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Optimising Irrigation Water Use in Punjab Agriculture: Role of Crop Diversification and Technology

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ABSTRACT

A linear programming model has been formulated to suggest the optimal cropping pattern for maximising net returns and ensuring significant savings of groundwater with the aim of sustaining groundwater use in the Punjab agriculture. The dominance of paddy-wheat crop rotation has led to over-exploitation of ground water resulting in rapid decline of water table in the entire state. The existing ground water draft for irrigation is 3.41 m ha m whereas the annual ground water availability is 2.03 m ha m, indicating a deficit of 1.38 m ha m of groundwater resources – a case of severe water imbalance in state. Diversifying agriculture towards less water consuming crops and use of resource conservation technologies is of utmost importance. The present study attempts to suggest a diversification plan for achieving water sustainability. The results revealed that a shift of area under maize and basmati in plan –I, resulted into a significant water saving of 8 per cent. The water saving amounted to 16.16 per cent when new crop activities, like paddy sown directly in the fields, i.e. resource conservation practices (DSR) technology and paddy sown by conventional method but irrigation scheduled by the use of tensiometer were introduced without any adverse impact on productivity.

Keywords: Water sustainability, Crop plans, Technology.

JEL: Q15, Q16, Q25

INTRODUCTION

The state of Punjab, in common parlance known as ‘Food Bowl’ of the country, is the largest surplus state in terms of food grains. It is one of the smallest states in India with 5.03 million hectare of land which accounts for only 1.5 per cent of the total area of the country. Of this, 4.2 million hectare is the net cultivated area, leaving less than 17 per cent of the area under habitations, road, rivers, canals, waste lands, etc. However, with the intensity of cropping at 190 per cent, the cropped area amounts to around 8 million hectare which accounts for 4.5 per cent of the cropped area in the country (Johl *et al.*, 2012).

With significant change in cropping pattern over five decades, the area under major crops has increased from 3.79 million hectare in 1960-61 to 7.88 million hectare in 2013-14, i.e., an increase of over 90 per cent. More importantly the area under wheat increased from 1.39 million hectare to 3.53 million hectare (1.53 times increase) and area under rice crop from 0.23 million hectare to 2.82 million hectare (11.36 times increase) over this period, (Government of Punjab, 2014). Thus, these two crops became dominant in the cropping pattern of the state. The dominance of paddy-wheat crop rotation has converted Punjab from water surplus to water

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scarce state. In Punjab, more than 98 per cent of area is irrigated; out of which 76 per cent is irrigated by groundwater and remaining by surface (canal) water. The existing annual ground water draft exceeds annual ground water availability by 1.38 m ha m – a case of severe water imbalance in state, (Government of Punjab, 2011). As a result, there has been an increase in investment on shifting from centrifugal to submersible pump. The small farmers also opted for co-sharing of motors in order to reduce the burden of increasing investments (Kaur and Vatta, 2015)

Paddy being the most water intensive crop uses 18 mm water per day for at least 100 days while the total water required for wheat is about 500 mm. Assuming 25 cloudy weather days when evapo-transpiration losses are reduced, for paddy grown in one hectare area, the depth of water required is 1600 mm out of which 500 mm may be available from rainfall and nearly 1100 mm comes from groundwater (Tiwana *et al*., 2005). If paddy-wheat cycle goes on, then by 2023 the water table depth in central Punjab is projected to fall below 70 feet in 66 per cent area, below 100 feet in 34 per cent area and below 130 feet in 7 per cent area (Sidhu *et al.,* 2010). Thus, the sustainability of irrigated agriculture in the state is under threat. In order to revitalise Punjab agriculture through exploring alternatives to rice-wheat system, various expert committees and other groups (Anonymous, 2002 and Government of Punjab, 2005; 2006) have recommended diversification of agriculture towards high value crops/commodities, that augment farm income, promote export and conserve soil and water resources. Underlying the importance of diversified agriculture Punjab government submitted a diversification plan in 2013 to the union government for shifting 1.2 million hectare of rice area to other crops like maize, cotton, sugarcane, agro-forestry, pulses, fruits and vegetables in the *kharif* season during the next six years and demanded funds worth Rs. 5000 crore from the Union government for this purpose. Government of India provided Rs. 500 crore to the North-west states in the year 2014-15 for shifting area from rice to other crops under Crop Diversification Plan.

Crop diversification in Punjab is a challenge as well as an opportunity. The challenge is that it appears to be a difficult task due to the public procurement of paddy and wheat and their relative profitability at current prices and productivity level, and the opportunities would be in generating employment and involving a number of additional stakeholders in the food-supply chain while maintaining at least current farm income level. For research and development, the key challenge would be to develop promising technologies and management options to raise productivity in a situation of deteriorating production environment at the lowest cost, i.e., to develop an optimisation model to support the analysis of decision making for maximising profitability. So keeping this in mind, the analysis was carried out to develop optimal crop patterns that are diversified away from cereal based crop patterns and sustain water resources.

DATA BASE AND METHODOLOGY

The paper is based on both primary as well as secondary data. The secondary data was obtained from multiple sources, viz., *Statistical Abstract of Punjab*, Directorate of Water Resources and Department of Agriculture Punjab, Chandigarh. The primary data was obtained from the scheme entitled, "Comprehensive Scheme for studying the Cost of Cultivation of Principal Crops in Punjab". The study was conducted for the Punjab state and the data for the year 2011-12 was used to work out the input-output coefficient for different crops. The budgetary analysis was performed to work out the economics of different crops. The design of the scheme is three stage stratified random sampling with tehsil as the first stage unit, village/cluster of villages as the second-stage unit and operational holding as the third and ultimate stage unit. The sample comprised a total of 30 villages with 300 farming households.

Programming Model

The results have been discussed on the basis of linear programming analysis. The solution to the linear programming model was obtained using the simplex method with a commercially available computer program. The linear programming model in farm management research is a very powerful technique, which can efficiently handle a large number of linear constraints and variables (activities) simultaneously (Sankhayan and Cheema, 1991; Panda *et al*., 1983). The model used is given below:

$$Maximize\ Z = \sum_{j=1}^{n} Cj\ \ Xj$$

$$Subject\ to = \sum_{i=1}^{m} a_{ij}\, x_j \ \leq b_i$$

$i = 1, 2, \ldots\ldots m$
$j = 1, 2, \ldots\ldots n$
$X_j \geq 0$

where,
Z = Total returns to fixed farm resources, C_j = Returns to fixed farm resources per unit of an activity, X_j = Level of the j-th activity, b_j = Availability of the i-th resource, a_{ij} = Input of the i-th resource per unit of the j-th activity, n = Number of real activities, m = Number of resource constraints, and $X_j \geq 0$ indicate non-negativity constraint for the activities.

Resource Restrictions:

(i) *Land Area Availability and Utilisation*:

By using input-output coefficients developed from micro field level data, model was formulated at macro level for the whole state of Punjab. The constraints on the availability of land (during both *kharif* and *rabi*) was equal to net sown area of the state. As the input-output coefficients were not developed for each and every fruit and vegetable grown in the state, land availability was restricted to the sum total of area under crops covered under the existing production pattern.

(ii) *Working Capital Restriction*:

The constraint for the use and availability of capital was worked out for both *kharif* and *rabi* seasons separately. The per hectare figures for capital used on the farm, i.e., the expenditure on seed, manures, fertilisers, plant protection chemicals, hired machine charges, hired labour payment, irrigation charges etc. were added up and cash requirement for *kharif* and *rabi* crops were worked out separately, which were multiplied by the area under different crops in the matrix for the whole of Punjab state to reach at capital used in the state. This estimated figure of working capital used in the state was put as constraint, as it was assumed that the expenditure incurred on variable inputs in the last season was available by the same amount for the next crop season.

(iii) *Irrigation Water-Use*:

The electric motors having different horse powers were brought to/changed on the same denominator by allocating different weights to different horse power electric motors on the basis of discharge rate in litres/second. Irrigation water-use for each crop was computed by estimating the total irrigation hours used for that crop and multiplying it with the volume of water drawn out per hour by the electric motor. The total volume of water drawn out by tube wells for a crop on the farm was divided by total area under the crop to arrive at the crop-wise per hectare water usage coefficients. So irrigation water availability was considered equal to irrigation water use under existing cropping pattern. The per hectare water usage coefficient were multiplied by area under crops in the state (crop year 2011-12) considered in the matrix to arrive at water availability in the Punjab state. In the present study, to meet the specific objective of water sustainability, it was considered that water draft should be equal to water recharge.

(iv) *Input-Output Coefficient for Pulses, Oilseeds and Vegetables*:

The input-output coefficients for pulses, oilseeds and vegetables were developed by preparing schedules and collecting data through personal interview method. The data was collected from respective regions or pockets where these crops were grown. As farmers were scattered over a large numbers of villages, so a suitable sample size of at least 40 growers for each such crop was taken for developing input-output coefficient for pulses, oilseeds and vegetables. The input-output coefficients were developed for moong, arhar, sarson, pea, okra, brinjal and cauliflower. The input-output coefficients were developed for important vegetables occupying sizeable area in the state.

(v) *Crop Maxima and Minima*:

There were some crop enterprises used in the matrix which gave quite high returns per hectare. Acreage under these crops was restricted, according to the diversification plan submitted to Union Government by the state.

(vi) *Input-Output Coefficient for Newly Introduced Crop Activities*:

The input-output coefficients for paddy sown directly in the fields without transplanting (i.e. DSR technology) for both basmati and other parimal varieties and paddy sown by conventional transplanting method but irrigation scheduled with the help of tensiometer were taken from the research project tilted, “Improving Food and Livelihood Security in Punjab through Water Energy Agriculture Management under Climate Change and Variability” currently being carried out in the Punjab Agricultural University and funded by the International Development Research Centre. This project examines the role of water saving practices/technologies in saving water during paddy cultivation in Punjab. In order to determine the optimum production plan for Punjab state, area under such resource conservation practices (DSR)/technologies (tensiometer for scheduling irrigation) was introduced to technically feasible limits.

EXTENT OF GROUND WATER EXPLOITATION IN PUNJAB

Ground water over-exploitation can be examined using three sets of statistics, namely, irrigated area statistics, volumetric data on ground water-use and data on decline in water- table. The statistics on ground water reveals a picture that there is a huge gap between the available sustainable water supplies and demand in the state. Not only the paddy–wheat cropping pattern but also the urbanisation and growth of industries, have contributed to increase in draft and a decline in recharge leading to depletion of ground water resources. The scenario is more grim in central Punjab.

The most important reason behind such increase in the use of ground water resources is phenomenal increase in growth of ground water abstraction structures (tubewells) due to their technical feasibility (ground water is sweet) and economic viability (electricity to pump out water for agriculture is free) backed by huge investments in generation and distribution of power to farm sector and good quality seeds and use of chemical fertilisers. There has been sharp rise in the total number of tubewells from 1.92 lakh in 1970-71 to 10.73 lakh in 2000- 01 and further to 14.05 lakh in 2013-14 in the state. The diesel operated tubewells showed an increase till the year 2005-06, thereafter showing a decline and the number has declined to 1.79 lakh only in 2013-14. The number of electric operated tubewells is continuously rising from 0.91 lakh in 1970-71 to 7.88 lakh in 2000-01 and further to 12.26 lakh in 2013-14. Subsidised power to agriculture led to installation of more and more electric tubewells and consequent greater withdrawal of ground water than ever before. 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.

The trends in net area under irrigation in Punjab through canals and tubewells further strengthen this argument. Area under canal irrigation increased from 1286 thousand hectares in 1970-71 to 1660 thousand hectares in 1990-91 and further to 1620 thousand hectares in 1996-97. Thereafter it has continuously declined and has reached to 1133 thousand hectares in 2012-13. On the other hand, tubewell irrigated area increased at a very rapid pace from 1591 thousand hectares in 1970-71 to 2233 thousand hectares in 1990-91 and swelled to 3074 thousand hectares in 2000-01 and 2982 thousand hectares in 2012-13. The growth rate of increase in area irrigated through ground water has been significantly positive from 1970-71 to 1999-2000 (Table 1).

TABLE 1. PERIOD-WISE COMPOUND GROWTH RATE OF TUBEWELL AND ANAL IRRIGATED AREA, PUNJAB

Period (1)	Canal irrigated area (2)	Tube well irrigated area (3)
1970-71 to 1979-80	1.38*	2.79*
	(0.34)	(0.246)
1980-81 to 1989-90	0.154^{NS}	2.36*
	(0.23)	(0.22)
1990-91 to 1999-00	-3.78^{NS}	2.39*
	(1.25)	(0.66)
2000-01 to 2012-13	0.65*	-0.09^{NS}
	(0.31)	(0.16)

*Indicates that growth is significant at 5 per cent level, NS means non-significant. Figures in parentheses are standard errors.

The perusal of Table 2 reveals that over time rate of over-exploitation has increased. In 1984 the proportion of over- exploited (OE) blocks was 45 per cent which swelled to 78.98 per cent in 2011. The white blocks which were 30.5 per cent in 1984 decreased to only about 15 per cent in 2011. As a matter of fact, the white blocks are only those blocks where extraction is either technically not feasible due to brackish water in south-west zone or is economically unviable due to rocky terrain in Kandi zone. This scenario of over-exploitation brings forth the fact that limited quantity of surface water resources and an over-time decline in their quantity as compared with increased demand for water on account of increasing cropping intensity, water intensive rice-wheat rotation, increased urbanisation and industrialisation have put huge pressure on ground water resources.

TABLE 2. INCREASE IN OVER-EXPLOITED AND DARK BLOCKS IN PUNJAB, 1984 THROUGH 2011

(*No.*)

Blocks/ time	1984	1989	1991	1997	2005	2011
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Over-exploited	53	62	62	73	104	109
	(44.91)	(52.54)	(52.54)	(52.89)	(75.91)	(78.98)
Dark	7	7	8	11	9	5
	(5.93)	(5.93)	(6.78)	(7.97)	(6.57)	(3.62)
Grey	22	20	15	16	8	2
	(18.64)	(16.95)	(12.71)	(11.59)	(5.84)	(1.46)
White	36	29	33	38	16	22
	(30.51)	(24.58)	(27.97)	(27.54)	(11.68)	(15.94)
Total number of blocks	118	118	118	138	137	138

Source: Government of Punjab (2011), Chandigarh.
Figures in parentheses are percentages to total no. of blocks.

The perusal of Table 3 shows that in the districts of Kandi Zone (Gurdaspur, Hoshiarpur, Ropar and Mohali) draft as a percentage of recharge increased from 49 to 103 from the year 1984 to 2011. The corresponding figures for South-west zone were 32 to 138 respectively. Though there was an increase in draft over recharge in the Kandi zone, but the year 2011 witnessed a sharp increase of water draft, i.e., 103. This was due to increase in the paddy area in this zone from 311 thousand hectares in 2004-05 to 345 thousand hectares in 2011-12. The central districts showed the highest percentage overdraft of 142 to 197 per cent over time. The area under paddy in central districts also increased from 1587 thousand hectares in 2008 to 1827 thousand hectares in 2011-12. Increase in paddy area and decrease in rainfall over time are two main reasons for such drastic increase in ground water balance in central districts.

TABLE 3. ZONE-WISE COMPARISON OF GROUND WATER DEVELOPMENT IN PUNJAB, 1984 TO 2011

(*Draft as a percentage of recharge*)

Districts/years	1984	1989	1991	1997	2005	2011
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Kandi Zone	49	60	56	57	86	103
Central Zone	142	149	149	156	172	197
South-West Zone	32	45	40	48	108	138

Optimal Crop-Mix

The crop diversification plan of the State government intends to shift 12 lakh hectares of land from paddy to other crops, which are less water consuming to check the rapidly falling sub-soil water table, control the mounting power subsidy bill and break the stagnation in agriculture growth. The action plan includes increasing the area under cotton and basmati cultivation by 2 lakh hectare each; both the crops consume less water as compared to traditional paddy. Besides, the area under maize has been proposed to be increased by 4 lakh hectares, sugarcane by 1.70 lakh hectares, pulses 0.70 lakh hectares, fruits and vegetable by 0.85 lakh hectares, agroforestry by 1.45 lakh hectares and green fodder by 0.50 lakh hectares. A linear programming model has been formulated to work out the optimal cropping pattern for the Punjab state as well as to visualise the trade-off between returns and ground water saving.

In optimal Plan-1, maximum area restriction of 7,75,000 hectares was imposed on basmati and 7,15,000 hectares on cotton. Further, increase in the area under basmati rice results in significant fall in its price. Based on diversification plan, maximum area under pulses was restricted to three times the area under the existing cropping pattern so, restriction of 19,800 hectares was imposed on *moong* crop. But due to low profitability this crop could not enter in optimal plan-I. The maximum area under all *kharif* and *rabi* vegetables was restricted to 1.5 times the existing area under them. The area under green fodder was restricted to 4,25,000 hectares in *kharif* and 3,25,000 hectares in *rabi* season respectively. In optimal plan-1, area under paddy decreased from 56.72 per cent of *kharif* cultivated area to 40.46 per cent, where as in basmati it increased from 14.54 to 19.59 per cent of *kharif* cultivated area respectively. Maize covered a significant area of 12.28 per cent in Plan-I. As sugarcane is also high water consuming crop, and to what per cent area under sugarcane is to be increased in the cropping pattern is a debateable issue, area under sugarcane was kept equal to the existing area under the crop. Major shift in the area occurred in two crops, namely, basmati and maize in optimal plan, which resulted into water saving of 8.15 per cent, whereas the return decreased by 2.57 per cent as compared to the existing plan. This was due to the low profitability of maize and basmati rice. The average price received by the farmers in maize and basmati was Rs 900 and Rs 1600 per quintal, respectively in 2011-12 (Table 4).

In the second alternative plan, two promising resource conservation technologies were introduced, namely, paddy sown directly in the fields through DSR technology and paddy sown through conventional transplanting but irrigated by the use of tensiometer (a device for irrigation scheduling as per requirement of the crop). As DSR technology is recommended on medium and heavy textured soils, maximum area restriction of 5 lakh hectares was imposed in case of parimal varieties and 2 lakh hectares in case of basmati varieties. Thus, in optimal Plan-II, 22.75 per cent of *kharif* cultivated area shifted to new methods/ techniques of growing/irrigating paddy rather than by conventional method, which resulted into water saving of 16.16 per cent, double than in plan I (Table 4). Yet, such water savings are lower than the savings required to restore balance between water draft and water recharge. This is due to the reason that area under paddy, both parimal and basmati, was 23.75 lakh hectares, much higher than the targeted 16 lakh hectares. Further, reduction in paddy area would decrease profitability more. Alternative crops give much lower returns as compared with paddy. Their productivity or prices or a combination of both need to be increased to increase area under them by replacing paddy.

TABLE 4. OPTIMAL CROP PLAN FOR SUSTAINABLE WATER USE IN PUNJAB, 2011-12

(*area in ha*)

Crops (1)	Existing production pattern (2)	Optimal plan I (3)	Optimal plan II (4)
Paddy (conventional)	2243000 (56.72)	1600000 (40.46)	700000 (17.70)
Paddy (DSR)	-	0	500000 (12.64)
Paddy (tensiometer)	-	0	400000 (10.11)
Basmati (conventional)	575000 (14.54)	775000 (19.59)	575000 (14.54)
Basmati (DSR)	-	0	200000 (5.06)
Bt cotton	515000 (13.02)	574650 (14.53)	715000 (18.08)
Maize	126000 (3.19)	485750 (12.28)	345400 (8.73)
Moong	6600 (0.17)	0	0
Arhar	3100 (0.08)	9300 (0.23)	9300 (0.23)
Kharif fodder	400000 (10.11)	425000 (10.75)	425000 (10.75)
Sugarcane	80000 (2.02)	80000 (2.02)	80000 (2.02)
Okra	2600 (0.07)	0	0
Brinjal	3200 (0.08)	4800 (0.12)	4800 (0.12)
Sub-total	3954500	3954500	3954500
Wheat	3528000 (86.85)	3528000 (86.85)	3528000 (86.85)
Rapeseed and mustard	29000 (0.71)	22540 (0.55)	22540 (0.55)
Potato	84000 (2.07)	76460 (1.88)	76460 (1.88)
Barley	12000 (0.30)	0	0
Rabi fodder	300000 (7.39)	325000 (8.00)	325000 (8.00)
Pea	20000 (0.49)	30000 (7.38)	30000 (7.38)
Cauliflower	9000 (0.22)	0	0
Sugarcane	80000 (1.97)	80000 (1.97)	80000 (1.97)
Sub-total	4062000	4062000	4062000
RFFR (million Rs.)	373801	362876	376495
Increase in returns per cent	–	-2.92	0.72
Water use (m ha m)	4.50	4.13	3.75
Water saving (per cent)	–	8.15	16.66

Sugarcane being a perennial crop, its area has been counted in *rabi* season as well.
Figures in parentheses indicate percentages to *kharif* and *rabi* cultivated area respectively.

CONCLUSIONS

Groundwater depletion is a major issue in Punjab agriculture due to its over-exploitation. Paddy cultivation on an area of 28 lakh hectares is considered to be the main reason for this because its cultivation requires very high amounts of water as compared to its competing crops. Two-pronged strategy is being used to reduce the use of groundwater resources. Government of Punjab has developed a crop diversification plan to shift around 12 lakh hectares of rice area to other crops over the next five years. Similarly, water saving practices like direct seeded rice, and technologies like use of tensiometer for scheduling irrigations as per crop requirement instead of flooding irrigation, are being promoted at farmers fields to sustain groundwater resources. The present study tests both these options with respect to their impact on farm income and water savings. The results revealed that a shift of area under maize and basmati in plan–I, would result into a significant water saving of 8 per cent, but profits would fall by 2.57 per cent as compared to the existing plan. This was due to the low profitability of maize and basmati. However, adoption of DSR and tensiometer would bring water saving doubled than that in plan-II by at least ensuring same level profits to the farmers. Yet, sustainability of groundwater resources was not achieved. This suggests that a single strategy will not work but a multi-prolonged strategy encompassing improvements in productivity of alternative crops, increase in their prices and strengthening of market infrastructure besides adoption of water saving practices and technologies will be required to ensure sustainable use of groundwater recourses in Punjab.

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APPENDIX I. NET RETURN AND VARIABLE COSTS OF DIFFERENT CROPS IN PUNJAB, 2011-12

(*Rs. per hectare*)

No. (1)	Crops (2)	Variable costs (Rs./ha) (3)	Gross returns (Rs./ha) (4)	Returns over fixed farm resources (Rs./ha) (5)
		Kharif crops		
1	Paddy (conventional)	22596	72417	49821
2	Paddy (DSR)	16468	79775	63307
3	Paddy (tensiometer)	22596	72417	49821
4	Basmati (conventional)	25266	61889	36623
5	Basmati (DSR)	15755	74252	58497
6	Bt cotton	31945	80002	48057
7	Maize	19573	49806	30233
8	Moong	16795	34699	17904
9	Arhar	20229	60144.5	39915
10	Kharif Fodder	21490	34288	12798
11	Sugarcane	54624	162899	108275
12	Okra	30982	61150	30168
13	Brinjal	36160	101412	65252
		Rabi crops		
14	Wheat	16049	68205	52156
15	Rapeseed and mustard	10014	64407	54393
16	Potato	88647	143852	55205
17	Barley	11451	38260	26809
18	Rabi Fodder	31105	51297	20192
19	Pea	40572	96478.2	55906
20	Cauliflower	34758	80067	45309

APPENDIX II. PER HECTARE IRRIGATION WATER REQUIREMENT OF DIFFERENT CROPS IN PUNJAB, 2011-12

No. (1)	Crops (2)	Area (ha) (3)	Irrigation water requirement (cu.m./ha.) (4)
1	Paddy	2243000	10683
2	Basmati	575000	9018
3	Bt cotton	515000	3055
4	Maize	126000	2763
5	Moong	6600	1516
6	Arhar	3100	2019
7	Kharif fodder	400000	2900
8	Sugarcane	80000	8669
9	Okra	2600	2160
10	Brinjal	3200	3456
11	Paddy (DSR)	–	5549
12	Basmati (DSR)	–	4639
13	Wheat	3528000	2655
14	Rapeseed and mustard	29000	2013
15	Potato	84000	3844
16	Barley	12000	1062
17	Rabi fodder	300000	7600
18	Pea	20000	1569
19	Cauliflower	9000	1023

APPENDIX III. DISTRICT-WISE COMPARISON OF GROUND WATER DEVELOPMENT IN PUNJAB, 1984 TO 2011

(*Draft as a percentage of recharge*)

Districts/years	1984	1989	1991	1997	2005	2011
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gurdaspur	51	71	67	71	104	124
Hoshiarpur	50	49	47	44	81	97
Ropar	35	51	47	45	84	105
Mohali	62	71	63	68	77	86
Kandi zone	49	60	56	57	86	103
Amritsar	97	104	102	111	144	176
Barnala	101	111	116	125	158	202
Fatehgarh sahib	200	159	167	141	159	206
Jalandhar	218	194	202	197	227.	227
Kapurthala	191	303	259	251	201	228
Ludhiana	134	139	123	136	138	162
Moga	83	120	141	252	176	201
Nawanshahr	113	105	111	97	173	113
Patiala	164	134	135	129	169	193
Sangrur	179	161	168	170	192	281
Tarn taran	87	115	112	112	155	180
Central zone	142	149	149	156	172	197
Bathinda	34	49	49	71	92	116
Faridkot	31	39	38	50	106	156
Ferozepur	45	65	60	64	104	145
Mansa	39	50	37	39	174	208
Muktsar	9	21	14	14	62	66
South-West zone	32	45	40	48	108	138