Socio-economic characterization and Natural Resource appraisal for watershed development around Pumped Storage Hydroelectric Project sites in Andhra Pradesh, India

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Abstract

A comprehensive baseline study was conducted to develop the watershed treatment plan around four Pumped Storage Hydro-electric Project sites in Andhra Pradesh, India. As a part of study, household survey was conducted with 450 samples around 10 km radius of project reservoir sites. The data was collected on socio-economic conditions of communities and natural resource status around the reservoirs. The study revealed that farming is the major source of livelihood and with majority is of small and marginal land holdings. Rainfed farming is predominant in Chitravathi, Gandikota, and Owk except for the Somasila watershed. The study further shows ample scope for alternative livelihood opportunities for farmers, particularly livestock rearing and dairy entrepreneurship, to enhance farm income due to the robust presence of livestock in the watersheds. The low cropping intensity was a major concern due to the lack of irrigation and poor adoption of SWCs in some watersheds. Further, watershed intervention prioritization matrix developed under study can be an effective tool for planning different interventions with better visualization and interpretation of socio-economic and natural resource details for greater impact and targeted watershed planning.

Key words: *Baseline survey, natural resources, socio-economic, planning, watershed*

Introduction

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The socio-economic resource characterization is vital for developing strategies that balance socio-economic development with environmental conservation (Mohammed et al., 2024). Understanding socio-economic dynamics allows for better integration of environmental objectives with broader development goals, such as poverty alleviation and food security. This holistic approach is essential for achieving sustainable development in the rainfed region. Thus, baseline survey of watersheds can facilitate the appraisal of existing natural resources and identifying socio-economic conditions for planning of various watershed interventions to improve wellbeing of the people in and around the watershed. It also aids in identifying key environmental challenges faced by the agroecosystem, such as land degradation and natural resource depletion in the study areas, which require scientific management through watershed interventions, otherwise may cause further degradation and deterioration of natural resources (Ravi et al., 2022). Further, the baseline information serves as a benchmark (Mohammed et al. 2024) for development planning (Ravi et al. 2020) and future assessments and project evaluations, allowing stakeholders to assess the long-term impacts of watershed activities implemented based on baseline socio-economic and natural resource status on hydroelectric project sites and surrounding local communities. Therefore, in the present study the aim was to develop watershed development plans surrounding Pumped Storage Hydroelectric Project sites in Andhra Pradesh. The scope for watershed development around the project site is a part of Environmental Impact Assessments (EIA) and Environmental Management Plans (EMP) conducted by the New and Renewable Energy Development Corporation of Andhra Pradesh (NREDCAP) to prepare a Detailed Project Report (DPR) of the projects across several districts endorse by Environmental Expert Committee of Ministry of Forest and Climate Change, Government of India. These assessments aim to identify and mitigate potential environmental impacts, including existing flora and fauna within the 10 km radius of the various Pumped storage hydroelectric power generation projects across Andhra Pradesh. Hence, a detailed baseline survey of the watersheds was conducted. The findings from this research will not only contribute to the successful implementation of the Pumped Storage Hydroelectric Project but will also serve as a model for future projects aimed at balancing economic growth with environmental stewardship (Ong and Liao, 2020) in similar agro-ecosystems across India. Meanwhile it establishes robust framework for monitoring socio-economic changes over time can enhance accountability and transparency in project implementation (Al-Subaiee, 2016). The significance of this study is to create a comprehensive micro-watershed plan that incorporates various soil and water conservation (SWC) and livelihood measures (Mouratiadou et al. 2024). Such interventions are designed to ensure the sustainability of the project area while fostering socio-economic development among local communities.

Materials and Methods

The socio-economic baseline survey in the watershed is conducted to characterize its overall socio-economic status, including demographic characteristics, social structure, the status of agriculture and allied sectors, land use patterns, production status, problems, and potential production constraints, and to propose watershed interventions for sustainable development in micro-watersheds/sub-watersheds within a 10-kilometer radius of the pumped storage project sites.

Study locations

The study sites located in Ananthapuram, YSR Kadapa, Nandyal and SPS Nellore districts of Andhra Pradesh (Table 1). All four proposed project sites were located near the respective reservoirs (Table 1).

Table 1: Details of study location and sample size for socio-economic survey

Hydro-electric project site	Reservoirs	District	Sampled villages	Sample size	Average rainfall (mm)
Chitravathi PSP	Chitravathi	Ananthapuram	8	90	577
Gandhikota PSP	Gandhikota	YSR Kadapa	11	120	572
Owk PSP	Owk	Nandyal	10	120	654
Somasila PSP	Somasila	SPS Nellore	13	120	984

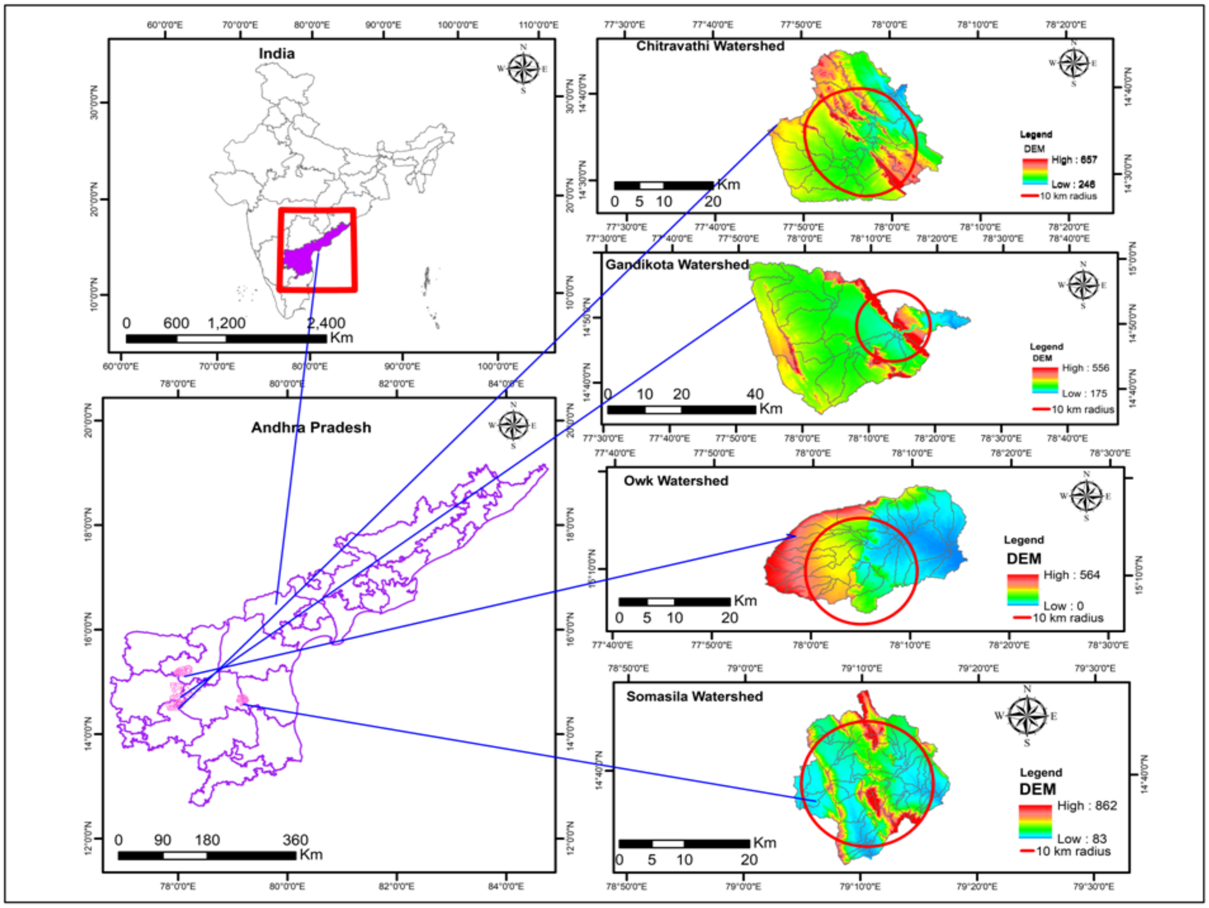

Fig. 1 Location maps of study watersheds in different PSP Project sites

Method of data collection

For the present socio-economic baseline survey semi-structured interview schedule were developed and responses were recorded through Household survey with the stakeholders in the sampled villages during 2023 and 2024. For ease of documentation and data analysis, the interview schedule was digitized and responses were collected through Google form. Experienced data enumerators collected the data using tablet PCs in the sample villages located within the 10 KM radius of the PSP project sites. Focus Group Discussion and PRA Transact walk was conducted in each sample village to capture the trends, existing cultivation practices, problems and constraints in the study area.

Sampling technique

A random sampling technique with 5% of the total household samples was collected for household interview purposes. A total of 450 samples were collected from the different project sites. 90 samples were collected from the Chitravathi PSP study area and 120 samples each from the Gandhikota, Owk and Somasila PSP projects. For the purpose of data collection 0-3 km radius (inner zone), 3-6 km (middle zone), and 6-10 km radius (outer zone) from the respective reservoir were identified and villages were identified in each circumference for the survey. The results were presented using descriptive statistics.

Computation of watershed intervention prioritization matrix

The baseline survey key results were arranged in the matrix format to easily understand the potential areas need to be focus for implementation of watershed implementation. For the purpose a matrix with focus area for intervention and their severity were marked with cross marks and the more cross marks interpret that more focus should be given for development through watershed interventions and planning may be done accordingly.

Results

3.1 Socio-economic baseline characterization of the different watersheds

The age profile of respondents was documented across watersheds surrounding hydroelectric project sites. The analysis reveals that the majority of respondents in all the watersheds belonged to the middle-aged category (35-64). The percentage of the population in the middle age group was higher in the case of Chitravathi (79 %) followed by Owk (74 %) watershed (Table 1). The average age respondents across different study area ranged from 49.3 years to 55.64 years. The primary source of livelihood for the majority of farmers across all the watersheds around the project site is farming followed by animal husbandry. Agriculture laboure in Gandhikota (26.7%) and Somasila (16.67%) watersheds are comparatively more (Table 1). The annual income of the respondents shows that farmers with an income level less than 25,000 is more in Chitravathi watershed (15.6%) followed by the Somasila watershed (14.7%). Whereas, the farmers with an income level of ₹ 25,000 to 50,000 is more in case of Gandikota watersheds followed by Owk watersheds. The highest percentage of low-income groups (₹<100000 per annum) prevailing in Gandhikota watersheds (82%). Furthermore, the study reveals that about 60% of the respondents in all watersheds have an income level of less than ₹ 100000 per annum, which indicates poor households' income across watersheds. The operational landholdings of the respondents in the study area found that the marginal and smallholders are prevalent in all the watersheds (Table 1).

Table 1 Socio-economic characteristics of respondents in different watersheds

Watersheds	Chitravathi PSP (N=90)		Gandikota PSP (N=120)		Owk PSP (N=120)		Somasila PSP (N=120)	
	f	%	F	%	F	%	f	%
Category of Age								
Young (18-34 years)	8	8.9	16	13.3	8	6.7	5	4.2
Middle (35-64 years)	71	78.9	82	68.3	89	74.2	87	72.5
Old (above 65 years)	11	12.2	22	18.3	23	19.2	28	23.4
Major source of livelihood								
Farming	51	56.7	68	56.7	101	84.2	71	59.2
Animal husbandry	20	22.2	7	5.8	2	1.7	8	6.7
Agricultural labour	12	13.3	32	26.7	7	5.8	20	16.7
Small business	2	2.2	2	1.7	3	2.5	3	2.5
Private job	4	4.4	5	4.2	1	0.8	14	11.7
Others	1	1.1	6	5.0	6	5	4	3.3
Annual Income								
<25000	14	15.6	4	3.3	11	9.2	17	14.2
25000-50000	22	24.4	47	39.2	24	20	28	23.3
50000-100000	20	22.2	51	42.5	40	33.3	45	37.5
100000-250000	7	7.8	13	10.8	37	30.8	26	21.7
>250000	4	4.4	4	4.4	8	6.7	4	3.3
Category of Holdings								
Landless	6	6.7	25	20.8	0	0	15	12.5
Marginal (< 1 ha)	16	17.8	16	13.3	48	40	62	51.7
Small (1-2 ha)	38	42.2	28	23.3	41	34.2	29	24.2
Semi-medium (2-4 ha)	28	31.1	30	25	17	14.2	14	11.7

Medium (4-10 ha)	2	2.2	19	15.8	14	11.7	0	0
Large (10 ha and above)	0	0	2	1.7	0	0	0	0

The farming system details in the study area reveal that per cent of rainfed agriculture is more in Gandhikota (70.8%) and Owk watersheds (56.9%). In contrast, Somasila watersheds have a high percentage of land under irrigation farming (57.9%) followed by the Chitravathi (56.5%) watersheds (Table 2).

Table 2 Type of farming system in the watersheds

Area under different farming system	Chitravathi PSP		Gandikota PSP		Owk PSP		Somasila PSP	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Total (ha)	170.96	100	88.92	100	197.52	100	100.6	100
Rainfed	74.28	43.4	63	70.8	112.32	56.9	42.28	42
Irrigated	96.68	56.5	25.92	29.2	85.2	43.2	58.28	57.9

Assessment of Natural Resource status of the watersheds

Source of irrigation in the watersheds

A major irrigation source of the respondents was analyzed in different watersheds revealing that borewells are the major source of irrigation in the Chitravathi (74.4%), followed by Somasila watersheds (44.17%) (Table 3). In contrast, borewell adoption is less in Owk (16.67%) followed by Gandikota watersheds (31.7%). Dependency on canal irrigation was high in the case of Somasila watersheds (15%) followed by Oak (7.5%), particularly in the lower reach of the sub-watershed located around 10 km radius (Table 3). The proportion of farmers practicing rainfed farming is highest in the Gandikota (65.8%), followed by the Owk (40%) and the Somasila watershed (30.8%) (Table 3).

Table 3 Major source of irrigation for respondents

	Chitravathi PSP (N=90)		Gandikota PSP (N=120)		Owk PSP (N=120)		Somasila PSP (N=120)	
Irrigation source	f	%	f	%	F	%	f	%
Borewell	67	74.4	38	31.7	20	16.7	53	44.2
Canal irrigation	1	1.1	1	0.8	43	7.5	18	15
Open well	1	1.1	2	1.7	9	1.7	4	3.3
Dryland farming	21	23.3	79	65.8	48	40.0	37	30.8
Community water tank	-	-	-	-	-	-	7	5.8

The data on the groundwater availability reveals that the average groundwater level availability in the Chitravathi (377.6 ft) is low, followed by Gandhikota (282 ft), Owk (247 ft) and Somasila (198.07 ft). The minimum-maximum groundwater depth range indicates that water availability is better in the Somasila watershed, followed by Owk, Gandhikota and Chitravathi. In the case of Chitravathi, the maximum groundwater depth reaches up to 1,400 ft, mainly due to the increased adoption and use of borewells in the upper reach of the reservoir, i.e. 7-10 km radius (see Table 4).

Table 4 Groundwater level availability in the watersheds of various PSP Projects

Particulars	Chitravathi PSP (N=90)	Gandikota PSP (N=120)	Owk PSP (N=120)	Somasila PSP (N=120)
Min	20	15	50	40
Max	1400	520	700	450
Average groundwater level	377.6	282	247	198.07

Availability of sufficient irrigation water was reported by respondents that about 26.6%, 34%, 31.7% and 31.67% of the respondent reported that insufficient of irrigation water for agriculture in Chitravathi, Gandhikota, Owk and Somasila PSP (Table 5).

Table 5 Availability of irrigation water in the watersheds

	Chitravathi PSP		Gandikota PSP		Owk PSP		Somasila PSP	
Availability of irrigation water	f	%	f	%	f	%	f	%

Sufficient	62	73.8	31	66	23	19.2	23	19.17
No Sufficient	22	26.6	16	34	38	31.7	38	31.67

Land use pattern identified in the study watersheds through GIS mapping reveals that, Chitravathi and Gandhikota watersheds have more than half of land was agriculture, Owk and Somasila watersheds have less are under agriculture land use. The barren land are is more prominent in Owk watersheds (39.5%) having prevelnt quarry mining in watershed (0.9%). Scrub and degraded forest are abundant in Somasila watersheds (21.3%) followed by Owk watershed (17%). Dense forest also prevalent in Somasila watersheds (38.6%).

Table 6 Land use status of the watersheds

Land use	Chitravathi PSP		Gandhikota PSP		Owk PSP		Somasila PSP	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture	39561.3	54.3	72611.8	54	52868.1	38	5319.34	14
Scrub and degraded forest	3936.6	54	10793.9	8	23702.3	17	8100.03	21.3
Water body	5192.3	7.1	14167.9	10	2579.8	1.9	682.13	1.8
Barren land	18156.4	24.9	32012.2	24	54963.6	39.5	6968.13	18.3
Habitation	6065.8	8.32	5913	4	3775.8	2.7	2315.44	6.1
Mine spoiled area	NA		NA		1265.2	0.9	NA	
Dense Forest	NA		NA		NA		14711.0	38.6

The cropping intensity of the Somasila (172%) and Chitravathi watersheds (136.31%) are better as compared to Owk (96.89%) and Gandhikota (81.64%). The cropping intensity in the Somasila watersheds is better due to the availability of irrigation water, which has been improved due to soil and water conservation activities implemented under various schemes. Meanwhile, the prevalence of borewells in Chitravathi Watershed leads to more area under irrigation that improves gross cropped area. In contrast, the cropping intensity in the Gandhikota watershed is significantly lower (81.64%) because of the predominant rainfed farming (Table 7).

Table 7 Cropping intensity of the study area

Area under crops	Chitravathi PSP Area (ha)	Gandikota PSP Area (ha)	Owk Project Area (ha)	Somasila PSP Area (ha)
Net area sown	170.96	222.30	202.37	103.08
Gross cropped area	233.04	181.50	196.08	177.91
Cropping intensity (%)	136.31	81.64	96.89	172.60

The livestock adoption data in the watersheds reveals that small ruminants are most prevalent in the Gandhikota watersheds (77.89%), where dryland farmers dominates, followed by the Owk watershed (74.3%). In contrast, livestock adoption rate is lower in the Chitravathi (16.1%) and Somasila watersheds (37.08%), where irrigated landholders are more common. Large ruminants, particularly, buffaloes, are more prevalent in the Somasila watershed (52.13%) and further, the cow population is notably high in the Chitravathi watershed (51.6%), due to better irrigation water availability. Their adoption is comparatively lower in the Gandhikota and Owk watersheds (Table 8).

Table 8 Livestock population status

Livestock status	Chitravathi PSP (N=90)		Gandikota PSP (N=120)		Owk PSP (N=120)		Somasila PSP (N=120)	
	f	%	f	%	F	%	f	%
Cow	32	51.6	40	4.50	63	8.4	48	10.79
Buffalo	20	32.3	159	17.70	131	17.4	232	52.13
Sheep and goat	10	16.1	701	77.89	560	74.3	165	37.08

The fodder availability data collected among the livestock holders reveals thatChitravathi watershed farmers havesufficient fodder availability (73.7%), followed by Ffarmers in Owk watershed (68.6%). However, in the Gandhikota watershed, 48.9% of livestock farmers indicated insufficient fodder availability due to limited irrigation and the prevalence of dryland agriculture (Table 9).

Table 9 Availability of fodder in the study area

Fodder availability status	Chitravathi PSP (N=90)		Gandikota PSP (N=120)		Owk PSP (N=120)		Somasila PSP (N=120)	
	f	%	f	%	f	%	f	%
Sufficient	42	73.7	27	51.9	35	68.6	65	54.1
Not Sufficient	15	26.3	25	48.1	16	31.4	16	31.37

Adoption of major soil and water conservation Technologies in the study area

The adoption of soil and water conservation technologies was studied across the different watersheds. It was found that the adoption of field bunds is better in the Chitravathi watershed (84.5%) followed by Somasila watershed (62.89%). Similarly, farm pond (20.2%) and Drip irrigation (48.8%) adoption farmers were higher in the Chitravathi watershed, followed by the Gandhikota watershed (21.05%). However, the adoption of micro-irrigation is very low in the Somasila watershed due to the extensive cultivation of water-intensive paddy as a major crop in the watershed. In addition, about 18.9% of the Gandikota watershed respondents adopted Horticulture plantation (Sweet orange) crops, but both Horticulture and Agro-forestry was adopted very negligible in all the watersheds (Table 10).

Table 10 Adoption of soil and water conservation measures by farmers in various watersheds

SWC adoption status	Chitravathi PSP (N=90)		Gandikota PSP (N=95)		Owk PSP (N=120)		Somasila PSP (N=105)	
	f	%	f	%	f	%	f	%
Field bund	71	84.5	23	24.2	65	54.2	66	62.9
Farm pond	17	20.2	3	3.2	4	3.3	5	4.8
Drip irrigation	41	48.8	20	21.1	3	2.5	2	1.9
Sprinkler irrigation	23	27.4	3	3.2	2	1.7	3	2.9
Mulching	3	3.6	2	2.1	3	2.5	4	3.8
Stone bunding	0	0.0	21	22.1	22	18.3	1	1.0
Dryland	14	15.6	18	18.9	2	1.7	2	1.9

Horticulture								
Agro-forestry	7	7.8	4	4.2	4	3.3	6	5.7

The watershed planning matrix will guide for planning of different interventions based on the score obtained in the each watershed. The prioritization matrix reveals that in Chitrvathi watershed, promotion of intervention to enhance groundwater improvement, fodder development for large ruminants, promote water saving techniques, agro-forestry and dryland horticulture. Meanwhile, in Gandhikota, interventions should be in line with development of irrigation sources, livestock interventions for small ruminents, fodder enhancement, income generation activities for landless, water saving techniques, agro-forestry and dryland horticulture. In Owk watersheds, focus should be more on enhancing irrigation sources, small ruminant livestock development, promote adoption of waters saving techniques, agro-forestry and dryland horticulture and in Somasila watersheds, focus should be more on promote adoption of waters saving techniques, agro-forestry and dryland horticulture and livestock promotion activities.

Watershed intervention prioritization matrix

Table 11 Watershed intervention prioritization matrix for planning different interventions

Focus intervention area	Criteria	Severity			
		Chitravathi	Gandhikota	Owk	Somasila
Groundwater Improvement	Average groundwater level	×××	××	××	××
Irrigation source improvement	% farmers not having irrigation source	××	××××××	××××	×××
IGA	Percent of agriculture labour	×	××	×	×

Livestock Development – small ruminants	Proportion of sheep and goat in total livestock	×	×××××××	×××××××	×××
Livestock Development – large ruminants	Proportion of cow and buffalo in total livestock	××××××××	××	××	××××××
Fodder development	% Fodder unavailability	××	××××	×××	×××
Adoption of farm level erosion control and WHS	% of farmers not adopted measures (at least one)	×	×××××	××	×××
Adoption of water saving techniques	% of farmers not adopted micro-irrigation	×××××	×××××××	×××××××××	×××××××××
Adoption of Agro-forestry intervention	% of farmers not adopted Agro-forestry	×××××××××	×××××××××	×××××××××	×××××××××
Adoption of Dryland Horticulture intervention	% of farmers not adopted Dryland Horticulture	××××××××	××××××××	×××××××××	×××××××××

Note: For every 10% (or 100 units, other than percent), one cross mark will be assigned. A higher number of cross marks indicate a greater priority for promoting interventions to improve the situation through watershed initiatives.

Discussion

Socio-economic status in the watersheds

This study presents a baseline survey that assesses the socioeconomic and natural resource status of watersheds and identifies key entities for effective planning of natural resources management and livelihoods security of people living around reservoirs of hydroelectric pumped storage project sites. The socioeconomic analysis of all four project areas indicates that the majority of the household heads are middle-aged, which indicates, if implemented, higher watershed interventions adoptability in the watersheds Since age of respondents are negatively affects the adoption of watershed interventions (Asfaw & Neka, 2017), which means more is the age, less is the adoption rate of watershed interventions among farmers, including their participation in other watershed activities. The predominant source of primary livelihood in the watersheds is farming followed by animal husbandry and agricultural labourers. The similar findings were revealed by (Sandur et al. 2018) in their watershed baseline socio-economic studies. While considering the income levels of the households in all the watersheds, the study reveals that about 60% of the respondents have having income level of less than ₹ 100000 per annum, showing a high percentage of poor households across watersheds. Several studies relate that farm income will positively influence farmers' attitudes towards the adoption of soil and water conservation measures (Ashoori et al. 2016; Sileshi et al. 2019; Zheng et al. 2024). Hence, the promotion of on-farm soil and water conservation measures with incentivisation will promote better adoption in these watersheds. Land holding is considered, more than 60% of the household respondents in Chitravathi, Owk and Somasila watersheds have marginal and small landholders, hence watershed activities were planned to benefit these resource-poor farmers. Studies also show that land size positively affects adoption (Belayneh, 2023; Mengistu, and Assefa, 2019). Hence, incentivisation of adoption measures coupled with greater awareness will enhance adoption. Mekuriaw et al. 2018 argue that support from local and international NGOs in providing equipment, training, and awareness activities boost the implementation of SWC measures. Hence recommended awareness and capacity building programmes in the watershed will be planned with local NGOs and Organisations. Strengthening training, and awareness of erosion and degradation implications on productivity to motivate smallholder farmers to adopt the measures (Sileshi et al. 2019), and improving extension services will strengthen the successful watershed implementation. Hence tailor-made problem specific and general training and awareness through local NGOs and KVK in the nearby locality are designed and they are part of watershed planning in the project areas. Zheng et al., 2024, identified that farmers are more likely to adopt SWC practices if they perceive significant benefits, such as reduced workload, decreased fertilizer and water use, and higher economic returns compared to traditional methods. The ease of operation of the technology also plays a crucial role, as farmers are more inclined to adopt practices that have a visible impact to implement. Simultaneously, support and positive attitudes from peers can significantly boost adoption rates, as farmers often look to their neighbours for guidance and validation. Hence, field day and result demonstration of improved practices were planned in the study. Apart, many factors influence the adoption of watershed interventions and we focus on those factors while planning and designing the watershed plans to get better impact and sustainability of watershed programmes/interventions. Further, the rainfed lands with no alternative irrigation source were high in the Gandhikota, followed by Owk watersheds resulting in poor cropping intensity.

Irrigation status in the watersheds

Due to the high adoption of borewells, the number of dryland farmers is very low in the Chitravathi watershed. The proportion of farmers practicing rainfed farming is highest in the Gandikota, followed by the Owk, which shows that the creation of irrigation sources and adoption of conservation measures are crucial in these watersheds in comparison with the other two project watershed areas. Cropping intensity was low in the Gandhikota and Owk watersheds due to the poor availability of irrigation sources and depletion of groundwater (Table 4). Cropping intensity is a measure of annual food security and greatly affects food production. It significantly affects net production, making it a vital factor in ensuring food security. Cropping intensity directly depends on groundwater availability (Jain et al. 2021). Hence decrease in cropping intensity is an indicator of water scarcity, groundwater depletion and climate change variability. Hence, more efforts will be made to increase the availability of water for irrigation through the creation of irrigation sources and improve groundwater in the study area through watershed interventions.

Livestock and fodder availability

Several studies show that factors like more livestock holding are negatively influence the adoption of mechanical soil and water conservation measures (Sileshi et al. 2019; Mengistu and Assefa, 2019). However, they accept agro-forestry and fodder interventions. Meanwhile, grazing also very much prevails in Gandhikota and Owk watersheds with the presence of high number of small ruminants, hence severe grazing and semi-arid conditions may lead to poor vegetation and exposure of soil to erosion and degradation. Hence, improved fodder grass and feed-making techniques including in-house raring techniques were proposed for small ruminants in these watersheds. However, chitravathi and Somasila have a high population of large ruminants, therefore fodder Napier and other hybrid fodder gases have to be introduced, including institutional arrangements for milk collection and distribution.

Adoption of soil and water conservation technologies

The adoption of soil and water conservation technologies is a key solution to address issues such as erosion, soil fertility loss, drought, water scarcity, and land degradation (Falloon and Betts, 2010). These measures serve as an effective coping strategy for the challenges posed by climate change. The study across different watersheds revealed that the adoption of soil and water conservation measures was very poor, making farmers more vulnerable to the depletion of natural resources as discussed in the baseline survey, which directly impacts their livelihoods. Specifically, the adoption of field bunds was poor in the Gandhikota watershed. Further, the adoption of farm ponds was very low across Gnadhikota, Owk and Somasila watersheds. Likewise, the adoption of micro-irrigation techniques was less than 5% in Owk and Somasila watersheds and Dryland Horticulture and Agro-forestry is less than 20% and 5% respectively in all the watersheds. Overall the data indicates that poor adoption of conservation measures which highlights the need for interventions to improve productivity, water use efficiency and control erosion.

Prioritization of interventions for watershed planning

The watershed planning matrix will guide for planning of different interventions based on the score obtained in the each watershed. Here priority should be given for the resource development for the intervention obtained greater score. Thus matrix score helps in quick assessment of severity of problem and thereby priority need for promotion of particular interventions to enhance those resources through watershed interventions. The results from the matrix show that need for overall improvement in Irrigation source, adoption of conservation techniques, dryland horticulture and agro-forestry in the watersheds.

Conclusions

The baseline survey of watersheds around hydroelectric project sites revealed that crop farming is the primary livelihood source for most farmers, with small and marginal landholders prevailing in all the watersheds. Therefore, interventions were planned for equitable distribution among all the stakeholders. The area under rainfed agriculture is high in all watersheds, except Somasila. Livestock status shows that large ruminants were high in the Chitravathi and Somasila watersheds and small ruminants are considerably high in Gandhikota and Owk watersheds. Hence livestock intervention will be planned accordingly. The cropping intensity is less in Gandhikota, Owk and Chitravathi, thus it calls for improvement of irrigation sources in those watersheds. Also, poor adoption of soil and water conservation leads to the depletion of natural resources and causes degradation of the arable lands. Hence, the promotion of soil and water conservation in all the watersheds was recommended for ecological restoration.

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Disclosure Statement

The authors declare no conflict of interest. The submitted work is original and has not been published elsewhere in any form or language.

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