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Study on Impact Assessment of Mega Watershed Project in Prakasam District, Andhra Pradesh, India

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Abstract: ***The physical geography of the watershed project is undulating with net treatable area of 4456 hectares, encompassing six micro watersheds. Integrated watershed management interventions impacted biophysical characteristics measured through remote sensing & GIS techniques, environmental and socio-economic aspects as evaluated by physical visit to the project area. Positive impacts observed in sustaining the productivity of crops even under aberrant weather conditions in successive years; development of waste lands and current fallow lands; increase in area of cultivation for agriculture and horticulture crops; improvement in agri-vegetation and vigor; expansion of water bodies; better soil moisture in the profile as a result of the effective in-situ soil and water conservation activities; increase in productivity of milk. The productivity of water also improved through conservation measures and judicious use of available water resources. Watershed interventions helped in enhancement of family incomes, especially the marginal and small farmers, landless poor sections of watershed community.***

Keywords: Normalized Difference Vegetation Index (NDVI); Normalized Difference Water Index (NDWI); Land Use Land Cover (LULC); Natural Resource Management (NRM); Geographic Information System (GIS)

1. Introduction

The overreaching vision of Pradhan Mantri Krishi Sinchayee Yojana (Watershed development) is for effective management of runoff water and improved soil & moisture conservation activities such as ridge area treatment, drainage line treatment, rain water harvesting, in-situ moisture conservation and other allied activities on watershed basis. Government of India sanctioned mega watershed project to Andhra Pradesh in the year 2010-11 was implemented until March 2018 in rain fed areas of kondamuru, Prakasam district, with recurring drought situation in kharif (rainy) season.

Location and Overview of the Watershed Project

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) watershed project sanctioned to kondamuru is located at an elevation of 10m above mean sea level (MSL), between the latitudes 15°46'54.23" to longitude 80°03'47.32" at ridge point and between latitude 15°48'05.54" to longitude 80°05'42.00" at valley point. The total geographical area of 8758 ha is undulating with a net treatable project area of 4456 hectares, covering Alavalapadu, Chanduluru, Kondamuru, J. Panguluru, Thurpu Takkillapadu and Thurpu kopperapadu micro watersheds. The total population of mega watershed cluster is 17825. The location and topographical maps of kondamuru watershed project are shown in Fig.1a & b.

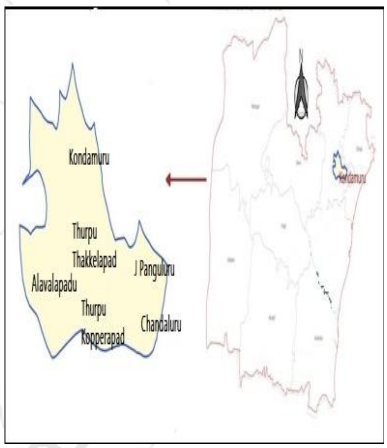

Figure 1a: Location map of Kondamuru PMKSYwatershed project

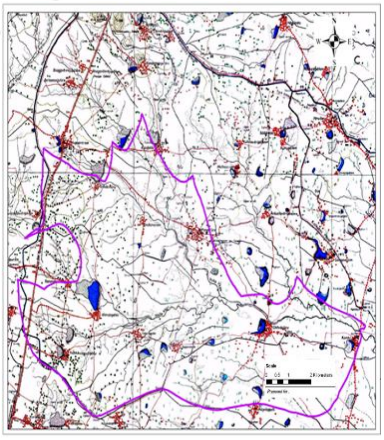

Figure 1b: Topographical map of Kondamuru PMKSY watershed project

NABARD Consultancy Services (NABCONS) as a Monitoring, Evaluation, Learning & Documentation (MEL&D) agency for Prakasam district has undertaken the

final impact study of Kondamuru Watershed project on bio-physical measurable characteristics through remote sensing & GIS techniques and socio-economic indicators.

2. Literature Survey

Integrated Management of watershed project have positive impacts on soil and water conservation measures, soil fertility status, soil and water erosion, expansion in cropped area, changes in cropping pattern, cropping intensity, production and productivity of crops. (Palanisami and Suresh kumar, 2009).

The satellite images provide planners, the true picture on the ground in an accurate, unbiased and transparent manner (The World Bank in India, 2011).

By the end of the project, crop yields increased by about 25percent, on average, across different crops relative to control groups. Runoff and soil erosion were reduced up to 21 cubic meters per hectare. The percentage of irrigated area increased between 6 percent and 14percent across project sites, average milk yields rose by around 20 percent, and ground water was available for longer periods. Household incomes increased by about 40 percent for small and marginal farmers (less than 2 ha), more than 50 percent for landless, and close to 80 percent for larger farmers (more than 2ha), compared to control groups. (The World Bank in India, 2011).

The watershed intervention was found to help the rural farm and non-farm households in enhancing their income level. The income of rural labour households in the treated villages was 28.73 per cent higher in Kattampatti watershed (Palanisami and Suresh Kumar, 2005).

3. Methodology

Methodology for Bio-Physical Study using Remote Sensing and GIS

The bio-physical indicators are studied using remote sensing and GIS techniques. ERDAS Imagine and ArcGIS software was used to prepare the final maps. Satellite imageries of LISS IV (5.8 m resolution) are procured from NRSC Portal for image interpretation. Date of satellite pass is 2nd September 2012 for pre project period and 31st August 2017 for post project period. At the time of image procurement, it was ensured that the images are not cloudy. The topography of the area was studied using the Survey of India Toposheet.

Remote Sensing and GIS Data Analysis was done by Satellite data processing and land use/land cover classification and mapping techniques. The classified images having different land use/ land cover categories pertaining to pre and post treatment period are compared to derive information on changes. Ground truth is undertaken in conjunction with the use of multi-resolution remote sensing data to assess the changes in land use with the implementation of watershed programme.

Normalized Difference Vegetation Index (NDVI) was computed using the Infrared and Red bands of satellite data, to monitor the vegetation condition/vigor and assess the biomass productivity,

NDVI= (IR–R)/ (IR+ R)

Normalized Difference Water Index (NDWI) was calculated for remote sensing of vegetation liquid water from space.

NDWI= (NIR–SWIR)/ (NIR+SWIR)

Methodology for environmental and socio-economic study

The field study was conducted in September and October months of 2018 as per the tool designed for the household survey and Focus Group Discussion (FGD), covering all micro watersheds of the project. Five per cent of households are randomly selected from each micro watershed community including OC, BC, SC, ST, and landless households, marginal, small and big farmers. The total numbers of households surveyed are 233 from six micro watersheds. The investigators conducted HH survey, organized Focus Group Discussion involving various stakeholders of watershed community, collected primary and secondary data, and interacted with the Watershed Committee members, PIA staff and officials of DWMA at district level. The information related to pre project period is captured from Detailed Project Reports (DPRs) of each micro watershed. The gross income per annum for each household (marginal, small, big and landless) at the start and end of project period is computed based on income from agriculture, milk and wage income.

4. Result and Discussion

The present study is focused mainly on bio-physical, environmental and socio-economic impacts of different interventions such as water resources development, soil and moisture conservation measures, drainage line treatments, and afforestation and assess the impacts on different aspects like increase in surface and groundwater resources, crop yield and income. Watershed developmental activities have made significant positive impacts on various biophysical aspects (Palanisami and Suresh kumar, 2009).

Bio-Physical Impacts

Land Use Land Cover

Land Use and Land Cover changes as observed from satellite imageries of LISS IV data for the year 2012 (kharif-pre project period) and 2017 (kharif-post project period) are provided in Table 1 and Fig.2a&b. The study results show that land use for agriculture crops increased by 3.9 per cent from 6614.0 ha to 6873.8 ha; agriculture Plantations area increased by 40.1 per cent (100.1 ha); water body coverage increased by 10.4 per cent and waste land decreased by 31.1 per cent in August 2017. Increase in area under vegetation (agrl. plantation) was observed mostly with development of the wastelands. There is no soil erosion in either of the satellite imageries of LISS IV data and with a spatial resolution of 5.8 m. Change detection of spatio-temporal

land use land cover help for optimum resource planning and utilization for sustainable development (Anurag et al, 2018)

Table 1: Satellite Imagery based Land Use/ Land Cover details

Land Use/Land Cover Class	Pre Project Area, ha (Sept. 2012)	% Change	Post Project Area, ha (Aug.2017)	% Change	Change Area, ha	% Change
Built up Land	282.8	3.2	281.5	3.2	-1.3	-0.5
Agriculture Crop	6614.0	75.5	6873.8	78.5	259.8	3.9
Vegetation (Ag. Plantation)	249.3	2.8	349.4	4.0	100.1	40.1
Waste Land	1268.1	14.5	874.0	10.0	-394.1	-31.1
Water Body	343.7	3.9	379.3	4.3	35.6	10.4
Total	8757.9	100	8757.9	100	0	0.0

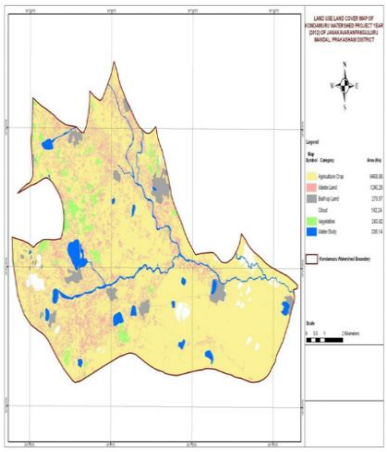

Figure 2a: Land use Land cover map of Kondamuru PMKSY watershed Project (2012)

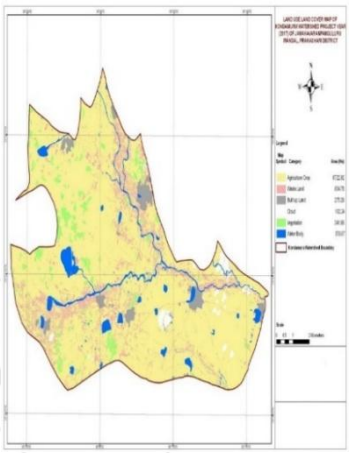

Figure 2b: Land use Land cover map of Kondamuru PMKSY Project (2017)

Vegetation Cover

The spatial and temporal changes in vegetation cover are presented in Table 2. In the year 2012, dense vegetation covered 23.3% of the total watershed area, open vegetation and sparse vegetation covered 31.9 and 36.2%, respectively of the watershed area. However, during the year 2017, the dense vegetation cover occupied 23.9% of the area followed by 34.4% of open vegetation, 28% of sparse vegetation. Compared to the pre-treatment period (Yr.2012), the dense vegetation cover increased by 58 ha and the open vegetation cover by 220 ha at the end of project period. Adoption of soil and water conservation practices increased the vegetation cover in the watershed area.

Table 2: Change in Vegetation Cover during the project period

Vegetation Cover Type	Pre Treatment (2012)		Post Treatment (2017)		Change	
	Area, ha	%	Area, ha	%	Area, ha	%
Dense Vegetation	2036	23.3	2094	23.9	58	2.8
Open Vegetation	2795	31.9	3014	34.4	220	7.9
Sparse Vegetation	3174	36.2	2452	28.0	-722	-22.7
Water Body, Built up, Barren land	753	8.6	1198	13.7	445	59.1
Total	8757.89	100	8757.89	100	0	0.0

Changes in Vegetation cover measured in pre and post project period through Normalized Difference Vegetation Index (NDVI) are represented in Fig.3a&b. NDVI is the suitable index for measuring changes in vegetation cover (Vani and Mandla, 2017). The extent of cropped area was assessed by NDVI (Miura et al, 2006; Vani and Pavan Kumar, 2018).

Soil Moisture

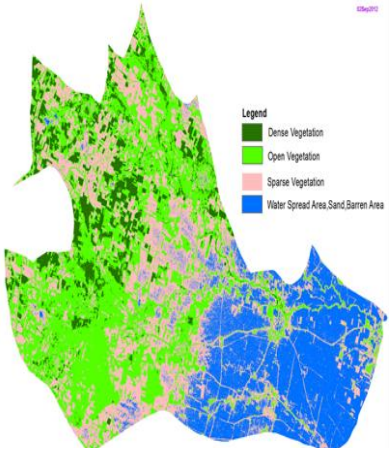

Figure 3a: Normalized Difference Vegetation Index (NDVI) map in Area for 2012

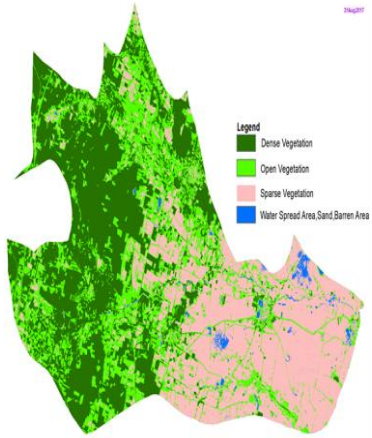

Figure 3b: Normalized Difference Vegetation Index (NDVI) map in Area for 2017

Soil moisture availability through wetness indicators was assessed by Normalized Difference Water Index (NDWI). NDWI is sensitive to changes in liquid water content of vegetation canopies. Based on computed NDWI as shown in Table 3 and Fig.4a&b, there was change in soil moisture of the watershed areas as a result of the watershed activities.

The area under very good soil moisture increased by 26.9 per cent from 2609.85 ha in pre project period to 4965.72 ha of watershed area at the end of project period; the area under medium soil moisture declined by 11.6 per cent from 2907.62 to 1874.19 ha, while the area under less soil moisture declined by 8.7 per cent. Based on indices of water index, the soil moisture decreased at north-west and western part and lightly increased in northern and south-western part. The climatic conditions of the respective years along with watershed interventions influenced the soil moisture index.

Table 3: Change in soil moisture during the project period

Water Index (Area in Ha)						
Soil Moisture Type	Pre treatment- 2012		Post treatment-2017		Change	
	Area	%	Area	%	Area	%
Good Soil Moisture	2609.85	29.8	4965.72	56.7	2355.874	26.9
Medium Soil Moisture	2907.62	33.2	1874.19	21.4	-1033.43	-11.8
Dry Soil Moisture	1865.43	21.3	1103.49	12.6	-761.936	-8.7
River/Water Spread Area & Cloud	1374.99	15.7	814.484	9.3	-560.506	-6.4
TOTAL	8757.89	100	8757.89	100	0	0.0

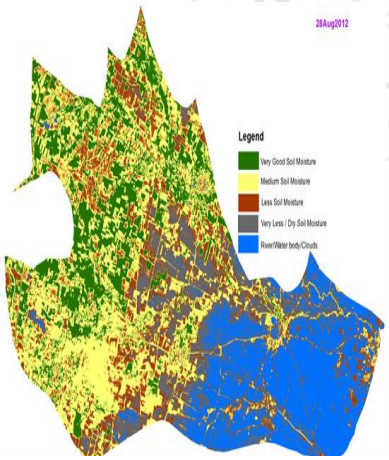

Figure 4a: Normalized Difference Water Index (NDWI) map in 2012

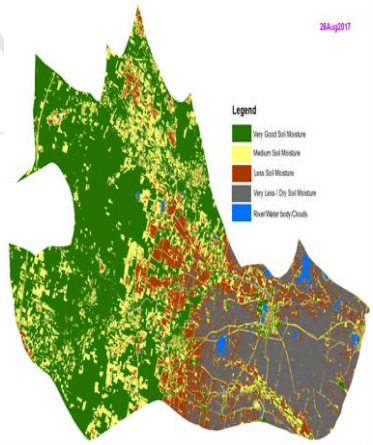

Figure 4b: Normalized Difference Water Index (NDWI) map in 2017

5. Environmental Impacts

Natural Resource Management

Natural Resource Management (NRM) is the major thrust area of watershed program for the works such as land, soil moisture conservation, water harvesting structures and afforestation etc., . The details of physical and financial achievements under NRM component are detailed in Table 4. In all, four hundred four works are executed with an expenditure of 300.03 lakhs, which is 58.9 per cent of the project cost. Effective management of natural resources (soil, water and vegetation) supported by other interventions of watershed project resulted in increased cultivation of field crops and plantations.

Table 4: NRM Category Wise Physical and Financial Achievements

Name of the Work	PMKSY Watershed Project	
	Physical, No.	Financial, Lakhs
Land development works	8	3.62
Water harvesting structures	128	256.88
Repairs to existing Water Harvesting Structures	8	15.04
Afforestation works	248	22.75
Livestock related works	12	1.74
Total no. of NRM works & expenditure	404	300.03
Total project area (ha)	4456	
Total project cost (Rs. in lakhs)		534.72
% of NRM expenditure		58.9

Source: IWMP AP MIS Report R: 2.1

Rainfall, Ground Water and Irrigation

i. Rainfall

The rainfall (actual and normal) data given in Table 5 for the project areas show that there was deficit rainfall in five of the seven years of project implementation period. The deficit rainfall was recorded in four successive years from 2014 onwards. The per cent deviation of actual rainfall in these four years varied from as low as 27.2 in 2015 to 43.0 in 2014.

Table 5: Annual Rainfall during the project period

Year	Total Rainfall, mm (Jan-Dec)		
	Actual	Normal	% of deviation
2011	570	871.5	-34.6
2012	886.4	871.5	1.7
2013	986.2	871.5	13.1
2014	497.1	871.5	-43
2015	634.1	871.5	-27.2
2016	549.5	871.5	-37
2017	615.2	871.5	-29.4

(Web source: IMD, Hydromet division, customized rainfall information system)

ii. Irrigation

In spite of better conservation of soil moisture and recharging and rainwater harvesting through soil moisture conservation (SMC) measures, the ground water table dropped as a result of rainfall shortage and excess tapping of ground water, by 2.0 m from 8.0 to 10.0 m. Aside all these constrains, the irrigated area increased by 14 per cent from 135 to 153 ha during the project period by tapping ground water from deeper depth with increased number of bore wells and better awareness on better water management practices, growing water efficient crops, and short duration crop varieties.

Crops and Cropping Pattern

i. Crop area

In the field study, change in land use was observed on implementation of watershed program with an increase in cropped area under agriculture and horticulture crops. The area under agriculture crops increased from 4241 ha to 4280 ha and horticulture crops from 80 to 118 ha in post treatment period. The waste land decreased by 57.8 per cent from 135 to 57 ha at the end of project period (table 6). Watershed interventions such as soil and moisture conservation measures, harvesting of rain water and recycling, development of waste lands and fallow lands resulted in such a change in land use.

Table 6: Change in land use and area under agriculture and horticulture, ha

Particulars	Pre Project Period	Post project period	% change
Agriculture	4241	4281	0.9
Horticulture	80	118	47.5
Waste land	135	57	(-)57.8
Total of watershed Project	4456	4456	

ii. Crop yield

The per hectare economic yield of all the major crops in the post project period was higher due to growing of high yielding crop varieties, adoption of recommended package of practices, effectively conserving and utilizing the soil moisture and rainfall. In convergence with agriculture department, the farmers were supplied quality seed, farm equipment's and technical knowhow, judicious utilization of available irrigation, timely credit supply and other production system improvement (PSI) activities. Besides, the farmers were involved in capacity building (CB) programs of training, field demonstrations and exposure visits.

In respect of individual crops, the yield of crops like rice, red gram, chillies, cotton, black gram and eucalyptus increased ranging from 2.4 per cent to 26.4 per cent (table 7) during the project period. The yield of crops are more due to adoption of improved cropping practices, conservation of soil moisture and judicious utilization of available irrigation, growing of high yielding varieties, timely credit supply and other production system improvement (PSI) activities. Yield increase was higher in pulse crops followed by cotton.

Table 7: Crop Yields in Pre and Post project Period

Crop	Crop Yield, q/ha		
	Pre project period (2011)	Post project period (2017)	% Change
Rice	50.7	53.0	4.5
Red gram	12.5	15.8	26.4
Black gram	12.0	13.5	12.5
Cotton	23.7	25.4	7.2
Chillies	45.2	47.3	4.6
Eucalyptus	543.0	556.0	2.4

iii. Cropping pattern

Cropping pattern did not differ much during the project period (Figure 5). Chillies, cotton and black gram are the major crops in pre and post project period, occupying 63.8 to 66.1 per cent of the cultivated area. The area under rice marginally decreased, while that of eucalyptus increased by 2.0 per cent. In focus group discussion, the stakeholders informed that the area under crops like eucalyptus is steadily increasing due to better income and its ability to withstand moisture stress conditions better in drought years.

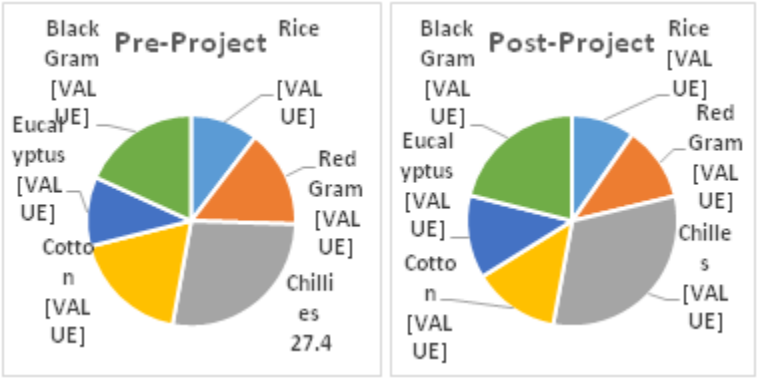

Figure 5: Cropping Pattern in Pre and Post Project Period

Milch Cattle, Milk Production and Productivity

The number of milch cattle decreased in the project period by 71.2 per cent from 5823 to 1680 (Table 8) due to shortage of open grazing lands and successive drought conditions. Consequently, the total milk production per year decreased by 48.3 per cent in the watershed project. However, the milk productivity of milch animals improved by 14.8 per cent during the project period, mainly with improved breeds, artificial insemination, and improved hygiene & health management in convergence with animal husbandry (AH) department and balanced nutrition. The farmers who own milch cattle have secured income to meet the family expenditure, even during drought years.

Table 8: Milch cattle, milk production and productivity

Indicator	Unit	Pre Project	Post Project	% Change
Milch Cattle	Number	5823	1680	(-) 71.2
Milk Production	KL/Year	4444	2298	(-) 48.3
Milk Productivity	L/day	4.1	4.7	14.8

6. Socio-Economic Impacts

Agriculture and allied activities are the predominant livelihood activity in watershed areas, as 71per cent of households are still depended during the project implementation period. The participation of watershed community in various group activities such as Self Help Groups (SHGs), User Groups (UGs), and Watershed Committees increased from 88 to 94 % after the initiation of the project, indicating the people's participation in the programme.

Gross Income of Households

The gross returns per annum of households based on size of land holding of beneficiary farmers from farming, dairying and wage labour is calculated and presented in Table-9. The mean gross income of households increased by 12.3 per cent from Rs.1, 73, 479 in the pre project period to Rs. 1, 94, 831 at the end of project period.

Table 9: Gross income of households

Particulars	Gross Income, Rs./Yr/HH		
	Pre Project	Post Project	% Change
Marginal Farmers	86899	102560	18.0
Small Farmers	256314	282305	10.1
Big Farmers	484244	525536	8.5
Landless HHs	53153	74217	39.6
All HHs	173479	194831	12.3

The gross incomes based on size of land holding of beneficiary farmers are presented in Fig.6. The annual household's income of marginal farmers after the project period is Rs.1, 02, 560/-, which is 18.0 per cent higher of the pre-project period. The annual gross income of small farmers increased by 10 per cent over the pre-project period raising to Rs.2, 82, 305 and the gross income of large landholders increased by 8.5 per cent over the pre-project period reaching Rs.5, 25, 536. The annual gross income of landless households from subsidiary activities like rearing of milch animals and wage income from agriculture and non-agricultural activities increased to Rs.74, 217 in the post-project period showing an increase of 39.6 per cent.

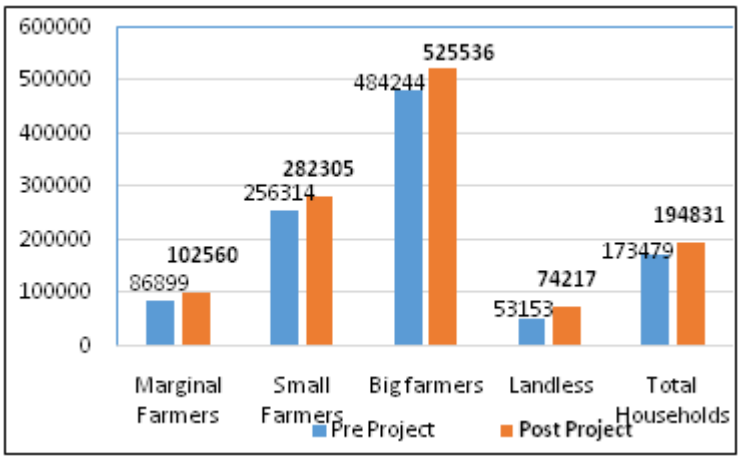

Figure 6: Gross returns based on size of land holding, Rs/Yr/HH

7. Conclusion

Study revealed impact of watershed interventions on bio-physical, environmental and socio-economic conditions in terms of soil moisture conservation, water resources development, waste land and fallow land development, increase in irrigated area and total area of cultivation for field crops, higher crop productivity, enhancement of milk productivity, and rise in income of households. There is overall socio-economic development of marginal and small farmers, and landless poor of watershed community with increased incomes due to agricultural and non-agricultural activities at the end of project period.

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Future Scope

The optimal level of people's participation is yet to be achieved in watershed development activities. More thrust to be given for convergence of various rural developments, agriculture, horticulture, livestock programmes in project are as to promote holistic development of watersheds. For its continued success, the programme should be economically efficient, financially viable, technically feasible and socially acceptable while ensuring equity. Mixed farming of growing crops and livestock rearing, especially milch cattle to cushion the impact of drought conditions in the years of crop failure due to scanty and deficit rainfall situations. Concurrent process and progress monitoring and periodical evaluation for assessing the physical and financial achievements of project implementation will further improve the impacts on watershed community.

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