REVIEW ARTICLE

Economic Performance and Optimum Cropping Patternbased on Alternative Price Scenarios in Arid-Western Plain Zone of Rajasthan State

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10.18805/ag.D-4923

Abstract

The present investigation was undertaken to work out the economic performance and optimum cropping pattern based on alternative price scenarios in the Arid-Western Plain Zone of Rajasthan state. In the present study, the unit-level cost of cultivation data of various crops for the triennium ending year 2013-14 which were collected from "Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Rajasthan state. The performance of different crops was assessed by calculating net returns under three alternative price scenarios, i.e. (i) Market prices (MP) (ii) Economic prices (EP) and (iii) Net income based on natural resource valuation technique (NRV). This study has considered subsidy as a cost to society. Similarly, greenhouse gas emissions from the crops have been taken as a cost to society and nitrogen fixation by leguminous crops has been taken as gain to the society. Results from the study show that the groundnut-barley combination of crop sequence was found the most remunerative in economic return generated over the year of ₹ 59418 per hectare followed by groundnut-vegetables (₹ 53930/ha) and groundnut-gram (₹ 52879/ha) combinations. The net gain to the farmers based on the alternative price scenarios viz. market, economic and natural resource valuation prices was estimated as ₹ 114.38 lakh, ₹ 114.45 lakh and ₹ 138.82 lakh, respectively. The overall gain to society has increased at economical prices by ₹ 49.39 lakh, whereas it was decreased by ₹ 93.24 lakh at natural resource valuation due to the lack of cultivation of legume crops. The optimal plan was suggested that more areas under cultivation of legume crops like groundnut, cluster bean, and gram because of they are less water-intensive and more environment-friendly and thus have a positive impact on natural resource valuation with the existing water availability.

Keywords: *Economic performance, Economic price and natural resource valuation, Optimum cropping pattern, Market price.*

Agricultural Science Digest (2019)

Introduction

Arid Western Plain Zone covers the five districts of Rajasthan state, namely Barmer, Bikaner, Churu, Jaisalmer, and Jodhpur. The climatic conditions are extremely arid. Rainfall received across the different districts of the zone within a year and years within the same districts are quite often erratic, so much so, that the entire rainfall of the year may fall on a single day and the rest of the year may be dry. It ranges from a high of 370 mm in Jodhpur to a low of just 100 mm in Jaisalmer. Desert soil, vast sandy plains with dunes, loamy coarse sand texture and some places calcareous soils are found in this region. Mostly rainfed crops are grown during *Kharif* season *i.e.,* bajra, cluster bean, groundnut, and *Kharif* pulses. In *rabi* season, wheat, gram, rapeseed and mustard, and cumin are grown only in areas where irrigation water facilities are available. It has a geographical area of 12367 thousand hectares, which is 36.13% of state's geographical area. In the zone, 13.56% share of gross cropped area is irrigated, and the average annual rainfall is less than 370 mm (Agricultural Statistics at a Glance, 2016). Out of 20 blocks of available replenishable groundwater, 16 blocks are overexploited in terms and the depth of groundwater level is approximately 150 meters below groundwater level (mbgl) in the zone (CGWB, 2014). Many studies have elucidated several hydrological (Gupta, 2009; Srivastava *et al.*, 2014), socio-economic (Nagaraj and Chandrakanth, 1997), institutional (Ballabh, 2003; Ghosh *et al.*, 2014) and policy (Sarkar and Das, 2014) related aspects of groundwater management, but without any systematic effort towards volumetric assessment of groundwater draft and extent of its over (under) use in crop production in the farmer's field.

Cropping pattern is inefficient in terms of resource use and unsustainable from a natural resource use point of view. This leads to serious misallocation of resources, efficiency loss, indiscriminate use of land and water resources, and it adversely affecting long term production prospects. Crop selection at the zonal level is a challenge that can be addressed using optimum crop planning. Best suitable crops

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How to cite this article: Jangid MK, Sharma L, Meena GL. Economic Performance and Optimum Cropping Patternbased on Alternative Price Scenarios in Arid-Western Plain Zone of Rajasthan State. Agri Sci, 39(3): 169-176.

Source of support: Nil

Conflict of interest: None

Submitted:02-04-2019 **Accepted:**10-07-2019 **Published:**02-10-2019

and other enterprises should be selected to achieve some set of goals particular to the zone. Typically, these goals involve the maximization of net return, the minimization of cost, the maximization of the total area cultivated, and/or the minimization of irrigation water use. Many studies in the past have attempted to development of optimum cropping pattern for maximizing net returns from farmers' perspective (Kaur *et al.* 2010, Husain *et al.* 2007 and Pradhan 2012). However, they ignored the social perspective and hence, did not assess any profits or losses to society. This study has considered subsidy as a cost to society.

Similarly, greenhouse gas emissions from the crops have been taken as a cost to society and nitrogen fixation by leguminous crops has been taken as gain to the society. To ensure the sustainable use of available groundwater in Arid-Western Plain Zones of Rajasthan state, it is necessary to revisit the existing cropping pattern and develop optimum crop plan for each zone as well as state which maximize net returns not only to the farmers but also to the society as a whole. Keeping in view the above considerations, a research study entitled "Economic Performance and Optimum Cropping Pattern based on Alternative Price Scenarios in Arid-Western Plain Zone of Rajasthan State" was conducted.

Material and Methods

The performance of different crops was assessed by comparing net returns under alternative three price scenarios. These are (i) Market Price (ii) Economic Price and (iii) NRV Technique (Raju *et. al.* 2015).

Net returns at market prices (NR_{MP})

Net returns at market price were defined as the gross return (value of main product and by-product) fewer variable costs (Cost A1 + imputed value of family labour) at the market price actually paid and received by the farmer or imputed in some cases.

$$NRMP = GR - VC \quad (i)$$

Where,

- NR_{MP}-net return at market price,
- GR- gross Returns and
- VC- variable Cost.

Cost A_1 as defined in Manual on Cost of Cultivation Scheme (CCS), Directorate of Economics & Statistics (DES), New Delhi includes all actual expenses in cash and kind in production by the farmer. The imputed value of family labour has been calculated as:

Imputed value of family labour = Working hours of family labour × labour wage rate per hour

Net returns at the economic price (NR_{EP})

Net return at the economic price was defined as the difference between net return or income at market price and subsidies on inputs like fertilizers and irrigation used in crop production.

$$\text{i.e. } NREP = NRMP - \text{Subsidy} \quad (ii)$$

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

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

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

The irrigation hours (hrs/ha) for each crop were taken from plot-wise CCS data. CCS does not collect information of ground water draft. Therefore, the groundwater draft was estimated using the following formula:

$$\text{Ground water draft (lit/sec)} = \frac{\text{HP x 75 x Pump efficiency}}{\text{Total head (m)}}$$

The information on horse power (HP) of the pumps owned by the farmers was available in CCS data set. For the households purchasing groundwater, average HP of the pumps (estimated separately for electric and diesel) in respective tehsil can be taken as a proxy. Pump efficiency was assumed to be 40 percent. The total head was obtained as per below equation:

Total head =Water level (mbgl*) + Drawdown (m) + Friction loss (10% of water level+ Drawdown)

Net returns based on natural resource valuation (NR_{NRV})

Net return based on NRV technique has taken care of nitrogen fixation by legume crops and green house gas (GHG) emission from crop production. As such NR_{NRV} was computed by adding value of nitrogen fixation by legume crops at an economic price of nitrogen (Value of N) and deducting the imputed value of increase in GHG emission cost to the atmosphere.

$$\textit{i.e. } NR_{NRV} = NR_{EP} + (\text{value of N} - \text{cost of GHG}) \quad (iii)$$

Optimization of Crop Model

The above linear programming model has been executed under the General Algebraic Modeling System (GAMS, Version: 12/2016) to develop different crop planning strategies. It develops the crop model which increases productivity with minimum input cost under the constraints of available resources like water usage and also labour, fertilizers, seeds, *etc.*, and ultimately getting maximum net benefits. Multi-crop models for two seasons are formulated in LP for maximizing the net returns, minimizing the cost and minimizing the water usage by keeping all other available resources (such as cultivable land, seeds, fertilizers, human labour, pesticides, capital, *etc.*) as constraints.

$$\text{Max } Z = \sum_{c=1}^{n} (YcPc — Cc)\, Ac \quad (1)$$

$$\sum_{Tc} \sum atcAc < NSt — OAt \quad (2)$$

$$Ac > A\ minc \quad (3)$$

$$Ac < A\ maxc \quad (4)$$

$$\sum_{C} wcAc < RGWAA \quad (5)$$

$$Ac > 0 \quad (6)$$

Mathematical specifications of the model

Mathematically, model specification for Rajasthan were presented by Equations 1-6 followed by equation wise description.

Objective function: maximization of net income (equation 1)

$$\sum_{(c=1)}^{n} (Y_c P_c - C_c) A_c$$

Let

Y_c: denotes yield of a crop c in one hectare of land,

P: the price received for the output from crop c,

C_c: refers to the cost incurred to cultivate crop c in one hectare of land and

A_c: is the area under cultivation of crop c

Then the RHS of the Equation 1 represents sum of net revenue obtained from all the crops considered for the optimum plan development. The objective was to maximize the net return(s) based on the optimum crop plan.

Land Constraint

Optimum use of land for each month is required. This has achieved by having a separate constraint equation (equation 2 is a compact form of 12 equations one for each month as shown below). This helps to have a separate sown area for each month and ensures that total cultivated area under selected crops in each month should be less than net sown area (NS_A) minus area under orchard (OA_t) crops. Further crop calendar has to be maintained as per format (Crop Calendar for Rajasthan).Thus, a_{tc} in equation 2 refers to the coefficient of crop calendar matrix for t^{th} month and c^{th} crop.

Minimum and maximum constraints (equation 3-4)

Crop planning model using LP primarily captures the supply side behavior specifically area response based on net returns and resource constraints ignoring the demand aspect. Such models tend to over-estimate or under estimate the area allocations for some crops. As a consequence, a single crop may cover an infeasible larger area (over estimation) or null/ negligible area (under estimation).

In some modeling solutions, some major crops may drastically lose their relevance and the corresponding area allocations may become negligible. Then, even though estimates are robust and mathematically proven, such allocations may not be desirable and practically possible from the viewpoint of food security of the country and livelihood security of the farmer because appropriate changes are required in policy framework of the country to adopt the optimum sustainable model. Similarly, area allocations for some crops may be over-estimated ignoring the demand. Such an area allocation is again undesirable as it may lead to glut in the market. To avoid such undesirable over-estimation or underestimation, assigning values to minimum and maximum area of the selected crops become essential in the model. To eliminate such practically undesirable solutions, concept of min, max constraints was used in the model as specified by equation 3–4.

$$\sum_{C} Jan_C A_C \le NS_{Jan} - OA_{Jan}$$

$$\sum_{C} Feb_C A_C \le NS_{Feb} - OA_{Feb}$$

$$\sum_{C} Mar_C A_C £ NS_{Mar} - OA_{Mar}$$

$$\sum_{C} Apr_C A_C \le NS_{Apr} - OA_{Apr}$$

$$\sum_{C} May_C A_C \le NS_{May} - OA_{May}$$

$$\sum_{C} Jun_C A_C \le NS_{Jun} - OA_{Jun}$$

$$\sum_{C} Jul_C A_C \le NS_{Jul} - OA_{Jul}$$

$$\sum_{C} Aug_C A_C \le NS_{Aug} - OA_{Aug}$$

$$\sum_{C} Sep_C A_C \le NS_{Sep} - OA_{Sep}$$

$$\sum_{C} Oct_C A_C \le NS_{Oct} - OA_{Oct}$$

$$\sum_{C} Nov_C A_C \le NS_{Nov} - OA_{Nov}$$

$$\sum_{C} Dec_C A_C \le NS_{Dec} - OA_{Dec}$$

$$\sum \sum a_{tc} A_C \le N$$

Groundwater constraints

Water is a scarce natural resource. The groundwater usage should be less than or equal to replenishable groundwater available for agriculture (RGWAA) for making the agriculture sustainable. Data of RGWAA was published by Central Ground Water Board. RGWAA was estimated by deducting water consumed by industries and other non-farm sectors from total replenishable groundwater.

Groundwater constraint used in linear programming (LP) model for Rajasthan agriculture was as follows:

$$\sum w_c A_c < RGWAA$$

Where,

- w_c: actual water drafted for a crop c in recent years based on Cost of Cultivation data.
- A_c: refers to the area allocation for a crop c.

Existing land area allocations under different crops are useful to make comparison with optimum crop plan model. This data is further useful for defining minimum and maximum area allocation limits for the selected crops.

Results and Discussion

The costs and returns of the individual crop enterprise are also influenced largely depending upon the degree of changes taking place in the resource use structure. The quantum and proportion of out-of-pocket expenses and imputed costs in the total cost structure which, either increase or decrease depending upon changes in the use of different resources and substitution of one form of resource for another. It is a matter of worldwide phenomenon that, in the process of transformation of traditional agriculture into a modernized one, changes usually take place through increased use of off-farm produced new forms of resources. The comparative cost, return and profitability is affected by factors like yield level, input use in production and their respective prices and output prices. The net return based on economic prices of different crops was computed by subtracting input subsidies like fertilizer subsidy, electricity subsidy, and diesel subsidy. Agriculture has considerable effect on climate primarily through production and release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. On the other hand side, legumes are environment-friendly crops and are different from other food plants because of the property of synthesizing atmospheric nitrogen into plant nutrients. As such, the natural resource valuation has been done by taking into account the positive impact of legume crops by biological nitrogen fixation and the negative impact of GHG emission. On adding these benefits and deducting the costs from net return based on economic price, we can get overall returns from cultivation of various crops to society and the natural resource valuation. In this view, the comparative returns at market price along with variable cost, net return based on economic price and net return based on natural resource valuation for various crops grown in Arid-Western Plain Zones of Rajasthan state were estimated and presented below

Net return based on market price (NR_{MP})

The comparative returns at market price along with variable cost for various crops in arid western plain zone during TE 2013-14 are depicted Table 1. The results from the table showed that the variable cost was highest in garlic (₹56772/ha.) followed by cotton (₹56549/ha.) and lowest in sorghum (₹6564/ha.). The cost structure varied across the crops. Among *Kharif* crops, cost for cotton cultivation was at higher end with variable cost of ₹56549 per hectare followed by groundnut (₹39930/ha.), castor seed (₹35453/ha.) and it was lowest in sorghum *i.e.* ₹6564 per hectare while in *rabi* season, the variable cost was highest in garlic (₹56772/ha.) followed by onion (₹54124/ha.), wheat (₹40934/ha.) and it was lowest in gram and fenugreek *i.e.* ₹14216 per hectare. Among *Kharif* crops, groundnut has shown the highest gross return (₹73557/ha.) while sorghum has reported the lowest value of output, *i.e.* ₹3700 per hectare during the study period. The cultivation of groundnut and castor seed were found most superior which provided much higher gross return and net return at market price as compared to other crops in *Kharif* season. Among *rabi* crops, cultivation of garlic has provided the highest gross return *i.e.* ₹68522 per hectare followed by onion (₹67603/ha.), wheat (₹61570/ha.) while the cultivation of fenugreek has reported the lowest value of output (₹13965/ha.).The return depends on cost of cultivation as well as on productivity of crop and its price. Among the *Kharif* crops, groundnut accrued the highest net return (₹33626/ha.) over variable cost followed by castor seed *i.e.* ₹20260 per hectare and the lowest net return was found in moth bean (-₹4683/ha.) which has shown the negative net return. While among the *rabi* crops, the net return was highest in barley (₹26284/ha.) followed by wheat (₹20637/ha) and lowest in cumin *i.e.* -₹10188 per hectare. The groundnut-barley combination of crop rotation in both seasons like *Kharif* and rabi season has generated higher net returns of ₹59910 per hectare which is higher than groundnut-wheat combination. Due to its lower cost of cultivation turns out to be the best combination as the net profit from other combination are less, *i.e.* groundnut-wheat (₹54263/ha) and castor seed-wheat (₹40897/ha). However, lack of domestic use of barley as staple food in the rural as well as urban areas are the main constraints to spread this combination of crop sequence.

Net return based on economic price (NR_{EP})

The net returns based on economic prices for various crops in *Arid*–Western Plain during TE 2013-14 are presented in Table 2. Results showed that wheat crop received the highest subsidy of ₹5140 per hectare because of higher fertilizer component use followed by barley *i.e.* ₹1677. Onion crop received the highest electricity subsidy of ₹3190 per hectare and barley received the highest diesel subsidy of ₹502 per hectare. Among the selected crops, the minimum subsidy was used in sesamum cultivation (₹37/ha). The groundnut remains most remunerative crop with net income of ₹31600 per hectare at economic prices followed by castor seed (₹18836/ha), vegetables (₹18120/ha) after deducting the subsidies. Wheat ranks first in terms of input subsidy used but is still not able to compete with other important crops in terms of net return per hectare. After removing subsidies, the net returns from rapeseed and mustard crop became negative (-₹57/ha) and also cluster bean becomes the least profitable crop in terms of economic prices. Thus, the withdrawal of all subsidies indicated that groundnut-barley combination of cropping pattern again generated the higher net return ₹55085 per hectare with the next best alternative combinations like groundnut-vegetables in the *Arid*–Western Plain Zone.

Net return based on natural resource valuation (NR_{NRV})

Table 3 presented the net returns based on natural resource valuation for various crops in arid western plain zone of Rajasthan state during TE 2013-14. Results of the table

Table 1: Comparative cost and returns of various crops based on market price during TE 2013–14 **(₹ /ha)**

S. No.	Crops	Variable Cost (A1+FL)	Gross return	Net return at market price
A	*Kharif crops*			
1	Bajra	15376	12895	–2482
2	Sorghum	6564	3700	–2864
3	Greengram	18251	17604	–647
4	Mothbean	13649	8966	–4683
5	Sesamum	7793	7458	–335
6	Groundnut	39930	73557	33626
7	Castorseed	35453	55713	20260
8	Cotton	56549	70158	13610
9	Clusterbean	13934	22092	8158
B	*Rabi Crops*			
1	Wheat	40934	61570	20637
2	Barley	21738	48022	26284
3	Gram	14216	28126	13910
4	Rapeseed and Mustard	15024	16144	1120
5	Cumin	32746	22557	–10188
6	Fenugreek	14216	13965	–252
7	Onion	54124	67603	13479
8	Garlic	56772	68522	11750
9	Vegetables	32132	52295	20163

Source: Plot level cost of cultivation data of Rajasthan (TE 2013–14)

indicated that the groundnut crop grown in this zone fixed nitrogen equivalent to the economic contribution of ₹4560 per hectare followed by cluster bean (₹3533/ha), gram (₹3140/ha) and green gram & moth bean (₹2235/ha). Vegetables caused the highest negative externalities by producing GHG's costing ₹235 per hectare followed by wheat (₹183/ha) whereas the minimum GHG costs were incurred by green gram, moth bean and gram (₹97/ha). Net return was found highest in groundnut cultivation of ₹36045 per hectare and it was lowest in green gram cultivation (₹1276/ha). Groundnut still stands at the top in seasonal crops in terms of gross return and net return per hectare whereas, in *rabi* season, the barley crop with ₹23373 per hectare net returns based on NRV come at the top. The crops like castor seed, vegetables, gram, and wheat have shown net returns of ₹18721, ₹17885, ₹16834 and ₹15313, respectively based on adding the positive benefits of nitrogen fixation and deducting the negative impact of GHG emissions. The groundnut-barley combination of cropping pattern was found the most efficient and superior in terms of financial return generated over the year of ₹59418 per hectare followed by groundnut-vegetables and groundnut-gram combinations based on natural resource valuation technique.

Comparative performance of crops based on various approaches of valuation

Comparative performance of net returns from various crops based on alternative price scenarios viz. market prices,

Table 2: Crop-wise net returns based on economic price during TE 2013-14 **(₹ /ha)**

S. No.	Crops	NPK subsidy	Electricity subsidy	Diesel subsidy	Total subsidy	Net return at economic price
A	Kharif crops					
1	Bajra	121	16	---	137	-2619
2	Sorghum	---	---	---	---	-2864
3	Greengram	216	---	---	216	-862
4	Mothbean	---	---	---	---	-4683
5	Sesamum	---	37	---	37	-372
6	Groundnut	1102	924	---	2026	31600
7	Castorseed	121	1303	---	1424	18836
8	Cotton	132	1347	---	1479	12130
9	Clusterbean	1	7	---	---	8149
B	Rabi Crops					
1	Wheat	3823	1317	---	5140	15496
2	Barley	1677	620	502	2799	23485
3	Gram	119	---	---	119	13791
4	Rapeseed & Mustard	479	699	---	1178	-57
5	Cumin	333	686	---	1019	-11207
6	Fenugreek	475	---	---	475	-727
7	Onion	193	3190	---	3382	10097
8	Garlic	817	2043	---	2860	8889
9	Vegetables	---	2042	---	2042	18120

Source: Estimated using plot level cost of cultivation data of Rajasthan (TE 2013-14)

Note: Subsidy @ ₹ 24.00/kg of N, ₹ 24.27/kg of P and `23.19/kg of K for TE 2013-14, diesel subsidy @ ₹ 12.95 per litre, electricity subsidy @ ₹ 3.03 per unit during TE 2013-14

economic prices, and natural resource valuation in Arid Western Plain Zone of Rajasthan state during TE 2013-14 are presented in Table 4. The result indicated that as expected, there is a moderate to high decline in net income from various crops after netting out subsidies like NPK, electricity, and diesel. The impact of subsidies was so large that in case some cases, the net return turned negative in rapeseed & mustard cultivation from ₹1120–₹57 per hectare whereas in case of wheat, the withdrawal of subsidies has reduced the net return nearby 25% from ₹20636–₹15496 per hectare followed by onion, garlic, barley, and groundnut. Due to the higher rate of profitability in groundnut, barley, castor seed, vegetables and wheat, the removal of subsidy lowered the net return moderately to high. Placing the economic value on the environmental effect further reduced the profitability in wheat, barley, vegetables, castor seed and rapeseed and mustard while the in case of groundnut, cluster bean, gram and green gram, the profitability has increased based on adding the positive benefits of nitrogen fixation and negative impact of GHG emissions. The crops like bajra, sorghum, mothbean, sesamum, cumin, and fenugreek have shown the negative return based on market prices, economic prices and natural resource valuation approaches. Similar findings were also found in the studies conducted by Raju *et al.* (2015), Rohit (2015), Burark *et al.* (2017), Yadav *et al.* (2017) and Ahmad *et al.* (2018).

Optimum crop model at existing groundwater use during TE 2013-14

The optimum crop plan and gain to society for AWP zone of Rajasthan state at existing groundwater use during 2013-14 are presented in Table 5 and 6. Results from the Table 5 show that the existing gross cropped area in the zone for TE 2013-14 was 7453.57 thousand hectares which has increased by about 5% and reached to 7811.69 thousand hectares in all three price scenario. In *Kharif* season, area under groundnut has increased by 75 percent from 239.14 thousand hectare to 418.49 thousand hectare followed by castor seed (15%), cluster bean (5%) and sorghum (5%) while the area under bajra, moth bean and sesamum has declined by 10% and cotton by 5 percent in optimal plan. In *rabi* season, the area under gram in optimal plan has increased by 75% from 602.97 thousand hectare to 1055.20 thousand hectare followed by barley (15%)

Table 3: Crop–wise net returns based on natural resource variation during TE 2013–14 (₹ /ha)

S. No.	Crops	Value of Nitrogen	Cost of GHG	Net return based NRV
A	*Kharif crops*			
1	Bajra	0	112	–2731
2	Sorghum	0	112	–2976
3	Greengram	2235	97	1276
4	Mothbean	2235	97	–2545
5	Sesamum	0	115	–487
6	Groundnut	4560	115	36045
7	Castorseed	0	115	18721
8	Cotton	0	NA	12130
9	Cluster bean	3533	NA	11682
B	*Rabi Crops*			
1	Wheat	0	183	15313
2	Barley	0	112	23373
3	Gram	3140	97	16834
4	Rapeseed and Mustard	0	115	–172
5	Cumin	0	NA	–11207
6	Fenugreek	0	NA	–727
7	Onion	0	NA	10097
8	Garlic	0	NA	8889
9	Vegetables	0	235	17885

Source: Estimated by using Plot Level Cost of Cultivation data for TE 2013–14 and based on Peoples et al. (1995), IIPR (2003) and IARI (2014).

Table 4: Net returns from crops using various approaches of valuation during TE 2013–14 (₹ /ha)

S. No.	Crops	Net return at market price	Net Return at economic price	Net return at natural resource valuation
A	*Kharif Crops*			
1	Bajra	–2481.50	–2619	–2731
2	Sorghum	–2864.13	–2864	–2976
3	Greengram	–646.62	–862	1276
4	Mothbean	–4682.97	–4683	–2545
5	Sesamum	–335.16	–372	–487
6	Groundnut	33626.43	31600	36045
7	Castorseed	20259.87	18836	18721
8	Cotton	13609.72	12130	12130
9	Clusterbean	8157.88	8149	11682
B	*Rabi crops*			
1	Wheat	20636.54	15496	15313
2	Barley	26284.15	23485	23373
3	Gram	13910.06	13791	16834
4	Rapeseed & Mustard	1120.38	–57	–172
5	Cumin	–10188.29	–11207	–11207
6	Fenugreek	–251.72	–727	–727
7	Onion	13478.87	10097	10097
8	Garlic	11749.67	8889	8889
9	Vegetable	20162.77	18120	17885

Source: Estimated by using Plot Level Cost of Cultivation data for TE 2013–14

and fenugreek by 5% whereas area under cumin in optimal plan has declined by 25 percent from 281.98 thousand hectares to 211.48 thousand hectares followed by rapeseed and mustard (15%), vegetables (15%), wheat, onion and garlic by 5 percent during the study period. The optimal plan suggested more area under cultivation of legume crops like groundnut, cluster bean and gram as they are less water-intensive and more environmentally friendly and thus have a positive impact on natural resource valuation with the existing water availability.

Results of Table 6 revealed that the existing revenue was ₹615.07 lakh at market price which has increased by about 19 percent and reached to ₹729.46 lakh from farmer's perspective in the study area. Thus, there is a potential to increase the returns by reorienting the existing cropping pattern at prevailing level of water use with optimal plan recommended by this model. At economic price and natural resource valuation, change in farmer's revenue has increased by ₹65.07 lakh and ₹232.06 lakh, respectively. Net gain under market, economic and natural resource valuation prices were estimated as ₹114.38 lakh, ₹114.45 lakh and ₹138.82 lakh. The social benefit has increased at economic prices by ₹49.39 lakh whereas decreased by ₹93.24 lakh at natural resource valuation during the study period. Similar findings were also reported by Rohit (2015), Burark *et al.* (2017), Yadav *et al.* (2017) and Ahmad *et al.* (2018).

Conclusion

Thus it can be concluded that the groundnut-barley combination of crop sequence was found the most remunerative in economic return generated over the year

Table 5: Optimum crop model at existing water use during TE 2013-14

S. No.	Crops	Existing Area (000 ha)	Optimum Area (000 ha)			Direction of Change
			At Market Price	At Economic Price	At Natural Resource Valuation	
A	Kharif Crops					
1	Bajra	1868.02	1681.22	1681.22	1681.22	– – –
2	Sorghum	65.58	68.86	68.86	68.86	+ + +
3	Greengram	204.53	173.85	173.85	173.85	– – –
4	Mothbean	809.64	728.68	728.68	728.68	– – –
5	Sesamum	57.34	51.61	51.61	51.61	– – –
6	Groundnut	239.14	418.49	418.49	418.49	+ + +
7	Castorseed	82.33	94.68	94.68	94.68	+ + +
8	Cotton	28.98	27.53	27.53	27.53	– – –
9	Clusterbean	2689.43	2823.90	2823.90	2823.90	+ + +
B	Rabi Crops					
1	Wheat	213.76	203.07	203.07	203.07	– – –
2	Barley	10.66	12.26	12.26	12.26	+ + +
3	Gram	602.97	1055.20	1055.20	1055.20	+ + +
4	Rapeseed and Mustard	240.04	204.04	204.04	204.04	– – –
5	Cumin	281.98	211.48	211.48	211.48	– – –
6	Fenugreek	23.59	24.77	24.77	24.77	+ + +
7	Onion	14.04	13.34	13.34	13.34	– – –
8	Garlic	4.03	3.83	3.83	3.83	– – –
9	Vegetables	17.52	14.89	14.89	14.89	– – –
C	Gross Cropped Area	7453.57	7811.69	7811.69	7811.69	+ + +

Table 6: Gains due to optimum crop model over the existing scenario during TE 2013-14

S. No.	Optimum Scenario	Change in GCA (%)	Existing Revenue (₹ in Lakh)	Optimum Net Returns (₹ in Lakh)	Change in Farmers Revenue (Optimal–Existing MP)	Gains to Society (₹ in Lakh)	Net Gain (₹ in Lakh)
1	Market Price	4.80	615.07	729.46	114.38	0.00	114.38
2	Economic Price	4.80	565.68	680.14	65.07	49.39	114.45
3	Natural Resource Valuation	4.80	708.32	847.13	232.06	-93.24	138.82

of ₹59418 per hectare followed by groundnut-vegetables (₹53930/ha) and groundnut-gram (₹52879/ha) combinations. Net gain to the farmers based on the alternative price scenarios viz. market, economic and natural resource valuation prices was estimated as ₹114.38 lakh, ₹114.45 lakh and ₹138.82 lakh, respectively. The overall gain to society has increased at economic prices by ₹49.39 lakh whereas it was decreased by ₹93.24 lakh at natural resource valuation due to the lack of cultivation of legume crops. The optimal plan suggested more area under cultivation of legume crops like groundnut, cluster bean and gram because they are less water-intensive and more environmentally friendly and thus have a positive impact on natural resource valuation with the existing water availability.

Acknowledgment

The author expresses their gratitude towards Dr. Latika Sharma, Assistant Professor and Officer Incharge (CCPC), Department of Agricultural Economics and Management, Rajasthan College of Agriculture, MPUAT, Udaipur for constant guidance during the Ph.D. research work.

References

Agriculture Statistics at a Glance. 2016. Government of Rajasthan. Available at: http://www.krishi.rajasthan.gov.in.

Ahmad, N., Sinha, D.K. and Singh, K.M. 2018. Optimal use of agricultural land and water resources through reconfiguring crop plans for different agro-climatic zones of Bihar (India). International Journal of Current Microbiology and Applied Sciences, 7(**1**): 3397-3409

Ballabh, V. 2003. Policies of water management and sustainable water use. India Journal of Agricultural Economics, 58 (3): 467-476.

Burark, S.S., Sharma, L., Meena, G.L. and Jat, S. 2017. ICAR-Social Science Network Project Report "Regional Crop Planning for Improving Resource Use Efficiency and Sustainability in Rajasthan". Department of Agricultural Economics and Management, RCA, MPUAT, Udaipur (Raj).

Central Ground Water Board.2014. Dynamic groundwater resources of India. Ministry of Water Resources, River Development & Ganga Rejuvenation Government of India, New Delhi.

Ghosh, S., Srivastava, S.K., Nayak, A.K., Panda, D.K., Nanda, P. and Kumar, A. 2014. Why the impacts of irrigation on agrarian dynamism and livelihoods are contrasting? Evidence from Eastern India States. Irrigation and Drainage, 65 (3): 573-583.

Gupta, S. 2009. Groundwater management in alluvial areas. Technical Paper in Special Session on Groundwater in the 5th Asian Regional Conference on INCID, December 9-11 at Vigyan Bhawan, New Delhi.

Hussain, I., Hussain, Z., Sial, M.H., Akram, W., and Hussain, M.F. 2007. Optimal cropping pattern and water productivity: A case study of Punjab Canal. Journal of Agronomy, 6 (4), 526-533.

IARI. 2014. GHG emission from Indian agriculture: trends, mitigation, and policy needs. Centre for Environment Science and Climate Resilient Agriculture, Indian Agriculture Research Institute, New Delhi, pp: 16.

IIPR. 2003. Pulses from a new perspective. In: Proceedings of the National Symposium on Crop Diversification and Natural Resource Management, Indian Institute of Pulses Research, Kanpur (U.P.), pp: 20-22.

Kaur, B., Sidhu, R.S. and Vatta, K. 2010. Optimal crop plans for sustainable water use in Punjab. Agricultural Economics Research Review, 23: 273-284.

Nagraj, N. and Chandrakanth, M.G. 1997. Intra and Inter-Generational Equity Effects of Irrigation Well Failures. Economic and Political Weekly, 32 (13):41-44.

Peoples, M.B., Ladha, J.K. and Herridge, D.F. 1995. Enhancing Legume N2 Fixation through Plants and Soil Management. Development in Plant and Soil Sciences, 174: 83-101.

Pradhan, K. K. (2012). A quantitative approach to profit optimization and constraints of mixed cropping pattern in Bargarh district of Western Orissa. International Journal of Advanced Research in Science and Technology, 1 (1), 81-85

Raju, S.S., Chand, R., Srivastava, S.K., Kaur, A.P., Singh, J., Jain, R., Kingsly, I. and Kaur, P. 2015. Comparing the performance of various crops in Punjab based on market and economic prices and natural resource accounting. Agricultural Economics Research Review, 28 (Conference Number): 189-198.

Rohit, G.V. 2015. Economic optimum crop planning for resource use efficiency and sustainability in the North-Eastern Dry Zone of Karnataka. M.Sc. Thesis (Unpublished), Department of Agricultural Economics, University of Agricultural Sciences, GKVK, Bengaluru.

Sarkar, A. and Das, A. 2014. Groundwater irrigation-electricity-crop diversification nexus in Punjab: trends, turning points and policy initiatives. Economic and Political Weekly, 49 (52): 64-73.

Srivastava, S. K., Srivastava, R. C., Sethi, R. R., Kumar, A. and Nayak, A. K. 2014. Accelerating groundwater and energy use for agricultural growth in Odisha: Technological and Policy Issues. Agricultural Economics Research Review, 27 (2): 259-270.

Yadav, D.B., Gavali, A.V. and Kamble, B.H. 2017. ICAR-Social Science Network Project Report "Regional Crop Planning for Improving Resource Use Efficiency and Sustainability in Maharashtra". Department of Agricultural Economics, MPKV, Rahuri (M.S.).