Conservation and Management of Natural Resources in Ramasagara Watershed, Molakalmuru Taluk, Chitradurga District, Karnataka, India

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NWDPRA

Ramasagara watershed

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Foreword

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Rainfed agriculture plays a vital role as it covers nearly 80% of arable crop land and produces most of the food in developing countries. Watershed development is a prospective way to make remarkable agricultural development in degraded and less fertile areas prevailing in rainfed and semi-arid regions. Conservation of natural resources through soil and water conservation measures and management of soil and vegetation in rainfed regions could lead for higher agricultural productivity, improved soil fertility and food security. The best effort set by the ICAR-Indian Institute of Soil and Water Conservation (IISWC), Research Centre, Ballari fits squarely into NWDPRA guidelines on watershed development for less fertile and fragile land-areas where agro-climatic conditions are having many challenges. This report is critically important for at least two reasons.

First, watershed team implemented well proven, technically feasible, replicable and economically viable technologies in the watershed by taking required concurrence of all stakeholder in the watershed.

Second, rural women's economic empowerment including livelihood of landless dwellers were taken into consideration in the project. It is pre-requisite for improved food and nutritional security, deals with increasing the productive potential of women, smallholders and landless beneficiaries in the watershed. The study examined additional income received by both the women and landless beneficiaries through livelihood security activities.

This report is now fully mature with the material that could definitely enrich the watershed activities for improving the food security in the most underprivileged region of the semi-arid areas of Karnataka. It has pursued all possible conservation technologies and innovative farming practices, and investigation of their efficacy for sustainable production under field condition. It mainly focussed on rainfed, marginal, fragile and degraded areas to check land degradation and their effective utilization for forestry and horticultural plants and also examined the impact of soil and water conservation structures improving water resources and ground water recharge in particular.

I am confident that this bulletin on Conservation and Management of Natural Resources in Ramasagara Watershed, Molakalmuru Taluk, Chitradurga District, Karnataka, India will facilitate all scientific and policy makers to unlock the vast potentials of rainfed regions and also help in increasing investment in rainfed agriculture in future, while conserving the natural resources and protecting the environment. It's a very valuable resource material for researchers, policy makers and development workers whoever involved in watershed management works for uplifting farming communities and rural landless people.

Director

Preface

Vast swathes of geographical area in Karnataka State are drought prone and it is second to the State of Rajasthan in the country. Thus, the State provides prime importance to dryland agriculture. Nearly 75% of the total cropped area in the State depends on low and uncertain rainfall. Further, agriculture plays a crucial role in the State's economy and more than half of its food production is managed through dryland agriculture. Therefore, management of such vulnerable ecosystem requires effective resource management tools and systems. Over the decades, watershed management techniques emerged as best possible way to deal with dryland ecosystems especially in the present scenario of climate change. Watershed development programmes in the country assumed as one of the extensive rural development initiative in India. It plays a vital role in enhancement of agriculture production and overall biomass productivity through management of natural resources available in a watershed and aims to alleviate poverty by ensuring availability of non-renewable resources for future generation with greater employment in the region.

Keeping pros and cons of dryland agriculture in SAT regions in view, a watershed project was undertaken by ICAR-IISWC (Formerly CSWCRTI), Research Centre, Ballari, Karnataka during 2008-2014. The Project was funded by Ministry of Agriculture, Government of India under Macro-Management of Agriculture (MMA) scheme which adopted guidelines of National Watershed Development Project for Rainfed Area (NWDPRA) scheme. Project was implemented in Ramasagara watershed in Molakalmuru Taluk, Chitradurga District of Karnataka.

The project concentrated in conservation and production aspects with improvement in basic livelihood through different resource conservation activities which sustain them, particularly during drought years. To gain the confidence of stakeholders in the first year of watershed implementation, entry point activities were taken followed by institution and capacity building, and sustainable biomass production in both arable and non-arable lands, enhanced employment opportunities through livelihood activities which in turn increased the overall income of the beneficiaries. This document presents a comprehensive assessment of the bio-physical and socio-economic impacts of various interventions in the Ramasagara watershed for augmenting socio-economic status and livelihood security of stakeholders.

It is expected that this publication will be highly useful to the different watershed functionaries who are working for improving the soil fertility, crop productivity, livelihood and income of farmers under low rainfall situations in the SAT region of northern and central dry zone of Karnataka. We appreciate and acknowledge all the staffs of Ballari Centre for supporting project team during implementation and bringing out this publication which is the need of the day.

Project Team

Acknowledgement

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The team gratefully acknowledge co-operation rendered by the KVK Programme Co-ordinator Dr. Salimath Sarvagna and KVK staff for capacity building and guidance to the farmers. We are also highly thankful to Deputy Director of Veterinary Dr. Shivarudrappa and hospital staff in successfully conducting Animals Health Camps along with advisories. Thanks are also due to Dr. H. Farahana and Dr. Shivashankrappa Mudegoudar and their staff for conducting Human Health camps in the different villages of Ramasagara watershed. We are also thankful to the Assistant Director of Agriculture, Molakalmuru for his help and co-operation during the Project implementation.

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Acronyms and expansion

Sl. No.	Acronym	Expansion
1	AH&VS	Animal Husbandry & Veterinary Services
2	AI	Artificial insemination
3	AICRPDA	All India Crops Research Project on Dryland Agriculture
4	ARF	Annual rainfall
5	ASRB	Agricultural Scientists Recruitment Board
6	BAIF	Bharatiya Agro Industries Foundation
7	CPCRI	Central Plantation Crops Research Institute
8	CSWCRTI	Central Soil and Water Conservation Research and Training Institute
9	DAC	Department of Agriculture & Cooperation
10	DDG	Deputy Director General
11	EPA	Entry point activities
12	ERF	Erosive Rainfall
13	FYM	Farmyard Manure
14	GOI	Government of India
15	ICAR	Indian Council of Agricultural Research
16	IFS	Integrated Farming System
17	IISWC	Indian Institute of Soil and Water conservation
18	KVK	Krishi Vigyan Kendra
19	LCC	Land Capability Classification
20	Mha	Million hectares
21	MMA	Macro-Management of Agriculture
22	MoA	Ministry of Agriculture
23	MSL	Mean Sea Level
24	NGO	Non-Governmental Organisation
25	NI	Nutrient index
26	NRM	Natural Resource Management
27	NWDPRA	National Watershed Development Programme for Rainfed Areas
28	OIC	Officer-in-charge
29	PHC	Primary Health Centre
30	PI	Principal Investigator
31	PIA	Project Implementing Agency
32	PME	Prioritisation, Monitoring andEvaluation
33	QRT	Quinquennial Review Team
34	RFD	Rock Fill Dams
35	RRA	Rapid Rural Appraisal
36	SAT	Semi-arid tropics
37	SC/ST	Schedule Caste/Schedule Tribe
38	SWC	Soil and Water Conservation
39	SWOC	Strengths, Weaknesses, Opportunities &Challenges
40	WDF	Watershed Development Fund
41	ZARC	Zonal Agricultural Research Centre

Executive Summary

1. Background

Watershed projects are recognized as potential drivers for sustainable development in rainfed areas. ICAR-Indian Institute of Soil and Water Conservation (IISWC), Research Centre, Ballari - has implemented Ramasagara watershed as a model watershed under the National Watershed Development Project for Rainfed Areas (NWDPRA) during 2008 to 2014, which was executed in participatory mode as farmer centric and holistic program. The aim of the project was to conserve natural resources, increase food, fodder, fruit, vegetables, trees productivity, employment, livelihood and knowledge of farmers and sustain farm income. The watershed bearing Code No.4D3C6A2c, in list of micro-watersheds enlisted by Watershed Development Department, Government of Karnataka was selected. The watershed is located in the Krishna river basin as lower catchment of river Vedavathi (a tributary of Tunga-Bhadra river) and falls in Central Dry Agro-Climatic Zone of Karnataka. Geographical area of watershed is 480.37 ha which is confined between 14°49'31" to 14°50'42" N latitude and 76°47'32" to 76°47'32" E longitudes in Molkalmuru taluk, Chitradurga district of South Indian state of Karnataka, with an elevation range of 500 m to 600 m above mean sea level. Watershed area includes Ramasagara, Devasamudra, Hanumapur and Venkatapur villages. The average annual rainfall of the watershed is about 417.3 mm of which 80% of the rainfall is received during the monsoon season (June to October) and climate could be best described as arid. The low rainfall and its erratic distribution result in three severe drought years, three drought years and four normal rainfall years in a decade. Out of 480.37 ha of watershed area, net arable, hillock and pasture areas are 355.48 ha, 97.00 ha and 18.69 ha, respectively. The soils in the watershed are derived from granite and gneiss and are medium to deep red sandy loams with gravels and pebbles. Nutritional deficiency soils in organic carbon, nitrogen and zinc was 63%, 86% and 58%, respectively. The pH of soils, classified as LCC class II, ranges from 7.1-7.8 and remain as neutral in soil reaction. Soil electrical conductivity (EC) also found suitable for crop production. Estimated organic carbon of the soil was in the range of 3.2- 3.5 g kg^{-1} while the range of available N, available P_2O_5, available K_2O are 297-353 kg ha^{-1}, 14.7-29.5 kg ha^{-1} and 218-378 kg ha^{-1}, respectively in rainfed areas. Land mass was classified based land capability (LLC) as Class-II (53.20 ha), III (338.07 ha), VI (18.81 ha) and VIII (70.29 ha). LCC classification indicates that 15% land area is not available cultivation however, about 81% of area suitable for cultivation with some limitation of excessive erosion, shallow soil depth and limitation to root zone. Groundnut, mono-cropping and intercropping with redgram/ragi/bajra/cowpea/ horsegram/ castor/greengram has been identified as major cropping system in the watershed. Under bore-well irrigation, crops like hybrid maize, Bt. cotton, hybrid sorghum, paddy, chilli, bajra, sunflower, groundnut, onion, green chilli, and cucurbits crops have been cultivated during *kharif, rabi* and summer and perennials like mango, coconut and pomegranate are also cultivated. Dissected and compact shape of the watershed renders shorter times of water flow concentration, which causes higher runoff rates in drainages. The maximum basin relief is 60 m. Length of main drainage line is 2750 m with drainage density of 1.52 km km^{-2}. Natural vegetation in the hillocks and uplands (20.2% of the total area) is very sparse. Pasture land of 18.69 ha (3.9% of total area) is degraded due to lack of controlled grazing and low rainfall. Consequently, the watershed was highly prone to erosion hazards due to higher slope, absence of conservation measures and poor vegetation.

Literacy rate in the watershed was low (15%). The total population of the Ramasagara watershed was 1056 (175 farm families) during Pre-Project period and increased to 1113 (184 farm families) during Post-Project period with an average family size of 6 persons. Based on landholdings 21.2% farmers in the watershed have been classified as small, 42.7% as marginal, 24.5% as medium and 7.6% as big farm families. Per farm family landholdings has been reduced to 1.93 ha in Post-Project year from 2.03 ha in Pre-Project year. Seasonal migration of labourers remains unresolved and observed commutation of about 120 labourers each day to the nearby cities during summer for work. Finally, problem identification and prioritization indicates that low production of field crops, lack of adequate irrigation water and low market rates and market facilities were more serious issues to be addressed immediately.

2. Community organization through Watershed Society

The Ramasagara watershed society was formed during May 2009 with Registration No. S.O.R. 438/2009-10. The watershed society has two bank accounts in Indian Overseas Bank, Rampur branch, Chitradurga district; (1) Ramasagara watershed Project Account as Current Account and (2) Ramasagara Watershed Development Fund (WDF), Account for depositing the farmers contributions as Saving Banks Account. The contribution collected from the beneficiaries for implementation of various interventions up to 31st March 2014 was Rs. 5,90,636/- which includes accrued interest of Rs 62,040/-.

3. Entry point activities

Construction of a platform for village meetings and drinking water troughs for cattle, organizing of animal health camps, human health camps, soil sample tests and bore well water sample test were taken up as a part of Entry Point Activities (EPA). A sum of Rs.1,96,353/- (4.2% of the total watershed budget) was spent for meeting invariable common needs of beneficiaries in the first year of preparatory phase. The EPA activities developed good social rapport and confidence among the beneficiaries with the Project Implementing Agency (PIA) in implementing all the watershed activities through villagers' participation.

4. Institution and capacity building

Five training programs, two exposure visits, six *kisan goshtis* were organized involving an expenditure of Rs. 1,50,181/- (3.2% of total budget). Two group of farmers visited Research Farm of IISWC, Ballari, Zonal Agricultural Research Centre (ZARC) Babbur Farm, Hiriyur and KVK, Hiriyur. BAIF, Tiptur, AICRPDA Bangalore and KVK, Suttur and thereby exposed to the improved agricultural practices for increasing crop yields, agri-horticultural plantation, integrated farming system including low cost vermicompost units and improved farm machinery.

5. Watershed Development Works

Soil and water conservation/developmental works were implemented. Interventions consists of construction of contour/field bunding (41263 running meters), stone checks/stone

revetment in 330 ha, percolation pond, fish pond, agronomic practices and horticulture plantation with drip irrigation in arable lands. In non-arable lands, construction of spill way and repairs of the existing percolation tank, diversion drain, de-siltation in existing percolation tank, drainage line treatment with masonry drop weir/check dam, rock fill dams, stone revetment to the nala banks, afforestation, grass sod and runoff gauging stations installed. These watershed development works incurred higher expenditure of Rs. 26,28,507/- (56.4% of total budget).

6. Livelihood and income generation activities

Need based and local specific livelihood supporting means were provided to the indigent and landless beneficiaries. Interventions such as distribution of vegetable seeds for kitchen garden, construction of vermicompost units, dairy (cows), poultry and goats/sheep were implemented. Further, tailoring machines, specialized barber kits, artisan tools (blacksmithy and carpentry), groundnut decorticators, cycle weeders, seed-fertilizer drills were distributed among farmers. Project amount of Rs.5,38,290/- (11.5% of total budget) was spent on these activities covering 241 beneficiaries in the watershed.

7. Crop production and micro enterprises

Crop diversification activities in 85.0 ha of rainfed area and 34.4 ha irrigated area was taken up. Nearly 218 farmers were supplied with *Rhizobium* and *Trichoderma* for groundnut seed treatment to enhance N availability and protect crop against fungal diseases. Six human health camps, eight animal health camps with 14 cases of artificial insemination were also taken up. Expenditure of this activity was Rs. 6,69,401 (14.5% of total budget). Besides, Integrated Farming Systems (IFS) was also introduced to three farmers in the watershed through Ballari Centre's Research Project. In total, 184 farm families were benefitted by this Project.

Whole watershed Project expenditure of all the above activities was Rs. 46,63,547/- which tantamount to unit treatment cost of Rs. 9708/- per ha. Overall financial achievement was 89.7% of the targeted outlay of Rs. 52,00,069/-.

8. Monitoring and impact evaluation

8.1. Impact on reduction in runoff and soil loss

Runoff reduction and soil loss were measured by gauging stations equipped with automatic stage level recorder. The runoff during Pre-Project was 12.6% of the total annual rainfall and it reduced to almost 50% i.e. 6.3% during Post-Project period. As a result, the land treatment in the Post-Project period has retained 0.15 ha-cm of runoff at the terrace level as against 0.13 ha-cm in Pre-Project period. The soil loss after treatment in the watershed was 4.91 tons ha^{-1} $year^{-1}$ which was within the permissible soil loss limit of 6.0 t ha^{-1} $year^{-1}$ and it is much below than the estimated soil loss of 11 to 16 tons ha^{-1} $year^{-1}$ in untreated areas of this region.

8.2. Runoff water storage created and impact on groundwater recharge

A large volume of 45,810 m^3 of runoff storage space was created during the project period by the construction of water harvesting structures and de-siltation of percolation tank for increasing ground water recharge and soil moisture in the profile. Designed live storage capacity, potential water storage (average) capacity and actually utilized stored water (after excluding losses of seepage, ET and miscellaneous use) are 1.4 ha-m, 4.59 ha-m and 3.89 ha-m, respectively. Out of 3.89 ha-m of actually utilized stored water, 70% to 87% percolates deep into soil profile, of which a part is available for ground water recharge. The inherent permeability of structures' bed geology ensures the rapid percolation of stored water. The pump test of the bore well reveals that the geology of this area is active (35.28 m^3 day^{-1} m^{-1} of transmissivity) that helps in groundwater recharge. Groundwater recharge phenomena also points to the lopsided time of recharge effect, in the sense that a good rainfall year has the time lag extended to the succeeding year. Therefore, bore well pump yields were observed to be normal in the succeeding year even if it happens to be a below normal rainfall year.

8.3. Impact on increased groundwater utilization

Nearly 47 bore wells irrigated an area of 72.2 ha during Pre-Project period steadily increased by around 40% to 66 Nos during the last year of the watershed project i.e. 2013-14. After the project implementation the irrigated area gradually increased from 78.3 ha in 2009-10 (first year of project) to 154 ha i.e. 113% increase during 2013-14. The number of irrigations to the crops increased from 6 to 11 (Pre-Project period) to 10-15 (Post-Project period) and the depth of irrigation was around 10.0 cm in Post-Project period as against 7.5-10.0 cm in Pre-Project period. However the command area per well has indicated declining trend. The groundwater table from ground surface was around 30.3 m in Pre-Project year while it is around 48.5 m in Post-Project period due 40% increase in number of bore-wells. The total (drilling) depth of bore wells varies from 48.5 to 90.9 m showing an increasing trend consequent to the more number of wells drilled in the project period. The command area per well in Pre-Project period was 1.6 ha it reduced to 1.4 ha during project period indicating low water yield due to the overdraft of groundwater in excess of recharge. Besides the prospective scenario of increased irrigated area and crop production, there was distress in terms of decline in groundwater table, poor success rate in getting water from fresh bore wells drilling and increase in failure of existing bore wells rendering farmers to the debt trap.

8.4. Impact on land use pattern

Net cultivable area remained almost same in Pre-Project period (355.48 ha) and Post-Project period (355.18 ha). However, net irrigated area increased from 72.19 ha in Pre-Project period to 118.26 (2013-14) and 147.98 ha (2012-2013) in Post-Project period that contributed stable and enhanced production changing the economic complexion of watershed.

8.5. Impact on use of FYM and fertilizers

As compared to recommended rate of fertilizer for both rainfed and irrigated crops, the fertilizers use was 57-60% of N, 60-80% of P, 75% of K in Pre-Project and it was raised to 85% in N, 78-80% in P, 75% in K in Post-Project period, which indicates increase of fertilizers consumption in

rainfed crops due to adoption of rainwater conservation practices that improved profile soil moisture from crop sowing to harvest. In contrast, it was observed that the fertilizers use in irrigated crops in Pre-Project was more than the recommended rate by 138-160% in N, 143% in K, 120% in K. Hence, the farmers were educated to follow the recommended rate of fertilizer application; consequently fertilizer use was restricted to reduce cost of cultivation. Due to increase in cattle population, correspondingly availability and application of Farmyard Manure (FYM) increased.

8.6. Impact on crop production and micro enterprises

8.6.1. Impact on Crop diversification

For improving the crop yields of the rainfed crops especially groundnut, improved varieties like K-6 and TMV-2, ICTP-8203 of bajra, GCH-4 and DCH-177of castor, ICPL-87 and BRG-2 of redgram and C-152 of cowpea were introduced. In the irrigated area improved maize hybrid Super 900M Gold, Gangavathi Sona (GGV-05-01) of paddy and Super Mallika, Mallika Gold, Sarvodaya Kanaka and Sashyashamla of Bt. cotton were introduced. The increase in crop yield was 27-83% in good rainfall year (2010-11) and 22-33% in deficit rainfall years (2011-12 and 2012-13) in Post-Project period.

8.6.2. Impact on crop productivity : Rainfed situation

Increase in yields of bajra varied from 33 to 64%, groundnut yield increased from 22 to 33% and intercropping of groundnut and redgram yield was higher by 18+30% inside watershed compared to the yields of outside watershed. However, demonstration yields are higher than farmers' yields by about 84% indicating lack of application of micro-nutrients and better plant protection management.

8.6.3. Impact on crop productivity : Irrigated situation

In irrigated crops during *kharif* season inside watershed, the productivity increased from 25% (hybrid maize) to 72% (Bt. cotton) compared to 24% in Bt. cotton to 48% in paddy over those of outside watershed. During late *rabi,* the yield increase inside watershed varied from 9% in hybrid maize to 15% in paddy compared to outside watershed. A drip irrigated system installed at mango and sapota orchard yielded 450 kg of mango whereas irrigated hybrid napier that was introduced during project also yielded around eight tons of green grass during the last year of the project (2013-14).

8.7. Impact on fodder production from arable and non-arable lands

Fodder production has increased by 78% in project period mainly contributed by increased irrigated area. The average fodder requirement per family was 3.93 quintals per month during Pre-Project year which increased to 4.91 quintals per month in Post-Project year due to increased cattle population and to meet this demand hybrid napier was introduced in irrigated area.

8.8. Impact on Livestock outputs

Interventions like animal health camps, adequate fodder availability and artificial insemination increased animal productivity as well higher cattle population in the watershed. The bullocks hiring days increased from 4710 days pair^{-1} year^{-1} in Pre-Project to 4980 days pair^{-1} year^{-1} in Post-Project period. In Post-Project period, there was an increase by 19% and 30% in milk production (3,08,880 litters year^{-1}) and dung production (1339 tones year^{-1}). The gross returns of live stock outputs at Post-Project (2014-15) prices are Rs. 83.41 lakhs year^{-1}.

8.9. Impact on livelihood and income generation activities

Kitchen garden activity has produced 4124 kg of vegetables enriching the nutrition to some extent. Total vermicompost production reached to 378 quintals in Post-Project year (2014-15) and eventually reduced dependence on fertilizers from 5% to 25% apart from improving soil physical and chemical properties. Total value of vermicompost produced was Rs. 2,78,950 during project period. Dairy enterprise has yielded a total net returns of Rs. 1,81,852. Forty six farmers earned net returns of Rs.7,62,220 by rearing of sheep and goats during the Project period. Total net income from poultry birds (Giriraj) was Rs. 95,585. Further, the total net income was Rs. 18,36,990 in 3 to 5 years of Post-Project period from various income generation activities consisting the beneficiaries of sewing machines (tailoring) (Rs. 2,50,000), black smithy kits (Rs. 5,19,800), barbers tools (Rs. 4,77,000), masonry tools (Rs. 1,85,440), carpentry tools (Rs. 4,04,050) and others. Of all the income generation activities, rams rearing was found more successful followed by occupation of village artisans.

8.10. Impact on economic returns from technology interventions

In rainfed areas, the gross returns gained by technology interventions (SWC measures) was Rs. 16,910/- ha^{-1} at the capital cost of Rs. 2,578/- ha^{-1} in Post-Project period compared to Rs. 13,120/- ha^{-1} at the capital cost of Rs. 1,300/- ha^{-1} during Pre-Project period. In irrigated areas, the gross returns gained by technology interventions (Water harvesting works) were Rs. 77,897/- ha^{1} at the capital cost of Rs. 36,741/- ha^{-1}. Technology interventions (Water harvesting works) were almost absent in Post-Project period. The maintenance cost of land treated terraces increased from Rs. 77/- ha^{-1} in Pre-Project period to Rs. 328/- ha^{-1} in Post-Project period.

1. INTRODUCTION

1.1. Background

Watershed projects are recognized as potential drivers of agricultural growth and sustainable development in rainfed areas. Success and sustainability of watershed programs are directly related to collective action directed towards conserving natural resources for enhancing crop, tree and water productivity, livelihood security and gender equity. In recent years, the Government of India has accorded high priority to watershed development programs as a strategy for improving livelihood and ensuring sustainability especially in drought prone areas that are vulnerable to climate change impacts. Community participation is an important aspect of watershed development programs, and it is necessary to include equity and gender parity into the program design.

ICAR-Indian Institute of Soil and Water Conservation (IISWC), Research Centre, Ballari - has implemented an integrated watershed development program at Ramasagara which is farmer centric, holistic, and in participatory mode to conserve natural resources, increase agricultural productivity and stakeholder's income. The IISWC watershed model ensured improved productivity with the adoption of cost-efficient water harvesting structures, crop intensification with high-value crops and diversification of farming systems that allowed households to achieve increased production of basic staple food and sale of surplus for modest incomes.

Watershed projects are more rewarding in locations with low and unevenly distributed rainfall, low agriculture and animal husbandry productivity, little attention on secondary agriculture practices etc. The watershed implementation in such locations will make a big turnaround in improving livelihood status of the local farmers and improving their living standards. The Ramasagara was one such place where the watershed implementation was thought as an ideal strategy to attain multiple objectives of sustainable income generation of farmers through soil and water conservation measures aiming at groundwater recharge, soil fertility improvement and promoting secondary agriculture practices. Therefore conservation of natural resources such as rainwater, soil and vegetation is imperative to restore the natural resource base in the watershed. Thus National Watershed Development Project for Rainfed Areas (NWDPRA) model watershed was implemented in a participatory mode with the following objectives.

Objectives

- Conservation, development and sustainable management of natural resources including their use.
- To explore the possibilities of rainwater harvesting, recharge and it's recycling through irrigation of crops and fruit trees for greater productivity.
- To conserve rainwater, reduce soil erosion and improve soil water and nutrient status for higher productivity in the region on a sustainable basis.
- To disseminate and demonstrate improved crop management technologies through crop diversification and farming system for sustainable development of farming community.
- Restoration of ecological balance in the degraded and fragile rainfed ecosystems by greening these areas through appropriate mix of trees, shrubs and grasses.
- Creation of sustained employment opportunities for the rural community including the landless.

1.2. Location and general description

The Ramasagara watershed is located in Molkalmuru taluk, Chitradurga district of South Indian state of Karnataka. Ramasagara watershed is located near Rampur town, 40 km away from Ballari (**Fig.1.1**). Watershed spans over an area of 480.37 ha was selected for project implementation as a model watershed under the NWDPRA during 2008. The project was implemented during 2008 to 2014.

General terrain of the watershed comprises of rock outcrops, cliff and Rocky Mountains (> 45% slope) with sparse vegetation in the upper reaches and plain cultivating areas in the valley. Excess runoff from the hillocks and agricultural fields drains through the numerous *nalas* and reaches an ephemeral rivulet-Chinnahagari. The average annual rainfall of the watershed is about 417.3 mm rainfall and climate could be best described as arid. Due to low and erratic monsoon rainfall (June to October) in the watershed region, watershed is facing three severe drought, three drought and four normal rainfall years in a decade.

The mean maximum and minimum temperature in the watershed is around 33^{0}C and 20^{0}C, respectively. The soils in the watershed are red sandy loams with low water holding capacity. Soil depth varies from shallow (at ridge) to medium to deep (at valley) with gravel and pebbles. Soils are medium to deep with higher fertility levels in the lower reaches and in the valley due to accumulation of sediment from the upper reaches. The watershed is highly prone to erosion hazards in the absence of conservation measures and poor vegetation. Groundnut based mono-cropping system prevails in the watershed and it has been practiced over many decades. Prevailing climatic and edaphic constraints in the watershed are gradually paving the way for deterioration of soil fertility thereby reducing crop and vegetation productivity with diminishing farm family income over the years.

1.3. Inauguration of watershed project

Project implantation was inaugurated at Ramasagara village on 17.6.2009. The Chief Guest Mr. A.D. Manjunath, Member of Zilla Panchayat, Chitradurga addressed the farmers and asked them to utilize opportunity to reap benefits designed under new NWDPRA guidelines of Central Government. The Principal Investigator of the Project Dr. S.L. Patil explained to the farmers about soil and water conservation, new crops/cropping system demonstration, horticulture, forestry, vermicompost and livelihood activities to be implemented in the watershed on participatory mode by collecting farmers contribution for ensuring success of the watershed development project as per the new guidelines of the NWDPRA, Ministry of Agriculture, GOI, New Delhi. Dr. Shivarudrappa, Assistant Director (AH&VS) briefed about the animal health and different activities i.e. animal health camps, importance of animal feed and fodder. Er. R.N. Adhikari explained about the terrace level rainwater conservation practices proposed in the watershed. Dr. D. Chandrappa apprised the farmers that KVK, Hiriyur will also participate in the watershed activities. Mr. Hanumantha Reddy, ADA Molakalmuru, addressed the farmers and encouraged to utilize all the new and improved agricultural practices that are demonstrated in the watershed for increasing crop and animal productivity. Further, seed treatment with microbes (*Rhizobium* and *Azosprillium*) to increase the productivity and to control crop diseases (*Trichoderma*) was demonstrated. Dr. S.K.N. Math, advised beneficiaries of watershed to participate actively in all activities of the watershed and make this watershed as one of the best watershed in the region for demonstration to the others around Molkalmuru (see the glimses on page 4&5).

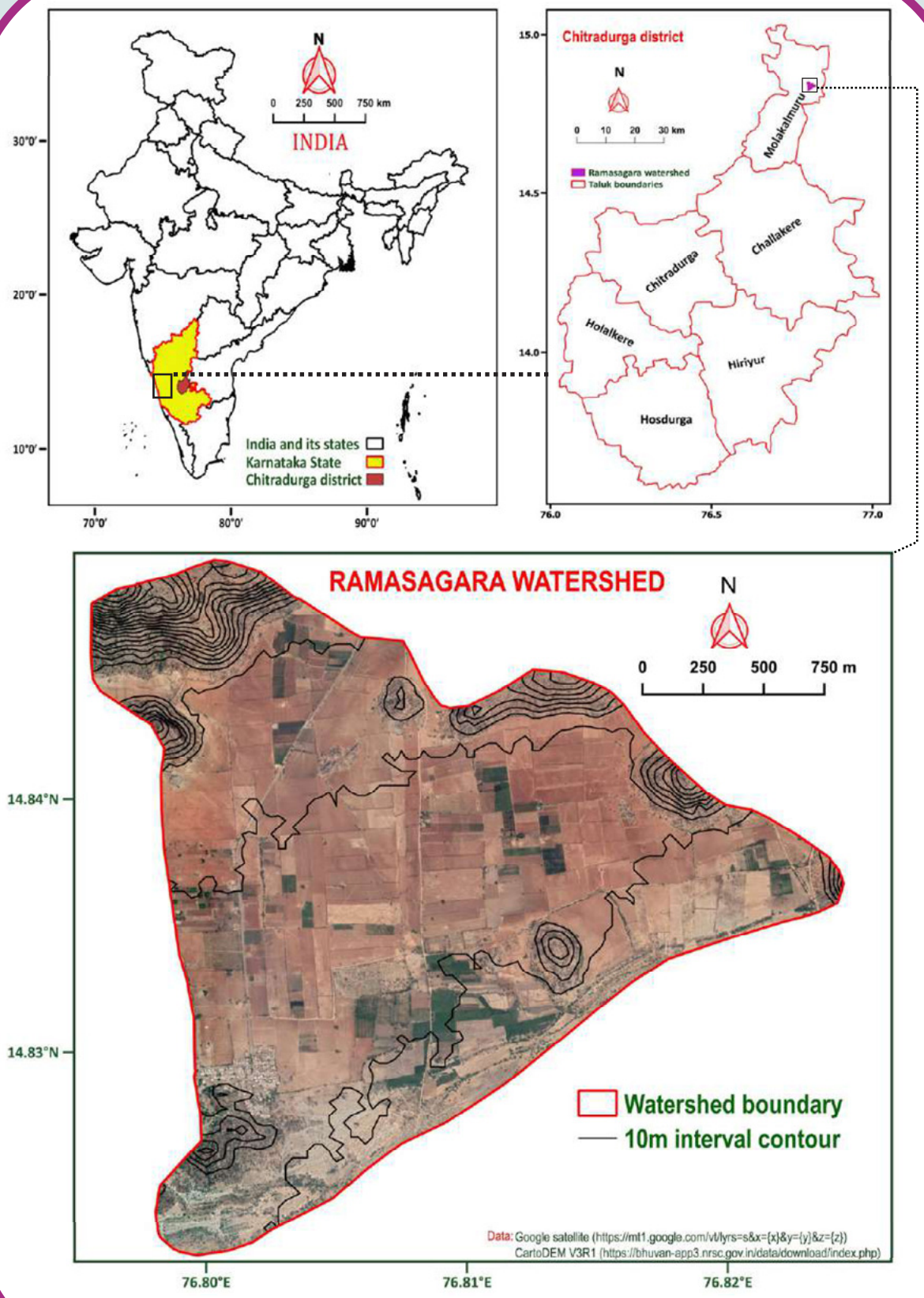


Fig. 1.1. Location of Ramasagara watershed in Chitradurga district of Karnataka State

Inauguration of Ramasagara watershed project

Seed treatment demonstration

Newspaper publication Of the Inauguration

ಜಲಾನಯನ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮ

ಮೊಳಕಾಲ್ಮೂರು, ಜೂ. 18: ಬಳ್ಳಾರಿ ಕೇಂದ್ರೀಯ ಭೂ ಮತ್ತು ಜಲ ಸಂರಕ್ಷಣೆ ಪರಿಶೋಧನೆ ಮತ್ತು ತರಬೇತಿ ಸಂಸ್ಥೆ ಪರಿಶೋಧನಾ ಕೇಂದ್ರದ ವತಿಯಿಂದ ಚಿತ್ರದುರ್ಗ ಜಿಲ್ಲೆ ಮೊಳಕಾಲ್ಮೂರು ತಾಲ್ಲೂಕು ರಾಮಸಾಗರ ಗ್ರಾಮದಲ್ಲಿ ಜಲಾನಯನ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮ ಏರ್ಪ ಡಿಸಲಾಗಿತ್ತು.

ಕಾರ್ಯಕ್ರಮ ಉದ್ಘಾಟಿಸಿ ಮಾತನಾಡಿದ ಮೊಳಕಾಲ್ಮೂರು ತಾಲ್ಲೂಕು ಪಂಚಾಯ್ತಿ ಸದಸ್ಯ ಎ.ಡಿ.ಮಂಜುನಾಥ್, ಸರ್ಕಾರಿ ಯೋಜನೆಗಳು ನೇರವಾಗಿ ರೈತರಿಗೆ ತಲುಪಲು ಇಂತಹ ಕಾರ್ಯ

ರಾಮಸಾಗರದಲ್ಲಿ ನಡೆದ ಜಲಾನಯನ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮವನ್ನು ತಾ.ಪಂ. ಸದಸ್ಯ ಮಂಜುನಾಥ್ ಉದ್ಘಾಟಿಸಿದರು.

ಕ್ರಮಗಳು ತುಂಬಾ ಸಹಾಯಕ ಪ್ರದೇಶಗಳಲ್ಲಿ ಕೈಗೊಳ್ಳುವ ಎಂದರು.ಸಂಸ್ಥೆಯ ಹಿರಿಯ ವಿಜ್ಞಾನಿ ಚಟುವಟಿಕೆಗಳ ಬಗ್ಗೆ ಮಾಹಿತಿ ಡಾ. ಎಸ್.ಎಲ್.ಪಾಟೀಲ್ ಪ್ರಾಸ್ತಾವಿ ನೀಡಿದರು. ಸಹಾಯಕ ನಿರ್ದೇಶಕ ಕವಾಗಿ ಮಾತನಾಡಿ, ಜಲಾನಯನ ಡಾ. ಶಿವರುದ್ರಪ್ಪ ಮಾತನಾಡಿ,

ಪಶುಪಾಲನೆ ಬಗ್ಗೆ ತಿಳುವಳಿಕೆ ನೀಡಿದರು. ಸಂಸ್ಥೆಯ ಮುಖ್ಯಸ್ಥ ಡಾ. ಎಸ್.ಕೆ.ಎನ್.ಮರ್ ಅಧ್ಯಕ್ಷತೆ ವಹಿಸಿದ್ದರು. ಕೃಷಿ ಇಲಾಖೆ ಸಹಾಯಕ ನಿರ್ದೇಶಕ ಹನುಮಂತರೆಡ್ಡಿ, ಹಿರಿಯೂರು ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರದ ಡಾ. ಡಿ.ಚಂದ್ರಪ್ಪ, ಕೃಷಿ ಅಧಿಕಾರಿ ಶೇಖರಪ್ಪ, ಜಲಾನಯನ ಸಮಿತಿ ಅಧ್ಯಕ್ಷ ಗುಡ್ಡದ ಗಂಗಣ್ಣ ಉಪಸ್ಥಿತರಿದ್ದರು.

ಜಿ.ಟಿ.ತಿಪ್ಪೇರುದ್ರಪ್ಪ ಪ್ರಾರ್ಥಿಸಿದರು. ಪಾಟೀಲ್ ಸ್ವಾಗತಿಸಿದರು. ಫಿ.ಎಸ್.ಪವನ್ ಕಾರ್ಯಕ್ರಮ ನಿರೂಪಿಸಿದರು. ಕೆ. ಕೆ.ರೆಡ್ಡಿ ವಂದಿಸಿದರು.

Glimpses of *Samyutkta Karnataka* and *Kannada Prabha* Newspaper report on the training programmes organized in the watershed

ಉದ್ಘಾಟನೆ... ಬಳ್ಳಾರಿಯ ಕೇಂದ್ರೀಯ ಭೂ ಮತ್ತು ಜಲ ಸಂರಕ್ಷಣಾ ಸಂಶೋಧನಾ ಘಟ್ಟು ತರಬೇತಿ ಸಂಸ್ಥೆ ಏರ್ಪಡಿಸಿದ್ದ ಜಲಾನಯನ ಚಟು ವಟಿಕೆ ತರಬೇತಿ ಶಿಬಿರ ವನ್ನು ಸಂಸ್ಥೆಯ ಡಾ. ಎಸ್.ಕೆ.ಎನ್. ಮರ್ ಉದ್ಘಾಟಿಸಿದರು.

ರಾಮಸಾಗರ ಜಲಾನಯನ ಪ್ರದೇಶದ ಫಲಾನುಭವಿ ರೈತರಿಗಾಗಿ ಬಳ್ಳಾರಿಯಲ್ಲಿ ಏರ್ಪಡಿಸಿದ್ದ ಜಲಾನಯನ ಚಟುವಟಿಕೆಗಳು ಕುರಿತ ತರಬೇತಿ ಶಿಬಿರವನ್ನು ಸಂಸ್ಥೆಯ ಮುಖ್ಯಸ್ಥ ಎಸ್.ಕೆ.ಎನ್.ಮರ್ ಉದ್ಘಾಟಿಸಿದರು. ಆರ್.ಎಸ್.ಅಧಿಕಾರಿ, ಡಾ. ಎಸ್.ಎಲ್. ಪಾಟೀಲ್ ಉಪಸ್ಥಿತರಿದ್ದರು.

2. BENCH MARK RESOURCE SURVEY AND ASSESSMENT

2.1. Watershed features

Watershed area covers Ramasagara, Devasamudra, Hanumapur and Venkatapur villages and lies between 14°49'31" to 14°50'42" N latitude & 76°47'32" to 76°49'16" E longitude with an altitudinal range of 500 to 600 m above mean sea level (MSL). The Ramasagara watershed is located in Agro-ecological region-3 (Hot Arid Eco-region with Red and Black soils) of India and Central dry zone of Karnataka.

2.2. Shape and Relief

The watershed is compact in shape and is likely to have shorter times of water flow concentration resulting in higher runoff rates. The average length and width of the watershed area are 2750 m and 1747 m, respectively with a length:width ratio of 1.57. Perimeter is 10.67 km. Therefore, the Compactness Coefficient is 1.36, Elongation ratio is 0.63, Circulatory ratio is 0.53 and Form factor is 0.63, suggesting the irregularity of watershed boundary and probability of rapid flood. Due to presence of hillocks in upper reaches, the maximum basin relief is 60 m however; average land slope in cultivated lands is 2.2%. The general features and morphological characteristics of the watershed are presented in **Table 2.1** and contour map of Ramasagara watershed is depicted in **Fig. 2.1.**

Table 2.1. General features and morphological characteristics of Ramasagara watershed

PARTICULARS	DETAILS
Agro-ecological region	3-Hot Arid Eco -region with Red and Black soils
Area (ha)	480.37
Elevation range (m amsl)	500-600
Average slope (%)	2.8
Cultivable land slope (%)	2.1
Length:Width ratio	1.57
Compactness co -efficient	1.36
Elongation ratio	0.63
Circulatory ratio	0.53
Form factor	0.63
Perimeter (km)	10.67
Watershed villages	Ramasagara, Devasamudra, Hanumapur and Venkatapur
Watershed code No	**4D3C6A2c** in Tunga Bhadra river valley which is a part of the Krishna basin
Latitude & Longitude	14°49'31" to 14 °50'42" N latitude & 76 °47'32" to 76 °49'16" E
Altitude	500 to 600 m above MSL
Crops cultivated	Groundnut, redgram, bajra, ragi, cowpea, greengram, hybrid sorghum, horsegram, sunflower, castor, cotton, maize, paddy, onion and chilli

2.3. Physiography

The watershed is located in the Krishna river basin as lower catchment of river Vedavathi (a tributary of Tunga-Bhadra River). The general slope of the watershed varies from 1% to 3% (2.1% average) in the arable lands (74% area of the watershed), except in the pasture land (4% area) where the slope varies up to 9% and hillocks in the upper reach with 20% to 30% (20% of the area of the watershed) slope (**Fig. 2.2**). The rainwater from the watershed area drains into a euphemeral rivulet, Chinna Hagari, which further flows into river Vedavati and joins the Tunga Bhadra River before confluence with Krishna River. The boundaries of the watershed conjoins boundaries of Rayadurg taluk of Anantapur district (Andhra Pradesh) in the East, in the West, Kudligi taluk of Ballari district (Karnataka), in the North, is Ballari taluk of Ballari District (Karnataka) and in the South, Challakere taluk of Chitradurga district (Karnataka).

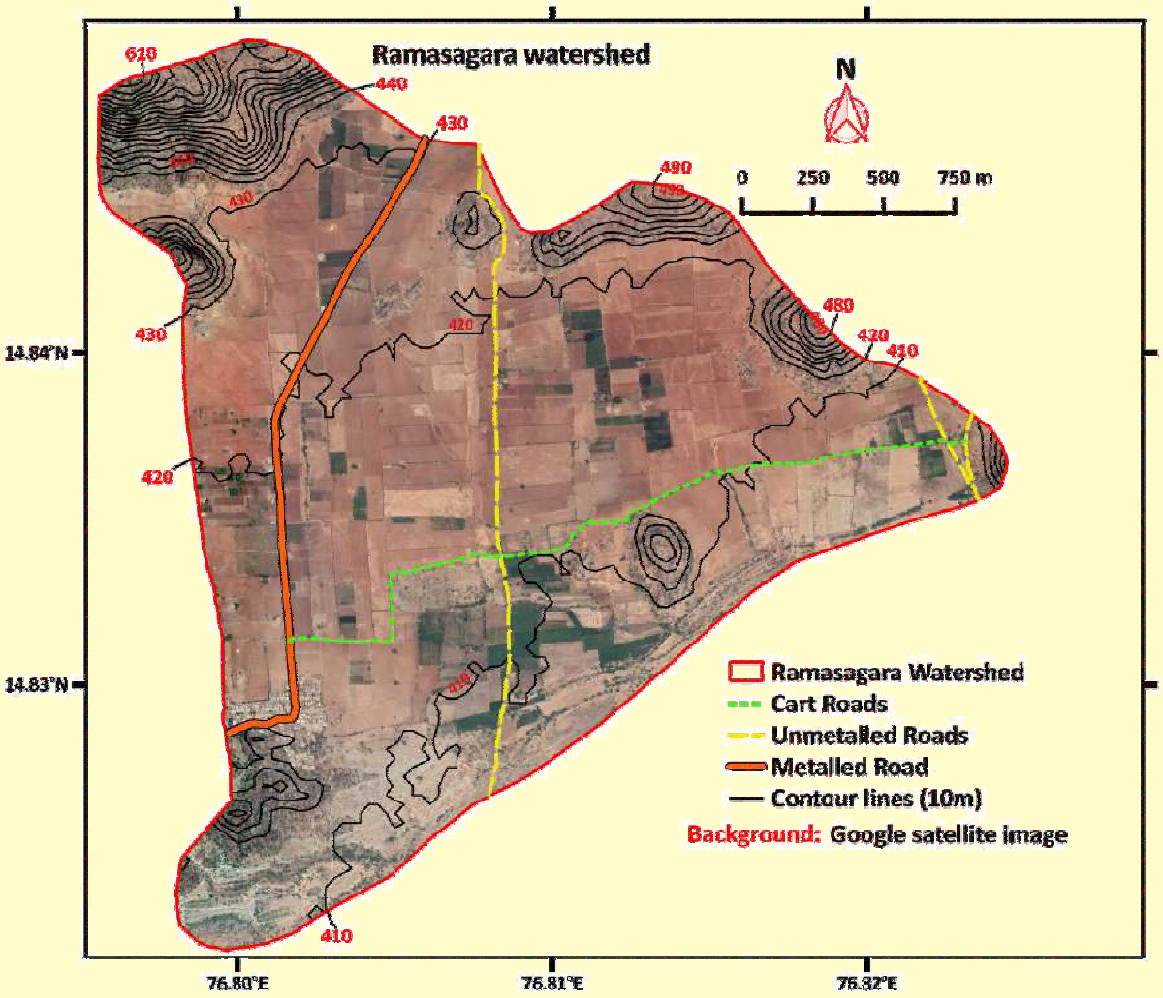


Fig. 2.1. Contour map of Ramasagara watershed

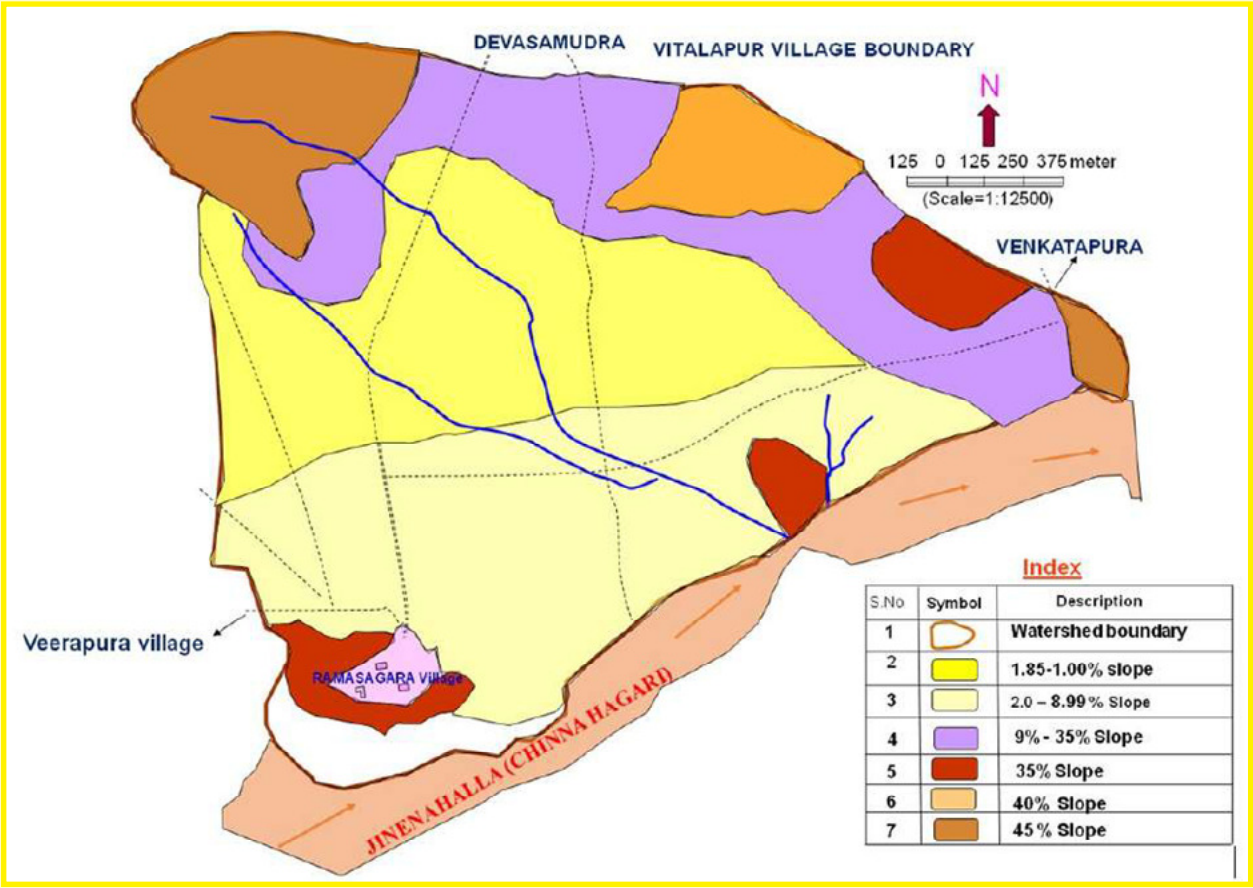


Fig.2.2. Slope map of Ramasagara watershed

2.4. Climate

The watershed receives the long term average annual rainfall of 417.3 mm distributed in 31 rainy days. Even though the watershed lies in the Semi-Arid region of Karnataka, however, mean annual rainfall is lower than 500 mm and this specific region is aptly classified as Arid. Nearly 80% of the total annual rainfall is received during the monsoon season from June to October. The rainfall distribution is highly erratic and about 10 to 20% of the rainfall received goes as runoff. It is not only the total rainfall, but also its ill distribution from June to October, causes frequent drought-years in the watershed. Nine years monthly average rainfall and number of rainy days (2005-2013) in the Ramasagara watershed area are presented in **Table 2.2** and **2.3** respectively, which shows higher average annual rainfall of 545.6 mm with annual variation ranges from 181.6 mm to 808.4 mm and rainy days also varied from 10 to 43. The years 2006, 2011 and 2013 were drought years, while ill distributed rainfall was received in crop season (March to August) in 2006, 2009 and 2012. The ground water supply is poor as most of the runoff flows into the *nalas* in the watershed within the few hours of the rainfall thereby limiting ground water recharge.

2.5. Geomorphology and Soils

2.5.1. Geomorphology

The area lies in the Vedavati river catchment, covered with red sandy loam soils that are derived from granites and gneiss. Numerable fractures on zones on prominent lineaments could also be identified in the watershed.

Table 2.2. Monthly average rainfall of Ramasagara watershed (Pre and Post Project)

Year	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
2005	--	--	--	4.2	41.4	--	133.4	109.6	133.2	133.4	34.4	--	**589.6**
2006	--	--	25.2	--	--	--	4.6	6.2	25.0	25.2	95.4	--	**181.6**
2007	--	--	--	65.6	54.0	138.8	30.2	23.2	205.6	148.4	3.0	1.0	**669.8**
2008	--	21.2	98.0	10.0	94.6	84.2	8.0	79.8	153.0	53.2	29.0	--	**631.0**
2009	--	--	0.2	--	195.8	15.2	--	110.0	126.2	172.6	98.0	--	**718.0**
2010	16.2	--	--	14.2	253.2	80.8	69.8	173.4	29.6	93.2	78.0	--	**808.4**
2011	--	--	--	11.2	85.6	78.0	45.9	43.3	5.7	112.3	9.6	--	**391.6**
2012	--	--	1.4	127.7	121.2	5.4	29.2	114.0	71.2	65.0	72.8	--	**607.9**
2013	--	--	--	3.8	97.6	18.0	49.8	28.8	68.8	16.0	--	--	**312.8**
Average	**1.8**	**2.4**	**13.9**	**26.3**	**104.8**	**46.7**	**41.2**	**76.5**	**90.9**	**94.4**	**46.7**	**0.1**	**545.6**

Table 2.3. Monthly rainy days of Ramasagara watershed in Chitradurga district

Year	Jan	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
2005	--	--	--	1.0	2.0	--	8.0	6.0	7.0	11.0	2.0	--	**37.0**
2006	--	--	1.0	--	--	--	--	1.0	3.0	2.0	3.0	--	**10.0**
2007	--	--	--	3.0	2.0	11.0	2.0	3.0	9.0	5.0	1.0	--	**36.0**
2008	--	1.0	7.0	1.0	4.0	3.0	1.0	8.0	8.0	3.0	2.0	--	**38.0**
2009	--	--	--	--	7.0	1.0	--	8.0	9.0	4.0	7.0	--	**36.0**
2010	2.0	--	--	2.0	7.0	5.0	4.0	9.0	2.0	6.0	6.0	--	**43.0**
2011	--	--	--	1.0	4.0	6.0	5.0	5.0	1.0	6.0	2.0	--	**30.0**
2012	--	--	--	4.0	3.0	--	4.0	7.0	8.0	3.0	3.0	--	**32.0**
2013	--	--	--	--	3.0	3.0	3.0	6.0	6.0	6.0	--	--	**27.0**
Average	**0.2**	**0.1**	**0.9**	**1.3**	**3.6**	**3.2**	**3.0**	**5.9**	**5.9**	**5.1**	**2.9**	--	**32.1**

2.5.2. Soils

The soils of the Ramasagara watershed are red sandy loam in the texture with varying soil depth from shallow (at ridge) to medium and deep (at valley). In general soil contains gravel and pebbles. Soil depth and fertility are higher in the lower reaches and in the valley due to higher sediment accumulation from the upper reaches and the ridges. The soils are low to medium in available N, P and K. The pH of soil is neutral with optimum electric conductivity (EC, dS m^{-1}).

2.5.2.1. Land Capability Classification (LCC)

Land Capability Classification (LCC) is crucial for appropriate land use planning consisting of practices like choice of vegetation/crops, tillage practices, use of scientific methods of cultivation and conservation practices. Detailed LCC survey carried out in Ramasagara watershed indicated that the prevailing LCC classes as II, III, VI and VIII. In addition, sub-class e indicates excessive erosion and sub-class; s-indicates shallow soil depth and limitation to root zone. The LCC map is shown as **Fig. 2.3.**

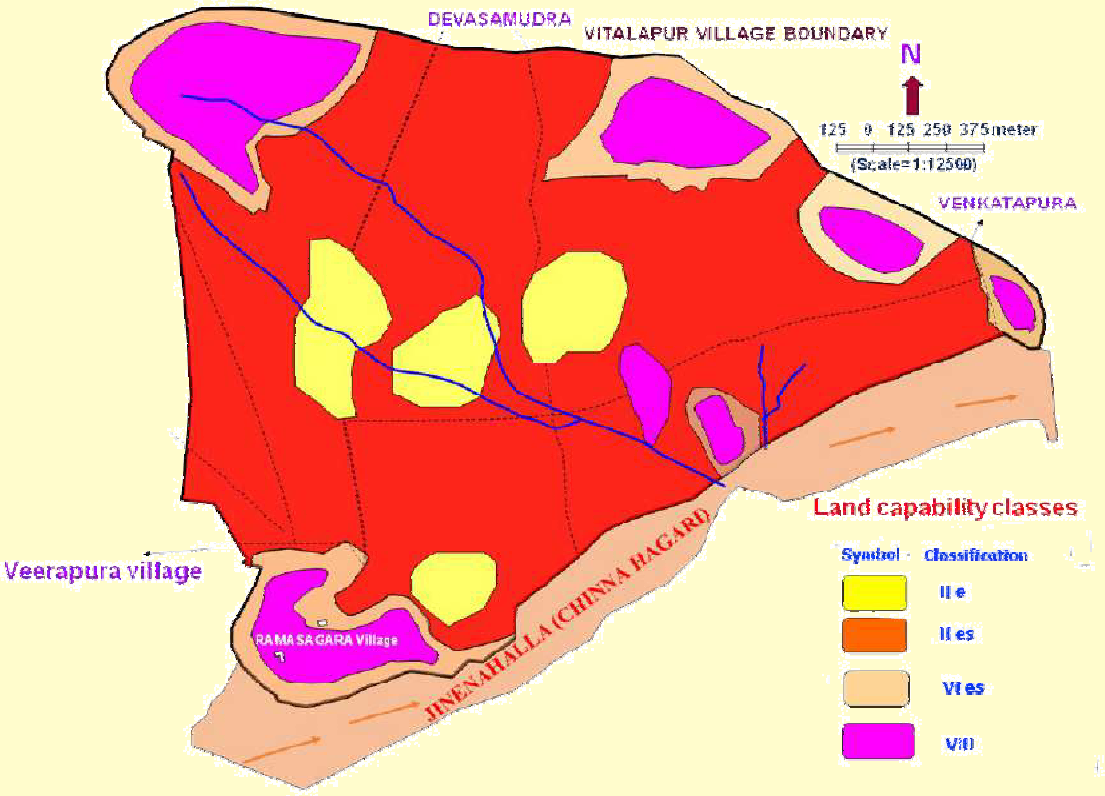


Fig. 2.3. Land Capability Classification (LCC) map of Ramasagara watershed

5.2.1.2. Land capability classification attributes

Detailed survey carried out in the Ramasagara watershed indicated that there are no class I, IV and V types of land in the watershed and a majority of the area falls under Class III category (70.3%), followed by class VIII, class VI and class II (**Table 2.4**). Farming is done in Class III lands. The land capability classification of the Ramasagara watershed indicates a moderate degree of hazards and limitations for use of the land under homogenous mapping units. Areas categorized as Class II are nearly leveled lands and crops are cultivated under rainfed and irrigated conditions using water from bore-wells. Class VIII lands comprise hillocks with exposed rock outcrops with sparse vegetative cover of trees and grasses.

Table 2.4. Area under various LCC classes in Ramasagara watershed

LCC class	Area (ha
IIe	53.20
IIIes	338.07
VIes	18.81
VIII	70.29
Total	480.37

The watershed has substantial area under class III (338.07 ha). These lands have medium to coarse texture, moderate slope and are being used for agriculture. However, class VI lands are more susceptible to erosion due to steep slopes and loose coarse texture and, need appropriate conservation measures including afforestation and pasture development to reduce erosion. These lands are generally under native pasture or forest. Class VIII lands are situated on the upper reach of the watershed with hillocks and water stream course. Prevalent conditions demands site specific conservation measures. As a thumb rule, the precipitous and rugged rocky stretches of this area should be maintained as a 'touch me not' eco-zone.

2.5.3. Physical attributes

Soil textural attribute derived from analysing 253 samples, indicated that most of the soils are sandy loam in nature with the sand content ranging from 65-78% and clay content vary from 9.4 to 14.9%. Thus, soils are very coarse nature with low water retention characteristics. Relatively, higher clay content was recorded in samples drawn from lower reaches of the watershed.

2.5.4. Fertility status of soils in the watershed

Assessment of the soil fertility status in a watershed was carried out for efficient soil management and cropping systems for sustainable yields. Composite soil samples in surface soil (0-15 cm) from 253 locations were collected from the watershed by considering their physiographic units. Samples were analyzed for pH, EC, organic carbon (OC), available N, P_2O_5 and K_2O and micronutrients i.e. Zn, Cu, Fe and Mn. Results revealed that Nutrient Index of organic carbon (g kg^{-1}), available N (kg ha^{-1}) and zinc (mg kg^{-1}) were very low and nutrient index was medium for available P_2O_5 and K_2O in the watershed. The extent of deficiency of organic carbon, nitrogen and zinc was 63%, 86% and 58% respectively. The study indicated that the low organic carbon and nitrogen in soils were attributed to low application rates of organic material, high temperature and low rate of application of N fertilizers, especially in the rainfed areas. To build up organic matter, nitrogen and maintain nutrient balance in the soil, farmers are advised to adopt FYM and $ZnSO_4$ application, crop rotation of groundnut with bajra, intercropping of groundnut with redgram in the rainfed areas. Whereas in irrigated areas, crop rotation along with application of FYM, SSP and $ZnSO_4$ recommended to enhance crop productivity and soil fertility.

2.6. Rainfed areas

The soil pH and EC are lower in the upper reaches but increase in the middle and lower reaches of the watershed where LCC class II and III lands prevails. The pH of LCC class II ranges from 7.1 (upper reaches) to 7.7 (middle reach), whereas LCC class III lands pH varied from 7.6 to 7.8. In fact, the soils of rainfed area are neutral in reaction. The EC in the rainfed soils is usually low and in the watershed it ranges from 0.07 dS m^{-1} (upper reach) to 0.22 dS m^{-1} (middle reach) in class II lands, while it was 0.10 dS m^{-1} (upper reach) to 0.17 dS m^{-1} (lower reach) in class III lands. This range of EC in rainfed lands is classified as good. Class VI lands have high pH (9.2) and EC (1.58 dS m^{-1}).

Organic carbon (OC) content varies from 2.8 g kg^{-1} to 3.5 g kg^{-1} in the class II lands while in class III lands it ranges from 3.3 to 3.6 g kg^{-1}. These soils are classified as low in OC content. These soils are very low in available N, the values ranging from 125 to 158 kg ha^{-1} in class II lands while in class III lands N availability is slightly higher (171 to 210 kg ha^{-1}). The OC (4.0 g kg^{-1}) and available N (245 kg ha^{-1}) are low in class VI lands.

Available phosphorus (P_2O_5) varied from 36 to 56 kg ha^{-1} in class II lands whereas in class III land it varied from 37 to 65 kg ha^{-1}. These soils are medium to high in available P with a majority of soils being classified as medium in available P content. The available K (K_2O) varied from 166 to 338 kg ha^{-1} in class II lands, while it is 270 to 298 kg ha^{-1} in class III lands indicating that these soils are medium in available K. The class VI lands are medium in available P (48 kg ha^{-1}) and K (290 kg ha^{-1}).

Zinc availability is low in class II land (0.57 to 0.67 mg kg^{-1}) and low to medium in class III lands (0.80 to 1.20 mg kg^{-1}) indicating that Zn has to be applied at 10 kg ha^{-1} $ZnSO_4$ at least once in 2 years. These red soils are not deficient in other micronutrients i.e. Cu, Fe and Mn. The Cu availability varied from 2.09 to 2.54 mg kg^{-1} while Fe availability ranged from 7.01 to 11.56 mg kg^{-1}. The Mn availability was very high and ranged from 15.58 to 37.40 mg kg^{-1}. In class VI lands the availability of micronutrients is higher compared to class II and III lands. The available Zn is medium (1.60 mg kg^{-1}) while Cu (4.41 mg kg^{-1}), Fe (31.64 mg kg^{-1}) and Mn (33.80 mg kg^{-1}) are very high in status.

Farmers in the region traditionally practice groundnut mono-cropping with *bajra* as crop rotation during late onset of monsoon or drought years and they normally apply FYM at 5 t ha^{-1} once in 3 years with application of Di-ammonium phosphate (DAP) at 50 kg ha^{-1}. To improve soil fertility, farmers need to apply FYM at the rate of 5 t ha^{-1} once in a year along with recommended rate of fertilizer i.e. 25:50:25 kg of NPK ha^{-1}.

2.7. Irrigated areas

The pH of class II and III lands varied from 8.2 to 8.6, while the EC ranged from 0.28 to 1.38 dS m^{-1}. Values of pH and EC increased from upper reach to lower reach in both class II and III land with higher values being recorded in class III lands. The OC was higher as compared to the rainfed area. The OC in class II lands varied from 4.8 to 5.2 g kg^{-1} while it ranged from 4.5 to 6.3 g kg^{-1} in class III lands. These soils are classified as low to medium in OC content. The available N was low in both class II and III lands and ranged from 190 to 285 kg ha^{-1}. The available P was medium and it varied from 36 to 55 kg ha^{-1} while available K was medium and ranged from 294 to 333 kg ha^{-1}. Low to medium status of nitrogen and phosphorus in cultivated fields might be ascribed to regular uptake of nutrient by crops, which tended to deplete nutrient status in soils. The trend in availability of micro-nutrients in irrigated area was similar to rainfed areas in the watershed with Zn availability being low to medium with 0.74 to 1.65 mg kg^{-1} in class II and III lands. Both Cu and Fe availability range from high to very high in class II and III lands. The availability of Cu varies from 2.46 to 4.72 mg kg^{-1} while Fe availability is 7.97 to 27.72 mg kg^{-1}. Deficiency of Mn in these soils doesn't exist as these soils are very high in available Mn and it varies from 20.79 to 38.68 mg kg^{-1}.

Generally, farmers are cultivating hybrid sorghum, paddy, maize and cotton in the irrigated areas and apply 5 to 10 t ha^{-1} of FYM along with almost recommended rates of fertilizers for all the irrigated crops. However, soil test values indicate that it will be beneficial to apply a minimum of 10 t ha^{-1} of FYM with 20 kg $ZnSO_4$ and micro-nutrients for improving soil physical properties and fertility with sustainable crop yields. Farmers are also advised to cultivate pulses and oilseeds as crop rotation in irrigated areas.

Nutrient Index (NI) was low for organic carbon, available N and Zinc while it was medium for available P and K. Nearly 63% of the soil samples were classified as low in OC content with NI of 1.15. The status of available N was low for 86% of the samples representing the watershed. Reports indicated (Katyal *et al.*, 1997) that nutrient removal by crops was in excess than the quantity applied through fertilizers resulting in a negative balance of 5.5 million tonnes of NPK. The available P and K status for more than 50% of the samples analyzed were in the medium category with NI of 2.30 and 2.38, respectively. The main problem of an unbalanced availability of nutrients in the watershed is attributed to continuous application of DAP fertilizer due to its high nutrient value of N (18%) and P_2O_5 (46%), non-availability of SSP due to Government policy and its

production in India. Reports suggest that application of SSP for crops increases yield by 17-41% in food grains, 18-32% in pulses, 16-33% in oilseeds and 17-45% in vegetables. Besides this, it helps to protect the soil from disintegration, promotes nodulation in legumes, removes soil acidity and compaction and restores soil health (Reddy, 2011). Venkateswarlu and Mishra (1987) reported that application of Zinc up to 12 kg $ZnSO_4$ ha^{-1} significantly increased grain and straw yields of rainfed wheat on sandy loam soils of alluvial origin in Varanasi. Groundnut yields in the watershed are 4.71 q ha^{-1}, which increased by 30% to 6.13 q ha^{-1} by the introduction of improved variety (K 6) and if recommended quantities of zinc were applied, these yields could potentially increase by 55% (Srinivasarao *et al.*, 2008) in the area, indicating a pressing need for the use of micronutrients to enhance yields.

Investigations on the assessment of soil fertility in Ramasagara watershed in the semi-arid tropics indicated low nutrient index and score is <1.5 for OC, N and Zn. Soil enrichment for replenishing deficit essential elements could significantly increase crop yields leading to increased food and nutritional security of the stake holders. Application of FYM, vermicompost and Zn as $ZnSO_4$ along with application of recommended nutrients are urgently required to improve soil fertility and crop productivity on sustainable basis.

2.8. Drainage

In this arid catchment, the rainfall/climate decides the drainage pattern model rather than shape of watershed. The entire runoff yield is derived from surface runoff draining intermittently in rainy season and completely dry during rest of the period. Length of main drainage line is 2750 m with drainage density of 1.52 km km^{-2}. The stream orders delineated in the watershed are presented in the **Table 2.5**.

Table 2.5. Drainage pattern in the watershed

Stream order	No. of streams	Length (m)	Bifurcation ratio
1st order	5	4700	2
2nd order	2	1950	4
3rd order	1	650	-
Total	**8**	**7300**	

As 20% of the watershed area is covered with hillocks (20-30% land slope) and 4% with pasture land (9% land slope), the 1st order streams are most prominent features in the watershed (4700 m) which proceed into 2nd order streams without any protection measures paves the way for gully formation. High drainage intensity (1.52 km km^{-2}) indicates rapid drain of watershed, which needs to be reversed for attaining maximum water storage by enhancing time of water residence. The drainage line is choked with excessive vegetation, siltation and encroachment. Thus, the drainage line is not able to discharge runoff volume; which spill over and flood farmers fields. The resultant top soil erosion on arable lands leads to low productivity.

2.9. Vegetation

Around 97 ha area is under hillock (20.2% of the total area), which is covered with scarce scattered vegetation. The vegetation in the Pre-Project period is highly degraded and is confined to the upper reaches of non-arable area with mixed ground flora. The vegetation cover in arable

areas is also very scarce. Major vegetation in hillocks consists of *Dodonaea viscosa, Cassia auriculata* and *Randia spp* bushes. *Acacia nilotica and Azadirachta indica* are common tree found on bunds of farmlands with low density. *Nala* bed in the lower reaches was infested with *Prosopis juliflora.* Vegetative cover in the Pre-Project period is degraded due to biotic interference. The natural vegetation of the watershed consists of *Acacia nilotica, Azadirachta indica and Prosopis juliflora.* In the hillocks and on the roadside the prominent shrubs include *Agave sisalana, Euphorbia tirucalli* and *Prosopis juliflora.* Very few trees like *Emblica officinalis, Ficus religiosa, Prosopis cineraria, Pongamia pinnata, Tamarindus indica* and *Mangifera indica* have been planted on agriculture lands in some areas.

2.9.1. Grasses

Pasture land of 18.69 ha (3.9% of total area) is available as common grazing land. This portion of land consists of fodder grasses like *Cenchrus ciliaris, Cynodon dactylon, Dichanthium annulatum, etc.* Due to lack of controlled grazing and low rainfall, it is degraded and hence, has low carrying capacity and productivity. Nala, passing through the pasture, accommodates sporadic

2.10. Socio-economic survey

Total population of the Ramasagara watershed was 1056 during Pre-Project period and increased to 1113 during Post-Project period with an average family size of 6 persons. During Post-Project period, there are 184 farm families residing in the watershed with 36% male, 33% female and 31% children population (**Tables 2.6** and **2.7**). In the watershed 21% of farm families holds <1 ha land and classified as marginal farmers, whereas 47% of families holds 1 to 2 ha and belongs to small category. Further, 24% families have land holdings between 2 ha to 4 ha, whereas farmers with land holding >4 ha are only 8% of the total farm families during Post-Project period. General economic condition of the farm families is poor. During Post-Project period the marginal and small have increased up to 21.2% and 46.7% (7 families each) whereas large family land holding (2-4 ha) and >4 ha have decreased by 4 and 1 family, respectively (**Table 2.8**).

Literacy rate of the farmers is low (15%). Among the beneficiaries in the watershed, only nine farmers have pucca houses. Nearly 124 farmers in the watershed have semi-pucca houses and 51 farmers are residing in the kachha houses. There were three tractors owned by large farmers in the watershed. Farmers who having irrigation facilities (bore wells) also have sprayers and electricity powered pump sets for lifting water from bore wells. Nearly 50 farm families own chaff cutters. There was no State Government transport facility in the watershed for daily commutation to nearby villages and towns. Auto Rickshaws/Tempos were operating as only means of transport. Professionally, all the families in the watershed are engaged in agricultural works except five beneficiaries who are employed in Government service and 8 in private factories on regular employment. Work oriented seasonal migration prevailed in the watershed and around 120 people visit to the nearby towns/cities during summer for work as there is no agricultural activities occurs in the watershed.

Table 2.6. Pre-Project demographic profile of the Ramasagara watershed (2008-09)

Land Holding size	No. of families	< 6 years		6 - 14 years		> 14 years		Total
		Male	Female	Male	Female	Male	Female	
< 1.0 ha	32	5	12	25	21	57	51	**171**
1-2 ha	79	24	24	39	37	178	149	**451**
2 - 4 ha	49	20	23	32	33	122	103	**333**
> 4.0 ha	15	7	3	10	**4**	36	41	**101**
Total	**175**	**56**	**62**	**106**	**95**	**393**	**344**	**1056**

Table 2.7. Post-Project demographic profile of the Ramasagara watershed (2013-14)

Land Holding size	No. of families	< 6 years		6-14 years		> 14 years		Total
		Male	Female	Male	Female	Male	Female	
< 1.0 ha	39	9	11	38	30	66	69	**223**
1-2 ha	86	29	31	36	44	185	164	**489**
2- 4 ha	45	14	18	29	27	120	98	**306**
> 4.0 ha	14	5	3	11	2	34	40	**95**
Total	184	57	63	114	103	405	371	1113

Table 2.8. Changes in land holding in the pre-project and post-project period

Land Holding size	Pre-Project (2008-09)		Post-Project (2013-14)	
	No. of families	% to total	No. of families	% to total
< 1.0 ha	32	18.3	39	**21.2**
1-2 ha	79	45.1	86	**46.7**
2-4 ha	49	28.0	45	**24.5**
> 4.0 ha	15	8.6	14	**7.6**
Total	175	100	184	100

2.11. Natural Resource Base

Out of 480.37 ha area of Ramasagara watershed, both agricultural and horticultural crops have been cultivated over an area of 355.48 ha. Major chunk of land area has been subjected to rainfed farming whereas irrigated land-use accounts a paltry. Transact of the watershed indicates the upper reaches has a hillock with open scrub forest of *Randia*, *Acacia* and *Prosopis julifloara* (**Fig. 2.4**). At base of the hillock the agricultural crops (rainfed and irrigated crops) are being cultivated (**Table 2.9**). In the middle and lower reaches both agricultural and horticultural crops are being cultivated as rainfed and irrigated with rainfall and borewell water, respectively. The red sandy loam soils in the watershed are well drained and the clay and silt content of the soil increases from the upper to the lower reaches of the watershed.

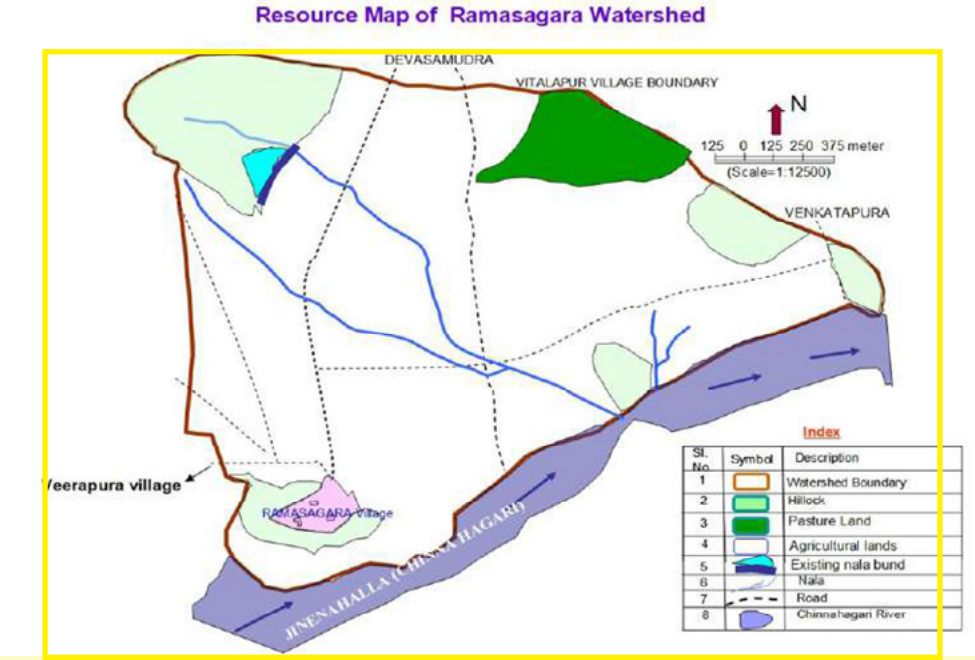


Fig. 2.4. Resource map of the village Ramasagara

Table 2.9. Natural resource base existing in different reaches of Ramasagara watershed

S. No.	Resources	Upper reach	Middle reach	Lower reach
1.	Vegetation	*Acacia spp., Agave, Euphorbia tirucalli,* Neem and *Prosopis juliflora.*	Acacia, Agave , *Euphorbia tirucalli,* Neem , *Prosop is juliflora,* Tamarind and Teak.	Acacia, Agave, *Euphorbia tirucalli,* Neem , Tamarind and Teak.
2.	Grasses	*Heteropogon contortus, Cenchr us ciliaris* and *Cymbopog on martini i.*	*Cenchr us ciliaris* and *Cymbopog on martinii.*	*Cenchr us ciliaris* and *Cymbopog on martinii.*
3.	Soil	Red sandy to red sandy loam.	Red sandy loam.	Red sandy loam.
4.	Crops	Maize, ragi, paddy, chilli, groundnut, castor and bajra.	Maize, ragi, paddy, chilli, groundnut, bajra castor, cowpea and redgram.	Maize, paddy, chilli, ragi, bajra, castor, groundnut, cowpea, and redgram.
5.	Fruits and Plantations	Sapota, Mango and Tamarind.	Sapota, Mango, Banana and Tamarind.	Sapota, Tamarind, Banana and Mango.
6.	Vegetables	Chilli, Coriander, Lady's finger and Onion.	Chilli, Lady's finger, Ridge gourd, beans and Onion.	Lady's finger, Ridge gourd, beans and Onion.
7.	Livestock	Buffalo, sheep, goat and cow.	Buffalo, sheep, goat and cow.	Buffalo, sheep, goat, and cow.
8.	Land use	Forest, Cultivable land.	Cultivable land, Shrubs.	Cultivable land and Village habitation.
9.	Water source	Seasonal water spring.	Seasonal water spring.	Ephemeral Vedavati River.

A typical cross section of the watershed is depicted in **Fig. 2.5**. In the arable lands the slope varies from 1% to 3% (2.1% mean). The slope is less than 1% in the irrigated area and 1% to 3% in the rainfed area. In the pastureland, the slopes varies up to 10%, whereas, in the hillocks the slope varies up to 30%.

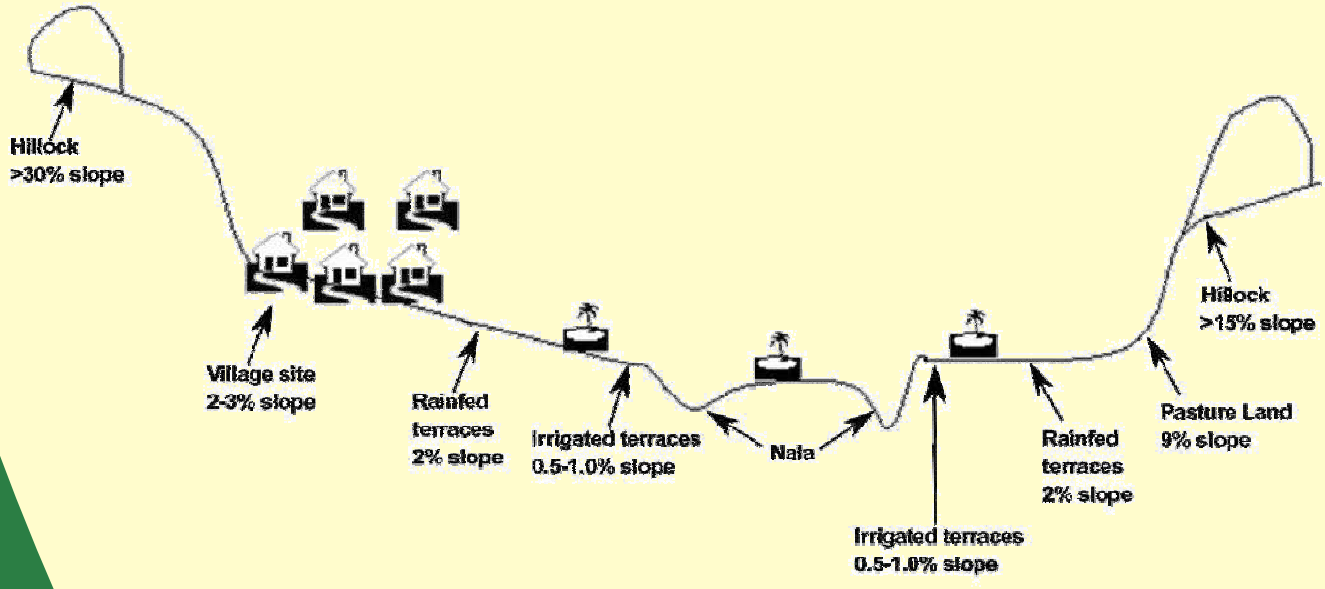


Fig. 2.5. A typical cross section of land use in Ramasagara watershed

2.12. Agriculture

2.12.1. Land use pattern

Agricultural land use predominates in Ramasagara watershed (Central Dry Zone of Karnataka) and details are presented in **Table 2.10.** The per cent of the net sown area in the watershed is higher (74%) than average net sown area of Chitradurga district (51%) and Karnataka State (52%). The area under rainfed and irrigation in the watershed is almost similar to the Chitradurga area and much higher than area of the Karnataka State. In the watershed out of the total 480.37 ha nearly 74% of the area is arable (355.18 ha) and 26% (125.19 ha) is non-arable land under hillocks, pasture land and roads, village etc. The arable land includes cultivated land (rainfed/irrigated) and fallow land varied on rainfall situations and farmers economy status. During 2013-14 the area under rainfed has decreased from 258.90 ha (Pre-Project) to 175.01 ha and the percentage decrease was nearly 32% (**Table 2.10**). The reason for decrease area under rainfed is attributed to increase in the area of current fallow (rainfed) from 24.39 ha to 61.91 ha, and it was mainly attributed to low rainfall received during 2013 in general and especially during sowing period, i.e. June and July in particular. Even the area under irrigation has increased from 72.19 ha during Pre-Project to 147.98 ha during 2012-13 and the per cent increase was 105%. Greater area under irrigation during 2012-13 was attributed to increased number of bore wells and higher available water from bore wells and also higher rainfall received during 2012 (607.9 mm) that might have recharged the ground water. The area under irrigation decreased to 118.26 ha during 2013 was attributed to the lower rainfall that fell during 2013 (312.8 mm) and it was only 64% of the normal year-rainfall in the region. The area under irrigation during Post-Project period has increased by 64% compared to Pre-Project period. However, rainfall regularity over the years plays a major role in the increase or decrease in the irrigated area in the watershed/region coupled with increase number of bore-wells. The non arable area prior to and after watershed implementation period has slightly increased due to conversion of agricultural lands for construction of houses in the Ramasagara village (**Table 2.10**).

Table 2.10. Land Use Pattern (area in ha) in the Ramasagara Watershed

S. No.	Particulars	Pre-Project	Post-Project				
		2008-200zzz	2009-10	2010-11	2011-12	2012-13	2013-14
Arable							
1	Rainfed	258.90	244.99	225.36	218.31	152.88	175.01
2	Protective Irrigation	72.19	78.30	109.29	120.11	147.98	118.26
3	Current Fallow (Rainfed)	24.39	32.19	20.83	17.06	54.32	61.91
Sub Total		**355.48**	**355.48**	**355.48**	**355.48**	**355.18**	**355.18**
Non-Arable							
1	Hillock	97.00	97.00	97.00	97.00	97.00	97.00
2	Pasture Land	18.69	18.69	18.69	18.69	18.69	18.69
3	Others (Roads, Village site)	9.20	9.20	9.20	9.20	9.50	9.50
Sub Total		**124.89**	**124.89**	**124.89**	**124.89**	**125.19**	**125.19**
Grand Total		**480.37**	**480.37**	**480.37**	**480.37**	**480.37**	**480.37**

2.12.2. Crops and cropping pattern

Groundnut is the major crop in the watershed that is also a major crop cultivated under rainfed situations by the farmer's in the red soils of Central Dry Zone of Karnataka. Mono-cropping of groundnut as a sole crop and intercropped with redgram/ragi/bajra/cowpea/ horsegram/castor/greengram. Contingent crops like bajra, ragi, sorghum and horsegram are usually sown during delayed onset of Southwest monsoon beyond July for subsistence, limited income and to ensure fodder for the animals. The productivity of crops depends on the onset, amount and distribution of SW monsoon during rainy season. The productivity of groundnut is low in the watershed and is attributed to continuous mono-cropping of groundnut and frequent dry spells and droughts and partially due to inadequate soil and moisture conservation measures. Mono-cropping with groundnut (about 90% of rainfed area) resulted in deficiency of sulfur and zinc in the watershed. Application of farmyard manure (FYM), gypsum and fertilizer containing sulfur are inadequate. Crop rotation with cereals and legumes with improved groundnut cultivars can considerably increase the productivity of groundnut and other crops cultivated as crop rotation. Indigenous implements are adequate for the tillage and cultural operations. However, use of manual groundnut decorticator helps in reducing the human drudgery and better seed germination. In irrigated lands, groundwater lifted through borewells is the main source of water and crops like Hybrid maize, Bt. cotton, Hybrid sorghum, paddy, chilli, bajra, sunflower, groundnut and horticultural annual crops like onion, green chilli, cucurbits were cultivated during *kharif, rabi*, and summer. Perennials like mango, coconut and pomegranate were also cultivated with irrigation.

2.13. Livestock population

Total livestock population of the watershed was 1066 during Pre-Project period (2008-09) and increased up to 1305 during Post-Project period (2013-14). Buffaloes were preferred as milch animals compared to cows. Goats are kept mainly for the meat purpose. Homestead poultry rearing is common among marginal farmers. During Post-Project period, nearly 12.7% of the animal population in the village was used for the draft purpose, whereas, 19.0% of the animal population meets the milk requirement of the village (Cows and buffaloes). Nearly 58.0% of the animal population meets the meat and chicken requirement of the village indicating larger dependence of the villagers on meat and chicken. The details of livestock population (in No's.) in the project area during the Pre-Project (2008-09) and Post-Project (2013-14) period were presented in **Table 2.11** and **Table 2.12**, respectively.

Table 2.11. Details of livestock population (in No's.) during the Pre-Project (2008-09)

Land Holding size	No. of families	Bullocks	Cows	Buffaloes	Young Stock	Goats	Sheep	Poultry birds	Others
< 1.0 ha	32	20	19	03	10	26	10	10	1 (Horse)
1- 2 ha	79	75	18	55	46	118	165	42	0
2- 4 ha	49	52	18	45	39	20	50	65	0
> 4.0 ha	15	10	06	24	19	20	70	10	0
Total	**175**	**157**	**61**	**127**	**114**	**184**	**295**	**127**	**1**

Table 2.12. Details of livestock population (in No's.) during the Post-Project (2013-14)

Land Holding size	No. of families	Bullocks	Cows	Buffaloes	Young Stock	Goats	Sheep	Poultry birds
< 1.0 ha	39	24	20	14	18	72	64	13
1-2 ha	86	80	28	67	50	148	189	48
2-4 ha	45	54	30	48	46	25	18	59
> 4.0 ha	14	08	13	27	20	25	82	15
Total	184	166	91	156	134	270	353	135

2.14. Problems and needs of the area

Problem identification and prioritization

Low crop productivity, lack of food sufficiency, economic growth, livelihood security, and stable ground water were identified as the major issues to be addressed in the watershed area. Low rainfall, its erratic distribution with few high intensity events coupled with undulating topography and inadequate adoption of soil and rainwater conservation practices has resulted in lower soil moisture availability in the profile and thus crop productivity. Low economic status of the farmers and small holdings are also main issues. Problems identified and prioritized during the transact walk and Rapid Rural Appraisal (RRA) exercises in Ramasagara village were pooled and a list of problems representing the whole watershed was prepared. Problems were ranked as per their total weightage given by the villagers. Lower crop productivity, low availability of ground water for irrigation and low market rates for their produce with lack of market facilities were the major problems encountered/expressed by the farmers. The problems faced by the farmers in the watershed area are presented rank wise in **Table 2.13.**

Table 2.13. Problem identification and prioritization of Ramasagara watershed

S.No.	Problem s	Rank
1.	Low production of field crops	I
2.	Lack of irrigation water	II
3.	Low market rates and lack of market facilities	III
4.	Lack of soil and water conservation practices	IV
5.	Insufficient credit from Banks and societies	V
6.	Low level of knowledge, skills and training	V
7.	Availability of inputs with reasonable prices	V
8.	Community organization and organization	VI

2.15. SWOC Analysis

2.15.1. Strengths

- Soils have higher infiltration rate (>20 mm Sec^{-1}) in the root zone which improves soil moisture for better crop yields.
- Medium to deep soils with better water holding capacity
- Sufficient sheep and goat population to meet out the meat demand and as a regular source of income especially during drought years as well waste of these animals improves soil fertility.
- Good potential exists for rain water harvesting due to presence of hill slopes.
- High permeability and trasmissivity of bed geology in Water Harvesting Structures (WHS) which provides location advantage of groundwater recharge.
- Deep aquifers are rich with fractured formulation and storitivity which help sustainability of groundwater tapping.
- Adequate human resources for farm activities.

2.15.2. Weaknesses

- Recurrent droughts, low rainfall and poor distribution of rainfall.
- Short crop growing season with limited choice of crops. Poor vegetation and tree survival.
- Soil and water erosion risk is high due to erosive land slope (1.0 to 6.0%) in arable areas and the steep hill slope (10 to 35%) on ridge (**Fig.2.6** and **2.7**).
- Low organic matter and N, low to medium in available phosphorus and high P fixation.
- Small and fragmented land holdings and large number of Small/Marginal farmers with limited economic resources.
- Watershed not connected with tar road and lack of government transport.
- Remoteness of villages to main road and market.
- Low water yields in bore wells during *rabi*/summer and during drought years
- Mono-cropping of groundnut with traditional variety leads to low crop productivity
- Low literacy level and awareness.
- Depleting ground water table and increasing bore wells failure.
- Lack of marketing, credit and warehousing facilities.

2.15.3. Opportunities

- Greater scope for creation of water resources by rainwater harvesting structures (WHS), recharging of ground water in deep layers and in-situ rainwater conservation in root zone.
- Scope for livestock management for assured income among landless and marginal farmers.
- Development of degraded and non-arable land through perennial vegetation and suitable agro-forestry systems.
- Scope for adoption of integrated farming systems (IFS) and crop diversification (climatic resilient crop).
- Value addition and agro-based cottage industries.
- Scope for dryland horticulture, cultivation of medicinal/aromatic plants in degraded lands.

2.15.4. Challenges

- Change in climatic conditions and shifting of crop seasons including mono-cropping.
- Low water use efficiency.
- Depleting groundwater resources and groundwater quality.
- Lack of farmers' participation in the adoption of soil and rainwater conservation practices due to the lagging of immediate and tangible benefits.
- Inefficient management of common property resources.
- Dissemination of IT supported advisories to farmers related to weather, crop practices and market prices.
- Capacity building of farmers for crop diversification, integrated farming system.
- Skill development of village artisans, women and un-employed youth.
- Timely supply of genuine inputs and buy-back systems.
- After withdrawal of Project, continuation of Watershed Society to maintain NRM structures, to organize Grama Sabha and to extend linkages with Research, Development Institutes, and Government/NGO Welfare Departments.
- Income generation through livestock rearing, value addition activities and feasible livelihood activities.
- Sanitary and health awareness.

Fig. 2.6. Breached bunds due to intense rain events in the watershed

Fig. 2.7. Severely eroded gravelly soils with breached bunds

2.16. Community organization

2.16.1. Watershed society

The Ramasagara watershed society of 14 members was formed during May 2009 with Mr. Guddada Ganganna as President and Mr. D.S. Parmeshwarappa as Secretary of the watershed and registered during December 2009 with Registration No. S.O.R. 438/2009-10. The society meets at regular intervals and passes resolutions/requests, which had been communicated to the PI from time to time for implementation of Socil & Water Conservation (SWC) works. The watershed society has two bank accounts i.e. (1) Ramasagara Watershed Project Account as Current Account and (2) a Saving Banks Account, Ramasagara Watershed Development Fund (WDF) account for depositing the contributions collected from farmers. The contribution of the farmers till 31st March 2014 was Rs. 5,90,636/- including accrued interest of Rs 62,040/- and deposited in the WDF account in the Indian Overseas Bank, Rampura Branch (**Fig. 2.8**).

Fig. 2.8. Watershed society meeting

3. ENTRY POINT ACTIVITIES

Past experience has indicated that watershed development without the participation of farmers has neither provided a sustainable impact on the productivity, nor has encouraged farmers to participate in development and management of watersheds. Hence, as per guidelines of NWDPRA program under Macro-Management of Agriculture (MMA) Scheme funded by the Department of Agriculture & Cooperation (MoA, GoI) in the XI Five Year Plan, the Ramasagara watershed project was implemented over 480.37 ha from 2008 to 2014, in a participatory mode. Nearly 5% of the total watershed budget was earmarked for Entry point activities (EPA) and spent for meeting invariable common needs of beneficiaries in the first year of preparatory phase. The EPA activity developed good social rapport and confidence among the beneficiaries with the Project Implementing Agency (PIA) in implementing watershed activities as planned. This kind of societal response was reported in many other studies (Dixit *et al.*, 2007; Rockström *et al.*, 2007; Wani *et al.*, 2003). In the watershed EPA activities were identified through PRA and periodical *Grama Sabha* meetings. While deciding the activities of EPA following criteria was considered for successful implementation.

1. Community need of the village that involves higher number of stakeholders in watershed.
   - Platform/Open theatre was constructed in front of community hall.

2. Common basic needs of the SC/ST colony in the watershed was animals' drinking water facility.
   - To address the problem, two concrete water troughs were constructed at Ramasagara and Devasamudra.

3. Both human and animal health was considered as priority.
   - One each animal and human health camps were organized at Ramasagara and Devasamudra villages.

4. Soil health and irrigation water quality was also given top priority.
   - Representative soil samples in upper, middle and lower reaches of watershed were analyzed for soil health and water samples from all the bore wells in the watershed were analyzed for quality and its suitability for irrigation.

3.1. Community needs of the watershed villages

3.1.1. Masonry open-theatre platform

The masonry open-theatre platform of 12.6 m length, 6.10 m width and 0.60 m height was constructed (**Fig. 3.1**). Platform was used for conducting village meetings, cultural programmes including marriages and drying of the food grains. Total cost of construction was Rs.1,14,172/- and it generated an additional employment of 128 man days.

3.1.2. Water troughs

Two water troughs were constructed at *Harijan* colony (SC) at Devasamudra and Ramasagara village. The length, width and height of the water troughs were 4.8 m, 2.1 m and 0.6 m (**Fig. 3.2**), respectively. These water troughs served as drinking water points for nearly 130 cattle in both villages and the cost incurred for construction water troughs were Rs. 19,366/- at Devasamudra and Rs. 21,115/- at Ramasagara villages. An additional employment of 128 man days was created by the above EPA activities.

Fig. 3.1. The masonry open-theatre platform

Fig. 3.2. Final view of the Animal water troughs at the Ramasagara watershed

3.2. Human health camp

A human health camp was organized at Ramasagara village on 22nd December 2009 in collaboration with Primary Health Centre, Rampur and Ashok Siddapur and Ayurvedic Hospital, Devasamudra. In this health camp nearly 100 farm families were treated for malaria, acute respiratory tract infection, acute diarrhea, worm infestation, antenatal cases, Pyoderma, viral fever, scabies and sexually transmitted diseases (**Fig. 3.3**). Blood smear examination was conducted for patients and medicines were distributed to farm families. Watershed beneficiaries were educated about awareness of cleanliness, personnel hygiene, importance of nutritious food to all and especially to the pregnant women and children during this camp.

Fig.3.3. Doctors treating patients and blood smear tests in Human health camp at Ramasagara

3.3. Animal health camp

The Animal health camp was organized on 29th June 2009 at Ramasagara village in collaboration with Animal Husbandry Department, Molkalmuru, Chitradurga district. Nearly 31 infertile cows and buffaloes was treated along with 600 cows, bullocks and buffaloes vaccinated for *Haemorrhagia septicimia* and 2000 sheep and goats were vaccinated with PPR for parasitic de-worming (**Fig. 3.4**).

Fig. 3.4. Animal health camp organized at Ramasagara watershed

3.4. Soil and water analysis

Soil samples analyzed from 35 farmers fields representing both irrigated and rainfed areas in the upper, middle and lower reaches of the watershed. Measured pH from top soil sample (0-15 cm) and sub soil (15-30 cm) was higher in irrigated areas compared to rainfed and sometimes recorded as high as 9.0 indicating alkaline conditions (**Tables 3.1** and **3.2**). The pH varied from 8.0 to 8.4 in rainfed whereas under irrigated situations it varied from 8.2 to 9.0 in top 0-15 cm soil depth. The electrical conductivity of soils in rainfed is varied from 0.08 to 0.12 dS m^{1} whereas in irrigated area it was 0.22 to 0.79 dS m^{1} and higher EC in irrigated areas was attributed to use of borewell water that was saline. Further higher EC was observed in lower reaches of watershed as compared to upper reach and it was also attributed to bad quality of irrigation water in lower reaches as compared to middle and upper reaches. The organic carbon content in rainfed soils was low in top and sub soil whereas in irrigated soils it was low to medium. Further these soils are medium in available nitrogen and potassium, low to medium in available phosphorus. Soil fertility did not vary much among upper, middle and lower reaches of the watershed. Irrigated soils were more fertile compared to the rainfed (**Tables 3.1** and **3.2**).

Table 3.1. Soil properties of the representative soil samples collected from the beneficiaries' fields in the watershed (0-15 cm)

Quality	Upper reach		Middle reach		Lower reach	
	Irrigated (Bore wells)	Rainfed	Irrigated (Bore wells)	Rainfed	Irrigated (Bore wells)	Rainfed
pH	8.5	8.4	8.2	8.0	9.0	8.3
E.C. (dS m^{-1})	0.33	0.08	0.54	0.09	0.79	0.12
Organic carbon (%)	0.48	0.35	0.66	0.44	0.65	0.32
Available N (kg ha^{-1})	320	353	387	334	365	297
Available P_2O_5 (kg ha^{-1})	19.2	29.5	45.4	31.8	19.5	14.7
Available K_2O (kg ha^{-1})	229	378	430	405	471	218

Table 3.2. Soil properties of the representative soil samples collected from the beneficiaries' fields in the watershed (15-30 cm)

Quality	Upper reach		Middle reach		Lower reach	
	Irrigated (Bore wells)	Rainfed	Irrigated (Bore wells)	Rainfed	Irrigated (Bore wells)	Rainfed
pH	8.0	8.3	8.2	8.0	8.9	8.3
E.C. (dS m^{-1})	0.22	0.11	0.41	0.10	0.59	0.09
Organic carbon (%)	0.37	0.32	0.43	0.35	0.35	0.21
Available N (kg ha^{-1})	267	272	259	258	271	271
Available P_2O_5 (kg ha^{-1})	19.0	29.1	43.9	31.4	19.3	14.6
Available K_2O (kg ha^{-1})	376	394	420	383	332	334

Water samples analyzed from 33 bore wells indicated that pH of the water is good in the upper reach and near alkaline in lower reach (**Table 3.3**). Quality of water in all the reaches is usually saline with better quality of water in the upper reach. Majority of the bore wells in lower reach are saline and the water can be used for protective irrigation only.

Table 3.3. Average values of water quality in bore wells of beneficiaries in the watershed

Quality	Upper reach	Middle reach	Lower reach
pH	8.1	7.9	8.3
E.C. (dS m^{-1})	1.22	1.82	3.27
Cl (m eq./l)	2.74	4.16	6.30
SAR	0.43	0.42	0.45
RSC	-0.58	1.76	1.86
% Sodium	12.7	11.4	12.9

3.5 Training Programmes

Two training programmes were conducted from 17th to 18th March and 19th to 20th March 2009 for 40 beneficiaries with 20 beneficiaries in each training programme. In the training programme, the beneficiaries were exposed to the soil and rainwater conservation and watershed management. The beneficiaries were exposed to different terrace and inter-terrace measures to conserve rainwater and top fertile soil in arable and non arable lands and control soil erosion. The interactions with beneficiaries on integrated nutrient management, improved crops and cropping systems in the watershed for higher yields were also fruitful. The beneficiaries have also expressed that they are ready to adopt the improved crop cultivation practices that results in greater conservation of natural resources and higher crop yields. The farmers were also exposed to the live soil and water conservation measures adopted for black soils at the Research Farm of the Centre (**Fig.3.5** and **3.6**).

Fig. 3.5. Visit of the farmers of the Ramasagara watershed to the IISWC Research Farm

Fig. 3.6. Snaps and report of two days training programme's inauguration in local dailies "Samyutkta Karnataka" and "Kannada Prabha"

3.6 Agro-meteorological Observatory

A class-III agro-meteorological observatory was established in the watershed during 2010 for continuous record of weather data. Anemometer, wind vane, Single Stevenson Screen – which contains four thermometer namely dry bulb, wet bulb, maximum and minimum temperature Thermometer, ordinary Rain Gauge and Open Pan Evaporimeter (**Fig. 3.7**).

Fig. 3.7. A class-III agro-meteorological observatory was established at Ramasagara

4. INSTITUTION AND CAPACITY BUILDING

4.1. Training programmes

Five training programs on rainwater conservation and watershed management in black and red soils were conducted. In which three were conducted at ICAR-IISWC, Research Centre, Ballari and two were conducted by KVK Chitradurga at Hiriyur. Totally, 100 farmers were trained in this Project. Training programs were structured in such a way that provides on field experience to the beneficiaries through field exposure visits for learning soil and rainwater conservation practices in Alfisols and Vertisols. Program schedules also covered different activities that are supposed to be carried out during watershed implementation in the watershed. Terrace and inter-terrace rainwater conservation measures in both arable and non arable lands that control soil erosion were demonstrated to beneficiaries. Beneficiary-Resource person interaction sessions were included for discussing on integrated nutrient management, improved crops and cropping systems in the watershed for higher yields and sessions were found effective in understanding local problems and solutions available. As a response, the beneficiaries agreed that the improved cultivars of groundnut, cowpea, redgram and bajra demonstrated in the farmers fields resulted in higher yields. Better vegetative and root growth of improved crops cultivars resulted in more rainwater conservation. Trainee farmers were also shown the horticultural plantations established at Research Farm of ICAR-IIWSC Research Centre. An awareness of different commonly occurring animal diseases and their control measures including cultivation of *Azolla* for improved animal health was imparted the trainees. In addition, farmers were also trained in improved methods of storage of their food grains (**Fig. 4.1**).

Fig. 4.1. Training programs conducted for watershed beneficiaries during March 2010 at Research Centre, Ballari

4.2. Exposure visit

Two exposure visits were arranged and 40 farmers of Ramasagara watershed visited different Research Institutes, KVKs, NGOs and farmers within the state of Karnataka from 9-12th March 2010 and 7-11th February 2011. Farmers were taught about improved agricultural practices for increasing crop yields and income. During the visit farmers were taken to the Zonal Agricultural Research Centre (ZARC), Babbur Farm, Hiriyur and KVK, Hiriyur. At ZARC, farmers were shown about cultivation of different field crops i.e. redgram, maize, cotton and onion and cropping system, i.e., onion + chilli and integrated farming system including low cost vermicompost units. Further, farmers were introduced to new agricultural implements, i.e., seed cum-fertilizer drills, cycle weeder and threshers including groundnut decorticators. In sideline, livestock unit and rabbit rearing unit were also visited by the farmers. The concept of watershed was once again explained to the farmers using a model watershed site developed within the Research Farm and a detail account of watershed activities were appraised to the farmers. Farmers were actively interacted with scientists to know about the improved cultivars of crops, better crop management practices including pests and disease control (**Fig. 4.2**).

During these exposure visits, farmers were also visited a model horticulture block/plantation unit at BAIF (Bharatiya Agro Industries Foundation), Tiptur. Farmers were taught about the cultivation of mango, jack fruit, cashewnut. Further, improved management practices for livestock for higher milk yield were explained to the farmers. Farmers visited the nursery of medicinal plants and horticultural blocks. Farmers were also educated about the raising of the seedlings of mango, sapota, cashew, jack and medicinal plants by conducting hands-on-experience budding and grafting techniques demonstration. Roof rainwater harvesting and its reuse methods were taught to the farmers at BAIF. In continuation, farmers paid a visit to Mailnahalli watershed and observed the vermicompost units in the farmers fields, cultivation of mango and sapota including viable Agro-forestry systems at the farmer's fields (**Fig. 4.2**).

At All India Crops Research Project (AICRP) on Dryland Agriculture, GKVK, Bangalore farmers were explained about farm pond technology in red soils. Various cementing materials to reduce the water seepage/percolation losses from the farm pond in Alfisols were demonstrated to the farmers. Different agricultural implements that are used in red soils for groundnut and *ragi* cultivation were scientifically explained and participants keenly observed. Viable Agro-forestry systems in the Experimental sites at GKVK, Bangalore raised in red soils were also seen by the farmers. Soil and rainwater conservation practices adopted in red soils both at terrace and inter-terrace measures were explained to the farmers. At KVK, Suttur, farmers were exposed to low and high cost vermicompost units and also visited Agro-Horti systems including sericulture block (**Fig. 4.2**).

4.3. Kisan Goshti

Ballari Centre organized seven Kisan Goshtis (29.6.2009, 23.2.2010, 29.10.2010, 21.2.2011, 26.3.2011, 23.6.2011 and 13.9.2011) at Hanumapura, Ramasagara and Venkatapura villages to create awareness among the farmers about the improved crop cultivation practices, rainwater and soil conservation measures, horticultural plantation, improving natural vegetation through planting of trees, grasses to meet the fuel and fodder requirements, improving knowledge of human, animal and soil health and livelihood.

Fig. 4.2. Krishi and hi-tech agriculture exposure visit to the beneficiaries of Ramasagara watershed

Exposure of farmers towards soil and water quality of bore wells. Highlights of individual Kisan Goshtis were as under:

I- Kisan Goshti at Ramasagara village (29.6.2009)

1. Cultivation of improved cultivars of groundnut, i.e., K-6 for higher yields and crop rotation with bajra, ragi and redgram in this mono-cropped area of groundnut including intercropping of groundnut with redgram. bajra, cowpea and castor for increased crop productivity in the region (**Fig. 4.3**).

2. Critical management practices in irrigated cotton and onion with soil fertility maintenance.

3. Preventive measures against seasonal animal diseases, artificial insemination and timely veterinary follow up of infertility animals.

II- Kisan Goshti at Ramasagara village (23.2.2010)

1. Soil and bore well water samples were analyzed and results were also explained to the beneficiaries (**Fig. 4.3**).

2. Application of fertilizers and crops to be cultivated based on the nutrient availability in the soil and on the quality of the irrigation water available.

3. The IFS farmer Mr. Marenna, shared his experience of cultivation of improved maize hybrid, i.e., Super 900 M Gold in his farm and requested the farmers of the watershed to cultivate this improved hybrid for greater productivity. This was explained by bringing the sample of maize cob with details of the number of seed lines per cob, seeds per cob, seed weight per cob, cob weight per plant and ultimately the yield with the improved cultivar verses the farmer cultivated cultivar to the farming community.

4. Common diseases in cattle, periodical vaccination, animal nutrition and improvement of dry fodder. Formation of milk producers' society for higher milk production.

III- Kisan Goshti at Venktapur village (29.10.2010)

1. Benefits of adopting crop rotation and intercropping in the mono-cropped area of groundnut with bajra, ragi, cowpea and redgram (**Fig. 4.3**).

2. Performance of improved variety of groundnut i.e. K-6 and crop rotation. Certified seeds of TMV-2 that were cultivated by the farmers during *kharif* season of 2010-11 for higher yields in dryland areas of watershed was explained to all the farmers of Venkatapur.

3. Higher yields that are realized from the improved maize hybrid, i.e. Super 900M Gold along with application of secondary and micro-nutrients were explained to the farmers.

4. Preventive measures required against seasonal animal diseases, artificial insemination and timely veterinary follow up of infertility animals.

5. Improved and low cost techniques of cultivation in mango, sapota, jackfruit, lemon and coconut were explained to the farmers.

6. Bunding and importance of terrace level soil and rainwater conservation practices for natural resource conservation was explained to the farmers of the village.

IV- Kisan Goshti at Ramasagara village (21.02.2011)

Kisan Goshti was conducted at Ramasagara village, especially for those farmers' who had planted horticultural crops, those who would be taking up irrigated cotton during 2011 and the Vermicompost units.

1. Discussed with the farmers about the cultivation practices and varieties/hybrids cultivated by the watershed farmers and supply of good cotton seeds for cultivation in summer/*kharif* 2011 (**Fig. 4.3**).

2. Adopt moisture conservation practices and low cost technologies in horticultural crops.

3. Farmers were advised to adopt scientific/correct management practices in horticultural plantations including the demonstration of staking and fencing of plants especially in coconut for better survival and growth.

4. Explained about importance of kitchen gardening and discussed about the choice of requirements of vegetable seeds by the farmers for kitchen gardening.

5. Sensitized the farmers' on common diseases in cattle, periodical vaccination, animal nutrition, *Azolla* cultivation and improvement of fodder production for higher milk production.

V- Kisan Goshti at Hanumapur village (26.03.2011)

1. Farmers were explained about the improved cotton hybrids, cotton cultivation, vermicompost, micronutrient application in cotton and maize (**Fig. 4.3**).

2. Improved methods of vegetable and fruit cultivation in red soils were explained to the farmers.

VI- Kisan Goshti at Ramasagara village (23.06.2011)

1. Farmers explained that few farmers who have multiplied and used the improved groundnut cultivars, i.e., K-6 and TMV-2 during 2011-12 and their performance was better than the other home-saved seed materials. Live plant samples were brought from the fields and were demonstrated to all the farmers (**Fig. 4.3**).

2. Farmers were explained the importance of vermicompost for crop productivity.

VII- Kisan Goshti at Venktapur village (13.09.2011)

1. Adopting suitable crop rotation and intercropping in the mono-cropped groundnut area with bajra, ragi, cowpea and redgram results in increased and sustainable crop yields under different rainfall situations (**Fig. 4.3**).

2. Farmers were explained the importance of vermicompost over normal composting.

3. Farmers were explained about the animal health and hygiene further they were advised to follow the preventive measures that are essential against seasonal diseases and artificial insemination.

4. Farmers were advised about low cost technologies of drip irrigation, soil and rainwater conservation mulching methods for reduced evaporation and saving of water for irrigation.

5. Further farmers were asked to adopt scientific management practices in horticulture including demonstration of staking of plants in coconut for better survival and growth.

6. Farmers explained that the vegetable seeds that were supplied for kitchen gardening and cultivated to meet their daily vegetable requirements. Majority of the vegetable seeds supplied may also be multiplied and used as seed materials even beyond the project period.

7. Farmers advised to better utilize the facilities of the project and improve their livelihood.

Fig. 4.3. Interactions with farmers during Kisan Goshtis at Hanumapur, Ramasagara and Venkatapur villages

5. WATERSHED DEVELOPMENT WORKS PHASE

Conservation measures

5.1. Arable land treatment

In the country, out of the 328.7 Mha of land area, it has been estimated that about 120.7 Mha of the total geographical area is degraded. Of the total degraded area, water erosion has affected 73.3 Mha, wind erosion 12.4 Mha, chemical deterioration has affected 17.45 Mha, physical deterioration occurred in 1.07 Mha (Maji *et al.*, 2010). This indicates large chunk land mass in the country requires to be treated with soil and rainwater conservation measures to reduce further degradation of these lands. Soil degradation occurs due to improper soil management practices adopted by the farming community in both arable and non-arable lands. The most serious soil erosion problem is sheet and rill erosion, which has a serious effect on agricultural production in red soils, which covers an area of 72 Mha in the country. The depth in these soils varies from 15 cm to 200 cm and is about 20 cm in most of the areas. These lateritic soils, associated with rolling and undulating topography and are located in low to high rainfall regions with soil erosion annually varying from as low as 2 t ha ^{1} to as high as 40 t ha ^{1} particularly in the absence of soil conservation measures (Sharada *et al.*, 2017).

Adoption of conservation measures both at terrace and inter-terrace levels including non-arable lands not only conserve the top fertile soil and also stores the rainwater and recharges the soil profile which in turn increase the productivity of crops, grasses and trees. In Ramasagara watershed, soils are classified as red sandy loams which usually exhibit low water holding capacity coupled with low rainfall hampers agricultural productions. Thus, harvesting every drop of rainwater *in-situ* is very important for crop production in the watershed. The old field boundary *bunds* have reduced in their size over time and also suffered frequent breaches. Lag in adoption of *in-situ* rainwater conservation practices, to conserve rainwater, fertile top soil and recharge the profile, accelerated soil erosion both at the field and terrace level. These constraints caused low crop productivity and low income of individual farm families, also deterioration in soil properties over the years. Conservation of natural resources such as rainwater and soil is imperative for improving the natural resource base in the watershed which in turn supports sustainable crop and vegetation production besides improving the economic status and livelihood of the beneficiaries. The watershed programs implemented by Indian Institute of Soil and Water Conservation, Research Centre, Ballari in a participatory mode from 2009-10 to 2013-14, rendered required motivation to the farmers for active participation in watershed activities. These conservation measures advocated to the farmers were cost effective and proved to be beneficial in increasing crop productivity, especially during drought years. Ramasagara watershed is located in semi-arid to arid region and district in which watershed is located has been identified as the 22nd most resource poor district in the country (NRAA, 2012).

5.1.1. Field bunding

Field bunding is a major land development activity aimed to enhance *in-situ* rainwater conservation and increase crop yields. The trapezoidal earthen contour bunds were constructed across the major slope (1 to 4%) of individual fields in arable areas (**Fig. 5.1**). Technical specification adopted in field bunds construction includes a burrow pit of size 1.37 × 0.6 m or 2.72 × 0.3 m was excavated to form the cross section of bund 0.82 m^2 as recommended by the Research Centre, Ballari (bottom width = 2.25 m; top width = 0.45 m and height = 0.60 m) over 41,263 m length at a

vertical interval of 0.6 to 1.5 m with permissible deviations at valley and ridge portion of the individual fields (**Fig. 5.2**). The bunds were aligned in such a way that they follow field boundary across the slope considering the cultivation constraints and property/subdivision issues of the beneficiaries. The total bunded area in arable lands was 333.0 ha and cost incurred was Rs. 8,58,487/- (including farmers' contribution @ 10%). Permissible deviations in top and bottom widths and height of bund were allowed at valley and ridge portions of the individual fields for ensuring stability of bund. The *Stylosanthes hamata* grass seed was broadcasted on bunds for stabilization. Castor, greengram and horsegram crops were cultivated on bunds for stabilization and utilization of the newly bunded area as the mix of fertile top and sub soil was spread on the bunds. It was observed that the bunds constructed withstood intensive rainfall events including an intense rainfall storm of 95.8 mm during 2010. The newly formed bunds intercepted and conserved the rainwater and the top fertile soil *in-situ* within the bunded area there by increasing the profile soil water leading to increased crop yields especially of groundnut (major crop) during drought condition. Bunding impact was apparently visible during low and ill distribution of rainfall years/situations wherein farmers harvested 21% higher groundnut yields compared to un-bunded area outside watershed especially during the drought year of 2011 with an annual rainfall of only 392 mm. Bunding activity created an additional 675 man days employment in the watershed.

On research point of view, bunding in the watershed reduces runoff and soil loss and improved soil moisture in the profile. Our Centre's scientific publication corroborates the impact bunding in the watershed (Adhikari *et al.*, 2010, 2015). Bunding extends moisture availability to the crops, especially during drought year of 2011-12. Thus, 29.2% higher bajra grain yield harvested over outside watershed area where no bunding done, whereas groundnut pod yield increased by 29%, from 367 kg ha^{-1} to 473 kg ha^{-1}. Similar trend was observed in groundnut + redgram intercropping system with increase in pod yield of groundnut by 35.4% and grain yield of redgram by 92.8% (**Table 5.1**).

Table 5.1. Grain yields of rainfed crops in bunded area compared with outside the watershed (Unbunded) area during 2011-12.

Crops	Grain yield (kg ha^{-1})		Per cent increase
	Inside watershed	Outside watershed	over outside watershed
Bajra	363	281	**29.2**
Groundnut	473	367	**28.9**
Groundnut+Redgram	402+27	297+14	**35.4+92.8**

5.1.2. Waste weirs/stone checks

Waste weirs were constructed using rubbles at valley points where the contour bunds meet waterways to dispose the excess runoff water from upper terrace to the below terrace (**Fig. 5.3**).

Fig. 5.1. Field bunding in the farmers fields

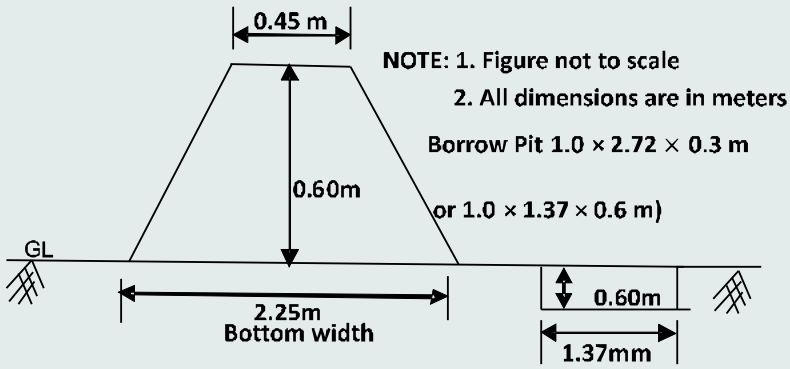
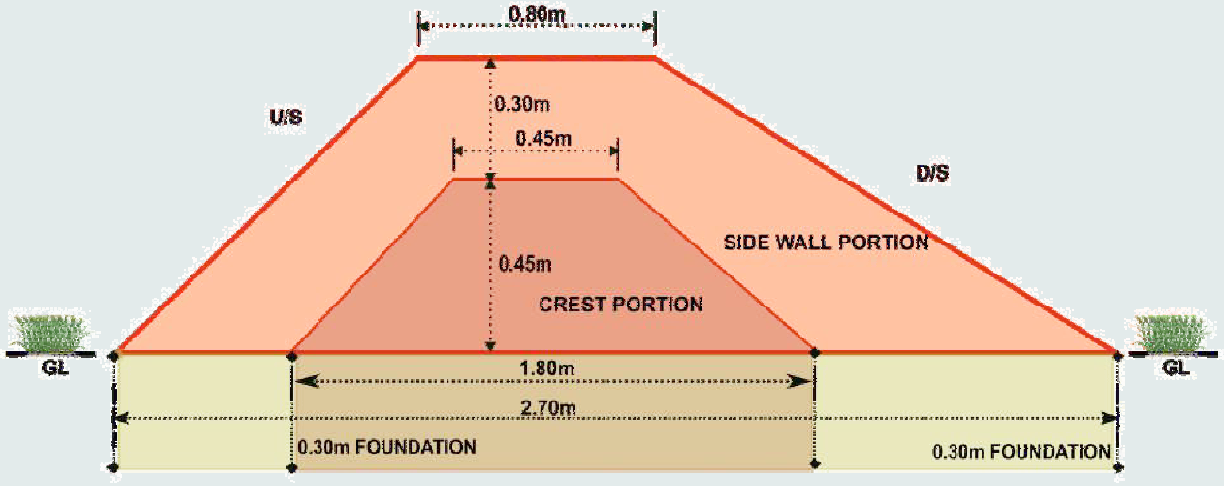


Fig. 5.2. Specification of the field bund

Engineering specification of the waste weirs are as follows. The crest height above ground level was at 0.45 m having upstream and gentle downstream slope of 1:1 and 1:2, the ends were anchored to side walls having a height of 0.7 m above ground while the length of crest was kept equal to the width of water way. The crest top width was 0.45 m and bottom width varied between 1.80 to 2.20 m. Side walls top width was 0.45 m and bottom width = 2.7 m both with a foundation depth of 0.3 m (**Fig. 5.4**). Total 197 waste weirs were constructed and the cost including farmers' contribution @ 10% was Rs 4,64,142/- (excluding masonry drop weir @ Rs. 22,964/- and repairs of waste weirs). A field study after 3 years of land treatment to find out the top soil retention by bunding with weirs revealed that considerable silt retention (4.13 t ha^{-1} $year^{-1}$) was observed on upstream side of waste weirs. An additional employment of 1348 man days was created through construction of waste weirs.

In the watershed, 72 ha hillock area have more than 15% slope and 30 ha land area having 3 to 6% slope. A research study at Research Centre, Ballari shows that higher degree of slope produces greater amounts runoff. The diversion drain and field bunds in these areas discharge high rates of runoff which culminates into flow concentration in waterways and aggravates hydraulic pressure on the waste weirs. As the waste weirs are basically loose boulder structures with inherent weakness in stability, there is a tendency for the breaching of waste weirs. Apart from this, they are prone to disturbance by cultivation operations and displacement by miscreants. The damage of waste weirs is a common occurrence observed in the watersheds either constructed by our Centre or evaluated, structures constructed by other agencies, due to the recurrence of concentrated water flow in the waterways caused by fresh bunding. Secondly, the siltation takes place up to crest height of waste weir within 3 years of their construction which asks for further rising of the crest level. Thus, the reconstruction or repair of waste weirs needs to be taken up at regular interval period of three years. Further, an alternative type such as semi-permanent waste weirs using cement concrete/granite slabs is to be employed for long term structural stability coupled with in-built provision for raising the height of crest wall equivalent to that of vertical interval. Moreover, as per guidelines of NWDPRA, outside experienced contractors were not to be engaged for implementation work. Therefore, in Ramasagara watershed local people recommended by Ramasagara Watershed Society have been trained and engaged in works as implementers. Thus, the masonry skills of trained persons were not adequate to match the expert person. In order to heighten the waste weir crest, a resolution was passed by the Watershed Society for repairing and crest heightening of 120 waste weirs at a cost of Rs. 1,48,361/- in the financial year of 2013-14.

Fig. 5.3. Waste weirs constructed at specified points for safe passage of runoff from fields



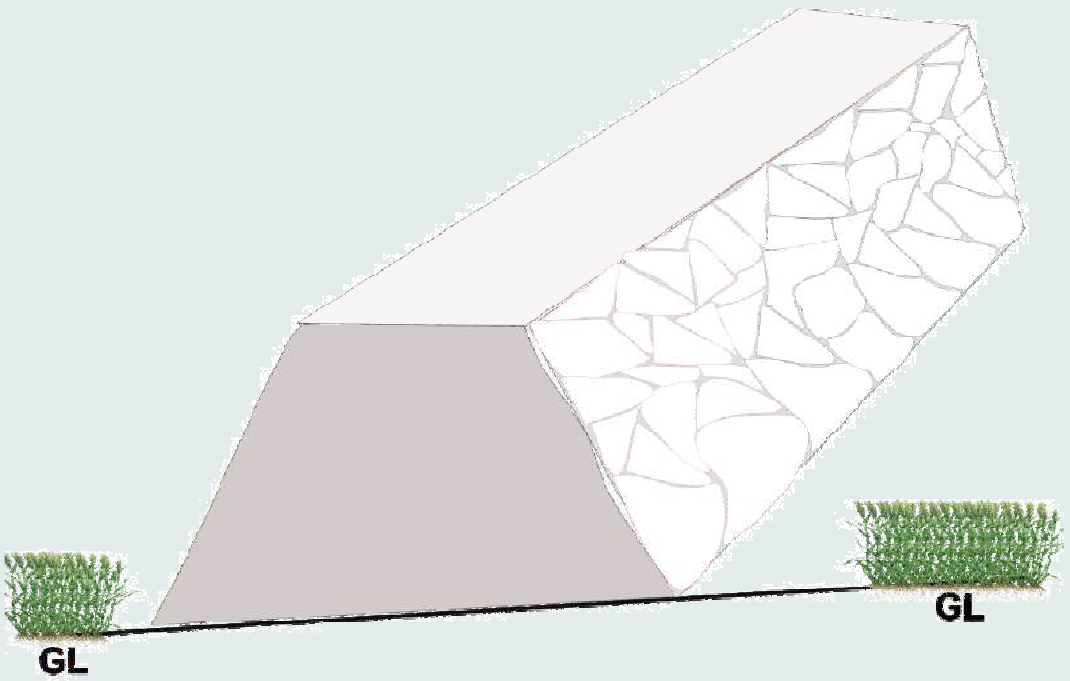


Fig. 5.4. Line diagram of waste weir (above) and isometric view of crest wall (below)

5.1.3. Drainage line treatment

5.1.3.1. Repairs and modification of an existing check dam for runoff and soil loss gauging/monitoring:

Repairs and modification of an existing check dam were done to convert it into a gauging station for runoff and soil loss measurement. Silt of 254.88 m^3 was excavated from the nala bed on upstream side. Side banks and flanks were formed and stone revetment (497.0 m^2) was provided for bank stability. The damaged apron was reconstructed in slanted shape (solid) including stone pitching and coping of its floor with cement concrete (1:3:6). In order to prevent runoff water seepage through bottom of head wall, a cutoff wall with cement concrete (1:3:6) was newly constructed and toe wall was also constructed. Stone work was extended up to end wall on downstream side. A stone check was also constructed on the upper side of the structure to prevent silt inflow in to the structure. Repairs to head wall were completed by concrete coping on its top surface. Provision for trickle flow was given in the head wall. Cement pointing of sides of head wall was provided. The crest length and height of the check dam is 11.0 m, 1.0 m respectively, and 2.6 m dam height was constructed to capture runoff from 60 ha catchment area. The cost incurred for repairs and modification of check dam was Rs. 91,907/- and 296 man days of additional employment was created in this activity. A gauging house for installing stage level recorder was constructed beside the modified check dam at a cost of Rs. 16,000/- (**Fig. 5.5**).

Fig. 5.5. View of the check dam modified as a gauging station

5.1.3.2. De-siltation of Percolation tank at the upper reach:

An old percolation tank that was existing in the watershed in the upper reach was silted up over a long period which reduced the storage capacity of the tank. Therefore, de-siltation work was taken up to increase storage capacity of the percolation tank by about 3095 m^3 with a cost of Rs. 1,18,780/- as desired by the beneficiaries of the watershed (**Fig. 5.6** and **5.7**). Trapezoidal shape of de-silted area measures 55 m and 48 m length, 26.5 m and 17.5 m width and dug up to the depth of 2.5 m. A 13 m length approach canal (L × B × D = 13.0 m × 1.16 m × 2.3 m) was dug to divert runoff to the desilted area. An appreciable sum of Rs. 2,32,050/- was spent by the farmers' as a contribution towards transportation and spreading of de-silted soil at farmers fields. The catchment area extends to large area outside the watershed with a long gully feeding the rainwater to the existing tank. The tank is expected to get filled up 4 to 5 times in a year during normal rainfall years. Due to high permeable geology of tank bed, the stored water percolates to deep aquifers and would improve the ground water recharge and thus, benefitting the bore wells which are only the source of irrigation in the watershed.

The tank silt that was applied in the arable lands improves soil physical and chemical properties and increases the crop yields on both rainfed and irrigated areas. De-silting activity generated 1671 man days employment. Construction of spill way and repairs for earthen embankment of percolation tank was also taken up for further increasing the storage capacity and safety to the earthen embankment. On the whole, a net storage capacity of 5570 m^3 was created in Post-Project period. A minimum of two fillings are occurring every year which amounts to a gross storage of 11140 m^3 per year, which would favour the groundwater recharge.

Fig. 5.6. Desiltation of percolation tank on the ridge in the upper reach of the watershed

5.1.3.3. Check dam (CD) cum drop weir

A small check dam cum masonry drop weir was constructed at a cost of Rs. 1,12,301/- on the upper reaches of watershed to store the excess runoff of 475 m^3 from the diversion drain and overflow from percolation tank and the water course is shaped to adequate cross section over a length of 316.8 m (**Fig. 5.8**). At the same time, due to diverted runoff and overflow, the velocity of runoff in water course is also reduced.

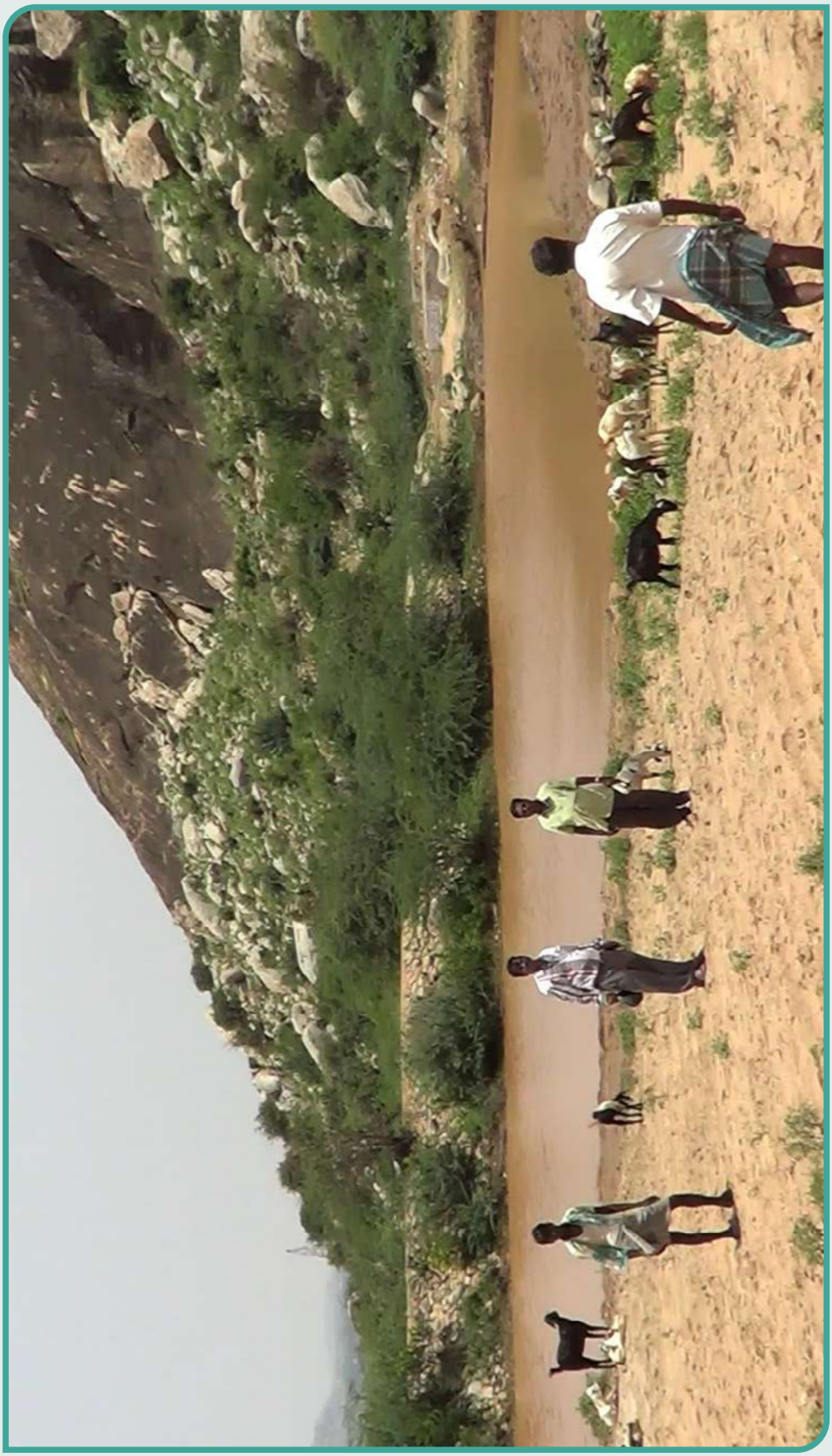


Fig. 5.7. Water harvested in desilted tank was effectively utilized for quenching thirst of goat-trips during summer

The catchment area of check dam is 25.8 ha. The dam length including extension is 17.5 m with a height of 1.95 m (including foundation) along with side walls, apron and end wall. Earthen embankment (length = 60 m) on either sides of CD was provided for ensuring firm planks and anchoring. This helps in ground water recharge in the bore wells situated on the downstream of the structure.

Fig. 5.8. Check dam cum drop weir with retention wall and embankment

5.1.3.4. Masonry drop weir:

There was a drop in the waterway at the tail end of Survey No. 10 which results in gully formation over a period of time. Hence, a masonry drop weir constructed for safe disposal of water flow in waterway. Monitory expenditure on construction and materials was Rs 22,964/-. The length and crest-height of drop weir was kept at 5.0 m and 0.6 m, respectively, with total weir dam height of 2.0 m.

5.1.3.5. Rock fill dams

Extensive bunding and proper drainage line treatment on arable area lead to an increase in runoff concentration in the water course with considerable velocity, which needs to be controlled to avoid gully erosion. Therefore, two Rock Fill Dams (RFDs) were constructed by using boulders across the water courses at middle reaches (Survey No.13) and lower reaches (Survey No. 19) of the watershed (**Fig. 5.9**). The cost of construction, including materials was Rs. 51,218/- and Rs. 1,22,208/-, respectively. The respective catchment area of RFDs are 8.82 ha and 31.54 ha. The structure was specifically selected for disposing high peak rate of runoff from undulated catchment area and farmers' preference. The foundation (spot consists of silt accumulation for many years) necessitating deep foundation wall up to 0.9 m. The peak discharge rate is 9.0 cumecs indicates high flow velocity at the site, which having 31.24 ha of catchment area including a part of hill slope. Measured elevation difference (drop) between upstream side (RL 100.38) and downstream side (RL 98.64) was 1.74 m. A cart road, which is passing along the structure at downstream side needs to be protected by safe disposal of excess runoff from the proposed structure (see **Fig. 5.9**). In view of this critical site condition, the head wall as per the standard design was constructed with a bottom width of 4.0 m in foundation and total height of 3.0 m. In general design of waste weir, usually bottom width of crest wall is 1.8 m which having the terrace catchment of 3 to 4 ha. In this particular case, since catchment area is large (31.24 ha), the bottom width was extended to 4.0 m. Squared stones were used instead of un-size boulders for ensuring structural coherence with least gaps.

Fig. 5.9. Rock Fill Dam

As per the demands of farmers and the President of Watershed Society as well as this Research Centre's observations and past experience in previous watersheds, the RFD at Survey No. 19 was later reinforced with cement mortar and concrete to prevent theft of stones (Rs 6/- to 8/- per stone) from the structure. The farmers, whose field lie adjoining to the structure contributed the cement for construction.

5.1.3.6. Stone revetment for the side face of watercourse

At selected specific sites that are vulnerable to severe side scouring, stone revetment was provided. Upstream side of the bunds on either sides of waste weir were also provided with revetment for stability and side faces of water courses to control the gully expansion in arable lands at middle and lower reaches of the watershed. The cost of work was Rs. 24,510/-. Average width and height of revetment for water courses are 0.36 m and 1.0 m (**Fig. 5.10**).

Fig. 5.10. Revetments of cut stones for side walls of water course

5.2. Non arable land treatment

5.2.1. Diversion drain

Diversion drain was excavated all along the foot of hillocks (a sum of 72.1 ha) at three places in the upper and middle reaches of the watershed. The drain size was based on the design using Ramsers' formulae considering modified "C" value to intercept runoff from hill slope (6 to 25%) and area spread over 92.1 ha for protecting arable lands located down below the hillocks (**Fig. 5.11**).

Modified 'C' (Runoff coefficient) value of 0.22 was adopted for diversion drain design as against the conventional 'C' value of 0.50 in 'Ramsers' formula. Thus the optimum size of diversion drain based on modified 'C' value (0.22) reduces the cost by 18.3% over conventional 'C' value (0.50). The total length of diversion drain was 5102 m with varied width of 1.3 m to 1.7 m and average depth of 0.8 m constructed at the cost of Rs. 4,56,577/-. Original drainage line that was choked or encroached was also restored or trained by widening and deepening the nala and removal of vegetation for safe disposal of runoff through arable lands. On the downstream side, runoff was diverted safely into natural nala. Bed stabilizers were constructed to prevent future gully expansion in the diversion drain. Nearly 16 ha of marginal land which was affected with severe erosion at the hill foot was recovered and brought under cultivation after diversion drain was constructed in the watershed.

5.2.2. Masonry Spillway

One spillway of size 8.0 m × 0.6 m for the percolation tank was constructed at a cost of Rs. 2.0 lakhs to store runoff of 2.34 ha m for groundwater recharge and also to protect the arable land at downstream (**Fig. 5.11**). The estimated potential groundwater recharge was around 15 mm out of average annual rainfall as worked out on the model formula of analogous situation

Fig. 5.11. Conservation of rainwater in non arable lands at the upper reaches of watershed

5.3. Income generation activities

5.3.1. Percolation and fish ponds

Dugout percolation pond was constructed at Survey no.10 on the natural depression in the nala course for ground water recharge that helps to raise water table of the downstream side and improves water yield in adjacent bore wells. The capacity of pond is 1222 m^3 and a portion of runoff water from 24.6 ha was collected. The cost of the structure was Rs. 83,900/-. The pond is in trapezoidal in shape (top width: 36.0 × 33.5 × 25.5 × 6.0 m and bottom width: 30.5 × 26.5 × 22.5 × 4.5 m and depth: 2.4 m) to fit into land piece available at the site of pond. It is demonstrated that the shape of the pond need not have to be conventional square or rectangular and it is to be according to the site geometry. Two inlets and one outlet were constructed. The rainwater to a height of 2.2 m was harvested in the percolation pond for 3 to 4 times in normal rainfall years. One mini-fish pond in Survey no 13 with a capacity of 421 m^3 (top width: 23 × 16 m and bottom width: 20 × 14 m and depth: 1.2 m) was constructed at a cost of Rs. 28,644/- for fish rearing (**Fig. 5.12**).

Fig. 5.12. Percolation tank and fish pond cum water storing structure in nala course and arable lands

6. LIVELIHOOD AND INCOME GENERATION ACTIVITIES

6.1. Livelihood support system

Agriculture and allied activities support livelihoods of nearly 70% of India's rural population. In the recent years, land based livelihoods of small and marginal farmers are increasingly becoming unsustainable, as their land has not been able to support the family's food, fodder and economic requirements (Sunanda *et al*., 2014). As a result, rural households are forced to look at alternative means for supplementing their livelihoods (Chen, *et al.,* 2013). The rapid changes witnessed in India's macroeconomic level since the early nineties has contributed to the instability of the livelihood systems of the poorer section of both rural and urban households. While the benefits of the globalization process have largely accrued to the urban sector growth, the rural sector has been left behind. Slowdown in agricultural growth and productivity, changing cropping patterns, increase in distress migration, changing consumption patterns, government policies favouring industrial houses among others have seriously undermined the food and livelihood security of the poor households. An integrated, multidimensional and holistic approach to poverty eradication efforts is crucial to preserve and enhance the livelihoods of the poor especially in the rural areas. A livelihood comprises the capabilities, assets and activities required for a means of living. It is deemed sustainable when it can cope with and recover from stresses and shocks especially climate change variations and maintain or enhance its capabilities, assets and activities both now and in the future, while not undermining the natural resource base. The concept of sustainable rural livelihoods is increasingly central to the debate about rural development, poverty reduction and environmental management. This idea was first introduced by the Brundtland Commission on Environment and Development in 1987 as a way of linking socio-economic and ecological considerations in a cohesive, policy-relevant structure. A sustainable livelihood approach is essentially a way of improvement in living standards of the small, poor and landless framers during weather aberrations and climate change situations.

In the Ramasagara watershed, several livelihood supporting activities were carried out. Need based and locale specific livelihood supporting means were given to identified beneficiaries and the necessary technical back up was given.

6.1.1. Kitchen garden

About 115 farmers were given with 10 varieties of vegetable seeds at a cost of Rs. 20,500/- for cultivation of vegetables in and around their house and in the farms of all four villages (Venkatapura, Hanumapura, Devasamudra and Ramasagara) of the watershed. Farmers in the watershed during 2011-12 had sown vegetables in an area of 0.23 ha and produced 4124 kg of vegetables (estimated productivity is 17.61 t ha^{-1}, see **Fig. 6.1**).

6.1.2. Low cost vermicompost units

Motivated ten small and marginal farmers belongs to different villages in the watershed have shown interest in converting their FYM pits into Vermicompost units. Accordingly ten low cost vermicompost units were constructed at a cost of Rs. 15,000/- each with beneficiaries' contribution of Rs. 3000/- (**Table 6.1** and **Fig. 6.2**).

Fig. 6.1. Vegetable cultivation in Ramasagara watershed

In general, these farmers were not skilled enough to handle the units as they were not trained. Oral, visual and exposure visits did not help these poor farmers in maintaining units due to shakes and shifts in motivation level. Further, farmers failed manage attack of ants on earthworms immediately after introduction and entry of rainwater in the units. Hence, these units were not successful in the watershed. Insufficient moisture is also a problem in maintaining the open-heap vermicompost units (**Fig. 6.2**).

Fig. 6.2 Low cost vermicompost unit

Table. 6.1. List of low cost vermicompost units constructed during 2010-11 in the watershed

Sl. No.	Name of the farmer	Village	Caste	Cost (Rs.)	Contribution (Rs.)
1	Angadi Manjunatha S/o Kalappa	Venkatapura	ST	1500	300
2	H.B.Basava Reddy S/o Gangappa	Venkatapura	ST	1500	300
3	K.Hanumaiah S/o Hanumanthappa	Ramasagara	ST	1500	300
4	A.K. Marenna S/o Hanumanthappa	Ramasagara	SC	1500	300
5	Narasimhappa S/o Upralappa	Hanumapura	ST	1500	300
6	Ganghara S/o Sanna basanna	Hanumapura	ST	1500	300
7	Devanna S/o Uparalappa	Hanumapura	ST	1500	300
8	Ananda S/o A.K. Durugappa	Hanumapura	SC	1500	300
9	Kukkala Gangappa S/o Gangappa	Ramasagara	ST	1500	300
10	T. Rudrappa S/o Thippanna	Devasamudra	SC	1500	300
	Total			**15,000**	**3,000**

6.1.3. Masonry vermicompost Units

Total 16 permanent masonry vermicompost units were constructed for beneficiaries from Devasamudra, Hanumapura, Ramasagara and Venkatapura villages. Cost of work was Rs. 1,30,654/- and contribution collected from the beneficiaries was Rs. 26,055/- during 2010-11 to 2013-14 (**Table 6.2**). Among the 16 vermicompost units, fourteen beneficiaries maintained the unit and produced vermicompost whereas two farmers could not (**Table 6.3**). The production of vermicompost varied from five quintal per unit to as high as twenty-one quintals per unit during 2011-12, whereas during 2012-13 production range improved to five to thirty quintal per unit. Further, production range during 2013-14 racketed to five to ninety-five quintals per unit (Amarappa). Total vermicompost production by six farmers has increased from 72 (2011-12) to 108 (2012-13) quintals and it was as high as 209 quintals during 2013-14 as seven more vermicompost units are newly constructed during 2012-13 and 2013-14 (**Table 6.3** and **Fig.6.3**). Total vermicompost produced was 389 quintals during three years in the watershed (2011-12 to 2013-14). Income from individual vermicompost ranged from Rs. 2,500/- to 10,500/- per unit during 2011-12, Rs. 2,500/- to 20,000/- per unit during 2012-13 and Rs. 2,500/- to 47,500/- per unit during 2013-14. Total income from vermicompost units increased from Rs. 36,000/- during 2011-12 to Rs. 1,04,500/- during 2013-14 with a total of Rs.1,94,500/- during project period. These varmicompost units benefitted financially to the individual beneficiaries, reduced dependence on fertilizers by farmers from 5 to 25% besides reducing expenditure on fertilizers and improving soil physical and chemical properties.

In addition, three masonry vermicompost units were constructed during March 2010 for IFS farmers in Integrated Farming System Project (**Table 6.4**). Among the three farmers, only one farmer (G. Ganganna) was successful in maintaining earth worms and produced nearly 168.9 quintals of vermicompost during three years (2011-12 to 2013-14) and its worth is around Rs.84,450/-. Specialty of this case is that, vermicompost produced was applied to fields crops which reduced nearly 30% synthetic chemical fertilizers requirement and augmented crop yields during 2013-14. He also expressed that vermicompost application improves soil fertility, conserves more rainwater, reduces runoff and increases soil moisture storage capacity in the soil and is more beneficial especially during drought years.

Table 6.2. Beneficiary profile and list of masonry vermicompost units constructed in the watershed

S. No	Name of the farmer	Village	Caste	Cost (Rs.)	Contribution (Rs.)
1	Giri Thimmanna	Venkatapura	ST	7000	1400
2	Amarappa S/o Karenna	Venkatapura	ST	7000	1400
3	Adimurthy S/o Badappa	Venkatapura	ST	7000	1400
4	Hulayya S/o Obanna	Ramasagara	ST	7000	1400
5	D. Sivanna	Hanumapura	OC	7000	1400
6	T.Ganganna	Hanumapura	ST	7000	1400
7	Uppanna S/o Uparalappa	Hanumapura	ST	7000	1400
8	Ganganna	Hanumapura	ST	7000	1400
9	Sreenivas	Venkatapura	OC	7000	1400
10	Ananda S/o Durgappa	Hanumapura	SC	9618	1924
11	J. Honnurappa	Ramasagara	ST	9618	1924
12	Yellu Venkatesha Reddy	Devasamudra	Gen	9618	1924
13	Yellu Bushappa	Devasamudra	Gen	9618	1924
14	Buketlu Thippeswamy	Ramasagara	SC	9618	1924
15	Shivaraj S/o Giritimmanna	Venkatapura	ST	9782	1918
16	Shivappa S/o Karianna	Venkatapura	ST	9782	1917
Total				130654	26055

Table 6.4. List masonry vermicompost units constructed and income generated under Integrated Farming System Project within the watershed

Sl. No.	Name of the farmer (IFS Project)	Vermicompost (Quintals/Unit)				Value of Vermicompost (Rs.)			
		2011-12	2012-13	2013-14	Total	2011-12	2012-13	2013-14	Total
1	E.Marenna S/o Jatingappa	2.0	15.0	---	17.0	1000	7500	---	8500
2	G.Ganganna S/o Bhimappa	1.5	50.0	100.0	151.5	750	25000	50000	75750
3	J. Ramesh S/o Jatingappa	0.4	---	---	0.4	200	---	---	200
Total		**3.9**	**65.0**	**100.0**	**168.9**	**1950**	**32500**	**50000**	**84450**

Table 6.3. Names of beneficiaries, villages and quantity of vermicompost produced during watershed implementation phase

Sl. No.	Name of the farmer	Village	Year of construction	Quintal/Unit				Cost of vermicompos t (Rs.)			
				2011-12	2012-13	2013-14	Total	2011-12	2012-13	2013-14	Total
1	Giri Thimmanna	Venkatapura	2011-12	21.0	30.0	35.0	86.0	10500	15000	17500	43000
2	Amarappa S/o Karenna	Venkatapura	2011-12	20.0	40.0	95.0	155.0	10000	20000	47500	77500
3	Adimurthy S/o Badappa	Venkatapura	2011-12	05.0	16.0	----	21.0	2500	8000	----	10500
4	Hulayya S/o Obanna	Ramasagara	2011-12	----	05.0	6.0	11.0	----	2500	3000	5500
5	D. Sivanna	Hanumapura	2011-12	15.0	10.0	15.0	40.0	7500	5000	7500	20000
6	T. Ganganna	Hanumapura	2011-12	06.0	07.0	10.0	23.0	3000	3500	5000	11500
7	Uppanna S/o Uparalappa	Hanumapura	2011-12	----	----	----	----	----	----	----	----
8	Ganganna	Hanumapura	2011-12	05.0	----	----	05.0	2500	----		2500
9	Sreenivas	Venkatapura	2011-12	----	----	----	----	----	----	----	----
10	Ananda S/o Durgappa	Hanumapura	2012-13	----	----	12.0	12.0	----	----	6000	6000
11	J. Honnurappa	Ramasagara	2012-13	----	----	10.0	10.0	----	----	5000	5000
12	Yellu Venkatesha Reddy	Devasamudra	2012-13	----	----	6.0	6.0	----	----	3000	3000
13	Yellu Bushappa	Devasamudra	2012-13	----	----	5.0	5.0	----	----	2500	2500
14	Buketlu Thippeswamy	Ramasagara	2012-13	----	----	5.0	5.0	----	----	2500	2500
15	Shivaraj S/o Giritimmanna	Venkatapura	2013-14	----	----	5.0	5.0	----	----	2500	2500
16	Shivappa S/o Karianna	Venkatapura	2013-14	----	----	5.0	5.0	----	----	2500	2500
Total				**72.0**	**108.0**	**209.0**	**389.0**	**36,000**	**54,000**	**104500**	**194500**

Figure 6.3. Vermicompost units in the farmers fields in the watershed

6.1.4. Dairy

In the year 2011, four farmers, who were already practicing dairy farming, were provided with cross breed Jersey cows at a cost of Rs. 57,000 in which Rs. 44,000/- from the project fund and Rs. 13,000/- farmers' contribution. Additionally, farmers also contributed Rs. 8,800/- to the watershed development fund (**Table 6.5** and **Fig. 6.4**). All beneficiaries purchased four cows at the unit cost ranging from Rs. 12,500/- to Rs. 15,500/- amounting to a total cost of Rs. 57,000/- and the difference of additional cost borne by the beneficiaries was Rs. 13,000/- in addition to contribution of Rs. 8,800/- to the WDF. Farmers contribution for purchase of cows in addition to project contribution varied from 1,500 to 4,500 totalling to Rs.13,000/-. Market values of cows including calves of all four beneficiaries was Rs. 87,000/- during March 2014 (**Table 6.5**). Total income from four cows during 2011-12 was Rs. 34,962/- both from milk and farmyard manure (**Table 6.6**). The net returns realized during financial year 2011-12 was negative (Rs. -3,400) for T. Parameshwarappa and however, Mr. M. Ganganna realized as high as Rs. 21,275/-. In total accrued net returns in the first year was Rs. 34,962/-. The negative net return reported for a farmer was attributed to late calving (July 2011), delayed milk production and low milk yield. During 2012-13, the total income from four cows was Rs. 1,29,000/- (milk and farmyard manure) with a net returns of Rs. 59,845/- (**Table 6.7**). Total income from milk and farmyard manure of four cows during 2013-14 was Rs. 1,34,970/- with a total expenditure as feed/fodder with labour cost was Rs. 69,425/- with a net returns of Rs. 69,545/- (**Table 6.8**). During 2013-14 a farmer's (Mr. J. Ramesh) net income was reduced to Rs. 6,925/- because he sold his cow with calves for Rs. 14,500/- during September 2013. Due to severe drought farmers find difficulty in arranging feed for cows. To settle personal loans and financial commitments farmers used sell their animals. However, higher net returns was

realized by M. Ganganna (Rs. 23,450/-) by exhibiting astute drought management skills. In the three years of study, total net returns excluding the investment made by the beneficiaries varied from Rs. 17,200/- (T. Parameshwarappa) to Rs. 75,655/- (Mr. M. Ganganna). Total net returns including asset value (animals) as on March 2014 was Rs. 1,81,852 (**Table 6.9**).

Table 6.5. Details of the cost, farmer's contribution and value of cows during March 2014

Sl. No	Farmer	Total cost of Cow (Rs.)	Project contribution (NWDPRA)	Farmers contribution		Value of Animals March 2014 (including calf)
				WDF	Additional cost borne by farmer	
1	M.Ganganna/Honnurappa	14000	11000	2200	3000	23000
2	J.Ramesh/ Jatingappa	15500	11000	2200	4500	14500
3	Giri Thimmanna	15000	11000	2200	4000	25500
4	T.Parameshwarappa /Narasimhappa	12500	11000	2200	1500	24000
Total		**57,000**	**44,000**	**8,800**	**13,000**	**87,000**

Table 6.6. Details of the economics of the cows during 2011-12

Sl. No	Farmer	Income/Returns (Rs.)			Expenditure (Rs.)			Net Returns (Rs.)
		Milk	FYM	Total	Feed/Fodder	Labour	Total	
1	M.Ganganna/Honnurappa	36000	1600	37600	9125	7200	16325	21275
2	J.Ramesh/Jatingappa	30000	1500	31500	8213	7200	15413	16087
3	Giri Thimmanna	15000	1600	16600	8400	7200	15600	1000
4	T.Parameshwarappa /Narasimhappa	9000	1400	10400	7300	6500	13800	-3400
Total		**90,000**	**6,100**	**96,100**	**33,038**	**28,100**	**61,138**	**34,962**

Table 6.7. Details of the economics of the cows during 2013-14

Sl. No	Farmer	Income/Returns (Rs.)			Expenditure (Rs.)			Net Returns (Rs.)
		Milk	FYM	Total	Feed/Fodder	Labour	Total	
1	M.Ganganna/Honnurappa	38280	2000	40280	10850	7500	18350	21930
2	J.Ramesh/Jatingappa	31900	2500	34400	9665	7500	17165	17235
3	Giri Thimmanna	33000	2000	35000	10700	7500	18200	16800
4	T.Parameshwarappa /Narasimhappa	17820	1500	19320	8640	6800	15440	3880
Total		**1,21,000**	**8,000**	**1,29,000**	**39,855**	**29,300**	**69,155**	**59,845**

Table 6.8. Details of the economics of the cows during Project period

Sl. No	Farmer	Income/Returns (Rs.)			Expenditure (Rs.)			Net Returns (Rs.)
		Milk	FYM	Total	Feed/Fodder	Labour	Total	
1	M.Ganganna/Honnurappa	39600	2500	42100	12250	6400	18650	23450
2	J.Ramesh/Jatingappa	18000	1250	19250	9125	3200	12325	6925
3	Giri Thimmanna	43200	3000	46200	16350	8400	24750	21450
4	T.Parameshwarappa /Narasimhappa	25920	1500	27420	6500	3200	9700	17720
Total		**1,26,720**	**8,250**	**1,34,970**	**44,225**	**21,200**	**65,425**	**69,545**

Table 6.9. Overall economics of the diary cows during Project period

Sl. No	Farmers	Net Returns (Rs.)			Total Net Returns (Rs.)	Animals Cost (March 2014)	Investment by farmers/ Project	Total net returns
		2011-12	2012-13	2013-14				
1	M.Ganganna/Honnurappa*	21275	21930	23450	66655	23000	14000	75655
2	J.Ramesh/Jatingappa**	16087	17235	6925	40247	14500	15500	39247
3	Giri Thimmanna	1000	16800	21450	39250	25500	15000	49750
4	T.Parameshwarappa***	-3400	3880	17720	18200	24000	25000	17200
Total		**34,962**	**59,845**	**69,545**	**1,64,352**	**87,000**	**57,000**	**1,81,852**

*Cow and calf were sold in Dec.2013 for Rs. 23000/-; **One cow and two calves were sold in Sept. 2013 for Rs.14500/-; ***One cow and a calf were sold for 8500/- during March 2013 and purchased another cow & calf during Nov. 2013 for Rs. 21000/-

Fig. 6.4 Cows with calves of beneficiaries in the watershed

6.1.5. Distribution of ram-lambs to the beneficiaries

Rearing of sheep and goats is a major activity among farmers in the Semi-Arid Tropics of Karnataka especially in the red and black soils of Chitradurga, Koppal, Gadag and Tumkur districts. Generally, these animals were usually held as ready cash in times emergency monitory requirement of the family and also provide nutritional security especially during drought years when the source of income from crops turns into negative. To improve the livelihood of the beneficiaries of the watershed, forty ram lambs were procured and distributed to 20 farmers of Ramasagara, Venkatapura and Hanumapura villages during March 2010 (**Table 6.10** and **Fig. 6.5**). All 20 beneficiaries belong to the marginal section of society, however they willingly contributed Rs.12,000/- towards their share for WDF fund. Eight beneficiaries purchased ram lambs

after selling their grown up rams during 2011 and the number of rams purchased varied from 2 to 4. Total beneficiaries investment for purchase of rams was Rs. 44,300/- and these rams were sold at a cost of Rs. 1,02,200/- and the net benefit derived was Rs. 57,900/- during 2011-12. During 2012-13, nearly 8 farmers have purchased the rams/buffalo and the total rams that were purchased were 43 including a buffalo at a cost of Rs. 1,29,000/-. Few of the rams purchased were sold and others were maintained by farmers and total sale/present value of rams/buffalo during March 2013 was Rs. 1,77,000/- with net benefit of Rs. 48,000/-. During 2013-14, farmers invested nearly Rs. 1,84,000/- for purchase of cows/rams and the value of these (including sale of animals) as on March 31, 2014 was Rs. 3,17,000/- with net benefit of Rs. 1,33,000/-. As on March 31st 2014, total farmers investment for purchase of Rams/buffalo was Rs. 3,57,300/- and gross benefit was around Rs. 7,22,520/- with a net benefit of Rs. 3,05,220/- (**Table 6.10** and **Fig. 6.5**) .

During March 2011, nearly 12 farmers from Ramasagara, Venkatapura and Hanumapura were distributed with 24 rams with a project expenditure of Rs. 60,000 and beneficiaries contributed Rs. 12,000/- to the WDF fund. Beneficiaries derived the total income from sale of rams is Rs. 1,09,000/- and the net benefit was around Rs. 49,000/- during 2011-12 (**Table 6.11** and **Fig. 6.5**). Two goats/rams were sold from as low as Rs. 6,800/- to as high as Rs. 16,000/- with a net benefit varying from Rs.1,800 to Rs. 11,000/-. Among the 12 beneficiaries nearly five farmers either purchased rams/maintained rams/brought a small cow after sale of rams during 2012-13. Mr. Marenna sold two rams at Rs. 6,800/- and purchased a calf at Rs. 5,000/- and grown up calf into heifer calved during March 31st 2014, both cow and calf costs around Rs. 12,000/-. Mr. Thippeswamy sold two rams during 2012-13 at Rs. 9,000/- and purchased two rams at Rs. 6,000/- during 2012-13, whereas these rams cost around Rs. 11,000/- during March 2014. Mrs. Ningamma sold two rams at Rs. 12,000/- during 2011-12 and brought 8 rams at a cost of Rs. 20,000/- during 2012-13 and sold them at a cost Rs. 32,000/-. During 2013-14 she invested Rs. 20,000/- for purchase of eight rams as she has 6 rams and sold 2 rams and the total returns from sale of two rams including the value of six rams as on March 31st 2014 was around Rs. 70,000/-. Mr. Gopal earned the greater income of Rs. 11,000/- during 2011-12 and brought 4 rams at a cost of Rs. 10,000/- and they fetch him Rs. 16,000/- as on March 2013 with net benefit of Rs. 6,000/-. Whereas again he invested Rs. 20,000/- and brought 8 rams during 2013-14 and sold four rams for Rs. 20,000/- with four rams in hand as on March 2014 with a total gross returns he earned during 2013-14 was Rs. 64,000/-. Mr. Thammaiah from Hanumapura sold his rams at Rs. 10,000/- and brought 4 rams at Rs. 6,000/- and sold these rams at Rs. 15,000/-. He brought six rams at Rs. 18,000/- and as on March 31st 2014 they value around Rs. 26,000/- with a net benefit of Rs. 8,000/-. The farmers' investment, market rate of rams and net benefit during 2012-13 was Rs. 47,000/-, Rs. 81,000/- and Rs. 34,000/-, respectively. During 2013-14, total gross, net benefit with farmers investment was Rs. 1,93,500/-, Rs. 1,16,500/- and Rs. 77,000/- respectively. Total twenty farmers' investment was Rs. 1,24,000/- with a gross returns of Rs. 3,75,500/- and net benefit of Rs, 2,19,500/- (Two lakhs nineteen thousand five hundred only) as on 31st March 2014.

Nearly 14 beneficiaries from four villages in watershed were distributed with two rams each totaling to 28 rams and these were purchased at a cost of Rs. 70,000/- (**Table 6.12**). Contribution to WDF from each beneficiary was Rs. 1,000/- totaling to Rs. 14,000/-. All 28 rams were sold for Rs. 1,57,500/- with a net benefit of Rs. 87,500/- during 2011-12, whereas, during 2012-13, of the total 14 beneficiaries, eight beneficiaries purchased rams/buffalo with an investment of Rs. 57,500/- out of the net benefit of Rs. 87,500/- derived during 2011-12 and these beneficiaries maintain rams/buffalo. Value of these animals during 2012-13 (March 2013) was

Rs. 93,500/- with a net benefit of Rs. 36,000/-. During 2013-14, beneficiaries invested Rs. 1,39,700/- to purchase rams/buffalo and gross returns as on 31st March 2014 was Rs. 2,53,700/- with a net returns of Rs. 1,14,000/-. Total farmers' investment, gross benefit along with market rate of rams/buffalo and net benefit as on 31st March 2014 was Rs. 1,97,200/-, Rs. 5,04,700/- and Rs. 2,37,500/-, respectively. Nearly 92 sheep and goats were purchased at a project cost of Rs. 1,90,000/- and distributed to 46 beneficiaries (two each) with their contribution to WDF fund was Rs.38,000/-. All the 46 farmers during the project period invested Rs. 6,78,500/- and realized the gross returns of Rs. 16,02,720 and net returns was Rs. 7,52,220/-. This clearly indicates that rearing of sheep and goats in this region is highly profitable and is an excellent livelihood system.

Fig. 6.5. Farmers who were successful in rearing Rams as livelihood

6.1.6. Poultry birds

Another intervention to secure livelihood of the beneficiaries in the watershed was promoting practice of keeping poultry birds. Backyard poultry practice was introduced to 20 farmers by distributing eight weeks old 275 Giriraj poultry chicks procured from UAS, Dharwad during March and September 2011 at a cost of Rs. 20,000/-. Beneficiaries contributed Rs. 7,200/- to the WDF. Total return from poultry birds up to March 2013 was Rs. 92,085. During 2013-14 only one beneficiary Mr. Tirumala maintained poultry birds and he sold 10 birds at Rs. 5,000/- and possessed nearly 30 birds on hand and their cost as on March 2014 was Rs. 12,000/-. Total income derived from poultry birds by Mr. Tirumala was Rs. 28,000/- (**Table 6.13** and **Fig. 6.6**). Overall, income from poultry birds up to March 2014 was Rs. 1,15,585/- from an investment of Rs. 20,000/- (**Table 6.14**).

Table 6.10. Names of beneficiaries, caste, villages, amount sanctioned, contribution of the beneficiaries for purchase of rams during March 2010, income derived, present success stories, investments and benefits to the farmers as on March 2014.

Sl. No	Name of the farmer	Village	Caste	Beneficiaries Contribution (Rs.)	Years												March 2014		
					2009-10/2010-11			2011-12			2012-13			2013-14			Farmers total Investment (Rs.)	Gross benefit (Rs.)	Net benefit (Rs.)
					Watershed Department Investment (Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Sale of Rams/Present value (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Sale of Rams /Present value (Rs.)	Net benefit (Rs.)			
1	Ganganna	Ramasagara	ST	600	3000	4770	1770	--	--	--	--	--	--	12500 (5)	17500***	5000	12500	22270	6770
2	G. Gangadhara	Ramasagara	ST	600	3000	5600	2600	--	--	--	5000(2)*	7000(2)*	2000	5000 (2)	8000	3000	10000	20600	7600
3	Siddamma	Ramasagara	ST	600	3000	5300	2300	--	--	--	--	--	--	--	--	--	--	5300	2300
4	Gangamma	Ramasagara	ST	600	3000	5300	2300	3500(3)*	9000(3)*	5500	19000(7)*	22500(7)*	3500	40000 (19)	94000	54000	62500	130800	65300
5	H. Ammannappa S/o Anjinappa	Ramasagara	SC	600	3000	6890	3890	--	--	--	--	--	--	--	---	--	--	6890	3890
6	Thirukappa	Ramasagara	ST	600	3000	5090	2090	--	--	--	35000(10)*	40000	5000	35000 (15)	53000	18000	70000	98090	25090
7	H. Hanumanthappa S/o Anjinappa	Ramasagara	SC	600	3000	5830	2830	--	--	--	8000(1)**	18000 (1+1)**	10000	8000 (1+1)cow*	20000	12000	16000	43830	24830
8	Honnurappa S/o Kattaiah	Ramasagara	ST	600	3000	5500	2500	10000 (4)*	16000 (4)*	6000	--	--	--	6000 2cow*	11500	5500	16000	33000	14000
9	Laxmidevi W/o Ganganna	Devasamudra	ST	600	3000	6360	3360	3000 (2)*	8000 (2)*	5000	--	--	--	--	--	--	3000	14360	8360
10	Gundappa	Devasamudra	ST	600	3000	5940	2940	--	--	--	--	--	--	--	--	--	--	5940	2940
11	Karadi Thippanna	Devasamudra	SC	600	3000	6890	3890	8000 (4)*	14000 (4)*	6000	24000 (8)*	28000 (8)*	4000	45000 (15)	58000	13000	77000	106890	26890
12	Dugamma W/o Yellappa	Devasamudra	ST	600	3000	6150	3150	3600 (2)*	8000 (2)*	4400	--	--	--	--	--	--	3600	14150	7550
13	Honnuramma W/o Hemanna	Devasamudra	ST	600	3000	4880	1880	--	--	--	--	--	--	--	--	--	--	4880	1880
14	Chalavadi Oblesh	Devasamudra	SC	600	3000	7850	4850	3000 (2)*	7600 (2)*	4600	10000 (4)*	14000 (4)*	4000	25000 (8)	39000	14000	38000	68450	27450
15	Ananda	Hanumapura	SC	600	3000	9000	6000	5700 (4)*	21600 (4)*	15900	22500 (10)*	41000 (8)*	18500	--	--	--	28200	71600	40400
16	Gudisalu Gangappa	Hanumapura	SC	600	3000	8050	5050	--	--	--	--	--	--	--	--	--	--	8050	5050
17	Narasimhappa	Hanumapura	ST	600	3000	6680	3680	--	--	--	--	--	--	3000 (2)	7000	4000	3000	13680	7680
18	Doddabasanna	Hanumapura	ST	600	3000	6040	3040	7500 (3)*	18000 (3)*	10500	5500 (2)*	6500 (2)*	1000	4500 (2)	9000	4500	17500	39540	19040
19	Palavar Ganganna	Hanumapura	ST	600	3000	7950	4950	--	--	--	--	--	--	--	--	--	--	7950	4950
20	Muradi Ganganna	Hanumapura	ST	600	3000	6250	3250	--	--	--	--	--	--	--	--	--	--	6250	3250
				12000	60000	126320	66320	44300	102200	57900	129000	177000	48000	184000	317000	133000	357300	722520	305220

*Rams; **Buffalo; ***Present value

Table 6.11. Names of beneficiaries and their contribution for purchase of rams, caste, villages, amount sanctioned and total incomeas on March 2014.

Sl. No	Name of the farmer	Village	Caste	Beneficiaries Contribution (Rs.)	Year 2010-11/2011-12			2012-13			2013-14			March 2014		
					Watershed Department Investment (Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers total Investment (Rs.)	Gross benefit (Rs.)	Net benefit Rs.)
1	Lokesh	Venkatapura	ST	1000	5000	7500	2500	--	--	--	--	--	--	--	7500	2500
2	Y.Thippeswamy	Venkatapura	ST	1000	5000	7000	2000	--	--	--	--	--	--	--	7000	2000
3	Marenna	Ramasagara	SC	1000	5000	6800	1800	5000 (1 cow)	8500 (1cow) *	3500	5000 (1+1) cow*	12000	7000	10000	27300	12300
4	Ningamma/ Ninganna	Ramasagara	ST	1000	5000	9000	4000	--	--	--	8000 (1+1)cow*	10500	2500	8000	19500	6500
5	Guddada Anjineya	Ramasagara	ST	1000	5000	7000	2000	--	--	--	--	--	--	--	7000	2000
6	Thippeswamy	Ramasagara	ST	1000	5000	8000	3000	6000 (2)	9500 (2)	3500	6000 (2)	11000 (2)	5000	12000	28500	11500
7	Ningamma	Ramasagara	ST	1000	5000	12000	7000	20000 (8)	32000 (8)	12000	20000 (8)	70000 (6)	50000	40000	114000	69000
8	G.Basanna S/o Nesanna	Ramasagara	ST	1000	5000	6500	1500	--	--	--	--	--	--	--	6500	1500
9	Gopal S/o Hanumakka	Ramasagara	ST	1000	5000	16000	11000	10000 (4)	16000 (4)	6000	20000 (8)	64000 (4)	44000	30000	96000	61000
10	Thammaiah	Hanumapura	ST	1000	5000	10000	5000	6000 (4)	15000 (4)	9000	6000 (2)	8000 (2)	2000	12000	25000	16000
11	Devanna	Hanumapura	ST	1000	5000	9000	4000	--	--	--	12000 (4)	18000	6000	12000	27000	10000
12	Durgamma	Hanumapura	SC	1000	5000	10200	5200	--	--	--	--	--	--	--	10200	5200
	Total			12000	60000	109000	49000	47000	81000	34000	77000	193500	116500	124000	375500	219500

*Cow

Table 6.12. Names of beneficiaries, caste, villages, amount sanctioned, contribution of the beneficiaries, availability of rams that were distributed during August 2011 and the benefit derived from rams up to March 2014.

Sl. No.	Name of the farmer	Village	Caste	Beneficiaries Contribution (Rs.)	Year									March 2014		
					2010-11/2011-12			2012-13			2013-14					
					Watershed Investment(Rs.)	Sale of Rams (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Gross benefit (Rs.)	Net benefit (Rs.)	Farmers Investment (Rs.)	Gross benefit (Rs.)	Net benefit (Rs.)	Farmers total Investment (Rs.)	Gross benefit (Rs.)	Net benefit (Rs.)
1	E.Hanumanna	Ramasagara	ST	1000	5000 (2)	12000	7000	--	--	--	--	--	--	--	12000	7000
2	K.Dadanuraiah	Ramasagara	ST	1000	5000 (2)	13000	8000	8100 (3)	15000	6900	8100 (3)	14000	5900	16200	42000	20800
3	Dodda Basanna	Ramasagara	ST	1000	5000 (2)	9000	4000	3500 (1)*	6000 (1)*	2500	3500 (1 buffalo)*	8000	4500	7000	23000	11000
4	Sanna Ganganna	Ramasagara	ST	1000	5000 (2)	11000	6000	7200 (1)*	12000 (1+1)*	4800	--	--	--	7200	23000	10800
5	K.Murukallaiah	Ramasagara	ST	1000	5000 (2)	11500	6500	4000 (1)	5000	1000	6000 (2)	13000	7000	10000	29500	14500
6	Uppanna	Hanumapura	ST	1000	5000 (2)	10000	5000	4700 (2)	7000 (2)	2300	9700(4)	21000	11300	14400	38000	18600
7	T.Ganganna	Hanumapura	ST	1000	5000 (2)	10500	5500	--	--	--	--	--	--	--	10500	5500
8	Sanna Basanna	Hanumapura	ST	1000	5000 (2)	13000	8000	5000 (2)	12500	7500	6000 (2)	10000	4000	11000	35500	19500
9	Shekarappa	Venkatapura	ST	1000	5000 (2)	20000	15000	10000 (3)	12000 (3)	2000	12000 (6)	24000	12000	22000	56000	29000
10	Thirumala	Venkatapura	ST	1000	5000 (2)	9000	4000	15000 (6)	24000	9000	45000 (14)	60000	15000	60000	93000	28000
11	Thippeswamy	Venkatapura	ST	1000	5000 (2)	9000	4000	--	--	--	--	--	--	--	9000	4000
12	Devendra	Devasamudra	ST	1000	5000 (2)	9500	4500	--	--	--	19800 (13)	52200	32400	19800	61700	36900
13	Bydra Hanumantha	Devasamudra	ST	1000	5000 (2)	9000	4000	--	--	--	11600 (3)	18000	6400	11600	27000	10400
14	C. Marenna	Devasamudra	SC	1000	5000 (2)	11000	6000	--	--	--	18000 (6)	33500	15500	18000	44500	21500
	Total			**14000**	**70000**	**157500**	**87500**	**57500**	**93500**	**36000**	**139700**	**253700**	**114000**	**197200**	**504700**	**237500**

Table 6.13. Income earned by Mr. Tirumala from poultry birds

Year	2011-12	2012-13	2013-14	Total
Income (Rs)	4,500	6,500	5,000 (Sale of 10 birds) + 12,000 (Value remaining 30 birds)	28,000

Table 6.14. Income (Rs.) from backyard Poultry enterprise during Project Period

Sl.No.	Details of Poultry Birds	2011-12	2012-13	2013-14	Total
1	Poultry Birds purchased during March 2011	33,350	6,500	17,000	56,850
2	Poultry Birds purchased during September 2011	40,375	18,360	---	58,735
	Total Income from Poultry Birds	**73,725**	**24,860**	**17,000**	**1,15,585**

Fig. 6.6. Farmer who was successful in rearing poultry birds during 2013-14 in the watershed

6.1.7. Sewing/Tailoring Machine

During March 2010 and 2011 five sewing machines were distributed among the women beneficiaries in four villages of watershed (**Table 6.15**). All the beneficiaries were skilled in tailoring and it helped them in fetching additional income besides engaging in normal farm works for their livelihood. During 2013-14, income from tailoring varied from Rs. 9,000 (Smt. Mamata) to Rs. 22,500 (Smt. Jayshree) per year. The total income from tailoring from five women beneficiaries was Rs. 32,400 during 2010-11, Rs. 72,600 during 2011-12, Rs. 75,500 during 2012-13 and decreased marginally to Rs. 69,500 during 2013-14 and the total income from tailoring beneficiaries till March 2014 was Rs. 2,50,000/- (**Table 6.15** and **Fig. 6.7**).

Fig. 6.7. Women beneficiaries with sewing machines

6.1.8. Barber improvement kits

The annual income of Mr. Nemkalla increased from Rs. 48,000/- (2009-10) to Rs. 54,600/- (2013-14) per year and the income for Mr. Achanna has increased from Rs. 42000/- (2009-10) to Rs. 50,800/- during 2013-14 (**Table 6.15** and **Fig. 6.8**). Income of both barbers have slightly decreased from Rs. 1,29,000/- during 2011-12 to Rs. 1,05,400/- per year during 2013-14 due to migration during these two drought years. Total income from barber beneficiaries till March 2014 is Rs. 4,77,700/-.

Fig. 6.8. Beneficiaries with hair cutting kits

6.1.9. Artisan tools

6.1.9.1. Blacksmith kits

Two blacksmith kits were distributed to beneficiaries belonging to Ramasagara and Devasamudra villages during 2009-10. These blacksmiths were happy with watershed livelihood activities and the income of the beneficiary (Mr. D. Basanna) increased from Rs. 48,000/- per year during 2009-10 (prior to kits distribution) to Rs. 53,500/- per year during a drought year of 2013-14, whereas the other beneficiary Mr. Anjanappa's income increased from Rs. 60,000/- (2009-10) to 59,300/- (2013-14). Total income from blacksmiths is Rs. 1,22,800 during 2013-14 whereas total income up to March 2014 is Rs. 5,19,800/- (**Table 6.15** and **Fig. 6.9**).

6.1.9.2. Masonry kits

Four mason kits were distributed to the beneficiaries during the project period from 2009-10 to 2011-12. This initiative helped masons in using better tools and implemts while performing their construction works. We recorded improved earning among beneficiaries in terms of annual income. Income of Mr. Maraiah, Hanumapura improved from Rs. 25,000/- in (2011-12) to Rs. 30,000/- in 2013-14 and others beneficiaries annual earnings were presented in **Table 6.15** and **Fig. 6.9.** Total income by four masonry increased from Rs. 1,40,000/- (2009-10) to Rs. 1,89,500/- during 2013-14 and the total income during the project period from all masonry beneficiaries till March 2014 was Rs. 6,32,900/-.

6.1.9.3. Carpenter kits

Four carpenter kits were distributed to the beneficiaries belonging to Hanumapura, Devasamudra and Venkatapura villages during the project period. These carpenters were happy with the livelihood activities of the watershed. Income of beneficiary Mr. B. Ganganna of Hanumapura was Rs. 25,000/- and it increased up to Rs. 45,500/- per year (**Table 6.15** and **Fig. 6.9**). The higher income of Mr. Vijendra was attributed to the wood cutting machine and help him to accomplish work contract on time and thus getting more work contracts. The total income of carpenters during 2013-14 is Rs. 1,47,500 and the total income from masonry beneficiaries till March 2014 was Rs. 4,04,050/-. The total income of all the beneficiaries from tailoring, blacksmiths, barbers, masons and carpenters was totaling to Rs. 22,84,450/-.

6.2. Distribution of groundnut decorticators, cycle weeder and seed-cum-fertilizer drill (farm implements) to the beneficiaries

Beneficiaries from Ramasagara, Devasamudra, Hanumapura and Venkatapura villages of the watershed were provided with seed-cum-fertilizer drills, cycle weeders and groundnut decorticators. All the beneficiaries were belonging to either SC or ST communities. Two beneficiaries from Ramasagara and one from Venkatapura were provided a seed-cum-fertilizer drill. Four cycle weeders were distributed to the four beneficiaries, one from each four villages of the watershed. Ten groundnut decorticators were provided to the beneficiaries from the four villages of the watershed. The total expenditure incurred towards this activity was Rs. 70,200/- and farmers contribution was Rs. 14,040/- (**Table 6.16**).

Fig. 6.9. Beneficiaries with artisan tools

6.3. Success stories in ram-lambs rearing

One of the farmers Mr. Ananda sold his two rams after six months for Rs. 9,000/- with a net benefit of Rs. 6,000/- during 2010-11 and brought 4 new born rams for Rs. 5,700/- and they were sold to Rs. 21,600/- after eight months (September 2011) with a net benefit of Rs. 15,900/-. Further he brought 10 rams in October 2011 for Rs. 22,500/- and after seven months he sold eight of them for Rs. 41,000/- during May 2012 with a net benefit of Rs. 18,500/. In this livelihood system total farmers investment was Rs. 28,200/- with a gross benefit of Rs. 71,600/- and a net benefit of Rs. 40,400/-. Another beneficiary Mrs. Gangamma from two rams that were given in the watershed activity has increased the rams up to 19 through sale and buying of new rams with a total investment of Rs. 62,500/- with gross benefit of Rs. 1,30,8000/- and a net benefit of Rs. 65,300/- from 2010 March to 2014 March. Even Mr. Honnurappa and Mr. Hanumantappa brought cows after sale of rams. Mrs. Ningamma and Mr. Gopala has improved their livelihood through rams rearing and derived net benefits of Rs. 69,000/- and Rs. 61,000/-, respectively (**Table 6.11** and **Fig. 6.10**).

Table 6.15. Names of beneficiaries, caste, villages, contribution of the beneficiaries & income derived from sewing machines, blacksmith, barber, Masson kits and Carpenter kits during the Project period

Sl. No.	Name of the farmer	Village	Caste	Materials Qty/no.	Beneficiaries contribution (Rs.)	Income before (Rs. Per year) 2009-10/10-11	Income 2010-11 (Rs. per year)	Income 2011-12 (Rs. Per year)	Income 2012-13 (Rs. Per year)	Income 2013-14 (Rs. Per year)	Total income up to March 2014 (Rs.)
	Sewing/Tailoring Machine										
1	Smt. Varalaxmi w/o. Eswarareddy	Devasamudra	OC	1	1400	---	9600	10500	12000	10500	42600
2	Smt. Mamata D/o Mallikarjuna	Venkatapura	OC	1	1400	---	8400	9000	8500	9000	34900
3	Smt. Jayshree W/o Thippeswamy	Devasamudra	OC	1	1400	---	14400	15500	18000	20000	67900
4	Smt. Devamma W/o Sidda Palaiah	Hanumapura	ST	1	1050	---	---	16000	14500	12000	42500
5	R.O. Mangalamma W/o Ramesh	Ramasagara	ST	1	1050	---	---	21600	22500	18000	62100
	Sub total			**5**	**6,300**	---	**32400**	**72,600**	**75500**	**69500**	**250000**
	Barber Kit										
6	Nemakalla S/o Nemkallappa	Hanumapura	ST	1 kit	600	48000	64800	67000	62500	54600	248900
7	Achanna S/o Nemkallappa	Hanumapura	ST	1 kit	600	42000	60000	62000	56000	50800	228800
	Sub total			**2 kits**	**1200**	**90,000**	**1,24,800**	**1,29,000**	**118500**	**105400**	**477700**
	Blacksmith Kit										
8	D. BasannaS/o Pennayya	Ramasagara	ST	1 kit	400	48000	66000	68500	59500	53500	247500
9	AnjanappaS/o Sanjeevappa	Devasamudra	ST	1 kit	400	60000	72000	75000	66000	59300	272300
	Sub total			**2 kits**	**800**	**108,000**	**1,38,000**	**1,43,500**	**125500**	**112800**	**519800**
	Masson kit										
10	SunkappaS/o Mareppa	Ramasagara	ST	1 kit	400	72000	84000	86500	75300	68500	314300
11	J. HonnurappaS/o Yerrappa	Ramasagara	ST	1 kit	400	30000	---	36500	42500	45000	124000
12	Maraiah S/o Parameshwarppa	Hanumapura	ST	1 kit	400	20000	---	25000	28000	30000	83000
13	*C. Shivappa S/o Chikkanna	Venkatapura	ST	1 kit	400	18000*	---	26000*	39600	46000	111600
	Sub total			**4 kit**	**1600**	**1,40,000**	**84,000**	**1,74,000**	**185400**	**189500**	**632900**
	Carpenter										
14	D. VijandraS/o Chandra Chari	Venkatapura	ST	1 kit	400	40000	---	49000	53200	60000	162200
15	B. GangannaS/o Maryappa	Hanumapura	SC	1 kit	400	20000	---	24000	22500	20000	66500
16	*B Kalachari S/oVeerappa	Venkatapura	ST	1 Kit	400	19000*	---	25000*	38500	45500	109000
17	*Eshanna KS/o Marenna	Devasamudra	ST	1 Kit	400	13500*	---	18100*	26250	22000	66350
	Sub total			**4 Kits**	**1600**	**92,500**	**---**	**1,16,100**	**140450**	**147500**	**404050**
	Total				**11,500**	**4,30,500**	**3,79,200**	**6,35,200**	**6,45,350**	**6,24,700**	**22,84,450**

Table 6.16. Distribution of seed-cum-fertilizer drills, cycle weeder and groundnut decorticators to the beneficiaries during 2009-10

Sl. No	Name of the farmer	Village	Caste	Total amount sanctioned (Rs.)	Total amount spent (Rs.)	Beneficiaries contribution (Rs.)
	Seed-cum-fertilizer drills					
1	Guddada Hanumantha	Ramasagara	ST	15000	15000	3000
2	Konapur Ganganna	Ramasagara	ST	15000	15000	3000
3	Thirumala S/o Thimmappa	Venkatapura	ST	15000	15000	3000
	Cycle weeders					
1	Honnurappa S/oYerrappa	Ramasagara	ST	1300	1300	260
2	Hanumantha S/o Devappa	Devasamudra	ST	1300	1300	260
3	Adimurthy S/o Badappa	Venkatapura	ST	1300	1300	260
4	G. Ganganna	Hanumapura	ST	1300	1300	260
	Groundnut decorticators					
1	Govindappa	Devasamudra	ST	2000	2000	400
2	Hanumanthappa	Devasamudra	ST	2000	2000	400
3	Jangali Sanna Thimmanna	Ramasagara	ST	2000	2000	400
4	Guddada Anjineya	Ramasagara	ST	2000	2000	400
5	Hanumakka	Ramasagara	ST	2000	2000	400
6	Govindappa	Ramasagara	SC	2000	2000	400
7	Thippeswamy	Venkatapura	ST	2000	2000	400
8	Angadi Kalappa S/o Ningappa	Venkatapura	ST	2000	2000	400
9	Honnurappa S/o Narasimhappa	Hanumapura	ST	2000	2000	400
10	P. Ganganna S/o Gangappa	Hanumapura	ST	2000	2000	400
	Total			**70,200**	**70,200**	**14,040**

Fig. 6.10. Distribution of rams to the beneficiaries

7. MONITORING AND IMPACT EVALUATION

7.1. Run off reduction

A broad-crest weir, constructed prior to the implementation of watershed project having a catchment of 60 ha, was repaired and modified for monitoring runoff and soli losses. A gauging station was installed and the runoff and soils loss gauging was initiated in the year 2008. Later on an automatic stage level recorder was installed and runoff/soil loss gauging was continued up to the closure Project in 2014. The runoff values are presented in **Tables 7.1** and **7.2**. The pre-project (2008) annual and erosive rainfall was 631.0 mm and 498.8 mm respectively. The Project period annual and erosive rainfall (2009 to 2014) was 653.9 mm and 420.64 mm, respectively.

Since there was low rainfall in 2013 (312.8mm), the comparison of conservation effect on runoff reduction between Pre-Project runoff (62.6mm) and Post-Project average runoff (26.1 mm) was more aptly reflected and presented in **Table 7.2**. There was 58.4% reduction in runoff over that of Pre-Project due to conservation measures (**Table 7.2**), especially due to field bunding. The land treatment during project period have retained the runoff at the terrace level itself which was evident from the reduced percentage of runoff to annual rainfall (6.3%) during Post Project period as compared to 12.6% runoff in the Pre-Project year.

Table 7.1. Reduction in runoff due to conservation practice in Ramasagara watershed in all the years

Year	Annual rainfall (ARF)	Erosive Rainfall (ERF)	Runoff (RO) (mm)	% Runoff to ARF	% Runoff to ERF	% RO reduction over Pre-Project
Per-Project (2008)	631.0	498.8	62.6	9.92	**12.55**	
Project 2009	718.0	763.0	49.0	6.83	6.42	
2010	808.4	568.4	32.0	3.96	5.63	
2011	391.6	193.0	13.8	3.53	7.17	**63.5**
2012	607.9	348.8	21.5	3.53	6.15	
2013	312.8	92.0	6.7	2.15	7.30	
2014	619.4	230.0	14.0	2.27	6.10	
Post-Project (Mean)	596.6	365.9	22.9	3.83	**6.46**	

Table 7.2. Reduction in runoff due to conservation practice in Ramasagara watershed in comparable years

Year	Annual rainfall (ARF)	Erosive Rainfall (ERF)	Runoff (RO) (mm)	% runoff to ARF	% runoff to ERF	% RO Reduction over Pre-Project
Pre-Project (2008)	631.0	498.8	62.6	9.92	**12.55**	
Project 2009	718.0	763.0	49.01	6.83	6.42	
2010	808.4	568.4	32.02	3.96	5.63	
2011	391.6	193.0	13.84	3.53	7.17	**58.4**
2012	607.9	348.8	21.45	3.53	6.15	
2014	619.4	230.0	14.3	2.27	6.10	
Mean of Project	653.9	420.64	26.07	3.99	**6.29**	

Note: Year 2013 was not considered being a drought year for comparison of Per-Project and Post Project runoff data

7.2. Reduction in soil loss

Soil loss measuring device such as Coshocton wheel could not be installed due to practical problems such as theft/damage and common mechanical problems of equipment. Hence a silt trap pit (140 sq mm of bed area) was located on u/s of runoff gauging station. The silt surveys were conducted in Pre-Project year (2008) and during 3rd to 5th year (2011 to 2013) of Project implementation. Significant siltation in the trap pit is discernible after three year of conservation measures implementation. The survey indicates that 4.91 tons ha^{-1} $year^{-1}$ was the soil loss in Post-Project period which is within the permissible soil loss limit (6 t ha^{-1} $year^{-1}$) and much below than the estimated soil loss of 11 to 16 tons ha^{-1} $year^{-1}$ in untreated areas in this region.

7.3. Impact of soil and water conservation on groundwater recharge

Synergy among runoff potential, additional water storage created in during project and soil infiltration rate/aquifer transmissivity resulted in improvement of ground water recharge.

7.4. Runoff water storage created during Post Project period

The two major contributors for improvement in groundwater recharge are (i) Chinnahagiri stream with seasonal flow on lower reaches and (ii) the terrain of hill slope in the watershed. Construction of barrage across Chinnahagiri on its upper reaches has stopped seasonal flow near watershed, thus this water body ceased to contribute to the groundwater recharge in the watershed. Hence, efforts were made for harvesting the runoff within the watershed itself and also harvesting of external runoff by constructing various water harvesting structures (WHS) in the watershed during Post-Project period (**Table 7.3**).

Watershed has a dissected topography consisting of 70 ha of hill slope (15 to 20%) terrain and 35 ha of land area with steep slope of 3 to 6%. High intense rains occur in the watershed. Thus, the interaction of steep land slope and high intense rains combindly leads to generation of high volumes of runoff. For harvesting such potential runoff of 45810 m^3, runoff-storage space was created (**Table 7.3**) in the Project period by various structures with the aim of improving ground water recharge. The two water harvesting structures provided with gauging scales in percolation tank at upper reaches and check dam at lower reaches have been monitored for three years (2010-12) for finding quantity of evaporation and percolation in the bed of these two structures. The data reveals that 70% to 87% of stored water goes as percolation into sub-soil of which a small part is available for ground water recharge. The inherent permeability of structures' bed geology ensures the rapid percolation of stored water.

7.5. Storitivity of geology

The pump test of the bore well reveals that the geology of the analogous area is active (35.28 m^3 day^{-1} m^{-1} of transmissivity) that helps in groundwater recharge. It also points to the lopsided time of recharge effect in the sense that a good rainfall year has the time lag extended to the succeeding year and bore well pump yields are observed to be normal in the succeeding year even if it happens to be a below normal rainfall year.

The area has undulating topography. The mean normal rainfall is 417.3 mm, which is characteristic of the semi-arid nature of the area. The area is covered with red to red loamy soils and underlined by granites of Archaean age. Ground water in the area occurs under water table conditions and is restricted to weathered and fractured portion of the formations. Ground water in the area is being extracted through bore wells. The pumping test by volumetric method (discharge type) was conducted on bore well and the parameters derived from the pumping test in analogous area are presented in **Table 7.4.**

Table. 7.3. Water storage created for groundwater recharge in Pre-Project period

Structure	Location	Net Storage Capacity (m^3)	Average no of fillings $year^{-1}$	Gross Storage Created (m^3)
1. Diversion drain	Upper reach at the foothill	6122.0	4	24488.0
2. Percolation Tank (storage through desiltation = 3095 cum and additional storage by raising spillway crest height = 2475cum)	1. Upper reach	5570.0	2	11140.0
3. Mini check dam cum Drop weir with retention wall & embankment along with impounding in the diversion channel with a length of 316.8 m & C/s of 1.5 m^2 in Survey No. 6 and 7	Upper reach	475.0	6	2850.0
4. Percolation pond	Middle reach	1222.0	6	7332.0
Total storage created (m^3) in Post-Project period				**45810.0**

Table 7.4. Pump test results

Location	Bore well diameter (mm)	Inlet and outlet Diameter (inch)	Type of Pump	Discharge in lpm	Transmissivity (T) $m^3 d^{-1} m^{-1}$	Specific capacity (c) $lpm^{-1} m^{-1}$	Command area (ha)	Remarks
Survey No.11	165	63&50 (2.5×2")	7.5 HP-EM	83	35.28	24.85	1.20 With Dry cum wet crops	Co-efficient of storage could not be not calculated due to non availability of peizometer observation. The general value in the analogous areas is 32.46 × 10^{-3}

Formulae used for computing above parameters

1. Transmissivity (T) = $\frac{2.3\,Q}{4\pi\Delta^h}$

Where, Q = Discharge in m^3 day^{-1} and Δ^h = Difference of Residual draw down per log cycle

2. Specific capacity of the well = Q/S, Where, Q = lpm and S = Draw down in meters

A typical lithology of bore well (**Fig. 7.1.**) indicates that permeable geology exists with sand and murram layers. The ground water could be struck at 60-70 feet.

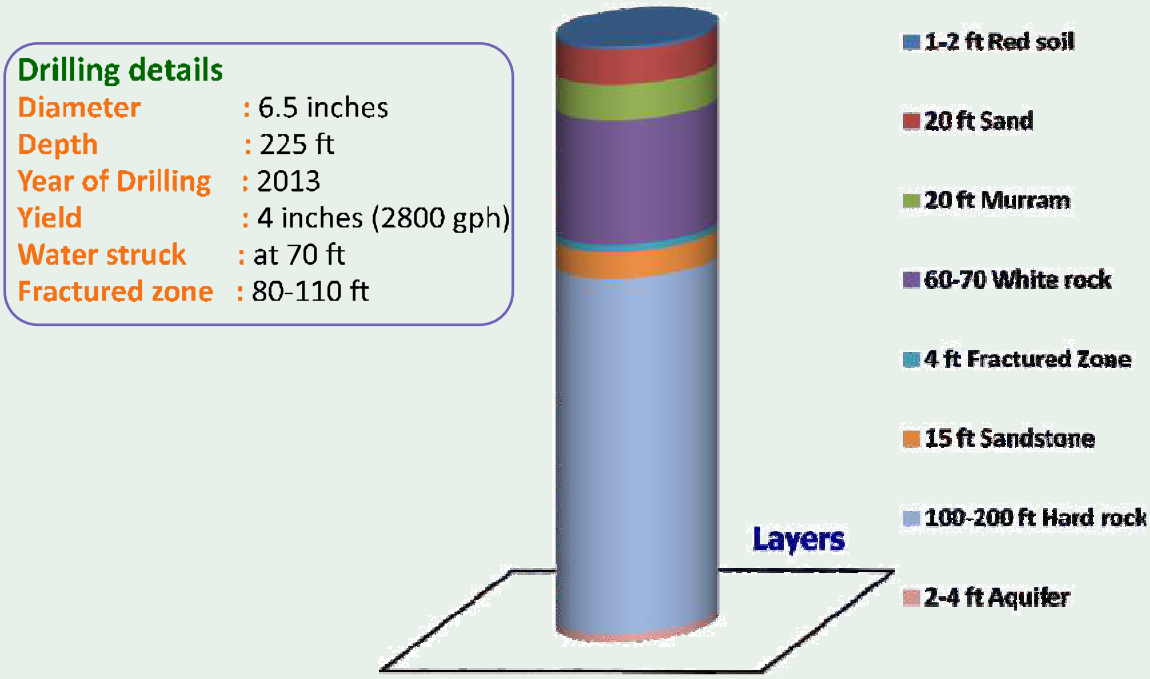


Fig. 7.1. Typical Lithological log of a bore well

7.6. Groundwater utilization

The data on the thirty bore wells with name of farmers, total depth of bore wells and groundwater table depth were presented in **Table 7.5**. There were 47 bore wells functioning in the watershed and were irrigating over 72.2 ha during Pre-Project period in the watershed. The chronicle increase in number of bore wells and irrigated area during project period was presented in the **Table 7.6**. Number of wells increased from 17% during first year of the watershed implementation (2009-10) to 40% (66 Nos) in 2013-14 during which the major watershed activities were completed. Correspondingly, the irrigated area increased from 8.4% (78.3 ha) in 2009-10 (first year of project) to 113% (154 ha) in 2013-14 (last year of project). However the command area per well has exhibited mixed trend of ups and downs. The command area per well in Pre-Project period was 1.6 ha while it ranged from 1.4 to 2.3 ha during Post-Project period depending on the rainfall. Overall, it indicates that over drafting of groundwater in the watershed. Besides the prospective scenario of increased irrigated area and crop productivity, ironically the distress was also present in terms of decline in ground water table, poor success rate in getting water from drilling of new bore wells and ever increasing failure of existing bore wells thus adding burden over farmers. However, competitive spirit among the farmers still persist in drilling bore wells despite the increasing probability of failure as number of attempts for a successful bore well are roughly three to four failures.

7.7. Additional man-days of employment generated in Engineering works

Additional man days of 13296 were created through various engineering works during watershed implementation as per the Government of Karnataka rate of Rs. 155 per day (**Table 7.7**).

Table 7.5. Groundwater table levels in bore wells from ground surface in 2014-15

Sl. No	Survey No.	Farmer's name	Groundwater table depth from ground level (m)	Total depth of bore well (m)
1	30	Uppanna	13.6	60.6
2	30	Sout Dhevanna	27.3	90.9
3	19	Shekhavappa	27.3	75.8
4	19	Shekhavappa	18.2	Not available
5	19	Thipppeswamy	15.2	60.6
6	19	Gauganna	21.2	75.8
7	02	Katle Basamma	13.6	60
8	17	Shushkala Laxmi Devi	27.3	69.9
9	30	Muvudi Gauganna	27.3	75.8
10	11	Jaugali Mareppa	15.2	89.7
11	11	Jaugali Mareppa	19.7	69.7
12	11	Jaugali Mareppa	27.3	60.6
13	11	Kali Adivappa (Nagaraj)	22.7	68.2
14	11	Kali Adivappa (Nagaraj)	29.1	60.6
15	11	Gollara Anumackka	19.7	Not available
16	32	Konapura Ganganna	27.3	60.6
17	01	Hulayya	29.1	60.6
18	03	Hulayya	19.7	60.6
19	03	Guddadha Marenna	27.3	60.6
20	03	Guddadha Hununna	30.3	63.6
21	17	Entaramayya Navaramarenna	28.8	63.6
22	17	A.T.Basavaraja	25.8	60.6
23	17	A.T.Basavaraja	33.3	69.7
24	18	Lokesh	30.3	60.6
25	18	Ramanjineya	25.8	60.6
26		Anandh	27.3	65.2
27		Rama lingappa	24.2	57.6
28		Parameshwarappa	18.2	51.5
29		Rudrappa	22.7	65.2
30		Uppal Narasimhappa	15.2	48.5

Table 7.6. Increase in number of bore wells and irrigated area

Year	Number of working bore wells	% increase of bore wells over Pre-Project	Irrigated area (ha)	% increase of irrigated area over Pre-Project	Command area ha well $^{-1}$
Pre-Project (2008-09)	**47**		**72.19**		**1.6**
Project Period					
2009-10	55	17.0	78.30	8.4	1.4
2010-11	62	31.9	109.29	51.4	1.8
2011-12	67	42.6	120.11	66.4	1.8
2012-13	75	59.6	147.98	105.0	2.0
2013-14	**66**	**40.4**	**154.00**	**113.0**	**2.3**

Table 7.7. Additional employment (man days) created by engineering works during Project period

Sl. No	Engineering works	Units	Qty	Employment Man -days
1	Manual Bunding & bund shaping	RM	42243	1869
2	Construction & repairs of Wastweirs	Nos	275	3732
3	RFD	Nos	2	2435
4	Revetment	nos	1	432
5	Masonry weir	Nos	1	203
6	Check dam	Nos	1	390
7	Animal water drinking trough	Nos	2	512
8	Platform	Nos	1	339
9	Vermicompost		7	159
10	Repair & modification of gauging station	Nos	1	1557
11	Transportation and spreading of silt in farmers fields			1671
	Total man days			**13296**

Note: Wage rates are as per MNREGA -2012-13(Rs 155/man day)and DSR of Watershed Development Department, Karnataka Government for the year 2012-13

8. CROP PRODUCTION AND MICRO ENTERPRISES

8.1. Crop diversification

To bring improvement in crop yields, improved varieties of crops were introduced during *kharif* (rainy) season of 2009-10, 2010-11, 2011-12 and 2012-13 in the watershed for rainfed and irrigated conditions. Particularly for rainfed farmers, K-6 and TMV-2 varieties of groundnut, ICTP-8203 cultivar of bajra, GCH-4 and DCH-177 varieties of castor, ICPL-87 and BRG-2 varieties of redgram and C-152 of cowpea were introduced by providing seed material to the farmers. Similarly, for irrigated farms, improved maize hybrid Super 900M Gold, Gangavathi Sona (GGV-05-01) variety of paddy and Super Mallika, Mallika Gold, Sarvodaya Kanaka and Sashyashamla hybrids of Bt.cotton were introduced.

8.1.1. During 2009-10

During 2009, soaking 205.2 mm rainfall received during May followed by 55.8 mm rain in June but no rain July, a critical month for sowing *kharif* rainfed crops. Further, 103.0 mm rainfall received during 2nd fortnight of August and rainfed crops were sown. Due to late sowing groundnut yield was reduced to only 30% to 40% of normal one, whereas cowpea yields were about 80% of the normal. Even though the total rainfall in the watershed was 48% higher (718.0 mm), the rainfed crop yields were lower and it was primarily due to ill distribution of rainfall. However, we recorded effect of new varietal/hybrids in the watershed and results were enlisted below.

- Groundnut pod yield increased by 35% by cultivation of TMV-2 and further increased by 51% with introduction of K-6 (Breeder seed) over local variety, whereas B:C ratio was higher by 20% for both varieties over the traditional variety (**Table 8.1** and **Fig. 8.1**).
- In groundnut and cowpea intercropping, the groundnut pod equivalent yield increased by 31% with cultivation of groundnut (TMV-2) + cowpea (C-152) and further increased to 48% with cultivation of groundnut (K-6) + cowpea (C-152) over cultivation of groundnut and cowpea local varieties and B:C ratio increased by 23% and 26%, respectively.
- Bajra grain yield increased by 83% with cultivation of ICTP-8203 over local variety (**Fig. 8.1**).
- Castor hybrids GCH-4 and DCH-177 and redgram variety ICPL-87 procured from UAS, Dharwad and distributed to 38 farmers and both crops failed due to low rainfall after sowing.
- Overall, groundnut and bajra yields reduced by 68% and 110%, respectively over 2008-09 due to low and ill distributed rainfall.

8.1.2. During 2010-11

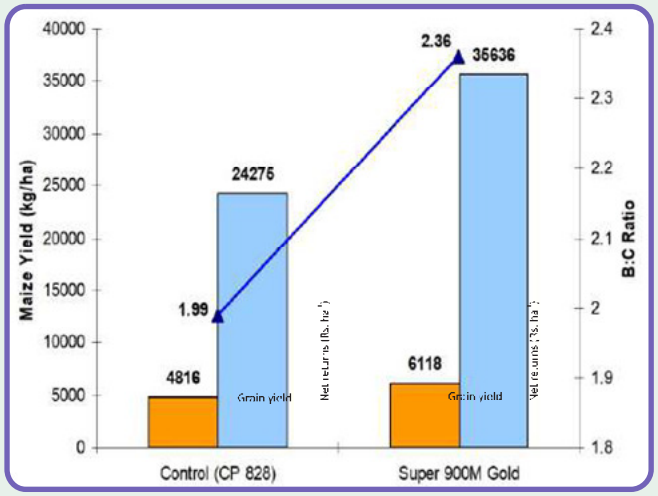
Higher yields of groundnut and redgram in the year 2010 were attributed to higher rainfall by 66% (808.4 mm) with its uniform distribution prior to sowing and during cropping season. Crops under rainfed situations were sown from 17th July (optimum sowing time) till the end of July. Rainfall that fell during cropping season was 424.6 mm in 26 rainy days.

- Groundnut+redgram yield increased from 35%+47% (TMV-2+BRG-2) to 45%+58% (K6 + BRG-2) over farmers' cultivated variety (**Table 8.1**, **Fig. 8.2** and **8.3**).
- Net returns increased by 82% in groundnut (TMV-2) intercropped with redgram to 100% with groundnut (K-6) intercropped with redgram (BRG-2) over local varieties of groundnut and redgram (**Fig. 8.3**).

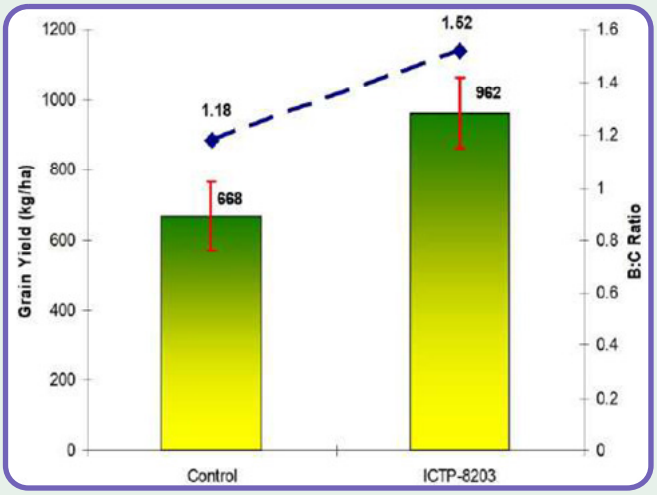
- Intercropping of groundnut (K-6) and redgram (BRG-2) recorded 2.33 B:C ratio and it was 2.08 for groundnut (TMV-2) and redgram (BRG-2) intercropping and the B:C ratio was higher by 43 and 31%, respectively over local variety as groundnut pod equivalent yield (**Fig. 8.3**).
- In bajra yield increased from 29% up to 74% with improved hybrid (ICTP-8203) and watershed management over local variety outside watershed. The ICTP-8203 cultivar recorded 44%, 156% and 29% higher grain yield, net returns and B:C ratio, respectively (**Table 8.1** and **Fig. 8.3**).
- Cultivation of improved hybrid maize (Super 900M Gold) increased the maize grain yield by 27% (6118 kg ha^{-1}) and straw yield by 20% (82.53 q ha^{-1}), net returns by 47% and B:C ratio by 19% over local maize hybrid (CP-828) cultivated by the farmers in the watershed (**Table 8.1** and **Fig 8.4**).

Fig. 8.1. Improved varieties of groundnut and redgram crops introduced in watershed

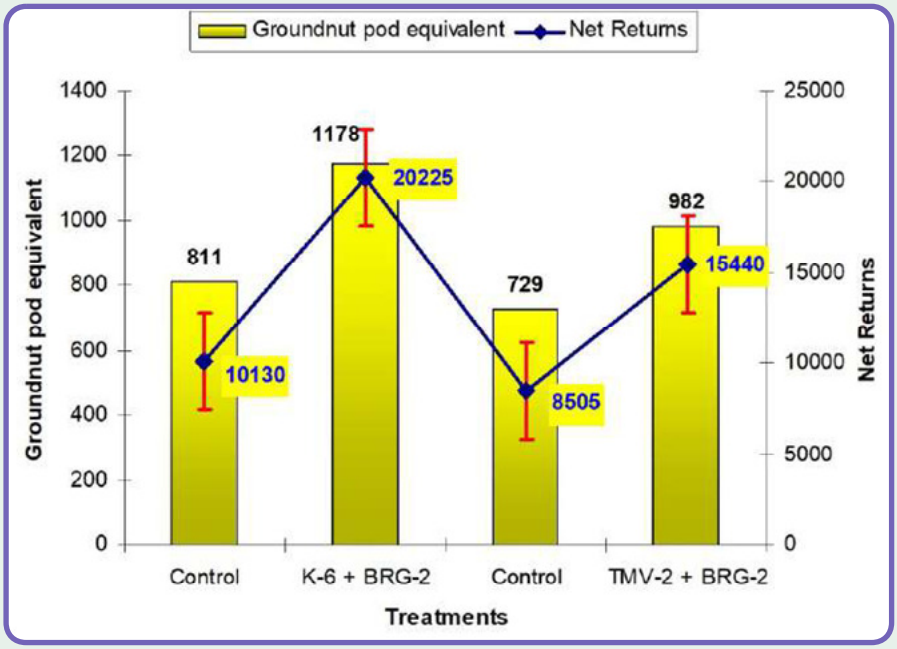
Fig. 8.2. Improved varieties of groundnut introduced in the watershed



Maize



Bajra



Groudnut + Redgram intercropping

Fig. 8.3. Improved cultivars of maize, bajra, groundnut and redgram during 2010-11 (crop diversification)

Fig. 8.4. Farmer cultivar (CP 828) Vs improved (Super 900M Gold) cultivar demonstrated in maize and bottom right) cultivar demonstrated in maize

8.1.3. During 2011-12

During 2011, lower rainfall of 391.1 mm (-20%) was received and it was ill distributed thus resulting in insufficient soil moisture during early vegetative stage and severe moisture stress during critical flowering to pod formation stage in groundnut producing only 50% to 60% of the normal yields even though the crop was sown during 2nd fortnight of July. The 112 mm rainfall received in October increased pod size and weight otherwise yields would have been low.

- Introduction of groundnut variety TMV-2 and redgramvariety BRG-2 increased the pod and grain yields by yield by 30% and 36%, respectively over local varieties cultivated by the farmers in the watershed (**Table 8.1** and **Fig. 8.5**).
- Intercropping of groundnut (TMV-2) and redgram (BRG-2) increased the groundnut pod equivalent by 30% and B:C ratio by 26% over traditional cultivars.

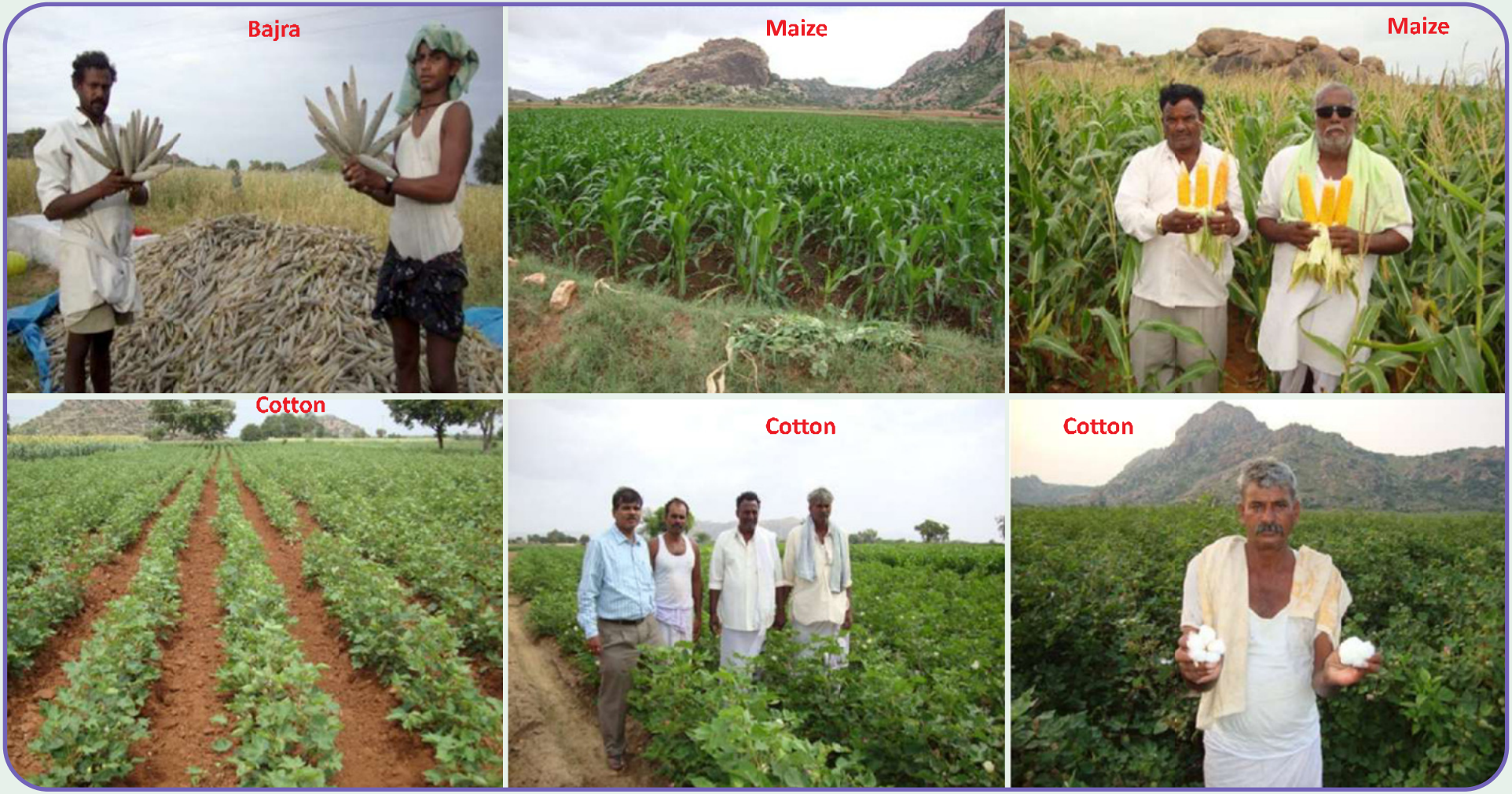


Fig. 8.5. Performance of improved varieties of Bajra, Maize and Cotton crops demonstrated on farmer fields

Table 8.1. Increased yields of Improved variety over traditional variety in Ramasagara watershed

Year	Rainfall (mm)	Higher/ Deficit (%)	Distribution	Crop	Improved variety /Hybrid	% Increase
2009-10	718.0	Higher by 48%	Erratic	Groundnut	K-6 (Breeder seed)	51%
				Groundnut	TMV-2	35%
				Groundnut+ Cowpea	TMV-2+ C-152	Up to 48%
				Groundnut+ Cowpea	K-6+ C-152	Up to 48%
				Castor hybrid	GCH-4	
				Bajra	ICTP-8203	83%
2010-11	808.4	Higher by 66%	Good	Groundnut+Redgram	K-6+BRG-2	45%+58%
				Groundnut+Redgram	TMV-2+BRG-2	35%+47%
				Groundnut+Redgram (G.nut Pod Equivalent)	TMV2+ BRG-2	36% (NR-82%) (BCR-31%)
				Groundnut+Redgram (G.nut Pod Equivalent)	K6 +BRG2	45% (NR-100%) (BCR-43%)
				Bajra hybrid	ICTP-8203	44% (NR-156%)
				Maize hybrid	Super 900M Gold	27% (NR-47%)
2011-12	391.6	20% Lower	Ill distributed	Groundnut+Redgram (G.nut Pod Equivalent)	TMV2+ BRG-2	30% +36% (GR - 30%) (BCR-26%)
				Bajra	ICTP-8203	32% (BCR-24%)
				Maize	Super 900M Gold	32% (NR-24%) (BCR-10%)
				Bt. Cotton	Super Mallika, Mallika Gold Sarvidaya Kanaka Sashyashamala Kanaka	31% (NR-78%) (BCR-23%)
2012-13				Groundnut	K-62 &TMV-2	22%
				Bajra	ICTP-8203	33%
				Sona rice	Gangavathi Sona	9-22%
				Cotton hybrid	Bt & Super Mallika	33%, (GR-98%, NR of Rs. 22184 ha^{-1})

BCR- B:C Ratio; NR- Net returns; GR- Gross returns

- Intercropping of groundnut (TMV-2) and redgram (BRG-2) increased the groundnut pod equivalent by 30% and B:C ratio by 26% over traditional cultivars.
- Cultivation of ICTP 8203 bajra cultivar produced 32% and 27% higher grain and straw yield, respectively over local variety. The net returns and B:C ratio increased by 141% and 24%, respectively with cultivation of ICTP 8203 over local bajra variety cultivated by farmers (**Table 8.1** and **Fig. 8.5**).
- Cultivation of improved hybrid maize (Super 900M Gold) increased the maize grain yield by 32% (6913 kg ha^{-1}) and straw yield by 23% (99.92 q ha^{-1}), net returns by 24% and B:C ratio by 10% over local maize hybrid (CP-828) cultivated by the farmers in the watershed (**Table 8.1** and **Fig. 8.5**).
- In irrigated crops maize grain yields were higher by 66% (maize-Super 900M Gold) inside watershed compared to outside watershed (**Table 8.3** and **Fig. 8.5**).
- Cultivation of improved Bt cotton hybrids, Super Mallika, Mallika Gold, Sarvodaya Kanaka and Sashyashamla Kanaka increased lint yield and gross returns by 31%, net returns by 78% and B:C ratio was higher by 23% over farmer cultivated hybrids (**Table 8.1** and **Fig. 8.5**).
- During kharif, the productivity of hybrid sorghum, maize and Bt. cotton increased by 66%, 67% and 53%, respectively over pre-project period (**Table 8.3** and **Fig. 8.5**).

8.1.4. During 2012-13

- Groundnut grain yield inside watershed was 22% greater than outside watershed and it was attributed to the cultivation of improved varieties of groundnut i.e. TMV2 and K6 and rainwater conservation measures adopted inside the watershed as compared to the outside watershed (**Table 8.3**).
- Grain yield of bajra (ICTP-8203) inside watershed was 33% higher than the yield recorded outside watershed (**Table 8.3**).
- Improved Bt. cotton hybrid, Super Mallika increased lint yield by 33%, gross returns by 98% and fetched additional income of Rs. 22184 ha^{-1} and B:C ratio increased by 26% over farmer cultivated hybrids (**Fig. 8.6**).
- Productivity of Bt. cotton increased from 1487 kg ha^{-1} (outside the watershed) to 2552 kg ha^{-1} (Inside watershed) and the per cent increase was 72%. Hybrid sorghum productivity inside watershed was 37% higher over outside watershed.
- Higher yields of Bt cotton and sorghum was attributed to cultivation of improved hybrids with timely sowing, optimum plant population and application of micro-nutrients (**Table 8.3** and **Fig. 8.6**).
- Grain yield of Gangavathi Sona rice variety increased from 9 to 22% whereas straw yield increase varied from 6 to 21% during kharif 2012. The market rate was also higher for Gangavathi Sona compared to Mulla batta or Hamsa coarse varieties cultivated by farmers (**Table 8.2 , Fig. 8.7** and **8.8**).

Fig. 8.6. Performance of cotton in demonstration farmer fields

Fig. 8.7. Paddy cultivation with local and improved cultivar (*Gangavathi Sona*)

8.1.5. During 2013-14

Acute deficit in rainfall during 2013 (312.8 mm) resulted in low crop yields. Farmers harvested around 40 to 60% low yields in rainfed situation. Hybrid maize cultivated in rainfed without supplemental irrigation yielded 70% less compared to irrigated maize.

Fig. 8.8. Expanded area under paddy cultivation with high yielding variety of Gangavathi Sona (GGV-05-01)

- The yield of rainfed groundnut alone has decreased from 556 kg ha^{-1} (Pre-Project/2008-09) to 361 kg ha^{-1} and the yields of groundnut with pulses also have decreased from 511 + 48 kg ha^{-1} to 308 + 36 kg ha^{-1} (**Table 8.3** and **Fig. 8.9**).
- The yields of bajra have also decreased from 1050 kg ha^{-1} during Pre-Project (2008-09) to 413 kg ha^{-1} during 2013-14 (**Table 8.3**).
- The average yields of Bt. cotton, horsegram, hybrid maize, sorghum and castor were very low, i.e., 595, 119, 829, 165 and 142 kg ha^{-1}, respectively during 2013-14 (**Table 8.3**).
- In irrigated conditions, during kharif season the area under Bt. cotton (57.52 ha), maize (35.67 ha) and hybrid sorghum (7.11 ha) was higher with total irrigated area being 117.81 ha during rainy season and 35.20 ha during *rabi* season.

Table 8.2. Paddy demonstration during summer and *kharif* 2012 in Ramasagara watershed

Name of the Farmer	GGV-05-01 Yield (kg)		Hamsa/Local Yield (kg)		Opinion of farmer
	Grain	Straw	Grain	Straw	
Giri Thimmanna S/o Thimmappa	1250 (16%)	2550 (6%)	1075	2400	Bigger earhead observed in Gangavathi Sona, higher yielding also. Other farmers visited demonstration plot and were happy.
G. Ganganna S/o Bhimmappa	1500 (22%)	2750 (8%)	1230	2550	Good seed quality, better for human consumption and higher market rate
Parameswarappa D.S.S/o D Sivanna	1650 (18%)	3200 (19%)	1400	2700	Good quality, suitable for salinity higher yield.
A.K.Ananda S/o Durugappa	1550 (15%)	3000 (21%)	1260	2480	Better for home consumption with good quality.
Parameswarappa S/o Narasimhappa	1200 (9%)	2150 (8%)	1100	2000	Bigger ear head size, better quality, suitable for home consumption, higher market rate.

8.1.6. Impact of watershed management on crop productivity during 2012-13 & 2013-14

In general, the crops yield improvement under rainfed situation was attributed to adoption of rainwater conservation measures through bunding and cultivation of improved varieties/hybrids by the farmers inside watershed as compared to outside watershed. Under irrigated situations, higher yields inside watershed are attributed to cultivation of improved cultivars, adoption of recommended rate of fertilizers including micronutrients and other crop management practices.

8.1.6.1. Rainfed Situations

- Increase in yields of bajra varied from 33 to 64% whereas groundnut yield increased from 22 to 33% during 2012-13 and 2013-14, respectively inside watershed compared to outside watershed. This was attributed to relatively higher rainwater conservation during drought year of 2013-14 as compared to the normal rainfall year of 2012-13 and also due to cultivation of improved varieties by the farmers inside watershed compared to outside watershed (**Table 8.3**).
- Similarly, in intercropping of groundnut and redgram yield was higher by 18+30% during 2012-13 and it increased up to 26+33% during 2013-14 compared to outside watershed (**Table 8.3** and **Fig. 8.9**).

8.1.6.2. Irrigated Situations

- In irrigated crops, during *kharif* season, inside watershed the productivity increased from 25 (Hy. Maize) to 72% (Bt. cotton) during 2012-13 compared to 24 (Bt. cotton) to 48% (paddy) during 2013-14 over outside watershed (**Table 8.3** and **Fig. 8.9**).

Table. 8.3 Comparison of crop productivity during 2012-13 and 2013-14

Crops	2012-13					2013-14				
	Inside watershed (Grain)		Outside watershed (Grain)		Per cent ↓/↑	Inside watershed (Grain)		Outside watershed (Grain)		Per cent ↓/↑
	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})		Productivity (kg ha^{-1})	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})	
Rainfed -*Kharif*										
Bajra	523	0	394	0	33	413	0	252	0	64
Groundnut	509	0	418	0	22	361	0	271	0	33
Groundnut + Redgram	448	35	381	27	18+30	308	36	244	27	26+33
Sunflower	212	--	198	--	7	--	--	--	--	--
Irrigated- *Kharif*										
Bt Cotton	2552	--	1487	--	72	1729	--	1391	--	24
Hybrid Sorghum	3107	--	2273	--	37	2233	--	1614	--	38
Paddy	4124	--	3095	--	33	3355	--	2263	--	48
Hybrid Maize	3876	--	3094	--	25	3601	--	2531	--	42
Irrigated-*Rabi*										
Hybrid Maize	4966	--	4537		9	2991	--	--	--	--
Paddy	3721	--	3239		15	2552	--	3476	--	27

- During late *rabi,* the yield increase inside watershed varied from 9% in hybrid maize to 15% in paddy during 2012-13 whereas it was 27% during 2013-14 compared to outside watershed.

Fig. 8.9. Groundnut and redgram intercropping, irrigated onion and Bt. Cotton during 2013-14

8.2. Development of dryland horticulture

Through the project, dryland horticulture interventions were implemented in the watershed. Totally, 16 farmers were selected and mango, sapota, guava, lime, pomegranate and coconut were introduced for securing both nutritional and income security of the farm family. One year old mango (variety Baneshan and Mallika), sapota (var. Cricket ball and kalipatti), guava (var. L-49), lime (var. Balaji) and coconut (var. Tiptur tall) have been provided to the farmers having irrigation facility to water the plants during hot summers months in the watershed. Nearly all coconut trees have been planted in irrigation channels for ease of watering. The performance of fruit plants has been satisfactory with less than 30% mortality. The survival of sapota was about 75% and 50% in coconut due to failure of farmers in providing supplemental life-saving irrigation. On-farm management skills were imparted to the farmers in horticultural crops before and after taking up the interventions. Growth observations on horticultural crops planted in farmers' fields indicated good performance (**Table 8.4** and **Fig. 8.10**).

Table 8.4. Growth observations recorded on horticultural crops in different fields

Crop	No. of fields	Average Plant height (m)	Av. root stock dia (mm)	Av. Scion diameter (mm)	Av. No. of fronds	Average Chlorophyll content
Mango	4	0.80	16.8	12.0	-	23.61
Sapota	4	0.51	11.8	09.5	-	10.51
Coconut	14	1.21	39.0	35.6	5	24.10
Lime	1	0.52	08.0	07.3	-	35.35
Pomegranate	1	0.43	05.8	-	-	25.12
Lemon	1	0.60	-	08.0		18.30

Fig. 8.10. Horticultural plantation in the watershed

8.2.1. Drip irrigation in dryland horticulture

Dryland horticulture was more successful especially mango and coconut plantation in the watershed among all the fruit/plantation crops. The mango trees have grown up to a height of 2.3 m in Mr. Amarappa field and coconut up to a height of 3.6 m in Mr. Guddada Ganganna's field. Drip irrigation for mango and sapota for one ha of Mango orchard was done at a cost of Rs. 46,575/- for increasing the water use efficiency and yield of fruit crops. Total 450 kg of mango were harvested and sold at Rs. 4,500/- during 2013-14 **(Fig. 8.11).** Mr. Amarappa cultivated cotton crop in the inter-spaces of mango trees and are harvested additional income. through this farmer fetched early regular income **(Fig. 8.12).**

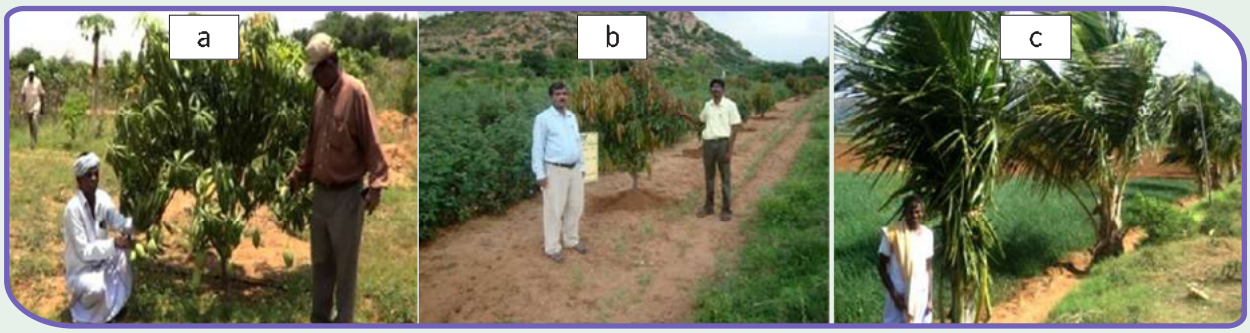


Fig. 8.11. Drip irrigated mango and sapota with cotton as intercrop (a, b) and border plantation of coconut with onion(c)

Fig. 8.12.Fruiting mango orchard with cotton crop in the interspaces of trees

8.3. Afforestation and Agro-forestry

Grasses were provided to 8 farmers in the watershed especially the farmers with irrigated lands and who had the animal component as one of the major component next to crop cultivation. Nearly 4000 slips of hybrid Napier, 2000 slips each of *Panicum maximum* and *Brachiaria decumbens* were distributed to the farmers to develop green fodder banks for their animals **(Fig. 8.13)**. These grasses were procured from IGFRI, Dharwad. Nearly 20 kg of *Stylosanthus hamata* seeds were sown on the newly formed bunds and the germination percentage was only 10% as it was the first year of sowing and due to the sub-soil on the bunds on which the *S. hamata* seeds were sown. During 2013-14, green grass yield of 8.0 tonnes was produced from irrigated Hybrid Napier that was planted in 0.07 ha in Mr. Marenna's field.

Fig. 8.13. Grass cultivation on farmers fields in watershed

8.4. Agronomic practices

Pre-sowing seed treatment was promoted in the watershed for enhancing crop productivity. Sixty farmers were supplied with *Rhizobium* and *Trichoderma* for treating groundnut seeds in order to ensure higher N fixation and protection against attack of fungal diseases.

9. LIVESTOCK AND HUMAN HEALTH CAMPS

9.1. Animal Health Camp & Artificial Insemination

ICAR-IISWC, Research Centre, Ballari in collaboration with Veterinary Department, Molkalmur organized nine Animal Health Camps and Artificial Insemination Camps (AI) from 23.02.2010 to 14.02.2012 at in Hanamapur, Venkatapur, Devasamudra and Ramasagara villages (**Table 9.1**). In these programs, 706 bullocks, 388 cows, 529 buffaloes, 331 young stocks, 2931 sheep and 1987 goats were treated for Anorexia, vaccinated against foot and mouth disease and de-worming of sheep and goats with vaccination for PPR. Nearly 240 kg mineral mixture with vitamin tablets (1000 nos.) were also distributed for improving animal health and reducing infertility. Even infertile cows and buffaloes were vaccinated for *Hemorrhagic septicemia* and treated for other common diseases. Artificial insemination was carried out for infertile cows with treatment.

Table 9.1. Animal health camps conducted at four villages during watershed phase

Sl. No.	Date	Place	Bullocks	Cows	Buffaloes		Young stocks	Sheep	Goats	Total
					He	She				
1	23.02.2010	Ramasagara	124	62	7	20	41	1044	620	**1918**
2	29.10.2010	Venktapur	50	32	17	30	30	385	478	**1022**
3	29.10.2010	Hanumapur	22	25	23	93	18	28	135	**344**
4	21.02.2011	Ramasagara	110	26	8	16	11	415	203	**789**
5	22.02.2011	Devasamudra	92	60	8	16	49	19	97	**341**
6	13.09.2011	Venkatapura	98	31	21	77	18	472	195	**912**
7	14.09.2011	Hanumapura	22	20	25	98	36	14	6	**221**
8	13.02.2012	Devasamudra	94	89	3	16	61	13	0	**276**
9	14.02.2012	Ramasagara	94	43	5	46	67	541	253	**1049**
Total			**706**	**388**	**117**	**412**	**331**	**2931**	**1987**	**6872**

During these animal camps, Dr. Shivarudrappa, ADAHVS, Molkalmuru enlightened the farmers about the common seasonal diseases that affect the animal health especially during October and beginning of summer during February and their remedial measures for better animal health and their maintenance. Dr. S.L.Patil, Principal Scientist (Agronomy) and Project leader of the Ramasagara watershed emphasized that animal component in the watershed management is as important as that of the crop and natural resource management and plays an important role in the income of the farmers in these villages/arid region. Further said that if animal component has been kept in the household, has it help generating FYM. Application of FYM helps in improving and maintaining soil fertility by supplying macro and micronutrients, enhancing soil water holding capacity and augmenting soil microbial activity. Sheep and goats serve as any time money for small and marginal farmers. Thus advised farmers to treat and maintain animals as their own children. He further emphasized farmers to fully utilize opportunities like animal camps. Dr. Ramajayam, Scientist (Horticulture) also advised the farmers to take utmost care of the animals as that of their own children for increased income. Dr. N. Loganandan Scientist (Ag. Extn.) suggested farmers to take appropriate care of the livestock for better animal health and increased income.

Fig.9.1. Animal health camp and artificial insemination at Ramasagara watershed

9.2. Human health camps

Six human health camps were organized in the Ramasagara watershed by ICAR-IISWC, Research Centre, Ballari on 26.3.2010, 18.12.2010, 23.02.2011, 31.03.2011, 24.9.2011 and 14.02.2012 in collaboration with Primary Health Centre (PHC), Rampur and Ashok Siddapur and Ayurvedic Hospital Devasamudra.

Physicians examined and treated nearly 846 farm families of Devasamudra, Hanumapur, Ramasagara and Venkatapura villages for malaria, acute respiratory tract infection, acute diarrhoea diseases, and worm infestation, antenatal cases, *Pyoderma*, viral fever, scabies and

sexually transmitted diseases (STD). Blood smear examination was also conducted for patients and the medicines were distributed to all the farm families who had undergone medical checkup and required treatment (**Table 9.2**). Prevalence of some widespread diseases in patients indicated lack of hygiene and clean drinking water as major causes of poor health among watershed inhabitants. Nearly 82 pregnant women were examined and prescribed with Iron and Calcium supplements in the form of syrup for healthy child development. In Human Health camps chronic patients were examined for Tuberculosis (TB) and leprosy and were advised to continue the remaining course of the treatment and nutritional supplementation. Majority of patients were suffering from gastritis and were advised with antacids. Patients suffering from cough and cold were thoroughly examined and prescribed with cough syrup and anti-cold tablets and antibiotics. Patients suffering from anemia were advised with iron capsules including vitamins. Among 846 beneficiaries who were examined in Human Health Camps nearly 73.2% were adults and 26.8% were children. Nearly 52% of female and 48% of male were examined by doctors in Human Health Camps in four villages during watershed implementation phase.

Table 9.2. Human health camps in different villages during watershed implementation

Sl. No.	Date	Place	Children (< 14 years)		Adults (>14 years)		Total
			Male	Female	Male	Female	
1	26.03.2010	Devasamudra	10	05	66	34	**115**
2	18.12.2010	Hanumapur	10	15	34	43	**102**
3	23.02.2011	Ramasagara	15	16	28	57	**116**
4	31.03.2011	Venkatapura	17	15	71	61	**164**
5	24.09.2011	Hanumapura	20	23	57	68	**168**
6	14.02.2012	Ramasagara	51	30	29	71	**181**
Total			**123**	**104**	**285**	**334**	**846**

Dr. R.K. Farahana, PHC, Rampur, enlightened the watershed beneficiaries about the cleanliness, personnel hygiene, importance of nutritious food and awareness to the women especially to the pregnant women and children. Lack of education and poverty has resulted in ignorance in health awareness among the farmers in the Ramasagara watershed area, as expressed by Dr Farahana. Dr. T.M. Virupakshaiah, advised the farmers about the importance of health. Dr. B. Madhu Kumar, PHC, Ashok Siddapur, advised the watershed beneficiaries that all the farmers especially old people, pregnant women and children should make use of the Human Health Camps as doctor himself is available in their village. Further he advised the beneficiaries of the watershed about the cleanliness, personnel hygiene, importance of nutritious food to the women especially to the pregnant women and children. Awareness about vaccines, anemia and tobactomy camps were discussed. Dr. Shivashankrappa MS M.Ch. explained the farmers to take care of their health especially the contagious diseases. He explained in details of the infection and causes for the kidney failure and its care including the basic physical exercises that keeps healthy body.

The PI of the Watershed, Dr. S.L. Patil, explained the farming community that the human health especially for children and old people is very important and the beneficiaries of the watershed should make use of the health camps as doctors are available in the village itself. He also advised the farmers to get timely health checkup and advice from doctors especially for the children and old people is very important and timely care should be taken. The health of people, who are mainly involved in agriculture, is as important as that of the soil health for greater crop productivity.

Thus human health is also given greater priority in the Ramasagara Watershed programme. Hence, human health camps were included in the planning of the watershed as per the new NWDPRA guidelines of the Ministry of Agriculture, New Delhi.

Fig. 9.2. Blood smear tests along with health check up and treatment to the patients by doctors during human health camps at Ramasagara watershed

10. LESSONS LEARNT

- Entry point activities play a significant role in building confidence and rapport with the watershed beneficiaries.
- Exposure visits and training programs improves adoption level of new technologies that conserve natural resources, improves crop productivity and income of farmers.
- Conservation measures in arable lands (field bunding) plays a significant role in reducing runoff, soil loss and improving crop yields in rainfed crops especially during drought years in the region with average rainfall of less than 500 mm.
- Conservation measures and gully control structures in non-arable land recharges ground water and bore wells in the watershed.
- De-siltation activity of tanks should invariably included as a part of watershed activity since it improves ground water recharge and soil fertility besides ensuring drinking water for animals.
- Livelihood activities should be part of the watershed activity. This activity should be assessed carefully and it should be need based and are more useful for sustenance of life during drought years.
- In livelihood activities, tailoring, artisan tools and animal components especially cow, sheep, goat, and vermicompost plays a greater role in improving livelihood beside reducing dependence on chemical fertilizers.
- Drip irrigation intervention plays a major role in improving water productivity.
- Animal and human health camps should be a part of watershed activity for improving the health.
- Demonstration with improved crop cultivars i.e. varieties/hybrids with micro-nutrient should be a part of watershed for improving crop productivity on sustainable basis.
- Permanent structures for rainwater conserving/recharging have to be constructed even though they are costly, as they last long and economically viable than temporary boulder structures.
- Introduction of fodder crops, forestry and horticulture plantations in the irrigated area plays a greater role in improving health of human, animal and environment besides sustaining farmer income for long run.

11. PHYSICAL AND FINANCIAL TARGETS AND ACHIEVEMENTS

11.1. Targets and Achievements

Total expenditure of the Project from 2008-09 to 2013-14 is Rs, 46,63,547/- as against the sanctioned amount of Rs. 52,00,000/- as per DPR. Total expenditure is 90% of the budget allotted with 58% spent under Institution and Capacity building to as high as 101 to 104 % in watershed developmental works and livelihood activities, respectively (**Table 11.1**).

Table 11.1. Physical and financial achievements of Ramasagara watershed

Sl. No.	Component/Activities	Units (DPR)	Total Target as per DPR			Total Achievement		
			Physical	Physical (ha)	Financial	Physical	Physical (ha)	Financial
1	**Management Component**							
	Administrative Costs:				520032			480815
	Monitoring				52003			0
	Evaluation				52003			0
	Sub Total				**624038**			**480815**
2	**Preparatory Phase**							
	Entry Point Activities							
a	Platform for village meetings	No.	1		120000	1		**114172**
b	Water Troughs	No.	2		46000	2		40481
c	Animal Camp	No.	1		5000	1		**5000**
d	Human Camp	No.	1		10000	1		10000
f	Soil sample test	No.	30		12900	30		12900
g	Water sample test	No.	30		13800	30		13800
	Sub Total		**65**	**0**	**207700**	**65**		**196353**
3	**Institutional & Capacity building**							
a	Training		5		50000	5		50000
b	Exposure visits		2		100000	2		80081
c	Kisan Goshti		6		20100	6		20100
d	Kisan mela		3		90000	**0**		0
	Sub total		16	0	260100	13		150181
	Preparation of DPR				**52003**			**0**
4	**Watershed Development Works Phase**							
a	**Arable Land Treatment**							
i	Stone checks/Gabions**/Stone revetment	No.	16	160*	160000	191	330 ha + 51 RMT**	637013
ii	Bunding	Ha	133.3	333	1600000	40543 RMT + 720 RMT**	333	855577
iii	Horticulture plantation/Drip irrigation#	Ha	8	8	160000		8	206374
iv	Agronomic practices	Ha	192	192*	60000		97*	12250
v	Strengthening of existing bunds	Ha	**11.4**	**11.4**	80000			
b	**Non Arable land treatment**							
i	Diversion drain/Bund/ Desiltation***	Rmt	1000	43.8	100000	5102 RMT + 3095 m^3	72.1	456577
ii	Afforestation	Ha	8	8	52000		**4.9**	44288
iii	Grass sodding	Ha	29.16	29.16	28160		14	20600
c	Drainage line treatment							
i	Upper reaches - Stone checks	No.	12		120000	7		18194
ii	Middle reach Loose boulder stone Gabion	No.	10		120000	2		173426
iii	Lower reaches-Check dam (masonry)	No.	1		120000	2		204208
	Sub Total		**1420.9**	**433.36**	**2600160**	**202**	**432**	**2628507**

Table 11.1 continued....

Sl. No.	Component/Activities	Units (DPR)	Total Target as per DPR			Total Achievement		
			Physical	Physical (ha)	Financial	Physical	Physical (ha)	Financial
5	**Livelihood support system**							
a	Kitchen garden	LS			21532			21532
b	Agave fibre extraction unit	No.	1		10000			
c	Vermicompost units					16		130655
i	Masonry unit	No.	15		90000			
ii	Conversion of FYM pits to Vermi units	No.	15		22500	10		15000
d	Dairy (Buffalo/Cow)	No.	4		44000	4		44000
e	Poultry	herds	10		20000	9		20000
f	Goats	herds	6		120000	10		190000
g	Tailoring machine	No.	6		21000	5		21000
h	Barber improvement kit	No.	2		6000	2		6000
i	Artisan tools (Blacksmith, carpenter)	No.	10		20000	10		19903
j	Groundnut decorticators	No.	40		80000	10		20000
k	Cycle weeder	No.	20		20000	4		5200
l	Farm implement (Seed-Fertilizer Drill)	No.	3		45000	3		45000
	Sub Total		**132**	**0**	**520032**	**83**		**538290**
6	**Production and Micro Enterprises**							
a	Crop diversification (ha)							
i	Rainfed (ha)	Ha	114	114*	477000		85.0*	447600
ii	Irrigated (ha)	Ha	27	27*	88050		34.4*	116801
b	Livestock management							
i	Animal camp (Nos.)	No.	9		45000	8		40000
ii	Human camp (Nos.)	No.	6		60000	6		60000
iii	Artificial insemination (Nos.)	No.	120		6000			5000
	Sub-total		276	0	676050	14	0	669401
7	**Consolidation Phase**	LS			260016			
	Grand Total		**1909.9**	**433.36 + 493***	**52,00,099**	**363 + 45645RMT + 720 RMT + 3095 m^3**	**432+216.4*+551 RMT+330 ha**	**46,63,547**

Note: *The area not accounted in treatable area as these areas are accounted elsewhere as treatable area; **Renovation of bunds and stone checks; ***Desiltation;#Drip irrigation; Total bunded area is 333 ha and stone checked area is 330 ha.

11.2. Farmers contribution to WDF fund

Total WDF fund accumulated as on 31st March 2014 is Rs. 5,90,636/- (**Table 11.2**). Contribution varied from Rs. 1,14,940/- in livelihood activities to Rs. 2,12,170 in Production & Micro enterprises and it was Rs. 2,01,286/- that was received from watershed development works. The periodic contribution to WDF fund varied from Rs. 27, 889/- (including Bank interest) during 2013-14 to Rs. 2,96,746/- during 2010-11 when major watershed works were carried out. Total Bank interest was Rs.62,040/-. Bank interest received was varied from Rs.107/- during first year of the Project implementation (2009-10) to as high as Rs. 22,271/- during last year of the Project implementation, i.e., 2013-14.

11.3. Distinguished Visitors

Dr. A.K. Singh, DDG (NRM), ICAR, New Delhi along with Dr. S.S. Khanna and Dr. S.G. Patil, Director of Education, UAS, Raichur visited on 19th November 2011. The comments of Dr. A.K. Singh are - "This was my first visit to the Centre and the watershed which was adopted by the Centre since 2009. The Centre has been doing remarkable work in this very vulnerable region of the Country. With the young batch of Scientists posted here, I am confident that this Centre will contribute much more for the benefits of the poor and resource constrained farmers of the region.

The progress made in the watershed project area during the last two years, were commendable and I am sure that the watershed development activities will lead to an overall improvement of the life style of the farmers. Dr. Singh discussed with farmers about natural resource conservation measures, i.e., bunding with stone checks, percolation tank for groundwater recharge and diversion drain and check dam adopted for rainwater conservation. Dr. Singh also visited farmers' fields and interacted with farmers. He discussed about the performance of improved cultivars of groundnut i.e. K-6 and TMV-2 and redgram i.e. BRG-2 in rainfed area and cotton i.e. Super Mallika in irrigated area and farmers given positive response about performance compared to local cultivars. Later, in a interaction meeting organized at the watershed, he inaugurated an Open Village Platform constructed at Ramasagara village and advised farmers to maintain rainwater conservation measures developed in watershed programme to protect natural resources. Further, Dr. Singh advised farmers to convert farmyard manure into vermicompost for resource conservation and to reduce costly chemical fertilizers. Dr. S.S. Khanna who visited watershed along with Dr. A.K. Singh said that visit to watershed was highly rewarding and working in such an areas is a challenging task. Further, he said that watershed team implemented well proven, technically feasible, replicable and economically viable technologies in the watershed by taking required concurrence of all stakeholder in the watershed.

Table 11.2. Farmer's contributions for WDF at Ramasagara watershed (Rs.)

Activities	2009-10	2010-11	2011-12	2012-13	2013-14	Total
Livelihood activities	32640	45380	23400	9620	3900	114940
Watershed development works	474	152336	29962	16996	1518	201286
Production & Micro enterprises	36775	94895	80500	---		212170
Bank interest	107	4063	14979	20620	22271	62040
Total	**69,996**	**2,96, 746**	**1,48,841**	**47,236**	**27,889**	**5,90,636**

The QRT team Chairman Dr. H.S. Chauhan along with team members Dr. R.S. Narang, Dr. K.K. Jindal and Dr. S.G. Patil and Member Secretary Er. K.P. Tripathi visited watershed on 8th January 2012. The comments of Dr. H.S. Chauhan are- "Excellent large scale field bunding, waste water weirs demonstrated in field conditions of nearly 300 ha along with numerous allied interventions in the engineering, agricultural and horticultural and animal husbandry, with provision of providing goats, sheep, poultry, cows, buffaloes. The spirit of the CSWCRTI staff was a good example. This needs to be encouraged and emulated at all Soil and Water Conservation Centres. He added "Keep it up and progress". The QRT team appreciated the bunding and other engineering structures for natural resource conservation along with crop, horticulture, grass and animal component improvement in the region for sustainable production in the backward and low rainfall Alfisols region of Karnataka. The QRT team was also happy about the progress of works in engineering especially bunding, spill way and percolation tanks for resource conservation and groundwater recharge. They further appreciated the achievements of higher crop yields in both rainfed and irrigated areas with interventions of the Centre. The new area under horticulture and grasses was most welcome as said by one of the QRT members. The maintenance of conservation structures was emphasized by all the QRT members for greater productivity especially during drought years. All the team members including Chairmen were most satisfied with the introduction of animal components in the region for higher income. All the QRT members had the meeting with all the beneficiaries of four villages of the Ramasagara watershed and efforts of Ballari Centre were appreciated by both farmers and QRT team.

Dr. H. P. Maheswarappa Project Coordinator (Palms) ICAR- All India Co-ordinated Research Project on Palms, ICAR-CPCRI, Kasaragod visited watershed during August 2012 and his comments are- "The visit made to Ramasagara Watershed located in Molakalmur Tq, Chitradurga Dist. during August 2012 was excellent and I could realize the impact of our technologies in the watershed area. He also added a world to the Principal Investigator along with the team that have carried out marvelous work in the watershed area involving the adoption of improved technologies of the ICAR and Agricultural University. The overall impact of ground water recharge, conservation of soil and water resources was observed by the farming community. In the nutshell, there was overall increase in the productivity of the crops and improvements in the socio-economic status of the farming community in the watershed area. I complement the dedicated work carried out by PI and team and wish you all the best in future to continue the same kind of work.

Dr. P.K. Mishra, Director ICAR-IISWC, Dehra Dun and Dr. C.P. Mansur, Dean, College of Horticulture, Horticultural University, Bagalkot, Karnataka also visited the Ramasagara watershed and expressed positive notes over the interventions executed in the watershed which benefitted the farming community in the region.

Fig. 11.1. Visit of Dr. A.K. Singh, DDG (NRM), ICAR, New Delhi

Fig. 11.2. QRT team visit to Ramasagara watershed

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Annexure 1: List of Publications

Published Research papers in Journals

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Book Chapters

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Abstracts in Conference

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