Environment and Sustainable Agriculture Through Community Action: A Case Study in Andhra Pradesh

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The ever growing human population and continuously declining productive capacity of the nature, has led to crisis of sustainability the world over. Sustainability is an ecological concept based on the fact that economic growth and human well being depends on the level of exploitation of the natural resource base (which ultimately decides the state of existing environment). This has led to the inherent contradiction in the treatment of ecology by the ecologists and biologists advocating for conservation of resources, whereas the development economists regard production of food and other commodities as the prime aim. The resulting gap between economic and ecological thinking is thus rather striking. The world commission on Environment and Development WCED (1987) popularly known as Brunt land Commission pleaded for sustainable development in the growing context of environmental concerns. It defined sustainable development as "Meeting the needs of the present without compromising the ability of future generations to meet their own needs". That a marriage between conservation (for the future generations) and economic development (which has an inherent futuristic dimension) was recognized more explicitly by Jodha when he says "Sustainability is the ability of a system to maintain a well defined level of performance output over time and if required to enhance the same including through linkages with other systems, without damaging the ecological integrity of the system" (Jodha, 2001).

The concept of sustainable development thus requires the establishment of linkages between environmental constraints and development indices. The important constituent of linkages between the ecosystem and the economic system are research, technologies, institutions and their relation with ecosystem characteristics. Since times immemorial the establishment and diversification of such linkages has been the prime feature of agriculture and land based activities and has remained to be the main strengths of traditional farming systems. The linkages can be seen between the activities based on annuals and perennials; intensive and extensive resource uses; and complementary uses of common property resources and private property resources.

The indigenous systems though oriented to resource use with conservation, do not possess high productivity technological components to ensure high use intensity and resource conservation simultaneously. The new science and technology based intervention have capacity to raise resource use intensity and thereby productivity of land but they are generally indifferent to conservation considerations. The above facts should form, the basic ground for blending the positive features of the two for an environmentally sustainable agriculture in drought prone areas. For this, soil and water conservation practices, and investment priority from the side of both the government and farmer in soil and water conservation are needed for better relationship between agriculture and environment. Though some work is already initiated in this direction through watershed development, not much thought has been given to quantity the factors which may be high yield oriented but are influencing the environment negatively which may have an ultimate effect on the yield itself. But the final act is always at the hands of the communities and community action decides the actual interrelations between the dynamics of population, land use and nature of production practices. The nature of these linkages may vary from place to place and region to region as well as from community to community depending upon overall environment and culture features of any area.

Against this backdrop the present paper presents a case study of Mahaboobnagar district of Andhra Pradesh, which environmentally falls into the drought prone area and primarily focuses on -

1. The issues related to balance between environment (mainly soil, water and green cover) and agricultural needs of the people in the study area and examine the linkages between agricultural and environment, and identify appropriate means for their growth and sustainability without competing with each other. And,

3. To assess the impact of community participation through watershed projects in resolving the conflict between

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ecology and economics for greater sustainability.

Study Area

The study is located in Mahaboobnagar district of AP, a major part of which is drought prone and frequently suffers from the miseries of climatic and hydraulic droughts. Two mandals from the district were selected based on land degradation classification 'D' grade and 'F' grade where there was severe degradation and mostly covered under rainfed agriculture. The data from AP State Remote Sensing Agency (APSARA) pertained to the year 1995-96. The information was taken from the soil erosion maps in the scale 1: 50,000.'

In this the mandal 'Damaragidda' falls under 'd' grade and the mandal 'Amangal' falls under 'f' grade of land classification. These two mandals were selected to study the improvement in environment resource position and productivity, after the implementation of soil and water conservation structures through watersheds. For this based on the information taken from 'District Watershed Management Agency' DWMA of Mahaboobnagar district two villages that covered under watershed programme from each mandal thus a total of 4 villages were selected. The total area under each watershed is 500 ha which covers almost entire village. A sample of 30 farmers from each village was selected based on simple random sampling technique, thus forming a total sample of 120. Data was collected during the period December 2003.

Study villages

A brief profile of the study villages is provided in the Table 1. In Ulligundam village the area under cultivation is 85.98 percent of the geographical area and land man ratio is slightly less with one per acre. In Udumulagidda where the area under cultivation is 66.66 percent of geographical area the land man ratio is 1.04 per acre. In Amangal mandal the area under cultivation is more for Ramanunthala with 78.63 percent of the geographical area and the land man ratio is 0.87 per acre and the corresponding figure for Karkalpahad village are 53.61 percent and 0.90 per acre. The presence of large areas under current fallows in Udumulagidda and Karlalpahad village represents the arable area under utilized or non-utilized. Table 2 provides livestock in the four study villages.

Table 1: Demographic profile and area under agriculture in the villages

Sl.No.	Characteristics	Damaragidda		Amangal	
		Udumulagidda	Ulligundam	Karkalpahad	Rananunthala
1	Total Population	1150	2000	824	1000
2	Total Families	320	300	217	230
3	Total Geographical area (in acres)	1800	2326	1384	1114
4	Area under cultivation (Percent of GA)	800 (66.66)	2000 (85.98)	742 (53.61)	876 (78.63)
5	Current fallow	250	--	150	100
6	Agricultural holdings	209	215	82	146
7	Land man ratio	1.04	1	0.90	0.87

Table 2: Livestock population in the villages

Sl. No.		Damaragidda		Amangal	
		Udumulagidda	Ulligundam	Karkalpahad	Ramanunthala
1	Buffaloes & Cows	150	1300	706	616
2	Sheep & Goat	3000	1200 (Sheep)	472	192 (Sheep)
3	Poultry	Household activity	HH activity	HH activity	HH activity
4	Scu	0.30	1.59	2.34	1.74

Note: Scu-standard cow units - i. e. Livestock Population per ha of cultivated land

Integrated farming particularly a synergistic blend of crops and livestock, to judiciously exploit the land, water and human resource as well as to distribute the risk usually associated with rainfed agriculture assumes high significance in rainfed areas. In drylands livestock besides being the major draught power are a major a source of food, nutrition income and insurance against drought. Livestock in a village has its own dynamics on the basis of breeding efficiency and fodder availability and land degradation. The degradation of land has an effect on livestock, which in turn exerts pressure on uncultivated land and forests by indiscriminate grazing. Livestock especially small ruminant experience grater degradation in drought prone and rainfed areas compared to others. It was observed that milch animals are less degrading when compared to small ruminants like sheep and goat (Rao, 1994)

Among the livestock population buffaloes and cows population is less for Udumulagidda with Scu of 0.30 and more for Ulligundam with Scu of 1.59 in Damaragidda mandal (Table2). Whereas, in Amangal Mandal the Scu is more for Karkalpahad with 2.34 and less for Ramanunthala with 1.74. Sheep and Goat population is more for Udumulagidda and there is only sheep population in Ulligundam. An interesting observation found in Ulligundam village is that in this village the entire community has abandoned goat raising since the year 2000 since they found that goats are exerting pressure on uncultivated barren lands by indiscriminate grazing. So they encouraged only the raising of sheep for which they depend on stall feeding. This has encouraged the plants to rejuvenate and regenerate even under marginal and sub marginal non arable lands, in Ulligundam village.

The increase in greenery has changed the climate in the surrounding areas which increased the rainfall content. All this had a positive effect on the availability of fodder and forage which increased the number of quality livestock from small ruminant based to milch giving like cows & buffaloes, which helped in increasing the availability of fym to the soil, which increased the productivity of almost all the crops. This is one of the classic examples of how communities through their collective action has established the linkage between environment, agriculture and livestock..

Land and Soil Characteristics

Almost all the types of soils are present in all the four villages which are classified into major red, sandy, loam and black soils. Fertility of the soils will be more if the depth is more but if the slope is more, the chances of subjecting to soil erosion is more. General observation is that in all the four villages fertility of loamy and black soils is good and sandy soils is poor.

Table 3: Land Characteristics

Village	Soil	Depth	Fertility	Slope	Degradation
Udumulagidda	Red	Medium	Medium	Medium	SE
	Sandy	Shallow	Poor	Level	SE+ND
	loam	Medium	Good	Medium	ND
	Black	Deep	Good	Medium	ND
Ulligundam	Red	Medium	Good	High	SE
	Sandy	Medium	Poor	Medium	SE
	loam	Medium	Very good	Medium	NP
	Black	Medium	Good	Medium	NP
Karkalpahad	Red	Medium	Poor	Medium	SE+ND
	Sandy	Medium	Poor	Level	SE
	loam	Deep	Medium	Level	ND
	Black	Deep	Good	High	SE+ND
Ramanunthala	Red	Medium	Good	High	NP
	Sandy	Shallow	Good	Level	SE
	loam	Deep	Very Good	Medium	NP
	Black	Deep	Good	Medium	NP

Note: SE: Soil Erosion; NP: No Problem; ND: Nutrient Depletion; For details see the annexure

All the four types of soils of Udumulagidda as well as Karkalpahad are facing the problem of land degradation, like soil erosion and nutrient depletion inspite of soil conservation works taken up during watershed development programme (Table 3). Land degradation is not a problem of Ulligundam and Ramanunthala soils except sandy soils of both villages and red soils of Ulligundam. This shows that maintenance of livestock in terms of scu and controlled grazing on marginal and sub-marginal soils may be one of the reasons for arresting the land degradation in case of Ulligundam and Ramanunthala. In case of Karkalpahad village though the number of scu is more when compared to the other three, land is subjected to degradation mainly due to lack of proper maintenance of soil conservation works.

Table 4 Benefits perceived by the farmer on adopting soil conservation measures

Village	Soil Fertility	Control Soil Erosion	Crop Productivity	Changes in Fertility when compared to earlier	Mitigation measures to counter soil fertility decline
Udumulagidda	No Change (75)	Controlled by 10% (60)	No Change (75)	No change (75)	Increase in Fertilzer use (70)
Ulligundam	Increased by 25% (80)	Controlled by 50% (65)	Increased by 10% (70)	Increased by 25% (80)	Application of Fym + Fertilizer use (65)
Karkalpahad	No change (60)	Controlled by 10% (75)	No change (70)	No change (60)	Increased in fertilizer used + FYM (60)
Ramanunthala	Increased by 25% (75)	Controlled upto 50% (60)	Increased by 10% (65)	Increased by 25% (75)	Application of Fym+Fertilizer use + Vermicompost (70)

Note: Fig. in Parenthesis indicate percentage to the sample

The watershed programme which is basically meant for water and soil conservation was started and saturated during at the same period in all the four villages. Control of soil erosion is instrumental in the analysis of watershed problems. Initially earthern bunds are the measures for soil conservation. Later, the focus was shifted to vegetative barriers as key contours lines which is a highly efficient and post effective method of soil conservation. But the Ulligundam is in better off position than Udumulagidda in Damaragidda mandal and Ramanunthala is in a better off position than Karkalpahad in Amangal mandal in terms of control in soil erosion, increase in soil fertility and productivity. 75% of the sample farmers in Ramanunthala have observed that (Table 4) even their sandy soils also converted into loamy by adopting soil conservation works like field bonds, feeder channels etc.

The farmers in Udumulagidda and Karkalaphad villages observed that though soil erosion is controlled to some extent by adopting soil conservation measures, the impact is insignificant in terms of soil fertility. Almost 70% of the sample farmers in all the four villages observed that there is an increase in the application of fertilizers to get the same yield like in the past (during 1980s). Lack of involvement of farmers in the maintenance of bunds is one of the reasons observed in Karkalpahad village for an absence of improvement in land degradation.

Apart from productivity, there are other externalities in the form of benefits associated with soil conservation technologies through watershed development programmes. These include increase in water table levels of the ground water of the dug wells, bore wells etc., which facilitate the irrigation of more area and reduce energy costs. The increase in the water table of Ulligundam village is from 160 ft to 140 ft and Karkalpahad and Ramanunthala village is from 120 ft to 80ft (Table 5). With increase in the availability of water, there is decrease in the current fallow and increase in the cropping intensity in these villages. Only exceptional feature is in Udumulagidda where there is no change in the water table, current fallows and cropping intensity. This village has experienced low rainfall in the past two to three years, and hence there has been poor recharge of the ground water. The decline in rainfall and depletion of vegetative cover due to over grazing by goats, improper agricultural practices have complemented each other accelerating degradation of land. The only alternative for such type of situation is adjusting the cropping pattern according to the availability of ground water and soil moisture.

Table 5: Benefits perceived by farmers in adopting soil conservation methods

	Udumulagidda	**Ulligundam**	**Karkalpahad**	**Ramanunthala**
Change in the water table level (ft)	No Change	-20	-40	-40
Change in current fallows (acs)	No Change	-600	-200	-250
Increase in cropping intensity (%)	No change	40	10	50

Sorghum and Castor are the main crops in all the four villages, which occupy around 19.38 and 18.19 percent on an average (Table 6). An interesting observation is in the villages Udumulagidda where there is a decline in the rainfall and ground water availability, Paddy, which is water and other input intensive crop occupies 31.25 per cent of the area under irrigated cultivation. There is an obvious mismatch between water availability and cropping pattern in this village resulting in apparent drought conditions.

Table 6: Area under different crops acres (Kharif + Rabi)

Crop	Udumulagidda	Ulligundam	Karkalpahad	Ramanunthala
Paddy	250 (31.25)	140 (7)	242 (32.61)	40 (4.56)
Sorghum	150 (18.75)	350 (17.5)	100 (16.17)	220 (25.11)
Groundnut	20 (2.5)	65 (3.25)	110 (14.82)	135 (15.11)
Greengram	100 (12.5)	200 (10)	--	--
Red gram	--	250 (12.5)	--	150 (17.12)
Cotton	80 (10)	10 (0.5)	50 (6.73)	50 (5.70)
Sunflower	--	200 (10)	--	0
Castor	150 (18.75)	650 (32.5)	75 (10.10)	100 (11.41)
Maize	--	100 (5)	50 (6.73)	--
Vegetables	--	--	80 (10.78)	150 (17.12)
Others	50 (6.25)	35 (1.75)	15 (2.02)	25 (2.85)

Note: Fig in parenthesis indicate % to cultivated area

Cotton, which is a commercial crop, also occupies major position (10%) in this village. As a result of allocation of more water to some crops in a limited area resulted in increased area under current fallows more in this village. With the introduction of watershed development programme, through soil and water conservation works there is an obvious increase in the availability of water in Karkalpahad village. But this water is also being used for the cultivation of water intensive crops like paddy and cotton resulting the area under cultivation limited to only 53.61 per cent of Geographical area.

Though the farmers were aware that the paddy is more water intensive crop and with the same quantity of water they could irrigate 3 to 4 acres of ID crops, still they prefer paddy because paddy is a pride crop and the farmer need not have to depend on others for his food as well as fodder. Perennial flooding of rice paddies and continuous rice culture lead to micro nutrient deficiencies, soil toxicities, formation of hard pans in the soil and reduction in nitrogen carrying capacity of the soil. Regular puddling also increases bulk density of soil, with consequent decrease in infiltration rate and also water storage in deeper soil layers. Excessive use of irrigation and adoption of cereal based crop system regularly has resulted in deterioration in soil texture, structure and fertility in these villages. So there is a need for shift in the cultivation to vegetables in place of rice or cash crops like cotton to more of irrigated dry crops. A general trend in the application of fertilizers to different crops is given in Table 7

The application of nitrogenous fertilizer is more than the recommended dose in all the crops except sorghum and castor. For crops like groundnut, cotton and paddy it is as high as 455.55 per cent, 87.5 and 42.85 per cent respectively. The actual application of phosphatic and potassic fertilizers is less than the recommended dose to an extent of 50% to 100% in all the crops except paddy and maize where the mu rate of potash is also being applied at a higher rate of 85.18 percent respectively.

Table 7: Fertilize Use kgs/ ac (Straight Fertilizers)

Crop	Actual application			Recommended dose		
	Urea	SSP	MOP	Urea	SSP	MOP
Paddy (48:24:16)	150 (+42.85)	100 (-33.33)	50 (+85.18)	105	150	27
Maize (RF) (36:20:16)	100 (+25)	50 (-60)	50 (+85.18)	80	125	27
Sorghum (24:16:12)	50 (0)	50 (-50)	-- (-100)	50	100	20
Groundnut (RF) (8:16:16)	100 (+455.55)	50 (-50)	-- (-100)	18	100	27
Castor (24:16:12)	50 (0)	50 (-50)	-- (-100)	50	100	20
Cotton (Hybrids) (36:18:18)	150 (+87.5)	100 (-9.09)	-- (-100)	80	110	30

Note: 1. The figures in parenthesis below the crop represents NPK dosage.

2 The figures in parenthesis below the actual application represents % less or more than the recommended dose.

The imbalanced application of fertilizers along with low addition of organic manure is one of the reasons for decline in fertility. As per the estimates of National Bureau of Soil Survey and Land use Planning (1990) average loss of top soil due to erosion is 19.6 tonnes per ha. Of this 1.39 per cent is actual nutrient loss in terms of NPK. In order to replace the nutrient losses through chemical fertilizers, the actual use of NPK should be 3.01 times of the nutrient losses. In other words, every unit of nutrient loss requires 3.01 units of chemical fertilizer i.e., over efficiency factor for NPK is 33% (Katyal et.al 1997). This implies that 50-70 per cent of the applied fertilizer does not contribute to crop growth and yield. For this, relying totally on organic manure is also not a practical solution because building up of soil organic manure in the dry lands of tropical regions is quite difficult (Singh et.al 1989). It can only be achieved if application rates consistently exceed the decomposition rates. But application rates depend upon the actual amount of FYM actually available at the farm level and competition from alternative uses such as domestic fuel (Hallam and Babu, 1988). In fact, employing organic manure as the primary source of nutrients may not support the sustainability concept. Katyal (1990) establishes that rice yields were maximum when its N needs are only partially substituted by FYM-N. For this there is a need for continuing a combination of inorganic fertilizers and organic manure. Since Nitrogen and Phosphorous are the major environment pressure points and there must be a major focus on improved N and P efficiencies. An estimated 70% to 80% of nitrogen inputs is not recovered in soil or in plant production and is lost to water in the form of nitrate contamination or to the atmosphere. A part from obvious environmental impact, this represents a substantial economic loss to farming [2]. Fertilizer use related concern on environmental degradation should not be plea to axe the rising trend in fertilizer consumption. Such a strategy will be catastrophic for a country like India where food grain production and fertilizer use run parallel (Dhar 1999). The soil fertility declines rapidly, if there is no replenishment even under modest productivity conditions. The environmental consequences may also stem from the absence rather than excessive use of nutrient inputs. Average low levels of fertilizer use per unit area supports impassivity towards this subject. Average annual removal of major plant nutrients (NPK) at the present level of food production (175 million tonnes) is about 7.5mt. by cereal crops only. While actual addition through 10 mt. Chemical fertilizer to all crops even in the best year in recent past has been about 3 mt. (at 37, 14 and 44% efficiency of added NPK respectively (Singh 1990). The current average use of N in India is only 40 kg/ha/annum. But dangers of environmental pollution are genuine and they have to be diminished by protecting the fertilizer N from various losses. Minimizing N losses is a fundamental step towards increasing the efficiency of N use. Timing of application is also very important which is being ignored by the farmers to a large extent. With increased efficiency lower application rates can achieve the targeted production and minimize environmental degradation. Till now fertilizer environmental pollution has rarely been considered as serious problem so far in dry land areas.

The data generated so far show that only in acid soils regular use of fertilizers which are physiologically acid will further cause a drop in soil P^H over a period of time. Past experiences dictates that fertilizer induced drop in P^H could be decelerated by liming and a further improvement in soil physical conditions could be obtained by supplementing inorganic fertilizers with organic manure.

Apparently complimentary and supplementary role of organic manure is a practicable and profitable strategy. Limitations on the coverage of arable land with organic manures may be partially solved by working out biennial or triennial schedule of application in place of repeat annual applications. Research is needed to explore the efficient use of organic manure.

An attempt is made to examine the relationship between the proportion of land degradation to the total area of sample farmers and various factors that are affecting it, through regression analysis.

$$Y = 40.528 - 0.435x1^{*} + 0.150x2^{*} - 0.001x3^{**} - 0.022x4^{*} - 0.821x5^{**} + 3.895x6 - 3.579x7 - 2.992x8 + 0.072x9$$

The R^2 in table 8 shows that 85% of the variation in independent variables is explained by the dependent variable. Similarly a 1% increase in the gross irrigated area decreases the proportion of area degraded by 0.43%. A 1% increase in the cropping intensity increases the land degradation by 0.15%. Similarly a 1% increase in the land productivity, fertilizer use and availability of total livestock decreases the land degradation by 0.001%, 0.02% and 0.82% respectively. The equation also shows that number of borewells and depth of borewells is also effecting the land degradation positively but not significant. This infers that cropping intensity aggravates the land degradation significantly and number of borewells and depth of borewells is also influencing the land degradation positively but not significantly. Whereas, increase in the productivity of land, fertilizer use and availability of total livestock affects the land degradation negatively, which shows that the principle of diminishing marginal returns cannot be applicable in these areas in the present condition as there is lot of potential for increase in fertilizer use as well as productivity. This infers that a balance in the agricultural needs of the people and environment (soil, water and green cover) is possible with an increase in the application of fertilizer and number of livestock without increasing cropping intensity, number as well as depth of borewells in the study area.

[2] There is a line or relationship between N application rate and losses through leaching and Nitrification (Watsen et al 1998). Research indicates that N leaching losses (Nitrates) is of the order of 15% to 35% Ammonia, Nitrous Oxide) is of the order of 10% to 20%.

Table 8: Regression Analysis

Variable	Coefficient (b_i)	Standard Error
A	40.528	
x1	-0.435*	0.096
x2	0.150*	0.065
x3	- 0.001**	0.001
x4	-0.022*	0.010
x5	-0.821**	1.152
x6	3.895	2.176
x7	3.579	9.544
x8	2.992	8.334
x9	0.072	0.058
R^2	0.853**	
Adj R^2	0.836**	

Note: **Significant at 1% level *Significant at 5% level

a = Intercept

y = Proportion of area degraded to the total area of sample farmers in %

x1 = Gross Irrigated area in %

x2 = Cropping Intensity in %

x3 = Land productivity in Kg/ha

x4= Fertilizer use in Kgs/ha

x5 = Availability of total livestock /ha

x6 = Land man ratio /ha of net sown area

x7= No.of borewells /ha

x8=Average farm size

x9 = Depth of borewell

Findings and Conclusions

It is crucial to maintain an optimal balance between economic system and environment in order to maximise the complementarities between the system while minimising the trade offs, which requires an in-depth analysis of linkage between economic systems, resource bases and available technology.

The presence of large areas under current fallows in Udumulagidda and Karkalpahad village represents the arable area under-utilised or non-utilised. These areas could be used for fodder augmentation, which is necessary to maintain livestock balance.

Overgrazing by the goats has resulted in changes in species composition and the elimination of certain species. High grazing pressure particularly on fragile non arable soils has the capacity to cause erosion. As most of the non arable lands are exposed to sub-soil surface, these become barren in the absence of proper care. Since the erosion problems are transboundary in nature, the excessive run of from these lands also contributes to erosion of soil on non arable lands. The degradation of non arable lands creates excessive pressure on cultivated lands for fodder. The increase in the availability of fodder by controlling grazing on marginal soils in the village Ulligundam has helped in the increase in the number of quality livestock like milch giving animals in the village Ulligundam. This has lead to the increase in the availability of organic manure which arrested the soil degradation and their by improving its productivity. This is a classical example of linkage between environment agriculture and livestock. By collective community action.. Grazing degradation links have to be established and appropriate grazing management techniques and grazing intensities for fragile drought prone rainfed areas is needed. Fuel-fodder plans in the village commons by involving community in the decision making, particularly in the degraded areas is most needed.

The urgent need to release the grazing pressure on the range lands by moving animals to the cultivated areas can be met by the introduction of fodder crops and building up of fodder reserves.

It is inferred from the regression analysis of the study that a balance in the environment, soil and water and agriculture needs of the people is possible by decreasing the cropping intensity (leaving the land fallow intermittently to recoup) and increasing the fertilizer use and number of livestock.

Land is considered as non renewable resource. It is subjected to physical chemical and biological degradation with agriculture contributing to these negative effects. In this regard, information on the qualitative aspects of soil is needed. Mobile soil testing laboratories can be facilitated to the farmers.

Degraded and marginal lands if not managed suitably would degenerate further and may even reach a point of no return. Appropriate cropping plans to meet food, for age and feed demands should be developed. Those areas which are not suitable for annual cropping and are likely to suffer more from soil and wind erosion should be developed as range lands and pastures. Optimise the use of land by putting it to the best use as is consistent with ecology and the capability of land. It is essential that land use planning be based on a research survey and production potentiality of the land. Choice of appropriate crops and varieties for balanced and sustained expansion of soil and water is extremely important for conservation farming.

There is a mounting evidence that in all the four villages though the soil erosion is controlled to some extent through the soil and moisture conservation works, these could not enable the improvement in fertility of the soils where it is already eroded. There is an increase in the application of fertilizers. But the increase is only in nitrogenous fertilizers like urea, which will increase the acidity of soils if there is no proper irrigation. Excess of nitrogenous fertilizers increases the potential of ground water contamination by nitrates. Minimization of loss will be a prerequisite on Maximization of use efficiency. Minimizing nutrient loss will diminish dangers of fertility related environmental pollution. For this timely as well as balanced application of fertilizers is needed. Stresses on the technology development leading to efficient fertilizer use will need high priority vis-à-vis sustainability aspects. Soil fertility research in future should address to soil-plant-animal system as a unit. Management protocol for efficient nutrient management in rainfed areas is needed separately.

There is increase in the cultivation of paddy with the increase in the availability of ground water in all the four watershed areas. The water use efficiency of paddy crop is very less when compared to some ID crops. Intensification strategies for fragile lands will have to be different from green revolution model. Poor infrastructure drought and lower yield response render high use of inputs uneconomic. At the same time, the poor soils of fragile lands cannot sustain intensive monocultures of annual crops. Since the issues involved in crop planning are complex, the cropping pattern for the year should be taken by the Panchayati Raj institution in relation to water availability in consultation with agricultural department, credit, marketing agencies and organisations dealing with supply of inputs.

Though there is an increase in the groundwater availability and the quality of livestock in terms of scu, is more in Karkalpahad the productivity of almost all the crops in this village is far less than the district average. This is mostly because improper management practices due to unawareness and lack of enthusiasm from the side of farmers. Several studies have also revealed that the gaps of technology transfer in rainfed agriculture are relatively much wider than those in irrigated agriculture. (Singh, 1989b). Information about latest technology and marketing is much needed.

The productivity of almost all the crops in the Ulligundam and Ramanunthala village is better than the Mahabubnagar district average productivity. This is a strong evidence indicating the relationship between higher productivity, quality livestock, better management practices and groundwater efficiency. However, groundwater is liable to over exploitation there by failing to sustain the long term growth process and also creating inequity, as resource poor farmers will be at disadvantage. Groundwater resource development should receive the highest priority in our water resource development planning but to avoid over exploitation and to ensure equitable distribution of water on a watershed basis, a legal framework should be provided. Unless groundwater is considered as property of the state and a concept of "water use rings" for coordinating its development and use on a watershed basis is adopted, the problem of over exploitation and social inequity can't be solved.

Agricultural practices with capacity for pollution must receive serious research attention in order to quantify the parameters of sustainable farming and also the trade-off between productivity and environment. In this regard parameters of good farming practice particularly in dry land areas needs to be established.

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