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RESEARCH PAPER

A study on resource characterization and analysis of watershed areas in semi-arid agro-climatic zones in Karnataka

G. N. KULKARNI, SUJITH SANDUR, P. L. PATIL AND G. S. DASOG

SUJALA III project, Department of Soil Science and Agricultural Chemistry
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
E-mail: gnkulkarni1663@gmail.com

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Abstract: Watershed management is being recognised as a suitable alternative intervention in managing natural resources in rain-fed agriculture ecosystem. This paper has analysed cropping pattern and cropping intensity, yield-gap against package yield and applied cost concepts of majorcrops in watershed areas. In addition,livestock economics of milch animals is also analysed to ascertain its contribution to the household income.The data were collected using baseline survey instruments. Cultivation of crops is found to be economically better viable and has shown net returns of ₹ 8547 acre^{-1} in green gram and ₹ 11064 in case of hybrid maize when the paid up costs on all variable inputs along with interest on working capital and family labour are taken for analysis however, the results have indicated relatively low cropping intensity of 120.64 per cent per year and in case of yield-gap analysis of a few major crops the gap is found to be in the range of 30-50 per cent across three seasons. Livestock economics has shown reduced level of livestock population,however, there is an encouraging trend in income generation from livestock enterprise as the average income obtained is ₹ 50,923 per household per lactation across different breed types. Highest income per lactation by households (HHs) is realised in case of cross breeds at rupees 65,930 followed by buffalos at ₹ 55992. It implied that dairy enterprise has an adequate potential in the area as could be found that as much as 35 per cent sample farmers adopted dairy enterprise.

Keywords: Applied costs, Characterization, Cropping intensity, Livestock, Watershed

Introduction

Agriculture is still a main-stay for many a community in the rural set-up in India. Most of the farmers in rain-fed areas are small farmers or smallholders and the landless, and farm sizes are very small (Devendra, 2010). Long-term rainfall data for India indicate that rain-fed areas experience 3-4 drought years in every 10 year period. Of these 2-3 are in moderate and one to two are in severe intensity (Srinivasarao *et al.,* 2013).No doubt Green revolution has brought self sufficiency but much of its technological progress that transformed agriculture is seen in irrigated areas while, it hasfailed to register a significant growth in less favoured rain-fed areas. Fan and Hazel (1999) have observed a decline of 20 percent in the absolute number of the poor in the irrigated areas of India while the figures roughly remained constant in the rain-fed areas. Palanisami and Kumar (2009) conducted a study on impact of watershed development programmes where they have recorded that watershed development activities have significant impact on groundwater recharge, access to ground water and hence the expansion in irrigated area. Watershed managementis being recognised as a suitable alternative intervention in managing natural resources and to increase the agriculture productivity in rain-fed agriculture ecosystem (ejournal.icrisat.org). Concerns about the sustainability of watershed management and the need to involve local resource users (participatory approach) in technology design and development have lead to the integrated watershed management projects (Wani *et al.,* 2002).

The semi-arid tropics are usually known to be experiencing low and irregular rainfall pattern. Its soil is also characterised by low productive potential and prone to high level of land degradation thus leading to reduced level of productivitymaking the eco-system very fragile, especially in rain-fed agriculture eco-system, eventually affecting its community (in terms of their livelihood opportunities), hard infrastructure (road, communication network *etc.*), soft infrastructure (health services, education institutes *etc.*) among others. Hence, technological and socio-economic interventions can be effectively combined to improve the productivity of rain-fed agriculture, allied agriculture enterprises and natural resource base of the watershed areas.

Sujala III, a project financed by the World Bank in association with Government of India (GoI) and Government of Karnataka (GoK) aims to demonstrate more effective integrated watershed management through greater integration of programs related to rain-fed agriculture, innovative and science based approaches and strengthened institutions and capacities of stake holders at different levels through characterization of natural resources and more effective measures of conservation and to understand hydrological dynamics vis-à-vis hydrogeology, climatic variability and to develop tools to measure them. In addition, the project also aims at socio-economic status evaluation of farmers at household level to understand the existing crop production pattern and farm economy. The results thus evolved as indicators can be identified and integrated with other components of the projectfor effective interventions by project monitoring and evaluation team of Sujala III.

Material and methods

This study was formally initiated in the year 2015. Formal questionnaires used as baseline survey instruments and were prepared encompassing the whole gamut of natural resources

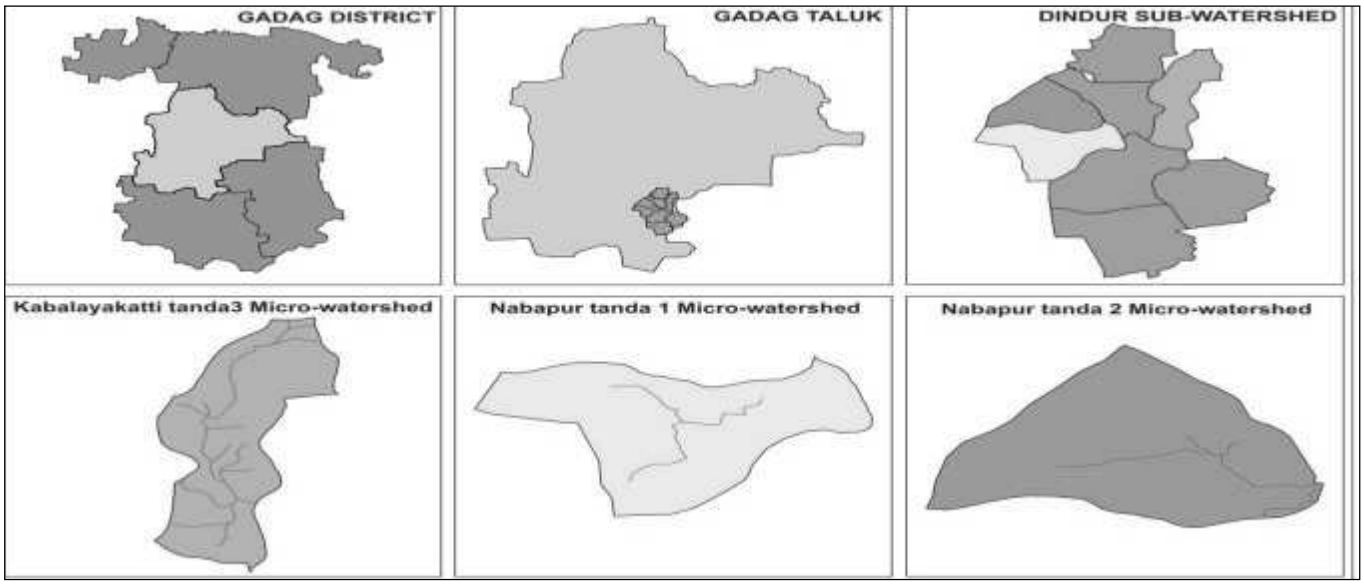


Fig. 1. Location of the study area

that are in line with the set objectives of the project. One of the broad objectives of the baseline survey was to ascertain the present status of the households in terms of available resources, assets, livelihoods *etc.*, in order to identify the factors manifesting their status and to establish benchmarks against which project progress is measured to profile the socio-economic status of the targeted micro-watersheds. The project districts are Gadag, Koppal and Vijayapura. This study is made of data generated from baseline survey carried out in three micro-watersheds of Gadag district. The identified watersheds are NabhapurTanda I, Nabhapur Tanda II and Kabulayakatti III, which are grouped in Dindur sub-watershed in Gadagtaluk of Gadag district.

Rain-fed farmers face substantial risk in generating income owing to fluctuations in rainfall, yield and price uncertainties. In addition, the area under dry-land agriculture is prone to periodic droughts severely affecting rain-fed farmers, especially the marginal and small farmers owing to their smaller landholdings are the most affected amongst the different categories of farmers. This is one of the important factors in selecting the watersheds for study.

The study has characterised socio-economic situation and resource use pattern across different farmers' size group of watershed area. The study has analysed farmers' agriculture practices to characterise cropping pattern and crop intensity, crop yield and the gap against expected package yield and applied cost concepts of majorcrops in watershed areas. In addition, livestock economics of milch animals is also analysed to ascertain its contribution to the household income.

The different size groups of farmers are marginal (0 to 2.47 acres), small (2.48 to 4.94 acres), semi-medium (4.95 to 9.88 acres), medium (9.89 to 24.7 acres) and large farmers (> 24.7 acres). In each micro-watershed thirty households were randomly selected and the pre-tested questionnaire was employed as an instrument to generate primary data. But, in case of Kabulayakatti III because of large forest cover and fallow land the number of farmers were found to be only 22 thus reducing the total sample size of three micro-watersheds (MWS) to 82 instead of 90. Data generation also included employing soil unit maps and cadastral maps to identify the farmers in order to have proper representation over the entire MWS by considering soil type and other MWS features such as forest cover and grazing land. Based on the information thus collected; data is tabulated and analyzed using an application software-automated land use evaluation planning (ALEP). In addition to the primary data, secondary information is sourced from published sources namely books and reports. In certain cases laboratory reports prepared on soil properties and water quality of micro-watershed area is used to cross compare the field information in order to further authenticate the findings.

Results and discussion

Micro-watersheds taken up for studies are in semi-arid tract of Karnataka and are drought prone. Average normal rainfallis in these watershed areas is 613 mm and average number of rainy days is 46 (DoA, Gadag). As far as soil type is concerned both red and black soils dominate certain areas the district. In case of study areastwo micro-watersheds (Nabhapur Tanda I and II) have over and above 54 percentredsoil coverage, whereas it is red soil again that has maximum coverage (97%) in Kabulayakatti III MWS.

Cropping pattern and crop intensity: Among the major crops, hybrid maize has occupied a major (37.76%) area of the annual gross cropped area (GCA) under rain fed condition followed by green gram (8.93%) and hybrid cotton (6.01%) during *kharif* season. The green gram is taken up by farmers only when they receive early monsoon rains. Area cultivated in *rabi* season accounted for 13 percent of the GCA. Irrigated area accounted for 13.27 percent of the GCA area during *kharif* seasonand 5.66 per cent in summer. Irrigated crops that occupy minor area include hybrid maize (9.86%), hybrid sorghum (1.80%).This

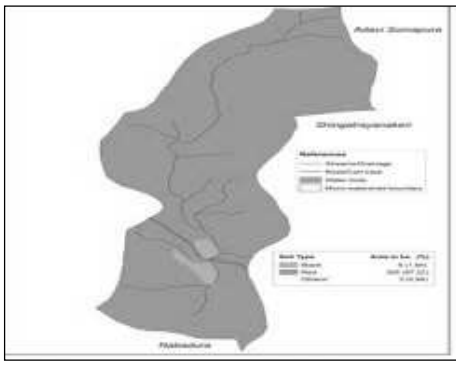


Fig. 2. Soil type Kabulayakattit and aIII,

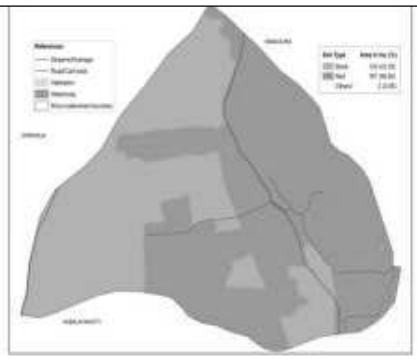


Fig.3. Soil typeNabhapurt and aII,

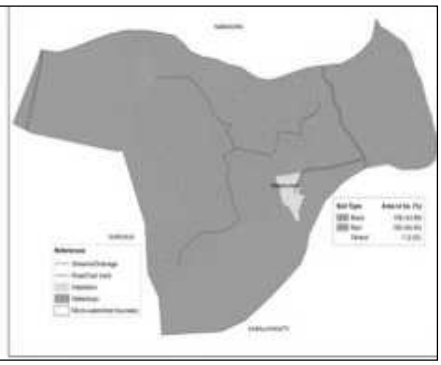


Fig. 4. Soil typeNabhapurt and aI

Table 1. General features of selected micro-watersheds for study

Micro-watershed	Red soil cover	Black soil cover	Avg. number of rainy days*	Natural vegetation
Nabhapur Tanda I	195 ha (54.00)	159 ha(43.98)	46	Tree species that are observed areMatti (Tectona
Nabhapur Tanda IÌ	167 ha(56.90)	124 ha (42.25)	46	Chabula), Subabul, Eculyptus, Accasia (*Accasia*
Kabulayakatti III	305 ha(97.22)	6 ha(1.84)	46	*auruculiformis*), Honge (*Pongamia Pinnata*),
Overall	222.33(69.37)	96.33(29.35)	46	Mayflower, Siris, Neem (*AzadirectaIndica*), Tamarind, Mango

implied of poor coverage in terms of area under irrigated condition in the micro-watersheds. Lesser irrigated area was attributed to lower water level in the bore-wells due to successive drought periods in the last two years. *Rabi* sorghum (rain fed) a major *rabi* crop hasoccupied 7.11 per cent area followed by foxtail millet (3.16%). It is ascertained from the analysis on cropping pattern that *kharif* is the major season for the farmers in the micro-watershed showing maximum (about 82%) cropped area of the gross cropped area (GCA). In all the GCA was about 294.71acres out of the total net sown area of 244.27acres (2.97 acres/household) in the micro-watershed areas. The annual cropping intensity (CI) is worked out to be low at 120.65 per cent in the micro-watershedareas indicating a large fallow land that has remained uncultivated during *rabi* season owing to poor rain fall pattern which is also evident to certain extent in *kharif* where poor soil moisture regime due to scanty rainfall was attributed as one of the primary reasons for relatively poor crop coverage. Meta analysis of 311 watershed case studies from different agro-eco regions in India have revealed that WS programs benefitted farmers through enhanced irrigation areas by 33.5%, increase in cropping intensity (CI) by 63% (Srinivasrao, *et al.,* 2016).

Crop yield performance and gaps: The low crop productivities in micro-watershed area are seen due to poor production conditions under rain-fed situation as against expected average package yield levels specified for different crops for Zone-3. Among the *kharif* crops, the actual yields are lower and is evident with respect to groundnut (3.39 q/ac against expected yield of 7.13 q/ac) showed yield gap of over 52 per cent with a standard deviation of 1.88 similarly hybrid cotton (3.80 q/ac)

Table 2. Gross cropped area in watershed areas (n=82)

Crop	*Kharif*				*Rabi*		Summer		Total
	Dry		Irrigated		Dry		Irrigated		Total
	Total area (Acre)	%	Total area (Acre)	%	Total area (Acre)	%	Total area (Acre)	%	Area (Acre)
Greengram	26.32	8.93	1.09	0.37					27.41
Hy Cotton	17.7	6.01	3.38	1.15					21.08
Hy Sorghum	15.87	5.38	5.3	1.80					21.17
Red gram (Intercrop)	12.85	4.36							12.85
Hy Maize	111.29	37.76	29.05	9.86	5	1.70			145.34
Groundnut	16.51	5.60	0.3	0.10			13.62	4.62	30.43
Foxtail Millet					9.3	3.16			9.3
Bengal gram					1.12	0.38			1.12
Rabi Sorghum					20.94	7.11			20.94
Wheat					2	0.68			2
Sugarcane							1	0.34	1
Coriander							2.07	0.70	2.07
Total	200.54	68.04	39.12	13.27	38.36	13.01	16.69	5.66	294.71

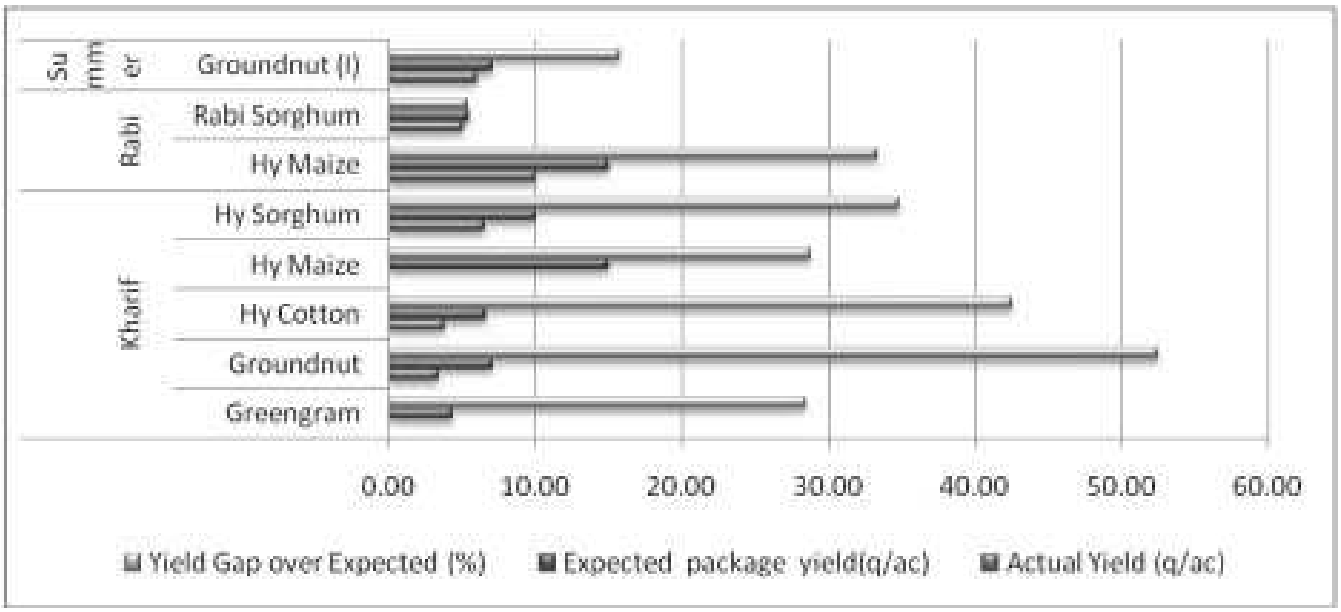
Table 3. Net sown area in the micro-watershed areas (n=82)

Size group	Irrigated Land (ac)	Rain-fed Land (ac)	Total Land (ac)
Marginal Farmer(>0 to <2.47)	15.62	57.13	72.75
Small Farmer(>2.47 to <4.94)	22.82	80.12	102.94
Semi Medium Farmer(>4.94 to <9.88)	5.20	52.38	57.58
Medium Farmer(>9.88 to <24.7)	0.00	11	11.00
Total	43.64	200.63	244.27

Table 4. Crop yield performance and gaps (n=82)

Season	Crop name	Actual	SD yield (q/ac)	Expected package yield(q/ac)	Yield gap over expected (%)
Kharif	Green gram*	3.15	0.59	4.40	28.48
	Groundnut	3.39	1.88	7.13	52.44
	Hy Cotton	3.80	1.07	6.60	42.50
	Hy Maize*	10.68	2.72	15.00	28.79
	Hy Sorghum	6.52	1.55	10.00	34.81
Rabi	Hy Maize	10.00	**	15.00	33.33
	Rabi Sorghum	5.09	0.15	5.40	5.37
Summer	Groundnut (I)	6.00	0.70	7.13	15.81

* includes both irrigated and rain-fed, ** only one farmer in a sample size of 82 SD= Standard deviation



and hybrid sorghum (6.52 q/ac) with a yield gap of 42 and 35 per cent respectively against the expected package yields. In case ofrabi crops, yield gap in maize is 33 percent below the package yield level thus pointing to a need for increasing the yields of various crops in the watershed areas through various soil and water conservation measures.

Livestock enterprise: Livestock enterprise income is analyzed to assess the present status of milch cow enterprise with respect to proportion of households engaged in this supplementary source of income, however, Chary et alhave reported that deficit rainfall leads to acute scarcity of quality of green water affecting animal health and draft power, milk yield and health, particularly in small ruminants as they over-graze the grasslands affecting quality and quantity of forage with limited water-points (Chary *et al.*, 2013).The present study included source, size unit, and productivity of milch cattle and the extent of income realized by households as parameters of assessment. Among those who

Table 5. Income from livestock enterprise (n=82)

Livestock	No. of households owning livestock	% households to the sample	No. of milch animals/ households	Average milk Yield/day/ animal (lit)	Avg. Lactation days	Avg. income/ animal/ lactation
Buffalo	10	12.20	1.20	5.5	176	55992
Crossbred Cow	11	13.41	1.27	10	189	65930
Local cow	8	9.76	1.63	3	144	30882
Overall	29	35.37	1.34	6.17	169.6	50923

owned (35.37%) milch animals, it is seen from the results that on an average at least one milch cattle owned by each household. The average productivity of local cow was very poor (3litres day^{-1}) and of buffalo is reasonably higher in comparison at 5.5 litre day^{-1}. Higher milk yield day^{-1} among households has influenced milk yield of cross breed cows at the rate of 10 litres day^{-1}. The average income obtained is Rupees 50,923 per household across different breed types. Highest income per lactation by HHs is realised in case of cross breeds at rupees 65,930 followed by buffalos at rupees 55,992. It implied that dairy enterprise has an adequate potential in the area as could be found that as much as 35 per cent sample farmers adopted dairy enterprise. Gopinath *et al.,* have reported that integration of livestock rearing with crop production improved the economic returns of farmers (Gopinath *et al.,* 2012). The watershed interventions through project efforts can further promote production of adequate fodder throughout the year with increased productivity of soils (conservation effects) as this would help in encouraging the farmers in the project area to go for this enterprise at much higher scale.

Crop economics

Cost of cultivation of crops in three different seasons: The applied costs concepts used in the farm management studies are employed for the critical analysis of costs and returns for major crops in the micro-watershed areas. Major crops analysed are rain-fed green gram and hybrid maize in *kharif,* rain-fed hybrid sorghum in *rabi* and irrigated groundnut in summer.

Applied costs and returns of green gram and hybrid maize

The cost and returns for rain-fed green gram and hybrid maize (Zea mays) in *kharif* showed gross returns of ₹ 19,040 and 23,830 acre^{-1}and total cost (Cost C_3) including fixed cost components accounted for ₹ 13,632 and 16,410 acre^{-1} each resulted in to a net returnof ₹ 5,408 and 7,420 acre^{-1} respectively. On the other hand, cultivation of crops is found to be economically better viable and has shown net returns of ₹ 8,547 acre^{-1} in green gram and 11,064 in case of hybrid maize when the paid up costs (Cost A_1) on all variable inputs along with interest on working capital and family labour are taken for analysis. This has sufficiently revealed of recovery of variable

Table 6a. Analysis of Costs and returns of major crops cultivated in 2015-16 in the selected watersheds (n=82) (₹/acre)

Sl.			Rainfed green gram, *kharif*			Rainfed hybrid maize, *kharif*		
No.	Particulars	Unit	Phy. Units	Value (₹) *	% to C3	Phy. Units	Value (₹) *	% to C3
	Cost A1							
1	Hired human labour	Man-days	15.23	2336.53	17.14	17.14	2602.72	15.86
2	Bullock labour	Pair days	1.64	1258.68	9.23	1.93	1678.09	10.23
3	Tractor	Hours	1.50	1375.00	10.09	0.91	835.61	5.09
4	Seed	Kg	4.90	454.93	3.34	5.53	730.61	4.45
5	FYM	Tons	0.00	0.00	0.00	0.10	134.16	0.82
6	Fertilizer				0.00			0.00
	N Kg		71.43	500.00	3.67	121.43	850.00	5.18
	P Kg		163.64	2159.09	15.84	125.00	1750.00	10.66
	K Kg		0.00	0.00	0.00	125.00	1750.00	10.66
7	Pesticides	Liquid in Litres.		0.00	0.00		0.00	0.00
8	Irrigation			0.00	0.00		0.00	0.00
9	Repairs			61.36	0.45		61.39	0.37
10	Misc. charges			66.09	0.48		72.24	0.44
11	Depreciation charges			264.09	1.94		240.97	1.47
12	Land revenue and Taxes			22.45	0.16		23.53	0.14
	Total Cost A1			8498.23	62.34		10729.33	65.38
13	Interest on investment			397.90	2.92		404.86	2.47
14	Interest on working capital			669.34	4.91		684.74	4.17
	Cost B1 = (A1 + Interests)			9565.46	70.17		11818.93	72.02
15	Rental value			1200.00	8.80		1210.53	7.38
	Cost B2 = (B1 + Rental value)			10765.46	78.97		13029.45	79.40
16	Family labour	Man-days	7.31	1326.18	9.73	7.64	1352.12	8.24
	Cost C1 = (B2 + Family labour)			12091.64	88.70		14381.58	87.64
17	Risk premium			63.45	0.47		76.08	0.46
	Cost C2 = (C1+ Risk premium)			12155.10	89.17		14457.66	88.10
18	Managerial cost **			1477.03	10.83		1952.08	11.90
	Cost C3 = (C2 + Managerial cost)			13632.13	100.00		16409.73	100.00
	Economics of the crop		qtl	Market value	Rs/q	qtl	Market value	Rs/qtl
a	Output	a) Main product	3.35	18090.00	5400.00	10.30	21630.00	2100.00
		b) By-product	4.75	950.00	200.00	11.00	2200.00	200.00
b	Gross Income			19040.00			23830.00	
c	Net Income			5407.87			7420.27	
d	Cost per quintal			3785.71			1379.59	

*Avg. Figures of variable & fixed costs of those farmers cultivating that crop. **Managerial cost is at 15% of C2 and is also of avg. figures of farmers cultivating that crop

Table 6b. Analysis of Costs and returns of major crops cultivated in 2015-16 in the selected watersheds (n=82) (Rs/acre)

			Irrigated Groundnut, Summer		
Sl. No.	Particulars	Unit	Phy. Units	Value (₹) *	% to C3
	Cost A1				
1	Hired human labour	Man-days	18.44	2863.04	14.97
2	Bullock labour	Pair days	2.01	2007.05	10.49
3	Tractor	Hours	0.00	0.00	0.00
4	Seed	Kg	36.57	2267.12	11.85
5	FYM	Tons	0.00	0.00	0.00
6	Fertilizer				0.00
	N Kg		108.33	758.33	3.97
	P Kg		116.67	2916.67	15.25
	K Kg		60.00	920.00	4.81
7	Pesticides	Liquid in Litres.		0.00	0.00
8	Irrigation			109.33	0.57
9	Repairs			70.50	0.37
10	Misc. charges			64.33	0.34
11	Depreciation charges			575.33	3.01
12	Land revenue and Taxes			25.00	0.13
	Total Cost A1			12576.71	65.76
13	Interest on investment			632.53	3.31
14	Interest on working capital			944.77	4.94
	Cost B1 = (A1 + Interests)			14154.01	74.01
15	Rental value			1050.00	5.49
	Cost B2 = (B1 + Rental value)			15204.01	79.50
16	Family labour	Man-days	8.65	1543.67	8.07
	Cost C1 = (B2 + Family labour)			16747.68	87.57
17	Risk premium			73.83	0.39
	Cost C2 = (C1+ Risk premium)			16821.51	87.96
18	Managerial cost $			2303.07	12.04
	Cost C3 = (C2 + Managerial cost)			19124.58	100.00
	Economics of the crop		qtl	Market value	Rs/qtl
a	Output	a) Main product	6.00	25800.00	4300.00
		b) By-product	4.50	900.00	200.00
b	Gross Income			26700.00	
c	Net Income			7575.42	
d	Cost per quintal			3037.43	

*Avg. Figures of variable & fixed costs of those farmers cultivating that crop.

** Managerial cost is at 15% of C2 and is also of avg. figure of farmers cultivating that crop

or short-term costs in the seasonal production. However, when the total cost (Cost C_3) is considered, per quintal cost of production was put at ₹ 3786 per quintal in case of green gram and 1,380 in case of maize, and then it is found to be lesser than the output market price (₹ 5,400/q green gram and 2,100/q maize) excluding by-product value.Benefit cost ratio was worked out for green gram and maize are1.39 and 1.45 respectively. Joshi *et al.*, have reported that the watershed programmes were beneficial and viable with a B C ratio of 1: 2.14(Joshi *et al.*, 2005).

Applied costs and returns of irrigated groundnut: On the other hand when we looked at the applied cost and returns of irrigated groundnut (summer) gross returns is observed at ₹ 26,700 acre^{-1} against the total cost (Cost C_3) including fixed cost components accounted for ₹ 19,125acre^{-1}resulted in to net return of ₹ 7,575acre^{-1}. In addition to this, cultivation of the crop is found to be economically better viable and has shown net returns of ₹ 11,634acre^{-1} when the paid up costs (Cost A_1) on all variable inputs along with interest on working capital and family labour (₹ 15,066acre^{-1}) are taken for analysis. This has sufficiently revealed of recovery of variable or short-term costs in the seasonal production. However, when the total cost (Cost C_3) is considered, per quintal cost of production was put at ₹ 3,037/q then it is found to be lesser than the output market price (₹ 4,300/q) excluding by-product value. Benefit cost ratio is worked out to be 1.39.

Conclusion

Costs and returns analyzed for major crops in the micro-watershed have revealed that farmers have recovered their variable/short-term costs on all major cultivated crops. However, cultivation of crops is found to be economically better viable and has shown net returns of ₹ 8,547 acre^{-1} in rain-fed green gram and rupees 11,064 acre^{-1} in rain-fed maize when the

paid up costs on all variable inputs along with interest on working capital and family labour are taken for analysis. However, the results have indicated relatively low cropping intensity of 120.64 per cent per year. Low productivity of majority of the crops in the watershed has resulted in to a high cost per unit of output. The productivities of the crops realised by farmers in the watershed areas are very low with a gap in yield ranging from 30 to 50 per cent in relation to expected package yields. Results have also indicated that livestock economics a profitable allied agriculture enterprises for non-watershed farmers, as the average income obtained is ₹ 50,923 per household across different breed types. Highest income per lactation by households is realised in case of cross breeds at ₹ 65,930 followed by buffalos at ₹ 55,992. It implied that dairy enterprise has an adequate potential in the area as could be found that as much as 35 per cent sample farmers adopted dairy enterprise.

Watershed interventions in the micro-watershed for enhancing crop productivities and there by help in the reduction of variation in yield levels. The efforts towards enhancing yields can be further augmented by increased implementation of water storage interventions which would serve as source of supplementary irrigation during critical crop stages. Livestock interventions calls for providing opportunities to increase the livestock population and fodder availability to increase milk production at household level thereby providing an opportunity to increase supplementary source of income. The intervention enhances the productive capacity of the farm resources and incomes of the farmers in general and of the small and marginal farmers in particular. In addition, there is also a need to strengthen out reach activities through trainings, demonstrations, *etc*., to impart skills on better farming practices towards increasing crop yields under rain-fed condition.

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