for different crops were computed by subtracting the input subsidies i.e. irrigation subsidy and NPK subsidy. Potato received the higher subsidy of ₹21104.41/ha because of higher fertilizer component followed by sugarcane planted (₹14870.13/ha), sugarcane-ratoon (₹14758.32/ha), paddy basmati (₹12656.15/ha) and paddy non-basmati (₹11789.60/ha). In total subsidy in paddy basmati, groundwater subsidy has the higher share of ₹6811.21/ha. Among the crops the minimum subsidy was used in rapeseed cultivation (₹5496.76/ha).

Table 7: Net returns from different crops using economic prices in Punjab, TE 2010-11

(₹/ha)

Crop	Ground water subsidy (Diesel & electricity)	NPK subsidy	Total subsidy	Net return on economic prices
Wheat	1565.73	8046.12	9611.85	27264.30
Paddy	4839.07	6950.52	11789.6	33570.99
Basmati	6811.21	5844.94	12656.1	41633.20
Cotton	2956.51	6337.43	9293.93	32780.14
Maize	882.96	7932.99	8815.95	6192.55
Rapeseed	716.06	4780.70	5496.76	8114.92
Potato	3824.00	17280.4	21104.4	6743.49
Sugarcane	4953.20	9916.94	14870.1	79784.44
Sugarcane	6796.15	7962.17	14758.3	105778.21
Fodder	2736.15	6381.38	9117.54	-8749.70
Vegetables	583.61	10634.4	11218.0	29425.31
Arhar	3572.01	2878.41	6450.43	15866.46
Barley	1623.75	5535.07	7158.82	17199.13
Groundnut	2298.76	1921.57	4220.33	-1378.59
Gram	1057.10	2306.06	3363.16	14731.34
Oilseeds	3134.67	2781.56	5916.23	15670.96
Mesta	4157.96	3079.48	7237.44	29087.35
Moong	3655.28	2330.97	5986.25	3625.86
Pea	3056.47	7827.31	10883.7	31332.96
Sunflower	1626.33	5081.07	6707.41	10766.59
Urad	749.53	1659.23	2408.75	-57.05

Net returns based on economic prices were the highest in sugarcane crop. Apart from the annual crop, the paddy-basmati remains the most remunerative crop with net income of ₹41633.20/ha at economic prices followed by peas per ha after deducting the subsidies. Potato ranks first in terms of input subsidy but is still notable to compete in the other important crops in terms of net income. Rice cotton and wheat provide net income of ₹33510.99/ha, ₹32780.14/ha, and ₹27264.30/ha respectively. After reckoning subsidies, the net returns from fodder became negative (₹8749.70/ha) and maize became least profitable crop in terms of economic prices.

Crop wise net returns based on natural resource valuation

Agriculture has significant effects on climate primarily through production and release of green house gas such as carbon dioxide, methane and nitrous oxide. Further open field burning of straw after combine harvesting is a common practice in the state in order to ensure early preparation of fields for the next crop. Economic valuation has been done by taking into account the positive impact of legume crops by biological nitrogen fixation and the negative impact of GHG emissions has been presented in Table 8.

Table 8: Net returns from different crops based on natural resource valuation in Punjab, TE 2010-11

(₹/ha)

Crop	Returns by adding economic value of nitrogen	Returns by deducting cost of GHG emissions	Net returns based on NRV
Wheat	27264.3	27081.3	27081.3
Paddy	33570.99	31732.99	31732.99
Basmati	41633.20	39795.20	39795.20
Cotton	32780.14	32729.14	32729.14
Maize	6192.55	6033.55	6033.55
Rapeseed	8114.92	7999.92	7999.92
Potato	6743.49	6508.49	6508.49
Sugarcane	79784.44	75986.44	75986.44
Sugarcane	105778.21	101980.21	101980.2
Fodder	-4562.70	-8846.70	-4659.70
Vegetables	29425.31	29190.31	29190.31
Arhar	17859.46	15769.46	17762.46
Barley	17199.13	17199.13	17199.13
Groundnut	3181.41	-1378.59	3181.41
Gram	18143.34	14634.34	18046.34
Mesta	29087.35	29087.35	29087.35
Moong	5860.86	3528.86	5763.86
Oilseeds	17663.96	15556.46	17549.46
Pea	32721.96	31332.96	32721.96
Sunflower	10766.59	10766.59	10766.59
Urad	2448.95	-154.05	2351.95

The fodder grown in Punjab fixed nitrogen equivalent to the economic contribution of ₹4187/ha while pea fixed nitrogen with ₹1389/ha (Appendix-I). Paddy caused the highest negative externality by providing GHGs costing ₹1839/ha whereas on the minimum GHGs costs were incurred by peas and fodder valued at ₹97/ha. On adding these benefits and deducting the costs from net returns on economic prices, overall returns can be obtained from cultivation of different crops to the society and the natural resource system. It can be seen from the table that net

income found to be the highest in sugarcane ratoon (₹101980.21/ha) followed by sugarcane planted (₹75986.44/ha). Paddy basmati still is at the top in seasonal crops in terms of net income. Peas found with the highest net returns based on NRV. Paddy non-basmati, cotton, vegetables and wheat have shown net returns of ₹31732.99, ₹32729.14, ₹29190.31, and ₹27081.30/ha, respectively on the basis of NRV.

Comparison of net returns using various approaches of valuation

It can be seen from Table 9 that there is a moderate to high decline in the net income from different crops after netting out subsidies on fertilizer, power and diesel. The impact of subsidy was seen so large that in some cases, the net income turned out negative (fodders). Placing economic value on the environmental effect further reduced the profitability of various crops. However, this effect was mild.

Table 9 : Net returns from different crops in Punjab using various approaches of evaluation, TE 2010-11 (₹/ha)

Crop	Based on market price	Based on economic price	Based on NRV*
Wheat	36876.15	27264.30	27081.30
Paddy	45360.58	33570.99	31732.99
Basmati	54289.35	41633.20	39795.20
Cotton	42074.07	32780.14	32729.14
Maize	15008.50	6192.55	6033.55
Rapeseed	13611.68	8114.92	7999.92
Potato	27847.90	6743.49	6508.49
Sugarcane	94654.58	79784.44	75986.44
Sugarcane	120536.53	105778.21	101980.2
Fodder	367.84	-8749.70	-4659.70
Vegetables	40643.32	29425.31	29190.31
Arhar	22316.89	15866.46	17762.46
Barley	24357.95	17199.13	17199.13
Groundnut	2841.75	-1378.59	3181.41
Gram	18094.49	14731.34	18046.34
Mesta	36324.79	29087.35	29087.35
Moong	9612.11	3625.86	5763.86
Oilseeds	21587.19	15670.96	17549.46
Pea	42216.74	31332.96	32721.96
Sunflower	17474.00	10766.59	10766.59
Urad	2351.70	-57.05	2351.95

Natural Resource Valuation

CONCLUSIONS

Thus it can be concluded that the present set of marketing infrastructure and agricultural technological know-how, the rice-wheat cropping patter is likely to produce the highest and more stable income. The sustainability of natural resources can be achieved only if same platform of technology-market-government assurance for other alternative crops will be provided to the farmers Market incentives for other crops should be explored so that farmers could move away from thirsty crops such as rice. The factors that are not captured by the market, like subsidies, is the direct cost to the society and factors affecting natural resources and environment as nitrogen fixation and green house gas costs need to be considered and should be internalized through appropriate policies.

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Appendix I

Economic valuation of nitrogen fixation and GHG emission by various crops in Punjab

Crops	Valuation (₹/ha)	
	Nitrogen fixation	GHG
Paddy	0	1838
Wheat	0	183
Maize	0	159
Sugarcane	0	3798
Rape and Mustard	0	115
Cotton	0	51
Potato	0	235
Peas	1389	97
Vegetables	0	235
Fodder	4187	97

Source: Peoples et al. (1995); IIPR (2003) and IARI (2014)