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# Comparing Performance of Various Crops in Punjab Based on Market and Economic Prices and Natural Resource Accounting§

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**Abstract**

The study has assessed the performance of different crops and cropping pattern in the state of Punjab using alternative scenarios like market prices; economic prices (net out effect of subsidy) and natural resource valuation (NRV) considering environmental benefits like biological nitrogen fixation and greenhouse gas costs. The study has used unit-level cost of cultivation data for the triennium ending 2010-11. It has analyzed crop-wise use of fertilizers, groundwater, surface water and subsidies. The paper provides insights into relative profitability of various crops with and without state support in the form of subsidies and by reckoning positive and negative environmental externalities. The study has shown that even after netting out the effect of input subsidies and effect on environment and natural resource, the relative profitability of various crops doesn't change. Under the present set of marketing infrastructure, minimum support price, and agricultural technological know-how, the rice-wheat cropping pattern produces the highest and more stable incomes. The study has pointed out that farmers may not move towards diversification until incentivized by economically attractive alternatives.

**Key words:** Market prices, economic prices, natural resource valuation, sustainability, input subsidy, Punjab

**JEL Classification:** Q13, Q12, Q18

## Introduction

The growth in agricultural output in Punjab, consequent to the onset of green revolution, has played a vital role in achieving and sustaining food security in India. However, in recent years, the strategic importance of the state has begun to decline. The state today stands at a critical juncture, with ecological thresholds for soil fertility and water availability nearing their tipping points (Singh *et al.*, 2012; Kulkarni and Shah, 2013) and fiscal burden of support to agriculture becoming unsustainable. This has raised serious questions about the future of agriculture in the state. The crisis manifests itself in a number of ways: stagnating growth rates in agricultural production and productivity, rising average cost of production, falling profitability in farming, swelling input subsidy bill, over-exploitation of water and land resources, resulting into degradation of the environment and ecology. A large number of studies point out that sustainability in agricultural production and the natural resource base are under threat in Punjab (Sidhu *et al.,* 2010).

The three pillars of agricultural revolution in Punjab — high-yield crop intensification, subsidized access to electricity for drawing water for irrigation and increased chemical fertilizer use under favourable

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§ The paper is drawn from the ICAR Social Science Network project 'Regional Crop Planning for Improving Resource Use Efficiency and Sustainability' output price policy regime—resulted in a tremendous increase in area under cereals, namely wheat and rice, cultivation. The state has reached cropping intensity of more than 189 per cent as against 140 per cent in the country as a whole, and consumption of fertilizer (NPK) is 250 kg/ha as compared to the all India average of 128 kg/ha in 2012-13. About 18 per cent of the total tractors in India are in Punjab and the production is supported by about 98 per cent irrigation coverage. However, these three pillars of agricultural revolution in Punjab have culminated in several negative ecological externalities. Thus, rising stress on water availability, rice-wheat monoculturing and higher use of energy and fertilizers in agriculture have necessitated optimum use of resources and reallocation of production choices without price distortions.

Many studies have raised issues regarding sustainability of agricultural production in Punjab (Shergill, 2007; Sidhu *et al.,* 2010; Kaur *et al*., 2010), deterioration of water, land and natural resources (Sidhu and Dhillon, 1997; Kaur and Vatta, 2015), and profitability of cropping patterns (Singh *et al.,* 2011; World Bank, 2003), but no systematic study has been done to link crop profitability with social cost, i.e. subsidy and natural resource accounting. The available literature compares the performance and profitability of various crops by using market prices of inputs which are highly distorted because of subsidy. For instance, electric power used for agriculture (irrigation) is free to farmers, but it has a cost for the society. Similarly, a farmer pays ₹ 276 for one bag of urea weighing 50 kg while society pays ₹ 480, as subsidy and total cost of one bag to society is ₹ 480, whereas its cost to the country is ₹ 756. Thus, computing cost and return at market prices of inputs represents income to the producer, but not to the society. The return to the society must consider subsidy as a cost while deriving figures of net return or value addition. The present study assesses the performance of various crops and crop sequences in the state of Punjab in terms of market prices, economic prices and natural resource valuation. It will help gain insight into the suitability of various crops in Punjab from long-term prospects of society. It will show the extent to which crop profitability changes based on alternative criteria for assessment. The study further estimates crop-wise fertilizer consumption, groundwater extraction and surface water use and their respective subsidies in the state of Punjab.

## Data and Methodology

The data for this study were taken from the "Comprehensive Scheme for Studying the Cost of Cultivation (CoC) of Principal Crops", Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Under this scheme, data in Punjab were collected from a sample of 300 farm households in 30 tehsils spread across three agro-climatic zones for the block year ending 2011. The data on per unit fertilizer subsidy were derived from the annual reports of Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India and data on per unit power subsidy were taken from the Punjab State Electricity Regulatory Commission (http://www.pserc.nic.in/). For estimating groundwater subsidies, the total volume of groundwater extraction was estimated using the data from cost of cultivation survey as well as ground water level data of Central Ground Water Board (CGWB), Ministry of Water Resources, Government of India. District-wise average ground water level data were compiled for the corresponding years of 2008, 2009 and 2010. For estimating canal water subsidies, data on financial aspects of irrigation projects were collected from the Central Water Commission, Ministry of Water Resources for the period 2008 to 2011.

The net return at market prices was computed as the gross return (value of main product and byproduct) less variable costs (Cost $A_1$ + imputed value of family labour) actually paid and received by the farmer or imputed in some cases.

The net return at economic prices was calculated as the net return or income at market prices less subsidies on inputs like fertilizers and irrigation used in crop production.

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

Crop-wise irrigation subsidy has two components: Surface water subsidy and Ground water subsidy. Groundwater subsidy was estimated by initially calculating the crop-wise groundwater-use, i.e.

Groundwater use (cubic metre) = Irrigation hours (hours/ha) * Groundwater draft (cum/hour)

The irrigation hours (hours/ha) for each crop were taken from the plot-wise CCS data. The groundwater draft was estimated using formula (1):

$$\text{Groundwater draft (L/sec)} = \frac{\text{HP*75*Pump efficiency}}{\text{Total head (m)}} \quad \ldots (1)$$

The information on horse power (Hp) of the pump-sets owned by the farmers is available in CCS data set. For the households purchasing groundwater, the average Hp of pumpsets (estimated separately for electric and diesel) in respective tehsil was taken as proxy. Pump efficiency was assumed to be 40 per cent. The total head was obtained as per Equation (2):

Total head = Water level (mbgl[#]) + Draw down (m) + Friction loss (10% of water level+ Draw down) …(2)

For submersible pumps, which are installed underground, additional 10 metre height was added to the total head after discussion with experts.

The summation of groundwater draft from each category of pumpsets provided the total groundwater-use (cum/ha) for each crop cultivated by the farmers. Further, the groundwater cost has been estimated separately for diesel pump, electric pump and submersible pump, as the summation of depreciation (tube-well and pump-set), interest (tube-well and pump-set) and upkeep costs. The subsidy per hectare of groundwater-use has been estimated for electric pumps [product of per kilo-watt groundwater volume (cum/kWh) and subsidy rate (₹/kWh)] and diesel pumps (product of diesel-use in extraction of groundwater and per litre subsidy rate during 2008-2011) separately.

Surface / Canal water irrigation subsidy was estimated using the data of Central Water Commission. For this, first total expenditure on major, medium and minor irrigation projects was estimated as the sum of capital expenditure and working expenses for TE 2010-11. Then, gross receipts out of irrigation projects were subtracted from the total expenditure to get the gross subsidy as shown in Equation (3).

[#]Metres below ground level

Gross Subsidy = Total expenditure – Gross receipts …(3)

The canal subsidy for each crop was estimated by allocating gross subsidy across different crops on the basis of proportion of their area under canal irrigation.

The net return based on natural resource valuation ($NR_{NRV}$) technique accounts for nitrogen fixation by legume crops and GHG emission from crop production. As such $NR_{NRV}$ was computed by adding value of nitrogen fixation by a crop at economic price of nitrogen (Value of N) and deducting the imputed value of increase in greenhouse gas (GHG) emission to the atmosphere.

The value of GHG emissions in terms of $CO_2$ kg equivalent was taken at the rate of US $ 10 per tonne of $CO_2$. The data on contribution of pulses by biological nitrogen fixation and emission of greenhouse gases of different crops were collected from the published scientific literature (Peoples *et al*., 1995; IIPR, 2003; IARI, 2014) and the value was calculated by taking the average value of nitrogen fixed by various legumes and then multiplied by the price of nitrogen prevailing during TE 2010-11.

## Results and Discussion

### Changes in Crop Pattern

The cropping pattern in Punjab has witnessed a significant shift during the past few decades. The changes since early-1970s are presented in Table 1. The crop pattern was directed by the state policy to meet food security in the country by raising supply of rice and wheat in the quickest way. The policy resulted in a remarkable increase in the share of paddy in GCA, from 7.15 per cent in TE 1972-73 to 26.74 per cent in TE 1992-93 and further to 35.88 per cent in TE 2012-13. Wheat from the very beginning, dominated the cropping pattern of the state and its importance has steadily increased as the area under wheat in 1970s, viz. TE 1972-73 was 40.57 per cent of GCA, which increased to 44.59 per cent during TE 2012-13. Overall, the cereals occupied 60.85 per cent of GCA during TE 1972-73 that rose to 73.0 per cent during TE 1992-93 and further to 82.19 per cent during TE 2012-13. The share of cereals like bajra and maize has declined sharply.

**Table 1. Changing cropping pattern of Punjab during 1970-71 to 2012-13**

(in per cent)

| Crop | | TE 1972-73 | TE 1992-93 | TE 2012-13 |
|---|---|---|---|---|
| Cereals | 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 | 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 |
| Cropping intensity | | 140 | 181 | 190 |
| GCA (`000 ha) | | 5589 | 7473 | 7887 |

*Source*: Government of Punjab, *Statistical Abstracts* (Various issues)

The area under pulses and oilseeds has recorded a sharp decline. The pulses share in area dropped from 7.17 per cent in TE 1972-73 to 1.53 per cent in 1990s and to 0.18 per cent in recent years. Similarly, area share of oilseeds fell from 5.41 per cent to 0.50 per cent over the period of forty years. The 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. Areas under commercial crops like sugarcane and cotton have also not remained stable. Consequently, wheat-rice crops rotation has come to dominate the cropping pattern in the state with a combined share of 80 per cent of gross cropped area. Notwithstanding, the cropping intensity of Punjab state has increased manifold, from 140 per cent in TE 1972-73 to 190 per cent in TE 2012-13 (Table 1).

## Irrigation Expansion and Sources

The increase in cropping intensity and coverage of rice–wheat rotation were accompanied and aided by the expansion of irrigation coverage from around 71 per cent of the total cropped area in 1970-71 to 98 per cent in 2012-13 (Table 2). The state has well developed surface and groundwater irrigation infrastructure. The surface irrigation distribution network comprises 1,45,000 kilometres of canals, including branch canals and minor distributaries, and one lakh kilometres of field channels or water courses (Singh *et al.,* 2012). The canal irrigation system irrigated 1116 thousand ha in 2012-13 accounting for 27.35 per cent of the net irrigated area in state (Table 2). As reported in Table 2, the share of canal irrigation has declined steeply from 44.53 per cent to 27.35 per cent of the net irrigated area in state during the past four decades.

On the other hand, the groundwater irrigation, i.e. tube-well irrigation, particularly in the central and northern regions of Punjab, has been on the increase. During 1970s, the irrigation done by using groundwater accounted for 55 per cent which has jumped to 72.58 per cent in 2012-13. The number of pump-sets has increased from 1.9 lakh to 13.85 lakhs (Table 2). Interestingly, the number of electric operated tube-wells has increased at a higher pace as compared to diesel-operated tube-wells. Free supply of electricity for irrigation, attractiveness of water-intensive cropping pattern and practices, and easy availability of institutional credit are the main factors behind steep

**Table 2. Trends of irrigation in Punjab during 1970-71 to 2012-13**

| Particulars | 1970-71 | 1990-91 | 2012-13 |
|---|---|---|---|
| Net irrigated area ('000 ha) | 2888 | 3909 | 4070 |
| Irrigation coverage (%) | 71 | 93 | 98 |
| Surface water (%) | 44.53 | 42.47 | 27.35 |
| Groundwater (%) | 55.09 | 57.12 | 72.58 |
| No. of pumpsets (lakhs) | 1.9 | 7.6 | 13.85 |
| • Electric pumpsets (%) | 47.40 | 73.68 | 79.69 |
| • Diesel pumpsets (%) | 52.60 | 26.32 | 20.31 |

*Source*: Government of Punjab, *Statistical Abstracts* (Various issues)

**Table 3. Crop-wise use of fertilizers and groundwater in Punjab, TE 2010-11**

| Crop | N (kg/ha) | P (kg/ha) | K (kg/ha) | NPK-use (kg/ha) | Groundwater draft (cum/ha) |
|---|---|---|---|---|---|
| Wheat | 171.6 | 68.7 | 42.0 | 241.7 | 2520 |
| Paddy—non-Basmati | 157.8 | 49.1 | 41.2 | 198.2 | 12127 |
| Paddy—Basmati | 105.5 | 46.5 | 46.0 | 140.6 | 12237 |
| Maize | 134.0 | 63.9 | 52.5 | 197.0 | 1485 |
| Potato | 263.0 | 188.7 | 102.2 | 532.6 | 2256 |
| Pea | 149.7 | 107.4 | 69.9 | 265.6 | 1604 |
| Sugarcane (Planted) | 255.2 | 87.7 | 38.8 | 344.1 | 6284 |
| Sugarcane (Ratoon) | 290.6 | 56.1 | - | 311.2 | 7053 |
| Rapeseed & mustard | 99.8 | 50.2 | 15.0 | 139.6 | 1670 |
| Cotton | 126.3 | 48.9 | 38.8 | 177.2 | 3920 |
| Vegetables | 123.6 | 101.5 | 78.8 | 229.8 | 3798 |
| Fodder | 127.8 | 59.3 | 29.1 | 162.1 | 4459 |

*Source*: Authors' estimations based on unit level cost of cultivation data of Punjab (TE 2010-11)

increase in the use of tube-wells, particularly electric pump-sets for irrigation in the state.

The extensive use of groundwater through tube-wells has led to over-exploitation of groundwater resources, resulting in lowering of the groundwater table in most parts of the state. The problem is more severe in the central pats of Punjab. On the other hand, south-western parts of Punjab face the problem of waterlogging. According to CGWB (2014), the net groundwater availability in Punjab is 20.32 billion cubic metre (bcm), while the annual ground water draft is 34.88 bcm, out of which 98 per cent (34.17 bcm) is used for irrigation purpose. As such, there is 14.56 bcm over-exploitation of groundwater in the state, leading to a sharp decline in groundwater level. In order to keep a check on groundwater level falling further, the state needs to reduce its current groundwater-use by 72 per cent.

### Crop-wise Fertilizer and Groundwater Use

The crop-wise fertilizer consumption and groundwater draft were estimated using the unit level CoC data of Punjab for 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 rice was 241.7 kg and 186.3 kg, respectively compared to 533 kg, 344 kg, 177 kg for potato, sugarcane and cotton, respectively. Basmati rice was applied (140.6 kg/ha) less fertilizers as compared to non-basmati paddy (198.2 kg/ha). However, potato and vegetables have been found to be the higher consumers of macro-nutrients.

The crop-wise estimated groundwater-use is given in Table 3. Paddy-Basmati was found to be the most water-intensive crop with groundwater-use of 12237 cum/ha, followed by non-basmati-rice (12127 cum/ha). Sugarcane-ratoon consumed 7053 cum/ha groundwater, while sugarcane-planted extracted 6284 cum/ha groundwater. Wheat consumed lesser water (2520 cum/ha) compared to paddy, but higher than potato (2256 cum/ha), rapeseed & mustard (1670 cum/ha), pea (1604 cum/ha) and maize (1485 cum/ha).

The wide spread paddy cultivation in the state and its cultivation practices like puddling and continuous submergence are the main causes for large-scale depletion of groundwater.

### Cost and Returns Based on Market Prices

The comparative return or profitability is affected by the factors like yield levels, input-use in production and their respective prices, and output price. The comparative returns at market prices along with variable cost for various crops in Punjab are shown in Table 4. The variable costs included the cost incurred on different inputs such as seed, fertilizer, manure,

**Table 4. Comparative costs and returns of different crops in Punjab based on market prices, TE 2010-11**

(₹/ha)

| Crops | Variable cost (Cost $A_1$+FL) | Gross returns | Net returns over variable costs |
|---|---|---|---|
| Wheat | 17413 | 53657 | 36244 |
| Paddy-non-Basmati | 21372 | 67570 | 46198 |
| Paddy-Basmati | 23853 | 77230 | 53377 |
| Maize | 19529 | 33321 | 13792 |
| Sugarcane (Planted) | 58028 | 156412 | 98384 |
| Sugarcane (Ratoon) | 34798 | 153474 | 118676 |
| Rapeseed and mustard | 16694 | 31144 | 14450 |
| Cotton | 29046 | 71233 | 42187 |
| Potato | 42256 | 69394 | 27138 |
| Peas | 30391 | 74940 | 44549 |
| Vegetables | 37745 | 74243 | 36497 |
| Fodder | 30764 | 35903 | 5139 |

*Source*: Authors' estimations based on unit level cost of cultivation data of Punjab (TE 2010-11)

insecticides, human labour (including family labour), machine labour and irrigation.

During TE 2010-11, the variable cost was highest in sugarcane-planted (₹ 58028/ha), followed by potato (₹ 42256 /ha) and was lowest for rapeseed & mustard (₹ 16694/ha).

The cost structure varied across different crops. Among *kharif* crops, cotton cultivation was at the higher end, with variable cost of ₹ 29046/ha, followed by paddy and maize. The variable cost incurred in production of Basmati rice was ₹ 23853/ha, which was 11.6 per cent higher than the cost of cultivation of non-basmati paddy. While in the *rab*i season, the variable costs were higher for potato as compared to its competing crops like wheat and rapeseed & mustard.

The return depends on cost of cultivation as well as on productivity of crop and its price. Among the crops, sugarcane accrued the highest net return (₹/ha) over the variable costs. As this 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. Interestingly, net returns from sugarcane at market prices turned out to be the higher even when compared with the sum of the net returns from paddy and wheat. The wheat-rice combination generated net returns of ₹ 83927/ha, which is lower than from the sugarcane cultivation. However, lack of marketing infrastructure for crops, other than wheat and rice, high transport costs and inadequate agro-processing units in the rural areas are the constraints to the spread of sugarcane cultivation in Punjab. The combination of wheat-rice (basmati), due to its lower costs of cultivation turns out to be the best combination as the net profits from other combinations are less — wheat-maize (₹ 50036/ha) and wheat- cotton (₹ 78431/ha). The wheat-cotton combination yields less profit due to high cost of cultivation and it also involves higher risk due to price instability of cotton.

Among *kharif* crops, paddy-basmati has shown the highest gross returns (₹ 77230/ha) while rapeseed & mustard has reported the lowest value of output (₹ 31144/ha) among all selected crops in TE 2010-11. Among all other crops, basmati rice reaps the highest net returns (₹ 53377/ha), followed by non-basmati rice. Cotton comes next with a net income of ₹ 42187/ha, while maize gives the lowest net income of ₹ 13792/ha. As can be observed from Table 4, the cultivation of basmati paddy in Punjab requires higher costs than non-basmati paddy, but provides much higher gross returns and net income. At market prices, basmati rice has been found most superior, when compared to non-basmati paddy.

Among *rabi* crops, pea gave the highest net returns of ₹44549/ha, although this commodity did not have the required marketing infrastructure in Punjab. Wheat and potato on an average, yielded net returns of ₹ 36244/ha and ₹ 27138/ha, respectively.

It may be concluded that the wheat-rice (basmati) cropping pattern provides, higher financial returns with relatively low risks. From the comparative cost and return analysis for different crops in Punjab in TE 2010-11, sugarcane and paddy-basmati have emerged to be the most efficient crops in financial aspects. Sugarcane and cotton seem to be the potential substitutes of rice. As such, the wheat- rice cropping pattern offers the best returns to the farmers in the given framework of productivity and marketing criteria.

## Net Returns Based on Economic Prices

The net returns at economic prices from different crops were computed by subtracting input subsidies, as shown in Table 5. Potato received the highest subsidy of ₹ 18929/ha, because of higher fertilizer component, followed by sugarcane (₹ 13231/ha), being an annual crop, closely followed by paddy-non-basmati (₹ 13007/ha). In the total subsidy in paddy-non-basmati, irrigation has a higher share with a subsidy of ₹ 6110/ha. Cotton received the highest canal water subsidy of ₹ 4405/ha. Among the selected crops, the minimum subsidy was used in rapeseed & mustard (₹ 6997/ha) cultivation.

Table 5 reveals that the net returns based on economic prices are the highest in sugarcane crop. Apart from the annual crop, the paddy-basmati remains the most remunerative crop with net income of ₹ 41789/ha at economic prices, followed by peas that offer the net returns of ₹ 33354/ha after deducting the subsidies. Potato ranks first in terms of inputs subsidy, but is still not able to compete with the other important crops in terms of net income. Rice, cotton and wheat provide net income of ₹ 33191/ha, ₹ 30530/ha and ₹ 25747/ha, respectively. After removing subsidies the net returns from fodder became negative (₹ 4829/ha) and also maize becomes the least profitable crop in terms of economic prices.

## Net Returns Based on Natural Resource Valuation (NRV)

Agriculture has significant effects on climate, primarily through production and release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide (GoP, 2011). 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. On the contrary, legumes are

**Table 5. Crop-wise net returns based on economic prices in Punjab, TE 2010-11**

(₹/ha)

| Crop | Irrigation Subsidy | | NPK # subsidy | Total subsidy | Net returns by economic prices |
|---|---|---|---|---|---|
| | Groundwater (diesel * & electricity$) | Canal water | | | |
| Paddy-non-Basmati | 5051 | 1059 | 6897 | 13007 | 33191 |
| Paddy-Basmati | 5031 | 583 | 5974 | 11588 | 41789 |
| Wheat | 1122 | 1454 | 8036 | 10612 | 25747 |
| Maize | 823 | 28 | 7547 | 8398 | 5394 |
| Potato | 1113 | 348 | 17468 | 18929 | 8209 |
| Pea | 754 | 0 | 10441 | 11195 | 33354 |
| Sugarcane (Planted) | 2559 | 352 | 10320 | 13231 | 85153 |
| Sugarcane (Ratoon) | 2446 | 144 | 8010 | 10600 | 108077 |
| Rapeseed & mustard | 1005 | 1285 | 4707 | 6997 | 7556 |
| Cotton-medium staple | 1074 | 4405 | 6178 | 11657 | 30530 |
| Vegetables | 2417 | 97 | 7440 | 9954 | 26543 |
| Fodder | 2441 | 1293 | 6234 | 9968 | -4829 |

*Source*: Estimated using unit level CoC data of Punjab (TE 2010-11)

*Notes*: # Subsidy @ ₹19.35/kg of N; ₹ 42.56/kg of P&K combine for TE 2010-11

*Diesel subsidy @ 12.95 per litre.

$ Electricity subsidy @ ₹ 2.40, ₹ 2.85 and ₹ 3.20 per unit in 2008-09, 2009-10 and 2010-11, respectively.

environment-friendly crops and are different from other food plants because of the property of synthesizing atmospheric nitrogen into plant nutrients. As such, the 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, and has been presented in the Appendix I.

The required data were available only for two legume crops — peas and fodder. The fodder grown in Punjab fixed nitrogen equivalent to the economic contribution of ₹ 4187/ha, while peas fixed nitrogen worth ₹ 1389/ha (Appendix I). Paddy caused the highest negative externality by producing GHGs costing ₹ 1838/ha, whereas the minimum GHG costs were incurred by peas and fodder, valued at ₹ 97/ha.

On adding these benefits and deducting the costs from net returns based on economic prices, we can get over-all returns from cultivation of different crops to society and the natural resource system. The information in Table 6 based on NRV indicates net income to be highest in sugarcane-ratoon (₹ 104279/ha), followed by sugarcane-planted (₹ 81355/ha). Paddy-basmati still stands at the top in seasonal crops in terms of gross and net income. In *rabi* season, peas with ₹ 34646/ha net returns based on NRV come at the top. Paddy-non-basmati, cotton, vegetables and wheat have shown net returns of ₹ 31353, ₹ 30479, ₹ 26308 and ₹ 25564/ha, respectively on the basis of NRV.

## Comparative Returns of Crops Using Various Approaches of Valuation

A comparative picture of net income from various crops based on market prices, economic prices (net of subsidies) and natural resource valuation is presented in Table 7. As expected, there is a moderate-to-high decline in net income from different crops after netting out subsidies on fertilizer, power, canal and diesel. The impact of subsidy is so large that in some cases, the net income turned negative (fodder) and in some cases, it reduced to one-third (potato). The withdrawal of subsidy reduced the net income from maize to 40 per cent and in rapeseed & mustard to close to half. Due to high rate of profitability in sugarcane, paddy and wheat, the removal of subsidy lowered net income moderately, even though subsidy level in paddy was much higher compared to in maize. Placing economic value on the environmental effect further reduced the profitability of various crops, except peas and fodder. However, this effect was mild.

It is often believed that free power supply in the state of Punjab is keeping profitability of paddy

**Table 6. Net returns based on natural resource valuation in Punjab, TE 2010-11**

(₹/ha)

| Crop | Returns on adding economic value of nitrogen | Returns by deducting cost of GHG emissions | Net returns based on NRV |
|---|---|---|---|
| Paddy-non-Basmati | 33191 | 31353 | 31353 |
| Paddy-Basmati | 41789 | 39951 | 39951 |
| Wheat | 25747 | 25564 | 25564 |
| Maize | 5394 | 5235 | 5235 |
| Sugarcane (Planted) | 85153 | 81355 | 81355 |
| Sugarcane (Ratoon) | 108077 | 104279 | 104279 |
| Rapeseed and mustard | 7556 | 7441 | 7441 |
| Cotton | 30530 | 30479 | 30479 |
| Potato | 8209 | 7974 | 7974 |
| Peas | 34743 | 33257 | 34646 |
| Vegetables | 26543 | 26308 | 26308 |
| Fodder | -642 | -4926 | -739 |

*Source*: Estimated by using unit level CoC data of Punjab (TE 2010-11) and based on Peoples *et al*. (1995); IIPR (2003); IARI (2014)

**Table 7. Net returns from different crops in Punjab using various approaches of valuation, TE 2010-11**

(₹/ha)

| Crop | Based on market prices | Based on economic prices | Based on NRV |
|---|---|---|---|
| Paddy-non-Basmati | 46198 | 33191 | 31353 |
| Paddy-Basmati | 53377 | 41789 | 39951 |
| Wheat | 36244 | 25747 | 25564 |
| Maize | 13792 | 5394 | 5235 |
| Sugarcane (Planted) | 98384 | 85153 | 81355 |
| Sugarcane (Ratoon) | 118676 | 108077 | 104279 |
| Rapeseed and mustard | 14450 | 7556 | 7441 |
| Cotton | 42187 | 30530 | 30479 |
| Potato | 27138 | 8209 | 7974 |
| Peas | 44549 | 33354 | 34646 |
| Vegetables | 36497 | 26543 | 26308 |
| Fodder | 5139 | -4829 | -739 |

*Source*: Estimated using unit level CoC data of Punjab (TE 2010-11)

artificially high and thus discouraging diversification of crop pattern away from paddy. Our study shows that under the present set of marketing infrastructure, minimum support price, and agricultural technological know-how, rice-wheat cropping pattern produces the highest and more stable incomes. Farmer may not move towards diversification until incentivized by economically attractive alternatives.

## Conclusions

The study reveals that sugarcane and paddy (both basmati as well as non-basmati) remain the most rewarding crops in terms of market prices, economic prices and natural resource valuation. Sugarcane and peas have potential for competing with rice–wheat rotation, but their prospects are marred by lack of marketing infrastructure and government incentives for crops other than wheat and rice. Thus, under 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 incomes. Farmers may not move towards diversification until incentivized by economically attractive alternatives.

The factors that are not captured by the market, like subsidies, is the direct cost to the society; factors affecting the natural resources and environment as nitrogen fixation and greenhouse gas costs, need to be considered and should be internalized through appropriate policies. Reckoning such costs and return alters the level of net income from various crops.

This study shows that even after netting out the effect of input subsidies and effect on environment and natural resources, the relative profitability of various crops doesn’t change. Among seasonal crops, paddy remains the most profitable crop in *kharif* and wheat remains the second most profitable crop after peas in *rabi*. The reason is that technological superiority of paddy and wheat in Punjab is much higher than the difference in input support given to various crops. However, these findings should not be taken to interpret that removal of subsidies on water or fertilizers will not affect use of these inputs. Use of fertilizers and irrigation will be definitely much lower without subsidy than what it is with subsidy. Thus, over-exploitation of water and indiscriminate use of fertilizer can be checked by reducing level of subsidies, but shift in crop pattern requires development of superior alternatives which are not there at present.

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## Appendix I

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

| Crop | 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*: Calculated by using Peoples *et al*. (1995); IIPR (2003) and IARI (2014)