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Review Paper

Effect of Integrated Watershed Management Programmes on Farming in Rainfed Tracts of Tamil Nadu: An Evaluation

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ABSTRACT

As a holistic approach, watershed development activities turn out to be very effective and convenient to manage water and land resources efficiently in the rainfed areas. The present study aimed to conduct an impact assessment of watershed development programmes in Thoothukudi, Krishnagiri, Perambalur districts of Tamil Nadu by using indicators on biological, physical, social and economic aspects. In the study area, watershed development structures are found to be satisfactory and contributed for additional storage capacity, rise in water table and prolonged water availability, increasing irrigation intensity and cropping intensity which resulted from enhanced gross cropped area, crop productivity and assured access to water. More number of water harvesting structures has to be developed by engaging private investments in constructing check dams, farm ponds, percolation ponds *etc.* in the farms. Creating awareness about responsibilities of stakeholders in maintenance of all the assets created in the watershed areas will ensure more empowerment of the community.

HIGHLIGHTS

- WSD programmes are performing well in enlightening natural resources conservation and enhancing irrigation intensity and cropping intensity.
- It improves the socio-economics conditions of the people by increased crop productivity, livestock population and employment opportunities.

Keywords: Agriculture, Irrigation, Productivity, Rainfed, Watershed

Major crop cultivation in the dry regions endures to be as rainfed agriculture. Many farmers in rainfed areas are dependent on rainfall to harvest water for supplemental irrigation. Accessibility of water resource plays a crucial role in the cropping pattern also (Shivakumara and Murthy, 2020). The existing scanty resources restrict the rural farmers to cut down the input application as subsistence farming with unstable agricultural productivity. Hence, there is a pressing need to bring a holistic approach for natural resources management in rainfed farming system (Govt. of India, 2013). In such a remedial approach that watershed development activities turn out to be very effective and convenient to manage water and land resources efficiently in the rainfed areas, which are acting as the hive of poverty, malnutrition, and water scarcity (Rockstrom *et al.* 2010). Molden *et al.* (2011) specified that water harvesting techniques are found to be useful for bridging short-term dry spell and investments made for these techniques are vital way to lessen risk in rainfed agriculture. Birhanu *et al.* (2019) examined that soil and water conservation practices were adopted mainly with a view to rise water availability in the subsurface area and to reduce water runoff

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in the farm and gully formations. This in turn improves nutrient content of the soil as well increase crop yield. Watershed development program is considered as an effective tool for addressing many of the problems associated with resource scarcity and renowned as a prospective mechanism to enhance agricultural and rural development in fragile rain-fed areas (Ahluwalia, 2005 and Joshi *et al.* 2005).The ultimate aim of these programmes is to maintain balanced social, economic, and ecological watershed functions, consequently to achieve long-term development and to decrease negative externalities (Willems *et al.* 2013). This phenomenon visibly stressed the importance of watershed development as a natural resources conservation programme is being recognized particularly in the rainfed areas, the present study is intended to assess the impact of watershed development programmes implemented under Integrated Watershed Management Programme (IWMP) in Tamil Nadu. From the present study, the upgraded soil and moisture conservation practices can be identified and assured that such conservation practices are also well suited to the conditions of the farm holding as well as the watershed as a whole. Thus, watershed development activities in these rainfed areas has enormous scope to strengthen the prevailing natural resources with the aim of optimal utilization by the community and also safeguarding livelihood of the households belong to the rainfed areas.

MATERIALS AND METHODS

Rainfed areas are those where irrigation is less than or equal to 30 per cent of the net sown area (National Rainfed Area Authority, 2012). Tamil Nadu has the net sown area of 4.63 million hectares and of which rainfed area constitutes 43 per cent (Govt. of Tamil Nadu, 2019) and characterized by lower productivity, degraded natural resources and inferior standard of living with poverty. There has been a lack of adequate attention to water conservation, efficiency in water use, water re-use, groundwater recharge, and ecosystem sustainability (Kavitha and Suresh Kumar, 2020). The paradigm change in rural development programmes provides a framework in which local land, soil and water conservation and developmental works, including watershed development programmes can be planned and implemented more effectively (Kavitha and Suresh Kumar, 2019). Consequently, there is an ample scope for stabilizing agriculture and allied activities in dry land areas by extending watershed development programmes on community basis, which received a good deal of attention from the Central and State governments. Keeping these issues as a whole, the present study is aimed to conduct the study on evaluating the impact of such watershed development programmes implemented in the rainfed areas of the state. In this framework, three districts namely Thoothukudi, Krishnagiri, Perambalur were chosen purposively on account of percentage of net irrigated area to the net sown area i.e. 23.10, 29.40, 29.87 per cent, respectively, which was less than 30 per cent. For the purpose of studying the impact, list of watersheds spread across these three districts was collected from TAWDEVA (Tamil Nadu Watershed Development Agency) and the district level officials. During the 2011-12 batch of IWMP, a total of 17 watershed committees for Thoothukudi, Krishnagiri, Perambalur were formed to treat 34 micro watersheds (25 per cent of the total watersheds) in the districts. Thus, totally 239 beneficiaries of watershed development program from the selected watersheds (Table 1) were identified for the impact evaluation study by employing simple random sampling procedure. The effect of watershed development programmes are classified in the aspects like agricultural production system, environment and socio-economic conditions of the watershed villages. Different indicators on these aspects were framed and used to assess the impacts of watershed development across the study area as following viz., (i) water level and its longevity, (ii) status of fallow lands, (iii) change in irrigation intensity, (iv) change in cropping intensity, v) livestock population, (vi) change in crop yields, (vii) vegetative cover, (viii) annual household income, (ix) women participation in various activities, etc.

RESULTS AND DISCUSSION

This section highlights the effect of watershed development programmes resulted from various dimensions such as impact of different interventions in terms of soil and moisture conservation measures, water resources development, establishment of suitable water harvesting structures and afforestation. These developmental activities created

Table 1: Number of samples in the selected micro watersheds

Sl. No.	Name of the District	Name of the Block	Name of the Project	Number of the Micro Watersheds	Number of samples
1	Thoothukudi	Vilathikulamand Pudur	IWMP VI	5	117
		Vilathikulamand Pudur	IWMP VII	10	
2	Krishanagiri	Shoolagiri	IWMP VI	9	53
3	Perambalur	T. Palur	IWMP VI	5	69
		T. Palur	IWMP VII	5	
	Total samples				239

positive changes in bio-physical, environmental, socio-economical, institutional indicators like increased surface water and groundwater resources, improved cropping pattern and crop yield, enhanced environmental conditions by vegetative cover and strengthened social capital, community participation and institutional building, infrastructures, *etc.*, which ended with the improved overall livelihood of the study area.

Description of watersheds

Watershed development has arisen as a new paradigm for planning, development and management of land, soil and water resources by applying a participatory bottom-up approach. Various watershed treatment activities classified under three major divisions such as natural resource management (NRM), farm production system (FPS) and landless activities (LHSS) were carried out in the study watersheds. On the basis of the selection criteria of a watershed, an amount of ₹ 201.65 lakhs, ₹ 64.89 lakhsand ₹ 142.8 lakhs had been utilized during the project period from 2011-12 to 2017-18 for such developmental activities in Thoothukudi, Krishnagiri and Perambalur districts of Tamil Nadu respectively and the area treated in the respective districts were 11135 ha, 5233 ha and 9895 ha. The scheme has been implemented in three phases viz. preparatory phase, work phase and consolidation phase funded by the Centre and the State government with a sharing pattern of 90:10 up to the year 2014-15 and 60:40 from the year 2015-16 onwards. The Joint Director of Agriculture, the project officer is providing funds directly to the project account controlled by watershed committee after examination with the approval of District Watershed Advisory Committee. It is observed that in most of the watersheds, complete fund utilization emphasized the successful implementation of PMKSY watersheds under 2011-12 batch. The funds were utilized properly for entry point activities, administrative cost, watershed treatment works, institution and capacity building, monitoring and evaluation.

Most watershed development programmes in India are implemented with a well-defined institutional framework. In Tamil Nadu, a state-level nodal agency for watershed development programmes called the Tamil Nadu Watershed Development Agency (TAWDEVA) coordinates the watershed development activities. Project Implementing Agency (PIA) for this IWMP project is Assistant Director of Agriculture for each block which provides necessary technical guidance to the watershed committees. The PIA undertake community organisation and training for the village committees, supervise watershed development activities, inspect and authenticate project accounts, mobilization of financial resources, encouraging adaptation of low cost technologies, monitor and review the overall project implementation. Watershed Development Team (WDT) is an integral part of the PIA. The WDT should have at least four members broadly expertise in agriculture, soil science, water management, social mobilization and institutional and capacity building. The WDT should be located as close as possible to the watershed project. It must be ensured that the WDT should function in close collaboration with the team of experts at the district and state level. The Watershed Committee (WC) comprises of at least 10 members, half of the members who will be the representatives of Self Help Groups, User Groups, women and landless labourers in the village. The Watershed Committee (WC) constituted User Groups (UGs) in the watershed area with the help of WDT. The Watershed Committee opened a separate bank account to receive funds for watershed projects and utilise the same for undertaking its activities.

These UGs are homogenous groups of persons most affected by each work/ activity and include those having land holdings within the watershed areas. As per the guidelines, the WC constituted Self-help Groups (SHGs) in the watershed area with the help of WDT from amongst poor, small and marginal farmer households, landless/asset less poor agricultural labourers, women, shepherds and SC/ST persons. These Groups are the homogenous groups having common identity and interest who are dependent on the watershed area for their livelihood.

Water level and its longevity

Agricultural activities are mainly based on irrigation by which maximum ground water is utilized (Bhattacharya, 2018). Deeper water table results in reducing soil moisture and hence reduces the crop yield, which affects the agricultural income (Bharathkumar and Aslam, 2018). Major wells are showing water level of more than 2 m followed by the range of 2.01 m to 5 m (Table 2). Due to these watershed development activities such as construction of percolation ponds, renovation of ponds, lakes, channel and check dams, totally 5 wells fall under more than 5 m category, which strongly proved the effect of such activities on water sources which matched with the findings by Seeyan *et al.* (2014) in which the rise in the water table indicates the situation when the recharge exceeds discharge. Sustained water availability in the wells prompts to assist the farmers to take decisions on investment in complementary inputs which surge crop yields considerably. Duration of water availability is also assessed and it is classified into four categories as wells with water availability for 12 months, 9 months, 6 months and 3 months, respectively. In all the categories, there is a significant increase in the number of wells after implementation when compared to the same as before in all three districts. Out of total wells, majority of wells have assured water availability for 3 months followed by the category of 6, 9 and 12 months, respectively. Persistent water availability empowered the farmers to alter their cropping pattern with more water consuming crops.

Table 2: Rise in water level due to watershed activities (depth in m)

District/Avg. of sample watersheds	Observed wells	Depth of water levels in the wells			Average of incremental water level in the wells (m)
		< 2 m	2.01-5 m	> 5 m	
Thoothukudi	31	17	13	1	1
Krishanagiri	25	14	10	1	1.3
Perambalur	15	8	5	2	1.5

Table 3: Surface water storage structures (in Nos)

District	Check Dam	Farm Pond	Village Pond	Percolation Pond	Cattle pond	Sunken pond	Tank Renovation	Gabion check dam	Baby Pond
Thoothukudi	45	32	38	8	0	15	26	0	0
Krishnagiri	125	88	0	173	0	0	0	0	0
Perambalur	14	41	0	22	5	0	8	0	0

Table 4: Duration of water availability in wells (in Nos.)

District/ Avg. of sample watersheds	12 months		9 months		6 months		3 months		Drained Wells		Total
	Before	After	Before	After	Before	After	Before	After	Before	After	After
Thoothukudi	3 (8.31)	4 (9.52)	6 (14.08)	8 (19.05)	11 (26.50)	12 (28.57)	13 (32.07)	18 (42.86)	8 (19.05)	0 (0.00)	42 (100.00)
Krishnagiri	6 (6.55)	9 (10.23)	12 (13.11)	21 (23.86)	23 (25.97)	26 (29.55)	26 (29.37)	32 (36.36)	22 (25.00)	0 (0.00)	88 (100.00)
Perambalur	1 (3.05)	3 (7.14)	3 (7.85)	7 (16.67)	10 (23.62)	13 (30.95)	13 (29.76)	19 (45.24)	15 (35.71)	0 (0.00)	42 (100.00)

It benefits farmers in the study area in terms of ground water recharge, preventing soil erosion and water conservation and soon.

Status of fallow lands

Diversification of land use in the watershed programs assumed greater importance, where the scientific techniques of deciding land use options considering present practices of the farmers is taken into account (Prakash *et al*. 2016). It is evidenced that the area under current fallow is found to be decreased by 1.52 per cent in Perambalur district and 0.96 per cent in Krishnagiri district whereas in the case of other fallows it is declined by 3.22 per cent in Perambalur district and 2 per cent in Krishnagiri district. This shows fringe impact on converting fallow lands into cultivable land due to soil and water conservation measures. It is similar with the study by Wani *et al*. (2009) that the changing scenario of the land use pattern due to watershed development in the Shekta watershed clearly revealed a significant increase in the irrigated area (96 % for seasonally irrigated and 88 % in perennial irrigated).

Change in irrigation intensity

Increasing irrigation intensity seems to have resulted in excess pressure on groundwater. Focusing on surface irrigation may not necessarily induce the growth rate of cropping intensity, whereas improvement in irrigation intensity and groundwater potentiality however, likely to bring sustainability (Paria *et al.* 2021). Palanisami and Suresh Kumar (2009) assessed the impact of various watershed development programmes in Tamil Nadu from which they stated that watershed development activities have created a significant impact on ground water recharge as well as on expansion in irrigated area. This scenario essentially highlights the trade of between irrigation-based intensification in agriculture and its sustainability. However, there would be less access to irrigation facilities before implementation, the farmers intend to cultivate only in *kharif* season. The sample farmers could irrigate more area to raise crops in their dry lands during the rest of the year also; the resultant irrigation intensity would be high in watershed areas when compared to the situation of before implementation. The reason for increasing area under crop cultivation may be due to assured availability of irrigation facilities which assisted the farmers to raise more crops in the study area.

Change in cropping intensity

There was an increase in water table, increase in perennial availability of water in the wells and in pumping hours. All of this appears to have contributed to an increase in the area under irrigation and crop diversification. Shilpa *et al.* (2017) reported that there was raise in the net cultivated area as well as the twice sown area under the DPAP (Drought Prone Areas Programme). Net sown area was found comparatively high at 1829.23 ha, 864.1 ha, and 2196.8 ha in Krishnagiri, Perambalur

Table 5: Status of fallow lands in selected districts (in ha)

District	Current fallows			Other fallows		
	Before	After	% Change	Before	After	% Change
Thoothukudi	811.24	818.57	0.90	728.23	739.87	1.60
Krishnagiri	748.41	741.26	-0.96	254.76	249.66	-2.00
Perambalur	307.34	302.66	-1.52	329.35	318.75	-3.22

Table 6: Change in irrigation pattern in selected districts

District	Net Irrigated area (ha)			Gross irrigated area (ha)			Irrigation Intensity (%)		
	Before	After	% Change	Before	After	% Change	Before	After	Change
Thoothukudi	1220.1	1239.5	1.6	1355.0	1399.7	3.3	111.1	112.9	1.8
Krishnagiri	1122.0	1140.7	1.7	1251.3	1293.2	3.4	111.5	113.4	1.9
Perambalur	478.6	489.6	2.3	557.6	575.7	3.2	116.5	117.6	1.1

Source: *Project Implementing Agencies of concerned districts.*

and Thoothukudi district, respectively after implementation when compared to 1753.2 ha, 825.1 ha and 2178.8 ha during before implementation. The watershed programme had a significant beneficial effect on gross cropped area also which expressed percentage change positively. Hence, the derived changes in cropping intensity were found high as 3.2 per cent, 3.4 per cent and 0.6 per cent in the area.

Change in Crop Productivity

Watershed development activities were contributed generally in raising yields especially in rain-fed crops, cropping pattern, diversification of agriculture and allied agricultural activities especially during the dry season, and income generating opportunities in rain-fed areas, where resource deterioration is existing (Datta, 2015). Tyngkan *et al.* (2022) from their study described that as one of the soil conservation measures, controlling soil erosion by adopting appropriate remedial measures in their field usher a positive return and enhance the soil productivity in the long-term. The crop yield in dry land area has been increased considerably for all the crops. This may be partially endorsed due to supplementary irrigation provided from the water harvesting structures (Manivannan, *et al.* 2021). The data on productivity of major crops in the study area during before and after implementation revealed that the yield increases in the range of 5 per cent to 23 per cent covering major crops in the rainfed area.

Impact on vegetative cover in selected districts

Watershed development play a significant role in distribution of vegetation as it affects the features of groundwater, surface water, soil, land and topography of the area. Watershed activity also involves a farm production system, which comprises of distribution of guava, sapota, and mango seedlings, afforestation through the plantation of teak and casuarina and provision of fodder crop. Vegetative cover is beneficial by means of preventing soil erosion, providing food and protection for many small organisms belonging to the area. The significant positive changes in terms of increased crop and fodder, tree crops and bushes was higher in Krishnagiri district of 121.13, 143.60 and 45.04 per cent, respectively. Perambalur district found more percentage change in area under fruits and grass land. Thus it was observed significant positive change under vegetative cover in all the selected watershed villages.

Impact on livestock population

Palanisami *et al.* (2011) stated that water harvesting structures had enhanced the available storage capacity in the watersheds, which further helped in improving the groundwater recharge and water availability for livestock and other non-domestic uses in the village. The subsidy provided under watershed helped the beneficiary farms to invest more on livestock purchase and maintenance. Watershed development programmes are highly encouraging both farm and non-farm households to rear livestock so as to earn substantial income from the sale of animals and its products thereby supported the number of households in the watershed villages. Bhavana and Mathur (2012) (http://sapplpp.org/filesrepository/goodpractices/Watershed%20and%20Livestock%20Rearing.pdf) reported that an increased agriculture productivity and water availability resulted in farmers moving to rearing high grade Holstein Friesian cows and the total livestock population in the watershed has also increased over time. There was an increase by 84.85, 76.83 and 51.72 per cent in cattle production and 36.11, -64.29 and 20.00 per cent in goat production in Krishnagiri, Perambalur and Thoothukudi, respectively. The share of household income from dairy production in different land holding categories reveals the critical dependence of landless and small landholders on livestock for their cash incomes.

Table 7: Change in cropping intensity in selected districts

District	Net sown area			Gross cropped area			Cropping Intensity		
	Before	After	% Change	Before	After	% Change	Before	After	Change
Thoothukudi	2178.8	2196.8	0.8	2383.4	2416.3	1.4	109.4	110.0	0.6
Krishnagiri	1753.2	1829.2	4.3	1935.2	2084.3	7.7	110.4	113.9	3.2
Perambalur	825.1	864.1	4.7	936.4	1013.9	8.3	113.5	117.3	3.2

Source: *Project Implementing Agencies of concerned districts.*

Table 8: Impact on productivity of major crops in selected districts (in kg/ha)

District/ Avg. of sample watersheds	Paddy			Millets			Sugarcane			Turmeric			Vegetables		
	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change
Thoothukudi	4125	4380	6	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Krishnagiri	4402	4668	6	3096	3282	6	91537	99035	8	2693.1	2830.6	5.1	8804.6	10833.1	23.0
Perambalur	4264	4585	8	3082	3466	11	0	0	0	3207.0	3295.3	2.8	6850.0	7442.9	8.7

Table 9: Impact on livestock population among the household (in Nos)

District/ Avg. of sample watersheds	Cattle			Buffalo			Goat			Poultry		
	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change
Thoothukudi	174	264	51.72	15	19	26.67	40	48	20.00	19	23	21.05
Krishnagiri	66	122	84.85	4	2	-50.00	72	98	36.11	33	24	-27.27
Perambalur	82	145	76.83	6	5	-16.67	28	10	-64.29	6	2	-66.67

Table 10: Impact on vegetative cover in selected districts(in ha)

District/ Avg. of sample watersheds	Crop & Fodder			Tree			Fruit			Bushes			Grassland		
	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change
Thoothukudi	458.05	472.52	3.16	154.06	180.9	17.42	22.54	28.91	28.26	610.34	620.45	1.66	285.78	215.32	-24.66
Krishnagiri	117.39	259.58	121.13	50.87	123.92	143.60	54.33	83.04	52.84	4.84	7.02	45.04	11.36	24.17	112.76
Perambalur	103.2	127.95	23.98	2.84	6.45	127.11	6.35	27.79	337.64	90.38	87.46	-3.23	4.1	10.13	147.07

Source: *Records of Project Implementing Agency, (PIA).*

Table 11: Impact on average household income in selected districts (in lakhs Rs)

District/ Average of sample watersheds	Crop production			Animal Husbandry			Off Farm Income			Non-Farm Income			Total Income		
	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change	Before	After	% change
Thoothukudi	1.18	1.30	10.23	0.10	0.11	12.57	0.05	0.05	10.09	0.25	0.26	3.85	1.57	1.71	9.36
Krishnagiri	1.19	1.33	11.88	0.03	0.04	22.58	0.05	0.06	9.43	0.14	0.16	20.30	1.41	1.59	12.83
Perambalur	1.09	1.21	10.87	0.08	0.10	25.66	0.07	0.09	15.97	0.26	0.30	16.41	1.51	1.70	12.87

Source: *Field visit*

Impact on annual household income

Watershed development programmes have been successful in raising income levels and generating employment opportunities and augmenting natural resources, specifically soil and water in the rain-fed areas. These programmes are intended not only to conserve the soil and water resources but also improving the socio-economic conditions of the people who depend upon those activities for sustaining their livelihood. Wang *et al*. (2016) recognized the watershed development projects as a holistic approach to improve and develop the natural resource and economic basis of dry and semiarid regions. Crop yields of the major crops have gone up noticeably, thereby improving the income from these crops. It is observed that the secured irrigation provided from water-harvesting structures stimulate yield increases (Singh *et al.* 2010). Ample number of employment opportunities were also generated during the execution of developmental works such as bunding, leveling, construction of check dams, percolation ponds, retaining wall, plantation etc. The income was derived from different activities such as crop production, livestock rearing; off farm income and non-farm income were collected for pre and post implementation period in the selected watersheds in all the districts. On an average, in Krishnagiri district, the total households' income in the watershed treated villages were found to be Rs. 159260 as compared to ₹ 141150 in pre-treatment period, which was 12.83 per cent higher than the past. The similar percent increase in average household income of 12.87 percent was found in Perambalur district and it was 9.36 per cent increase in total income which was observed in Thoothukudi district. It is evidenced that the watershed interventions were found to help the rural farm households in enhancing their income level. Pankaj *et al.* (2021) studied that more than 90 per cent respondents agreed on the response of increased per capita income and living standard of people due to increase in wages (about 85 per cent respondents were agreed), employment opportunities, agricultural yields, etc., in comparison with pre-watershed management practices.

CONCLUSION

The present study on assessing the effect of watershed development program has evidently shown that the conservation of soil and harvesting and storage of the excess rainwater are acted as measures for alleviating farm and community level constraints, which impede the agricultural and rural development in the rainfed areas. Watershed development structures are found to be satisfactory and performing well in stimulating the substantial rise in water table and also prolonged water availability. It was observed that drinking water facility created in the watershed areas largely benefitted to the rural community. The watershed development program is successful in increasing both irrigation intensity and cropping intensity in all Krishnagiri, Perambalur and Thoothukudi districts resulted from enhanced gross cropped area, its productivity and assured access to water for irrigation. There had been a notable increase in productivity of major crops and livestock population recorded positively in the study areas attributed due to fodder availability adequate financial support for the purchase of livestock. Watershed interventions were found to help the rural farm households in enhancing their income level. The diversified cropping pattern, access to new technologies for resource use, creation of employment generation activities, etc. gave incremental income per annum in the watershed area. As the watershed development activities have a significant impact on ground water recharge, suitable water harvesting structures must be developed in large numbers by incorporating private investments in constructing farm ponds, percolation ponds, etc. wherever feasible. Creating awareness regards to rights and responsibilities will ensure more empowerment and involvement of stakeholders in maintenance of all the assets created in the watershed areas. As farmers cannot adopt the advanced crop production technologies due to risky nature of rainfed farming, access to crop insurance schemes for drought protection should be generated.

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