Participatory Resource Conservation and Management in Semi-arid India – A Case Study from Netranahalli Watershed (Karnataka)

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Contents

Sl.No.	Particulars	Page No.
	Preface	
I	Dryland agriculture in India	**1**
II	CSWCRTI Research Centre, Bellary – An Introduction	**2**
III	Netranahalli Watershed project	**2**
a)	Climate and Hydrology	**4**
b)	Geology and Soils	**8**
c)	Cropping pattern	**8**
d)	Vegetation	**9**
e)	Area of the watershed	**9**
f)	Demographic and land holding patterns in the watershed villages	**10**
IV	Problems of the area	**10**
V	Objectives of the programme	**11**
VI	Initial Activities	
a)	Inauguration of the Project	**11**
b)	Gram Panchayat (GP) resolution	**13**
c)	Watershed Committee formation	**14**
d)	Participatory Rural Appraisal (PRA)	**14**
e)	Assessment of the natural resource base	**18**
f)	Soil quality analysis	**19**
g)	Ground water quality	**21**
VII	Interventions carried out under the watershed project	
A	Off Farm Development (Community based)	
1	Entry Point Activities	**22**
2	Renovation of existing water harvesting structure	**23**
3	Drainage line treatment (Gabion structure gully plugs and vegetative barriers)	**24**
4	Afforestation, Plantation of TBOs and silvi-pastoral development	**26**
5	Income generating activities for landless and marginal farmers	
i	Establishment of Vermi-compost units	**26**
ii	Mulberry cultivation for sericulture units	**28**

iii	Bee keeping	**28**
B	On Farm Development	
1	Construction of field bunds	**29**
2	Renovation of the existing bunds and *in situ* moisture conservation	**31**
3	Determination of impact of soil conservation activities	**32**
4	Introduction of forage legumes on bunds and creation of fodder banks	**33**
5	Dry land horticulture development	**34**
6	Crop production and diversification of agriculture	**37**
7	Construction of recharge filter	**38**
C	Livestock Development	
1	Animal health camps	**51**
2	Introduction of pond pisciculture	**52**
D	Training and Extension	
1	Exposure visits	**53**
2	Farmers training	**55**
3	*Kisaan Goshties*	**56**
4	*Kisaan Mela*	**57**
VIII	Employment generation through various interventions	**58**
	Summary	**60**
	Lessons learnt	**63**
	References	**65**

PREFACE

Integrated Watershed Development Programme (IWDP) was initially envisaged as a measure for poverty alleviation and improving livelihoods has gained even greater importance in light of its worldwide recognition of its effectiveness in combating climatic change. In India, several ministries namely, Ministry of Agriculture, Ministry of Rural Development and Ministry of Environment and Forests have been involved in Watershed Development Programs with substantial variation in their approaches. The Ministry of Rural Development had been co-ordinating sector-wise flagship schemes such as IWDP, DPAP and DDP under Watershed Development Programmes. The main objective of the WDP was to improve soil and water conservation, irrigation facilities, and land use pattern leading to increased agricultural productivity in drought prone and desert prone areas. It is expected that these programmes will led to poverty reduction, improved livelihoods and improved bio-physical and socio-economic conditions leading to sustainable rural development.

An interdisciplinary approach has been followed for this study, given the complex and diverse factors, such as bio-physical, social, ecological, institutional and economic factors, besides the regional variations. The programme is operational since 2008 at Netrenahalli watershed in Mokamuru taluk,,Chitradurga district of Karnataka that involves multiple stakeholders. In the present study, the effort has been to assess the impact of WDPs – the effectiveness of the programmes, identification of issues and lacunae in project implementation.

The study noticed improvement in ground water levels, enhanced soil and moisture conservation, development of irrigation facilities, water regeneration capacity, forestry and horticulture development, change in land use pattern and cropping pattern, improvement in animal health, employment and income generation etc.. Some areas need further attention such as, greater involvement of the communities during implementation & post implementation phases, training & capacity building, social audit, gender mainstreaming and sustainable income generation. It is observed that farmers need to be trained for carrying out minor maintenance work of the numerous development activities.

We are grateful to the Ministry of Rural Development (MoRD), Department of Land Resources for generous funding of the project under the TDET programme'. We also express our gratitude to the evaluating agency (MYRADA) whose reports were immensely helpful in improving the implementation. We gratefully acknowledge the contribution of Dr P.K.Mishra,, Director of CSWCRTI and scientists of the Institute who directly or indirectly provided their valuable inputs during various forums of discussions.

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I. Dryland agriculture in India

Dryland agriculture occupies 68% of India's cultivated area which produces 44% of the country's food requirement, supports 40% of the human population and 60% of the livestock population. Nearly 15 m ha of the region receives 500-750 mm of annual precipitation which is erratic in its occurrence and distribution. Droughts are fairly common and occur once in 3-5 years because of rainfall deficit during the cropping season or poor soil moisture during prolonged dry spells between rainfall events. Most of the soils come under the category of Alfisols, Entisols and Vertisols, which are coarse textured with low water retention capacity, highly clayey soils with poor infiltration and have multiple nutrient deficiencies (Virmani *et al.,* 1991).

The crops cultivated in the region are diverse, depending on soil type, length of growing season and availability of soil moisture. The predominant crops are sorghum, pearl millet, maize, red gram, chickpea and other pulses, groundnut, sunflower, safflower, cotton. With the introduction of irrigation, improved crop management practices and introduction of high yielding varieties, the productivity of dryland crops has improved significantly. However, crops grown under rainfed situations continue to be at the mercy of annual precipitation and are prone to risk of failure. Most of the farmers in the region are small to marginal with scattered land holdings making integrated technology transfer a difficult exercise. Due to the vagaries of climate, farmers' dependence on livestock as an alternate source of income is high. A recent report (Rangnekar, 2006) revealed that income from small ruminants ranged from 17-24% for the rural poor. Further, rearing of small ruminants provides gainful employment of 180-330 man days per year depending on flock size (Misra *et al.,* 2000).

With a gradual tapering in farm productivity in the irrigated areas and the need to meet increased food requirement in the future, there is an urgent need to lay special emphasis on the drylands of India. There is a need for focused and integrated multi-disciplinary measures to conserve the natural resource base and increase farm and livestock productivity in the coming years. Among the numerous strategies available, integrated soil and water conservation measures, improved rain water storage and delivery measures, enhanced ground water recharge and integrated watershed development are of special importance. Further, formation of village level institutions and capacity building of farmers are some of the interventions required to sustain new interventions which are being implemented by various agencies in the dryland regions. This report covers the various activities which were implemented in a participatory mode in a resource poor, back ward district in Karnataka through a sponsored watershed programme of the Department of Land Resources, Ministry of Rural Development and implemented by the CSWCRTI Research Centre, Bellary.

II. CSWCRTI Research Centre, Bellary – An Introduction

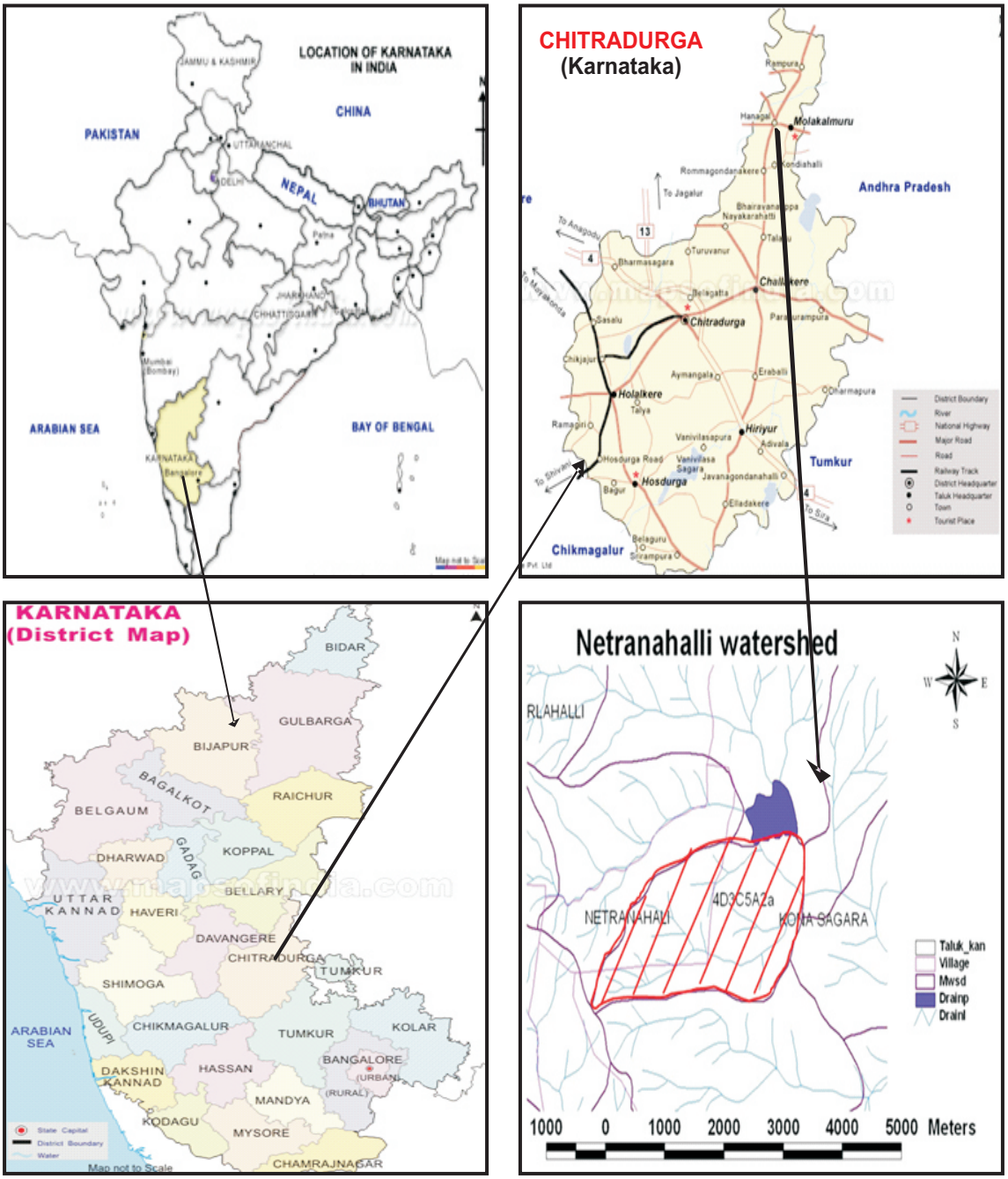
The Regional centre of Central Soil and Water Conservation Research and Training Institute (CSWCRTI) was established on 20th October 1954 at Bellary, Karnataka. The centre was brought under the administrative control of the CSWCRTI, (ICAR), Dehradun on 1st April 1974. The centre's mandated area of functioning are:

- ❖ To undertake research on soil erosion problems of the region and evolve suitable agronomic and mechanical measures for effective conservation of soil and water.
- ❖ To investigate physical, chemical and micro-biological aspects of soils of the region with special reference to black soils for increasing the structural stability and water retention capacity.
- ❖ To impart specialized training in soil and water conservation to officers/assistant trainees from different states.

The centre has evolved several suitable agronomic, alternate land use and mechanical measures for effective resource conservation in black and red soils of the dry parts of Karnataka, Andhra Pradesh, Maharashtra and parts of Tamil Nadu. Further, in order to test and demonstrate these technologies to stake holders, the centre undertakes development of integrated watershed projects in different districts under various central schemes. One such project was taken up by the centre in Netranahalli, a remote backward area of Karnataka in 2007 with generous financial assistance from the Department of Land Resources, Ministry of Rural Development, New Delhi.

III. Netranahalli Watershed project

The Netranahalli watershed project was taken up under the IWDP scheme, sponsored by Ministry of Rural Development, Government of India. The two villages under watershed, Netranahalli and Konsagara are located in Molakalmur Taluk of Chitradurga District, Karnataka. In a recent report of the NRAA (2012), this district has been ranked at serial number 22 (out of 499 districts), indicating a high prioritization for development of rainfed areas. This rainfed area prioritization has been prepared using 2 indices – Natural Resource Index (NRI) and Integrated Livelihood index (ILI). The ranking indicates that the area is affected by a degraded natural resource base (rainfall, soil water content, area under wastelands, groundwater status, rainfed area and irrigation intensity) and poor economic and infrastructure development.



The watershed (14°37'50" to 14°38'47" N Lat. and 76°42'46" to 76°44'51" E Long.). is surrounded by Kudligi and part of Sandur *taluks* of Bellary district to its north and west, Challakere *taluk* of Chitradurga to its south and Andhra Pradesh to its east. Its altitude ranges from 550 to 570 above MSL. The morphological characteristics of the watershed are given below.

Table 1: Morphological characteristics of the watershed

Sl. No.	Feature	Formula	Value
1	Catchment (A)	-	480 ha
2	Average slope	-	2.5 %
3	Slope Length (L)	-	3800 m
4	Difference in elevation between highest point in remote and lowest point the gully	-	30 m
5	Average width of the catchment "W"	A/L	1263 m
6	Form Factor (F)	W/L	0.33
7	Perimeter (P)	-	9800 m
8	Compactness Coefficient (C)	$\frac{0.28P}{\sqrt{A \times 10000}}$	1.25
9	Time of concentration (minutes) (Tc)	$\frac{L^{0.77}}{0.01948 \times S^{0.385}}$	71 miniutes
10	Drainage density (DD)	(km/100sq km)	158
11	Slope of the major nala ranging from highest to lowest	-	2 to 5%

Perusal of the information given above indicates that the watershed is 'petal' shaped with a mild slope of 2.5% and with a long opportunity time (71minutes) indicating the potential of land surface modification for *in-situ* water conservation. A moderate drainage density of 158 indicates the watershed is well drained and the velocity of water in the channels is mild under normal rainfall situations, which indicates that small conservation measures at a number of locations will be more effective than large mechanical measures.

III. a. Climate and Hydrology

The climate of the region is characterized as arid to semi-arid with an average annual rainfall of 417.3 mm annually with an average of 31 rainy days, out of which about 80 % is received during the north east monsoon season (September to November). The trend of rainfall is highly erratic and maximum water goes waste as runoff. The area is well drained through gullies and *nalas*. The groundwater table is available at 100-300ft, but ground water recharge is poor since most of the runoff flows down the slopes in very short duration thereby limiting ground water recharge. Large fluctuation in water table can be observed during pre and post-monsoon season.

Monthly along with annual rainfall data from 2008 to 2011 is presented below. The *taluka* (Molakalmuru) average of different rain gauges is also presented. Perusal of data indicates that 2008 and 2011 were drought years and 2009 was a high rainfall year which damaged the fields and crop yields were not satisfactory. Only 2010 year was a good rainfall year (Table 2).

Table 2: Month wise distribution of rainfall (mm) during project period along with *taluka* average of pre -project period.

	2008	2009	2010	2011	Average rainfall (2008-11)	Taluk average rainfall
Jan	0	0	2.2	0	0.55	1
Feb	20	0	0	0	5	1.4
Mar	141.4	0	0	0	35.35	1.8
Apr	6	0	26.2	34	16.55	19.7
May	17.4	123.8	235.1	45.4	105.42	56
Jun	0	64.8	53.8	44.2	40.7	35.2
Jul	6	3.2	95	37.2	35.35	37.3
Aug	86.2	169.7	218.4	87.7	140.5	47.6
Sep	0	258.5	56.6	9.9	81.25	89.6
Oct	0	23.6	71.5	64.2	39.825	96.3
Nov	0	130.2	102.4	15.9	62.125	22.6
Dec	0	0	0	0	0	8.5
Total	277	773.8	861.2	338.5	562.625	417

The selected district is located in the central dry zone of Karnataka bordering arid condition. It receives low to moderate rainfall and is one of the most drought prone areas of the state. Standardized Precipitation Index (SPI) calculated from annual rainfall data for 36 years period (1971-2009) showed that the value was negative for 56% of cases and 3 years viz., 2004, 2005 and 2006 experienced moderate to severe drought (McKee *et al*., 1993) with the values being less than -1 (Fig. 1).

Rainfall analysis of the *taluk* for the period from 1994 to 2011 revealed that out of 18 years the area received deficit rainfall for 9 years and there was a severe drought during 1994, 1995, 2003, 2008 and 2011 (Fig. 2). SPI calculated from quarterly rainfall data revealed that July to September was the most critical period that experienced maximum number of high intensity droughts which led to inadequate soil moisture during the crop growing season and caused extreme crop stress and wilting (Table 3).

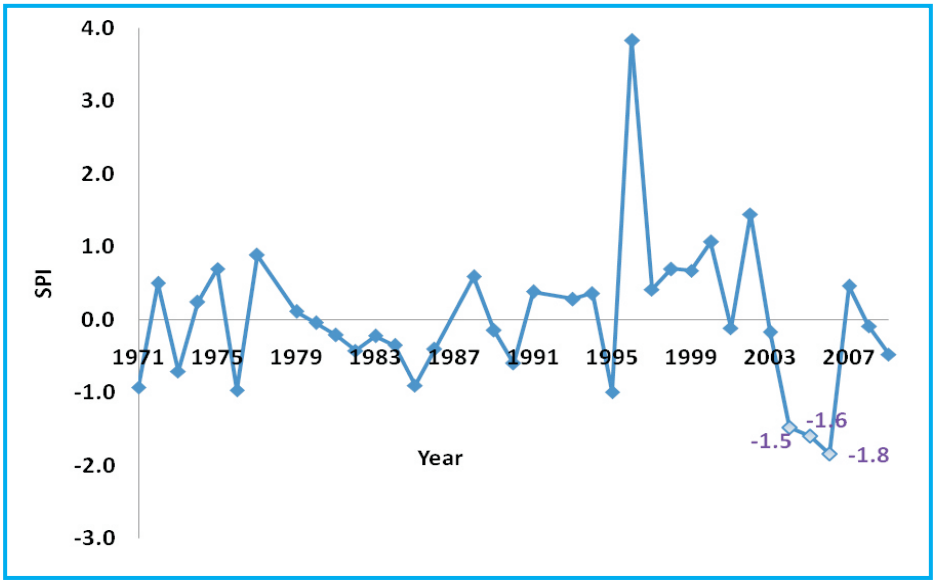


Fig. 1: Annual SPI values for 36 years rainfall at Chitradurga district

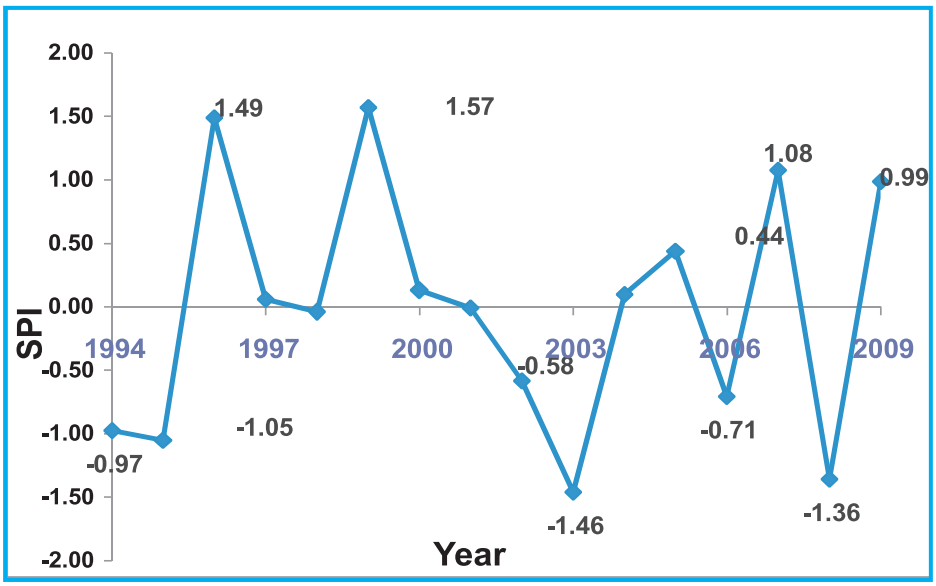


Fig. 2: Annual SPI values for 18 years rainfall at Molkalmuru *taluk*

Table: 3. Quarterly Standardized Precipitation Index (SPI) values for 1994-2011 at Molkalmuru *taluk*

Year	Quarter I (Jan.-March)	Quarter II (April-June)	Quarter III (July-September)	Quarter IV (October-December)
1994	-0.41	-1.33	-1.33	0.99
1995	0.12	-0.82	-0.61	-1.03
1996	-0.40	1.11	1.06	1.33
1997	-0.19	0.09	-0.96	1.56
1998	-0.44	-0.22	0.31	-0.13
1999	-0.40	1.24	1.01	1.49
2000	-0.18	-0.58	0.52	0.24
2001	-0.44	-0.22	0.81	-0.79
2002	0.08	-0.31	-0.62	-0.32
2003	-0.35	-1.23	-1.17	-0.63
2004	0.12	1.19	-0.05	-0.94
2005	-0.21	-0.09	0.96	-0.10
2006	0.57	-0.91	-1.21	0.62
2007	-0.44	0.79	0.87	0.89
2008	3.85	-1.34	-1.26	-2.03
2009	-0.44	0.64	1.54	-0.17
2010	-0.38	2.15	1.03	0.07
2011	-0.44	-0.14	-0.91	-1.06

EI_{30} values and long term average along with 2009 (unprecedented rainfall) rainfall of Bellary (about 60km away from the watershed) is presented below. It is observed from the table that on an average total rainfall and EI_{30} is 500.5 and 311.5, respectively. September and October shows the maximum rainfall and EI_{30}. In 2009 the highest rainfall during last 100 years was recorded. Total rainfall and EI_{30} was 994.5 and 1033.2 (Table 4) which led to extensive soil erosion.

Table 4: E I_{30} values and long term average along with 2009 (Unprecedented rainfall) rainfall of Bellary

	Average EI_{30}	EI_{30} (2009)	Average Rainfall	Rainfall during 2009
Jan	3.3	0.0	3.2	0
Feb.	1.6	0.0	2.2	0
Mar	3.2	0.0	6.4	1
Apr	8.5	0.0	20.3	0.2
May	35.7	351.9	50.8	115.2
Jun	56.0	232.7	62.2	166.9
Jul	26.1	12.1	44.8	33.7
Aug	23.3	4.7	52.5	59.6
Sep	52.1	149.0	115.3	253.5
Oct	94.2	262.9	104.1	313.5
Nov	7.5	20.0	29.8	51
Dec	0.0	0.0	8.9	0.0
Total	311.5	1033.2	500.5	994.6

III b. Geology and Soils

The watershed has a rugged topography with small rocky hills. The rock types are basement granites, gneisses quartzite and schist, forming ridges and shallow erosion valleys. The drainage pattern in the watershed is of third order. The soils of the watershed are shallow to medium in depth, well drained to excessively drained, moderately to severely eroded and gravelly sandy loam to sandy clay loam in texture. These soils have a low available water capacity (AWC) of < 50 mm m^{-1} due to shallow depth, high gravel content and low clay content. The major soil constraints are shallow rooting depth, high gravel content, low fertility status and moderate to severe erosion. These soils are classified as lithic Ustrothents, lithic Ustropepts and Typic Ustorthents.

III c. Cropping patterns

Agriculture is the main occupation in this region in arable lands. The major cultivated crops in rainfed areas include groundnut, sunflower, redgram, *bajra* and *ragi* as sole crops and intercropping of groundnut with red gram, cowpea, green gram and horse gram. Castor is sometimes intercropped with groundnut or sown on field bunds. All the rainfed crops are cultivated during rainy/*kharif* season with onset of monsoon from June/July to December. In irrigated areas, sorghum, maize, paddy, sunflower and groundnut are raised in *kharif* and *rabi* or during early summer.

III d. Vegetation

The watershed falls in the agro-ecoregion 3 spread over 4.9 m ha, which experiences hot arid climate for a major part of the year. The soils are mixed red and black, coarse to gravelly in texture and with poor water retention capacity. According to Champion and Seth's Forest Classification (1968), the general vegetation of the area is classified as Tropical Dry Deciduous Forest (sub-type 5A/C3) with summer deciduous species and dry evergreen species co-existing in barren hill slopes and along seasonal water courses. Large areas are occupied by dense thickets of *Prosopis juliflora*; the other species being *Acacia nilotica*, *Anogeissus pendula, Dalbergia sissoo, Inga edulis, Azadirachta indica, Butea monosperma, Hardwickia binata.* Given the climatic and edaphic conditions, species regeneration is very poor providing opportunities for gregarious species to spread over larger areas annually. Fodder yielding trees and fodder grasses are poor in productivity leading to wide spread over exploitation and continued degradation of forest vegetation. Open access grazing by hundreds of small ruminants and cows during the hot summer months is rampant, leading to further damage.

III e. Area of the watershed

The watershed area is 479.17 ha, of which 410.12 ha is under agriculture. The following table (Table 5) shows the area under different categories in the two villages. The area under irrigation is only 7.5% of the total watershed area, while wastelands occupy about 5.23% of the total watershed area. Konasagara village which is situated in the lower part of the topography has a larger area under bore well irrigation (11.8%) of the total area of the village (244.18 ha).

Table 5: Distribution of area of the watershed

Villages	Rainfed area (ha)	Irrigated area (borewells) ha	Wasteland (ha)	Total (ha)
Netranahalli	146.34	1.68	18.22**	166.24
Konasagara	211.88	29.02	3.28	244.18
Total	358.22	30.70	21.50	410.42

** Out of 18.22 ha, approximately 15.28 ha is Government land

III f. Demographic and land holding pattern in the watershed villages

There are a total of 187 farm families in the two watershed villages, 128 in Netranahalli and 59 in Konasagara, with Table 6 showing the distribution of these farm families under different categories. The figures reveal that most of the farmers are illiterate (59% each in Netranahalli and Konasagara), more than 90% of the population belong to the ST communities and about 77% of them belong to small and marginal farming community on the basis of their land holdings.

Table 6: Demographic and land holding pattern in the watershed villages

Particulars	Nentranahalli	Konasagara
No. of farm families	1 28 (68.4 %)	59 (31.6 %)
Education		
Illiterate	76 (59.3%)	35 (59.3%)
Literate	52 (40.6%)	24 (40.6%)
Caste		
OC	0 (0%)	7 (11.8%)
OBC	1 (0.8%)	8 (13.6%)
SC	0 (0%)	0 (0%)
ST	127 (99.2%)	44 (74.6%)
Land holding pattern		
Landless	0 (0%)	0 (0%)
Marginal (0 – 1 ha)	9 (7.03%)	4 (6.77%)
Small (1 - 2 ha)	101 (78.9%)	31 (52.54%)
Medium (2 – 4 ha)	18 (14.06%)	20 (33.89%)

IV. Problems of the area

The problems identified in the watershed are:

- Due to undulating topography, coarse textured soil and absence of any soil conservation measures in the upper reaches of the watershed, high rates of run off and soil loss have been observed.
- Coarse textured soils with poor water retention capacity lead to moisture stress in the dry periods leading to poor crop performance and productivity, since a bulk of the agriculture is carried out under rain fed conditions.
- Stake holders mostly mainly belong to the marginalized sections of society; hence have poor risk bearing capacity, are resource poor and continue to grow traditional crops using seeds saved over many years.

- Awareness about improved farming practices, availability of high yielding cultivars, balanced use of fertilizers are rare and farmers carryout subsistence farming
- Dependence on livestock and small ruminants is high although animal quality and hence productivity is poor
- Assured sources of fodder and feed do not exist and animals are reared on agricultural waste or resort to open access grazing. Distress sale of animals during periods of crisis is wide spread.
- Low productivity of land coupled with the lack of alternative sources of income has a severe impact on the investment capacity by farmers. This combined with continuous soil erosion and non-availability of groundwater for irrigation leds the area into a perpetual trap of ever worsening living conditions.

V. Objectives of the programme

The primary objectives of the programme are-

- To develop appropriate technologies for watershed development and test their application in farmers' fields through participatory learning.
- To determine the impact of integrated watershed development on the social and economic development of stake holders due to interventions carried out in the watershed, and
- To quantify the effect of other income generating activities in enhancing the livelihood security of watershed farmers.

VI. Initial Activities

VI a. Inauguration of the Project

A decision to select a new watershed area for funding by the Ministry of Rural Development under the scheme of Technology Development, Extension and Training (TDET) was taken in October, 2006. Subsequently the area was selected on the advice of the DWDO, Chitradurga. The watershed was subsequently visited by a team of scientists from the research centre and they had fruitful discussions with the A.O and the farmers. Basline information was generated from toposheets , watershed boundaries were identified and approximate delineation was done.

After obtaining a 'No objection certificate' from the Commissioner (WDD) Bangalore in November, 2006, a detailed project proposal was prepared and sent to the

Director for critical examination. After suitable modifications the proposal was sent to the Additional Secretary, Dept. of Land Resources, (MoRD) and the project was discussed in the presence of the Project Sanctioning Committee at New Delhi in July 2007.

On 03-08-07 the project "Resource Conservation and Management in Netrenahalli Watershed in Chitradurga District, Karnataka" was officially sanctioned by the Ministry of Rural Development (Sanction No.8/2007-08/TE). Information about the project being sanctioned was conveyed to the DWDO, CEO and President Z.P and KVK, Hiriyur. It was on 24th October, 2007 that the centre's staff participated in a Ground nut field day organized by AME and GUARD, local NGOs. The Head of the Research centre briefed the gathering about the project which served as a preamble for the formal inauguration of the project in November.

Plate 1: Views of the project launch function held in the watershed

The project was formally inaugurated on 29th Nov 2007, by organizing a *Kisaan Goshti* on "Creation of Awareness about the Project" which was organized on the same day. Around 200 participants (PRI members, NGO (GUARD) staff, SHG members, Farmers etc) attended the event. A training programme on "Participatory Collection of Soil Samples" was also organized in the afternoon of the same day.

VI b. Gram Panchayat (GP) resolution

On 22-03-08, a meeting for passing a resolution by the GP was organized. The Head of the Research Centre, Project Investigator (PI) and Scientist's of the centre, G.P. members (about 10 in number) and watershed farmers attended the meeting. The following issues were discussed during the meeting, in which the farmers agreed to extend their whole hearted support for the programme.

- Working through Net planning and farmers' cooperation for Net planning,
- The concept of watershed,
- The benefits for two villages, their contribution,
- EPA activities,
- Committee formation etc.

Finally the *Gram Panchayat* resolution was signed by the Project Ivestigator, *Gram Panchayat* president and all the farmers.

Plate 2: Views of the first Gram Panchayat meeting

VI c. Formation of Watershed Committee

As per the *Hariyali* guidelines, a watershed committee is essential for a watershed programme to achieve its desired objective of sustainable production and environmental security. Hence, efforts were made in the initial period to constitute a committee. The help of a local NGO (GUARD) was sought to select the members.*Gram Panchayat* members were informed about the need for constituting the committee. On 15-04-08 a *gram sabha* meeting was organized to select the members. There were also demands to form two separate committees for two villages. But, the purpose of constituting this committee was explained to the members and finally they agreed for one committee. About 25 members including stakeholders from marginalized communities and women were selected. The committee was named as "Netrasagara watershed committee". It was decided to call for meetings on every alternate Monday and the members were encouraged to put forth their voices through this committee for a smooth functioning of the project. The committee put forth some specific requirements in the initial meetings, as given below:

1. *Bunding* works in the farmers' field wherever necessary.
2. Distribution of improved seeds of crops groundnut, maize and sorghum for higher productivity.
3. Health camps for their animals.
4. Provision of fruit tree saplings.
5. De-silting of existing water storage structures.

VI d. Participatory Rural Appraisal (PRA)

PRA is a way of enabling local people to analyze their living conditions, to share the outcomes, and to plan their activities. It involves "handing over the stick from outsider to insider" in methods and action. The outsiders' role is catalytic, as a facilitator of processes within a community that is prepared to alter its own situation. In the earlier system of top down approach, the beneficiaries had no role in planning the programme or taking the decisions based on their demands. The plans were merely supply driven than demand driven. Even in the RRA (Rapid Rural Appraisal), the experts used to consult only few of the contact farmers and plans were made as per their feedback. This led to an incoherent system of programme management, ultimately resulting in failure in most of the cases. Hence, PRA was considered as a panacea to nullify these problems.

Three basic components of PRA are:

- Facilitation
- Attitude, and
- Behaviour of outsiders and culture of sharing.

The two most important PRA tools for a watershed management are Time Line and Social, Resource and Land Use Map. Time Line is a record of events and activities which occurred in the community in the past. This activity involves discussion with a group of local people (usually 4-8) regarding what they consider to be the most important past events in the community. This is a good ice-breaker for building rapport with local people as it shows an interest in their lives. The main purpose of the time line is to identify events in time to which local people can refer when discussing historical issues.

Plate 3: PRA exercises in progress in the watershed

Plate 4: Social and Resource Map being prepared by stakeholders

Social, Resource and Land Use Map is a sketch of the community compiled in co-operation with a group of local men and women to identify physical and socio-economic details along with the infra-structure available with the community. Depending upon the purpose of the exercise, different names can be given to such sketches such as social map,

resource map, land-use map, etc. The aim of mapping is to allow local people to express their perceptions of locations, usage patterns, and changes of local resources or facilities.

Table 6: Time line of Netranahalli village

Year	Activity
1846	Tank formed
1900	Village formed
1957	*Belli* groundnut (Local variety) cultivation started
1958	School (I to IV) opened
1960	Road *(Kachcha)* constructed
1960	Lift irrigation scheme launched
1961	Electricity provided to farms
1965	Cultivation of groundnut (var. GBBD-28) started. No change afterwards
1965	Hand pump installed
1968	Electricity supply to village
1970	1st SSLC pass out
1977	Occurrence of severe drought
1977	Water tank (Panchayat) constructed
1978	1st PUC pass out
1980	First bore well dug, water table starts to go down; first flour mill begins to function; first graduate in village.
1983	First use of chemical fertilizers
1983	Use of chemical plant protection measures started
1987	First self help group (SHG) formation
1991	Start of railway services at Molkalamuru
1992	First electrically operated pumpset installed
1994	School (IV to VII), Start of cattle breeding (AI) at the village
1995	First *Anganwadi* in the village
1996	Water tank constructed with DANIDA help
1998	First tractor in the village, Construction of community hall
1999	First bullock cart with tyre mounted wheels
2000	Construction of check dam
2003	Construction of metalled road
2003	Purchase of first two wheeler
2005	Installation of first phone
2006	First TV set purchased, start of Noon-meal scheme
2007	Arrival of bus services; use of cell phone; introduction of exotic breeds (HF); first LPG connection; start of MNREG programme; first ration shop outlet

Two PRA exercises were carried out at the watershed during April to June 2008. On 15 th April 2008, a Time line exercise was conducted at Netranahalli. Interaction was carried out with a group of ten local people for this purpose including six key informants. Following table shows the details of Time line of the Netranahalli village.

The Social mapping exercise was carried out on 28th June 2008 at Netranahalli village. Mapping of different features of the watershed was conducted with the help of NGO staff. At the initial stage, there was poor response from the participants. But, as the activity progressed, most of them started participating. At the end, one of the villagers explained the gathering about the village pattern, issues concerned, possible solutions etc. Following were the discussions held and conclusions drawn during this exercise:

1. The village pattern of the watershed is in such a way that the Netranahalli village is located in mid reach and Konasagara village at the outlet. Apart from Netranahalli, there is a hamlet called Enimegalatti located in the eastern border of the watershed.
2. Though there is a tank in the eastern end of the watershed, there are very few beneficiaries out of it, who fall within the watershed. Similarly, though majority of residents from Netranahalli and Konasagara villages are beneficiaries of the watershed (187 farm families in total), there are few who have lands outside the watershed as well.
3. The social structure of the watershed villages were in such a way that majority of the rainfed lands are spread in the upper ridge. There are no dwellings nearby these lands. Whereas, in the middle and lower reaches, the pattern of having houses along with lands is starting. These households are involved in both irrigated and rain fed farming. There are a few water storage structures in the lower middle region, de-silting of which was suggested by the farmers.
4. Though the watershed receives scanty rainfall, there are high chances of erosion as major part of the lands has not been properly treated with bunds, especially in the upper region. Hence, the areas to be treated immediately were identified from this exercise. Issues like safe disposal of runoff water was also discussed in detail.
5. Majority of the villagers fall under Schedule Tribe (ST) category. Though there were few programmes for their development before this project, they did not seem to address their needs fully. As they started knowing about this watershed project,

which addresses their source of life i.e. agriculture, they were highly motivated to involve themselves in the project.

6. Apart from the major thrust on agriculture, the project planned to provide support to other activities like vermi-compost, sericulture, fishery etc, which motivated considerable number of farmers. Further, the marginalized sectors, who depend on animal population, also found the project beneficial due to the animal health camps and other related activities that are proposed.
7. As unemployment and migration for work was high in this region, assurance was given to use the local laborers for *bunding* and other related works. This was well received by the farmers.
8. Acute water scarcity during summer was mentioned by the participants during PRA. As most of the villagers depend on bore -well water for drinking and irrigation, this issue was considered to be a serious one. It was assured that interventions like *bunding*, check-dam and recharge-filters (along with open and bore-wells) would solve this problem, provided they were maintained properly.
9. Though the watershed project invariably aims at conservation of resources, farmers' intention will always be of higher crop production using improved varieties. This need was projected by many of them. As assured earlier, provisions to meet this demand, like distribution of HYVs and guidance for appropriate cultivation practices, was explained in detail to the stakeholders.
10. The demands raised from the participants were noted down. Further, it was decided to plan the DPR (Detailed Project Report) as per the demands of the stakeholders so as to achieve the overall livelihood improvement of the beneficiaries. To conclude, the villagers were assured that the project activities would be designed as per their demands and whole hearted cooperation from all the stakeholders was earnestly requested for a successful completion of the project.

VI e. Assessment of the natural resource base

Rainfall situation in the watershed and susceptibility to drought

The Chitradurga district is one of the most backward districts in the country when measured in terms of Natural resource Index (NRI), Integrated Livelihood Index (ILI) and

is ranked at the 22nd position in the list of Rainfed Area Prioritization Index (RAPI) prepared by NRAA (2012). One of the major reason for this backwardness can be attributed to the high frequency of "below average" rainfall received in the district. As is evident from Figure 3, the annual rainfall received over 18 years was below average in seven years, normal in five years and above normal in six years. This clearly indicates that the spectre of drought is always prevalent which has made rainfed farming a risky proposition. Further, since most of the farmers are capital and resource poor, investment in agriculture has never been a priority and most of the land owners who are already marginalized, have been forced to carry on with just subsistence farming.

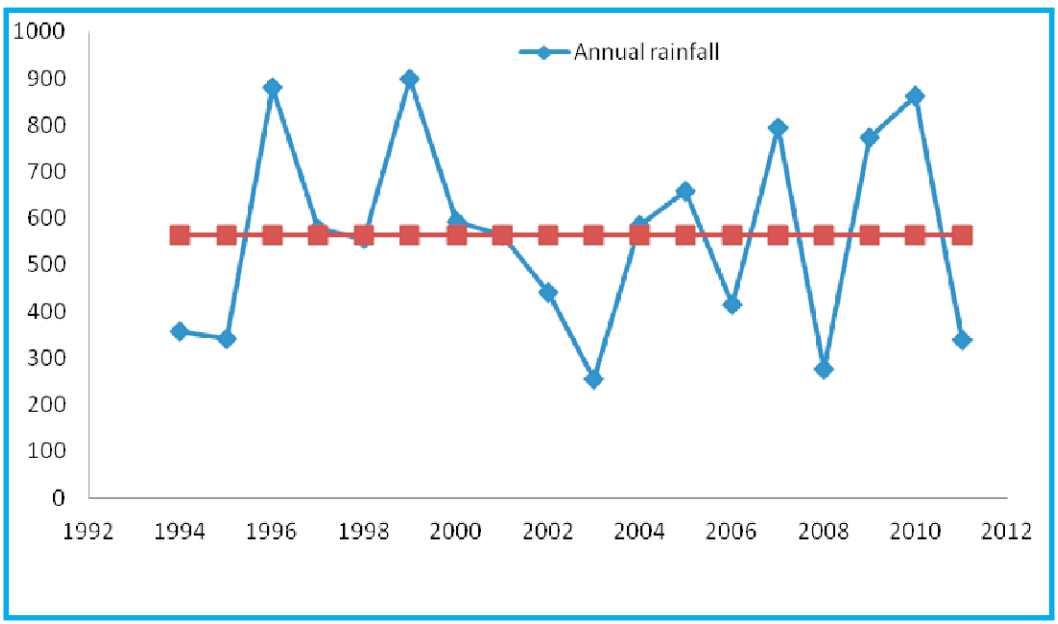


Fig. 3: Occurrence of rainfall in Molakalmuru *taluk* and the long term mean

VII. f. Soil quality analysis

Systematic assessment of the soil in a watershed are useful tools for making recommendations for the application of fertilizers to crops, assessment of risk to erosion, suitable crops to be grown etc. Due to adoption of multiple cropping and introduction of high yielding varieties of principal crops in our country, soils are depleted in nutrients at much faster rate than in case of old cropping system. As a result, crop production has become highly fertilizer oriented requiring a judicious use of fertilizers. Extensive soil

sampling was carried out during 2007-08. For effective sampling, the watershed was divided into 3 groups based on the positions of the fields on a toposequence - top, middle and bottom.

Soil samples from 46 farmer's field were collected at 2 depths (0-15 cm and 15-30 cm) and brought to, the centre for analysis. Prepared soil samples were analyzed for various fertility characteristics i.e., texture, Bulk density, pH, EC, Organic carbon, N, P_2O_5, K_2O, Zn, Cu, Fe and Mn. Texture of the soil varied from loamy sand to sandy clay loam with bulk density ranges between 1.36 and 1.65 g/cc with an average of 1.48 g/cc. The results of the analysis of soil samples collected from the watershed are shown in Table 7.

Table 7: Chemical characteristics of soil samples (0-15 & 15-30 cm depth) collected from farmers fields of Netranahalli Watershed during 2007-08.

S.No	Parameters	0-15 cm depth		15-30 cm depth	
		Range	Average	Range	Average
1.	pH	6.71-8.83	7.85	6.34-8.82	7.65
2.	EC	0.01-0.40	0.13	0.01-0.29	0.12
3.	Organic carbon (%)	0.08-0.84	0.40	0.12-0.82	0.44
4.	Available N (kg/ha)	90.9-573	273	103-572	284
5.	Available P_2O_5 (kg/ha)	10.7-339	70.9	11.8-276	51.6
6.	Available K_2O (kg/ha)	137-1102	452	137-794	376
7.	Zinc (ppm)	0.19-0.70	0.49	0.19-0.78	0.45
8.	Copper (ppm)	0.31-2.47	1.27	0.24-3.11	2.01
9.	Iron (ppm)	2.06-33.50	19.25	1.83-35.0	20
10.	Manganese (ppm)	2.77-25.45	18.65	4.40-25.5	17.3

Results show that almost all fields sampled were low in organic carbon and available N. Available P_2O_5 and K_2O status of watershed samples are adequate. The status of micronutrient is high to very high except for Zinc. Hence, application of FYM or vermi-compost @ 5-7.5t/ ha along with additional dose of Nitrogen fertilizer is recommended. Application of Zinc sulphate @ 20 kg/ha is also recommended to enhance the crop yield since the status of zinc is low in the soil samples analyzed.

VI. g. Quality of Ground Water

Bore well water samples (15 Nos.) were collected and analyzed from farmers' field considering upper, middle and lower reaches of watershed. Analysis was carried out for its chemical characteristics viz., pH, Electrical conductivity (EC), Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Carbonate (CO_3), Bicarbonate (HCO_3), Chloride (Cl), Sulphate (SO_4), Mg/Ca ratio, Residual Sodium Carbonate (RSC), Sodium Adsorption Ration (SAR) and Soluble Sodium Percentage (SSP). The details of analysis results are given in Table 8 below.

Analysis result shows that most of the bore well water samples have excess of salt and sodium hazards (excess HCO_3 and SAR). In addition to this, the high Mg/Ca ratio (ideal ratio <1) will hamper calcium availability to crops. Application of this water with high bicarbonate, sodium and magnesium will weaken the soil structure, reduce infiltration and permeability. Hence, it is recommended that these waters may be used after it has been treated with gypsum to replace Na by Ca and to bring the Mg /Ca ratio upto the desirable level.

Table 8: Analysis results of water samples collected from Netranahalli watershed

S.No	Particulars	Range	Average	Permissible limits
1	pH	7.31-8.71	8.43	6.5 – 8.5
2	EC dS/m	1.07-2.40	1.78	1.5
3	Ca (meq/L)	1.40-4.60	2.56	3.75
4	Mg (meq/L)	3.40-10.20	6.81	2.5
5	K (meq/L)	0.03-0.28	0.19	0.25
6	Na (meq/L)	6.70-29.26	11.39	4.35
7	CO_3 (meq/L)	0.0-1.60	0.80	-
8	HCO_3 (meq/L)	5.60-9.60	7.31	-
9	Cl (meq/L)	1.00-3.40	2.13	7.04
10	SO_4 (meq/L)	1.28-26.09	5.66	6.25
11	Mg/Ca	1.96-5.71	2.84	<1
12	SAR	4.00-11.22	5.25	-
13	RSC	-6.80-3.40	-1.26	-
14	SSP	43.82-68.27	54.53	-

Interventions carried out under the watershed project

A OFF FARM DEVELOPMENT

VII. A1. Entry Point Activities (EPA's)

Mini water tank

EPAs are considered essential during the initial stage of the watershed programme to develop rapport among the farmers and to improve confidence levels for unhindered developmental activities planned in the project. EPA's when carried out in a participatory and transparent manner usually "break the ice" between the stake holders and the development agency. In this regard, a committee meeting was organized at the watershed, inviting all the members and other stakeholders. In that meeting, it was proposed to construct a mini drinking water tank near Netranahalli village. Subsequently, estimates for the tank were prepared and a mini drinking water tank with a capacity of 2000 litres (which included 60 m long pipe line) was constructed at a cost of Rs.61,000/-) was constructed at Netranahalli village which is being used by the villagers. This water tank serves as a source of assured clean drinking water for a cluster of about 50 families.

Plate 5: A mini water tank constructed in Netranahalli village as an entry point activity

Development of water resources

Agricultural development and sustainable crop production in the dry regions is totally dependent on rainfall and consequent storage of surface water in storage structures and their indirect impact on recharging ground water resources. The watershed receives an

annual rainfall of 417 spread over 31 rainy days. However, the EI_{30} values indicate (Table 3) that short duration rainfall with high intensities occur during September & October each year, leading to high volumes of flow in a short period, which are damaging and erosive. This leads to significant debris and soil movement over the undulating terrain and resultant high soil loss, estimated to be about 10 t/ha/yr. It was therefore envisioned that it is necessary to de-silt major channels and reservoirs and repair existing structures to enhance storage capacity and allow runoff water to move without damaging water courses.

VII.A.2. Renovation of existing water harvesting structure

Under this activity, one *nala bund* and one check dam were de-silted; some water courses which are silted up and moving water was washing away quality arable land were deepened to facilitate the safe disposal of runoff water. Nine farm ponds were desilted and restored to their original capacity, thereby creating an additional storage of 4657 cu m at a cost of Rs.1,04,783/-. Details of de-siltation and water storage created at Netranahalli watershed are given in Table 9.

Table 9: Details of de-siltation and water storage created at Netranahalli watershed

Sl. No.	Name of the structure	No. of structures	Additional storage created (cum)	Expenditure incurred
1	Village tanks and *nala bund/nala* deepening in a length of 452 m	5	1958	44055=00
2	Ponds	9	2612	58770=00
3	Check dam	1	87	19578=00
			Total Rs.	104783=00

Note: - Cost of storage works out to be Rs.22.50 per cu m

Plate 6: Views of desiltation activitis carried out at different locations.

A 3. Drainage line treatment

The watershed has a total drainage density of 158 km per 100 sq.km, which need to be adequately treated to prevent excessive erosion in the upper reaches (average slope 5%) and encroachment by high flows into agricultural fields. Wired check dams (gabions) were constructed, across a *nala* in the lower reaches to control the velocity of runoff water from agricultural fields and to reduce soil erosion. A gabion is a porous dam which arrests silt but allows clear runoff water to pass through it at a controlled velocity. This is a low cost semi - permanent structure (Plate 7) which has several advantages over costly cement-masonry structures.

These gabions are made at suitable sites in a *nala* with the following site features-

* Narrow cross section of nala
* Scope for anchoring of side walls
* Sufficient space available on the upstream for temporary impounding of water
* Clear channel on the downstream for safe and quick discharge of water

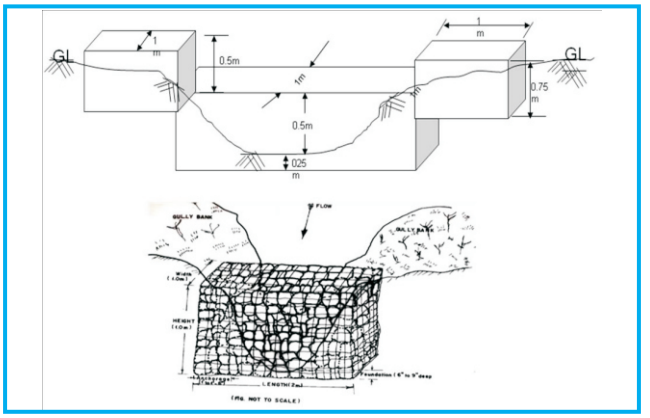


Plate 7: Views of gabions made in the lower reaches to reduce velocity of flowing water

Channels from non-arable areas which contribute significantly to overland flows have been treated with rock-fill dam and gabion structures (1m wide, 1m height, 0.7 m above GL, 0.3 m below G.L.) in critical areas. This activity will enhance *in-situ* moisture conservation in apart from reducing velocity in the ensuing rainy season. A total of 6 gabions (54 m total length) have been made covering a catchment of 151.73 ha at a total cost of Rs.80408/- which works out to Rs1489/- per m length of gabion.

As a consequence of this treatment, further lateral spread of *nala* banks has been prevented and silt deposition on the upstream of gabions has led to the re-establishment of native trees (*Acacia nilotica, Prosopis juliflora, Pongammia pinnata*) and shrubs (*Dodonea viscosa*, *Carrissa carandus*) in the *nala* course. It is expected that under continued protection from biotic disturbances this vegetation will begin to act as a natural retarding mechanism and prevent soil erosion.

A4. Afforestation, planting of Tree Borne Oilseeds (TBOs) and silvi-pastoral development

Rehabilitation of *nala* banks in the upper reaches of the watershed was done by planting of 550 seedlings of different species like – *Gliricidia maculata, Tectona grandis, Grewellia robusta* all along the *nala* bank, in pits of size 60 cm^3. Tree species which bear oil bearing seeds are commonly called as tree borne oil seeds (TBO's). These species have significant potential to generate village level employment for marginal farmers. Accordingly, seedlings of *Pongammia pinnata* and *Simaruba glauca* were planted along the main *nala* during the rainy season of 2011. The initial establishment and survival has been satisfactory.

A5. Income generating activities for landless and marginal farmers

Establishment of vermi-compost units

Soil fertility is the most important aspect in any farming activity. Every farmer who wants to reap a better harvest needs to develop and sustain the soil fertility status by incorporating residue and adopt appropriate cropping practices. In the present farming system scenario, a majority of the farmers consider application of chemical fertilizers as the only source of soil fertility enhancement, and remain indifferent towards the use of other sources of natural and organic matter. Farm Yard manure (FYM) and vermi compost are the two significant sources of natural manures which not only provide the required nutrients to the soil, but also improves physical and biological conditions. Between these two, vermi compost has an edge, as it provides the nutrients in still more available form. Hence, it was considered necessary to create awareness about the benefits of the use of vermi-compost among farmers. Based on the feedback and willingness of farmers it was considered appropriate to provide each such unit to farmers who were willing to share a part of the cost of the construction of the unit.

The construction of vermi-compost pits was carried out with farmers' participation at 25 locations using locally available burnt stone/Cuddapah slabs. Each unit is of 3 m x 2 m size with a mud base and is shaded with locally available material. Earthworms were introduced in each pit after one week of addition of farm residue and

cow dung. A total of 25 units were constructed at a total cost of Rs.89956/-, out of which farmers contribution was in the way of concrete base to the unit, shade etc.,

Plate 8: Low cost vermi-compost unit made in the watershed.

Over a period of three months manures from vermi-compost pits were obtained and analyzed for their nutrient quality. The results are shown in the table below.

Table 10: Elemental analysis of vermi-compost manure

Nutrient	Range	Average	Recommended level*
Organic carbon (per cent)	2.31-6.55	4.09	9.8-13.4
Nitrogen (per cent)	0.62-1.37	0.98	0.51-1.61
Phosphorus (per cent)	0.22-0.27	0.25	0.19-1.02
Potassium (per cent)	0.36-1.06	0.66	0.15-0.73
Zinc (mg kg^{-1})	17.9-35.2	27.7	42-100
Copper (mg kg^{-1})	26.7-78.3	51.1	26-48
Iron (mg kg^{-1})	2543-27.5	2624	2050-13310
Manganese (mg kg^{-1})	245-570	331	105-2038

*Source: An open-access journal published by ICRISAT

Further, in the second phase farmers were asked to first construct their units at locations close to cattle sheds to reduce drudgery of transport of cattle dung and a subsidy to the tune of Rs.4000 per unit will be paid once the work is completed as per project specifications.

Mulberry cultivation for sericulture units

Silk worm rearing is an activity carried out by several enterprising farmers with large land holdings and irrigation facilities. Silk worms are processed and threads purchased by silk saree weavers which is a very old traditional cottage industry in the region. Five new blocks for the production of mulberry leaves were provided to five farmers along with a drip irrigation set-up connected to a bore well in each of the fields. The cost of each unit was restricted to Rs.0.50 lakhs per farmer irrespective of area to be covered. Any additional cost incurred was borne by the farmers themselves. These mulberry blocks had come up well with cuttings being arranged locally from other established growers. The subsequent prolonged dry spell and drying up of wells led to restricted water supply and drying up of many young cuttings. All farmers subsequently rolled back the drip line to prevent damage by heat.

Bee-keeping

Pollination is one of the most important mechanisms in the maintenance and conservation of plant biodiversity and life on earth, in general. The services of honey bees as pollinators are essential in enhancing both quantitative and qualitative crop productivity. Besides the indirect benefits, honey is one of the purest forms of sugar with immense commercial value. It was also envisaged that apiculture as a secondary activity will benefit the farmers who can potentially sell the honey or use it for self-consumption

Apiculture as a secondary occupation is carried out by few farmers in the dry regions due to the poor availability of flowers for a major part of the year. Initial enquiries revealed that honey bees along with properly designed boxes were available with (Mr. Maruti L. Arkasali) from Dharwad, Karnataka. So, thirty five live colonies were procured from him and distributed directly to the identified farmers. These farmers had also been exposed to the benefits of apiculture during one of the exposure visits organized in the project. Hands on training by experts from Dharwad were also arranged for them on bee rearing. Maintenance tips like safeguarding the colonies from enemies like lizards, ants, moths were given to the farmers. Further, a honey bee extraction machine was also purchased and given to them. Visits were made to monitor the colonies, exchange the affected boxes, divide the over developed colonies etc.

Plate 9: View of a bee box along with a well made honey comb structure.

However, apiculture in the dry zone and in this watershed has not been very successful. This can be attributed to several reasons – poor availability of flowers, long distance to be covered by bees in search of flowers, susceptibility of bees to disease caused by bacteria and fungus and predators like lizards etc. Examples of successful apiculture are few, with only two farmers able to get two kilograms of honey, which they were able to sell at a price of Rs 350/- per kg. Arrangements were made to form groups headed by successful farmers, so as to train others who are trailing behind.

B. ON-FARM DEVELOPMENT

Erosion by water and wind in arable lands constitutes the single major problem for ensuring sustained agricultural production primarily in rainfed regions, leading to soil loss which is more than the permissible limits. Continued loss of soil has led to decline in productivity for almost all major crops in India.

Measures for natural resource conservation in most agricultural farms are rarely implemented due to lack of awareness on soil erosion and loss, poor financial status of most farmers, poor co-operation of different land owners in executing measures for safe disposal of runoff water, absence of technical support from state departments in construction of measures for soil and water conservation etc. The problem of serious soil erosion was also mentioned by farmers and it was decided that field *bunding* would be carried out in the watershed with the active participation of farmers and their token contribution in the activity

B1. Construction of field *bunds*

This activity was originally initiated from the ridge towards the valley, with the land owner physically demarcating his field boundary; this was necessary to avoid controversies at a

later date. After measurements were made, borrow pits of size 3.0 m x 2.75 m x 0.30 m were manually excavated and soil from these borrow pits was used to form bunds. Waste weirs of suitable size were constructed in natural waterways for safe disposal of excess runoff from arable lands. Rough stone revetment has been provided on either side of waste weirs to protect *bund* damage at the time of maximum runoff disposal. These low cost measures will enhance *in-situ* moisture conservation, increase crop yields besides reducing soil erosion.

Arable lands in the watersheds were provided with field *bunding* of size 0.81sqm cross section (top width = 0.45m, bottom width = 2.25m and height = 0.6m)was been taken up in the fields beginning from the upper reaches of the watershed. This entire exercise has been taken up with the active involvement of farmers since this provided village level employment to them and there was no need for them to go elsewhere for search of wages. In order to dispose the excess runoff safely out of the field, construction of stone checks/waste weir (of crest size: Top width = 0.45m, bottom width =1.80m, height = 0.45m and side wall dimensions were: top width = 0.45m, bottom width = 1.80m, height = 0.80m, to an extent of 0.5m long on either side of weir) were also constructed at the lowest point. This activity will ensure safe movement of runoff water from the fields to the next lower field and result in increased moisture conservation during the rainy season, resulting in higher yields.

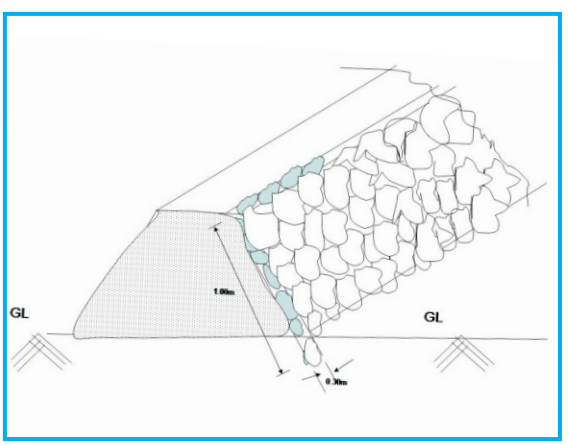


Plate 10: Series of field bunds with waste weirs established in arable land. Sketch of loose stone revetment alongside.

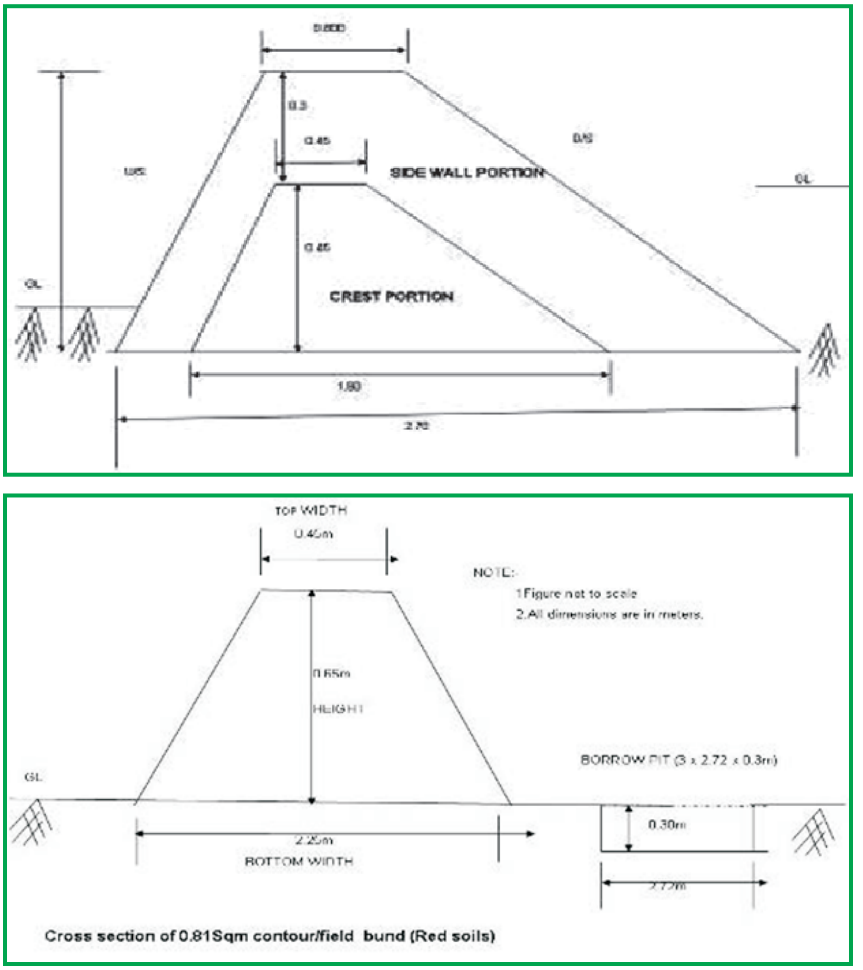


Fig.4 : Cross section details of waste weirs and sidewalls above that of field bund and waste weir below.

B.2. Renovation of existing *bunds* and *in situ* moisture conservation

In the watershed there are some existing bunds (30 ha) with smaller cross section without waste weirs. These bunds were renovated to be make them to 0.81sqm cross section apart from providing waste weir in the *nala* course for safe disposal of runoff water.

During September 2009 there was heavy rainfall of 120 mm in a single storm Despite the high rainfall, bunds of 0.81sq.m cross section along with waste/gully plugs and revetment remained intact. This indicates that a bund of cross section of 0.81 sq m is effective in withstanding high rainfall events and should be recommended for the semi-arid red soil regions. However some minor breaches along some of the waste weirs were

noticed and these breaches were subsequently filled through renovation of existing bunds. Hence, the bunding programme proved to be very successful in these fields with enhanced moisture conservation leading to good crop growth and higher yields (26% increase on an average) in the *bunded* area.

Plate 11: View of construction of bunds using soil from borrow pits

Plate 12: Horse gram in the *bunded* areas after the harvest of groundnut (main crop)

Determination of impact of soil conservation activities

Silt survey has been conducted using standard procedures, by taking the observation to compute the volume of silt held against the waste weirs located in the upper, middle and lower reaches of treated arable area of the watershed spread over 165 ha. Soil samples were collected and analyzed for particle density. It was estimated that the total volume of silt held up on the upstream of waste weirs was equivalent to 685 cu m. The average soil loss works out to 10 ton per hectare. The study reveals that 685 cum of soil

from 165ha has been conserved in the watershed due to adoption of soil conservation measures, like bunding along with waste weirs, gabions, rock fill dam etc. The market value of the soil conserved is equivalent to Rs. 2, 39750/-, while the cost could be higher if the value of nutrients conserved were to be added.

B.3 Introduction of forage legumes on bunds and creation of fodder banks

The dry zones are perennially short of fodder and substantial amount of time is spent by women and children in either collection of fodder for their animals or moving along with their animals (cows and buffaloes) as they search for any type of fodder. During drought years the problem becomes more acute and in any cases farmers go for distress sale of animas since they are unable to provide fodder for their live stock. Every year hundreds of cattle are left open to graze freely leading to significant damage to unprotected agricultural fields, naturally regenerating forest vegetation and extensive overgrazing in common grazing lands

Forage legumes play an important role in livestock rearing, by providing nutritious supplement with dry grass and improving milk quality. During 2011, sowing of *Stylosanthes hamata* (Stylo) seeds was carried out on newly formed field bunds in 16 locations, the bund length varying from 102 m to 550 m and a total length of 4907 m was covered. Seeds were sown in small furrows in two lines on top of the bund during the rainy season. Initial germination was poor (<40%) due to the nature of the bund forming material but subsequent dry spell led to large scale mortality and no material was available for harvest.

Besides fodder legumes, slips of fodder grasses were obtained during 2011 from the IGFRI campus at Dharwad and were provided to seven willing farmers who insisted on growing these slips under assured irrigated and protected conditions. The grasses obtained from IGFRI Dharwad were – Guinea grass (*Panicum maximum*), Para grass (*Bracharia decumbens*) and hybrid Napier (*P.purpureum* x *P.typhoides*). Slips of these grasses were planted in prepared fields at the recommended spacings and their performance has been satisfactory. The yields obtained in the first year were 3.0,2.4 and 3.2 tons /ha, in case of Guinea grass, Para grass and hybrid Napier, respectively, which is lower than their

optimum range. By the second year yields declined due to paucity of water and lesser number of irrigation being provided by farmers.

Plate 13: A fodder bank of *Brachairia decumbens* developed under irrigated conditions

B.4. Dry land horticulture development

A total of 50 ha area has been developed under dry land horticultural development works by planting mango (var. Mallika, Baneshan and Alphanso), sapota (Cricket ball and Kalipati), guava (Allahabad safeda), lime (Balaji), Mosambi, coconut (var. Tiptur tall) and tamarind (PKM-1) in the field of 18 farmers during the year 2010-11 and in fields of 50 farmers during 2011-12. The plants collected from various quality sources have been provided to willing farmers who have planted them under protective irrigated conditions, due to the extremely hot summers in the watershed. Farmers have contributed their share by pit digging, provision of manure, planting, staking and after care. Only 20% of the pitting cost was borne by the farmers which was added to the corpus of the watershed development fund.

The performance of the fruit plants has been satisfactory with mortality on an average being about 27%.The survival of sapota is the highest averaging about 75% and lowest in coconut (mortality of about 50%) due to low level of irrigation which is constrained by low ground water levels. The initial growth parameters like average plant height, rootstock and scion diameters were measured and presented in the Table 11.

Table 11: Average initial plant height, rootstock and scion diameter of the different fruit species planted at Netranahalli watershed

S. No.	Name of the fruit species	Plant height (cm)	Rootstock diameter (mm)	Scion diameter (mm)
1	Lime (seedlings)	79.5	-	7.72
2	Coconut	145	-	-
3	Sapota	93.3	13.80	12.46
4	Mango	96.3	15.08	11.13
5	Guava	79	11.41	8.93
6	Mosambi	121.3	-	15.15

Plate 14: Planting of fruit sp. & boundary plantation

In order to make farmers aware about "high value-low volume" crops, introduction of olericulture was carried out in the fields of 6 farmers who were provided with vegetables seeds of hybrid tomato (H. No.618) cabbage (F1- Balaji), carrot (var. Tokito), cauliflower (F1 – Utapati), from an area of 0.5 acre each, yielded a net return of Rs5000/- each in a period of 3 months, indicating a high rate of return. Hybrid tomato was cultivated by a farmer for local market in one acre. This farmer (Shri B. Boraiah) has earned Rs.20,000/- from 15 pluckings over a period of 6 months, from well managed and staked tomato plants. A new filler crop combination of hybrid papaya (var. *Sunrise solo*) which is a high yielder (in six months) has been raised with annual Moringa (var. *Dhan raj*), with mango and sapota as the main fruit plants over an area of 1 ha in the watershed.

Plate 15: Hybrid tomato and cabbage

Plate 16: View of the farmer with his bumper tomato crop

Plate 17: Papaya as a filler crop with Mango and Sapota

Plate 18: Cultivation of pumpkin in the basins of drip irrigated mango plants

An innovative modification has been done by one farmer in which white pumpkin has been raised in the basin of mango plants, which have been provided with drip irrigation. White pumpkin is traditionally used in *pooja* ceremonies.

Table 12: Growth observations (average) recorded on horticultural crops planted in different farmers fields.

Fruit crops	Plant height (m)	Root stock dia.(mm)	Scion dia(mm)	No. of fronds	Chlorophyll content *
Mango	0.53	9.3	8.2	-	24.46
Sapota	0.56	11.2	8.3	-	18.6
Tamarind	1.14	19.4	16.6	-	
Coconut	1.34	25.7	-	4	12.8
Lime	0.7	-	8.3	-	58.3
Mosambi	1.23	-	18.7	-	80.17
Pomegranate	0.46	-	7.5	-	54.45

* Apogee index (Apogee 2006)

B.5. Crop production and diversification of agriculture

In India, about 60% of the cultivated area is rainfed which contributes to nearly 40% of the total crop production, mainly of coarse cereals, oilseeds, pulses and fruits, About 93% of cultivated area is under sorghum, 94% under pearlmillet, 79% under corn, 87% under pulses, 76% under oilseeds, 64% under cotton and 59% under tobacco in India's drylands. These soils are generally highly degraded with low water retentive capacity, and have multiple nutrient deficiencies. In the dryland's of India, human population is likely to reach 600 millions by 2025 from the present 410 millions. Similarly, the livestock population is likely to exceed 650 million by 2025 from the present 509 million. On the other hand, the area under dryland crop production may decrease to 85 million ha by 2025 from the present 97 million ha. Thus, from such a significantly reduced cultivated area, crop production must increase from the present 0.8 to 1.0 t ha^{-1} to 2.0 t ha^{-1} by 2025. Furthermore, the quality of the produce must improve the meet the global market standards. Also, the cost of production needs to be reduced in order not only to improve the farmers' net income but also remain globally competitive. This would help in maintaining the food security in the years ahead.

Crops cultivated in a specific area are determined by number of factors. Even with adequate precipitation and sunlight, optimum temperature and fertile soils, it is quite possible that other factors such as economic concerns (commodity prices, transport costs,

marketing facility etc.) or even Government policies (marketing boards, price controls, price stability) determine the crop choices that farmers cultivates. In the past, selection of crops and varieties was governed by the needs of a farm family rather than the crops suitability for a given environment. In case of rainy season crops, the timing and quantity of precipitation should decide the choice of crops and varieties. Cultivation and the choice of rainy season crops and their cultivars in red soils (Alfisols) in Semi-Arid regions of northern Karnataka and adjacent Andhra Pradesh depends on the rainfall pattern and length of the effective growing season, economic returns and fodder requirement.

In India, low yields and crop failures in these drylands often lead to food and fodder scarcity resulting in a near–famine situation that further accelerate the process of land degradation. Alfisols, Entisols, Vertisols and associated soils dominate the SAT areas (Virmani, *et al*., 1991). The dryland eco-system in India is characterized by erratic rainfall and frequent droughts and in such situations, rainwater conservation at terrace level in a watershed plays a significant role for maintaining and increasing crop productivity.

Crops and cropping systems: The major crops cultivated under rainfed conditions in the watershed are groundnut *bajra,* and *ragi* as sole crops and groundnut is also intercropped with redgram, cowpea, castor and greengram during rainy *(kharif)* season. Crop failure is common in this region and is attributed to low i.e. 420 mm (average rainfall in a year) and erratic rainfall both during a year and cropping season. Paddy, sorghum, maize, cotton and sunflower are cultivated both during rainy and post rainy (*rabi*)/early summer with irrigation from bore wells.

Introduction of resource conservation measures in the watershed like contour *bunding* being adopted in nearly all agricultural fields, resulted in the conservation of rainwater within the field boundaries. It was therefore necessary that this conserved rainwater be efficiently utilized for higher production by the introduction of improved cultivars and replace traditional low yielding varieties of major crops which are being grown in rainfed and irrigated conditions. Groundnut is the major crop being cultivated during rainy season with low productivity (300 to 400 kg ha^{-1}) due to low average rainfall (420 mm) with irregular distribution, absence during flowering to pod formation and sometimes during pod filling stage to maturity (Table13), low input and inadequate application of fertilizers. The cropping pattern for the watershed during the pre-project

phase (2007-08) indicated that groundnut and maize are major crops cultivated in the rainfed and irrigated areas,respectively (Table 14).

Table 13: Rainfall distribution, sowing and harvest dates for each season in the watershed

Particulars	2008	2009	2010	Average
Total rainfall (mm) (rainy days)	277.2 (17)[a]	773.8 (32)	861.2 (40)	417.0
Crop season rainfall (mm) (rainy days)	74.0 (3)	425.5 (17)	498.2 (27)	234.0
Crop season + antecedent rainfall (mm)	74.0+12.2 = 86.2	425.5+156.5 = 582.0	498.2+45.7 = 543.9	234.0+30.6 = 264.6
Sowing date	16th to 21st Aug. 2008	23rd to 28th Aug. 2009	9th to 12th July 2010	15th to 21st July
Harvest date	12th to 16th Dec. 2008	15th to 20th Dec. 2009	23rd to 29th Nov. 2010	1st to 8th Dec.
Percentage of rainfall during the year	66.5	185.6	206.5	--

[a] Values in parenthesis are number of rainy days

Table 14: Area (ha) under different crops in the watershed during different project phases

Crops	2007-08	2008-09	2009-10
	Pre-Project	Project period	
Groundnut	193.84	197.49	206.31
Redgram/Horsegram	8.12	7.33	9.04
Maize	34.70	35.41	36.55
Onion	30.73	33.91	35.28
Sorghum	10.26	13.14	19.08
Bajra and other crops	3.04	7.74	13.14
Total	280.69	295.01	319.40

In view of the existing rainfall situation, crops and cropping patterns with low yields recorded in groundnut (0.3 to 0.4 q ha^{-1}) and maize (3 to 4 t ha^{-1}) efforts were made to improve the yields of major crops by the introduction of improved cultivars (varieties/hybrids) with intercropping and crop rotation practices to meet out family needs,

increase yields and income with consequent improvement in soil properties. It was envisaged that by the introduction of new cultivars two objectives could be met simultaneously – farmers could be made aware about new cultivars and improved cropping practices and that seeds of these new cultivars would be carried over for the next cropping season and farmers would become self-reliant in growing new cultivars.

To improve crop yields in rainfed and irrigated conditions in the watershed, six improved varieties of groundnut (GPBD-4, K-134, K-6, R2001-2, R2001-3 and TMV-2), two redgram cultivars (ICPL-87 and BRG-2), cowpea variety C-152, greengram variety - China *mung*, two castor hybrids (GCH-4 and DCH-177), bajra cultivar ICTP-8203 and maize improved hybrid (Super 900M Gold) were evaluated for their performance both as a sole and intercrop/border planting in rainfed and irrigated conditions from 2008 to 2010.

Evaluation of new and improved cultivars of major crops was carried out for three years (2008-10). During this period, rainfall in the watershed was highly variable; while the average rainfall is 417 mm, rainfall during 2008 was only 67% of the normal (277.2 mm) leading to widespread failure of almost all crops.

Crop demonstration during 2008: During the first year of the project (2008) innoculant material for seed treatment by *Rhizobium, Azospirillum* and *Trichoderma* were distributed to more than 50 farmers for cereals, pulses and oilseeds for enhanced N fixation and to reduce disease incidence. Groundnut, greengram and cowpea seeds were treated with *Rhizobium, Trichoderma* and castor and bajra seeds were treated with *Azospirillum* and *Trichoderma*. The methodology of seed treatment of different crops was demonstrated to the farmers in their fields (Plate 19). However, the impact of inoculation could not be assessed due to crop failure in 2008.

Plate 19: Demonstration of seed inoculation by N-fixing bacteria and sowing of groundnut

Groundnut: Six groundnut varieties i.e. GPBD-4 (UAS Dharwad), R2001-2, R2001-3 (from RRS Raichur), TMV-2 (from NSC Bellary), K-134 and K-6 (from ARS Anantapur) were distributed to evaluate the performance of these varieties.

Redgram: There was a demand from the watershed farmers for introducing a short duration red gram as compared to the regular redgram varieties that mature in 150 to 180 days. In view of this, a short duration (120 to 130 days) redgram variety i.e. ICPL-87 from UAS Dharwad was procured and distributed among 31 farmers.

Cowpea and greengram: Cowpea (cultivar C-152) and greengram (cultivar China mung) were procured from UAS Dharwad and KSSC Bellary, respectively and distributed to 31 farmers for sowing as intercrops. The germination of cowpea and greengram varied from 30 to 40% but crops failed due to low rainfall.

Castor: Two castor cultivars - GCH-4 and DCH-177 procured from UAS Dharwad, were distributed to 14 farmers for demonstration. Crop failed to yield due to low rainfall after castor had germinated in 50% of the sown area.

Bajra: Bajra cultivar ICTP-8203 was distributed to 28 farmers as border row crop to protect groundnut from pests and diseases attack; the seeds germinated but failed due to low rainfall.

Crop demonstrations during 2009: Total rainfall during 2009 was 85.6% higher (773.8 mm) than the normal (417.0 mm) received in 32 rainy days. Higher rainfall of 2009 failed to produce higher pod and straw yields of groundnut with yields being normal to slightly higher which was attributed to poor distribution of rainfall. Only 3.2 mm was received in July. Rainfall of 156.5 mm that occurred during 13-21st August led to late sowing of groundnut. Due to higher rainfall, improved groundnut cultivars (TMV-2 and K-6) produced higher yields over local varieties. Pod and straw yield of improved groundnut cultivar (K-6) increased by 127% (825 kg ha^{-1}) and 126% (14.55 q ha^{-1}) respectively, over local variety. Introduction of cultivar TMV-2, increased pod yield significantly by 152% (808 kg ha^{-1}) over local cultivar (321 kg ha^{-1}) (Table 15).

Table 15: Groundnut yield as influenced by cultivation of improved cultivars

Particulars	Pod yield (kg ha^{-1})	Straw yield (q ha^{-1})
Control (Local variety)	321	5.78
Improved cultivar (TMV-2)	808	14.55
Per cent increase	152	152
S.Em. ±	40	0.72
LSD at 5%	124	2.24
Control (Local variety)	364	6.55
Improved cultivar (K-6)	825	14.85
Per cent increase	127	126
S.Em. ±	55	0.99
LSD at 5%	171	3.08

Table 16: Groundnut and intercrops pod/grain and straw yields and groundnut pod equivalent (GPE) under different intercropping systems under rainfed conditions.

Particulars	Pod/Grain yield (kg ha^{-1})	Straw yield (q ha^{-1})	Groundnut pod equivalent
Groundnut + cowpea intercropping			
Control (Local varieties)	592 + 09	10.66 + 0.16	658
Improved cultivars (TMV-2 + C-152)	770 + 27	13.86 + 0.48	877
Per cent increase	30 + 200	30 + 200	33
Groundnut + cowpea intercropping			
Control (Local varieties)	716 + 09	12.89 + 0.16	793
Improved cultivars (K-6 + C-152)	770 + 36	13.86 + 0.65	891
Per cent increase	8 + 300	8 + 306	12
Groundnut + redgram intercropping			
Control (Local varieties)	412 + 18	7.41 + 0.32	471
Improved cultivars (TMV-2 + ICPL-87)	754 + 49.2	13.57 + 0.89	884
Per cent increase	83 + 173	83 + 178	88
Groundnut + redgram intercropping			
Control (Local varieties)	412 + 17.7	7.41 + 0.32	471
Improved cultivars (K-6 + ICPL-87)	779 + 86.3	14.03 + 1.55	958
Per cent increase	89 + 388	89 + 384	103

Intercropping of improved cultivars of groundnut (TMV-2 and K-6), cowpea (C-152) and redgram (ICPL-87) resulted in increased yields over traditional cultivars (Table 16). Groundnut pod equivalent (GPE) increases were 12% in groundnut (K-6) + cowpea (C-152) intercropping and 33% in groundnut (TMV-2) + cowpea (C-152) intercropping (Table 4). Even in groundnut + redgram intercropping, GPE were 88% higher in groundnut (TMV-2) + redgram (ICPL-87) and 103% higher in groundnut (K-6) + redgram (ICPL-87) over control, Similarly introduction of improved cultivar of bajra i.e. ICTP-8203 increased grain and straw yield of bajra by 66% over local cultivar of bajra (Table 17) during 2009.

Table 17: Bajra yield as influenced by cultivation of improved cultivar practices

Particulars	Grain yield (kg ha^{-1})	Straw yield (q ha^{-1})
Control (Local variety)	933	16.80
Improved cultivar (ICTP-8203)	1550	27.90
Per cent increase	66	66

Crop diversification during 2010

Demonstrations of improved crop cultivars and low cost inputs were continued for increased productivity and income for the stake holders. Two groundnut varieties evaluated earlier (K-6 and TMV-2), cowpea cultivar C-152 and redgram cultivar BRG-2 were distributed among 60 beneficiaries. Redgram and cowpea were cultivated as intercrop along with groundnut during 2010 *kharif* season.

Performance of improved groundnut variety K-6 over TMV-2: The total rainfall during 2010 was 106.5% higher (861.2 mm) as compared to the normal rainfall (417.0 mm)., but pod and straw yields were lower than expectation. This was attributed to the uneven distribution of rainfall leading to moisture stress from the sowing stage up to the flowering and initiation of pegging stage and excess rainfall at physiological maturity (Table 18). However, groundnut pod yield were higher by 35% and 30% and straw yield by 33% and 77% with TMV-2 and K-6, respectively over control. Gross returns increased by 35% and 33% with cultivation of TMV-2 and K-6, respectively over control, while net returns increased from Rs. 2023 per ha to Rs. 5689 per ha in TMV-2 (increase of 181%), while net returns increased from Rs. 3183 per ha to Rs. 7558 per ha in K-6 (increase of 137%). The B:C ratios of these cultivars were also

higher in comparison to traditional cultivars (Table 18). However, the availability of seeds of cultivar K6 continued to be a hindrance for its wider dissemination in the watershed and adjoining areas.

Table 18: Groundnut yields of farmers' cultivar vs. improved cultivars

Particulars	Grain yield (kg ha^{-1})	Straw yield (q ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs./ha)	B.C Ratio
Farmers variety (Control)	403	8.02	11268	13290	2023	1.17
Improved variety (TMV-2)	545 (35%)	10.67 (33%)	12273	17962 (35%)	5689 (181%)	1.45 (24%)
LSD at 5%	80.2	1.71	--	2646	2160	0.15
Farmers variety (Control)	471	7.36	12056	15239	3183	1.24
Improved variety (K-6)	613 (30%)	13.00 (77%)	12776	20334 (33%)	7558 (137%)	1.57 (27%)
LSD at 5%	125	2.48	--	4094	3398	0.25

Cost of cultivation, gross and net returns were worked out with the rates of March 2011; Values in parenthesis are % increase

The higher pod, seed and straw yields in K-6 was attributed to greater dry matter accumulation in pods (46%), seeds (50%), straw (100%) with more seeds per plant (49%) and was superior to the traditional variety in terms of pod weight which was 148% higher and number of seeds which was 83% higher (Table 19).

Table 19: Performance of improved groundnut variety K-6 over local varieties

Description	Variety	
	K-6	Local
Weight of straw (g)	25.06	12.54
Weight of pods (g)	14.28	9.76
No. of pods (no)	18	12
Weight of seeds (g)	9.28	6.00
No. of seeds	29.2	19.6

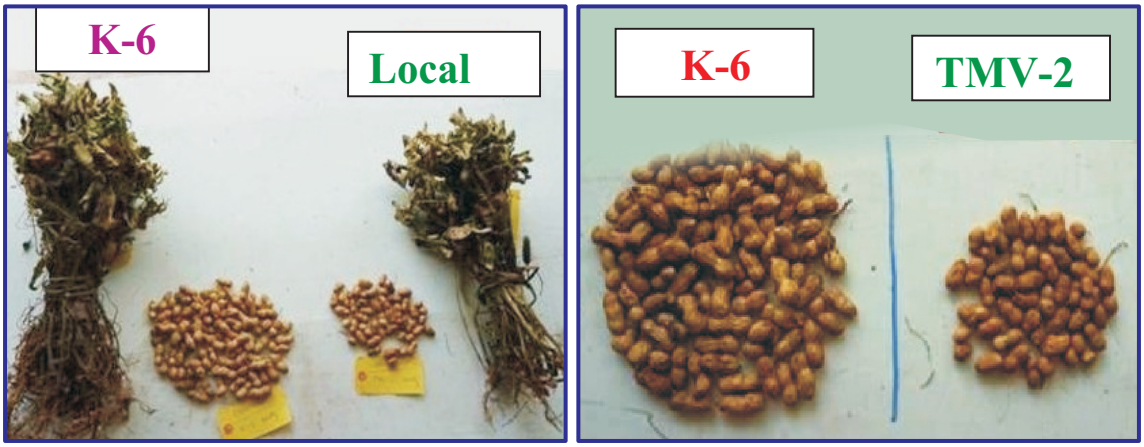


Plate 20: Performance of groundnut varieties

Plate 21: Improved varieties of groundnut in *bunded* area in watershed during *kharif* season 2010

Inter-cropping of groundnut, redgram and cowpea

Intercropping of improved cultivars of groundnut TMV-2 and K-6 with redgram i.e. BRG-2 and cowpea cv. C-152 increased pod/grain and straw yields over local cultivars, which was attributed to improved crop growth with higher dry matter translocation to pods at physiological maturity stage and harvest (Table 20).

Table 20: Groundnut and cowpea intercropping in the farmers fields

Particulars	Grain yield (kg ha^{-1})			Straw yield (q ha^{-1})		
	Groundnut	Redgram	Cowpea	Groundnut	Redgram	Cowpea
Groundnut intercropping *Farmers practice* Groundnut + Redgram (Local) + Cowpea (Local)	388	20.3	18.1	7.36	0.34	0.27
Improved practice Groundnut (TMV-2) + Redgram (BRG-2) + Cowpea (C-152)	494	32.1	21.6	9.14	0.52	0.36
Groundnut intercropping						
Farmers practice Groundnut + Redgram (Local) + Cowpea (Local)	454	42.9	32.7	8.51	0.67	0.53
Improved practice Groundnut (K-6) + Redgram (BRG-2) + Cowpea (C-152)	635	48.9	54.1	12.01	0.74	0.83

Intercropping of groundnut (TMV-2) with redgram (BRG-2) and cowpea (C-152) increased GPE from 461 to 587 per ha with an increase of 27% (Table 21). Gross returns increased by 27% (Rs. 13830 to Rs. 17597 ha^{-1}). Net returns were higher by 102% and B:C ratio increased from 1.21 to 1.41 (increase of 17%).Intercropping of groundnut (K-6) with redgram (BRG-2) and cowpea (C-152) increased GPE from 577 to 783 per ha . The GPE increased by 36%, gross returns increased from Rs. 17,306 per ha (with local cultivars) to Rs. 23,493 per ha (improved cultivars), which is an increase of 36%. Net returns increased by 85% (Rs. 10,596 ha^{-1}) with improved cultivars over local cultivars (Rs. 5,736 ha^{-1}). The B:C ratio by cultivation of improved cultivars was 1.79 (an increase of 21%) over a B:C ratio of 1.48 with local cultivars (Table 21).

Table 21: Groundnut pod equivalent and economics of groundnut, redgram and cowpea intercropping

Particulars	Groundnut pod equivalent	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B.C Ratio
Groundnut + Redgram + Cowpea intercropping					
Farmers practice Groundnut + Redgram + Cowpea (Local)	461	11305	13830	2525	1.21
Improved practice Groundnut (TMV-2) + Redgram (BRG-2) + Cowpea (C152)	587 (27%)	12491	17597 (27%)	5106 (102%)	1.41 (17%)
LSD at 5%	98	--	2955	2473	0.19
Groundnut + Redgram + Cowpea intercropping					
Farmers practice Groundnut + Redgram + Cowpea (Local)	577	11570	17306	5736	1.48
Improved practice Groundnut (K6) + Redgram (BRG-2) + Cowpea (C152)	783 (36%)	12895	23493 (36%)	10596 (85%)	1.79 (21%)
LSD at 5%	132	--	3953	3419	0.21

Plate 22: Intercropping of groundnut, redgram and cowpea during *kharif* 2010

Performance of improved cultivar of maize

It was estimated that the average productivity of maize in the watershed was about 3.5 to 4.0 t ha^{-1} with the cultivation of seeds of different cultivars currently available in the local market. Interventions were carried out to improve the productivity of irrigated crops by

providing seeds of improved cultivars recently released. Three farmers were selected and supplied with Super 900M Gold as an improved hybrid for evaluation in farmers' fields under irrigated conditions. The performance of improved maize hybrid (Super 900M Gold) as compared to the existing cultivated maize hybrid (CP828) increased the grain yield which varied from 39% to 68% with an overall average increase of 49% (Table 22).

Table 22: Performance of improved cultivar of maize

Farmers	Grain yield (t ha^{-1})		Per cent increase
	Super 900M Gold (Improved)	CP 828 (Control)	
I	6.00	3.57	68
II	5.00	3.60	39
III	5.50	3.90	41
Mean	5.50	3.69	49

Plate 23: Introduction of improved maize hybrid Super 900M Gold under irrigated conditions

B.6. Construction of recharge filter

Unusually high and intense rainfall events along with the absence of suitable soil and water conservation measures often lead to high run off, which moves in natural drainage channels and exits the watershed. This hydrological behavior provides no benefits to the stake holders either directly nor does it lead to the augmentation of ground water. As is common in most parts of semi-arid India ground water level in the watershed is low.

Uncontrolled exploitation has also led to rapid decline in ground water tables. There is an urgent need to dispose off runoff water safely and also augment ground water availability through artificial recharge.

As part of project activities, suitable sites for installing recharge filter were identified along with dried up open wells. Since rainfall in the watershed is low, the only opportunity available to harvest runoff water was to carefully channelize the flow of runoff into recharge filter and allow the water to fall into the open dried up well. In this direction 3 dried open wells located nearby natural waterway was identified and recharge filter was constructed in the waterways. Recharge filters and dried open wells are connected through 3" diameter PVC pipe in the fields of willing farmers.

Recharge filter of size, 5m width and 5m length 1.5m depth was constructed at the end of a *nala* course just along the side of an open well.. The recharge filter was filled from the bottom to a depth of 0.6m with 20-40mm size jelly, next layer of 0.6m depth with 15-20 mm size jelly and top 0.3m should be filled up with coarse sand. A PVC pipe 3" diameter was installed in the bottom of the filter and connected to open well in order to carry the water from the filter directly into the well. Coconut/jute thread was provided at the entry point of the pipe in the recharge pit to prevent choking of the pipe with debris and coarse sand (Plate 23). During a single storm event on 19th April 2012 rainfall of 92 mm was received in just 2½ hours and water moved rapidly in the deepened channels and was drained safely into the well, through the recharge filter. A water level of 3m was recorded in the well after 4 to 6 hours after the rainfall event.

Plate 24: Views of the channel leading to a recharge filter pit and open well in which surplus water is safely diverted.

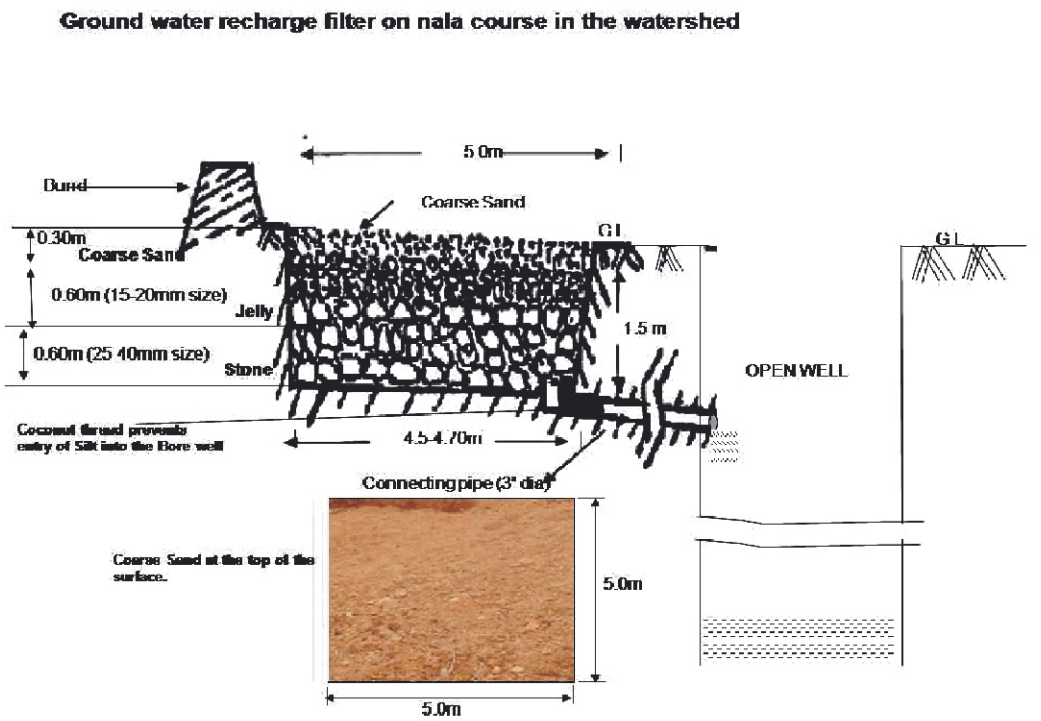


Fig. 7: A schematic diagram of a recharge filter made in the watershed

C. LIVESTOCK DEVELOPMENT

C1. Animal Health Camp

Livestock plays an important role in the sustainable livelihood of poor people of rain-fed agro-ecosystem, because of inherent risk involved in the crop farming due to uncertainty of rainfall and occurrence of recurrent droughts. They provide income and increased economic stability, and often the most important "cash crops" in small-scale mixed farming systems. Hence, livestock should be integrated as an active component in all watershed development programmes because watershed projects have the potential to improve livestock services and opportunities to the farmers and this can be best achieved through proper integration of breeding, feeding and health measures into the programme activities.

Overall, about 63% households in the watershed own at least one species of livestock and sheep and goat accounted substantial percentage of total livestock holding by numbers at both watershed villages. However, inadequate availability and poor quality of feed and fodder; high incidence of diseases; and inadequate knowledge on appropriate management of livestock in the watershed posed as the major problems facing smallholder farmers. As a part of the programme animal health and vaccination camps were organized in five occasions during 2008-2012, in the watershed villages. Around 1032 heads of cattle and buffalo as well as 7239 heads of small ruminants (sheep & goat) were treated and vaccinated against various seasonal/ chronic ailments. Artificial insemination for cows and buffalo and castration of bulls were also carried out during the event. In addition, feed supplements (by-pass protein feed, salt licks, mineral tablets, etc.) also distributed among the farmers for improving the health and productivity of livestock.

Animal health camps created awareness among farmers regarding the adoption of better livestock practices like supplementation of mineral mixture in the feed, proper watering and housing of animals, etc. They reported that disease incidence in livestock reduced considerably in the watershed and productivity of milch animals increased due to feed supplementation. Through interaction, many farmers realized that integration of livestock and fodder production within their limited land and water resources can provide a better livelihood option in dry lands.

Plate 25: Animal health camps organized at the watershed

C2. Introduction of pond pisciculture

Large scale desiltation activity has been taken up in order to create additional water storage in the watershed where existing tank/pond located to facilitate pisci-culture activity and more water availability for irrigation purposes. Fish fingerlings of *Rohu, Catla,* and *Common Carp etc)* were obtained from the state fisheries department and introduced in 11 ponds of willing farmers. The selected farmers were provided with a technical manual in the local language to maintain healthy fishes by feeding them their preferred diet at regular interval, which in turn help the farmers in creating additional income. The total cost of this intervention was Rs15000/- which was met out of project funds. However, due to continued dry spell and absence of rain, water from bore wells was used for irrigation of crops and little water was available for rearing of fish leading to high mortality. Fish eating birds like the common egret also consumed many fishes. This trial indicated clearly that while pisci-culture has potential in the region, assured water supply for fish all through the year is a major constraint.

Plate 26: Introduction of fingerlings in a newly excavated pond

D TRAINING AND EXTENSION

D.1. Exposure visits

The domain of knowledge and its development in an individual are directly proportionate to the level of exposure. Hence, more a person exposes himself to various activities of his interests more will be his understanding of that subject. In a study conducted by one of the authors of this bulletin, confirm that study tours was considered by most farmers as the most efficient extension method for transfer of technologies. So, in the watershed plan, exposure visits were kept as an important activity in order to expose stake holders to new and improved production technologies and alternate sources of livelihood.

In the first two years (2008 and 2009), two exposure visits (25-26 December 2008) and (19-20 February 2009) were organized for watershed farmers. Farmers of the two villages were taken to the Dharwad centre of IGFRI (ICAR) and University of Agricultural Sciences in Dharwad and a field extension centre of a Bhartiya Agro-Industries Foundation (a leading NGO of the region). During these tours, farmers were exposed to production of fodder for livestock rearing, improved crop production technologies, cultivars and farm machinery. The tour was arranged in order to create awareness among the stakeholders to enhance income from dry land agriculture. The tour were very effective in creating interest and there was a demand for more such tours.

Another exposure visit comprising of 20 farmers of the watershed who practiced dryland horticulture and were keen to further improve the production of fruit trees and also develop silvi-pastoral systems in their holdings were taken to Bangalore, Mysore and Kolar during 27 – 31st January, 2011. Information of various technologies such as cultivation and nursery management of medicinal and aromatic plants, extraction of essential oils, management of orchards and maintenance of vermin-compost units were provided to the group at University of Agricultural Sciences, Bangalore. At IIHR (ICAR) the group was informed about the recent advancement in the production of fruit crops, hybrid vegetables, floriculture and also home scale preparation of jam, juice, pickles, dehydrated onions, etc. A young progressive farmer Mr. Manjunath, near Kolar shared his experiences with the farmer's group on the production of mango grafts and profitability of nursery business, advantages of drip system in mango orchard, intercropping of hybrid tomato, capsicum and mulberry for sericulture in the mango

orchards, advantages of raising of grasses on the bund under drip irrigation and cultivation of hybrid napier under drip system. Sri. Borayya, a progressive farmer for Konasagara, learnt the details of tomato cultivation explained by Mr. Manjunath and emulated the same in his field and was able to obtain higher yields and profit.

Plate 27: Exposure visits of watershed beneficiaries to different locations

During 09-12, August, 2011, another visit was arranged for a group of selected farmers from the watershed. The visit covered places like BIRD-K (a NGO) at Tiptur, KVK at Suttur near Mysore, GKVK campus at UAS, Bangalore, IIHR, Bangalore and KVK at Hirehalli, Tumkur. Famers were exposed various subjects including, vermin-compost preparation and management, nursery management of horticulture crops, bio-control measures in crop cultivation, growing crops under poly-house condition, different soil and water conservation measures, drought tolerant varieties and farm machinery suitable for dry land tracts, conservation practices in vegetable and fruit tree cultivation, various micro- nutrient manures necessary for growth of different crops, etc.

D2. Farmers training

Training is one of the most important methods of extension as far as transfer of technology is concerned. It helps in building the human resource through appropriate skill and knowledge development. Especially in case of agriculture, farmers need to be empowered by involving them in appropriate training programmes.

- A Training Programme on "Participatory Collection of Soil Sample" was organized on 29-11-2007.
- Around 200 participants (PRI members, NGO (GUARD) staff, SHG members, Farmers etc) participated in the programme.
- A two days training programme on "Introductory cum Resource Appraisal of the project" was organized for 40 selected farmers from the Netranahalli and Konasagara villages of the watershed on 5th and 6th December 2007 in order to further disseminate the importance of project and benefits to the watershed farmers.

Plate 28: Classroom training programmes of farmers being conducted.

Two training programmes for farmers were conducted on 10-11 and 25-26 March 2011 at Central Soil and Water conservation Research and Training Institute, Research Centre, Bellary. Twenty farmers from Netranahalli and Konasagara villages attended in each programme. They were explained about watershed activities that were taken up and to be taken up, apart from importance of maintenance of the soil conservation measures as a part of watershed management. Three video films on bee keeping, dryland horticulture and water harvesting were shown to the farmers.

D3. *Kisaan Goshties*

Kisaan ghosties are important for a watershed programme not only to disseminate the knowledge but also to receive feedback from farmers for improved implementation of the programme. In general, during these programmes, subject matter experts, within the implementing agencies or from outside are invited to share their knowledge on any recently popular improved technologies or methodologies along with the farmers. Farmers are encouraged to actively participate in the programme and receive the first hand knowledge about the technology. Especially, in a watershed projects *kisaan ghosties* play a major role as the very nature of the project demands multi-level interventions of various technological inputs.

In this project also, efforts were taken at every stage to conduct a *kisaan ghostie* for the benefit of farmers. On the inauguration day of the watershed project (29-11-2007) a *kisaan ghostie* was conducted involving farmers of the watershed, NGO staff, watershed committee members, scientists and technical staff of the research centre. The main objective of the programme was to bring awareness among the farmers about the various aspects of the watershed and its benefits.On 28-06-08, a *kisaan ghostie* on ground nut (improved varieties) demonstration was conducted at Konasagara. Sr. Scientist (Agronomy) and Scientist (Ag.Extension) and Technical officer (Agronomy) explained the farmers about different varieties of ground nut and their usages. After discussions with farmers, around 35 farmers were selected for demonstration and distribution of seeds. On18th January, 2011 one more *kisaan ghostie* was organized for the farmers of Netranahalli and Konasagar villages. The following decisions were taken after thorough discussions with farmers:

- *Bunding* work will be done with manual labour and by a JCB machine.

- Development of horticulture in irrigated fields, afforestation and sericulture will be done for willing farmers, as per prevailing norms. Suitability of site would be ascertained by the project team.
- De-siltation of tank and construction of one recharge filter would be done using JCB.
- Crop demonstration would be considered as per fund availability.
- Animal health camp, *kisaan ghostie*, two training programmes and two exposure visits and one *kisaan mela* would be conducted within 2-3 months.
- Stone removal in dry lands cannot be done as it is not an approved item in the DPR.
- Additional check dams cannot be made since no funds are available.However, gabion structures could be made wherever feasible.



Plate 29: Interaction with farmers during a *kisaan ghostie*

D4. *Kisaan Mela*

Kisan Melas are one of the basic and important methods of extension which act as a platform to interact with the farmer beneficiaries and also to exhibit the details of activities

that are carried out. Especially in case of watershed development programmes, they help in building the rapport among stakeholders and also in understanding their feedback about various interventions.

In the present watershed project also a *kisaan mela* was organized on 13th October 2011, at Konasagara village of the watershed. About 200 participants consisting of officers from government and non-government organizations and farmers participated. *Zilla* and *Taluk panchayat* presidents were the chief guests of the function. Technologies adopted in the watershed and their benefits were briefed by the scientists to the participants. Charts on interventions made under various sections were displayed.

Plate 30: *Kisaan mela* conducted at Netranahalli village

VIII. Employment generation in the watershed

Earlier experiences have indicated that that soil and water conservation programmes executed on a watershed basis are ideally suited for rural employment generation and there is a potential to dovetail land development and resource conservation activities in centrally sponsored schemes currently in operation all over the country. Different types of treatment activities were carried out in the watershed like soil and moisture conservation measures in agricultural lands, drainage line treatment, water resources development/ management, crop demonstration, horticultural plantations and afforestation works as per the needs and priorities of the watershed community and their technical feasibility. A total of 3623 and 2375 man days employment worth rupees 5.29 and 3.49 lakhs at the prevailing wage rates have been generated under different engineering works and plantation/afforestation works, respectively during 2009 to 2011 (up to 31st March, 20011). The magnitude of employment is significant; further, these activities will help in

generating recurring employment in the future when the trees would mature and yield fruits. Available literature suggests that not only temporary employment but regular employment opportunities in agriculture increased significantly during the post-intervention period. Hence, efforts should be made to develop a plan in future watershed programmes which aims for maximizing the total on-farm and off-farm employment by integration of various land-based and non-land-based measures in carrying out the watershed programmes.

Table 23: Casual employment generated through engineering measures over different years

Sl. No	Name of the work	Man days generated during the year			Total mandays generated (2009-2011)	Worth of man days generated* (Rs. in lakhs)
		2009	2010	2011		
1.	*Bunding*	1123	525	745	2393	3.50
2.	Waste weirs	362	306	232	900	1.31
3.	Revetments	77	23	55	155	0.23
4.	Gabion structures	-	90	-	90	0.13
5.	Other structures	85	-	-	85	0.12
	Total	1647	944	1032	3623	5.29

*@ Rs. 146 per day for un-skilled labour

Table 24: Employment generated through development of fruit orchards

Sl. No.	Particulars	Year		Total
		2010-11	2011-12	
1.	Area covered (ha)	10.9	34.4	45.3
2.	No. of pits excavated	1603	5524	7127
3.	Mandays utilized (nos.) (@ 3 pits per day of 1 cu m each)	534	1841	2375
4.	Average man days per ha generated (no.)	49	54	52
5.	Worth of employment generated per ha of fruit trees planted (Rs.)	7154	7884	
6.	Total worth of employment* (Rs. in lakhs)	0.78	2.71	3.49

*@Rs. 146 per day for un-skilled labour

SUMMARY

An integrated watershed development project was taken up in one of the most backward district districts of India that lies in the semi-arid parts of the Deccan. The Chitradurga district is drought prone and nine years out of eighteen were rainfall deficit.

The petal shaped watershed (480 ha) represents typical topographic features of the region with mildly sloping lands, rock outcrops, sparse vegetation and shallow gravelly soils. The Netranahalli watershed consists of two villages – Netranahalli and Konsagara with a population of 187 farm families. The annual rainfall is 417.3 mm, 80% of which is received in a short spell leading to high runoff and soil loss in the absence of any conservation measures. Demographically also the watershed is backward, with 90% of the farm families belonging to the marginalized sections of society and 70% of these are small and marginal farmers. Due to this, their risk bearing capacity is low, continues with traditional crop cultivation practices and is heavily dependent on livestock of poor quality for exigencies. The productivity of the production system is poor with a continuously degrading resource base and uncertain rainfall, forcing the inhabitants to lead a life of hardship and misery.

With generous funding from the MoRD under the TDET scheme, the project was officially launched in September 2007 and inaugurated in November 2007. The *gram panchayat* resolution of March 2008 highlighted the need for effective NRM practices to be executed with the willing participation of all beneficiaries. The resolution put forth the following requirements – field level *bunding*, introduction of improved crop cultivars, animal health care, de-siltation of water storage structures and investments in horticulture (fruit cultivation) for enhanced income security. Assessment of the natural resource base indicated that besides the frequent 'below average' occurrence of rainfall, soil fertility is also poor with low organic carbon status, available N and zinc. Bore well water has excess of HCO_3 and high sodium absorption ratio (SAR), including high Mg-Ca ratio (2.84) making the use of this water for irrigation undesirable in the long run.

As an entry point activity, an RCC mini-water tank was installed in village Netranahalli with a capacity of 2,000 litres which proved to be highly useful for inhabitants in its vicinity. Existing water storage structures (9 farm ponds) were de-silted and *nala* courses deepened to ensure free and rapid movement of water into these structures. By deepening of ponds and impounding area of a check dam, an additional water storage capacity of 4657 cu m was created at a cost of Rs.1.04 lakhs only. Drainage line treatments were carried out by

using wire re-enforced gabions to moderate flow from 152 ha moving into the main channel. As a consequence, stream bank erosion has become negligible and primary colonizing plant species have become established in the *nala* course. A recharge filter was constructed using standard designs, near a dried up open well at the end of a small *nala* to harvest free flowing water. Only one storm of 92 mm has occurred in which water has moved through the channel and filter into the well upto a depth of 3 m.

Field *bunding* was carried out over 220 ha using borrow pits and making bunds of 0.81 sq. m. cross section along with waste weirs for safe disposal of run off water. Similarly, existing bunds over an area of 30 ha were renovated to the same cross section. This cross section of bunds was observed to be stable even in high intensity storms with high EI_{30} values. At many locations these bunds were seeded with stylo (*Stylosanthes hamata*) for fodder production but germination was poor due to moisture stress. Seven farmers with irrigation facilities created fodder banks using fodder grasses like guinea grass, para grass and hybrid napier.

Since the soils are poor in organic matter and very little biomass is available for biomass recycling, twenty five vermi-compost pits were established and earthworms introduced. Farmers were also provided with hands on training to look after these units and using compost for fruit plants and crops. Drip irrigation set-up was established for five farmers for mulberry cultivation (Rs.50,000 per farmer) with water being obtained from bore wells in individual land holding.

An area of 50 ha has been developed under dryland horticulture using fruit plants of mango (Mallika, Baneshan and Alphanso), sapota (Cricket ball and Kalipatti), guava (Allahabad safeda), lime (Balaji), coconut (Tiptur tall) and tamarind (PKM1) and papaya (Sunrise solo). This activity has been done in a participatory mode with farmers sharing 20% cost of pitting and providing FYM, planting, staking and after care. Moisture stress due to limited irrigation water availability led to 50% mortality in coconut and 25% in other plants. Olericulture with limited irrigation facilities was profitable for cultivation of hybrid tomato, cabbage, cauliflower in an area of 0.5 acres each.

Groundnut, red gram, maize and sorghum are the major crops grown in the watershed but yields are low due to poor seed quality, poor inputs and uncertain rains. Yields of groundnut (0.3 to 0.4 q/ha) and maize (3 to 4 t/ha) are far below the state average but introduction of improved cultivars and improved farming practices dramatically increased

crop yields. Groundnut cultivars (TMV-2 and K-6) produced higher yields (126% more) over local cultivars, while intercropping of groundnut with cowpea (C 152) and redgram (BRG-2) also proved profitable with a 36% increase in groundnut pod equivalent (GPE) and a BC ratio of 1.79 (at 2011 prices) which is 21% higher than local cultivars. Introduction of maize hybrid (Super M Gold) increased yields by an average of 50% over the local variety and yields of 5.5 t/ha were recorded.

Animal husbandry is integrated with farming systems in the dry zones; sheep and goats account for a large share of the livestock population. Animal health and vaccination camps were organized for improvement of animal health and productivity. The camps were very successful and created awareness about improved livestock rearing practices. Pond-based pisciculture established in nine ponds, however, it did not prove successful due to water shortage and predation by birds.

Watershed projects create substantial casual employment within the project area itself and help to reduce migration of stakeholders in search of livelihood. During the project implementation phase, a total of 5998 man days were generated equalling wages worth Rs.8.78 lakhs (@ Rs.146/- per day), a bulk of which was created in *bunding* and horticulture activities.

Training, exposure visits, *kisaan ghoshties* and extension activities carried out in the project proved immensely helpful to the stakeholders since they were exposed to new technologies under real field situations at various locations in the region and which also provided them an opportunity to interact with other farmers. Informal meetings with implementing team and discussions on problems allowed for mid-term corrections in project activities especially in the field of crop production and diversification, horticulture and NRM activities. Gender issues and participation of women in many watershed activities were also discussed although the response from women in forming self help group has been muted.

LESSONS LEARNT

1. Participatory Rural Appraisal (PRA) should be carried out with active participation of all stakeholders with special focus on women and weaker sections of the society. The DPR should be prepared as per the actual needs of the beneficiaries identified through PRA and village meetings.
2. A consensus on NRM activities to be undertaken should be discussed in the meeting of the WDC and to be agreed upon by all stakeholders. This will ensure greater co-operation by the stakeholders at all stages of the programme.
3. Participatory soil and water sampling should be carried out in the beginning of the project and results should be made available to the stakeholders. Based on the results, soil health cards should be prepared for every land owner along with recommended fertilizer rates and management practices for different crops.
4. While ridge to valley approach is the norm, there must always be some flexibility in implementing land based activities, since there are always some stakeholders who adopt the "wait and watch approach" and then decide to allow these activities on their fields.
5. Creation of water resources is appreciable by the stakeholders but management strategies also have to be planned in the WDC meeting. Use of excavated silt by farmers for use in their fields should also be decided in the WDC meeting.
6. Field *bunding* with manual labour should be preferred since it provides casual employment and is more accurate. As far as possible, making boundaries and measurements should be done in the presence of the farmers concerned, in order to avoid disputes with adjoining land owners.
7. Marginal lands and community owned lands are best suited for development of grasslands or grazing lands, but a consensus on their management must be reached in the WDC meeting, before implementation.
8. De-silting of all existing water harvesting structures like ponds, village tanks, check dams, etc. and widening of natural waterways for safe disposal of runoff water should be emphasized.

9. The demand for fruit plants is always high in this region. In order to ensure that farmers involve themselves in this activity, they should be educated about the cultivation of fruit plants; water, nutrient, pest and disease management practices.
10. After successful seed demonstration of improved cultivars, it is pre-requisites that seed must be available at the nearest market or other assured sources of seed supply. The best and suitable varieties for the region can be multiplied by the farmers through 'seed village' concept.
11. Greater importance to be given to the ground water recharge and management; which can be promulgated through the construction of recharge filter, percolation ponds, etc.
12. Farmers need to be sensitized for using bio-fertilizer and steps need to be taken up for construction of more number of vermi-compost units under the watershed programme.
13. Livestock development has to be given greater importance and can be an integrated component of the watershed programmes in this region as livestock makes an important contribution to the survival of economically weaker sections of the society.
14. Liaisoning with state line departments and convergence should begin right at the beginning of the project and regularly followed up by inviting these departments during meetings, trainings, *kisaan goshties*, etc.
15. Appropriate provision for formation of SHGs/thrift groups, capacity building for alternate sources of livelihood, etc. needs to be incorporated in the DPR which would benefit weaker sections of the society.
16. SHG's linkages with banks, co-operative societies, market, etc. needs to be developed and strengthened. The benefit of these linkages would follow much after the withdrawal of project.
17. Exposure visits to the places within the same agro-ecological zone, soil types with similarities in cropping practices, climate, soils etc., so that interactions by the visiting farmers could be a learning experience. The visit should also cover organizations where skill development centres are functioning and farmers which can be useful for capacity building of stakeholders subsequently.
18. Recognition of entreprenuring farmers, farm women and successful SHGs in an appropriate forum is always a source of encouragement and should be done at the village level, with full justification and transparency.

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