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PRA Study for Resource Characterization in a Tribal Dominated Watershed

Gouranga Kar, Ashwani Kumar, R.Singh and A. Pal

WATER TECHNOLOGY CENTRE FOR EASTERN REGION
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Preface

The challenge before the rainfed rice farmers of eastern India is to transform rainfed farming into more sustainable and productive system through efficient use of existing natural resources that too on the basis of natural hydrological boundary. Watershed is defined as a natural hydrological entity that covers a specific expanse of land surface within whose boundaries the entire rainfall-runoff ultimately passes through a specifically defined stream. This calls for integrated and holistic management of natural resources by promoting effective in-situ water utilization, rainwater conservation for providing supplemental irrigation to second crops and proper residual soil moisture management on watershed basis. For effective watershed management, it is necessary to get the first hand information on the existing agro-ecology, land use pattern, cropping system, basic resources and production constraints of the region. In this regard, participatory rural appraisal (PRA) technique is useful to assess strength, resources and weakness of a society and ensures active participation of rural mass for effective watershed management.

Keeping the importance of above aspects in view, the present study was aimed at improving productivity of a tribal dominated watershed through better management of socio-economic and natural resources. We take this opportunity to extend our deep sense of gratitude and indebtedness to the Director General, ICAR and Secretary, DARE Dr. Mangala Rai, Deputy Director General (Natural Resources Management), Dr. J.S. Samra and Assistant Director General (IWM), ICAR, Dr. P.D. Sharma for their encouragement and guidance to carry out the study. The authors are extremely helpful to Department of Science and Technology, Govt. of India for providing fund to execute on-farm research work in the tribal dominated watershed. We are grateful to Director, WTCER and different programme leaders, scientists of WTCER, Bhubaneswar for providing laboratory facilities for soil and plant analysis.

AUTHORS

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1.0 INTRODUCTION

In the new millennium, watershed management has emerged as a new paradigm for planning, development and management of land, water and vegetation resources through development of efficient farming system with a focus on social and institutional aspects apart from bio-physical aspects. It necessitates the management of resources following bottom-up approach. Since majority of Indian farmers are resource poor with marginal and small economic holdings, it is very difficult to enhance the farm income and purchasing power unless crop based agriculture is supplemented by other farm enterprises like livestock production, fishery, duckery and horticulture etc. through integrated watershed management. Looking to the serious issues of water scarcity and food, nutrition, environmental security of the country, the present research work is planned for overall development of a tribal dominated watershed of Orissa (Bahasuni watershed, Dhenkanal).

In the present study, concerted efforts were made to study the problems and prospects of tribal farming system through research and social motivation for improving sustainability of the cropping system, conservation of natural water resources to augment food production and net income. In this regard, Participatory Rural Appraisal (**PRA**) study was useful to get the first hand information on the existing agro-ecology, land use pattern, cropping system, basic resources, management practices, productivity, trend and constraints analysis. The present study was carried out to assess the traditional tribal farming system, their social, economic and cultural attributes, available technologies and their gaps to reach potential yield.

The PRA study helped in appraising resources, strengths, weaknesses of a society and ensures active participation of the people for the successful translation of the findings of the research project. The PRA study also provided an opportunity to gain an insight and appreciation about the indigenous technologies of the farmers and the ways and means to build on them to generate appropriate technologies, through bottom-up research and development.

2.0 DATA RECORDING AND SURVEY PROCEDURE FOR PRA STUDY

The data recording and survey for participatory rural appraisal (PRA) study were carried out using 6 following important procedures.

(i) On the spot visualization: On different aspects of local resource base like crops and genotypes practiced, animal husbandry, fisheries etc.

(ii) Secondary data source from: (a) Deputy Director of Agriculture Office, Dhenkanal (b) Saptasajya Gram Panchayat (c) Meteorological observatory of Central Rubber Board Office, Dhenkanal

(iii) Semi-structural interview: In this method, a set of questions was prepared before hand while discussing with various organizations for collection of information. The questions arouse during course of discussion were also taken care of.

(iv) Key informants interview: The constraints, adoption gaps and problems related to agricultural development and water management were analyzed on the basis of key informants' information.

(v) Personal or group Interview: Information on daily routine, livelihood, preferential ranking were also collected through personal and group interviews.

(vi) Cartographic representation or mapping: The maps like agro-ecological map, social map, transect, technology map were drawn with the active participation and help of the tribal people to appraise the agro-ecological and social resources, social stratification, technology adoption in the watershed etc. in the watershed.

The water management and agricultural production constraints in the watershed were studied using Rank Based Quotient (RBQ) technique.

$$RBQ = \sum_{i=1}^{n} \frac{F_i(n+1-i)\times 100}{N \times n}$$

F_i = Frequency of key informants for the i^{th} rank

n = Number of rank

N = Number of key informants

3.0 BASIC INFORMATION ABOUT THE STUDY AREA

A tribal dominated watershed (Bahasuni) located in Dhenkanal district of Orissa, [longitude ($85^0 32'$ - $85^0 35'$) and latitude ($20^0 35'$ - $20^0 39'$)] was taken up as the study area. The area is part of Saptasajya hills of Dhenkanal district, Orissa and according to NARP (1979) classification, the area comes under the mid-central table land agro climatic zone of Orissa. The watershed is dominated by two tribal villages viz., Majhi Sahi and Bana Sahi with their typical tribal farming system. The zone is undulating and has folded topography, surrounded by hillocks. In general, the climate of the area is hot and sub-humid. The mean maximum

Photo 1 : Overview of the watershed in the IRS-P6 satellite imagery

temperature occurs in the month of May with the value being 46.2°C and the mean minimum temperature occurs in December with the value being 9.0°C and mean annual rainfall of the region is 1420 mm. The study watershed is mainly rainfed where, southwest monsoon normally breaks on 10th June. The dominant soil groups of the watershed are *Typic Haplaustalf* and *Rodulstalf*.

Total geographical area of two villages was 373 ha, out of which 60 and 40 ha were under gross cultivable area in Majhi Sahi and Bana Sahi, respectively (Table-1).

Table 1: Land Distribution Pattern

Distribution Pattern	Majhi Sahi (ha)	Bana Sahi (ha)
Gross Area	245	128
Gross Cultivated Area	60	40
Net Cultivated Area	35 [Low(4), Medium(8) Up(23)]	20 [Low(3), Medium(7) Up(10)]
Cultivable Waste	50	25
Social Forestry	10	8
Pasture Land	10	5
Natural Forest	105	50
Irrigated Land	4	3
Rainfed Land	56	22

The total number of holdings in the tribal study villages, are 75 (34 in Majhi Sahi and 41 in Bana Sahi) with 336 population. The PRA study under the report covers all 75 tribal families. All holdings belong to schedule tribe (Santala and Munda cast) who were migrated from different western districts of Orissa. Out of total population, 111 are male, 102 are female, and 123 are children of age below 12 years (male-64, female-59), with a sex ratio is around 1:1 (Fig 1). Most of the families belong to medium size holding (Fig 2).

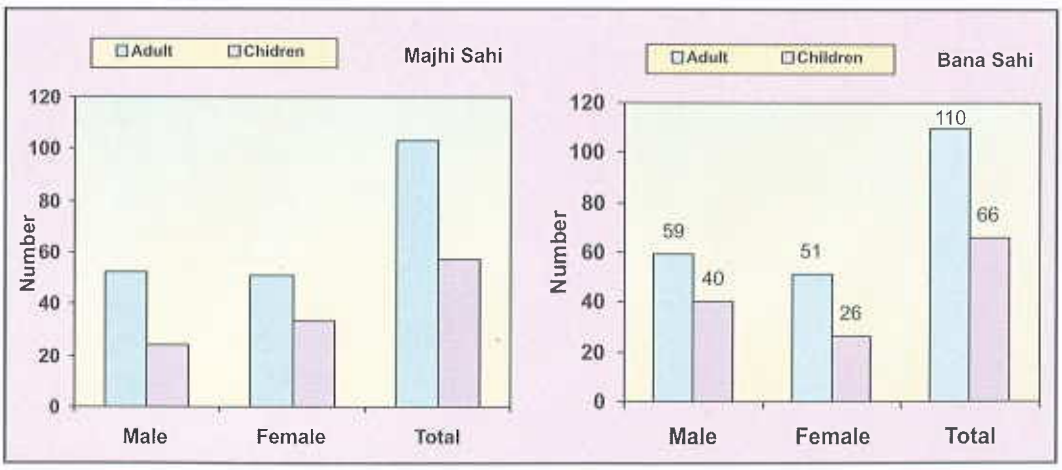

Fig 1: Population distribution in the village

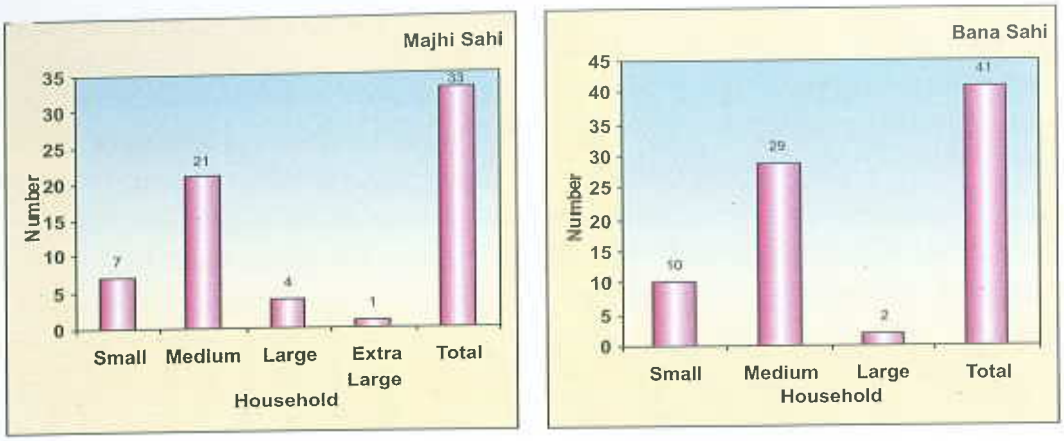

Fig 2: Household distribution in the village

Out of 74 farm families, 90% are either marginal/small farmers with an average holding size of less than 2 hectare of land and rest are large farmers (with >5 ha of land). Study reveals that, majority of farm families use their own traditional implements and don't use improved farm machineries and tractors.

Total 514 numbers of domestic animals (250 in Majhi Sahi and 264 in Bana Sahi) were available in two villages (96 milch cows, 33 buffaloes, 28 young stocks and 117 goats and 240 poultry birds) (Fig 3).

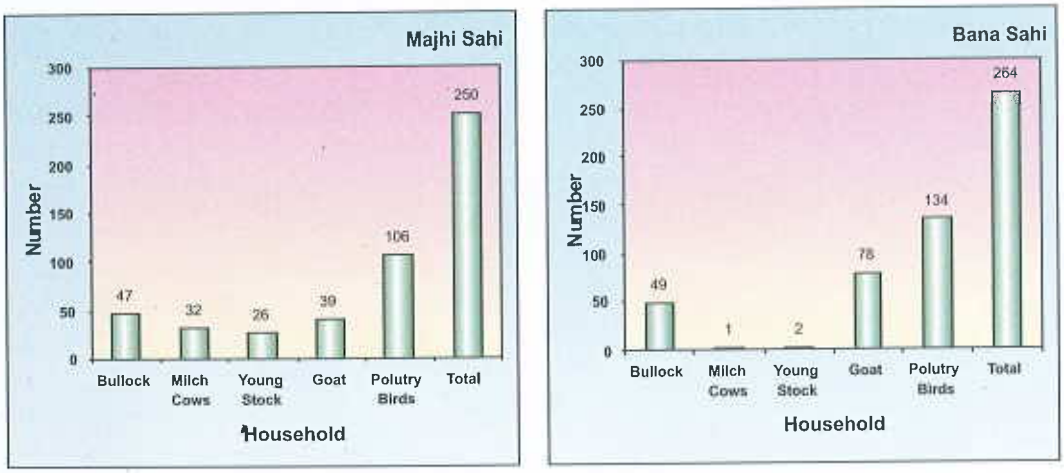

Fig 3: Livestock distribution in the village

The basic facilities in these two tribal villages, are very poor and for various activities they depend on different nearby institutions villages/towns. Important places of villagers with their distance from the study area are given in Table 2.

Table 2: Important places for villagers with their distance from the study area

Important Institutions	Where situated	Distance from Majhi Sahi (km)	Distance from Bana Sahi (km)	Year of Establishment
A. Social Institutions				
Anganwadi	Majhi Sahi	0	1	2001
Primary School	Bankual	3	2	1980
High School	Kankadahad	5	4	1970
College	Dhenkanal	15	14	-
Primary Health Centre	Beltikiri	25	24	-
Gram Panchayat	Saptasajya	5	5	1985
Temple	Saptasajya	5	1	-
Youth Club	Majhi Sahi	0	0	1986
Mahila Samiti	-	0	0	1986
Gramya Bank	Dhenkanal	13	12	-
Non-Government Organizations	Samajik Seva Sadan	13	13	1982
Recreational Facility	Nil	-	-	-
Local Committee	Nil	-	-	-
Nearest Market	Dhenkanal	15	14	-
Bus Stop	Kankadahad	5	4	1985
Post Office	Saptasajya	5	5	-
Court	Dhenkanal	13	12	-
B. Govt. Offices				
District Hospital	Dhenkanal	15	14	-
B.D.O. office	Dhenkanal	14	13	-
DRDO	Dhenkanal	10	9	-
Panchayat President	Sadeiberini	6	5	2001
Dist. Executive Engineer	Dhenkanal	12	11	-

4.0 TRANSECTS

Transects are observatory walks or tracks across the countryside and fields in any given area, village or watershed. It is helpful to assess the (a) physical features such as topography, hydrology, soil types, (b) locally evolved technologies and management systems which include

Photo 2 : Gathering in-formation while performing transect

traditional ITK (indigenous technical knowledge) that farmers have been using, (c) crops and agriculture where land use, cropping practices and patterns, productivity, net income are studied and (d) local vegetation which include not only prominent tree species in the area but also other local vegetation and its uses particularly medicinal plants and fodders. Three transects were made in the village from east to west and features spotted in Transects are presented in Table 3.

Table-3: Transects of Maji Sahi village

Item	Transect-I	Transect-II	Transect-III
Soil type	Lateritic acidic	Sandy clay	Clayloam and gravel
Land use	Upland crop cultivation	Pond and forest plantation	Reserve forest, crop
Crop	Paddy, tomato, drumstick	Paddy, vegetables	Paddy, Okra
Forest/plantation	Acacia, Teak, Rubber, Arjuna	Sal, Mahula, Jamua	Sal, Teak, Mahula, Eucalyplus
Irrigation source	Spring water from Sapta Sajya hill	Village pond water	Natural nalahs
Animals	Milch cows, bufflows, goat, poultry	Fish	Bear, Deer, wild pig
Problems identified	Low productivity acidic soils, No proper water conveyance system to collect spring water	Cross bund is to be repaired, Too much water creates water logging below the pond	Water scarcity
Opportunities for reserch and implementation	Tapping of spring water, preparing proper conveyance system, reclaimation of upland acid soils	Cross bund is to be strengthened, Existing village pond is to be renovated	Soil, water conservation measures are to be taken, Afforestation

5.0 SOCIAL MAP

The social map represents the social structure, social institution, neighbourhood pattern, occupation, religion, value system, etc. those exists in the villages. The social map of a representative tribal village (Majhi Sahi) under the study watershed (Bahasuni) is depicted in Fig. 4 and the social resources of the village are given in Table 4.

Photo 3 : Typical tribal house in the watershed

The study area has 75 tribal families with a total population of 336 and all of them belong to Scheduled Tribe (Santala and Munda). The people are assiduous, simple and hospitable. Most of the families are engaged in farming, and most of the cultivated lands are owned by marginal and small farmers. Houses are mostly thatched with mud wall and are situated along the village *kachha* road in Majhi Sahi village and the houses are placed in a scattered manner in other tribal village (Bana Sahi) of the watershed. Most of the houses have cattleyard in the front and small backyard. In the backyard some farmers are having open space to stack straw after paddy threshing. An anganwadi, a youth club, a Mahila Samiti, each in Majhi Sahi and Bana Sahi, are existing in the study watershed. Mostly nuclear family is prevalent in the village.

Photo 4 : Participation of tribal women of the watershed for preparing social map

Social values are expressed by peace and good health. There exists co-operation among the farmers in agricultural activities, in sharing labour and inputs. They have their relatives at nearby towns/and districts like Kamakhyanagar, Bhubaneswar, Cuttack, Anugul and Mayurbhanj etc. Political influence/ interference are not prevalent in these tribal villages of the study watershed.

The villagers perform their festivals, rituals, marriage ceremony, funeral and other functions with their own traditional tribal customs. But unlike other tribal people, they do not believe in the supernatural powers. A number of deities are worshiped by

them like, *Maranburu* (Siva), *Jaheray* (Devi), *Lita* (all nearby God), *Thakur & Dharma* (God of Forest). They worship *Majhihadam* in their households. All the rituals are perforemed at the starting of important agricultural operations like sowing, planting, harvesting the crops. Sometimes, they organize ceremony for village welfare on a common date, fixed by the village head-man in consultation with the village priest (*Gauntia*). They worship for safety against natural hazards, wild predators and poisonous reptiles and also to secure good harvest. They celebrate a number of festivals throughout the year with much of enthusiasm and excitement. The festivals observed by them are Makar (January), Magha puja (February), Holi (March), Raja (June), Asalia (July), Gamha (August), Nuakhai (October) etc. On the date of Makar Sankranti and Chaita Parab, tribal people go on a hunting expedition. They have their unique tribal, rhythmic dance and music which depicts their rich cultural heritage.

Photo 5 : Tribal village God which they worship

Photo 6 : A tribal farmer with traditional bow and arrow

Regarding type of marriage, love marriage is preferable to arrange marriage in the village. In their traditional marriage custom, groom has to provide at least some cloths, utensils, 2 cows, 1 hen, 12 kg rice and Rs. 21 to the bride's family.

Majority of the tribal farmers are uneducated or dropped from primary school. Recently, farmers are sending their children to high school (17 girls & 13 boy in Majhi Sahi and 5 girls & 10 boy in Bana Sahi). Three students are also studying at colleges (2 in Majhi Sahi and 1 in Bana Sahi). Only a lower primary school with a strength of 30 students are existing

Photo 7 : Tribal children of Majhisahi are in Anganwadi

Fig 4 : Social map of the village prepared by villagers

in Majisahi village of the watershed. Primary school is situated at Kankadahada (6 km), high school in Badagila and college at Dhenkanal.

Social evils like alcoholism, chewing of tobacco and smoking are highly prevalent in the village. The community media is mainly radio.

Major Social constraints

(i) There is no proper transportation facility from the watershed villages. In the rainy season, muddy road worsens the situation of transport.

(ii) There is no primary health care system in the area, though it is a malaria prone area.

(iii) No electricity connection is in the watershed villages.

iv) There is no facility for education, except a lower primary school is in Majhi Sahi, village

Photo 8 : Approach kachha road towards the watershed

6.0. RESOURCE MAP

The resources of the representative tribal village of the watershed are characterized through resource map and are depicted in Fig 5. It reveals that the watershed is mainly agrarian, surrounded by hillocks and forests. Bamboo, karanja, asana, kunguda, piasal, teak, eucalyptus and sal etc. are the major forest trees found in the watershed. Agriculture is the major sources of income of the villagers. Rice is the main crop in the *kharif* season. A small area is under vegetable cultivation during winter/*rabi* season,

Fig-5 : Resource map prepared by tribal farmers

Photo 9 : The village pond - only source of water for irrigation during winter (*rabi*) season

Photo 10 : Desi Cows are in grazing field

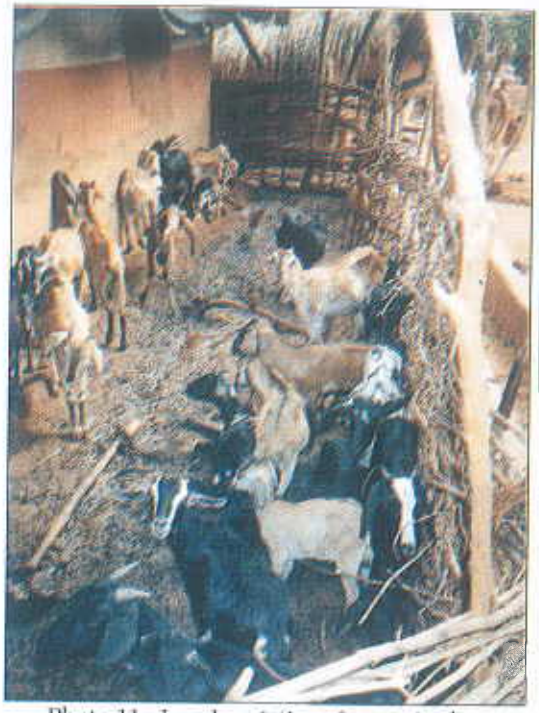

Photo 11 : Local varieties of goats in the backyard of tribal household

Photo 12 : Hand pumps in a tribal village

where irrigation facilities exist. Bullock cart and cycle are only means of transport and country plough is used for pulverizing soils. Apart from sickle and spade, equipment like sprayer, motor pump, winnower, paddy thresher, krushak Bandhu (KB) pump are also being used by 2-3 tribal farmers of the watershed. Main source of water for agriculture is rainfall in *kharif* and harvested water in the pond during *rabi* season. Fifteen (9 in Majhi Sahi and 6 in Bana Sahi) open wells (locally known as "Jeevan Dhara") and 2 hand pumps are also available for drinking purpose. There is no fertilizer and other agricultural input shops in these villages. All the livestock like cattle, goats and poultry are of deshi type.

7.0. AGROECOLOGY MAP

Agro-ecological map depicts the climatic and environmental conditions in relation to agricultural practices prevalent in the village. It helps in better understanding of the village topography, land use/land cover, soil type, variation of main climatic parameters, hydro-geomorphological features, irrigation system prevailing in the village, cattle tracts, dominant crops, trees, shrubs, weeds and any other agro-ecology related conditions of the village. The agro-ecology map of Majhi Sahi village of the study watershed is depicted in Fig. 6. The tribal farming system before the interventions of the WTCER has been presented in Table 4. Study reveals that climate of the study area is hot sub humid and according to the NARP (1979) classification it belongs to mid central table land zone of Orissa. The mean annual rainfall of the area is 1420 mm and 84% of the rainfall occurs due to southwest monsoon with the highest rainfall during July. Average number of rainy days are 73 in a year. The southwest monsoon normally onsets on 10th June, Rainfall statistics shows that coefficient of variability of

Photo 13 : Typical red laterite soils of upland part of the watershed

rainfall is very high (99-197%) during winter and low in the month of July (13.1%), followed by June (17.2%) and august (19.9%). The weather parameters of the study area is presented in Table 5 and runoff available for harvesting in the area are given in Table 6. Some of the soil physical and physico-chemical properties of the forest land, upland and lowlands are given in Table 7(a-c).

The agriculture is mostly rainfed and confined to Southwest Monsoon (June-September). Major crop in *kharif* (rainy season) is rice, occupying 90% of the total cultivated area. In winter season they grow vegetables, pulses in very small areas (3-4 ha) where irrigation facilities exist. The fruit plants like mango, papaya and

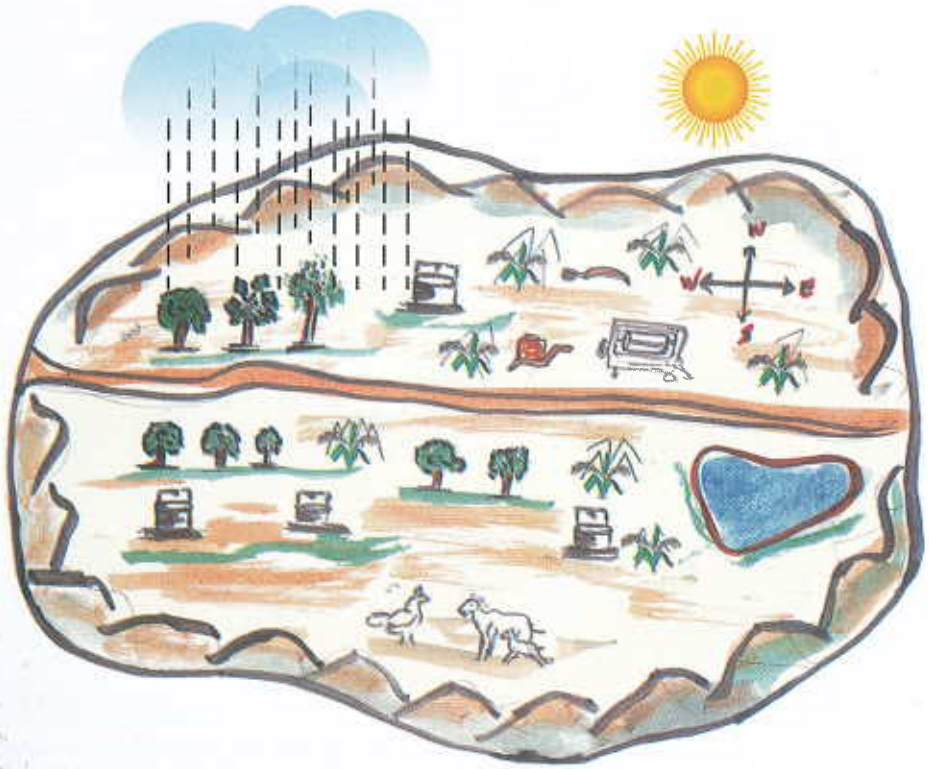

Fig 6 : Agro-ecology map prepared by tribal farmers

drumstick are available in their backyards. One tribal farmer of Maji Sahi village (Dularam Baske) has undertaken rubber plantation. Tribals of the study watershed use their traditional skills and utilize the indigenous implements like desi plough, sickles etc for their agricultural activities. Inorganic fertilizer application is at lower rate, farmers mostly depend on organic matter for crop cultivation. For controlling pest and diseases of crops, they use their own indigenous technological knowledge whereas, inorganic pesticide application is rare. After harvesting paddy, farmers dry it under the sun and stake in heap. For paddy threshing, farmers either use manually operated paddy thresher or they thresh the paddy by biting on a bamboo platform. Tribal farmers store the grains in a storage bin, prepared with paddy straw. The existing cropping pattern prior to starting of the project is presented in Table 4.

Photo 14 : Tribal women threshing paddy with the help of bamboo platform

Photo 15 : Lime concretion in some parts of the watershed

Table 4: List of head of farm families with their existing cropping pattern prior to starting of the project

Sl. No.	Name of the head of farm family (all belong to ST)	Age	Occu-pation	Crops till 2003 *Kharif*	Crops till 2003 *Rabi*	Plantations undertaken
VILLAGE - MAJHI SAHI						
1	Chaitanya Baske	52	Agri-culture	Paddy	Paddy & Tomato	Drumstick, Muguna, Mango, Bamboo
2	Durga Hembram	35	-do-	-do-	-do-	-do-

3	Madan Mardi	53	-do-	-do-	-do-	-do-
4	Ananta Baske	44	-do-	-do-	-do-	-do-
5	Karu Baske	65	-do-	-do-	-do-	Drumstick, Muguna, Mango, Bamboo
6	Rupai Baske	36	-do-	-do-	-do-	Muguna, Bamboo
7	Dularam Baske	48	-do-	-do-	-do-	Rubber, Drumstick, Mango, Bamboo
8	Durga Hansda	35	-do-	-do-	-do-	Drumstick, Muguna, Mango, Bamboo
9	Shaun Hansda	40	-do-	-do-	-do-	-do-
10	Rama Tudu	28	-do-	-do-	-do-	-do-
11	Gurubari Muduya	35	-do-	-do-	-do-	-do-
12	Sarkar Munda	55	-do-	-do-	-do-	-do-
13	Pitha Mandri	45	-do-	-do-	-do-	-do-
14	Jatia Hembram	45	-do-	-do-	-do-	Muguna, Mango
15	Budhan Hembram	51	-do-	-do-	-do-	-do-
16	Rama Hembram	50	-do-	-do-	-do-	Drumstick, Muguna, Mango, Bamboo
17	Pareshlal Tudu	38	-do-	-do-	-do-	-do-
18	Saluk Kumar Tudu	40	-do-	-do-	-do-	-do-
19	Purmi Kudarda	50	-do-	-do-	-do-	-do-
20	Laxman Hansda	45	-do-	-do-	-do-	-do-
21	Bada Sunia Champaya	50	-do-	-do-	-do-	-do-
22	Bhanja Tudu	50	-do-	-do-	-do-	-do-
23	Shyam Sunder Tudu	30	-do-	-do-	-do-	-do-
24	Bhagban Murmu	48	-do-	-do-	-do-	Mango, Bamboo, Muguna
25	Mani Mardi (F)	38	-do-	-do-	-do-	-do-
26	Raghu Murmu	45	-do-	-do-	-do-	-do-
27	Chana Murmu	52	-do-	-do-	-do-	-do-
28	Heera Tudu (F)	60	-do-	-do-	-do-	-do-
29	Rani Besra (F)	60	Service	-do-	-do-	-do-
30	Fatu Tudu	70	Agri-culture	-do-	-do-	-do-

F = Female tribal farmer

31	Debendra Tudu	33	-do-	-do-	-do-	Drumstick, Muguna, Mango, Bamboo
32	Maha Tudu	50	-do-	-do-	-do-	-do-
33	Chhotray Tudu	45	-do-	-do-	-do-	-do-
34	Sidhu Mardi					
		VILLAGE - BANA SAHI				
35	Balaram Hansda	45	-do-	-do-	-do-	Drumstick, Muguna, Mango, Bamboo
36	Mrata Jamuda	55	-do-	-do-	-do-	-do-
37	Mutura Briluee	35	-do-	-do-	-do-	-do-
38	Dashmuth Hembram	60	-do-	-do-	-do-	-do-
39	Kailu Hansda	30	-do-	-do-	-do-	-do-
40	Shikendra Beruli	45	-do-	-do-	-do-	-do-
41	Salga Murmu (F)	30	-do-	-do-	-do-	-do-
42	Chandu Hembram	35	-do-	-do-	-do-	-do-
43	Maheswar Murmu	40	-do-	-do-	-do-	-do-
44	Bhoda Naguni	40	-do-	-do-	-do-	Drumstick,Bamboo
45	Brasha Murmu	50	-do-	-do-	-do-	-do-
46	Shantya Murmu	40	-do-	-do-	-do-	-do-
47	Jena Naguni	45	-do-	-do-	-do-	-do-
48	Saacharna Murmu	35	-do-	-do-	-do-	Drumstick, Muguna, Mango
49	Sarat Haiban	45	-do-	-do-	-do-	-do-
50	Mangal Nagari	35	-do-	-do-	-do-	-do-
51	Sama Mardi	60	-do-	-do-	-do-	-do-
52	Samu Mardi	50	-do-	-do-	-do-	-do-
53	Amina Pradhan	25	-do-	-do-	-do-	-do-
54	Bidyadhar Pradhan	60	-do-	-do-	-do-	-do-
55	Jarilula Kalu	60	-do-	-do-	-do-	-do-
56	Kamal Majhi	25	-do-	-do-	-do-	-do-
57	Laxman Hembram	50	-do-	-do-	-do-	-do-
58	Dubraj Mardi	60	-do-	-do-	-do-	Bamboo, Muguna, Mango,
59	Jhara Hembram	40	-do-	-do-	-do-	-do-
60	Goduram Murmu	50	-do-	-do-	-do-	-do-
61	Manshing Hembram	60	-do-	-do-	-do-	-do-
62	Laxmidhar Beruli	40	-do-	-do-	-do-	-do-
63	Bali Hembram (F)	50	-do-	-do-	-do-	Bamboo, Muguna

64	Rama Kisku	50	-do-	-do-	-do-	-do-
65	Chakradhar Sreeka	45	-do-	-do-	-do-	-do-
66	Jitendra Hansda	25	-do-	-do-	-do-	-do-
67	Bhugo Hembram	50	-do-	-do-	-do-	Drumstick, Muguna, forest sp.
68	Prabhat Hansda	65	-do-	-do-	-do-	-do-
69	Golakha Deuri	60	-do-	-do-	-do-	-do-
70	Gouranga Deuri	25	-do-	-do-	-do-	-do-
71	Shuree Hansda	35	-do-	-do-	-do-	-do-
72	Prabhakar Behera	48	-do-	-do-	-do-	-do-
73	Bikram Kandakuit	40	-do-	-do-	-do-	-do-
74	Degiri Behera	35	-do-	-do-	-do-	-do-
75	Champiya Murmu	45	-do-	-do-	-do-	-do-

Table 5 : Mean monthly major weather parameters of study area

Month	TMAX (°C)	TMIN (°C)	MH (%)	AH (%)	RET (mm)	Rain (mm)	Wind (km/hr)	Av.VP (mb)	Av.AP (mb)
January	30.9	9.7	75	47	3.5	15.5	4.8	14.05	999
February	36.5	10.0	70	38	4.6	17.2	5.8	14.3	997
March	38.7	12.7	66	33	6.1	25.4	6.6	15.3	994
April	44.6	20.6	64	34	7.8	37.5	8.1	19.7	991
May	46.2	21.5	65	39	8.7	64.8	9.6	24.3	986
June	42.0	23.6	73	60	6.7	263.6	9.3	24.3	986
July	35.7	24.6	82	77	4.7	369.1	8.2	30.05	985
August	38.0	23.4	83	79	4.6	281.6	7.2	30.05	985
September	33.6	23.4	83	77	3.7	220.6	6.3	29.9	988
October	33.8	18.6	80	67	4.4	93.6	5.5	25.7	994
November	32.2	11.5	74	53	3.6	25.2	4.5	18.2	998
December	29.4	9.0	73	48	3.3	4.5	5.0	14.4	1000

TMAX = Maximum temperature, TMIN= Minimum temperature, MH = Morning relative humidity, AH = Afternoon relative humidity, RET = Reference evapotranspiration, VP = Vapour pressure, AP = Atmospheric pressure

Table 6 : Runoff (mm) at different probability levels with actual runoff (mm)

Month	Runoff at probability (mm)				Actual runoff (mm) during study years			
	10%	25%	50%	75%	1999	2000	2001	2002
Jun	150	131	89	81	145	104	124	95
July	153	169	129	101	153	145	228	104
August	201	153	139	97	123	99	137	93
September	195	161	141	102	153	102	134	95
Total	699	614	498	381	432	451	625	387

Table 7(a) : Physical and physico-chemical properties of forest soils

Soil depth (cm)	EC (mmhos/ cm)	pH	Bulk density (g/cc)	Organic carbon (%)	Sand (%)	Silt (%)	Clay (%)
0-15	0.02	5.54	1.51	0.686	55.3	12.5	32.2
15-30	0.01	5.48	1.54	0.336	52.8	10.5	36.7
30-45	0.02	5.52	1.55	0.482	51.8	12.0	36.2
45-60	0.02	5.53	1.56	0.526	52.8	11.0	36.2
60-90	0.02	5.67	1.58	0.307	47.8	15.0	37.2
90-120	0.01	5.64	1.58	0.161	50.8	10.5	38.7

Table 7(b) : Physical and physico-chemical properties of upland rice soils

Soil depth (cm)	EC (mmhos/ cm)	pH	Bulk density (g/cc)	Organic carbon (%)	Sand (%)	Silt (%)	Clay (%)
0-15	0.02	5.02	1.39	0.365	65.4	8.9	25.7
15-30	0.02	5.10	1.42	0.453	66.4	9.4	24.2
30-45	0.02	5.09	1.46	0.307	65.4	7.9	26.7
45-60	0.02	5.07	1.48	0.027	62.4	9.9	27.7
60-90	0.01	5.35	1.50	0.073	61.4	9.4	29.2
90-120	0.01	5.37	1.52	0.307	59.4	13.4	26.7

Table 7(c) : Physical and physico-chemical properties of lowland rice soils

Soil depth (cm)	EC (mmhos/ cm)	pH	Bulk density (g/cc)	Organic carbon (%)	Sand (%)	Silt (%)	Clay (%)
0-15	0.07	8.24	1.52	0.086	70.4	7.9	21.7
15-30	0.06	8.30	1.54	0.292	71.4	4.4	24.2
30-45	0.07	8.30	1.54	0.350	60.4	10.9	28.7
45-60	0.08	7.98	1.56	0.453	61.4	7.9	30.7
60-90	0.08	8.22	1.58	0.310	71.4	5.9	22.7
90-120	0.08	8.18	1.58	0.292	70.4	7.9	21.7

8.0 INDIGENOUS TECHNOLOGICAL KNOWLEDGE (ITK)

Indigenous technological knowledge (ITK) is the knowledge that people in a given community have developed over time, and continue to develop it which is based on experience, often tested over long period of use, adopted to local culture and environment, dynamic and changing and lay emphasis on minimizing risks rather than maximizing profits. It covers various aspects of agriculture and allied activities such as soil, water and nutrient management, crop cultivation, plant protection, farm equipment, post harvest preservation, animal rearing and health care, animal products preservation and management, fisheries and fish preservations, weather forecasting etc. Some of the ITKs on various aspects of agriculture are studied in the tribal villages of watershed and are briefed below.

(A) Rainwater management in the watershed

(i) Use of cowdung, leaf litter in field to improve soil fertility and rainwater holding capacity of the soil.

(ii) Storing of rainwater in pond for providing supplementary irrigation during winter season.

(iii) Making of dykes/bunds around the field to retain water for paddy cultivation.

(B) Tillage and intercultural management in the watershed

(i) Use of country plough for land preparation and line sowing.

(ii) Farmers prefer leveling of land and pulverizing the soils with ladder.

(C) Crops and cropping system in the watershed

(i) Use of bullock cart/cycle for transport of agricultural inputs and outputs.

(iii) Growing of short duration crops to complete life cycle of the crop before withdrawal of monsoon and early return.

(iv) Crops shown in line give better yield.

(v) Country plough is used for line sowing to save labour.

(vi) Puddling is done with country plough and ladder for weed control.

Photo 16 : Local made sprayer for controlling pests

(D) Pest and disease management

(a) Agriculture

(i) Growing marigold as intercrop in tomato field to control disease in tomato.

Photo 17 : Growing of Tomato + marigold intercrops to reduce disease infestation

(ii) Use of cowdung ash for controlling pests in vegetable crops.

(iii) Early sowing of blackgram, green gram to avoid mosaic diseases.

(iv) Healthy seeds for better germination, good plant vigour and less disease.

(v) Use of scarecrow for frightening birds in crop fields.

(vi) Use of neem/sunflower/kusum oil cake with tomato/brinjal for improving fruit yield and with chilli to increase pungency.

(b) Livestock

(i) Feeding of salt, jaggery and 'tyhantitri' leaves for indigestion.

(ii) Application of hot water, *kochila* bark, karpur, coconut oil to control leg diseases of cow.

(iii) Use of lemon leaf juice for skin diseases.

(iv) 'Ganga seuli' and 'Nirmuli' leaves for cow fever.

(vi) Running of bullock into mud to control foot and mouth disease.

(c) Human being

(i) In case of Scorpion/ snake bite villagers cry like a peacock on the hill top to reduce the poison.

(ii) 'Bhuin neem' or 'patal garuda' are taken as remedy for stomatche.

(iii) 'Ganga seuli' leaves mixed with honey/ black piper are taken to control malaria.

(iv) 'Bisalyakarani' leaf is crushed and wrapped on the wounds for control bleeding.

(v) Applying natural extract from neem and karanja leaves for healing wounds.

(vi) In severe cold, tribals take juice of bark of arjun tree.

(E) **Post harvest**

(i) Paddy grain is mixed with neem leave powder for preventing store grain pest attack.

(ii) Use of paddy straw for preparation of storage bin for paddy grain storage (after drying the grain).

(iii) Seeds of chickpea and pigeonpea are stored with neem/begunia leave.

(v) Dhenki is used for dehusking paddy.

(vi) Drying and adding salt for fish storage.

Photo 18 : Local made storage bin of paddy

Photo 19 : Dhenki for dehusking paddy

(F) **Cattle feed and fodder management**

(i) Grazing in the nearby forest.

(ii) Grazing on rice stubble in the field-after harvesting rice.

(G) **Weather forecasting**

(i) Ants coming out of the hole or migrate with eggs in the mouth indicating heavy rain.

(ii) Blowing of wind in cloudy climate indicates no rain.

(iii) Movement of white cloud on the sky is an indication of no rain. Dark clouds, lightening are the indication of rain.

(iv) Very scorching sun in the forenoon and after during post-monsoon and monsoon season indicates rain in the evening.

(v) Deforestation or cleaning jungle is the main cause of drought.

(vi) If cows run aimlessly by raising their tail, it indicates possibility of earthquake.

9.0 TIME LINE

Time line is a chronological sequence of events that have taken place in a village or area. Those may pertain to the general history of the village, or to specific subjects or sectors such as health, education, agriculture, animal husbandry etc. The time line for different activities before starting the project was studied and results are presented in Table 7.

Table 7. Major events with their year of introduction in the village.

Events	Figure	Year (Majhi Sahi)	Year (Bana Sahi)
Bicycle introduced		1984	1986
Radio introduced		1985	1986
Diesel Pump introduced		1988	1989
Introduction of crops (other than Paddy), Forest products (Mahul, Tolo, & Char)		1989	1990
Use of chemical fertilizers		1990	1990
Use of chemical pesticides		1991	1991
Pond and well Construction		1988	1989
Tube-well Construction		1998	2001
Introduction of improved farm implements (Thresher, Weeder)		1999	-
Use of bio-fertilizers and bio-pesticides		2002	2002

10.0 TIME TREND

Time trend reflects the quantitative changes of particular activities or products over a period time. It represents the rate of progress and development in the rural area.

Study reveals that average paddy yield has been increased from 7.5 q/ha to 15 q/ha in the past 20 years. The school going children from the tribal villages of the watershed are in increasing trend. The area under upland rice is in decreasing trend, which indicates that farmers are adopting improved cropping system for yield stabilization and generating higher income.

11.0 WEALTH RANKING

Wealth ranking is carried out to study the perception of wealth differences and inequalities in community and to establish relative position of households in the community. Wealth ranking has been carried out with the help of local key informants based on some criteria like income, assets, employment etc. Study found that only one category of wealth classes exit in the village i.e. poor category and source of income is only agriculture. Each farmer is having the average cultivated area of about 1.6 ha, two or three desi cattle, two or three hens and few have local varieties of goats.

Photo 20 : Typical land size in the watershed

12.0 LIVELIHOOD ANALYSIS

Livelihood analysis is the study of income and expenditure of the farm families of the village. All are poor farmers depending mainly on agriculture for their livelihood. But their income from agriculture fails to feed them throughout the year. So to supplement their agricultural incomes, they migrate to nearby towns for wage earning in off-seasons. Tribal women also collect drywood from nearby forest for fuel purpose.

Photo 21 : Tribal women collect drywood from watershed forest

The various sources of income and major items of expenditure are of poor categories (Fig. 7). They earn mainly through agriculture (60%), labour wages during lean period (25%), sell of forest products (10%) and rest 5% from livestock. They spend most of their earning on food, household, purchasing agricultural inputs, cloths, house repairing. They also keep some share of income for festivals, education and medicine.

Photo 22 : Tribal women engaged in hoeing operation

It was found that on an average, each family has borrowed Rs. 5000/- from commercial banks (mostly ADB, an associate of SBI) for buying cows/buffaloes or for performing different agricultural operations.

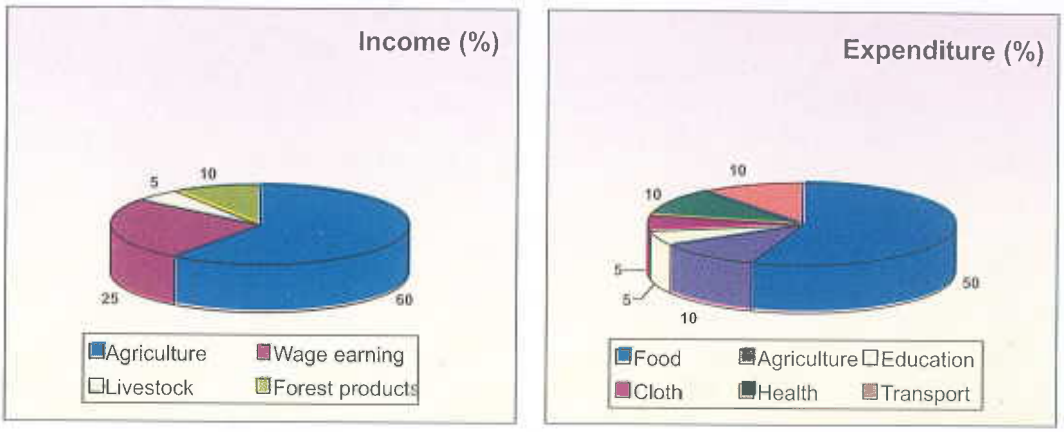

Fig 7 : Sources of income and expenditure (% of totoal)

13.0 VENN DIAGRAM ('Chapati' diagram)

The purpose of Venn diagram is to get the villagers perspective on the impact/ influence of local and outside institutions in a particular area.

A 'Venn diagram' of tribal villages (Majhi sahi and Bana sahi) of the study watershed is represented in Fig. 8, which shows relationships of various institutions, organizations, policy makers or individuals with each of the village as perceived by the villagers. Major organizations engaged for various activities in the village are Water Technology Centre for Eastern Region (W.T.C.E.R.), Bhubaneswar, Samajik Seva Sadan (NGO), Dhenkanal and Orissa University of Agriculture and Technology, Bhubaneswar. Presently, W.T.C.E.R. is working closely in two tribal villages of the

watershed for enhancing their income and improving their socio-economic status through agricultural diversification, development of alternate land and water resources for sustainable agriculture. The institute is also maintaining a cashew orchard in the village. The other institutes working directly ot indirectly in the watershed are BDO office, Dhenkanal, DRDO, Dhenkanal, Saptasajya vetenary hospital, Badagila market (Fig. 8).

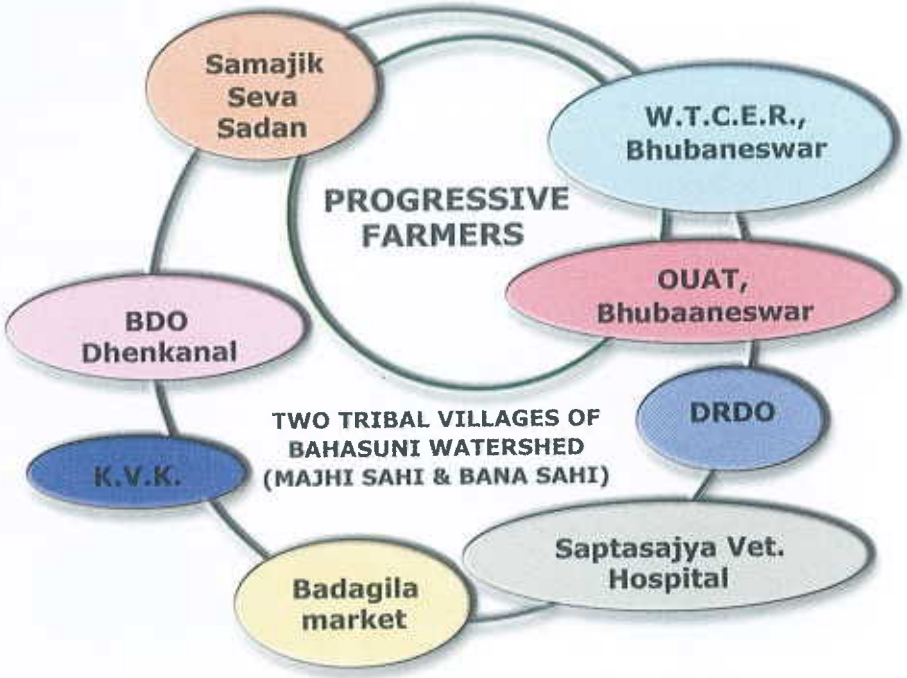

Fig 8 : Venn diagram of the study watershed

14.0 MOBILITY DIAGRAM

The mobility map depicts the movement of villagers for various activities and purpose like purchase of seeds and other agro-inputs, for labour wages, hospitals and marketing etc. The duration, mode of transportation, frequency and direction of movement are also indicated in the mobility map. The mobility map of Bahasuni watershed (mode of transportation and distance from the village) was prepared and is presented in Fig. 9 and Table 8.

As there is no infrastructure facility available in the area, they have to depend on the nearby area for their sustenance. They face an acute problem of transportation during rainy season due to the worst condition of the only katcha road, approaching to the watershed.

Table 8 : Distance and mode of transportation to different places.

Place	Distance form Majhi Sahi (km)	Distance from Bana Sahi (km)	Mode of transportation	Purpose	Frequency (per Week)
Dhenkanal	15	14	Cycle/Jeep/ Bus	Block, P.S., Bank, Major Marketing, College	Twice Daily
Kankadahad	5	4	Cycle/walking	Grocery, Rice mill	3 / 4 times
Bhapur	15	16	Cycle/Bus	College	Daily
Badagila	4	3	Cycle/walking	High School	Daily
Bankuala	3	2	Cycle/walking	Rice Mill, Market	Daily
Kapilash	17	16	Bus	School	Daily
Cuttack	60	59	Bus	Major Medical case	Seasonal

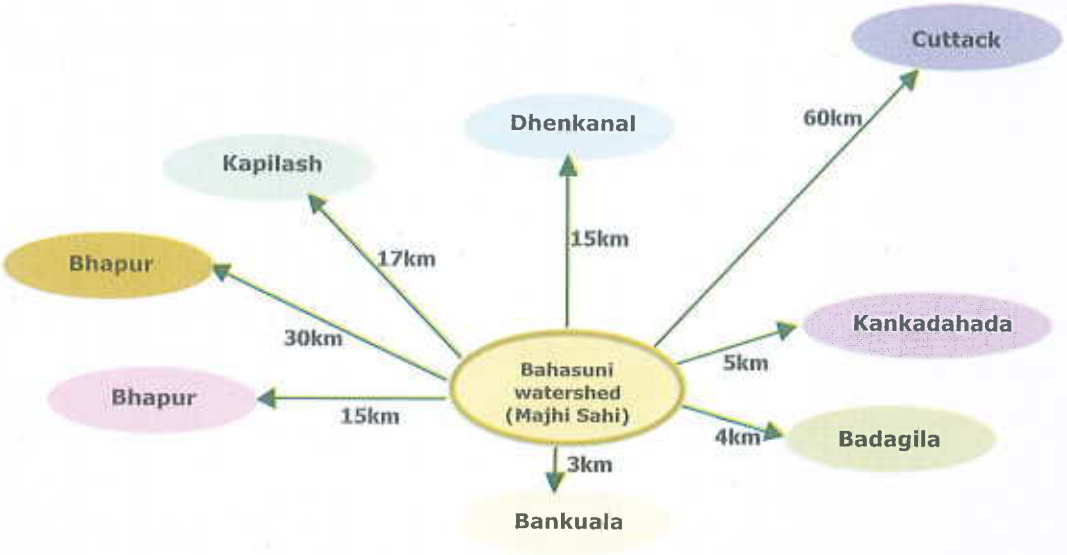

Fig 9 : Mobility diagram of Bahasuni watershed

They go nearby village Bankuala and Badagila for small marketing and purchase and Badagila for sale of livestock. For bank, panchayat work, they visit Saptasajya gram panchayat. For inputs purchasing, post office, grocery and high school, villagers go to Badagila. They visit district headquarter, Dhenkanal, for legal works, collector's

office, hospital, M/s. Sakti Sugar factory etc. For paddy dehusking, oil crushing they depend on nearby village 'Bankuala'. In the village, cycle or walking is the main mode of transportation. They avail bus, zeep facilities from 'Kankadahad' bus stop (5km). The nearest college is at Bhapur or Dhenkanal town, which are 15 km away from the watershed. For major medical treatments, they depend on Dhenkanal town or Cuttack city hospital.

15.0 SEASONAL ANALYSIS

Seasonal analysis is carried out to get insight into the seasonal variation of different activities in the area with respect to farming operations, rainfall occurrence, disease outbreak, labour migration, festive season, employment etc. Seasonal analysis for the study watershed is depicted in Fig 10, which are prepared on the basis of interview, group discussion using stones and sticks of various lengths.

Fig. 10: Seasonal analysis of different activities

Items	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Festivals	√		√			√		√		√	√	
Sowing And Transplanting Of Crops						√	√					√
Weeding	√							√				
Labour Shortage							√	√				
Rainfall						√	√	√	√			
Food Security							√	√				
Animal Disease							√				√	
Crop Pest Attack	√	√					√	√				
Loaning Period						√	√	√	√	√		
House Repairing			√	√	√							
Harvesting Of Crops				√				√		√	√	
Labour Migration				√	√							
Sowing Of *Rabi* Pulses, Relay Cropping										√	√	
Unemployment			√	√	√	√						
Stray Animals			√	√	√			√	√	√		
Water Scarcity	√	√	√	√	√	√						

The study indicates that main cropping season starts from June after a local festival 'Raja'. They celebrate 'Makar' festival in the month of January, when they assemble at a common place with new dresses and perform dance drama in a typical tribal fashion. During June and July farmers are busy in collecting inputs like seeds, fertilizers. Rain is mainly confined to southwest monsoon season i.e. from second week of June to last week of September. Weeding is confined to January (*rabi*) and July (*kharif*). Water scarcity is a major problem in the first half of the year. In July and August farmers are busy in rice land preparation and rice transplanting. During that time farmers face the problem of labour shortage. During January-February and July-August crop pest outbreaks. They sow *rabi* crops like horsegram, sesamum under rainfed condition during October-November and harvest the *Kharif* paddy during November-December. During April-May, no agricultural operation is performed and as a result desperate labour migration is observed. They also repair and colour their houses during March to May with the beautiful tribal painting. During March, April and May, they require financial assistance from moneylenders, banks and friends etc. Seasonal human diseases are common after withdrawal of monsoon (October). Foot and mouth disease of cow occurs during July-August at the time of transplanting of *kharif* rice. The festivals like Makar (January), Magha puja (February), Holi (March), Raja (June), Asalia (July), Gamha (August), Nuakhai (October) are celebrated by the tribes.

16.0 PREFERENTIAL RANKING

Villagers' preference and attitude towards a particular crop of interest have been revealed by this technique. It helps in understanding farmer's priorities of field crops, vegetables, fruit trees, animals etc. The villagers were asked to indicate their choice by putting stones to each crop or plants according to their preferences and the details of preferential ranking is given in Table 9 (a-d). Among sole upland field crops,

Table 9(a): Preferential ranking of upland field crops in study villages for more productivity

Crops	Food	Fodder	Market value	Dura-tion	Yield Cert-ainty	Produ-ctivity	Total Score
Rice (Vandana)	10	8	3	8	6	6	41
Groundnut	8	8	9	9	8	8	50
Rice + Arhar	8	7	7	6	6	7	41
Maize + Cowpea	8	8	8	6	8	7	45
Maize + Dioscoria	6	7	6	5	5	6	35
Groundnut+arhar	9	7	8	7	8	7	46

*Maximum score: 10. KI: Dularam Baske, Chaitanya Baske, Rama Kisku, Dubraj Hembram

Table 9(b): Preferential ranking of vegetable crops in the study watershed to increase productivity

Crops	Food	Fodder	Market value	Dura-tion	Yield Cert-ainty	Produ-ctivity	Total Score
Bean	9	6	8	8	8	9	48
Cowpea	6	7	5	8	7	8	41
Tomato	7	3	5	8	6	8	37
Okra	8	3	8	7	7	7	40
Cucumber	6	3	7	5	5	8	34
Pumpkin	6	3	7	7	6	7	36

*Maximum score: 10. KI: Madan Mardi, Sauna Hansda, Balaram Hansda, Samu Mardi

Table 9(c): Preferential ranking of fruit crops in the study watershed to increase productivity

Crops	Food	Seedling morta-lity	Market value	Dura-tion	Land use suiata-bility	Produ-ctivity	Total Score
Banana	9	6	8	8	9	9	49
papaya	8	5	7	8	7	6	41
Guava	6	5	5	4	5	5	30
Mango	8	6	8	5	7	6	40
Drumstick	8	5	6	6	8	8	41
Cashew	6	6	9	4	7	7	39
Sapota	6	5	8	5	5	4	33

*Maximum score: 10. KI: Rama Hembram, Durga Hansda, Rani Basra, Heera Tudu

Table 9(d): Preferential ranking of plantations in study watershed to increase productivity

Crops	Timber	Fuel	Market value	Land use suitability	Produ-ctivity	Total Score
Teak	10	8	9	6	9	42
Sal	9	6	8	6	7	36
Non-sal	7	6	7	8	6	34
Karanja	6	6	7	7	7	33
Mahua	2	6	7	8	8	31
Neem	6	6	7	6	6	31

*Maximum score: 10. KI: Fatu Tudu & Budhan Hembram, **Barsa Murmu & Maheswar Murmu

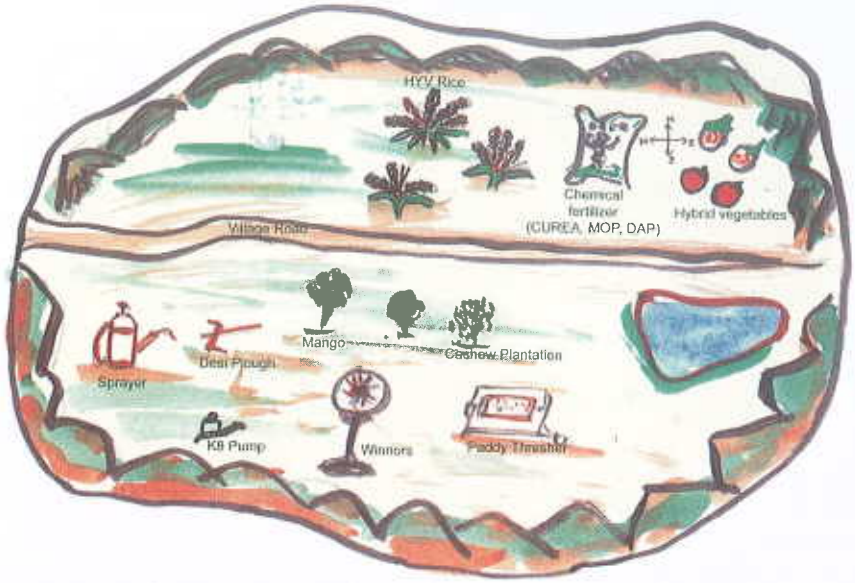

Fig 11 : Technology map of Majhisahi village as prepared by villagers

Photo 23 : A tribal farmer is standing nearby a Krishak Bandhu Pump

Photo 24 : Winnower for cleaning paddy grain

groundnut is the best preferred followed by groundnut+arhar and maize+cowpea intercropping. Groundnut is preferred most because of its market value, duration, productivity and yield certainty. The maximum score and key informants (KI) for studying preferencial ranking are also given in table 9. Among vegetables, maximum farmers perfer cowpea and okra. Among fruits banana is preferred the most, because of its land suitability and short duration.

Photo 25 : Paddy thresher is being introduced in the Majhisahi village

17.0 CONSEQUENCE DIAGRAM

Consequence diagram is a type of flow chart, which depicts the impact of any interventions in the village. The effects may be positive or negative. This diagram shows the impact point and linkages established as a result of impact.

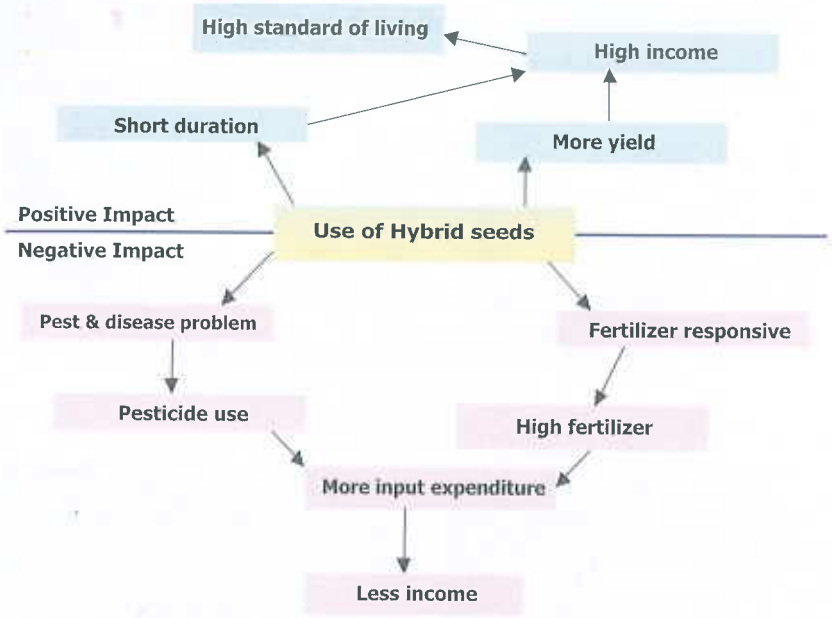

Fig 12(a): Consequence diagram (Agriculture)

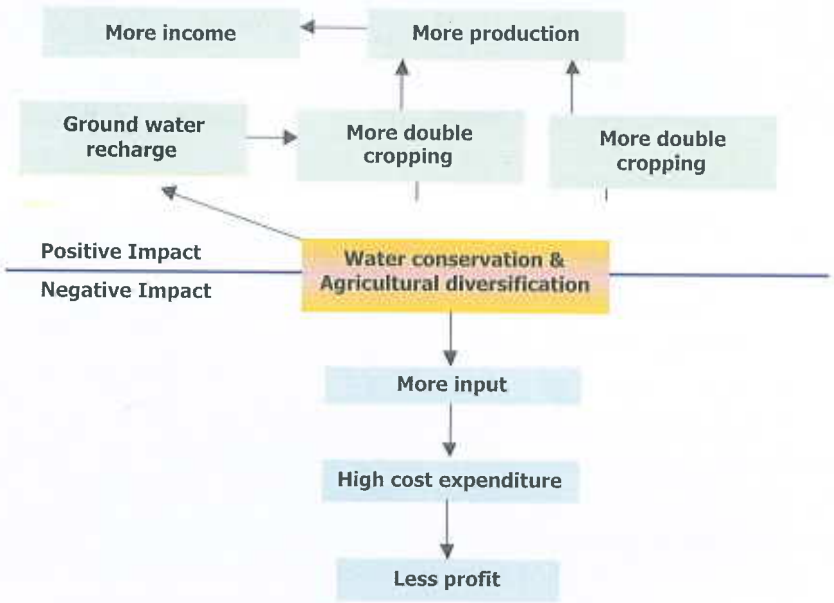

Fig 12(b): Consequence diagram (Water management)

The consequence diagram for use of hybrid seeds is shown in Fig 12 (a). The villagers feel that use of hybrid seeds of low water requiring, short duration vegetables will give more yield and return than that of paddy and as a result their standard of living will be improved. The negative impact may come in the form of high investment because of more fertilizers and pesticides use. The consequence digrame of water conservation is given in Fig 12(b). Water conservation will increse the cropping intensity of the area. On the other hand, more input will be required to adopt multiple cropping.

18.0 DAILY ROUTING DIAGRAM

Daily routine diagram depicts the different activities of rural people on daily basis. In the village daily routine differs according to the season. To get an idea about the daily routine of the inhabitants of the study area during the peak (*kharif*) season, the daily routine diagram was constructed (Fig 13).

During *Khairf* season the farmers are engaged mainly in their fields in sowing paddy, intercultural operations and weeding etc. during daytime and in the afternoon, they go to market for selling their products and to buy the grocery. In the evening they participate in some recreational activities or discuss important farm activities or

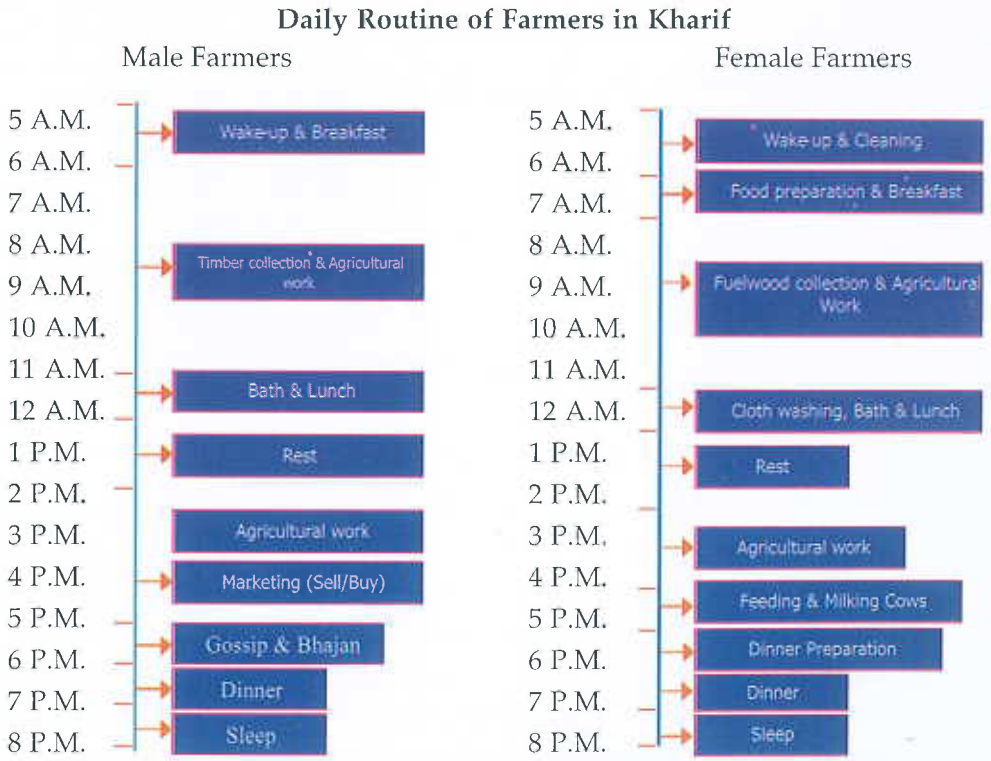

Fig 13 : Daily routine of the farmers in rainy season

community problem of the village. The women members assist them in different farm activities like treating grains with insect repellent, weeding, transplanting paddy, manuring, thinning plant population, post harvest operations (making heaps of harvested paddy, threshing, winnowing, drying and cleaning of grains, rice processing), feeding pets, preparing food for family, collection of fuel wood from nearest forest, and house maintenance. In summer, most of tribal farmers migrate to nearby towns for daily wages.

19.0 BIO-RESOURCE FLOW DIAGRAM

A tribal farmer, Mr. Dularam Baske (Age : 48 years) of the study watershed was selected for preparing bio-resource flow diagram. He has 4 acres of land under rice and 0.25 acre land under vegetable cultivation and 1 acre is under rubber plantation. He is getting 25 quintal of paddy (Rs.5000) and spends Rs. 3000/- towards cost of cultivation.

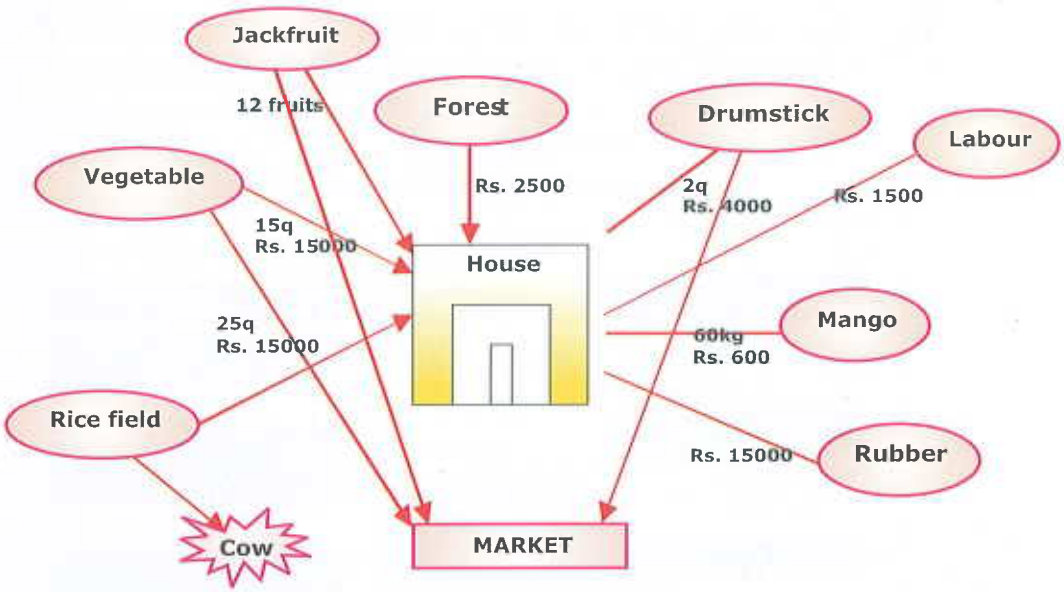

Fig 14 : resource flow diagram of a typical household of the village

The income from the rubber plantation is Rs. 15000 and he spends Rs. 1000 towards maintenance of the plantation. He has three deshi cows, yielding only 2 litres of milk/day. He is getting about Rs. 1500/month from labour wages. On an average he gets 2q drumstick (Rs. 4000) from trees grown in front of the house. He also has 5 hens, 3 calves. He gets Rs. 1500 from minor forest products. He also gains a profit of Rs. 6000 from vegetable cultivation with a investment of Rs. 3000. He gets 60 kg mango (Rs. 600) from the 2 trees and 12 fruits from a jackfruit tree. The bio-resources flow chart is shown in Fig. 14.

Photo 26: Farmers-Scientists intraction for RBQ study

20.0 PROBLEM IDENTIFICATION FOR RESEARCH PRIORITIZATION

The identity existing problems in the tribal dominated watershed, key informants of Majhisahi and Banasahi villages were asked to rank the problems of different categories. The Rank Based quotient (RBQ) was computed and based on RBQ values problems were prioritized. The results are presented in Table 10.

Table 10: Ranking of various agricultural problems based on RBQ

Sl. No.	Problems in Agriculture/	I	II	III	IV	V	VI	VII	VIII	IX	X	RBQ	Rank
01	Drought/ Erratic Rainfall	15	3	2	-	-	-	-	-	-	-	96.5	I
02	Non availability of harvested water for irrigation	12	5	2	1	-	-	-	-	-	-	94	II
03	Lack of knowledge about residual soil moisture utilization	1	2	-	2	-	-	8	3	2	2	44.5	VIII
04	No concept of multiple use of water	2	1	-	-	2	-	3	7	3	2	51	VI
05	Poor purchasing power	8	5	4	2	1	-	-	-	-	-	86.5	III
06	No soil & water conservation measures	3	2	-	-	1	2	-	4	6	2	45	VII
07	Non-synchronization of inputs	10	3	1	-	2	1	2	1	-	-	75.5	V
08	Stray and wild animals	-	-	-	-	-	-	2	1	1	3	8	X
09	Grazing Problem	-	-	-	-	-	-	1	1	-	4	12	IX
10	Lack of Farm Implements & Electricity	3	4	10	-	2	1	-	-	-	-	81.5	IV

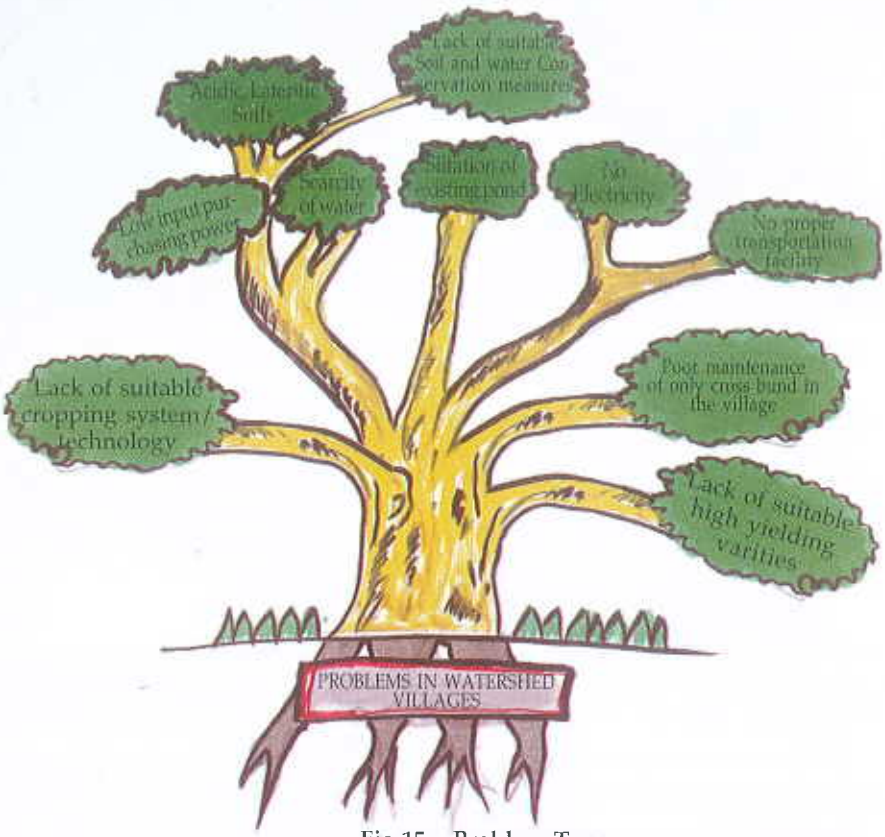

Fig 15 : Problem Tree

21.0 DEVELOPMENT OF ACTION PLAN FOR OVERALL DEVELOPMENT OF THE TRIBAL DOMINATED WATERSHED BASED ON PRA STUDY

(1) Replacement of rice in rainfed upland

The PRA study revealed that ninety five per cent of farmers of the selected watershed felt that rice cultivation in rainfed upland is risky. In rainfed upland, productivity of rice is very low (<1 t/ha) and unstable due to erratic rainfall, dry spells during growing season but farmers of the region grow rice traditionally on such land. The soils of upland rice area are also light textured with low water holding capacity, acidic and severe nutrient deficiencies, which results in low and unstable rice yield. Weeds are also important biological constraints for rainfed upland rice cultivation followed by diseases and pests. In-situ rainwater management and replacement of rice (crop diversification) with low water requiring crops (oilseeds, pulses, cereals) may be one of the options in the hands of farmers for drought/dry spell mitigation and to improve water productivity of the rainfed upland. Replacement of rice on such rainfed upland is also socio-economically feasible due to unstable productivity, farmers neither expect yield certainty nor depend for food security from such rice ecosystem. Growing of rice

on such rainfed upland after creating irrigation facilities is also not cost effective. Further, absence of ponded water in rainfed rice upland does broaden the scope of crop diversification.

Some of the profitable crops/cropping systems in rainfed upland are (i) Maize-sesamum/horsegram (ii) Groundnut+ pigeonpea (iii) Sole Groundnut (iv) Rice+pigeonpea (vi) Maize+cowpea (vii) Cucurbits (viii) Brinjal (ix) Amorphophalus (x) Bean

(2) In-situ rainwater management

In-situ rainwater management technology, which involves adoption of crops, varieties and cultural practices which make the best use of rainwater by low water requiring non-rice crops, adoption of methods that conserve in-situ soil moisture and make the best use of the stored soil moisture. To avoid waterlogging for non-rice crops during heavy downpour, ridge and furrow methods of sowing should be adopted for low water requiring crops. The same furrow can be utilized during low rainfall period for conserving in-situ soil moisture after closing their ends. On sloppy land, crop rows are to be made across the slope and excess water should be disposed off through grass waterways to avoid breaching of ridges. The excess runoff will be collected in farm ponds for supplemental irrigation.

(3) Rainwater harvesting and agricultural diversification

The study watershed receives 84% of annual rainfall (1000 – 2000 mm) during four southwest monsoon months (June to September), most of it is not accessed and lost as runoff. As a result, there exists a great scope to harvest excess rainwater of rainy season in water harvesting structure like pond and tank etc. and to utilize that during dry season (November-March) as supplemental irrigation for growing second crops after rice. The total water productivity can be enhanced through multiple use of harvested water or agricultural diversification (horticulture, crop husbandry, poultry, duckary, fisheries, apiculture etc.). Site-specific agricultural diversification through multiple use of water could be proved as effective means in mitigating drought because it provides opportunity to farmers to have a 'basket of complementary options' for reducing the weather risks. It also provides higher income, regular employment, balanced and quality food even with less water.

(4) Development of rice based improved and diversified farming system for enhancing overall wate rproductivity.

The development of improved rice based farming system like rice-fish-duck in lowland ecosystem will enhance overall water productivity of the ecosystem . The existing pond/tank should be utilized to collect runoff water during southwest monsoon season. These runoff water will be used in multiple ways such as supplemental irrigation to the *rabi* crops and during occurrence of dry spell to kharif crops, for rearing fish &

duck inside the pond, growing of short term horticultural crops like papaya, banana on the pond bund, spices like ginger, turmeric in shaded area of the bund. Creeper vegetables like bottle gourd, ridge gourd, pumpkin, Indian bean can be grown on sloppy part of pond.

(5) Employment opportunities and generating income in lean periods

To check the desperate labour migration from tribal villages of watershed, employment opportunities should be created through agro-based farming system in the villages. The effective rainwater utilization, agricultural diversification and residual soil moisture management will ensure double/triple cropping along with subsidiary animal husbandry practices in rainfed ecosystem, which will keep whole farm family busy for longer period, as a result desperate migration will be checked. Farmers can earn good amount of money in lean periods (August-September) through early sowing and harvest of short duration rice substituted crops in rainfed upland ecosystem such as from green cob of maize, groundnut. During that period farmers of the watershed face financial crisis. Better employment opportunities will have to be generated as a result of engagement of tribal people in soil and water conservation work, horti-plantation programmes, intensification in agriculture, agro-processing (vegetables, mushroom, cashew processing etc.), greater access to micro credit for soico-economic activities by self help group (SHGs) of women.

(6) Environmental security

In-situ rainwater management, water harvesting will help better recharge of soil profile, reduction of soil erosion, as a result bio-physical conditions of soils will be improved and environmental security will be enhanced through reduced degradation of natural resources. Alternative sustainable cropping system will reduce the use of fertilizers or pesticides as a result environmental pollution will be reduced. Effective soil and water conservation measure followed by agri-horticultural as well as plantation activities will qualitatively improve the ecology in a sustainable manner.

(7) Alternative sustainable land use system

Dry land horticultural crops, agro-forestry are one of the alternatives of drought mitigation which can be adopted in the study watershed. In addition to drought mitigation these will help to generate off-season employment, utilizes off-season rains, prevents degradation of soils and restores ecological balance. In the agro-forestry system crops like maize, cowpea can be compatible grown with tree species like *Albizzia lebbeck* (Sirsih) and *Gmelina arborea* (Gambhari). Crops like sesamum, groundnut, ragi can be profitably intercropped with Australian teak (*Acacia mangium*). Dry land horticultural crops like guava, custard apple, mango, jackfruit, pomegranate, aonla, karonda, tamarind, ber and cashewnut are suitable in the rainfed unbunded upland areas. The crops like maize, arhar, cowpea, niger are suitable to grow within these crops.

(8) Indigenous rainwater management for drought mitigation

Indigenous drought management practices refer to proven farmers practices developed over long period of time from the experiences of farmers themselves which can be effectively implemented to overcome drought. Some of the indigenous agronomic measures for rainwater management are contour farming, conservation tillage, mulch tillage, off-season tillage, dead furrow/shallow trenching. Proper mechanisms should be created to harvest the spring water from hill top of the watershed, which can be perrennial irrigation source for watershed villages.

(9) Integrated nutrient management

In the study watershed, deficit soil moisture and erratic rainfall are major constraints for sustainable agriculture. Under drought conditions combination of organic and inorganic fertilizer improves moisture retention capacity of soils. Due to limited soil moisture, application of fertilizer in furrows below the seed is recommended. Application of compost, farmyard manures and raising legumes add the organic matters to soils as well as increase the water holding capacity of soils. Introduction of legumes for grain, fodder or green manures through sole or intercropping will improve soil fertility and sustain soil physical health.

(10) Improvement of basic facilities in the watershed.

Presently, farmers of the tribal dominated watershed are facing acute problems because of the worst condition of the approach road. In the rainy season, it is very difficult to use the muddy road for any transportation. The government should take sufficient attention for preparing a good approach road towards watershed. Electriicty connection is also needed to remove the darkness from this tribal dominated watershed.

(11) Creation of family assets and common property resources

Since the land holding size is small, attention should be given for creation of family assets and common property resources. The community assets like fuel-wood plantation, silvi-plasture, community nurseries, model kitchen-cum-herbal gardens, smokeless chullhas etc. will meet the long-term needs of the farming community.

(12) Ensuring Social Equality in water distribution

To resolve social conflicts on the question of equitable distribution of water, it is recommended that "Water Users association" ,may be formed in the pattern and principles of Participatory Irrigation Management (PIM), in canal command areas.

(13) Social Upliftment

Self-help Groups, with the help of local-based women organizations can organize literacy campaigns and opened informal educational centers for the benefit of women and children. This will definitely reduce drop-out rates of girls in primary and high schools. For better education of tribal children, a primary school can be established. Awareness programme can be organized on conservation aspects of water and envi-

ronment. Public health security should be one of the concerns for development of this tribal dominated watershed. Particularly Tirple Polio Vaccination and BCG immunization programme, chlrorination of infected wells, distribution of smoke less chullahs to women, malaria eradication programme are important medical related activities which can be undertaken in the watershed.

(14) Inter-Institutional Co-ordination

The PRA study reveled that many organization are working in these tribal villages but close interaction between Government Departments, Research Institutions, Credit Institutions etc has to be established. Treatment of Forest lands, waste lands and Panchayat lands by the Forestry Department and Village Working Committee, raising community nursery with the help of Line Departments, dairy and animal health care with the help of Animal Husbandry Department and Financial Institutions are some of the good examples wherein inter-institutional coordination efforts can be made for successful implementation of any watershed development programme in the area.

(15) Long-term Sustainability Participatory Watershed Management

A comprehensive understanding of and relevance to the changes in environmental, economic, social and institutional paradigms relating to the participatory watershed development programme is necessary for long term sustainability of the watershed development project. Peoples' participation is the key to the success of any watershed development programme. The project should emphasize the participatory management, involvement of the local people right from the planning for smooth and successful implementation of the programme. Motivation is another aspect in getting response and the response depends upon the *modus operandi* in establishing rapport, convincing the community, appropriateness of the technology and reaching the farmer in his own language.

(16) Last but not the least a new era should be begin towards sustainable development of watershed by evolving a development plan with a high level of community participation utilizing scientific planning tools like remote sensing and geographic information system (GIS) to help the local people to build a sustainable future with their own hands.