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Resource Use Efficiency in Indian Agriculture

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The term 'resource use efficiency in agriculture' may be broadly defined to include the concepts of technical efficiency, allocative efficiency and environmental efficiency. An efficient farmer allocates his land, labour, water and other resources in an optimal manner, so as to maximise his income, at least cost, on sustainable basis. However, there are countless studies showing that farmers often use their resources sub-optimally. While some farmers may attain maximum physical yield per unit of land at a high cost, some others achieve maximum profit per unit of inputs used. Also in the process of achieving maximum yield and returns, some farmers may ignore the environmentally adverse consequences, if any, of their resource use intensity.

Logically all enterprising farmers would try to maximise their farm returns by allocating resources in an efficient manner. But as resources (both qualitatively and quantitatively) and managerial efficiency of different farmers vary widely, the net returns per unit of inputs used also vary significantly from farm to farm. Also a farmer's access to technology, credit, market and other infrastructure and policy support, coupled with risk perception and risk management capacity under erratic weather and price situations would determine his farm efficiency. Moreover, a farmer knowingly or unknowingly may over-exploit his land and water resources for maximising farm income in the short run, thereby resulting in soil and water degradation and rapid depletion of ground water, and also posing a problem of sustainability of agriculture in the long run. In fact, soil degradation, depletion of groundwater and water pollution due to farmers' managerial inefficiency or otherwise, have a social cost, while farmers who forego certain agricultural practices which cause any such sustainability problem may have a high opportunity cost. Furthermore, a farmer may not be often either fully aware or properly guided and aided for alternative, albeit best possible uses of his scarce resources like land and water. Thus, there are economic as well as environmental aspects of resource use efficiency. In addition, from the point of view of public exchequer, the resource use efficiency would mean that public investment, subsidies and credit for agriculture are

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used in an efficient manner. However, for the sake of brevity, the present paper restricts its scope to the analysis of resource use efficiency in crop production, as reflected through changes in factor productivity/profitability over time, along with some discussion on sustainable use of land and water resources and required policy interventions.

Changes in Factor Productivity Over Time

According to Planning Commission (Tenth Five Year Plan), the incremental capital output ratio in agriculture and allied sector increased from 1.59 in the Eighth Five Year Plan, to 4.05 in the Ninth Five Year Plan, while the Tenth Five Year Plan aimed at bringing it down to 1.99. Also quite a number of research studies in the recent years have shown that factor productivity in agriculture has substantially decelerated over time. Fan *et al*. (2000) estimated that the annual growth rate of land productivity in irrigated zone of the country decelerated from 2.8 per cent in the 1970s and 1980s to about 0.4 per cent in the early 1990s, while yearly growth rate of labour productivity decelerated from 1.2 per cent in the 1970s to 0.8 per cent in the 1980s and (-) 0.1 per cent in the early 1990s. The annual growth rate of total factor productivity (TFP) in irrigated zone decelerated from 1.5 per cent in the 1970s to 1.1 per cent in the 1980s and (-) 1.0 per cent in the early 1990s. The study by Sen and Bhatia (2004) showed that aggregate output input ratio, based on both costs A_2+F_L and C_2 substantially declined during 1988 to 2000 in most of the states. In a study of Punjab agriculture, Singh and Singh (1998) pointed out that the gross value of agricultural output in real terms increased during 1970-71 to 1994-95, but the gross value of output per thousand MJ of energy used declined substantially. It was further expressed that due to decline in ground water table, increasing nutrient deficiencies and lack of breakthrough in energy saving technique of production, the energy requirement for sustaining the yield level will further increase and the returns per unit of energy are likely to decline in future.

A more disaggregated analysis of changes in factor productivity of irrigated crops (as shown in Table 1) reveals more or less a similar trend with minor variation as between states. In the case of paddy in Punjab, the index of factor productivity remained largely depressed in the decades of 1980s and 1990s, while during 1999-2000 to 2001-02, it was quite high. But in Uttar Pradesh, the index of factor productivity of paddy remained largely depressed, and during 2000-01 to 2002-03, it remained below the level of 1981-82. In the case of wheat, the index of factor productivity was depressed in the 1980s in both Punjab and Haryana, but quite robust in the 1990s, while during 2001-02 to 2003-04, there has been a decelerating trend. In Madhya Pradesh however, the index of factor productivity of wheat in all the years between 1983-84 to 2002-03 remained depressed and below that of 1982-83. In Uttar Pradesh, the index of factor productivity in wheat was comparatively higher in the late 1990s than in the 1980s, but from 2000-01 onwards, there has been some decelerating trend. The index of factor productivity in sugarcane remained largely depressed in both Uttar Pradesh and Haryana, although during 1997-98 to 2001-02, it was quite buoyant in Haryana, presumably under the impact of high State Advised Prices. The index of factor productivity in cotton has remained largely depressed from 1999-2000 onwards in Gujarat and since 1996-97 in Punjab.

TABLE 1. CHANGES IN FACTOR PRODUCTIVITY OVERTIME BY CROP AND REGION
(BASED ON A2+FL)

(*Base = 1981-82=100*)

	Paddy		Wheat				Sugarcane		Cotton	
Year (1)	Punjab (2)	Uttar Pradesh (3)	Punjab (4)	Haryana (5)	Madhya Pradesh (6)	Uttar Pradesh (7)	Uttar Pradesh (8)	Haryana (9)	Gujarat (10)	Punjab (11)
1981-82	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1982-83	103.97	94.42	101.86	90.82	121.56	117.73	114.33	170.04	89.80	106.52
1983-84	96.83	109.29	95.91	88.53	94.48	106.06	N.A.	89.25	117.12	80.27
1984-85	90.00	112.81	105.15	102.71	94.00	111.29	99.31	101.20	N.A.	165.34
1985-86	100.16	142.78	109.44	110.42	94.30	117.98	135.79	139.44	N.A.	132.07
1986-87	106.84	112.24	92.12	101.63	84.89	122.70	111.32	132.46	78.45	117.51
1987-88	109.68	113.09	107.10	111.35	101.81	112.69	110.22	N.A.	123.44	200.50
1988-89	114.73	94.65	107.99	117.65	91.56	97.97	100.07	N.A.	120.17	132.53
1989-90	108.57	101.02	115.45	132.25	83.07	100.12	135.54	N.A.	113.23	162.86
1990-91	102.97	102.39	106.88	143.79	92.88	117.73	109.17	115.73	N.A.	107.32
1991-92	113.23	109.93	123.04	158.29	96.63	N.A.	100.93	N.A.	N.A.	N.A.
1992-93	123.55	106.24	120.74	137.00	78.39	N.A.	105.00	93.27	110.74	127.97
1993-94	136.55	N.A.	N.A.	N.A.	N.A.	N.A.	115.85	N.A.	146.58	N.A.
1994-95	119.88	N.A.	119.80	135.45	75.80	N.A.	107.02	N.A.	N.A.	158.53
1995-96	103.36	N.A.	96.36	133.64	90.59	122.44	96.45	N.A.	163.09	109.82
1996-97	112.77	124.61	141.62	138.87	94.27	148.24	109.81	N.A.	123.13	94.99
1997-98	124.65	106.93	119.14	133.85	82.26	143.84	125.04	120.82	152.16	59.42
1998-99	106.89	105.55	142.32	158.65	85.78	149.73	113.20	157.76	142.56	58.11
1999-2000	132.94	108.41	159.10	156.24	97.46	142.59	96.18	128.77	93.39	69.66
2000-01	132.06	92.80	142.30	133.52	77.07	125.74	95.22	135.65	70.94	95.34
2001-02	137.60	90.42	133.78	124.92	77.17	126.65	90.46	135.46	72.61	60.02
2002-03	99.81	83.71	124.70	121.86	74.41	121.86	85.24	80.35	102.71	79.16
2003-04	N.A.	N.A.	117.49	114.70	N.A.	125.39	N.A.	N.A.	N.A.	N.A.

Source: Based on data of Comprehensive Scheme for Cost of Cultivation of Principal Crops, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

While a short term fluctuation in factor productivity due to either weather or price variability, need not be a cause for concern, any secular declining trend over a long period should certainly be a matter of concern, especially in a situation where still there are large yield gaps. The results of ICAR's field demonstrations indicate that yield gaps exist in respect of almost all crops and in all regions. In a study of paddy cultivation in Tamil Nadu, Mythili and Shanmugam (2000) pointed out that the mean technical efficiency was only about 82 per cent, indicating further that the realised output can be increased by 18 per cent without any additional resources. Also in a study of wheat crop in Punjab Singh *et al.* (1998) showed that there is scope for raising the crop yield through improved farm management practices.

Inter Regional and Inter Farm Variations in Factor Productivity

Due to varying influence of different factors (as discussed above) in different regions, there are large scale inter regional as well as inter farm variations in factor productivity. In fact, all crops cannot be profitably grown in all regions. It may be seen from Table 2 that even the principal crops like paddy and wheat have higher productivity, lower costs of production and higher net returns in some regions than in others, the precise reasons for which would need more close analysis. Similarly, in each region, there are farms which are relatively more cost efficient and productive than others. It has been observed that the average costs of production per quintal of paddy in Punjab in 1998-99 was only about Rs. 250 for 10 per cent of efficient farmers having high yield, while it was as high as Rs. 463 for bottom 10 per cent having low yield. Also in the case of wheat, 10 per cent of the efficient farmers had an average cost of Rs. 312 per quintal as against Rs. 449 per quintal by 10 per cent of

TABLE 2. AVERAGE PER HECTARE COSTS AND RETURN IN THE CULTIVATION OF WHEAT AND PADDY IN VARIOUS REGIONS (AVERAGE OF 2001-01 TO 2002-03)

(Rs.)

(1)	Cost A2+FL (2)	Gross value of output (3)	Net return (4)
		Wheat	
Bihar	9898.87	14894.38	4995.51
Gujarat	12889.10	23340.95	10451.85
Himachal Pradesh	6810.33	8855.70	2045.37
Haryana	13453.19	29275.80	15822.61
Madhya Pradesh	7642.05	13915.51	6273.47
Punjab	13227.88	30725.14	17497.26
Rajasthan	13659.34	26558.40	12899.06
Uttar Pradesh	11161.32	20516.44	9355.12
		Rice	
Assam	9731.73	12609.42	2877.69
Bihar	8494.16	11393.40	2899.24
Haryana	16569.55	29292.90	12723.35
Karnataka	20461.47	31084.12	10622.64
Kerala	19026.42	25766.27	6739.85
Madhya Pradesh	8398.83	9172.77	773.94
Orissa	11726.32	14843.54	3117.22
Punjab	15855.47	32606.06	16750.59
Uttar Pradesh	11194.74	15737.18	4542.44
West Bengal	16181.34	17840.41	1659.07

Source: Based on data of Comprehensive Scheme for Cost of Cultivation of Principal Crops, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

the most inefficient farmers (Haque, 1998). A number of management factors such as timeliness and method of sowing, transplanting, irrigation and application of right doses of inputs and input mix play an important role in influencing inter-farm variation in crop productivity (Selvarajan *et al.*, 1997). In some situations, as farm size increases, factor productivity also decreases even though the marginal as well as large farmers are generally less productive than the small and medium farmers (Sen and Bhatia, 2004; Haque, 1996).

FACTORS INFLUENCING CROP PRODUCTIVITY

A double log regression equation was worked out to find out whether farmers in different regions used various inputs in crop production efficiently during 1981-82 to 2002-03, keeping in view their marginal value products or elasticity coefficients. It may be seen from Table 3 that human labour continued to influence productivity of paddy in Punjab, cotton in Gujarat and sugarcane in Uttar Pradesh quite significantly, while machine labour influenced wheat productivity positively and significantly in Uttar Pradesh. The expenditure on irrigation had negative elasticities in almost all cases, excepting sugarcane in Maharashtra and cotton in Punjab in which case the relationship between irrigation expenditure and crop productivity was positive, but statistically non-significant. The expenditure on fertiliser had negative elasticities in both Punjab and Haryana for paddy, in Uttar Pradesh for both wheat and sugarcane and in Maharashtra for sugarcane. Also the expenditures on seed had negative elasticities for paddy in Punjab and Haryana, wheat in Punjab, Uttar Pradesh and Madhya Pradesh and cotton in both Gujarat and Punjab. These results do indicate that farmers in several instances do not use their inputs optimally.

TABLE 3. ELASTICITY COEFFICIENTS OF FACTORS DETERMINING CROP PRODUCTIVITY DURING 1981-82 TO 2002-03

	Paddy - Punjab		Paddy - Haryana	
	Coefficient	T-value	Coefficient	T-value
(1)	(2)	(3)	(4)	(5)
Intercept	3.7130	2.8500	2.0350	6.4430
Total human labour	0.5300	1.7270	1.7890	4.9240
Total bullock labour	-0.1220	-1.5560	-0.1040	-2.1600
Total machine labour	0.2540	2.0710	-0.7990	-1.7680
Seed	-0.1760	-0.9220	-0.2140	-1.4050
Fertiliser	-0.2900	-1.1150	-0.6390	-2.1550
Manure	-0.1390	-2.8910	-0.0110	-0.4830
Insecticide	0.4320	1.5730	0.1340	2.2310
Irrigation charges	-0.4570	-1.7490	-0.3770	-1.7220
R Square	0.987		0.992	

(Contd.)

TABLE 3. (*Concld.*)

	Wheat - Punjab		Wheat - Haryana	
	Coefficient	T-value	Coefficient	T-value
(1)	(2)	(3)	(4)	(5)
Intercept	-0.0060	-0.0150	0.5680	1.0320
Total human labour	0.1890	0.7170	0.1820	0.8990
Total bullock labour	0.5080	1.3270	0.0310	0.1170
Total machine labour	0.1310	0.5960	0.2570	0.9410
Seed	-0.0168	-0.3510	0.0070	0.9530
Fertiliser	0.0890	0.7490	0.0860	0.4390
Manure	0.0570	0.8350	-0.0350	-0.2880
Insecticide	0.5410	3.7990	0.6510	2.5070
Irrigation charges	-0.0740	-0.7930	-0.0300	-0.7530
R Square	0.991		0.987	
	Wheat – Madhya Pradesh		Wheat – Uttar Pradesh	
	Coefficient	T-value	Coefficient	T-value
(1)	(2)	(3)	(4)	(5)
Intercept	1.9850	3.4930	0.9280	3.3970
Total human labour	0.0510	0.2000	-0.0930	-0.5150
Total bullock labour	0.7160	2.8100	0.7680	5.4240
Total machine labour	-0.1380	-0.7750	0.2450	2.4540
Seed	-0.0990	-1.8030	-0.0120	-0.2730
Fertiliser	0.2050	1.5270	-0.0030	-0.0420
Manure	-0.3480	-1.4990	0.0040	0.0680
Insecticide	0.2300	1.2860	0.2010	1.4810
Irrigation charges	-0.0080	-1.2260	-0.0030	-0.2370
R Square	0.988		0.996	
	Sugarcane - Maharashtra		Sugarcane - Uttar Pradesh	
	Coefficient	T-value	Coefficient	T-value
(1)	(2)	(4)	(5)	(6)
Intercept	2.2890	3.3260	1.7720	6.2180
Total human labour	0.2410	1.1150	0.8180	5.7920
Total bullock labour	0.2290	1.3120	0.0330	0.2430
Total machine labour	0.0300	0.2130	0.0350	0.1650
Seed	0.0450	0.3420	0.0004	0.0060
Fertiliser	-0.1040	-0.5310	-0.0610	-0.4600
Manure	0.1380	1.3590	-0.1490	-1.7360
Insecticide	0.0980	1.7280	-0.0017	-0.0180
Irrigation charges	0.0010	0.2500	0.0020	0.0670
R Square	0.959		0.989	
	Cotton - Gujarat		Cotton - Punjab	
	Coefficient	T-value	Coefficient	T-value
(1)	(2)	(3)	(4)	(5)
Intercept	0.7520	0.8050	0.7190	0.2840
Total human labour	1.1170	3.1530	0.3210	0.5490
Total bullock labour	-0.0320	-0.0950	-0.4000	-0.4670
Total machine labour	0.5900	1.4240	0.2490	0.3100
Seed	-0.3940	-1.1760	-0.0300	-0.2960
Fertiliser	0.5390	1.2980	0.3220	1.2960
Manure	-0.7940	-1.4700	0.2630	0.7820
Insecticide	0.0880	0.3490	-0.3880	-1.0000
Irrigation charges	-0.1990	-0.5180	0.7450	0.7050
R Square	0.889		0.837	

Source: Based on data of Comprehensive Scheme for Cost of Cultivation of Principal Crops, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

Besides, one can draw several inferences from the decelerating and fluctuating trends in factor productivity. First, the factor like erratic weather could still influence factor productivity in irrigated areas. Second, it would mean failure on the part of both ICAR and the state governments to help innovate yield augmenting, albeit profitable technologies and cropping patterns through integrated support system. Third, low and sometimes even negative return in agriculture, coupled with high risks due to weather and price variability could discourage the farmers to take proper interest in farming. In a number of states, including Assam, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa and Rajasthan, the net returns per hectare are so low that based on traditional crop farming, the small and marginal farmers do not earn enough to stay above the poverty line (Sen and Bhatia, 2004; Haque, 1996). This coupled with inadequate access to institutional credit at low rate of interest, disables them to invest in farm improvement. Besides, growing marginalisation and fragmentation of land holdings, coupled with rising incidence of informal, albeit insecure tenancies and poor rural infrastructure such as road, electricity, markets and education affect factor productivity (Haque and Sirohi, 1986; 1996 and 1998; Fan *et al.* 2000). Some recent studies by Fan *et al.* (2000) and Fan *et al.* (1999) show that investments in roads, electricity and education have high pay-offs in terms of raising factor productivity in agriculture and giving decent returns per rupee of investment.

Issues Relating to Profitable and Sustainable Uses of Land and Water

In the present context when Indian agriculture should become cost efficient and globally competitive, it is often suggested that there should be regionally differentied production strategy so that each region specialises in the production of those crops in which it has relative advantages in terms of costs, yield, prices and also ecology. But the problem arises when there is large trade-off between economics and ecology in the short run. For example, based on ecological consideration, there is no reason why states like Punjab and Haryana should be growing paddy on a large scale, especially because it requires more intensive use of water in a situation where there is scanty rainfall and also the water table is reported to be depleting very rapidly (DRR, 1991; Chaudhary and Harrington, 1993; Chand and Haque, 1997). But the cost, yield and assured price considerations encourage the farmers in Punjab to grow paddy. In fact, due to both technological and price factors, coarse cereals and pulses have lost acreage significantly to high water consuming crops like paddy, sugarcane and wheat in many states. This is because the individual farmers are most concerned with their private gains and costs, while completely ignoring the social cost of over-exploitation of ground water resource (Joshi and Tyagi, 1991; Dhawan, 1995; Vaidyanathan, 1996 and Marothia, 1997). Crops like pulses, oilseeds and coarse cereals may be more eco-friendly in Punjab and Haryana region, but currently the structure of relative net returns from alternative crops are such that farmers would not easily shift away from paddy wheat cropping system (Table 4). The existing low yields, coupled with inadequate and effective price as well as marketing support would constrain large scale adoption of pulses, oilseeds and coarse cereals by farmers in view of their expected lower relative returns. Conversely, in a state like Kerala, paddy area has been replaced by plantation crops like coconut, rubber arecanut, etc., based on economic consideration, even though plantation crops are currently under stress due to pest attack as well as competition from outside.

TABLE 4. NET RETURNS OVER PAID OUT COST IN SELECTED CROPS

	Net Return (Rs./ha.)		
	2000-01	2001-02	2002-03
(1)	(2)	(2)	(4)
Punjab			
Paddy	16851.15	19436.88	13963.74
Wheat	18957.84	17779.37	15754.58
Rapeseed and Mustard	3766.84	5932.25	8224.35
Cotton	7198.33	-1762.07	3999.45
Haryana			
Paddy	14195.33	13001.48	10973.25
Wheat	16125.77	15396.44	15945.63
Rapeseed and Mustard	10687.98	9999.05	8071.24
Cotton	9537.97	-5892.69	7115.29
Bajra	55.08	-1032.85	484.65
Gram	4529.55	2060.31	3990.89
Sugarcane	41248.34	46404.90	24178.83
Karnataka			
Maize	5411.33	2546.26	3109.87
Sunflower	-285.49	3108.27	2292.03
Gujarat			
Groundnut	390.99	13526	5473.82

Source: Based on data of Comprehensive Scheme for Cost of Cultivation of Principal Crops, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

Similarly, the cultivation of many fruits and vegetables which are generally considered as high value crops, would appear risky to a vast majority of small and marginal farmers, unless there are provisions for effective technology, price, marketing and insurance support.

In fact, the pace and patterns of agricultural diversification in any location would depend on a number of factors such as soil type, climate, relative costs and returns, riskiness of alternative sources of income, farmers' attitude as well as the ability to bear risks, availability of appropriate and adequate seed and plant materials, flexibility of irrigation and drainage, infrastructure and institutions, especially for efficient marketing, price discovery and price support as well as credit, insurance and finally the growth of demand for diversified products both within and outside, depending on the growth and distribution of income. However, one should keep in mind that while all these factors are important, the availability of good quality irrigation water, coupled with flexibility of irrigation and drainage system and appropriate methods of application as well as pricing of irrigation water would be crucial for sustainable use of land and water resources. Currently, the sustainability of irrigated agriculture in the arid and semi-arid regions of the country is faced with the challenge of alkalinity and salinity problems as indiscriminate use of poor quality water in the absence of proper soil water crop management practices, poses grave risks to soil health and environment, while affecting the crop yields and returns at the same time (Datta and Dayal, 2000).

It should also be mentioned in this context that some macro economic policies such as restrictions on land leasing, supply of either free or highly subsidised power and water and also high rate of interest on agricultural credit have affected resource use efficiency in agriculture. For example, restrictions on land leasing in many states have either encouraged some land owners to keep their land fallow or resulted in the growth of informal tenancies which have reasons to become less efficient (Haque, 2000). Similarly, either free or subsidised power and water supply for irrigation in several states have resulted in over-exploitation of ground water. In many cases, farmers' application of irrigation is also not associated with increased productivity. Therefore, some of our existing policies may need to be properly amended. At the same time, farmers must have timely access to adequate credit, at reasonable rate of interest, quality seeds, fertilisers and other inputs, along with knowledge of integrated resource management and facilities for convenient and competitive marketing of agricultural produce. Besides, appropriate risk management policy would be crucial for stabilising farm income which would encourage the farmers to take proper interest in farming and maintain resource use efficiency.

Irrigation Charges and Water Use Efficiency

It is often said that low irrigation charges encourage farmers not to bother about water use efficiency and also cause the problem of rapid depletion of ground water in many areas. Following Dublin Principles of 1992 it is argued that the price of irrigation water should be such that farm water use approaches its scarcity value (Solanes and Villarreal, 1999). In fact, if water prices rise adequately to reflect its opportunity cost, the farmer may respond in any of all of the following ways (Gardner, 1983; Ray, 2005). He can cultivate all his land with critical number of irrigation, but stress the crop a little, but maximising output per unit of water rather than output per unit of land. He may diversify in favour of more water efficient crops and he may invest in more efficient irrigation technologies such as sprinkler and drip systems. It is reported that shortening the length of the irrigation furrow could raise field level irrigation efficiencies by upto 10 per cent (Ray, 2005). However, there are also other types of argument, saying that only if the water cost were significant in the overall crop budget and as a fraction of crop net revenues, the farmers would be motivated to change. Besides, if water is charged by a unit of area, as it is usually the case, its marginal cost is zero and therefore, higher prices may not induce farm level efficiency. Moreover, the cost of infrastructure required for implementation of volumetric pricing such as measuring devices, channels for conveyance, managerial and administrative changes may neutralise the expected gains from efficient water use. Hence crop pricing as a means of conserving water may be more effective than water pricing (Ray, 2005).

As a matter of fact, both the above types of argument have their relevance in a specific context. In states like Punjab and Haryana where irrigation charges as percentage of net crop revenue from paddy are in the range of 26 to 30 per cent (as of 2002-03) and 20 to 23 per cent of operating costs, any rise in volumetric water price would certainly demotivate the farmers to use more water and along with crop price disincentive, farmers may be induced to replace paddy by other low water requiring crops such as cotton, maize, soyabean, etc. Alternatively, farmers may reduce the number of irrigation in paddy by changing the time of sowing and transplanting from a high temperature month of May to mid-June when the onset of monsoon is expected to provide the required quantity of water. Nevertheless, the final outcome would depend on the interplay of various factors such as technology, infrastructure, availability of alternative albeit cost effective methods of irrigation, input-output price policy, Exim policy and consequent overall behaviour of input-output markets.

EMERGING ISSUES

The foregoing discussion throws up several issues for future research and policy interventions. Some of the emerging issues of concern could be listed as follows:

(i) Can the government and the ICAR-SAU system help innovate demand-driven, albeit location-specific yield augmenting, eco friendly and profitable technologies and cropping patterns in different regions through an integrated support system, for raising factor productivity in a continuous manner?

(ii) How do we motivate the farmers in different regions to adopt regionally differentiated, albeit appropriate cropping patterns and agro-based enterprises (having both subsistence and commercial orientation), not only for improving cost efficiency and returns, but also sustainability?

(iii) Are there appropriate methods of estimating social costs and benefits or opportunity cost of farmers for adopting an economically rewarding and ecologically sustainable cropping patterns in a given region?

(iv) To what extent low resource use efficiency in agriculture is due to farmers' growing lack of interest in farming and farm improvement measures under the impact of low and even negative returns?

(v) To what extent, the farmers' differential access to rural infrastructure and institutions, such as road, electricity, markets, banks, co-operatives and even legal as well as administrative infrastructure influence resource use efficiency in agriculture in different regions?

(vi) What kind of policy interventions in land, labour, water, credit and product markets will be required to help promote profitable and ecologically sustainable cropping patterns and related enterprises in different regions?

(vii) Can we develop an integrated policy support system to encourage farmers in improving farm level irrigation efficiency.

(viii) What should be the government's strategy to remove various demand side constraints to ecologically sustainable diversified growth?

The answers to these questions would go a long way to plan things better for improving resource use efficiency in Indian agriculture.

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