ESTIMATION OF ECOSYSTEM SERVICES OF REJUVENATED IRRIGATION TANKS: A CASE STUDY IN MID GODAVARI BASIN

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Abstract

Adoption of certain tank management practices was a part of the culture in semi-arid regions to ensure tank's sustainability. However, gradual neglect has led to a decline in its role in local economy and ecology and therefore caused consequent hardships to all stakeholders concerned. With aid of external agencies, community has removed 74,000m^2 of silt from 12 tanks in Warangal district, mid Godavari basin of Andhra Pradesh. Its impacts were monitored before and after intervention in kharif and rabi seasons. Estimated benefits both tangible and intangible, suggest that tank rejuvenation makes economic sense and must be adopted on a larger scale.

1. INTRODUCTION

The management of natural resources requires high degree of participation by those who benefit directly and indirectly from that resource. Proper management of natural resources is the most essential step towards sustainable development. Environmental degradation is one of the first indications of unsustainable social and economic systems. Various studies have indicated that renewable resources are under immense stress and as a result their productivity is on the decline. Competing demands exceed supply in many parts of the world, constraining development and laying the foundation for social revolts and conflict. Consequently, humans use the common pool resources for individual benefit with no regard to long term sustainability, which leads to the depletion and degredation of resources. Further, institutions for promoting participatory development of natural resources are not crafted, individual initiatives did not sustain and finally, the agencies created by the government for the management of these resources were highly centralised and bureaucratic (Hooja and Joshi, 2000).

The tanks of South India suffered a similar fate. A study by Sharma and Selvaraj (1999) on Vallakulam cascade of tanks has addressed governance issues and challenges. The study concluded that the lateral spread of authority across many formal and informal institutions, lack of alignment between roles performed, responsibilities, absence of operational synergy and partnerships and no direct mechanisms to ensure accountability of the governance structures to the system users are responsible for the present state of tanks. Suggestions have been made for integrating the mechanisms or authorities to manage the entire cascade of tanks and lands irrigated under one administrative unit and creating direct accountability for performance. Shah (2003), in her study has used the design of tanks as a way to examine the social and political implications of technology that emerged and were managed in a society that was ridden with class, caste and gender inequalities. It supports the widespread view that the crisis in natural resource management, including the management of tanks, was because of state interference and communities should have been left to manage the resources by themselves.

Sreenivasan et.al., (1999) have highlighted the need for location specific studies to understand the situation to make right interventions. Issues like encroachment of tanks have been obvious due to interventions by people, government or nature. It is imperative that organizations should be formed to protect the tanks and

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strengthen the process of management (Manikandan et.al., 2000). A paper by Kumar (2004) has discussed key issues and specific experiences in the various districts of Karnataka. Mismanagement of water and bad cropping practice have led to negative impacts of water scarcity and ground water depletion due to excessive drilling of borewells. A study by Kanniappam et.al., (2000) highlights the dependency of livestock on tanks and the ill-effects of its negligence. Use of chemical fertilizers and decline in organic manure has contaminated the food chain, and affected the fertility of the soil. Common areas set apart for pasture has been virtually wiped out increasing costs of purchasing fodder. Near most of the tanks, common grazing lands do not exist making it very difficult for the livestock (Ramakrishnan, 2000). Poor and marginal farmers depend on livestock for additional income apart from their various uses like ploughing, land preparation and sowing seeds (Elangovan, 2000).

Proper management of irrigation tanks may be a good solution to addressing the current water crises. Several studies have indicated community participation as the key for rejuvenation. For example, study on rehabilitation of tanks (Dhan Foundation, 2001) for providing drinking water in drought prone Ramanathapuram District of Tamil Nadu, has highlighted the need for community involvement with contribution to resolve their problem and made recommendations for improving the Tank Development and Management Programmes under the 10th Plan based on its experiences and has specifically laid emphasis on involvement of local management in the tank systems.

1.1 Importance of Tanks – An Overview

Tank based water management system is an integrated watershed system with tank as its central point. Historically, India, particularly in the southern states, have been following traditional methods of water management by harnessing runoff from uncertain monsoon through a large network of water holding bodies in the form of tanks. According to the Minor Irrigation Census conducted in 1986-87, the country had over 750,000 minor irrigation structures using surface water. Approximately, 700,000 of the structures were found to be in use. In terms of numbers, a large majority of them consisted of small-scale local diversion of water or lifting from streams and rivers. Tanks, which were relatively small, shallow storages, constituted about a third of all minor works in use. In terms of area irrigated, however, they were far more important, accounting for nearly 80% of the net area irrigated by all minor surface water resources. Country has an estimated 208,000 tanks irrigating 3.5 million ha. Andhra Pradesh, Karnataka and Tamil Nadu account for 60% of tank irrigation in the country. Together, they have nearly 120,000 tanks irrigating 1.8 million ha. In eight districts of Andhra Pradesh and Tamil Nadu, over a fifth of the sown area depends on tank irrigation (Vaidyanathan, 2001). In addition, as source of irrigation, tanks play a significant role in supporting the livelihoods of the marginalised groups and activities like making bricks, pots, baskets, ropes, fisheries etc, in the rural areas apart from numerous other ecological services. In simple words, the entire village economy is linked to the tank directly or indirectly.

Apart from the above-mentioned factors, tanks are eco-friendly and proper management ensure protection and preservation of the micro ecosystem and it provides services like, recycling of nutrients, purification of water, recharge of groundwater, augmenting and maintenance of stream flow and habitat provision for a wide variety of flora and fauna in addition to aesthetic values. It is home for a wide variety of medicinal plant species, which were, used by the rural masses to treat several health disorders. Thus, the tank occupied central part in ecological, economical, social and cultural benefits to its immediate environment. Further, it served as flood moderators during heavy rains and served as water points during drought conditions. Tank irrigation was superior in distributing water, economical in terms of energy utilization compared to the groundwater system or even the major irrigation projects.

But, over time, mismanagement has resulted in decline of tank system, which can be attributed to various factors like interference of the State resulting in disturbing the community institutions. The degree of involvement of farmers itself was reduced as other sources of irrigation like borewells came into existence since the 1980's, further leading to poor resource allocation, encroachments and siltation.

2. THE STUDY

In this context, a study on rejuvenation of tanks and its impacts were taken up in the mid Godavari basin[3]. These tanks are a part of the mid Godavari basin and were built centuries ago. The interlinking channel moved excess water from upstream to downstream tanks. Final surplus flowed into the Godavari river. The system functioned efficiently under the management of village level authorities who contributed to the upkeep of the tank and feeder canals.

Table 1: Some of the Eco-System services of the Irrigation Tanks.

Component	Direct Impact	Indirect
On Groundwater Resources	Recharge of ground water table	Recharge of open wells and bore wells
	Horizontal infiltration of water	Higher level of soil moisture
	Sedimentation of substances	Chelating of chemicals in anioxic sediments
On Land Resource	Moisture content in soil profile	Vegetation growth
Aquatic Flora	Sustenance of submerged, emergent and floating plants	Extension of food chain
Habitat	Diverse and stable habitat with diverse niche for fauna	Extended food web – supporting the natural predators

Inflows into the tanks in this region have decreased due to the expansion of agriculture in the catchment areas. Apart from this, the main links to the tanks have been cut-off with the construction of the Sri Ram Sagar Project Canal. This has given rise to various conflicts concerning rights to water resources. The present status of the system, with the interlinking channels, is mostly in a state of disrepair and the hydrological connections between the tanks have broken down. Extensive deforestation and denudation of the catchments have damaged the catchment's water collecting capacities – resulting in reduced inflows into tanks. Catchment erosion has resulted in rapid silt accumulation on the tank bed and reduced water storage capacity, and decreased groundwater recharge. Unchecked weed growth has further reduced the water storage capacity of tank and the efficiency of the feeder canals. The natural phenomenon of drought was exacerbated by inconsistent agricultural management practices and faulty irrigation norms[4]. In this context, this paper has addressed the valuation of ecosystem services in the context of rejuvenating 'Tanks' in the mid Godavari basin. Various reasons for the decline/degradation of this time-tested system are of the absence of local management, encroachments by public and private with the ultimate result of dilapidated and weak or cut down tank bunds, choked sluices and damaged weirs, sluices with missing shutters, large-scale infestation of weeds, siltation in tank and channels (Raju *et al.*, 2002).

Restoration and rehabilitation of existing irrigational tanks are vital to revive and restore the rural economy. Evolving appropriate methodology on restoration and management can lead to sustainable development. In the current situation, the advantage is that, most of the areas have existing structures and as such do not demand any significant capital investment as compared with other modes of water resource management.

2.1. Tanks of Andhra Pradesh

Andhra Pradesh has 82,500 tanks irrigating more than 48 lac ha of land. At the end of the First Five Year Plan, there were 58,518 tanks in Aandhra Pradesh with an irrigated area of 1.07 million ha, accounting for about two-fifths of the irrigated area of the state. Eight districts of the state were declared drought-prone where tanks were the main source of water supply in these districts for ages. Tanks have been classified into various

[3] Project was funded by WWF- International and desiltation was done by the local NGO - Modern Architects of Rural India (MARI). International Crop Research for the Semi-Arid Tropics (ICRISAT-Hyderabad) conducted the soil analysis and the Institute for Social and Economic Change conducted a study on the socio-economic and ecological impacts of intervention.

[4] This region has also witnessed numerous suicides by farmers for the past few years due to continuous drought because of high debt burden. Maximum number of suicides was reported from Warangal district.

categories for administrative purposes. In Aandhra Pradesh, the Minor Irrigation Department is responsible for its maintenance, repair and water regulation of tanks with ayacuts exceeding 400 ha, and for maintenance and repairs only for tanks with ayacuts between 80 – 400 ha, (40 ha in Telangana), while Panchayatraj institutions maintain the smaller tanks. Similar to other states, the situation with respect to tanks in Andhra Pradesh is also one of negligence. Over the last decade, efforts by various institutions (government, NGOs and collective action efforts) across the country have been striving to revive traditional methods of water management while taking cognizance of modern conditions. Many NGOs have initiated tank restoration and renovation projects, and though they remain minor players, have addressed the immediate issues.

3. STUDY AREA

Warangal district lies between $17^{0}\,19^{1}$and $18^{0}\,36^{1}$ north latitude and $78^{0}\,49^{1}$ and $80^{0}\,43^{1}$ east longitude. The elevation ranges from 870 ft to 1700 ft MSL. The geographical area of the district is 12,846 sq. km. About 41% of total area is under cultivation, while 29% is under forest. Current and other fallows account for about 15% and the rest 15% is under miscellaneous category (non-agricultural, barren, grazing land, cultivable waste, etc.). Administratively, the district is divided into four divisions and 51 mandals. The entire area is studded with isolated hills, hill streams, rainfed tanks and large lakes. The soils of the district comprise of sandy loam with patches of shallow black soils, and at places even medium and deep black cotton soil. All the mandals receive about 1,000 mm rainfall mainly through Southwest monsoon. The study was carried in four mandals of the district, which had high percentage of cropped area under irrigation, and irrigated mainly through tanks and open dug/bore wells. The district falls in the catchment of both Krishna and Godavari rivers, two important rivers of Andhra Pradesh. Salivagu micro basin of Godavari river, which has 447 tanks spread over 878.35 sq. km of catchment was selected for the study. Twelve tanks were identified in the Salivagu micro basin for de-silting on pilot basis during 2005-06 (see Annexure I, for the name of the village, tank and the number assigned to the tank and the number is referred in figures). All the tanks were geo-referenced using GPS and a map was prepared using GIS (Fig. 3). The Mid-Godavari Basin (MGB) is endowed with a number of large tanks constructed during the Kakatiya times, which serve as the major source for local irrigation.

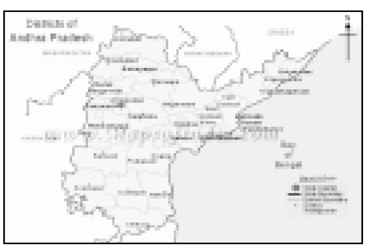


Figure 1: Map of Andhra Pradesh

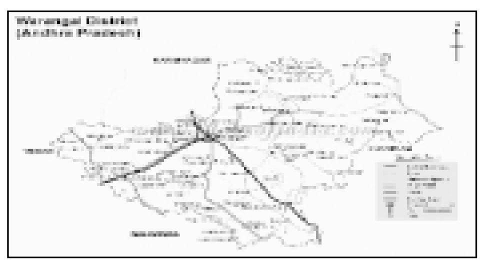


Figure 2: Study Area

Figure 3: Location of Study Tanksanks

The specific objectives of the study included estimating increase in water availability due to desiltation, assessing resultant advantages, both tangible and non-tangible, developing an information gathering process at different levels, which would include data from water users associations, state departments and scientific establishments to establish local institutions for optimum water use; documenting immediate gains versus long-term gains following the restoration process; and preparing a policy document on the valuation of services of the tank– in particular assessing the necessity for their integration in larger irrigation schemes.

The methodology adopted for the study included collection of primary and secondary information. Field studies were conducted at several intervals to note the changes, viz, before and during desiltation, after khariff and rabi crops using indicators to measure impacts and benefits. Informal discussions were held with various groups of people in the village apart from structured interviews and focus group discussions.

3.1 Ecological Impacts of Tank Desiltation

During earlier years, when the village community as a whole used to participate in tank maintenance, desiltation was a primary activity followed by deweeding, strengthening the bunds. The silt from the tanks was applied to the farms to enhance its productivity, as it was rich in nutrients essential for the plant growth. Though desiltation is not the only way to rejuvenate tanks, most efforts involve it, making silt disposal a very important aspect. In the study area, desiltation was carried out by forming various committees within the village and silt thus excavated was lifted by the farmers themselves for field amendments, depending on the nature of silt.

3.1.1 Silt Amendment Benefits

Soil is considered as a pool of nutrients present in both available and reserve forms. Depletion occurs when nutrients do not get replenished from the reserve pool. Depending upon the capacity, the farmers applied 50 – 250 tractor/ha. The tractor has a volume of 2.5 m^3 and when applied it worked to be 1.2cm to 6.0cm depth of soil. 70% of the farmers applied less than 100 tractor loads per ha. 96% of the farmers who applied tank sediment had less than 2 ha of land-holding and 78% of them belonged to backward classes (scheduled caste, scheduled tribe and backward classes). 97% of the farmers applied silt to dry lands. An attempt was made to assess the impact of its application on soil, crop and land use.

3.1.2 Positive Changes in Soil Content

The clay content of the tank sediment ranged from 60%-80% while its application to the field reduced the bulk density of the soil from 1.5 to 1.25 gm/cm^3. Addition of tank sediment at the rate of 50, 100, 150 and 350 tractor loads per ha improved the available water content by 0.002, 0.007, 0.012 and 0.032 gm/gm soil, respectively. All the farmers were in agreement that the moisture retention had gone up by 4 to 7 days, which played an important role during the period of prolonged dry spells. This was confirmed from our studies that the available water content in the root zone had gone up by 1%, i.e., from a normal 6%-7%, which would go a long way in drought-proofing. Farmers did believe that once applied, the impact on crop yield would remain for three years but the invisible aspect was the permanent change in soil physical property. Improved clay and silt content would not only retain higher moisture but would also reduce the losses of nutrients applied through leaching because of improved Cation Exchange Capacity (CEC).

3.1.3 Plant Nutrients from Silt

The quantity of sediment removed from different tanks amounted to 76,393 ton. The total cost incurred in the removal of this sediment amounted to Rs. 1133190. The value of sediment was quantified in terms of fertilizer equivalent costs. The nutrients retrieved from sediment were considered to be the profit (benefit) as against the expenditure (cost) incurred in removing the sediment from the tanks. Additionally, the process of sediment application to farmlands that was rich in organic carbon would result in carbon mineralisation and higher nutrient availability thereby helping plant growth and greater fixation of C through photosynthesis. The benefit-cost ratio ranged from 0.9 to 2.06. The benefit-cost ratio averaged to 1.51 for all the 12 tanks under study.

Average benefits (Table 2) has suggested that desilting operations were not only economically viable but also had additional benefits like environmental protection, increased soil microbial bio-diversity, improved soil quality and increased water storage. If indirect additional environmental benefits were added to the benefits, then there would be even more benefit. Application of sediment back to the agricultural fields formed an improved agricultural management system that enhanced and protected the soil quality resulting in improved production capacity of soil and reversing the process of land degradation.

3.1.4 Increased Yield

Harvest data of Kharif crops have indicated that all the farmers who had applied silt reported increased yield and the details have been given in Annexure 3. As can be seen from the survey results from ten farmers from each of the desilted tank villages, there was increased yield in the crop produce. Highest was observed in groundnut and maize with an average increase of 11.5 qtl / ha and 11.2 qtl/ha respectively in the study area. Lower rates of increase were recorded in case of turmeric with an average of 4.2 qtl/ha. To quantify the economic impact of silt amendment, existing market prices were considered. In all the 12 villages, about 50 ha of land was amended with silt and the resultant economic benefits are presented in Table 2[5].

Table 2: Increased Economic Returns from Enhanced Productivity (in Rs)

Crop	Increased Productivity/ ha in qtl	Market Price / Unit	Economic Benefit / ha	Total Benefits
Cotton	5.75	2,000	11,500	368,0000
Chilly	6	1,500	9,000	108,0000
Maize	11.25	460	5,175	207,000
Groundnut	11.5	1,200	13,800	55,200
Turmeric	4.25	2,600	11,050	33,1500
Total				5,850,500

Source: Survey

3.1.5 Reduced Consumption of Pesticides

With enhanced nutrient availability, vigorous plant growth, higher rate of soil moisture content and microbial population presence (natural predators), the pest incidence was reported less in the silt amended soils thereby reducing the need for repeated application of pesticides. However, the reduction in the pesticide consumption by farmers could also be attributed to the shift to pest resistant types of cotton and climatic conditions. Therefore, though there was significant reduction in pesticide consumption, it was not considered in computing economic benefits (Annexure 3). Summary of the Benefits derived from all the above, silt amendment, increased produce and nutrient recycling has been given in Table 3.

Table 3: Summary of Benefits and Their Economic Equivalents (in Rs.)

Activity	Costs	Benefits
Silt amendment process	1,133,190	
Produce increase		5,850,500
Nutrient recycling		800,018
Total	1,133,190	6,650,519

Source: Survey

[5] Prevailing market prices were considered

3.1.6 Increased Growth of Natural Predators

As a result of reduced use of the agro-chemicals it is, theoretically expected that natural predators of pests would have better chance of survival as pointed by Odum (1992), and this was reported by the farmers who had applied silt. Presence of higher number of natural predators like lady bird beatle (*Epilachna batles*), chysopa, spiders, dragonflies, wasp were observed.

Other positive benefits included increased soil moisture around the tank and enhanced capacity of this wetland ecosystem to provide niche and habitat support to wider species. Here is a brief account of the impact of tank desiltation on the birds. Before this study was undertaken, there was no documentation of the avifauna of these twelve tanks. Though there was evidence of migratory and resident wetland birds, the baseline data did not exist. Based on the orinthological studies and farmers' perceptions it was found that both density and diversity of avian community was better than previous years when drought conditions were prevailing in the study area.

3.2 Socio- Economic Impact

As the tank is central to most of the activities in the village, desiltation activity is bound to have influence on the village life where primary occupation is farm based and very little population is involved in non-farm based occupations, which again is indirectly influenced by farming. The impacts of desiltation in the study area on various activities are as follows.

3.2.1 Increase in the area irrigated before and after Desiltation

The backbone of the economy in the study area is agriculture, which is primarily rain-fed. Some areas exploit the groundwater table, which again is dependent on monsoon. Major crops include rice, cotton, chillies and some horticultural crops. The total command area is 1200 ha. Depending on the water sources, Kharif or Rabi is grown and details of the same are given in Table 4.

Table 4: Total Area Cultivated (Command Area)

Specifics	Before desiltation (BD) 2004-05	After Desiltation (AD) 2005-06
Area Cultivated	Kharif (in ha)	Rabi (in ha)
Wet Kharif	416	1146
Wet Rabi	116	340

Source: Survey

Difference in total area irrigated, before and after the intervention is huge from 416 to 1146 ha in Kharif and 116 to 340 ha in the Rabi[6]. This huge variation is the difference between a drought prone year and best monsoon year. However, for this study, a comparison was made between the area irrigated in the tank command area between two normal years of monsoon when the last time the tank had been filled and after desiltation. The difference is an increase of 58 ha. Table 5 shows the total yield and additional economic value of paddy across villages. However factors like, increased water holding capacity of the tanks due to desiltation, recurring tank filling from Sri Ram Sagar Project (SRSP) in good monsoon and groundwater recharge are equally important. Hence, it cannot be attributed only to desiltation.

Table No 5: Enhanced Production of Paddy

Additional Area Cultivated	Average Yield Per Acre (in bags of 75Kg)	Total Yield	Market Value Per Bag (in Rs)	Total Economic Equivalent (in Rs)
58 hec	34.5	2018	500	1,009,200

Source: Survey

[6]Compared to the year before desilation, the current year has received very good rainfall and thus, the increase in irrigated area can not belinked to the desiltation alone.

Looking at the economic aspect of this extra land where paddy had never before cultivated in Rabi season, would mean that about 58 ha were cultivated this year. The revenue from the extra land that was brought under irrigation in the rabi crop, primarily because of tank desilation resulted in production of paddy, the economic value of which is Rs. 1009200. As opined by the farmers, there was about 25 - 35% profit depending on the number of households engaged in the farming activities.

3.2.2 Reduction in the extraction of groundwater for irrigation

While upland farmers had to depend on the wells for irrigation, command area farmers had the option of making use of open wells (depending on their existence) or tanks for irrigation, depending on the availability of water. A comparison was made on the source of irrigation and number of times irrigation was provided to the major crop, i.e., paddy before and after desiltation. The primary objective was to compare groundwater extraction and number of irrigation during different years. The results given in Table no.6 have shown that after desilting, no farmer in command area of these 12 tanks had used groundwater for irrigation during Kharif crop, as tank water was sufficient, with a result of reduced groundwater use.

Table 6: Number of Irrigations and Source for Paddy

Village	Before Desiltation (BD)			After Desiltation (AD)			
	Kharif		Rabi	Kharif		Rabi	
	Tank	Well		Tank	Well	Tank	Well
1.	8	5	No crop	16	Nil	19	
2.	10	6	No crop	16	Nil	12	
3.	10	6	No crop	15	Nil	13 to 15	
4.	10	6	No crop	17	Nil	14 to 16	
5.	4	7	No crop	15	Nil	6	12
6.	6	10	No crop	16	Nil	16	2
7.	4	12	No crop	4	Nil	10	6
8.	13	5	No crop	16	Nil	18	
9.	7	9	No crop	15	Nil	20	
10.	11	5	No crop	15	Nil	18	4
11.	10	7	No crop	16	Nil	20	
12.	10	6	No crop	15	Nil	16-18	

Source: Survey

As evident form Table 6, though the number of irrigations required remained more or less the same, the source of water, after desiltation continued to be tank unlike the previous year when groundwater was used significantly even for Kharif and no Rabi crop was grown. Only four villages used groundwater to irrigate paddy.

3.2.3 Electric Power saving

The water from the tank flows under gravity and does not require any power in contrast with groundwater, which needs to be lifted using electricity, thus tank water use save electricity. As the State government was not collecting any charges for electricity for irrigation economic savings were not calculated. If one takes the power tariffs into account, for irrigating one ha of paddy it requires 10-15 hrs of pumping of water and money saved would be enormous.

3.2.4 Augmented water flow distance

In addition to the recharging of groundwater, more water in the tank made the water flow longer distances when the sluice gates opened for irrigation thus enabling the lower reach farmers to cultivate. To study the impact of desiltation on the distance of flow of water, comparison was made between the distances of water travelled in the current year with that in previous year. With water flowing longer distances in distributory canal network the fields in the lower reach could also be irrigated as shown in Table 7. Again, this could be attributed to desiltation coupled with good monsoons.

Table 7: Distance of Flow between Head and Tail-end farmers (in kms) (Rabi)

Village	Ideal flow distance Sluice 1	2004-05 BD			2005-06 AD		
		Head Reach	Mid Reach	Tail Reach	Head Reach	Mid Reach	Tail Reach
1	1.0	0.5	Nil	Nil			1.0
2	1.0	0.5	Nil	Nil			1.0
3	1.5	0.5	Nil	Nil		1.0	Nil
4	1.5	1.0	Nil	Nil		1.0	Nil
5	2.0	1.0	Nil	Nil			2.0
6	2	Nil	Nil	Nil		1	Nil
7	3.0	Nil	Nil	Nil		1.0	Nil
8	1.0	Nil	Nil	Nil		2.0	Nil
9	2.5	1.5	Nil	Nil		2.0	Nil
10	1.0	Nil	Nil	Nil	0.5	Nil	Nil
11	2.5	Nil	Nil	Nil	0.25	Nil	Nil
12	2.5	1	Nil	Nil			2.5

Source: Survey

3.2.5 Improved employment opportunities for landless labourers

Around 30% of the villagers were landless labourers. Depending on the demand for labour and its availability, the wages were determined. General daily wages were Rs.50 for men and Rs.25 for women. Due to failure of monsoon in the previous years, there was very little work in the farm sector. However, after desilting and good monsoons, this year there was good demand for labour. Further, with the introduction of National Rural Employment Guarantee Scheme, off-season period also provided significant employment opportunities.

From Table 8, one can see that the number of person-days in the Kharif season itself equaled the employment that was offered during the previous year. However, on account of tank desiltation, an additional area of about 58 ha was cultivated with paddy and without desiltation, this would not have been possible. Cultivation of one hectare of paddy requires about 200 man-days. Thus 58 ha have potential of providing employment in Rabi season. This increase was the result of only 30% desiltation work and would increase if the rate of desiltation were higher.

Table 8: Additional Employment Generated - Agriculture

Additional Hectares Irrigated	Number of Man-days /ha of Paddy	Total Man-days	Daily Wages in Rs.	Economic Equivalent in Rs.
58	200	11,600	45	5,22,000

Source: Survey

3.2.6 Boost in fodder production

A primary factor that influenced the livestock population in the village was the availability of fodder and water. In the previous years, on account of the total failure of the paddy crop, entire villages were forced to buy fodder with the exception of one village, which had three water sources. On the contrary, this year as most of the catchment area was cultivated, there was surplus fodder. Previously, both on account of poor monsoon and less water holding capacity of the tanks, the area cultivated was lesser with the result of perennial shortage of fodder. As can be seen, with significant increase in the area of paddy cultivation this year, there was no fodder problem for the cattle. Looking from an economic point of view, fodder from one ha would be about eight cartloads and would suffice for a pair of cattle for a year and cost about Rs. 5000 in normal demand year.

The fodder from 58 ha in the command area of 12 tanks could support extra 150 pairs of cattle for one year. A pair of cattle in a year produced about two cartloads of organic manure which was very much in demand. The present price for a cartload of cattle manure is about Rs.100. Therefore, the total economic value of manure that would be produced from 150 pairs of cattle would be Rs. 15000. This appears to be a small amount but it has added effects. For instance, with organic manure use, the consumption of synthetic fertilizers would be reduced. Soil biota thrive better without these chemicals and create a better soil ecosystem which helps healthy growth of the plant with less requirement of pesticides. The economic quantification of these impacts is difficult to measure and is a long drawn process and not undertaken in this study[7].

3.2.7 Enhancement in fish production

Investments and profits derived from fishries before and after desiltation indicate major change as indicated in Table 9. This year, there appears to a net profit of Rs. 167000 in all the tanks together. The reason for the losses in the year even when the tank was filled previously could be attributed to the less duration of water available for the fish growth as there was conflicting interests between the farmers and fisher community, while the former wanted to go for rabi crop and latter opposed. However, being minor stakeholder, the fisher community had to accept the irrigating during the rabi with a result of poor fish harvest.

Table 9: Fish Harvest Before and After Tank Desiltation (in Rs.)

Village	Last time when tank filled		After tank desiltation	
	Investment	Profit	Investment	Total Profits
All 12 villages	584,000	122,000	595,000	762,000

Source: Survey

With the desiltation of tanks, the following changes took place in the tank aquatic ecosystem, viz., increase in the retention of water in the tank as well as the depth which was also a determining factor for the fish growth and secondly, release of micro-nutrients which otherwise were locked in the anixioc sediments of the lake which promoted better plankton growth in the lake. All these changes, contributed to good harvest of fish.

3.2.8 Better benefits to washerman community

Traditionally, washermen depended on tanks for washing clothes. With the tanks being in the proximity of the village and the availability of water would reduce the time required to complete their work and allow them to attend to work on their own lands or as labourers. With the drying up of the tanks in previous years, this community faced inconvenience, both in terms of commuting long distances for washing clothes and missing the limited employment opportunities in the farm based activities. Inconveniences were encountered with the

[7] Another benefit of livestock is that it is used for seeding in the cotton fields. Only animal drag power is used. Mechanized means cannot be used after seeding, but only bullocks can be used. Generally, Rs. 150 was paid to the man with bullocks and in a year, about 150 days, the oxen remain occupied.

onset of summer, beginning from January to April, depending on the strength of monsoon. During lean monsoon years, it was common for them to even walk up to 3 km in some villages in search of bore wells or other water sources. At times, they were forced to request bore well owners for water to wash clothes. Though the prevailing drought conditions during previous years had not made much difference in the employment of washer community, during discussions with them, it was generally opined that with good monsoons, they also engaged in farm activities and required less time to spare and good economic returns.

3.2.9 Decline in migration

The impact of varying water level hits hard, particularly the landless as most of them earned wages on daily basis. During poor monsoon, there was significant amount of out-ward movement of labour from the villages to urban centres seeking employment. In the process, young and old people were left behind in the village. This phenomena, however, appeared to have changed in the study area from this year. Migration to urban centers was highest in summer months and previous year being drought year, there was significant daily and seasonal migration.

However, as desiltation work was carried out in summer, it provided employment opportunity for the labourers, with the result of no migration. With the onset of monsoon, farming activities started requiring all the labour for farm activities resulting in no migration at all. However, some sections of the village, like washerman community and fishing community had reported migration for better employment. Compared to previous years, this year the migration rates had shown a drastic reduction in both short-term and long-term migration.

Table 10: Migration during Crop Season

Specifics	BD	AD
Total families	528	70
Short term	267	45
Long term	98	10
Everyday	300	80

Source: Survey

3.2.10 Reduced drinking water problems

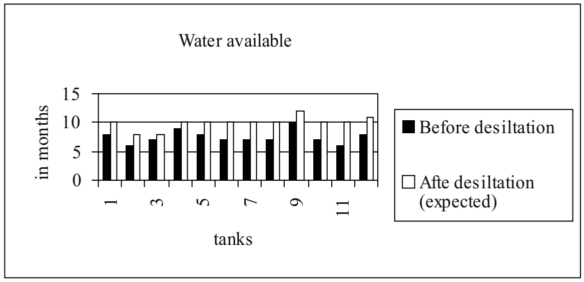
To meet the requirement of water both for domestic and agricultural purposes, the community used open and bore wells to cater to the domestic requirements of the village community and private open and/or bore wells for agricultural demands. The quantum of water available in these sources was primarily dependent on the recharge rate of the groundwater table, which, in turn, was based on monsoon and percolation rates of precipitation with a direct relationship between quantum of water in these sources and water percolation. During previous years, insufficient percolation resulted in drying up of most wells (Figure 5).

From the tables, it is quite clear that there was remarkable groundwater recharge after tank desiltation with the result that many bore and open wells are now active. More than 50% of the wells were functional after tank desiltation and this could be attributed directly to tank desilation partly and good monsoons. The removal of compact silt enhanced the groundwater table recharging and with enhanced water holding capacity, more recharge was possible.

3.2.11 Increased water holding capacity of the Tank

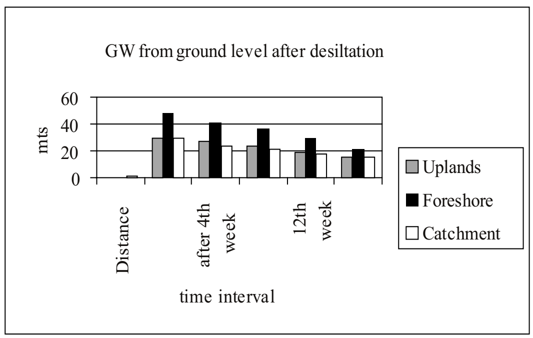
One of the most tangible impacts of any desiliation programme would be the enhanced water holding capacity of the water body. However, the duration of water holding depended on the location of desiltation as it determined whether water would be drained out for various purposes or would remain in the tank. In the study area, desiltation was carried out at places desired by the farming community and location of these places was such that the water would not drain out but would remain in the tank. A comparison has been made regarding water available in the various tanks between the scenario before tank desiltation and present year.

Figure 4: Water Availability



As can be seen from Figure 4. water in all the tanks was available for longer period of time as compared to before desiltation. With the water available and with removal of compacted silt, ground water table got recharged continuously. This was very useful for plant growth as more soil moisture would be available in the root zone. A study was made to understand the impact of desiltation in wells in three regions, viz. foreshore, uplands and command area.

Figure 5: Water Table Fluctuations in Villages



Water retention in the tanks coupled with copious rainfall recharge groundwater. With the groundwater table coming from about 40 ft to as high as 4ft in some villages, it was nothing but natural to assume, that the root zone in the soil profile had high content of moisture. Even after the 16th week after the onset of monsoon, Groundwater table showing this results indicate that even for the coming months, the moisture content remained and promoted both plant growth and detritus cycle in the A, B horizons of soil profile. This faster rate would enable higher recycling of both micro and macronutrients which enhanced the health of the soil profile.

4. INSTITUTIONAL MECHANISMS

The benefits of tank maintenance was well recognized and the same was interwoven into various religio-cultural aspects of the village which made participation of the entire village in tank upkeep a norm over the years. However, with policy shifts only about two centuries back, the prime concern was revenue generation and put a back burner to other systems of water resources management. This alienated the village community from tank upkeep efforts, and subsequent deterioration of tank as an ecological entity. Various stakeholders are dependent on the tank, thus the potential of conflicts are a norm.

Table 11: Conflicting Situations

Situation	Potential Conflict
Lack of water	Between head reach and tail reach farmers
	Between command area farmers and other stakeholders
Surplus water	Between headreach and tail ender regarding the Rabi crop
	Fishries and livestock rearing

All these conflicts used to be resolved within the village with amicable solutions, but with state intervention conflict, resolution entered the domain of formal conflict resolution mechanism, which suited very stakeholders. This resulted in the farming community adopting the energy-subsidized bore wells and marginal stakeholders shifting to other occupations. All these changes had a cascading effect on the tank's health where very few farmers had interest in the tank. For others, tank maintenance lost its significance.

Recent changes to introduce the local management of these micro watersheds, no doubt a good beginning in the decentralization in natural resource management, still isolate a few sections of the community – mostly command area farmers and no role for other stakeholders. For the optimum efficiency of the decentralization efforts, as was attempted in the Andhra Pradesh in the form of Andhra Pradesh Farmer's Management of Irrigation Systems (APFMS) Act, other stakeholders should be provided direct role in the tank management.

5. SUMMARY OF FINDINGS

Thus, to sum up the benefits of silt amendments in the agro ecosystem, survey of 120 farmers across tanks indicate that it is economically and environmentally beneficial. All the benefits and their economic equivalents terms have been given in Table 12 and 13.

Table No: 12: Economic Quantification of Benefits accruing from desiltation of tanks

Activity	Quantum	Economic equivalent	Remarks	Total (Rs)
Tangible				
Paddy Cultivation	Additional area of 58 ha	With yield of 2018 bags	Each bag @Rs. 500	1,009,200
Fisheries	Increased production		Average Rs.25/kg	167,000
Fodder production	1 tractor load / acre	150 tractor loads	Each load @ Rs. 2,000 and can support couple of cattle for one year	300,000
Total benefits				1,476,200
Total Costs				1,133,190

Table 13: Approximate non-tangible benefits

Non-Tangible	Service	Output	Unit value	Total in Rs
Organic manure production	240 cattle can be supported	120 cartloads of OM	Each cartload is @Rs. 100	12,000
Farm Traction	Weeding in cotton field	@Rs. 50 / 150 days		7,500
Milk production	Assuming 2 lt @ Rs. 10 and 50% of cattle are buffalows and milk production is only 6 months	240 lt/day	Rs. 2400 /day	21,600
Silt Amendments	Reduced fertilizers		Each bag is about Rs. 200	24,000
Total Benefits				65,100

Further, the study shows very good rate of return based only on the Kharif and Rabi results of one year. Benefits of the silt amendment are expected to last for 3-4 years, but with slow decrease in impacts.

6. WAY FORWARD

From a hindsight, involvement and active participation of the village community by formation of various committees for tank restoration process would have taken longer time but for the intervention of Community Based Organizations. Influence of the drought conditions prevailing in previous years was also one of the drivers coupled with Collective Action in the study villages. Participation of the community was essential for the optimization of these efforts. Tank desiltation is one part of the management while management of inflow and distributory network, cropping pattern forms the other component. Through Water User Association, a holistic management model needs to be adapted wherein interests of other stakeholders like fishing community also receive consideration. Mobilization of financial resources could be from NREGS and other such schemes. Some farmers were unable to lift silt for the field amendments on account of financial reasons at the time of desiltation and financial institutions may be motivated to extend loan facility for this purpose.

ANNEXURES

Annexure 1: Tanks and Villages Identified and Desilted

Tank Number	Tank name	Village Name
T1	Pedda Cheravu	Koppula
T2	Tummala Cheravu	Relakunta
T3	Yerra Cheravu	Rudragudam
T4	Pedda Cheravu	Chinnakodipaka
T5	Bokki Cheravu	Gorikothapalli
T6	Thimmanakunta	Gangerenigudam
T7	Reddy Cheravu	Nizampalli
T8	Moggulacheravu	Pathipaka
T9	Pedda Cheravu	Dammanapet
T10	Oora Cheravu	Rayaparthi
T11	Oora Cheravu	Repaka
T12	Venkarapalam Cheravu	Muchimpalla

Annexure 2: Economic Valuation of Tank Sediment in Terms of Plant Nutrients Returned to Farm

Name of village and tank	Quantity of sediment (ton)	Amount spent (Rs.)	Nutrients in terms Rupee equivalent					
			N	P	K	Zinc	Boron	Total
Koppula	4478	59700	20903	2711	17931	479	801	42828
Relakunta	7034	93780	55388	9523	34059	4268	1007	104247
Rudragudum	14184	189120	52679	4888	35668	2025	4062	99324
Chinnakodipaka	7853	104700	47423	24358	36152	1028	1405	88445
Gorikothpally	11356	151410	66364	7156	41703	7567	2032	124825
Gangrirenigudum	1355	18060	8087	1100	5918	145	339	15591
Nizampally	7538	100500	34999	1781	20221	1973	1079	60055
Pathipaka	4084	54450	18878	1668	16376	388	731	38044
Dammanapeta	2100	50400	12027	3029	8686	399	375	24518
Rayaparthy	3713	89100	17218	6453	14816	309	531	39329
Repaka	4938	118500	30312	3039	24262	528	1060	59203
Munchupla	7760	103470	65747	5157	29649	1662	1389	103605

Annexure 3: Yield Details from the Silt Amended Fields in Kharif

Name of the village and tank	Quantity of silt (ton)	Amount spent (Rs.)	Market rate and agro produces per quintals in Rs				
			Cotton @Rs.2000	Maize @Rs.460	Chilles @Rs.1500	Ground Nut @ Rs.1200	Turmeric @ Rs. 2600
Koppula	4478	59700	2	5	2	5	1.5
Relakunta	7034	93780	2	4	3	4	2
Rudragudum	14184	189120	2.5	5	3	4	2
Chinnakodepaka	7853	104700	2	5	2	5	1.5
Gorikothpally	11356	151410	2.5	5.5	2	5.5	2
Gangrirenigudum	1355	18060	2	4	3	4	1.5
Nizampally	7538	100500	3	5	2	5	2
Pathipaka	4084	54450	2	4	3	4	1.5
Dammanapeta	2100	50400	2	5	2	4	2
Rayaparthy	3713	89100	3.5	4	2	5	2
Repaka	4938	118500	2	4	3	5	1
Munchupla	7760	103470	2	4	2	5	1.5
Average			2.3	4.5	2.4	4.6	1.7

Annexure 4: Reduced Consumption of Pesticides

Name of village and tank	Quantity of sediment (ton)	Amount spent (Rs.)	Bt Cotton	Chillies
Koppula	4478	59700	6000	5000
Relakunta	7034	93780	5000	4500
Rudragudum	14184	189120	4500	6000
Chinnakodepaka	7853	104700	6500	5500
Gorikothpally	11356	151410	5000	5000
Gangrirenigudum	1355	18060	4000	4500
Nizampally	7538	100500	5000	6000
Pathipaka	4084	54450	4500	5500
Dammanapeta	2100	50400	4500	6000
Rayaparthy	3713	89100	5000	7000
Repaka	4938	118500	4500	4500
Munchupla	7760	103470	3500	5000

Annexure 5: Status of Open Wells in the Study Area

Details	Open wells			Borewells		
	Total	Functional last summer (BD)	Functional present summer	Total	Functional I BD	Functional present summer
Village (GP)	39	13	20	68	66	67
Private	1741	492	1133	149	48	87
Command Area	284	55	154	26	6	24
Upland Area	1468	273	616	240	51	157
Total		833	1923		171	335

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