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RESEARCH ARTICLE

DO WATERSHED PROGRAMS ENSURE DROUGHT PROOFING? – EVIDENCE FROM GOVERNMENT INTERVENTION IN KARNATAKA, INDIA

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ABSTRACT

Watershed development has been an important strategy to raise agricultural productivity. An important intervention of the Ministry of Rural Development in association with state governments is the Drought Prone Areas Programme (DPAP). The study was conducted in Karnataka which is the third highest state in the country in the proportion of dry land area. The outcomes in terms of crop productivity, livestock assets and migration have been poor during the post-project year largely due to poor rainfall since the implementation of the project. This lends support to the Meta-analysis study by Joshi *et al* (2005) that watershed programmes have performed well in areas with rainfall in the range of 700-1000 mm. Since the rainfall has been less than 700 mm in the study villages it is not surprising that the outcomes have been less than what one would expect. Due to climate change, rainfall is predicted to became more erratic and dry regions are expected to became drier. Extreme and intense droughts are expected at higher frequencies in coming years. The development of the rainfed areas only by relying on monsoons would not be the right strategy in the coming decades and the policy implications are outlined.

INTRODUCTION

Dry regions in India constitute about 94 mha and about300 million people (one-third of India's population) livein these areas. More than 50% of the region is affected bydrought once every four years (Gupta, Tyagi and Sehgal, 2011). Droughts in 2016 affected a quarter of the Indian population in 254 districts of 10 states in the country (Choudhury and Sindhi, 2017) and 16% of India's geographical area is drought prone (Reserve Bank of India, 2013). Due to climate change, rainfall would become more variable and the dry lands regions would becomedrier. Intense and extreme droughts are expected at a higher frequency in the near future.Watershed development has been an important strategy to raise agricultural productivity and reduce poverty in the semi-arid regions (Kerr, Pangare and Pangare 2002). In India, the development of dry lands has become a matter of urgent need due to the agrarian crisis that the country has been facing. For the first time since the mid-1960's, food grain production grew slower than the population in 1990s. The situation in the country has become precarious with stagnation in irrigated agriculture and neglect of dry land farming. It is projected that even in the most optimistic scenario of irrigation development, nearly 40 per cent of India's demand for food in 2020 will have to be met by increasing the productivity of dry land agriculture.

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Simulation output analysis conducted by researchers from International Crop Research Institute for Semi-Arid Tropics (ICRISAT) reveal that crop yield will decrease due to climate change and variability in dry-lands (Jat, et.al, 2002). This paper examines whether watershed programmes can ensure drought proofing under a scenario of low rainfall. We examine this with evidence from a government implemented watershed project (Drought Prone Areas Programme) in central Karnataka. The DPAP was initiated in 1973 covering 947 blocks of 155 districts in 13 states. This has been a centrally sponsored scheme with central and state governments sharing the expenditure. The origin of the Drought Prone Areas Programme (DPAP) can be traced back to the Rural Works programme launched in 1970-71. The basic purpose of DPAP has been to restore ecological balance through soil and moisture conservation on a watershed basis. It has been, however, noted that these programmes have been "implemented in a fragmented manner by different departments through rigid guidelines without any well-designed plans prepared on watershed basis by involving the inhabitants" (GOI 1994: i). Consequently, the programmes have been unable to arrest the process of ecological degradation. The successful experiments achieved such co-ordination due to "Planning on watershed basis through the participation of people at all stages, active involvement of the voluntary organisations and co-ordinated effort by the administration" (GOI 1994: i).

MATERIALS AND METHODS

We have selected Karnataka state for our enquiry, which is the third highest state in the country in the proportion of dry land area (88%) (Shah et al 1998: 121). Chitradurga district from Karnataka state has been selected for the study for the following reason. This is a semi-arid and backward district with 460,797 ha of area requiring watershed intervention. The mean annual rainfall in the district was 565 mm during the 1901 to 1990 period. In the study area of Molkalmurutaluk (administrative unit below the district) period, there was intervention of both DPAP and Karnataka Watershed Development Agency (KAWAD) and their comparison was part of a wider study. The rainfall has ranged from a high of 876.70 mm in 1999 to a low of 441.20 mm in 2002 (for the years 2000 and 2001, it was 591.80 mm and 562.70 mm respectively).The district falls under the Krishna River basin and two major rivers Vedavathi and Tunghabhadra drain the district. The mean annual rainfall for the 1901 to 1990 period was 565 mm. Chitradurga District falls under the Central Dry Agro Climatic Zone, which comprises 17 taluks from Chitradurga as well as Tumkur districts. The total geographical area is 1,998,509 ha and the Gross cropped area is 109,169 acres. The major crops grown in the district are ragi, rice, jowar, pulses and oil seeds.

within the purview of the Bommadevarahalli watershed. Third, villages (a) to (c) form part of a single watershed area, while Bommadevarahalli and Muthigarahalli are stand-alone villages.The basic information of the farm households was collected during the walk undertaken by the author from the upper to the lower reach of the micro watershed. This information was used to stratify the households and select the sample households. Two levels of stratification were followed. At the first level, the reach of the farmer (upper or lower reach) was identified based on the location of the plot in the micro watershed. The demarcation of the watershed into upper and lower reach was done during the walk with the help of cadastral maps and in discussion with key informants and officials. At the second level, farm households were classified into small, medium and large based on landholding size. The stratification across location and landholding size was undertaken to study the differential processes and outcomes. From the list of farm households, on whose land the soil and water conservation treatment were undertaken, 25 per cent were selected from each stratum, using the lottery method. The stratification was based on the location within the micro watershed – upper or lower reach and size of land holding – small, medium and larger farmer. Based on this stratification, 150 farm households were interviewed.

Table 1. Design features of DPAP and expected outcomes

Particulars	Design features	Expected outcomes
Approach to watershed intervention	Ridge-to valley Treatment Water harvesting as a predominant strategy of watershed development	Treatment of the entire watershed (both private and common land) based on the technical feasibility would reduce soil and water run off, facilitate moisture retention and enhance crop and biomass productivity
Common property resources (CPRs)	Rejuvenation and optimal use	Incremental gains in terms of fuel wood and fodder availability
Water harvesting structures	Construction of check dams, farm ponds.	Recharge of wells in the downstream and augmentation of drinking water availability
Use of labour in the implementation of the SWC works	Labour –material component in the ratio of 60:40	Employment generation for wage labourers in particular and for the wider farming community

In Molkalmuru taluk, the DPAP project has been implemented in several phases. But, we have considered only Phase II villages for the study for the following reason. Since the watershed programmes as per the Common Guidelines were initiated in 1999 and completed in 2003, Phase II villages provided an opportunity to examine and analyse the processes and outcomes. Although the DPAP programme was supposed to be completed during 2002-03, the implementation went on up to the end of 2003 due to non-implementation in 2000, on account of creation the Watershed Department that year and the transfer of the programme from the Department of Agriculture to the new department. Second, watershed interventions in phase I villages, though they provided an opportunity to examine processes and outcomes, were not implemented as per the Common Guidelines. Third, the phases after the second were still ongoing and hence were not suitable for the study.Of seven villages where Phase II interventions were made, five villages, namely, (a) Devasamudra, (b) Venkatapura, (c) Vittalapura, (d) Bommadevarahalli, and (e) Muthigarahalli have been selected on the following grounds. First, three out of four villages belong to one watershed area. However, Oorthalu village, though it belongs to this watershed area, was not considered for the study, as the only intervention in the village was the construction of a diversion drain. Watershed interventions in the other villages were reasonably substantial. Second, Rajapura village was excluded as it came

Design of the DPAP project

The technical design of DPAP was expected to lead to the following outcomes. The ridge-to-valley approach followed in this project would lead to the treatment of entire watershed area based on technical feasibility, and this would, in turn, reduce soil and water run-off, facilitate moisture retention, enhance crop productivity and biomass development. Rejuvenation of common property resources and construction of water harvesting structures such as check dams would lead to gains in terms of fodder availability and improved ownership of livestock assets. The use of labour in watershed activities together with improved crop productivity would result in lesser migration rates. In Table 1 we summarise the design features of DPAP and expected outcomes. Did DPAP project succeed in achieving these outcomes? We analyse this question in this paper by examining the impact of project interventions in the study villages by comparing the outcomes of 2003 (completion year of the project) with those of 1999 (pre-project intervention year). We examine outcomes relating to crop productivity, migration and livestock ownership.

Study Area

Chitradurga historically has been a rainfall-deficient district. The problem is much severe in Molkalmuru taluk. Although the average rainfall during the period 1901 - 1990 was 565.5

mm (Table 2), this varied considerably across the seasons. Since the land is predominantly dry, a majority of the farmers cultivated only during the kharif period. Hence, the rainfall received during the South-West Monsoon becomes more relevant to the farmers (Table 2). The taluk faced 19 droughts during the ninety-year period ending with 1990 (Table 2). Thus, one in every 4 - 5 years has been a drought year in the taluk.For our study, it is important to examine the pattern of rainfall in the taluk during the period 1999 to 2003, when the DPAP project was implemented (Table 4). Before we examine the data from our field, we provide definitions of meteorological and hydrological drought.

meteorological drought resulting in depletion of surface water from reservoirs, lakes, streams, rivers, cessation of spring flow, and fall in groundwater levels causing severe shortage of water for livestock and human needs.The rainfall in the district during 1999 was 33 per cent more than normal (GOK 1999:48) while the rainfall in Molkalmuru taluk was excess by 59 per cent. The quantum of rainfall declined after 1999 and during 2003, the annual rainfall was 243.99 mm. The rainfall received during the South-West monsoon for the 2000 to 2002 period ranged from 198.4 mm in 2002 to 399.3 mm in 2001 (Table 4). Was the rainfall in the study villages different? Going by the data collected from rain-gauge stations nearer to

Table 2. Variations in the annual rainfall in Molkalmuru taluk (1901 - 1990)

	Pre-Monsoon (Jan - May)	S.W. Monsoon (June - Sep)	N.E. Monsoon (Oct - Dec)	Annual (Jan -Dec)
Mean	109.2	291.4	164.9	565.5
S.D (mm)	44.5	88.9	86.2	132.7
C.V. (%)	41.0	30.0	52.0	23.0
Maximum rainfall	277.7	489.1	387.4	919.2
Minimum rainfall	32.3	116.3	12.1	288.3

Source: GOK (1995: 7)

Table 3. Decade-wise Number of Droughts in Molkalmuru taluk (1901-1990)

Decade	1901-1910	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	Total
No. of drought years	1	3	1	3	2	2	2	2	1	19

Source: GOK (1995: 13)

Table 4. Rainfall in Molkalmuru taluk during 1999 to 2003

Year	Annual rainfall		South-west monsoon	
	Rainfall (mm)	Class - meteorological drought	Rainfall (mm)	Class - meteorological drought
1999	887.70	No drought	376.3	No drought
2000	591.80	No drought	354.0	No drought
2001	562.70	No drought	399.3	No drought
2002	441.20	No drought	198.4	Moderate drought
2003	243.99[1]	Hydrological drought		Hydrological drought

Source: Drought Monitoring Cell (Bangalore) records.

Table 5. Rainfall (in mms) in the study villages

Month	Bommadevarahalli				Devasamudra				Muthigarahalli			
	2003		1999		1999		2003		2003		1999	
	QR	RD	QR	RD	QR	RD	QR	RD	QR	RD	QR	RD
January	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0.0	0
February	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0.0	0
March	7.8	2	0.0	0	0.0	5	11.6	0	0	1	15.0	2
April	24.6	3	0.0	0	0.0	0	0	0	0	0	0.0	0
May	21.2	1	42.6	5	27.0	0	0	3	0	0	13.8	7
June	21.5	2	41.4	7	105.0	2	40.0	7	35.0	3	13.6	3
July	0.0	0	12.4	5	90.0	0	49.0	5	23.0	1	98.6	4
August	67.92	9	17.0	4	92.0	11	92.0	6	88.0	5	23.4	3
Sept.	7.22	2	64.8	8	154.0.	2	39.0	8	39.0	3	108.8	5
October	56.7	7	92.6	6	91.0	7	120.0	5	120.0	7	143.6	7
Nov.	0.0	0	4.0	1	4.20	0	0.0	1	0	0	7.2	1
Dec.	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0	0
Total	206.94	26	274.8	36	563.2	27	351.6	35	305.0	20	424.0	32

QR: Quantum of rainfall in millimetres
RD: Number of rainy days
Source: Data collected from the Panchayat offices in Molkalmur taluk.

The definition of "meteorological drought" adopted by the Indian Meteorological Department is a situation when the deficiency of rainfall at a meteorological sub-division is 25 per cent or more of the long-term average of that sub-division for a given period. The drought is considered "moderate" if the deficiency is between 26 and 50 per cent and "severe" if it is more than 59 per cent. According to the National Commission of Agriculture, hydrological drought is prolonged

and/or located in the study villages, it can be concluded that the rainfall during the completion year (2003) was low and deficient not only in terms of total rainfall but also in terms of rainy days as compared to the pre-project intervention year (1999) (Table 5). The rainfall data shows that the Ramapura station (nearest to Bommadevarahalli village) recorded rainfall of 206.94 mm (26 rainy days) (63.37% lower than normal rainfall) in 2003, while the average rainfall in 1999 was marginally better at 274.88 mm (36 rainy days). At Devasamudra station (nearest to Venkatapura and Vittalapura villages), the rainfall recorded in 2003 was 351.6 mm while it was 563.2 mm (with 27 rainy days) in 1999. At B.G. Kere station (nearest to Muthigarahalli village), the total rainfall was 351.66 mm (20 rainy days) in 2003 as compared to 424 mm (with 32 rainy days) in 1999. It needs to be, therefore, kept in mind that the lower rainfall in the completion year of the project would influence the project outcomes.

Crop Productivity

Improved crop productivity is an important outcome expected of watershed interventions. The SWC works relating to farm bund, boulder checks and check dams would arrest the run off of soil and water, and improve the soil moisture. There are two ways by which soil-moisture improves the crop yield; increasing the uptake of nutrients and enhancing the physiological activities of plants.

Table 6. Distribution of land (%) by soil types and villages

Village	Red soil - highly fertile	Black soil - medium fertile	Saline alkali - Low fertility	Gravely soil - low fertility	Total	Proportion of areaIrrigated
Bommadevarahalli	78	13	6	3	100	4
Muthigarahalli	69	14	14	3	100	4
Vittalapura	83	10	7	0	100	11
Venkatapura	45	14	35	6	100	34
Devasamudra	83	10	7	30	100	13

Table 7. Distribution of land (%) by farm categories and soil types

Strata	Red soil - highly fertile	Black soil - medium fertility	Saline Alkali - Low fertility	Gravely soil – very low fertility	Total	Proportionof area Irrigated
Upper Small	85	7	4	4	100	9
Upper Medium	69	19	8	4	100	4
Upper Large	55	25	20	0	100	13
Lower Small	65	6	29	0	100	4
Lower Medium	59	5	36	0	100	4
Lower Large	68	14	9	9	100	16
Total	67	12	18	3	100	11

Table 8. Productivity of groundnut (quintals per hectare) in Chitradurga district

Year	Irrigated	Un-irrigated	Irrigated and un-irrigated
1999-2000	14.05	7.14	7.16
2003-04	7.55	3.62	3.69

Source: Records of the Department of Agriculture, Government of Karnataka

The land owned by the sample households can be divided[1] into four types; red, black, saline alkali and gravely soil. Red soil is highly fertile, black soil is medium fertile, while saline alkali and gravely soil have low fertility. Although 67 per cent of the soil in the study villages (barring Venkatapura village) is fertile red soil, the proportion of the low fertile saline alkali soil is also significant. The proportion of irrigated area is the highest in Venkatapura, while it is the least in the villages of Bommadevarahalli and Muthigarahalli (Table 6). The data on soil types across the farm categories (Table 6) shows that the small farmers in both the reaches owned a relatively larger proportion of the fertile red soil. The proportion of the medium fertile black soil was higher among the upper large and upper medium farmers. The proportion of the low fertile saline alkali soil was high in the lower medium and lower small reach. The very low fertile gravely soil was present to a larger extent in the lower large reach. The proportion of irrigated area was only 11 per cent and this was higher among large farmers located in both the reaches.

FINDINGS

We examine the outcomes in the study with respect to crop productivity, crop failure, livestock ownership, migration and common land development.

Crop productivity in this study is the simple arithmetic mean of crop yields across plots in particular strata. Table 8 shows that the crop productivity in 2003 was low as compared to 1999 due to the low rainfall in 2003.It is, however, explained that although SWC interventions lead to an improvement of soil quality in the long run, in the short run, the improved soil quality may not result in "increased levels of yield unless a threshold level of rainfall or soil nutrients are available" (Shah, A 1997: 459). This is because "in arid conditions…reducing run off and increasing infiltration rates were found ineffective because moisture stored in the soil was still below the threshold level" (*ibid*: 459). This suggests that SWC interventions in semi-arid area like Molkalmuru may not immediately result in improved productivity not only because of low threshold level but also because of poor rainfall. We examine the productivity of important crop in this area (groundnut) across the farm categories under various soil and water conservation interventions.

Productivity of Farm Bund Treated Plots

The average productivity of groundnut in the farm bund treated plots was 1.75 quintals per ha in 2003 as compared to 6.90 quintals per ha in 1999. The variation in crop productivity across the plots was lower in 2003 with standard deviation of 4.67 as compared to 12.42 in 1999, probably because all the plots suffered from poor rainfall in 2003. However, in absolute terms, the variation was higher in 2003 as compared to 1999 due to inter-village variations in rainfall across the five study villages (Table 9).

[1]The classification of soil into highly fertile (red sandy loam), Black soil (medium fertility), Saline alkali soils (low fertility) and gravally soils (very low fertility) has been done, based on Rajan and Rao (1978).

Table 9. Groundnut productivity in plots with farm bund treatment

Strata	2003 productivity (Quintals/ha)	1999 productivity (Quintals/ha)	Productivity under normal rainfall condition (Quintals /ha)	CV 2003	CV 1999
Upper small	1.63 (3.13)	5.55 (8.49)	6.97	192.02	152.97
Upper medium	0.63 (1.77)	7.31 (10.04)	10.36	280.95	137.34
Upper large	2.38 (8.19)	5.89 (12.18)	9.44	344.11	206.79
Lower small	2.17 (4.51)	7.37 (8.26)	8.49	207.83	112.07
Lower medium	1.10 (2.71)	5.80 (21.49)	8.81	246.36	370.51
Lower large	1.22 (3.69)	6.13 (9.57)	8.19	302.45	156.44
Average productivity for the DPAP farmers	1.75 (4.67)	6.90 (12.42)		266.85	180.28

Note: Standard deviation in parentheses.

Table 10. Groundnut productivity in plots with construction of check dam

Strata	2003 productivity (Quintals/ha)	1999 productivity (Quintals/ha)	Productivity expected under normal rainfall conditions (Quintals/ha)	CV 2003	CV 1999
Upper small	0.94 (0.21)	10.27 (1.76)	15.54	19.74	17.13
Upper medium	0.75 (0.37)	5.93 (2.88)	8.45	49.33	48.56
Upper large	2.92 (21.21)	8.42 (46.66)	15.28	726.36	554.15
Lower small	3.22 (2.79)	5.82 (1.97)	6.73	86.64	33.84
Lower medium	0.3 (0.21)	8.47 (16.97)	8.17	70.00	200.35
Lower large	N.A[1].	N.A.			
Average productivity	1.55 (8.49)	8.28 (17.85)			

Note: Standard deviation in parentheses.

The highest productivity in 2003 (at 2.38 quintals/ha) was in the upper large strata, which was much lower than the expected productivity in a normal rainfall year (9.44 quintals/ha) and also as compared to 1999 (5.89 quintals/ha). The reason for the high productivity in the upper large strata[2] was due to a better endowment of red soil plots and a high proportion of irrigated land (16%). The relative variation was lower in 2003 (Standard deviation of 8.19) as compared to 1999 (Standard deviation of 12.18). The reason for this is while all plots suffered from low rainfall in 2003, the variation was lesser; while in 1999, certain plots with better endowment were able to achieve better productivity due to better rainfall.
The lowest productivity was in the upper medium strata with an average productivity of 0.63 quintals/ha as compared to 7.31 quintals/ha in 1999. The productivity in 2003 was 93.91 per cent lower than the productivity under normal rainfall conditions (10.36 Qtls/ha). In terms of the variation in the output, the relative variation was higher in 1999 (10.04) as compared to 2003 (1.77) due to higher rainfall in 1999, as plots with better endowment (red and black soil) were able to achieve higher productivity as compared to those having saline alkali and gravely soil. However, the absolute variation was higher in 2003 (CV-280.95) as compared to 1999 (CV-137.34) due to the higher variation in rainfall across the villages and plots.

Productivity of Check Dam Constructed in the farmer's Plot

The construction of check dam in the farmer's plots did not make any difference for incremental gains to be achieved; the yield was lower in 2003(1.55 quintals/ha) as compared to 1999 (8.28 quintals/ha) (Table 6.23). The relative variation was higher in 1999 (standard deviation of 17.85 as compared to 8.49 in 2003) as certain plots with better soil quality were able to achieve greater productivity vis-à-vis other plots. However, the absolute variation was higher in 2003, vis-à-vis 1999, as the variation in the rainfall across the plots and villages was higher (coefficient of variation of 547.74 in 2003 as compared to 215.57 in 1999).The highest productivity was in the lower small stratum with a productivity of 3.22 quintals/ha in 2003, which was lower than productivity expected under a normal rainfall conditions (6.73 quintals/ha) and in 1999 (5.82 quintals/ha). The relative variation was lesser in 1999 vis-à-vis 2003 (standard deviation of 2.79 in 2003 as compared to 1.97 in 1999). The lowest productivity in plots situated in close proximity to a check dams was in the lower medium strata, with 0.3 quintals/ha in 2003 as compared to 8.47 quintals/ha in 1999 and a productivity of 8.17 qtls/ha expected under normal rainfall conditions. The reason for the low productivity in this stratum is due to a high proportion of low quality soil (Saline alkali - 36%). The proportion of irrigated area in these strata is also lower, 4 per cent as compared to an average of 11 per cent. In comparison, the productivity in 1999 was 4 per cent higher than the expected productivity under normal rainfall conditions. The relative variation in productivity was higher in 1999 (16.97 in 1999 as compared to 0.21 in 2003) due to better rainfall, as certain plots were able to achieve higher productivity vis-à-vis others. Similarly, the coefficient of variation was higher in 1999 with a CV of 200.35 as compared to 70 in 2003. The reason for the low yield in 2003 was due to the occurrence of a hydrological drought in 2003. In contrast, there was good rainfall in 1999, in the kharif season the rainfall was 376.3 mm and the annual rainfall was 887.70 mm (excess by 59%).

Crop Failure in DPAP villages

Typically, farmers in semi-arid India would not harvest one or more of their plots because of low production. The incidence

[2] The highest proportion of irrigated land is in the lower large strata – 16.3%.

of crop failure varies over time across farmers within a village, and across villages in a region and unfavourable agro climatic events strongly covariate across many villages within a region and result in widespread crop failure (Singh and Walker 1982). We examine in the context of our data, the differential crop failures across plots with regard to two attributes - presence of irrigation and the type of soil. While, crop failure is identified with a plot that is not harvested, non-harvest implies that it simply did not pay the cultivator to put forth the effort to harvest the plot (Singh and Walker 1982: 3).The highest concentration of crop failures is in the lower small reach (44%) in which 29 per cent of the plots had the low fertile saline alkali soil. The least extent of crop failures was in the lower large reach, and this is due to the higher proportion of area being irrigated, 16 per cent. The higher number of crop failures reported during 2003 kharif was in plots having the highly fertile red sandy loam having (44%), which indicates that the fertility of the soil did not matter. The second highest proportion of such failures was in the low fertile alkali soil (32%) and least was in the lowest fertility gravely soil (7%). This indicates that rainfall was a more crucial determinant than soil type in determining the extent of crop failure. Seventy per cent of the plots in which the farmers chose to leave the plot fallow; the soil was red sandy loam (highly fertile). The reason for farmers choosing to leave the land fallow is due to the prediction of the farmer that the poor rainfall scenario would continue and he did not want to take the risk of sowing the seeds. A farmer's decision to sow the seeds at a particular point of time is determined by various factors. A crucial determinant also includes the experience of his fellow set of farmers who might have sown the seeds but since germination did not take place, would have gone for resowing. The farmers who did not sow the seeds therefore would have factored in this in deciding to leave the plot fallow.A large proportion of crop failures occurred in Venkatapura (40%) followed by Vittalapura (30%), Devasamudra (20%) and Bommadevarahalli (10%). The higher extent of crop failure occurred in Venkatapura, despite it having a very large proportion of red sandy loam (most fertile) which shows that the rainfall was a more crucial determinant influencing crop production (average rainfall is 174.02 mm in the Devasamudra sub-station, closest to the study village), while the village reporting the least extent of failure was in Bommadevarahalli, which had a slightly higher rainfall of 206.4 mm) and also a marginally higher proportion of the most fertile red sandy loam soil (78%).

Livestock

The poor rainfall and consequent meteorological drought in 2003 not only resulted in the low productivity and crop failures, but also led to death and distress sale of livestock in all the villages due to acute shortage of fodder. While a few of the farmers could afford to buy fodder, which had to be transported from irrigated areas near Bellary and from neighbouring Andhra Pradesh, the rest had to depend on the crop residues and grazing on the local commons. In this context, it becomes relevant to see which type of livestock assets would be adversely affected during the drought period. Puskuret al (2004) has formulated the following hypotheses on relationship between drought and livestock assets.

- For owners of large ruminants (cow, buffalo and ox), the effects of the drought are not adverse as these species depend largely on crop residues and stall-feeding.
- For the 'marginal' land owners, who depend on the small ruminants (goat and sheep), the effects of drought are adverse, as the farmers tend to resort to selling of goats and sheep as they are not able to prevent the death of the livestock due to fodder scarcity.

Table 11 provides information on changes in the ownership of livestock assets between 1999 and 2003. It can be seen from the table that there was a decline in stock ownership across all the livestock categories. However, there was some variation in the extent of decline between small and large ruminants. The extent of decline was comparatively smaller in the case of large ruminants. At first sight, the data supports Puskuret al's hypotheses, to some extent. But the extent of decline was high in the case of large ruminants as well, particularly, among cows and buffaloes. The extent of decline was somewhat lower in the case of ox. Thus, our evidence does not support the hypothesis relating to the large ruminants. This can be attributed to the following. First, the option of stall-feeding was largely available only to farmers owning irrigated land while this was not available for dryland farmers. Further, the proportion of irrigated land to the total was low in all the study villages. Second, the option of stall feeding through crop residues was also not widely available as the cross residues would be less during the drought year. Third, only a small proportion of the farmers could afford to stall-feed their livestock, as they had to purchase a lorry load of fodder from the irrigated villages in Bellary district or from Andhra Pradesh by paying Rs. 3,000.

Table 11. Changes in livestock ownership

Livestock	Stock in 1999	Proportionate Increase or decline from 1999 to 2003 (- indicates decline)
Cow	245	- 49 (120)
Buffalo	160	- 23 (37)
Ox	177	- 15 (27)
Goat	1461	- 56 (818)
Sheep	536	- 81 (434)

Note: Figures in parentheses are actual numbers

Local common lands also could not be relied upon for the purpose of accessing the fodder, as overgrazing of common land had taken place in the study villages. Consequently, the loss of large ruminants was high in all the study villages. In Bommadevarahalli village, the temple committee appointed a villager to graze the ruminants in the common land. Even in this village, the loss was high due to lesser fodder availability. There were no restrictions on grazing in the common land and the fodder requirements for larger livestock could not be met.In the case of goats and sheep, as hypothesised, the extent of decline was high. Pasha (1991) found that sheep and goat tend to die in larger numbers during drought as they have to depend mainly on grazing of poor quality herbages on commonland. Although similar reason was cited by some owners of sheep and goat, we feel that the main reason for a large decline in the number of goats and sheep was due to fodder shortage.Our data does not support the argument of Pasha (1991) that the loss of sheep and goat would usually be low during the drought period. Pasha (1991: A-29) writes that "these (sheep and goats) animals are adaptable to harsh environments also. When other animals, including the non-descript cows, cease to be productive during droughts, small ruminants come to the rescue of poor farmers in terms of liquidity. When poor farmers lose the kharif crop also, they can survive on sheep and goats. These animals are helpful in building large ruminant stocks as the farmers can sell a few sheep and goats to buy one or two large ruminants after the drought".

Migration

A crucial purpose of the watershed intervention under the DPAP mode was to generate employment opportunities and multiplier effects in and around the watershed. The evidence from our study villages reveals that wage labour generation was an extremely important felt need of the village community as they were facing poor crop productivity and crop failure in the 2000 to 2003 period. However, there was lack of sensitivity on the part of the Watershed Development Team staff members, who chose to implement the programme using machinery or by hiring contractors, who hired labourers from outside. There was no engagement with the village community on this issue and by the time the SWC interventions started in the villages, the wage labourers had already migrated. In fact, lack of wage employment generation has been an important contributing factor for the poor processes in the project (Vadivelu, 2008). The rate of migration was marginally higher in 2003 with migration occurring in 17 per cent of households (at least one member of the household migrating) as compared to 1999 wherein migration occurred in 12 per cent of the households. The rate of migration during 2003 was the highest in upper medium reach while it was the least in the upper small strata (Table 12). The reason is that the farmers in the upper medium strata had poorer endowments with 53 per cent of their soil being gravely or saline alkali kind and had the least proportion of area irrigated (4%). In contrast, the farmers in the upper small strata had comparatively better irrigation availability (9 per cent of the area owned). Although they had a higher proportion of poor quality soil, these farmers could manage their livelihood without having to resort to migration as they could work as agricultural labourers within the village or nearby villages. Significantly, 10 per cent of the upper large and 13 per cent of the lower large households also reported migration in 2003 showing that some proportion of larger households were not entirely immune from short-term migration.

Table 12. Proportion of households (%) reporting migration

Strata	Households (%) reporting migration of at least one household member	
	1999	2003
Upper small	13	3
Upper medium	16	27
Upper large	10	10
Lower small	15	24
Lower medium	14	23
Lower large	18	13
Total	12 (18)	17 (26)

Note: Figures in parentheses are actual numbers

The predominant cause for migration in 2003 was due to crop failure or/and poor productivity in the years preceding the survey year. About 42 per cent of the reporting households migrated only for a short period of 1 - 2 months. This proportion was more in the case of lower medium households (60%) followed by upper medium (50%) and lower large households (50%). Migration involving a greater amount of time (more than 6 months) occurred only in 15 per cent of the households. In comparison, the migration that occurred in 1999 was largely 'routine' in nature as these households have been migrating every year.The villages wherein the migration level was the least were in Venkatapura (3%) followed by Vittalapura (4%), while the village of Bommadevarahalli had the highest proportion of households migrating (47%) followed by Muthigarahalli (24%). The reason for high migration in Bommadevarahalli and Muthigarahalli[3] was largely due to the land use pattern of these villages with these villages having a low proportion of irrigated area. Such a low proportion of area under irrigation, under condition of drought and crop failures, naturally leads to a greater proportion of migration of these farmers to the nearby irrigated villages in Bellary district and in Andhra Pradesh.

Common Land Development

Common land development was an integrated part of the ridge-to-valley approach. Development of Common Pool Resource (CPR) regimes by exploiting the inherent interconnectedness of watershed areas would enhance fuel wood and fodder availability to the village community. It was envisaged that, under the DPAP mode, the watershed development plan would outline the problems and develop an approach to tackle the development of CPRs. There was, however, no attempt in sample villages to rejuvenate the commons (to increase fuel wood and fodder availability) by attempting to convert the open access nature of the resource to a common property regime. The only intervention attempted was the construction of check dams across the drainage line, located in both the private and common land. This did not, however, result in groundwater recharge due to poor rainfall. The only benefit was the drinking water for the livestock, confined only to structures, where damage had not occurred and where water overflow was excessive. In the village of Bommadevarahalli, the Temple committee made arrangement with a person appointed to take all the livestock in the village to the commons in the morning, and bring them back in the evening. There was however no attempt to regulate the excess grazing of the commons, which led to faster depletion of fodder. Although common land development was one of the priorities of DPAP, there was hardly any success in this regard largely due to poor skills/attitude of the WDT staff in engaging the community on these issues. The failure in developing the common land has lead to the high levels of mortality and distress sale of livestock during the 1999 to 2003 period. Although the Government did take some initiative in terms of creating fodder 'banks' in Ramapura*hobli* (administrative division below the sub-district level), this intervention was very late, as by then quite a few of the livestock had already perished. Those who benefited from such availability of fodder were only a fewand could cope with the problem to a limited extent. While the better-off farmers could ensure fodder availability by undertaking purchases from the neighbouring irrigated villages (by paying Rs.3000 for a truck load of fodder), the majority of small and medium farmers could not afford to buy fodder.

Conclusion

In the DPAP mode, the ridge-to-valley approach was to be adopted to ensure that both the private and common land is

[3] The presence of a tank in the Muthigarahalli village obviously did not benefit those section of households which chose to migrate as their plots could not benefit from the higher moisture availability due to their proximity to the tank.

treated in a comprehensive manner to enhance crop and biomass productivity. This approach was however, compromised in two out of five villages.It was envisaged that most of the funds would be spent on generation of wage employment. This, however, did not happen and the labourers had begun migrating in search of employment. By the time the implementation began, most of the labourers had already migrated. By stating that labourers were not available, the implementation was carried through contractors and use of machinery. If the staff had shown some sensitivity in terms of an initial engagement with the village community and outlined their intentions of undertaking the work with labour, the migration could have been prevented. The outcomes in terms of crop productivity, livestock assets and migration have been poor during the post-project year largely due to poor rainfall since the implementation of the project. This lends support to the Meta-analysis study by Joshi *et al* (2005) that watershed programmes have performed well in areas with rainfall in the range of 700-1000 mm. Since the rainfall has been less than 700 mm in the study villages it is not surprising that the outcomes have been less than what one would expect.This finding throws up a challenge to policy makers in India on how to ensure development of rainfed areas, were rainfall is poor. Due to climate change, rainfall is predicted to became more erratic and dry regions are expected to became drier. Extreme and intense droughts are expected at higher frequencies in coming years. The development of the rainfed areas only by relying on monsoons would not be the right strategy in the coming decades. There is need for surface water to supplement the erratic rainfall and there are examples of agricultural growth through a strategic reform of the irrigation sector in Madhya Pradesh, from which Karnataka can learn (see Shah and Kela, 2015). There is need for an integrated water management strategy wherein there is need for seeing soil moisture, groundwater and surface water as an integrated resource (Srinivasan and Lele, 2017).

REFERENCES

Choudhury, PranabRanjan, Sumita Sindhi, 2017. Improving the Drought Resilience of the Small Farmer Agroecosystem, Economic and Political Weekly, August 12, Vol. LII, No.32.

GOI, 1994. Report of the Technical Committee on Drought Prone Areas Programme and Desert Development Programme, Ministry of Rural Development, Government of India.

GOK, 1995. Drought Assessment and Response System Chitradurga District, Bangalore: Drought Monitoring Cell, Government of Karnataka.

Gupta, A. K., Tyagi, P. and Sehgal, V. K. 2011. Drought disaster challenges and mitigation in India: strategic appraisal. *Current science,* 100(12), 1795-1806.

Jat, R. A., Craufurd, P. Q.,Sahrawat, K. L., &Wani, S. P. 2012. Climate change and resilient dryland systems: experiences of ICRISAT in Asia and Africa. *Current Science,* 102(12), 1650-1659.

Joshi, P. K, Jha, A. K, Wani, S. P, Joshi, Laxmi, Shiyani, R. L. 2005. Meta-analysis to Assess Impact of Watershed Program and People's Participation, Comprehensive Assessment Research Report 8, Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Kerr, J., Pangare, G., and Pangare, V.L. 2002. Watershed Development Projects in India-An Evaluation, Research Report 127, International Food Policy Research, Institute. Washington, DC: International Food Policy Research Institute.

Pasha, Syed Ajmal1991. Sustainability and Viability of Small and Marginal Farmers, Animal Husbandry and Common Property Resources, Economic and Political Weekly, 30th March, 26(13): A-27-A30.

Puskur, Ranjitha, JetskeBouma and Christopher Scott 2004. Sustainable Livestock Production in Semi-Arid Watersheds, Economic and Political Weekly, 39(31): 3477-3484.

Rajan, Govinda S.V, and H.G. Gopala Rao 1978, Studies on Soils of India, New Delhi: Vikas.

Reserve Bank of India 2013. Reserve Bank of India Annual Report 2012-13, New Delhi: Government of India.

Shah, Amitha 1997. Moisture-yield Interaction and Farmers Perceptions: Lessons from Watershed Projects in Gujarat", ArthaVijnana, 34 (4): 457- 472.

Shah, Mihir, and Pankaj Kela, 2015. MP lessons for bumper agricultural growth, www.financialexpress.com

Shah, Mihir, Debashis Banerji, P. S. Vijayshankar and PramateshAmbasta1998. India's Dry Lands – Tribal Societies and Development through Environmental Regeneration, New Delhi: Oxford University Press.

Singh, R. P and T. S. Walker 1982. Determinants and Implications of Crop Failure in the Semi-Arid Tropics of India, Economics Program, Progress Report 40, ICRISAT.

Srinivasan, Veena and SharachchandraLele, 2017, From Groundwater Regulation to IntegratedWater Management, The Biophysical Case, Economic and Political Weekly, Vol. LII, No. 31: 107-114.

Vadivelu, Ananda, 2008. Choosing 'Not' to Participate-Evidence from Drought Prone Area Programme (DPAP) in Chitradurga, Karnataka in Development in Karnataka: Challenges of Governance, Equity and Empowerment, (Eds.) Gopal Kadekodi, Ravi Kanbur and Vijayendra Rao, Academic Foundation, New Delhi, p.377-406.

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