Range Mgmt. & Agroforestry 30 (2) : 140-146, 2009
ISSN 0971-2070

Impact of Tejpura watershed project on crop and livestock production

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Received : 12th October, 2009 Accepted: 26th December, 2009

Abstract

The study was conducted to assess impact of the Tejpura watershed project in the village Tejpura-Ghurat in Bangra Block of Jhansi district of Uttar Pradesh. The random sample of 96 farmers households were selected and interviewed with the help of well structured schedule and focused PRA including transect walk. The data had been compared with sample survey of the year 1991. The gross cropped area had increased by 264.82 per cent. The over all cropping intensity showed a marginal increase (0.34 per cent). The irrigated area and cultivated area had increased in all categories of farmers. The area under pulses, fodder crops and vegetables also increased, while the area under cereals and oilseeds showed a decrease. With regards to number of livestock across the sample households, the maximum decrease was observed in medium farmers and minimum large farmers. In medium and large farmer's categories, the percentage decline in livestock was 24.20 and 12.47 per cent respectively. The supply elasticity of mustard (1.32), black gram (1.40), lentil (4.29) and pea (107.03) showed that their supply is elastic. Supply elasticity of other commodities showed values less than unity or were inelastic. Positive values for producer's surplus were observed in wheat, barley, black gram, lentil and mustard while the values obtained for consumer's surplus showed that the consumers were the major beneficiaries of the total economic gains. Higher economic gains were obtained for (descending order) bread wheat, black gram, durum wheat, gram and sorghum and higher economic loss was observed in pigeonpea and pea.

Key words : Bundelkhand, Crops, Livestock, Tejpura watershed

Introduction

In India about 61 per cent of total cropped area is under rainfed farming. Hence, rainwater-harvesting approach, which is used as one of the several principles of watershed development, is essential for assured crop production and livelihood security of the farmers. In Bundelkhand region, about 66 per cent of total area is used as cultivated area. This area is characterized with its large-scale variation within the region. The cropped area under *kharif* crops is less as compared to that under *rabi* crops. The erratic precipitation pattern (ranging from 417 to 1330 mm) along with seasonal temperature variation, are also major limiting factor for development in Bundelkhand region. The Tejpura watershed comprising of 775.7 ha area is located in the village Tejpura-Ghurat in Bangra Block of Jhansi district of Uttar Pradesh (U.P.). The project was implemented by State Soil Conservation Department of U.P. under technical guidance of Indian Grassland and Fodder Research Institute (IGFRI), Jhansi between 1983-84 to 1986 –87. This watershed area drains to the river Lakheri - a tributary of Betwa River. The different interventions implemented under this project were rainwater conservation, crop production, agroforestry and dryland horticulture. In June 1987, the project was reorganized and further extended up to Kharaiya Nala – Lakheri river (five sub watersheds). In watershed programmes, significant period is required to achieve the expected potential impacts, hence the watershed programmes needed to be evaluated after certain gestation period. With this in view, the study was conducted to assess the impact of Tejpura watershed on land use, cropping pattern, resource use and soil fertility status and livestock productivity as specific objective.

Methodology

Ninety six households comprising of 29 marginal farmers, 27 small farmers, 25 medium farmers and 14 large farmers were selected by applying random sampling technique for collecting information using interview method. Focused PRA was also conducted to obtain specific information on the farming community in this

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watershed. The data collected in 2002-2004 was analyzed and compared with the published literature and sample survey conducted in 1991. Numerous monitoring tools required to quantify the changes in indicator values over time were used (Singh, 1991; Ajora, 1998)

Measurement of elasticity of supply: Elasticity of supply is expressed in relative or proportionate terms. It expresses the absolute value of rate of percentage change in supply divided by rate of percentage change in price. It can be measured by following formula. The elasticity of supply ranges from 0 to infinity.

Es = Percentage change in quantity supplied / Percentage change in price

Elasticity of demand: The demand elasticity is ratio of relative change in quantity to relative change in price.

Ed = Percentage change in quantity demanded/ Percentage change in price.

Economic gain – surplus approach: The effect of development activities on change in economic gain in particular year can be expressed in terms of consumer's gain or surplus and producer's gain or surplus. The following equations represent the calculation of economic gain using the above mentioned principle.

The Consumers' gain, $G_{cit} = ½(P_{it}-P_{-it})* (Q_{dit}+Q'_{dit})$

where

G_{cit} = Consumer's gain
P_{it} = Price in year 2002
P_{-it} = Price in base year (1991)
Q_{dit} = Consumption/demand in year 2002
Q'_{dit} = Consumption/demand in base year (1991)

The Producer's gain, $G_{pit} = ½(K_{it}-(P_{it}-P_{-it})* (Q_{sit}+Q'_{sit}))$

Where,

G_{pit} = Producer's gain
K_{it} = Vertical shift $=(Y_t-Y_{t-1})*A_t/b_{it}$
P_{it} = Price in year 2002
P_{-it} = Price in base year (1991)
Q_{sit} = Supply / production in year 2002
Q'_{sit} = Supply / production in base year (1991)
b_{it} = Slope of supply curve
b_{it} = $(Q_{sit} / P_{it})*e_i$
e_i = Elasticity of supply
Y_t = Yield in 2002
Y_{t-1} = Yield in 1991
A_t = Area of harvest in 2002

Economic gain = Consumers' gain + Producer's gain

The economic gains comprising of both the producer's and consumer's gain or surplus, were estimated by taking the data for the year 1991 as the base data. Estimates of gains were measured in terms of changes in producers and consumers surpluses (Kumar 2004; Mruthyunjaya *et al.,* 2004).

Results and Discussion

Impact on land-use: The land holding owned by medium and large farmers declined by 4.89 per cent and 11.52 per cent respectively over base year 1991 (Table 1). In 1991, the large, medium, small, and marginal households were 11.50, 26.53, 23.94 and 29.81 per cent respectively. By the year 2002, the number of households increased mainly due to division in the family. The number of large households declined, while number of households of other categories increased. The average size of holding declined in all categories but reduction was more in the case of marginal (-22.62 %) and medium (-15.85) sized farm households. The average size of holding also declined in large (-3.58 %) and small (-7.78 %) categories of households (Table 2).

Area under *kharif* crops increased at a higher rate than that under *rabi* crops. The gross cropped area increased by 264.82 per cent. The over all cropping intensity increased during the period 1985-86 to 2002 (Table 3). The spread of adoption of cropping in different seasons is influenced by the risk due to weather abnormalities which is measured by cropped area distribution across seasons and was measured by *Kharif* to *rabi* ratio. The value obtained was 2.77 in 1985-86, which decreased to 1.71 by the year 2002. This indicates that the farmers are better equipped to cope up with the risk associated with any one particular season. Compared to 1991, the irrigated area and cultivated area had increased in all categories of farmers. The area cropped under pulses, fodder and vegetables increased, while the area cropped under cereals and oilseeds decreased.

Impact of the watershed on crop production : Area under pulses, vegetables and fodder crops increased by 82.35, 158.16 and 54.99 per cent, respectively (Tables 4 & 5). The area under cereals and oilseeds decreased by 39.10 and 33.07 per cent respectively over the base year 1991. Among the *Kharif* crops, significant increase in crop productivity was recorded in case of tomato (269 per cent). Sorghum and groundnut recorded a negative growth in yield during the period (1991 to 2002).

Kharif cropped area also increased. The area under black gram, fodder sorghum and tomato increased by 279.46, 462.59 and 158.16 percent, respectively (Table 4). It was observed that the farmers started rearing more milch animals as they increased cropped area under fodder

Table 1: Land use pattern of command area of Tejpura watershed (Area in ha)

Land	Marginal		Small		Medium		Large		Total	
	1991	2002	1991	2002	1991	2002	1991	2002	1991	2002
Irrigated	79.38	83.22	104.75	161.05	258.57	258.26	80.78	190.70	523.48	693.23
Un-irrigated	27.18	33.33	65.79	86.06	144.48	135.66	335.77	176.24	573.22	431.29
Wasteland	-	4.04	-	4.1	-	-	6.92	7.56	6.92	15.70
Grassland	-	9.90	-	1.64	11.40	0.26	1.58	1.58	12.98	13.38
Cultivated area	106.55	116.55	170.54	249.12	403.05	393.92	416.55	366.95	1096.70	1124.53
% increase / decrease		+9.38		+44.90		-2.27		11.91		+2.54
Total area	106.55	130.49	170.54	252.85	414.85	394.18	425.05	376.09	1116.60	1153.61
% increase / decrease		+22.46		+48.26		-4.89		-11.52		+3.31

Table 2 : Farm families and their average land holding (ha)

Category	1991			2002			% change from 1991
	Families	% of total households	Av. land holding	Families	% of total households	Av. land holding	
Large (> 5 ha)	49	11.50	8.67	45	8.32	8.36	-3.58
Medium (2-5 ha)	113	26.53	3.66	128	23.66	3.08	-15.85
Small (1-2 ha)	102	23.94	1.67	164	30.31	1.54	-7.78
Marginal (<1 ha)	127	29.81	0.84	202	37.34	0.65	-22.62
Landless	35	8.22	0.00	2	0.37	0.00	0.00
Total	426	100.00		541	100		

Table 3: Tejpura watershed : Land use changes

Particulars	Area (ha)			Percentage change over 1982-83	
	1982-83	1990-91	2002-03	1990-91	2002
Kharif	116.0	509.28	585.57	339.03	403.46
Rabi	320.8	1064.54	1039.54	249.04	214.69
Gross cropped area	436.8	1573.82	1625.01	272.94	264.82

sorghum, when black gram was sown as short duration crop during the *kharif* season. The main impact of watershed programme was introduction of tomato cultivation in this area.

The yield of almost all the *Rabi* crops increased in the shidy area, highest being in improved varieties of wheat. Further the area under wheat (sp.aestivum), wheat (sp. *durum*), wheat + mustard and wheat (sp. *durum*) + gram were decreased by 7.71, 37.98, 23.21 and 58.24 percent, respectively. The area under sole cropping of gram was also decreased (54.44%). The area under mixed cropping of gram with linseed decreased by 91.96 percent, while the area under gram+mustard increased by 45.48 percent. The area under sole cropping of pea increased by 758.48 percent whereas a new crop combination of pea + mustard was introduced and occupied 174.81 hectares. Total *rabi* crops area decreased by 9.84 percent over 1991 base year. Further it was observed that area under cultivation of crops combination such as black gram+ sesame, green gram + sesame, groundnut + sesame, sorghum + pigeon pea, sorghum + green gram, sorghum + black gram had come down to nil during 2002. Area under pulse crops in both the seasons was increased by 84.21 % whereas area under cereal crops and oil seed crops decreased by 39.10% and 33.07 % respectively. Area under vegetables and fodder crops increased by 170.27 and 54.99 % respectively (Table 5).

Elasticity of supply: The supply elasticity of mustard (1.32), black gram (1.40), lentil (4.29) and pea (107.03) were more elastic. The supply of black gram, pea and lentil increases by 437.42, 1121.81 and 464.27 percent, respectively in this watershed area and supply elasticity of other commodities were less than unity. It means that the supply elasticity of other commodities were inelastic.

Elasticity of demand: The elasticity coefficient for pea (91.99) and lentil (11.45) were greater than 1, which showed an elastic demand for these commodities. The values obtained for demand elasticity of other commodities were inelastic in nature (Table 6).

Economic gain – Consumer's surplus approach: The producer's surplus was obtained from cultivation of the crops, namely, bread wheat, barley, black gram, lentil and

mustard in this watershed area which showed positive values while all other crops showed negative values. The values of consumers surplus gave the idea that consumers were the major beneficiaries from the crops (commodities) cultivated in this area and contributed significantly to the positive values obtained for economic gain. Higher economic gains were obtained from bread wheat, urd, durum wheat, gram and sorghum in decreasing order and higher economic loss was found in pigeon pea and pea (Table 7). Regarding the per hectare economic gains, the higher economic gains were obtained from berseem, bread wheat, barley, durum wheat, over the year 1991. Pigeonpea was found to have highest negative value for economic gain.

Table 4 : Crop area with percentage change in Tejpura watershed

Crops	Area (ha)		
	1991	2002	Change(%)
Kharif crops	509.28	585.47	14.67
Black gram	104.42	396.23	279.46
Green gram	61.69	36.23	-41.27
Pigeonpea	00.00	4.87	0.00
Ground nut	97.36	76.2	-21.73
Sesame	26.32	10.56	-59.88
Sorghum (grain)	115.74	6.26	-94.59
Sorghum fodder	0.54	3.04	462.59
Paddy	00.00	16.05	00.00
Tomato	13.05	33.69	158.16
Black gram+Sesame	6.48	00.00	00.00
Moong+Sesame	7.62	00.00	00.00
Groundnut+Sesame	12.14	00.00	00.00
Sorghum+ Pigeon pea	42.41	2.34	-94.48
Sorghum+Green gram	15.92	00.00	00.00
Sorghum+Black gram	5.60	00.00	00.00
Rabi Crops	1064.54	1039.54	-9.84
Wheat (aestivum)	218.96	202.07	-7.71
wheat (Duram)	68.17	42.28	-37.98
Barley	15.54	36.06	132.05
Gram	89.10	40.59	-54.44
Lentil	10.00	12.53	25.30
Peas	3.42	29.36	758.48
Berseem	3.57	3.33	-6.72
Wheat+mustard	165.73	127.26	-23.21
Wheat Durum+linseed	54.34	00.00	00.00
Wheat Durum+Gram	208.59	87.11	-58.24
Wheat Durum+ Mustard	00.00	28.31	00.00
Gram+mustard	101.53	147.71	45.48
Gram+linseed	117.84	9.47	-91.96
Lentil+mustard	7.75	87.38	1027.48
Pea+mustard	00.00	174.81	00.00
Mustard	00.00	4.20	00.00
Barley + gram	00.00	4.19	00.00
Barley + mustard	00.00	2.87	00.00

Resource use: The main inputs for the *kharif* crops were seed and labour. The uses of other inputs were very less. Farmers' were generally using local seeds for sowing of *kharif* crops but improved varieties were used for groundnut and tomato cultivation. The gross return and net return indicated that black gram, groundnut and tomato were the most profitable crops in *kharif* season. Unlike *kharif* season, in *rabi* season more crops are taken and better inputs are provided.

The adoption of mixed crop system was more profitable compared to sole crops. The analysis of per hectare input use (Table 4), indicated that fertilizers were mainly used in *rabi* crops only. Analysis of input use based on the size of land holding indicated that on unit basis, the input use did not differ much except for the thrashing charges where the large farmers were making more expenditure. The gross return and net return (average of all crops / ha) indicated an increasing trend as the size of holding increases.

Table 5: The crop type wise summary changes

Crop type	1991	2002	Change (%)
Pulses	509.85	93918.00	84.21
Cereals	911.00	554.79	-39.10
Oilseeds	135.82	90.98	-33.07
Vegetables (tomato)	13.05	33.69	158.16
Fodder	4.11	6.37	54.99
Total cropped area	1573.82	1625.01	3.26

Livestock: The livestock resources comprised of 1503 bovine (cattle and buffaloes) and 1396 goats and sheep. The average number of bovine and small ruminants owned by marginal, small, medium and large farmers was 1.46, 2.28, 3.25 and 5.39 respectively. The marginal, medium and large farmers were more dependent on cows for milk production due to lower input requirement for the maintenance. Small farmers preferred more buffaloes so that it could supplement their income and in addition they required fewer inputs. On an average 2 to 3 goats were reared by all the farmers, whereas sheep were reared mainly by small and medium farmers. There has been an increase in the number of milch and dry cows, buffaloes, sheep and goats in 2002 over the year 1991 while the number of bullocks was decreased considerably. There was an overall increase in the number of livestock. The population density in terms of number of animals per ha of area was increased from 0.94 to 1.15 (Table 8).

Milk productivity per cow was highest in case of large farmers (1.77/day) with an overall average of 1.43 l/day. Milk productivity per buffalo was highest in case of small and marginal farmers (3.60 and 4.96, respectively) with an overall average of 3.09/day. The average ACU (adult cattle unit) showed a decline in the case of large and

Table 6 : Elasticity of demand and supply

Crop	Production 2002	Production 1991	% change	Consumption 2002	Consumption 1991	% change
Barley	570.96	286.25	99.46	334.63	575.76	-41.88
Berseem	2837.20	2772.30	2.34	2837.20	2772.40	2.34
Groundnut	586.36	617.55	-5.05	135.87	146.29	-7.12
Gram	1705.40	2379.70	-28.33	383.69	1021.50	-62.44
Lentil	551.12	97.67	464.27	207.44	15.48	1240.08
Green gram	83.24	328.68	-74.67	277.81	130.10	113.54
Pea	2442.40	21.58	11218.07	283.45	2.91	9640.47
Pegionpea	11.33	209.30	-94.59	12.63	104.71	-87.94
Sorghum	50.01	1631.20	-96.93	52.78	1985.90	-97.34
Sesame	32.42	171.17	-81.06	23.68	124.35	-80.96
Black gram	1457.70	437.42	233.24	456.91	216.44	111.10
Wheat	7387.70	6494.40	13.75	6579.70	6600.10	-0.31
Durum	1087.20	1955.00	-44.39	919.47	1869.20	-50.81

Table 7: Economic gain (Rs)

Crop	Area ha (2002)	Price (1991)	Price (2002)	Consumers gain	Producers gain	Economic gain	Economic gain/ ha
Barley	43.12	195.00	492.00	135192.79	8002.28	143195.07	3321.08
Berseem	3.33	35.00	60.00	70120.45	-72.90	70047.56	21035.30
Durum wheat	127.70	250.00	600.00	488022.50	-96500.86	391521.64	3066.07
Gram	188.29	640.00	1488.00	595815.36	-259095.58	336719.79	1788.30
Groundnut	76.20	850.00	1402.00	77876.97	-36554.82	41322.15	542.30
Lentil	99.91	680.00	1416.00	82036.06	11989.81	94025.87	941.11
Moong	36.23	650.00	1600.00	193757.33	-167496.31	26261.02	724.90
Mustard (mixed crop)	4.20	700.00	1200.00	235618.76	597.23	236215.99	
Pea (mixed crop)	204.17	480.00	983.00	21732.12	-25989.92	-4257.80	
Pigeon pea	4.87	650.00	1450.00	46937.13	-80648.82	-33711.70	-6916.64
Sorghum (mixed crop)	8.60	200.00	412.00	216104.01	-61341.45	154762.56	
Til	10.56	950.00	2028.00	79785.38	-64523.85	15261.53	1445.49
Black gram	396.23	600.00	1600.00	336676.36	157837.15	494513.50	1248.04
Bread Wheat	329.33	280.00	556.00	1849200.00	79314.27	1928514.27	5855.89
Total	1532.73					3894391.50	2540.82

Table 8: Livestock population and impact

Animals	Large		Medium		Small		Marginal		Total	
	1991	2002	1991	2002	1991	2002	1991	2002	1991	2002
Milch cow	36	48	90	118	44	76	21	84	191	326
Dry cow	62	64	45	72	29	76	106	104	243	316
Cow calf	27	26	136	51	59	53	84	56	306	186
Heifer	22	71	23	102	15	64	0	63	124	300
Total cows	147	209	294	343	147	269	211	307	864	1128
Milch buffalo	40	26	23	41	15	35	0	7	78	109
Dry buffalo	80	35	79	36	0	59	21	7	180	137
Buffalo calf	22	6	23	20	0	23	0	7	101	49
Heifer	18	26	45	41	15	6	0	0	151	80
Total buffalo	160	93	170	138	30	123	21	21	510	375
Bullock	71	26	226	97	204	100	191	63	692	286
Goat	58	84	452	384	44	363	42	306	596	1137
Sheep	0	0	283	154	29	105	0	0	312	259
Total population	401	351	996	755	433	620	446	414	2401	2071
Total ACU	283.31	242.54	401.53	416.47	123.88	373.31	181.39	294.06	1050.3	1326.9
Average ACU	5.78	5.39	3.55	3.25	1.21	2.28	1.43	1.46	2.69	2.46
% change in ACU		-6.78		-8.43		87.42		1.92		-8.35
Population density - no. of animal ACU/ ha	0.67	0.64	0.97	1.06	0.73	1.48	1.70	2.25	0.94	1.15

Table 9 : Change in milk production

Particulars	Large		Medium		Small		Marginal		Total	
	1991	2002	1991	2002	1991	2002	1991	2002	1991	2002
Cow milk production l/day	97	85.05	136	144.64	58	90.98	21	146.25	312	466.79
Cows' productivity (l/day/animal)	2.69	1.77	1.51	1.23	1.32	1.2	1	1.74	1.63	1.43
Buffalo milk production l/day	195	78.75	94	97.28	52	125.95	0	34.74	341	336.72
Buffalos' productivity (l/day/animal)	4.87	3.03	4.09	2.37	3.47	3.6	0	4.96	4.37	3.09
Total milk production l/day	295	163.8	230	243.92	110	216.8	21	180.99	656	805.51
Average milk production / household l/day	6.02	3.64	2.04	1.91	1.08	1.32	0.165	0.895	1.68	1.49

medium farm families but showed a reverse trend in the case of small and marginal farmers. The total animal population of the study area increased even though the animal population per farm family declined by 8.35 percent (Table 9).

Soil fertility status: Four types (Raker, Parwa, Kaber and Mar) of soils were found in the study area. The productivity of Parwa soil is high as compared to others but Kaber and Mar is most suitable soils for rainfed cultivation. The area (ha) under different soils was Parwa (Entisol) - 462.45, Kaber (Inceptisol) - 344.59, Raker (Aridisol) - 187.57 and Mar (Vertisol) - 45.60 ha. The available nitrogen and organic carbon content has not changed much. Majority of the soil samples were showing high available phosphorus and medium to high available potassium content. Continuous use of DAP may be the cause of increase in phosphorus content of the soil. Hazra (2002) reported medium value for available P and K content of the same area and consequently some improvement in fertility of the soil was observed.

Ground water level: The changes in ground water level over the years (Table 10) indicates a decrease in water table depth due to watershed development project implementation.

Table 10: Water table depth (m)

Year	Summer	Rainy	Winter
1982-83	14.6	6.0	12.0
1991-92	6	3	3.5
1995-96	8	4	10
2002-03	7-8	1-2	6-8

In post development stage (2002), while comparing with Hazra (2002) in Ghurat (Tejpura) village, the irrigated area and rainfed cultivated area was 693.23 and 431.29 ha. The degraded area and area under miscellaneous uses (ha) was 15.7 ha (owned by the farmers only) which is not under cultivation. The number of wells increased to 440 but the recharging capacity had been reduced. The cropping intensity was 134.03 per cent, which is much less than the one achieved before the government withdrawal of the project. The season-wise crop area was 585.57, 1039.54 and 0.0 ha under *kharif*, *rabi* and zaid respectively. The crop area under pulses, cereals, oilseed, vegetables and fodder crops was 929.7, 524.79, 100.45, 35.27 and 6.37 ha, respectively. The zaid crop had been discontinued mainly due to free grazing lack of irrigation. The productivity of different crops has increased but the increase had been less than 50 per cent for all the crops except for tomato (64 %). The cropped area of groundnut, sorghum grain, sesame, green gram, bread wheat, durum wheat, gram and berseem had decreased. The tomato, sorghum fodder and pigeon pea, pea, lentil and barley area had increased. The gross annual income (Rs./family/yr) increased by 47.64 per cent only as compared to 1991. The nutrient consumption was 12.84, 17.96, 0.0 kg/ha for N, P_2O_5, and K_2O_5 respectively. The organic carbon (%), available N, P, K, and S (in kg/ ha) in soil was 0.23-0.45, 185.56, 28.78 and 282.33 respectively. Overall, the total production of the oilseeds was increased from 5 t to 778 t, pulses 60 t to 410 t, cereals 243 t to 1079 t and vegetables from 0 to 4865 t. The total forage production had increased from 52 t to 280 t (438 %). In addition, there was an annual production of 3 t fish per year. The increase in human employment was 3.4 times over the base year.

Conclusion

There had been both qualitative and quantitative changes in cropping pattern. All categories of farmers had diversified their farm activities. The watershed development programme resulted in shift in the composition of animal species reared in this area. The number of cows and she-buffaloes had increased. The number of bullocks decreased by 81 per cent. Population of goats was increased while population of sheep decreased which was mainly due to regulation on free grazing. There was low organic carbon and nitrogen in the soil. Among the *Kharif* crops, significant increase in crop productivity was recorded in the case of tomato by 269 per cent. Sorghum and groundnut recorded a negative growth in yield during the period 1991 to 2002. Regarding

rabi crops, almost all the crops recorded an yield increase with the highest increase in improved varieties of wheat. The value of agricultural produce per unit area (ha) was increased by 164 per cent from 1991 to 2002.

Acknowledgement

The project team is highly thankful to Dr. P.S. Pathak, then Director, IGFRI, Jhansi for encouragement to initiate this project, and help during implementation of the project. We are thankful to Dr. Panjab Singh, Ex-Director, IGFRI, Jhansi and Dr. C. R. Hazra, Ex-Project Coordinator, AICRP on Forage Crops, who guided the development of Tejpura Watershed. The authors are grateful to Dr. D.K. Murothia, Ex-Dean, IGKV, Raipur for guiding the data analysis and editing the project report. The authors extend cordial thanks to Dr. N.P. Singh, Sr. Scientist (Ag. Economics), ICRISAT, Hyderabad for peer review of manuscript.

References

Ajora, R. 1998. *Integrated Watershed Management*. Rawat Publications, Jaipur.

Hazra, C.R. 2002. On farm research at Tejpura watershed-A model for agricultural development for rainfed areas. *Agriculture Situation in India*. September: 325-336.

Kumar A. 2004. *Estimation of economic gain from technological advances in crop production. Impact assessment of prevailing technologies for sustainability in agriculture via econometric empiricism- a reading manual*. 225-237

Mruthyunjaya, S. Pal, L. M. Pandey and A. K. Jha 2004. Impact of selected technologies refine under NATP. *Agricultural Economic Research* Review 17: 1-16.

Singh, K. 1991. Dryland watershed development and management. A case study in Karnataka. *Indian Journal of agriculture Economics*. 46 : 121-131