Indian Journal of Agricultural Sciences **84** (11): 1415–22, November 2014/Article
https://doi.org/10.56093/ijas.v84i11.44653

Rainfed agriculture in India: An analysis of performance and implications

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Received: 12 October 2013; Revised accepted: 8 September 2014

ABSTRACT

The paper examines the trend in the performance of rainfed agriculture in India across major crops during pre- and post-liberalisation period; and ascertains the trend in net income of crop groups of different water requirements in rainfed regions. The major crop groups considered in the analysis are coarse cereals, oilseeds, pulses and cotton. The results indicate that the growth in production of oilseeds and pulses during 1980s and early 1990s weaned out during the subsequent period, probably due to the dilution of some of the policy initiatives like mission mode operation for these crops and adverse terms of trade. However, the yield of most of the crops has increased during the post-liberalisation period. This was also associated with a sharp increase in cost of cultivation. The rate of increase in cost of cultivation was severer for traditional rainfed crops compared to water intensive crops like sugarcane and paddy. Also, the growth in value of production has been lower than the growth in cost of cultivation for the rainfed crops during the post-liberalisation period. The parity of the net income also favoured cultivation of water intensive crops in rainfed lands. Rainfed regions need to focus on yield enhancement through natural resource conservation notably, water; and, incentivise rainfed agriculture through price policies and market opportunities. The study calls for increased investment for rainfed regions for creation of affordable technologies for water conservation and increasing water use efficiency; creation of institutions for better water management and spreading water literacy for sustainable crop production.

Key words: India, Liberalisation, Performance, Rainfed agriculture, Water management

The development issues of rainfed agriculture assume critical importance on account of the slow growth and its implications on livelihood security of significant number of rural poor in India (Rao 2004). About 56 % of the total cultivated area in India falls under rainfed agriculture. The importance of the rainfed agriculture can be gauged from the fact that it contributes to 40 % of the country's food production; accounts for much of the national area under coarse cereals (85%), pulses (83%), oilseeds (70%) and cotton (65%); and holds 60 % of the total livestock populations (Venkateswarlu and Prasad 2012). Even after attaining full irrigation potential, about half of the country's cultivated area would continue to be under rainfed farming. Even at the best possible growth scenario of irrigated agriculture, about 40% of the long term additional foodgrain requirement needs to be met out from the rainfed regions (GoI 2006). Therefore, the developmental needs of the rainfed regions would be of foremost importance in future too. Given the high concentration of rural poverty and backwardness in dry and rainfed regions and the strong linkages of agricultural development on poverty reduction, bringing in a breakthrough in the performance of rainfed agriculture forms an important poverty alleviation strategy in the country.

However, a major concern about the rainfed agriculture in India is the low level of productivity, in fact one among the lowest in dry and rainfed regions in the world (GoI 2011). In this context it is reported that while irrigated crops has registered an improvement in yield and total productivity since the 1960s, those of rainfed crops or dry farming have stagnated. Yet, the average crop yield under rainfed conditions in research and demonstration plots is two to four times higher than the national average crop yields (Lal 2008). Many research and development programmes have been implemented by central and state governments to improve the productivity of rainfed agriculture. However, these programmes often failed to take note of the certain unique characteristics of the rainfed farming system, viz. highly diverse activities/ enterprises; strong linkages with common pool resources; significant role of livestock; and, weak institutional support in terms of markets, credit and inputs (GoI 2011). This has led to missing the context in the development approach, and gradual spread of green revolution type of high intensity agriculture including spread of groundwater based irrigation even in hard rock dry areas of peninsular India (Raina 2006). A notable negative externality of this mismatch has

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been degradation of the natural resources, particularly groundwater, which would have serious implications on inter- and intra-generational equity and sustainability (Nagaraj and Chandrakanth 1995, Kumar 2003). Therefore, appraisal of rainfed agriculture with respect to economic performance of crops of varying water use is of utmost importance in devising long term plans for sustainable crop production in rainfed regions.

It is also pointed out that the macroeconomic policy changes in the form of liberalisation of Indian agriculture has affected the favourable terms of trade enjoyed by some rainfed crops like oilseeds (Chand *et al* 2010). In the long run this has resulted in different growth experience for dominantly irrigated and dominantly rainfed regions. This suggests that the developmental course of the rainfed regions has been influenced by both internal and external factors; and therefore, any attempt to assess the performance of rainfed agriculture needs to factor-in these dimensions. In this backdrop, the present study examines the performance of rainfed agriculture in India across major crops/crop groups during pre- and post-liberalisation period; and ascertains the trend in net income of crop groups of different water requirements in rainfed regions.

By analysing the shift in area between various rainfed crops, Rao (2004) observed that the farmers in the dry and rainfed regions respond fairly well to the market signals, and are willing and able to resort to modern inputs. In that context, the increased farm distress in the rainfed regions since mid-1990s was attributed to price risk; weak institutional mechanisms for credit, markets and delivery of services related to quality inputs; and adoption of modernised agriculture from a vulnerable position. Such vulnerability has been rooted most prominently in case of expansion of groundwater based irrigation. For example in Madhya Pradesh, the expansion of irrigation has been associated with substitution of less water-consuming local varieties with varieties that are high yielders, but high water consumers also (Shankar 2005). An astronomical increase in the number of tube wells, both operated through electricity and diesel has been noted in the state, accounting for 70% of total irrigated area. In the efforts to increase the area under irrigation, competitive deepening is undertaken in arid and semi-arid regions (World Bank 2010).

The emerging constraints in rainfed agriculture have been noted in earlier studies as well. For example, Jodha (1991) has noted emergence of indicators of unsustainability in dry land agriculture as a result of resource intensification disregarding of the unique features of the production system, and cautioned that it would in long term affect the sustainability of the very system. Ninan and Chandrashekar (1993) have reported increase in instability in output and yield moving in symphony with growths in dry land crops in Karnataka since green revolution, and attributed this to the shift from risk spreading and risk adjusting crop patterns to specialisation, and transition to high input oriented agriculture.

MATERIALS AND METHODS

Rainfed agriculture is characterised by large diversity of crops or crop groups. Due to unavailability of relevant data for all the rainfed crops consistent with the period of analysis, certain crops and crop groups representing coarse cereals, pulses, oilseeds and commercial crops, typical of dry and rainfed agriculture from representative states were selected. The representative states for the selected crops were identified based on the highest production of the crop under consideration. Such a methodology has been adopted by Rao (2004) while undertaking a comprehensive study on the performance of the rainfed agriculture in India. However, unlike Rao, pulses and cotton also were included in the present study. For analytical purpose, the rainfed crops were classified into three major groups, based on some considerations pertaining to water requirement and technology changes. These considerations were: firstly, though the rainfed agriculture consists of mostly crops with little irrigation, water intensive crops like paddy and sugarcane are gradually spreading in rainfed regions, mainly through groundwater based irrigation. These water intensive and irrigated crops perform distinctly different compared to purely un-irrigated crop system. Secondly, cotton, though is largely a rainfed crop, has witnessed a technological breakthrough on account of Bt cotton introduction. This technological breakthrough has made marked effect on the economics of cotton cultivation in India in terms of cost of cultivation, cost of production and input usage. Based on these considerations, the three crop groups identified were (1) dominantly rainfed crops with the inclusion of cotton; (2) dominantly rainfed crops excluding cotton; and (3) irrigated crops in dominantly rainfed regions. The crops and states that were selected are bajra and jowar from Rajasthan and Maharashtra respectively representing coarse cereals; chickpea and redgram from Madhya Pradesh and Maharashtra representing pulses group; groundnut, rapeseed/mustard, soybean and sunflower from Gujarat, Rajasthan, Madhya Pradesh and Karnataka respectively representing oilseeds; and, cotton from Maharashtra. As noted earlier, the major irrigated crops are sugarcane and paddy selected from all the rainfed states. As Andhra Pradesh has not ranked first in any of the rainfed crops under consideration as per the sampling framework, the results for the state are not reported. The analysis has been undertaken for the period of 1980-81 to 2010-11. The entire timeframe of the analysis, has been categorised into two separate periods, viz. maturing phase of the green revolution (1980-81 to 1995-96, period I, pre-liberalisation period) and post-liberalisation period for agriculture (1995-96 to 2010-11, period II), two periods known to have distinct impacts on agricultural performance.

RESULTS AND DISCUSSION

Performance of rainfed agriculture in India

The trend in the share of foodgrains and irrigation at all India level and in dominantly rainfed states is provided in Table 1. Also provided there is the trend in dominantly

Table 1 Comparison of selected parameters of the dominantly rainfed and some dominantly irrigated states

States	Share of foodgrains in the respective state's net sown area (%)			Net area irrigated as a percentage of net sown area (%)			Share in value of output in agriculture (% to All India)		
	1980-81	1995-96	2010-11	1980-81	1995-96	2010-11	1980-81	1995-96	2008-09
Dominantly rainfed states									
Andhra Pradesh	71.1	55.3	55.4	36.0	40.7	47.0	7.5	7.7	9.2
Gujarat	42.9	37.3	35.2	20.2	32.5	45.1	6.3	5.1	6.3
Karnataka	65.6	57.0	62.0	15.5	23.4	31.0	5.6	5.8	5.5
Madhya Pradesh	83.2	71.2	67.1	11.4	23.9	45.9	7.6	8.1	8.0
Maharashtra	70.2	63.4	54.0	12.0	14.9	19.3	9.3	10.0	9.9
Rajasthan	72.5	65.2	62.3	21.1	30.8	34.9	5.3	6.0	5.5
Dominantly rainfed states	70.1	61.1	56.0	18.1	26.3	33.3	41.5	42.7	42.8
Dominantly irrigated states									
Haryana	75.9	69.1	71.9	59.5	79.0	86.2	4.2	4.1	4.5
Punjab	73.4	75.7	82.3	85.0	95.9	97.8	6.0	6.5	6.1
All India	73.7	65.8	63.7	28.5	37.5	45.2	100.0	100.0	100.0

Sources: Computed by the authors using data from Agricultural Statistics at a Glance, Ministry of Agriculture, GoI (Various issues) and National Accounts Statistics, Central Statistical Organisation, GoI, New Delhi (2012).

irrigated states of India (Punjab and Haryana) for the purpose of comparison. At national level, the share of area under foodgrains reduced by about 10 per cent points during 1980-81 to 2010-11. Though the decline in foodgrains' area share was pervasive across most of the states, it was more pronounced in the rainfed states compared to irrigated states. In the rainfed states, as on 2010-11, the share of irrigation (net irrigated area as a percentage of net sown area) ranged between 19 % in case of Maharashtra to 47 % in case of Andhra Pradesh. As on 2008-09, the rainfed states together accounted for about 43 % of the total value of output in agriculture, and there was improvements over years.

The trend in the area under the rainfed crops and irrigated crops in the rainfed states is provided in Table 2. During 1980-81 to 2010-11, the area under rainfed crops (excluding cotton) declined from 82 to 79 m ha, at the rate of -0.28 % per year. Between period I and period II, the reduction of area under rainfed crops was sharper during period II. On the otherhand, the area under cotton and water intensive crops (paddy and sugarcane) witnessed expansion at the rate of 1% and 0.42 % per year respectively (Table 2). In case of cotton, all the states with the exception of Karnataka and Rajasthan have witnessed an area expansion. It is striking to note that among the rainfed states the area under paddy and sugarcane registered positive growths in all the states, with the exception of Madhya Pradesh and Rajasthan.

Growth and instability

A summary of the yield statistics of the selected crops in the selected states as on 2011-12 is provided in Table 6. Also provided therein is the relative share of the selected states in area and production at national level. The performance of the rainfed agriculture is examined by using a set of indicators, viz. growth and instability in area, production and yield of the major rainfed crops. The growth rates were estimated by using semi-log model. This model

Table 2 Trend in area under dominantly rainfed and irrigated crops in the major rainfed states of India (Triennial Ending averages)

States	Dominantly rainfed crops ('000 ha)						Dominantly irrigated crops (Paddy +Sugarcane) ('000 ha)			Growth rates 1980-81 to 2010-11 (% per year)		
	Rainfed crops (except cotton)			Cotton								
	1980-81	1995-96	2010-11	1980-81	1995-96	2010-11	1980-81	1995-96	2010-11	Rainfed crops	Cotton	Paddy + Sugarcane
Andhra Pradesh	7197	6289	5505	404	877	1582	3824	3825	4375	–0.90[a]	4.04[a]	0.19
Gujarat	5988	5924	5159	1681	1247	2484	614	741	933	–0.84[a]	2.29[a]	1.27[a]
Karnataka	7278	8188	8037	1021	628	470	1276	1627	1861	0.05	–2.44[a]	1.18[a]
Madhya Pradesh	3886	13643	14926	624	494	629	4879	5191	5356	0.7[a]	0.29	0.4[a]
Maharashtra	13211	14055	13373	2549	2773	3528	1722	2025	2333	–0.04	0.87[a]	0.91[a]
Rajasthan	11197	13462	16078	382	537	361	230	170	144	0.81[b]	0.31	–1.09[c]
All India	81857	81206	78661	7901	8094	10258	42856	46173	47931	–0.28[a]	1.00[a]	0.42[a]

Note: Rainfed crops include coarse cereals, pulses and oilseeds. The data for MP for the year 2010-11 includes that of Chhattisgarh as well. The superscripts a, b and c indicates statistical significance at 1, 5 and 10 per cent levels, respectively. *Source:* Computed from Agricultural Statistics at a Glance, 2012.

Table 3 Growth and instability in area, production and yield of major rainfed crops in selected states, across time periods

Crop	Area			Production			Yield		
	PI	PII	Overall	PI	PII	Overall	PI	PII	Overall
Growth (% per year)									
Bajra	–0.4	1.3[b]	0.1	3.0	6.7[b]	4.2	3.5	5.2[b]	4.1
Jowar	–1.2[a]	–2.5[a]	–1.9[a]	1.3	–2.8[b]	–1.3[a]	2.5[b]	–0.2	0.6
Groundnut	–0.8	–0.3	–0.2	–1.4	4.3	2.9[b]	–0.7	4.6[c]	3.1[a]
Rapeseed/ mustard	12.7[a]	0.9	5.3[a]	14.6[a]	3.7[b]	7.1[a]	1.6[b]	2.6[a]	1.7[a]
Soybean	19.7[a]	1.8[a]	8.8[a]	25.5[a]	3.1[a]	11.3[a]	4.9[a]	1.3	2.3[a]
Sunflower	19.4[a]	0.8	4.5[a]	17.2[a]	1.3	4.8[a]	–1.8[c]	2.2[b]	0.3[a]
Chickpea	1.8[a]	1.3[b]	1.5[a]	3.9[a]	2.0[b]	2.9[a]	2.0[a]	0.7	1.4[a]
Redgram	3.6[a]	1.0[a]	1.7[a]	3.0[b]	2.6[b]	2.5[a]	–0.5	1.6	1.1[b]
Cotton	0.3	1.1[b]	1.0[a]	4.8[a]	8.0[a]	5.7[a]	4.5[b]	6.8[a]	4.6[a]
Instability (%)									
Bajra	10.2	12.1	11.8	49.6	46.7	49.5	40.2	26.0	17.5
Jowar	4.2	4.2	4.7	21.4	14.7	21.0	13.3	14.5	15.4
Groundnut	14.3	4.6	10.7	53.2	46.8	51.4	59.1	39.3	39.2
Rapeseed/ mustard	16.0	27.3	28.3	18.7	30.6	29.1	5.7	4.5	3.0
Soybean	19.3	6.3	26.0	26.7	19.6	31.9	3.8	14.0	4.9
Sunflower	34.1	34.3	40.1	34.7	38.9	40.9	11.9	10.3	19.3
Chickpea	6.6	9.2	8.9	11.2	17.9	15.7	1.3	12.6	2.9
Redgram	4.6	5.6	7.8	20.6	19.9	20.3	20.7	17.2	15.5
Cotton	5.0	8.4	7.4	27.8	31.7	33.3	15.9	5.7	5.5

Note: PI, PII and overall corresponds to periods 1980–81 to 1995–96; 1995–96 to 2011–12; and 1980–81 to 2011–12, respectively. The superscripts a, b and c indicates statistical significance at 1, 5 and 10 per cent levels, respectively. The estimates for the crops are for selected states as provided in the material and methods section. *Source:* Estimated by the authors.

was selected based on best fit among alternate specifications. Out of several methods available for measuring the instabilities, Cuddy- Della Valle Index (CDVI) (Cuddy and Della Valle, 1978) has been adopted for the study as this method enables us to use the adjusted R^2 available from the growth models in estimation of instability as well.

CDVI = CV*(1-R2)0.5, where, CV = Simple coefficient of variation and R2 = Coefficient of determination from time trend regression adjusted for degrees of freedom

The growth and instability of area, production and yield of the selected crops are provided in Table 3. The area of all the crops except jowar and groundnut posted positive growth during the overall period. The highest growth in area has been noted in case of soybean (8.8 %). Both the periods exhibited glaring differences in growth performances. Period I accomplished higher area growth compared to period II for oilseeds and pulses. For example, between period I and period II, the growth rates of area under rapeseed/mustard, soybean, and sunflower declined from 12.7, 19.7 and 19.4% to 0.9, 1.8, and 0.8%, respectively; whereas, that in case of chickpea and redgram declined from 1.8 and 3.6 % to 1.3 and 1.0 %, respectively. The fast expansion of oilseeds and pulses during period I owe it probably to the favourable policy supports under National Missions on oilseeds and pulses. Consistent with area growth, the production also depicted a positive growth for the overall period under analysis for all the crops except for jowar. Correspondingly the growth in production was higher during period I for all the crops except bajra, groundnut and cotton.

As far as yields are concerned, during 1980-81 to 2011-12, all the crops registered positive growth in the representative states. The overall yield growth ranged from as low as 0.3 % in case of sunflower to as high as 4.6 % in case of cotton. Period II registered higher growth than period I for all the crops except jowar, soybean and chickpea.

It could be concluded from the above analysis that the rainfed crops in general registered positive growth for area and production during the overall period under analysis. Growth in area and production for oilseeds and pulses in general was better during period I compared to period II. As far as yields are concerned, period II turned out better for most of the crops. Overall, there was an increase in the area under water intensive crops as well.

The technology growth entails achievement of higher production and yields with lower instability. This is because higher level of instabilities transmits to the decisions of the farmers regarding production, investment, and marketing and thereby to their livelihood security, besides transmitting sub-optimal signals to the economy. During the overall period under analysis, the instability in the yield was the lowest in case of chickpea and the highest in case of groundnut, which is strongly transmitted to the instability in production as well. The instabilities in production and yield moderated for most of the crops during period II compared to period I.

Table 4 Trend in the performance of rainfed agriculture, across various systems, 1980-2010

Particulars	Irrigated system (Paddy+ Sugarcane)		Rainfed system (Including cotton)		Rainfed system (Excluding cotton)	
	Cost of cultivation	Value of production	Cost of cultivation	Value of production	Cost of cultivation	Value of production
TE ending (₹/ ha, real prices, 1986-87 base)						
1982-83	3197	5570	1604	2443	1515	2349
1995-96	4112	7287	1762	3235	1603	2823
2009-10	6158	11124	2766	4505	2478	4125
Growth rates (% per year)						
Period I	2.9	2.8	1.9	4.3	1.5	3.2
Period II	3.3	3.1	3.1	2.4	3.1	2.7
Overall	3.2	2.8	3.0	2.7	2.9	2.7

Note: Period I, Period II and Overall refers to 1982-83 to 1995-96, 1995-96 to 2009-10 and 1982-83 to 2009-10, respectively. *Source:* Computed by Authors.

Trend in cost of cultivation, value of production and net income in rainfed states

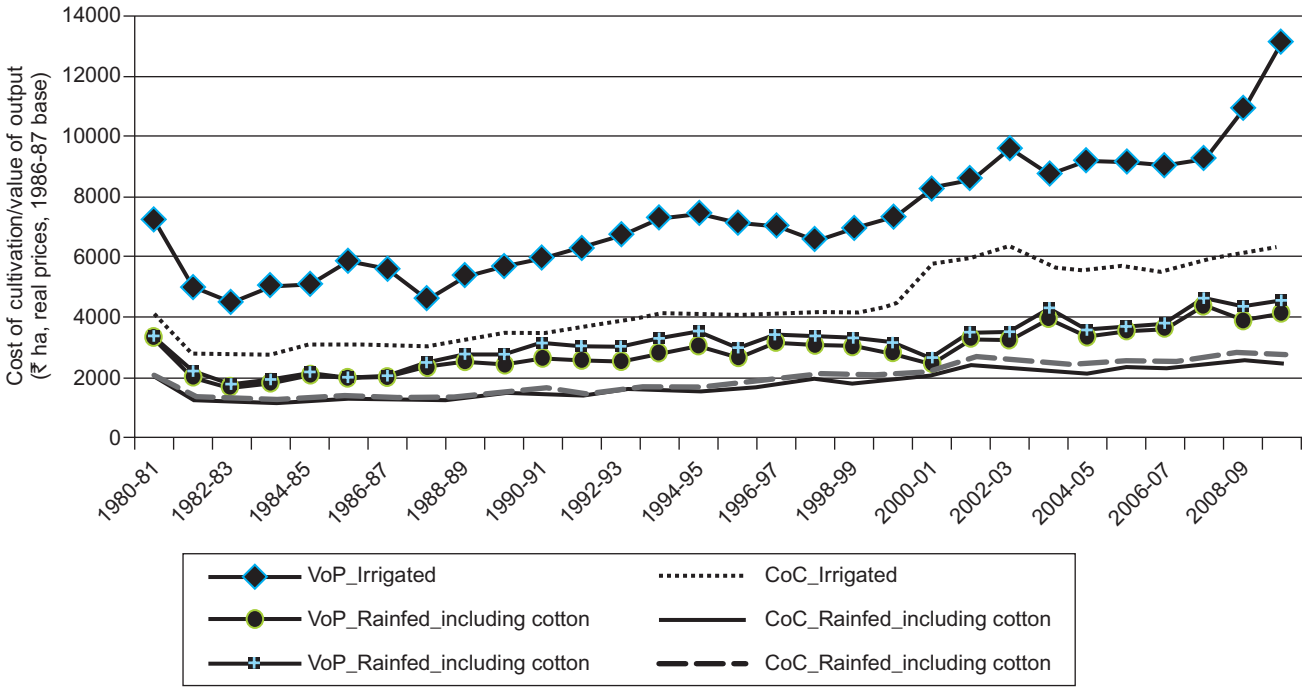
The performance of rainfed agriculture has been examined by analysing the trend in cost of cultivation (CoC), value of production (VoP) and net income over paid out cost (Cost A2, as per the norms of Commission for Agricultural Costs and Prices), using the cost of cultivation estimates provided by Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The nominal values were converted into real terms by deflating with consumer price index for agricultural labourers (CPI-AL). The latest data series on CPI- AL is available with the base year 1986-87. The estimates were arrived at by using weighted averages, with area of the respective crops as the weights. Paddy and sugarcane was clubbed into a single group, by using their area in all the rainfed states.

The analysis with respect to the trend in the cost of cultivation, value of production and net income in rainfed states provided some interesting insights (Table 4). The real cost of cultivation has been consistently higher for the irrigated system, followed by rainfed crops including cotton and rainfed crops excluding cotton, in that order, for all the years under consideration. Both the real cost of cultivation and value of production consistently increased over years. While the growth in the real CoC for the irrigated crops for the overall period was 3.2 % per year, that for the rainfed crops including cotton was 3.0 % and that for rainfed crops exclusive of cotton was 2.9 %. It is noteworthy that the growth in VoP was lower than growth in CoC for all the crop groups, for the overall period.

The Table 4 also reveals significant difference in growth performance during the two periods under consideration- the period II exhibited a raised growth rates of CoC compared to period I for all the three crop groups. During period II the growth in CoC more than doubled in case of rainfed crop excluding cotton. It is also observed that the value of production of both the rainfed crops systems (inclusive and exclusive of cotton) which were growing at a rate higher than that of the cost of cultivation during period I has reversed during the period II. The irrigated crops in rainfed regions witnessed higher rate of growth in value of production during Period II, compared to that of rainfed crops. Nevertheless, it was at the cost of higher levels of growth in cost of cultivation as well. It is also worthwhile to note that the rate of growth of the cost of cultivation has registered raised values for all the three crop groups during period II compared to period I; but in case of value of production while irrigated system posted raised growths (from 2.8 to 3.1 %) that of both the rainfed systems posted sharp declines in growths (from 4.3 to 2.4% in case of rainfed system inclusive of cotton and from 3.2 to 2.7% in case of rainfed systems exclusive of cotton). It is clearly evident that the production and policy environment was unfavourable for rainfed crops in comparison with irrigated crops during the post- liberation period.

Table 5 provides the estimates of net income of various crops groups and the parity of net income over years. As on 2009-10, the real net income remained highest for irrigated system (₹ 4 966/ ha), followed by rainfed system including cotton (₹ 1 739/ ha) and rainfed system excluding cotton (₹ 1 647 /ha) (all at constant prices of 1986-87=100, based on Cost A2). Over years, there is an increase in the real net income for all the crop groups. As far as the rainfed crops are concerned, the percentage increase in the net income during the period 1995-96 to 2009-10 was less than that during 1982-83 to 1995-96; whereas, for the water intensive crops the period of 1995-96 to 2009-10 was more favourable than the Period 1982-83 to 1995-96. This is sharply brought into focus by the parity of net income of various crops groups as could be noted from Table 5. It reveals that the water intensive and irrigated system is favoured in rainfed regions, and this has strengthened during the period II.

Though the rainfed crops provide a margin over paid out costs, it was much less compared to that in case of irrigated crops, notably during 2009-10. Fig 1 illustrates the temporal movement of real cost of cultivation and gross value of output for all the three crop groups, highlighting



Source: Computed by the authors.

Fig 1 Trend in the real cost of cultivation and value of output in rainfed agriculture, various crop groups, 1980-81 to 2009-10

the advantages of irrigated crops in dryland. It is discernible that the growth in the real net income of rainfed crops might have failed to catch up with the increase in the real cost of living of the cultivators; and this must have contributed to agrarian distress of the marginal farmers in rained areas.

CONCLUSION AND POLICY IMPLICATIONS

The analysis clearly brings forth the fact that the rainfed agriculture in India is facing some serious challenges. The growth in production of oilseeds and pulses observed during 1980s and 1990s weaned out during post-liberalisation period, probably due to the dilution of some of the policy initiatives like mission mode operation for these crops and adverse terms of trade in agriculture in the aftermath of trade liberalisation. The yield of most of the crops has increased during post-liberalisation period. However, it has been at the cost of higher growths of cost of cultivation as well, and, therefore, may not be sustainable in the long run. Post-liberalisation period has witnessed a sharp increase in cost of cultivation all the crop systems, including water intensive crops; with a sharper effect on traditional rainfed crops. The parity of the net income also favoured cultivation of water intensive crops. Consequently the area under water intensive crops is increasing, exerting pressure on scarce groundwater resources. This has strong connections with the price policy for the crops as the irrigated crops like paddy and sugarcane enjoys various price support mechanisms. This can be corrected mainly by providing incentive prices to dominantly rainfed crops through various supportive measures and market opportunities. This points to the need to provide parity with the water intensive crops, taking into considerations, the cost of cultivation, yields and livelihood needs. In view of the lower yields of the rainfed crops compared to the water intensive crops, such a parity needs to look beyond the price aspects, and align

Table 5 Trend in net income of various crop systems in rainfed agriculture, 1980-81 to 2009-10 (Triennial ending averages, real prices)

Period	Net income over variable cost (₹/ha)			Net income over total cost (₹/ha)			Net income parity *		
	Irrigated System	Rainfed System (Including cotton)	Rainfed System (excluding cotton)	Irrigated System	Rainfed System (Including cotton)	Rainfed System (excluding cotton)	Irrigated System	Rainfed System (Including cotton)	Rainfed System (excluding cotton)
1982-83	2373	838	834	492	105	109	2.85	1.00	1.00
1995-96	3175	1473	1220	784	426	226	2.60	1.21	1.00
2009-10	4966	1739	1647	1637	322	286	3.02	1.06	1.00

Notes: All estimates are on real terms. *The net income parity has been arrived at by calculating the ratio of the net income over variables costs of crop groups with respect to that of rainfed crops (excluding cotton). *Source:* Computed by the authors.

Table 6 Yield and share of area and production of rainfed crops, 2011-12

Crop	States with the highest area	Yield (Kg/ha)	Share in area at national level (%)	Share in production level (%)
Jowar	Maharashtra	818	51.6	44.3
Bajra	Rajasthan	832	57.5	41.4
Groundnut	Gujarat	1603	31.0	38.1
Rapeseed/ mustard	Rajasthan	1187	42.3	43.9
Soya bean	Madhya Pradesh	1108	55.7	51.1
Sunflower	Karnataka	503	53.2	38.6
Red gram	Maharashtra	704	29.9	32.1
Chickpea	Madhya Pradesh	1081	36.6	43.4
Cotton	Maharashtra	689	24.3	34.1

Source: Computed from Agricultural Statistics at a Glance, 2012

with the net income.

Further, the study also provides some policy directions towards the need for better water management in rainfed regions so as to ensure water availability for sustainable farming. Studies have noted that out of the total rainfall received in India, 45 % is lost as runoff (*blue water*) and some are stored in the soil (*green water*) and is subsequently lost through soil evaporation. The productive *green water* used as direct transpiration is rather small. Further, India is anticipated to face severe water shortage in the coming decades as well. In that context greater emphasis needs to be accorded to supplementary irrigation and better water governance by proper management of water resources. Another important aspect will be the direction of future investments in agriculture. Various governments have allowed more resources to irrigated areas in the past. This has resulted in significant socio-economic outcomes like poverty reduction through increased agricultural production in such areas. However, the marginal returns of the investment in irrigated area is on decline, and it appears logical to suggest for better investment flow towards the rainfed regions where the marginal returns are higher. However, here the focus needs to be towards water conservation, creation of institutions for better water management and water literacy programmes. Rather than area expansion under water intensive crops, the strategy needs to focus on development of small scale and easily financeable technologies like low cost sprinkler and drip irrigation systems and water storage devises which are accessible to large number of small farmers and improve water use efficiency. Providing enhanced market opportunities for the typically rainfed crops and diversification to less water consuming crops etc would be relevant strategies on a long term basis.

REFERENCES

Chand R, Pandey L M and Garg S. 2010. Rise and decline of rainfed agriculture: perspectives and challenges. (*In*) *Rainfed Agriculture in India*. Singh S and Rathore M S (Eds). Rawat Publications, Jaipur.

Cuddy J D A and Della Valle P A. 1978. Measuring instability index of Time Series Data: A generalization. *Oxford Bulletin of Economics and Statistics* **40**(1).

GOI.2006. *From Hariyali to Neeranchal: Report of the Technical Committee on Watershed Programmes in India*, Parthasarathy Committee Report, Department of Land Resources, Ministry of Rural Development, New Delhi.

GOI. 2011. *Report of the XII Plan Working Group on Natural Resource Management and Rainfed Farming*. Planning Commission, New Delhi.

Jodha N S. 1991. Sustainable agriculture in fragile resource zone. *Economic and Political Weekly* **26**(13).

Kumar D. 2003. *Food Security and Sustainable Agriculture in India: The Water Management Challenge*. Working Paper No 60, International Water Management Institute, Colombo.

Ninan K N and Chandrashekar H. 1993. Green revolution, dryland agriculture and sustainability: insights from India. *Economic and Political Weekly*, March 20-27: A2-A7.

Raina R S. 2006. Researching the drylands. *Seminar* 546: 25–9.

Rao V M. 2004. *Rainfed Agriculture. State of the Indian Farmer – A Millennium Study*. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India and Academic Foundation, New Delhi.

Shankar V P S. 2005. Four decades of agricultural development in Madhya Pradesh: An agro-ecological sub-regional approach, *Economic and Political Weekly* Nov 26: 5 014–24.

Venkateswarlu B and Prasad JVNS. 2012. Carrying Capacity of Indian Agriculture: Issues Related to Rainfed Farming. *Current Science* **102** (6): 882–8.

World Bank. 2010. *Deep Wells and Prudence: Towards Proper Actions for Addressing Groundwater Over-exploitation in India*.