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Participatory Agricultural Resource Mapping for Crop Planning and Enhancing Productivity of Rural Areas, Bastar Plateau, Chhattisgarh, India

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A B S T R A C T

Agriculture describes routine activities related with weather change; water is centre point of whole components whether it is used for agricultural or non-agricultural process. Classification of land resource is on the basis of farming situation *i.e.* upland (*Baadi, Tikra and Marhan*), midland (*Maal*) and lowland (*Gabhar*). Revenue map incorporated with survey map for delineating land resources of the village in which upland, midland and lowland were classified on the basis of slope and soil depth pertaining crop growing capability. Water bodies counting and measurement was done by individual visit of farmer's home to record the number and measuring dimension of water bodies (ponds, wells and bore wells) by tape. The PRA was an interactive process spreading over four months period with planning occurring on site. Based on soil survey data, soils of Tahkapal village were classified in to six series with maximum area (151.78 ha) under Marhan soils followed by Tikra (81.48 ha) and Gabhar (58.01 ha). The lowest area coverage was under *Baadi* (14.67 ha) but Maal had higher (34.41 ha) than that of *Baadi*. Among the techniques, farmers actively adopted improved varieties, direct seeded rice in place of transplanting, weed management, nutrient application with sowing in furrows. In offset of such huge quantity of rainfall; 39 wells and 24 ponds having capacity of 2276668.23 litres water could be stored into wells as much as 12198780.01 litres in ponds. Another side of in-situ water storing 17390900.02 litres through compartmental bunding. Midland (*Inceptisols)* had silt loam in texture, sub angular blocky in structure, 14.2% water holding capacity, 0.08 dSm^{-1} EC, whereas pH, available nitrogen, P_2O_5, and K_2O were 6.02, 156, 16 and 290 kg/ha respectively for midland and lowland. The nutrient status was improved in pH (6.5), available nitrogen (192.4 kg/ha), phosphorus (8.4 kg/ha), potash (212.4 kg/ha) along with Ca 5.6 c mol (+) kg^{-1} and Mg 4.3 c mol (+) kg^{-1}.

Introduction

The dynamic unit of social life is defined as village which includes many components in different livelihoods of daily routine life and impact longer on the society. Habitat of villages settles on hamlet and sliding side of the hamlet as sloppy elevated area of the village designated as *Baadi* system where little organic matter availability provide vegetable cultivation for self consumption and local market. Small mud houses are constructed thatching with paddy straw and locally available wood poles where they reside in small rooms. Agriculture describes routine activities related with weather change; water is centre point of whole components whether it is used for agricultural or non-agricultural process. Agriculture is integral part of village life and agriculturally supportive years show marked different than remaining non profitable years. It completely depends on available water which comes through rainfall and ground water although ground water is not involved in rainfed agriculture system as a result surface water is primarily available for cultivation. However, the amount of water received through rainfall and lost as runoff alongwith storage into soil profiles and structures describes water balanced of village which is also important in planning for crop fitting ideology, resource conservation and planning. Land use planning aims to encourage and assist land users in selecting options that increase their productivity, are sustainable and meet the needs of society (FAO, 1993).

Resource mapping of village is prime focus for extracting conclusion to plan and execute utilization of resources available with farmers. In this continuation resources concerning with agricultural practice were characterized based on farming situation and water and land resources in the village. Drainline delineation was done considering *Khasara* number and crop growing strategies of farmers. Although there has been considerable conceptual development addressing the nature of lands environment interaction. In contrast, farm diversification has been the subject of highly varying aspects. Farm diversification often occurs without state assistance; farm diversification therefore cannot be operationalised on the basis of scheme-based definitions, unless scheme uptake is the purpose of the study (Ilbery and Bowler, 1993). In India, land use planning at local level are governed by farmers own requirement and market prices (Velayutham *et al.,* 2001) rather than land suitability criteria (Ramamurthy *et al.,* 2000) which is followed in developed countries. Moreover suggested plans developed from soil survey and land capability assessments (Dhanorkar *et al.*, 2013), focuses upon the relationship between land use and its environmental compliance alone. The aim of PLUP is to strike a balance between technical approach and farmer's requirements to maintain natural resources in sustainable manner.

Village land resource is divided into upland, midland and lowland (Fig 1) as relief is varied throughout farming system, top hamlet provides habitat alongwith *Baadi* which is just next to habitat having higher organic matter than remaining farming situations mostly allocated for vegetables, cereals (Maize and Sorghum), *Hibiscus sabdariffa*, Beans, leafy vegetables etc., as moves down to low lying areas from habitat first encounters upland which is divided in part one as unbunded upland and second bunded uplands mostly prefers for upland rice (90- 100 days), small millets (finger millet, kodo millet and little millet), horsegram and urd which occupy considerable areas of the uplands; midlands are intermediate of upland and lowland characterized by compartmental bunding for rain water ponding and the ponding increases infiltration and supports rice crop during break of monsoon, this is in preference for rice cultivation in low lying area demarcated by variable clay which is lower than midland generally situated in last of farming sequence, but sometime under extreme lowlands promote stream flow due to creation of natural drain lines as *Bahara* situation or *Jhodi*, moisture lasting longer upto January, this extreme *Gabhar* is only used for early season growing rice in Kharif and some crops in Rabi. Unlikely most other entrepreneurs and producers cannot predict with certainty for their production process, due to external factors such as weather, pests, and diseases (Van de Steeg *et al.,* 2009). Rapid and uncertain changes in temperature and rainfall patterns markedly affect food production, lead to food scarce, increase the vulnerability of small holding farmers and accentuate rural poverty. Crop adaptation, including diversifying agriculture with crops and varieties that can perform better under various climatic stresses and substitution of plant types, is among the most cited strategies for adapting agriculture to climate variability and change for resource planning (Cooper *et al.*, 2008; Di Falco *et al.*, 2006; Kurukulasuriya and Mendelsohn, 2006; Nzuma *et al.*, 2010). Small holders grow short duration vegetables on their backyard for earning year round which includes brinjal, cauliflower, bottle guard, coriander and onion with time frame of one year using well water size of 4 metre diameter and 9 metres deep.

Participation of villagers in crop planning and resource mapping is involved because villagers are native to the place, well known to farming in the village, so information gathered through scientific approaches validated with farmers' participation. Perception involves crop grown on particular land and soil with suitable management techniques, how that mitigates the abbreviations of weather, intensity and frequency of the technologies also taken in consideration. Estimation of water availability in the village is demarcated through drawing contour line. In contrast, formal enterprises are constrained by narrow crop choice and affordability (Sperling and McGuire, 2010), and are considered particularly weak in high stress areas (Tripp, 2001). This puts farmer agriculture system at the heart of strategies for coping with stress. However, being integral to farmers' crop production, farmer seed systems are affected by the same factors on crop production. There is therefore need to enhance resilience of farmer resource systems to continue to provide the required plan at the right time. Resilient systems have the capacity to absorb shocks, and reorganize to maintain production security over time (Cabell and Oelofse, 2012), which has direct links to food security and resilient livelihoods in general.

Last 10 years of rainfall distribution was somewhat different than earlier 20 years period of rain in *Kharif*, and 80-100 mm rain received during June 10^{th} to June 25^{th} which was just heavy showers as conducive condition for primary tillage, afterward rain cease for 10-15 days, in conducive periods farmers go for dry seeding of upland crops in the regions. Sufficient moisture avails for germination of seeds and establishment of crop plants become easier but later in July coincides the dry spell while vegetative phase. This period needs intensive care of the crops due to unavailable soil moisture also requires contingency plan. The next months (August-September) and even in October receives more than 100 mm rainfall.

Materials and Methods

Village profile

The village *Tahkapal* adopted for study is really represented the region's resources located 30 km west ward from Jagdalpur city geographically referred latitude of $81^0$51'58, longitude of $19^0$06'48 with elevation of 554m under Tehsil (block) - Tokapal of district Bastar and is typically tribal dominated village covering 178 households with population of 391 males and 396 females *i.e.* total 787, among them 360 males and 355 females belongs to scheduled tribes. The village having all category of farmers who are engaged in cultivation and allied enterprises, small (<1 ha) farmers are 68% leading to manage the existing and substantial agricultural for livelihood security followed by 21% medium farmers involved in intensive agriculture and large and landless farmers are 5 and 6%, respectively over the village demography.

Land resource

The selected village was demarcated by hydrological line to confine as hydrological unit of one watershed in which the total rain receiving catchment of the watershed was considered as a domain for water resource analysis, cropping and resource mapping with suitable revenue village. Classification of land resource on the basis of farming situation *i.e.* upland (*Baadi, Tikra and Marhan*), midland (*Maal*) and lowland (*Gabhar*). Revenue map incorporated with survey map for delineating land resources of the village in which upland, midland and lowland were classified on the basis of slope and soil depth pertaining crop growing capability. Meanwhile classification of land farmers was asked to give working suggestions on their land categories. The revenue map was collected from concerned revenue office for cross referencing with GIS map and survey maps, pixels wise classification of land, midland and lowland were identified by pixel matching process with LISS-III available of three cropping season in one year. The soil resource inventory of Tahkapal village (1:5000 scale) was carried out simultaneously as per the guidelines outlined by Soil Survey Manual (2000). The soil profiles were excavated and studied for morphological features alongwith horizon-wise soil samples were collected and analysed for some important parameters as per the standard procedure. The soils were classified as per guidelines given in Key to Soil Taxonomy and identified six soil series in the village and are correlated with existing soils of Bastar district. The soil series were evaluated for different crops suitability by using revised criteria developed by Naidu *et al.,* (2006) and soil suitability map is prepared (Fig. 1).

Water resource

Water bodies counting and measurement was done by individual visit of farmer's home to record the number and measuring dimension of water bodies (ponds, wells and bore wells) by tape. The quantum of water gaining and dropping the water level as rainfall variation occurred in the water bodies. Rainfall recorded regularly in continuous 10 years and analyzed for summary extract established village meteorological observatory at villages. The adopted village was gone under 25 visits of scientists in a year to complete the data record. Runoff was also recorded by measuring the flowing out water from village through the common outlets establishing rectangular weirs. Run off was measured and recorded by establishing rectangular weirs at common drain point of watershed area with measuring runoff water fluctuation daily as raise or drop in water level.

Storage structures were categorized as dug wells, ponds and seasonal stream, the dug wells and ponds were accepted for measuring water level on 15 days intervals throughout the years in consecutive 10 years to assess changing water table and recharging.

Simultaneously moisture content of cultivated fields was also recorded in 25 fields having depth of 20 cm on 15 days interval considering farming situations for reducing errors with rainfall frequency and moisture gain while observation. For participatory approaches of villagers, villagers-scientists interaction and interviewed were organized 15 times to know their view in resources characterization while resource mapping survey.

Participatory Rural Appraisal (PRA)

To assess the problems of land use decisions, a participatory rural appraisal (PRA) was conducted in the summer 2015. The PRA was an interactive process spreading over four months period with planning occurring on site. Farmers identified the causes for land degradation and its effect on their livelihood. Through focused PRA, farmers' perception and priorities of land use were identified. Land suitability map of village was discussed with each landholder and their opinion was incorporated before implementation.

Results and Discussion

Soil characteristics

Based on soil survey data, soils of Tahkapal village were classified in to six series (Table 1) with maximum area (151.78 ha) under Marhan soils followed by Tikra (81.48 ha) and Gabhar (58.01 ha). The lowest area coverage was under *Baadi* (14.67 ha) but Maal had higher (34.41 ha) than that of *Baadi*. The surface texture of these soils varied from sandy to sandy loam and slope ranged from 1 to 15 percent in different landforms. The soils were low in nitrogen and medium in phosphorus and potash. Nearly 325 ha were under different land use and remaining area under settlement, forest, road etc. *Marhan* soils, which are dominated in the village, are under rainfed crops.

Land use dynamics

Before implementation of land use planning, initial land use and land cover was studied. Out of 502.18 ha geographical area of the village, 372.35 ha was under cultivation further dividing into *Baadi* (46.67 ha), Tikra (81.48 ha), Marhan (151.78 ha), gabhar (58.01 ha) and Marhan had highest (151.78 ha) area followed by Dongari (129.83 ha) and Tikra (81048 ha). The higher quality land – Gabhar was lesser than Tikra which was mre productive. Rice was predominantly grown on *Baadi*, Tikra, Marhan, Gabhar and Maal due to their food habit but it was completely unplanned leads to low productive lands because rice was not studied perfectly at various farming that was changed according land capability and production potential. Land holding of the village ranged from 0.06 ha under Tikra to 76.37 ha of *Baadi*. After land use planning, highest land cover was under Marhan (201.58 ha) followed by Tikra (107.47 ha) due to plenty of scope in reuse and crop diversification that reflected in enhancing land use after implementation. The implementation includes cultivation small millets, maize, vegetables in their farming situations. As per suitability evaluation, only 92.42 ha (gabhar+maal) area is suitable for rice cultivation, but due to socio-economic compulsions and other factors as discussed above. These reasons were drawn to different land holdings. Participatory resource mapping options implemented integrating farmer's perception and scientific land evaluation is depicted in Table 4.

Characteristics of soil

The land units are locally divided into *Baadi, Marhan, Tikra, Maal, Gabhar and Bahara* ranging soil depth 15 cm to 150 cm in *Baadi* to Bahara. The *Baadi* has lowest soil depth whereas Bahara with highest soil depth. *Baadi* of the farming situation gradually increased in depth, slope, clay content and crop accommodations. The cultivation of sorghum and small millets extended upto *Marhan*, vegetables confined in *Baadi* with intensive care, rice mostly covers *Tikra, Maal, Gabhar and Bahara* was improved with varietal intervention like suitable varieties of rice. The constraints were advocated by sorting out problems of nutrient management, water logging of lowland fields was planned with long duration (140 days) varieties along with draining of water from field through cut out in down side of lo wland directing water to stream except Baadi, remaining categories of land fall under I to IV land capability classes showing higher suitability with gabhar and lowest suitability with Marhan. The Baadi was selected plan for which water resource structures enhanced to harvest rain water and intensified vegetable cycle involving market demand, this planned enhanced incomes of each family at village level. Marhan was targeted with short duration crop like small millets which easily accommodate with rainfall scenario and plantation fruit crops was also taken in consideration to land use. The acidic soils were reclaimed by applying lime to bring pH of soil in neutral condition so that crop could perform better than existing (Table 1). The soil suitability ratings were compared to farmer's preference and perception at each land holding level. The perceptions did not match with the scientific soil suitability ratings. More than 60 per cent of the farmers' opinion on suitability of soil site characteristics (soil depth, slope per cent and stoniness) to different crops were corroborated with that of scientific criteria.

Many of the practice adopted for imposing cultivation as problems associated: low productivity, crop establishment, dry spells, weed infestation, labour wages by suitable varieties, nutrient management, scooping to conserve moisture, appropriate cultural operation and herbicides, direct seeding of rice technique, supplemental irrigation, plantation etc, among the techniques, farmers actively adopted improved varieties, direct seeded rice in place of transplanting, weed management, nutrient application with sowing in furrows (Table 2). The analysis further revealed that even though farmers perceive the optimum LUP correctly, in practice, the existing land use is quite often objectively unsuitable under the current evaluation system in many ways. This is because of the fact that farmers have to strike a balance between available or mobilizable resources (physical and economic) and the diverse household needs and decide according to the market forces.

Over all interventional impact on crop production was assessed after implementation by crop wise yield gaps of existing with comparison of present status. Rice crop mainly recognized as upland, midland and lowland rice which was increased more (22.88%) in lowland rice followed by midland (21.66%) due to mentioned interventions. Among small millets, maize and vegetables, small millets (30.99%) were more responsive to intervention than vegetables (12.48%), whereas maize was similar in response of technologies used after resource mapping (Table 4). This indicates that the PLUP created awareness and build the knowledge base among the stakeholders to use available natural resources more appropriately for improving the productivity.

Rainfall-catchment-command

Last ten years experiences over the village was year round variation in trend, almost 10 year's data expressed the onset, frequency and cessation of rainfall. Onset was occurred in conjunction of two month starting with June or first fortnight of July. Timing of rain is crucial in planning of crop management, if rain comes early in season (*i.e.* 1^{st} week of June) promotes dry seeding in all farming situations, little late in onset (Mid June) also provide preparatory tillage with dry seeding immediately but last week of June or 1^{st} week of July limits the sowing window of dry seeding, it leads farmers to nursery raising and transplanting paddy on puddle fields later.

Heavy down pour is always happened in July to September before and after this period rain frequency and amount was not high.

Table.1 Characteristics of Soils of Tahkapal village

Soil class	Characteristics	Effective depth (cm)	Major land use/constraints	Some Soil physico-chemical properties (Ranges) through depths					LCC*	Irrig-ability subclass	Produc-tivity potential	Soil taxonomy (sub group)
				Clay (%)	OC (%)	CEC emol (+)/kg	$CaCO_3$	pH				
Baadi	Shallow, brown, loamy, excessively drained soils of backyard	15	Sorghum, vegetables, hibiscus, hardly prefer for crops	Sandy loam	0.58-0.70	3.42-4.50	0.00	5.4-5.80	IV-VII	3rd	Very low	Lithic Rhodustalfs
Marhaan	Shallow to medium, yellow medium drain	45	Small millets, maize, horsegram, niger	Sandy loam	0.42-0.52	3.40-5.42	0.00	5.2-5.8	IV-VII	3rd	Very low	Lithic Haplustalfs
Tikra	Medium to deep, brownish, medium drain	70	Lack of short duration varieties, no second crops in cropping sequence	Sandy loam	0.48-0.62	3.80-5.88	0.00	5.60-6.02	III-IV	3rd	Low to medium	Typic Haplustalfs
Maal	Deep soil, lack of drain, suitable for rice and other crops	100	Lack of medium duration rice, weeds, labour problems	Loam	0.46-0.68	4.25-6.72	0.03-0.05	6.02-6.80	III-IV	2nd	Medium	Typic Plinthaualfs
Gabhaar	Very deep soil, less draining water, suited for rice	125	Lack of improved varieties, Nutrient management	Loamy clay	0.52-0.76	5.70-7.25	0.03-0.05	6.26-7.02	II-III	2nd	Medium	Chromic Haplusterts
Bahara	Deep soil, prolonged water logging condition or more	150	More than 140 days varieties, continuous flow of water	Loamy clay	0.62-0.74	5.70-7.00	0.03-0.05	6.48-7.00	II	2nd	Low	Chromic Haplusterts

Table.2 Mutually agreed land use options for different soils based on farmer's perception and scientific land evaluation

Present land use	Farmer's perception on present LUP	Suggested for	Farmer's perception on suggested LUP	Mutually agreed on land use
1.Fallow upland mixed cropping	• Low productive • No suitable varieties • Washing out of silt • Early dry spells • Weed infestation	• Suitable varieties • Resilting of top soil • Scooping after sowing • Weed control method • Placing of nutrients	• They accepted the suitable varieties, scooping, weed management practice and nutrient placing while drilling	• Varieties replacement, weed control practice and placing of nutrient
2.Traditional rice cropping at midland farming	• Broadcasting of seed • Traditional rice variety • Lack of nutrient management • Terminal drought • Weed infestation	• Rice variety MTU 1010 • Drilling of seeds • Balanced NPK • Supplemental irrigation • Weed control method	• They accepted MTU 1010, seeding by seed drill and weed control	• Farmers agreed on suitable varieties, drilling, weed management
3.Traditional lowland rice	• Lack of suitable variety • Labour intensive cultivation • Transplanting • Water logging • Dry spells • Weed infestation	• Rice variety *Samleshwari, Sahbhagi* • Drilling of seeds • Balanced NPK • Supplemental irrigation • Weed control method	• They accepted varieties, seeding by seed drill and weed control	• Farmers agreed on suitable varieties, drilling, weed management
4. Barren hill top	• Unsuitable for arables	• Plantations	• Need fencing	• Plantation with fencing

Table.3 Average yield of crops for pre and post inventions in Tahkapal village

Crops	Average yield (kg/ha)		Per cent increase
	Pre project	Post project	
Upland rice	312.34	373.56	19.60
Midland rice	503.54	612.60	21.66
Lowland rice	720.56	885.44	22.88
Small millets	232.87	305.04	30.99
Maize	419.34	541.21	29.06
Vegetables	3223.25	3625.6	12.48

Table.4 Impact of interventions on land holding of Tahkapal village

Farming	Pre project				Post project			
	Area (ha)	Average holding (ha)	Area (ha)		Area (ha)	Average holding (ha)	Area (ha)	
			Max	Min			Max	Min
Dongari	129.83	64.19	75.27	54.56	101.25	78.915	95.27	62.56
Baadi	46.67	0.51	76.34	54.58	63.25	0.69	98.56	73.51
Tikra	81.48	3.54	22.67	0.06	107.45	4.65	31.20	0.09
Marhan	151.78	3.79	8.39	0.52	201.58	5.02	11.20	71.00
Gabhar	58.01	2.01	4.02	0.26	78.54	3.56	5.46	0.36
Maal	34.41	5.63	15.07	1.71	46.25	8.12	19.56	3.21
Var. (n-1)	**2569.5**	**2.20**	**66.28**	**0.55**	**4479.2**	**3.83**	**124.9**	**1219.3**
SD (n-1)	**50.69**	**1.48**	**8.14**	**0.74**	**66.93**	**1.96**	**11.18**	**34.92**

Fig.1 Execution of Land use planning

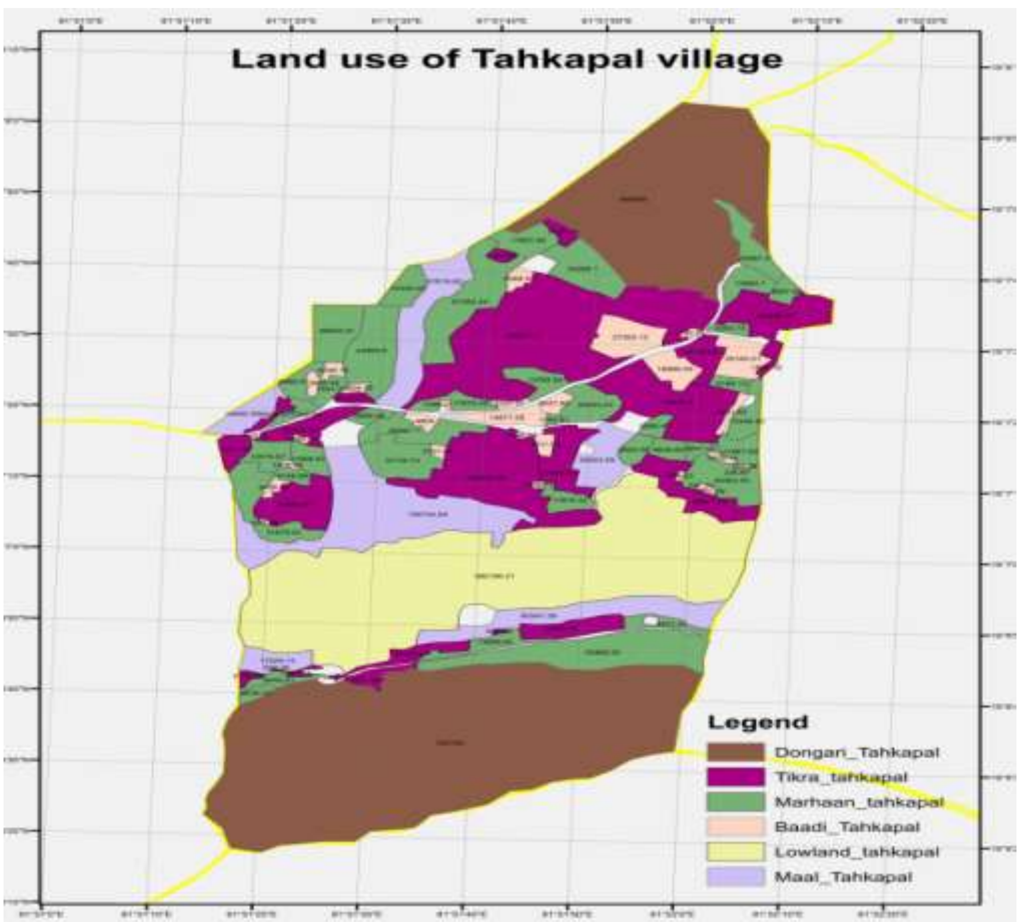


Table.5 Summary statistics (Quantitative data) on health of land resource

Correlation matrix (Pearson):Variables	pH	EC	OC (%)	Avail. N	P (kg/ha)	K (kg/ha)	Aval. S (ppm)	Avail. Zn (ppm)	Avail. B (ppm)	Avail. Fe (ppm)	Avail. Mn (ppm)
EC	-0.024										
OC (%)	-0.182	0.061									
Avail. N	-0.124	-0.008	0.728								
P (kg/ha)	-0.071	-0.076	-0.178	0.023							
K (kg/ha)	0.415	0.172	0.052	0.086	0.240						
Available S	-0.028	0.091	0.260	0.255	0.435	0.230					
Available Zn	-0.046	0.137	0.177	0.197	-0.005	0.227	0.101				
Available B	-0.227	0.150	0.350	0.065	-0.199	-0.234	-0.096	-0.040			
Available Fe	-0.165	-0.133	0.177	0.087	-0.065	-0.145	0.106	0.003	0.016		
Available Mn	-0.050	0.054	0.229	0.022	-0.191	0.175	0.140	0.247	-0.093	0.127	
Available Cu	-0.284	-0.043	0.134	-0.030	-0.075	-0.047	-0.044	-0.069	0.274	0.198	0.255

Fig.2 Rainfall-Runoff relationship (square root of value)

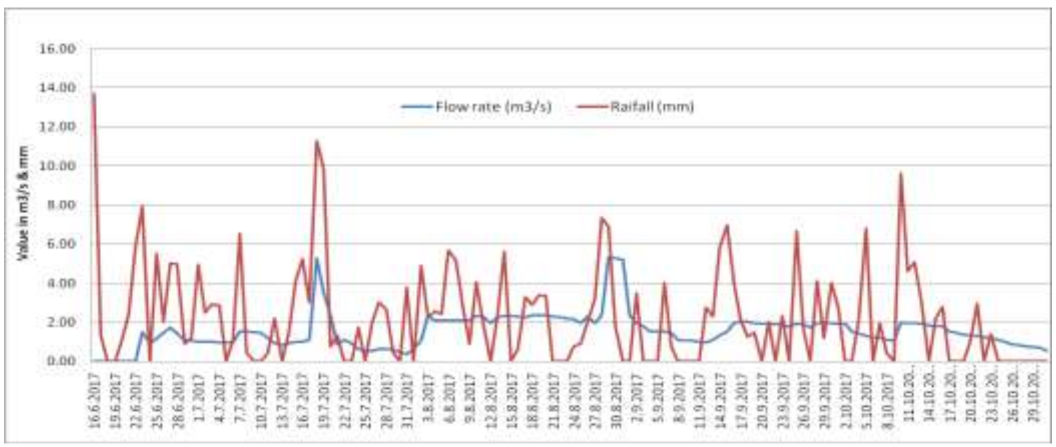
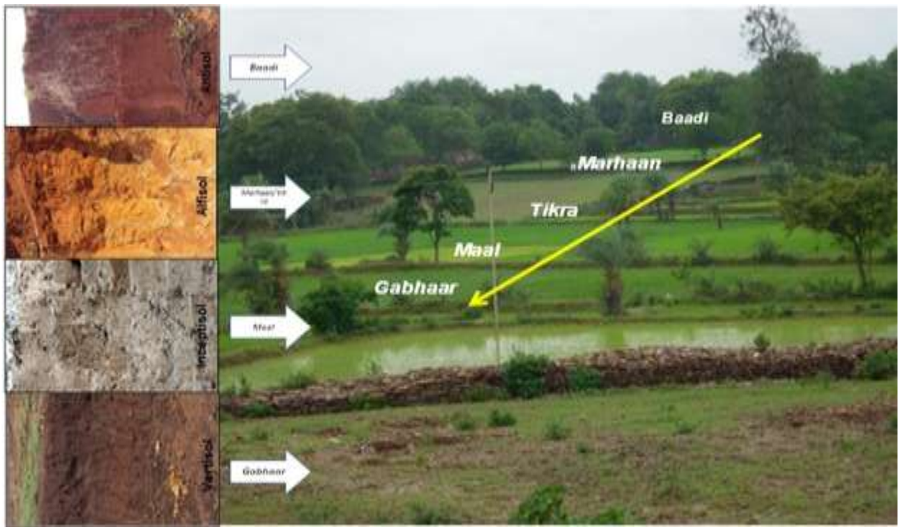


Fig.3 Farming situation of Bastar plateau



Transplanting of nursery in July month save the resources and avoid conservation techniques. This period having high intensity of rain influences to newly established paddy crop. In vice-versa, heavy rain on upland with high frequency do not affect much to the crops if cover crops or contour farming is properly applied, otherwise most of the top soil moves down with velocity of rain.

Storage capacity of village

The rainfall trend of the region is irrational that could not be met with uniform water quantity from rain in villages drain lines. This was measured with rectangular weirs placing three places to know the flowing out water as runoff and runoff was started with nearly 231.20 mm rainfall in flow after soil saturation more than 10 mm rainfall maintained the flow height of runoff under defined watershed at village. 10 mm rainfall in single event would help raising head of flow, such event was observed 23 with more than 10 mm rainfall received giving raise of 1 m^3/second, some rainfall event like more than 100 mm in a day was recorded 2 days during whole rainfall period of year.

The intensity of rain was more pronounced in July and August months that led to increase flow rate having 3 to 5 m^3/second in a single day as runoff from village. The event was more rampant when triggered with soil erosion, flowing out fertile surface soil.

The velocity of runoff was reduced by gradually through storing in stop dam, check dam and compartments of cultivated rice fields and vegetative barriers on the way of flow, which reduced up to 30% soil loss. In offset of such huge quantity of rainfall; 39 wells and 24 ponds having capacity of 2276668.23 litres water could be stored into wells as much as 12198780.01 litres in ponds. Another side of in-situ water storing 17390900.02 litres through compartmental bunding. The still higher amount of runoff is to trap in village because higher amount moved out with valuable natural resources of the village.

Nutrient status

pH, EC, OC, P, S, Fe and Mn had high level of variation in soil accorded to sampling plots of different farming situations, whereas potassium and copper were low variable nutrient among the other nutrient and medium variation was nitrogen and zinc in soil sampled from village.

Physio-chemical properties of *Baadi* was fine loam in texture, slight acidic in reaction (5.6), physical structure of soil is skeletal having water holding capacity 16.4% and electric conductivity 0.06 dsm^{-1}. Nutritional status of *Baadi* was low in nitrogen (192.4 kg/ha), low in phosphorus (8.4 kg/ha) and high in potash (212.4 kg/ha) as available in soil solution other important nutrient like calcium {5.6 c mol (+) kg^{-1}}, magnesium {4.3 c mol (+) kg^{-1}} were low in quantity. *Baadi* based well model always dictated open dug well as irrigation source with site characteristic of upland entisols having fine texture loamy soil, skeleton, 16.4 water holding capacity and electric conductivity of 0.06 dSm^{-1} as physical characteristics whereas chemical properties showed the status of pH (6.5), available nitrogen (192.4 kg/ha), phosphorus (8.4 kg/ha), potash (212.4 kg/ha) along with other nutrients found after analysis of Ca and Mg was 5.6 c mol (+) kg^{-1} and 4.3 c mol (+) kg^{-1}. Midland (*Inceptisols)* had silt loam in texture, sub angular blocky in structure, 14.2% water holding capacity, 0.08 dSm^{-1} EC, whereas pH, available nitrogen, P_2O_5, and K_2O were 6.02, 156, 16 and 290 kg/ha respectively for midland and lowland. The quantitative data explained the summary statistics on pH, EC, OC, available nitrogen, sulphur, Zinc, boron, iron, manganese and copper, phosphorus and potassium. The highest standard deviation was found with nitrogen and potassium (83.67 and 80.125), the deviation levels on phosphorus, sulphur, iron, manganese were similar ranging from 4.488 to 4.669, pH and organic carbon were similar in standard deviation. The lowest standard deviation was recorded with electric conductivity (0.046) followed by zinc, boron and copper.

The Pearson correlation matrix of soil physio-chemical properties of pH, EC, OC, available nitrogen, sulphur, zinc, Fe, B, Mn and Cu, phosphorus and potassium were tested to know the correlation among these soil nutrients. The pH was negatively correlated with EC (-0.024), OC (-0.0182), available nitrogen (-0.124), phosphorus (-0.071), sulphur (-0.028), Zinc (-0.046), boron (-0.227), iron (-0.165), manganese (-0.050), copper (-0.0284) and phosphorus was negatively correlated with zinc (-0.005), boron (-0.199), iron (-0.065), manganese (-0.191) and copper (-0.075) and remaining were in positively correlated (Table 5).

Improved production at village level is now apparently seen as a result of resource based planning and measures coupled with application of required inputs which enhanced the livelihood of people by improving cash flow and conserving the natural resources of the village. Although this exercise was operationalized for 10 years, the degree of change of attitude by the villagers towards adopting participatory resource planning is found satisfactory.

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