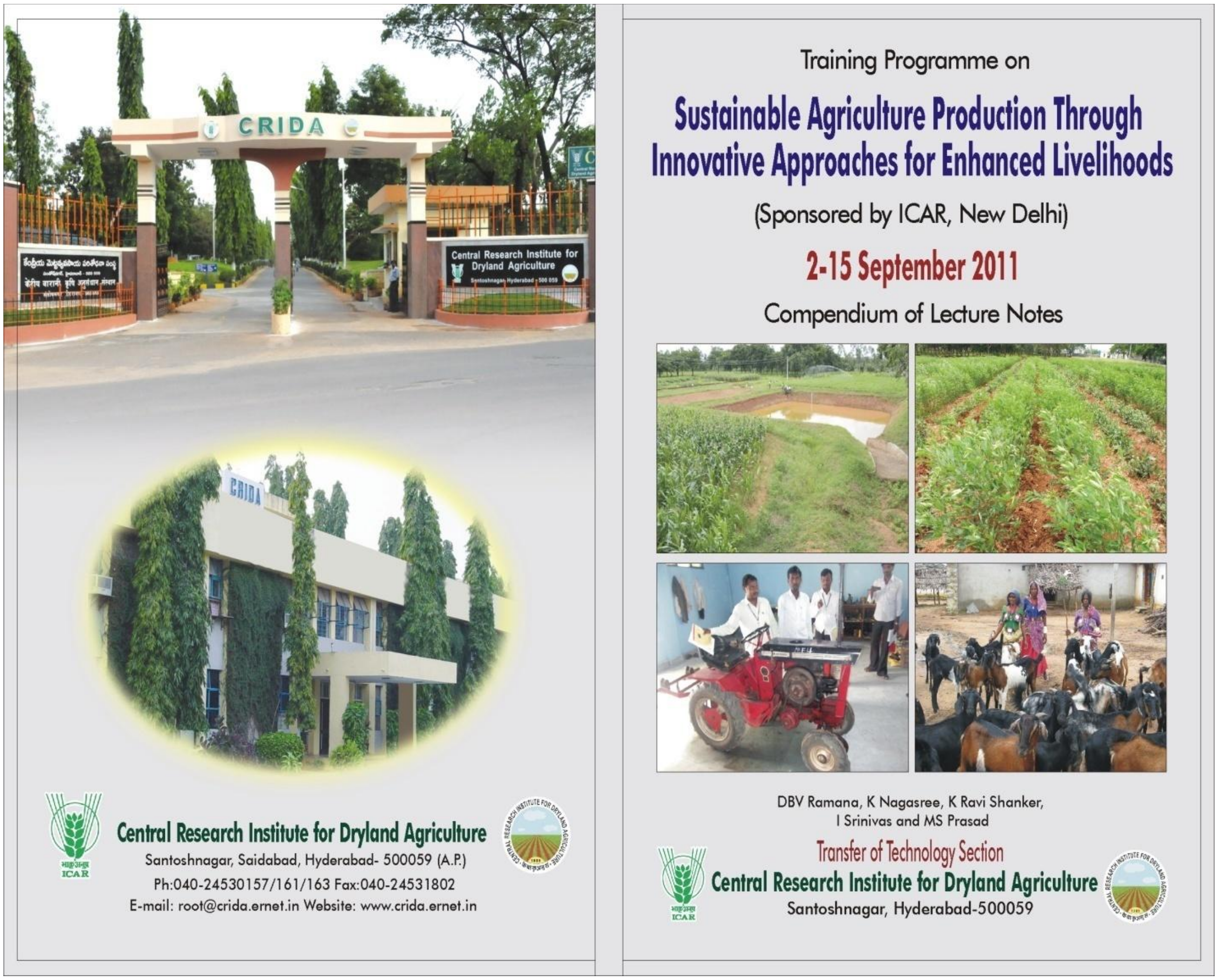
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RAINFED AGRICULTURE: STRATEGIES FOR LIVELIHOOD ENHANCEMENT

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Abstract

Indian economy is mainly dependent on agriculture, which contributes 21 per cent of the country's GDP and 60 per cent of the employment. Rainfed agriculture occupies 67 percent net sown area, contributing 44 percent of food grains and supporting 40 percent of the population. In view of the growing demand for food grains in the country, there is a need to increase the productivity of rainfed areas from the current 1 t ha^{-1} to 2 t ha^{-1} in the next two decades. The quality of natural resources in the rainfed ecosystem is gradually declining due to over exploitation. Rainfed areas suffer from bio-physical and socio economic constraints affecting the productivity of crops and livestock. In this context a number of economically viable rainfed technologies have been discussed. These include soil and rainwater conservation measures, efficient crops and cropping systems matching to the growing season, suitable implements for timely sowing and saving of labour, integrated nutrient and pest management (INM and IPM). To provide stability to farm income during drought and to utilize the marginal lands, different alternative land use systems like silvipasture, rainfed horticulture and tree farming systems were evolved and demonstrated on watershed basis. Integration of livestock with arable farming systems and incorporation of indigenous knowledge in farming systems perspective are also discussed. Formation of self help groups, use of innovative extension tools like portable rainfall simulators and focus group discussions to help for quick spread of the rainfed technologies in the farmers' fields are highlighted. The farming systems approach in rainfed agriculture not only helps in addressing income and employment problems but also ensures food security.

Introduction

The Indian economy is mainly dependent on agriculture, which contributes 21percent of country's capital GDP and 60 percent of employment potential. India made rapid strides in food production during last three decades culminating in self-sufficiency and surplus production. However, feeding the ever-increasing population through the next millennium remains an uphill task. The country will have to feed about 1.3 billion people by the year 2020 requiring 5-6 mt of additional feed grains every year. Besides, the problems of poverty and malnutrition have their own implication to national food security. Over 70 percent of Indian population, which is predominantly rural, do not have proper access to food and non-food commodities due to poor employment and infrastructure facilities. This reminds all those concerned with the country's food security of the daunting task ahead in order to ensure access to food to the growing population. Rainfed agriculture occupies 67 percent of net sown area, contributing 44 percent of food grain production and supporting 40 percent of the population. Even after realization of full irrigation potential of the country, 50 percent of net sown area will continue as rainfed (CRIDA, 1997).

At present 95 percent of area under coarse cereals, 91 percent under pulses. 80 percent under oilseeds, 65 percent under cotton and 53 percent under rice is rainfed (Government of India, 1994). Livestock forms an integral part of rainfed ecosystem and two out of every three animals are thriving in these regions. These areas are spread-out throughout the length and breadth of the country with semi-arid to sub-humid environments, shallow textured light soils to deep textured black and alluvial soils with varied effective crop growing periods from 90 to 180 days.

Scenario of food demand and resources

The food grain requirement of the country is 243 mt by the year 2007-08, out of which food demand could be about 104 mt of rice, 84.3 mt of wheat, 34.4 mt of coarse grains and 21.5 mt of pulses, 9.5 mt of oilseeds and 119.5 m t of milk and 110.7 mt of vegetables and for fruits 70.5 mt. The food grain requirements have been projected for 2025 at 308 mt with low growth population of 1286 million. But at higher population growth scenario(1333 million), the projected food grain production is 320 mt by 2025 (Kumar et al,2005).More than the calories, ensuring protein security will become an important issue in view of the predominantly vegetarian habits of the populace and the dwindling availability of vegetable (pulses) proteins whose current supply is about 25 g head^{-1} day^{-1} against the minimum dietary need of about 70 g.

The agriculture production increased from 50 mt to over 200 mt, between 1950-2000, thanks to green revolution. This, however, had its own costs in terms of degradation of land and water resources, loss of plant biodiversity, shift of agricultural land to non-agricultural uses, polluted environment, widening gap between the rich and the poor. Thus, physical access to food was the most important food security challenge in the past but economic and access to food has now become the most important cause of hunger and ecological access to food might become the most important concern in the next millennium owing to the damage now being done to land, water, flora, fauna and atmosphere.

Shrinking of natural resources

The per capita availability of agricultural land in India was 0.46 hectares in 1951 which decreased to 0.15 hectares in 2000 as against the global average of 0.6 ha. Number of persons per hectare of net-cropped area was 3 in 1951, 6.5 in 2000 and is estimated at 8 persons in 2025. This situation of rapidly declining land to man ratio is likely to worsen further owing to competitive demand for food, fibre, fuel, fodder, timber and developmental activities such as urbanization and industrialization, special economic zones,mining, road construction and reservoirs etc.

Constraints of production in rainfed areas

The rainfed lands suffer from a number of biophysical and socio-economic constraints which affect productivity of crops and livestock. These include low and erratic rainfall, land degradation and poor productivity (Abrol and Katyal, 1994), low level of input use and technology adoption, low draft power availability (Mayande and Katyal, 1996), inadequate fodder availability low productive livestock (Singh, 1997), and resource poor farmers and inadequate credit availability.

Strategies for Sustained Food Production in Rainfed Region
Identification of viable rainfed technologies

A number of economically viable rainfed technologies have been developed over the years in the country to address the problems of food production in rainfed agriculture through CRIDA and its network centre for the last three decades. These technologies have been evolved after refining them in farmers' field through Operational Research Projects, Institute Village Linkage Program (IVLP) and farm science centres. These include simple practices like off-season tillage in rainfed Alfisols and related soils for better moisture conservation and weed control. Farmers in Operational Research Project (ORP) areas of Hyderabad adopted this practice in sorghum and castor and realized yield advantage by 40 percent over traditional practice. Lack of adequate draft power with many small farmers, however, is one of the major constraints to popularize this practice. Custom hiring of tractor is effective solution of farm mechanization on these lands.

Soil and rain water conservation techniques

Efficient conservation of rainwater is the central issue in successful dryland farming. Extensive trials conducted by the soil conservation and dryland research centres have led to the identification of a number of inter-terrace land treatments besides contour and graded bunds (Sharma et al., 1982). These techniques are location specific and the benefits from their adoption are highly variable depending on the rainfall intensity, slope and texture of the soil besides the prevailing crop/cropping system. (Katyal and Das, 1993).

Farmers have not widely adopted mechanical measures like contour bunds, graded bunds, grassing of waterways and construction of farm ponds without the government support due to financial constraints. However, studies at Hyderabad, Bangalore and Anantapur revealed that more than 80 percent farmers follow simple conservation measures like sowing across the slope, opening of dead furrows and key line cultivation. The yield improvement by adoption of soil and water conservation measures vary between 12 and 20 percent which are at times not convincing enough to farmers. However, cumulative effects are significantly visible at some locations. Since such measures help in long-term conservation of resources, these are implemented through the Government of India or the respective State Government sponsored watershed management programmes.

Timely planting of crops

Timely sowing and precision are essential for getting good plant stand, higher yield and optimum utilization of rainfall and reduction in the incidence of pests and diseases. A number of demonstrations have been taken up in farmers fields through ORPs, KVKs and IVLP programmes in different rainfed regions of the country .In case of sorghum and castor in farmers fields of Hyderabad, a fifteen day delay in sowing led to reduction of 300 and 850 kg/ha compared to normal sowing. Inadequate availability of farm implements and draft are major constraints. However, seeding and interculture experiments developed by CRIDA and AICRPDA centres helped in overcoming the constraints to some extent.

Adoption of improved crop varieties

A number of improved varieties and hybrids were evaluated in the farmers fields to identify suitable ones for matching growing periods for inter and sequence rainfed cropping systems. For example, farmers gained additional benefit ranging from Rs. 2000-4000/ha by adopting improved varieties of sorghum, castor and sunflower in Alfisols of Hyderabad.

Efficient crops and cropping systems

To achieve appropriate land use, efficient inters and sequence-cropping systems were recommended based on soil type, rainfall and length of growing seasons. The studies at Hyderabad indicated only 25 percent farmers adopted 2:1 ratio of sorghum-pigeonpea. Whereas 45 percent of farmers adopted the finger millet + pigeonpea system (8:1) ratio in Alfisols of Karnataka and maize + soybean system (2:2) was accepted by Ranchi farmers. Groundnut + pigeonpea (7:1) was widely accepted by the farmers in Rayalseema of Andhra Pradesh. Some of the constraints for wider adoption by the farming communities are preference for fodder genotypes in cereals rather than grains for feed to live stock, lack of suitable farm implements to seed in different ratios, delay in planting of kharif for double cropping systems. These have to be refined under on-farm situations for greater acceptance by the farmers

Farm implements

Proper tillage and precise placement of seed and fertilizers in the moist zone are most critical to for successful crop establishment in drylands. Since the sowing of crops must be completed in a short span of time, use of appropriate implements is necessary to cover large area before the seed zone dries out. Suitable implements have been recommended for various locations to meet this requirement. These are designed to suit the soil type, crop and the draught power availability. In many cases, the existing local implement used by the farmers have been improved to increase their working efficiency (Gupta and Sriram, 1987).

Studies at CRIDA in farmers' fields of Telangana indicated that use of the drill plough for sowing of castor and sorghum crops showed no variation in yields of the crops and plant as compared to farmers practice resulted 1 ½ times more coverage compared to farmers' method of seeding . Two labourers who are required for placement of seed and fertilizer in farmers methodcan be saved with the drill plough. Thus a saving of Rs. 187/ha is possible wit a drill plough compared to the traditional plough and plant system.

Nutrient management

Fertilizer recommendations in rainfed crop production have been made primarily for NPK along with the conjunctive use of chemical, organic and bio-fertilizer (Rao and Das, 1982). Inclusion of legumes in cropping systems can supplement fertilizer N to the extent of about 20 kg N per ha. Conjunctive use of fertilizer N with FYM, croppings of luecaena and gliricidia help in reducing the requirement of fertilizer by 50 percent (Reddy et al., 1996).

Integrated pest management (IPM)

Pests and deceases constitutes a major constraint to increased food production. Crop losses due to pest attack range from 10-30 percent depending on the crop and environment. Complete crop failure may occur in case of serious attack. Indiscriminate use of the pesticides in rainfed crops will lead to harmful side effects such as direct toxically to the applicator or consumer, development of strains or pests resistant to pesticides, resurgence of pest species, outbreak of secondary pesticides, destruction of non-target organisms such as parasites and predators and accumulation of harmful residues of food products. Integrated pest management is one of the alternatives for the chemicals used for pest management. IPM encourages the most comfortable and ecologically sound combination of available pest suppression techniques and to keep the pest population below economic threshold. Easily adaptable and economically viable integrated pest management strategies have been developed for the control of major pest in rainfed crops like cotton and pulses.

Alternate Land use Systems

Despite evolving a number of production technologies, arable cropping in drylands continues to suffer from instability due to aberrant weather. To provide stability to farm income and also utilize the marginal lands for production of fodder, fuel wood and fibre, a number of alternative land use systems were evolved based on location specific experimentation and cafeteria studies (Singh, 1988). In addition to the above general guidelines, specific experiments have been carried out to develop land use practices for different categories of soils across the centres integrating annual crops with the perennial component in order to utilize the off-season rainfall (Katyal et al., 1994). Different alternate land use systems include agri-silviculture, silvi-pasture, agri-horticulture, alley cropping etc.

Integration of live stock with rainfed farming systems

Live stock is treated as a part of farming system in rainfed agriculture in India. The soil, plant, animal cycle is the basis for all feed used by the animals. The livestock in the rainfed regions are weak. Farmers in this area often sell their cattle due to the scarcity of fodder. In India the land holdings are being reduced with increased population pressure. Hence, land not suitable for agriculture has to be diverted for raising fodder need of animals through the appropriate alternate land use system such as improved pasture, silvipasture, hortipasture and tree techniques.

Integration of the technologies through watershed approaches

The concept of watershed is important in efficient management of water resources. As the entire process of agricultural development depends upon the status of water resources, the watershed with distinct hydrological boundary is considered ideal for taking up a development programme. In brief, planning and designing of all soil conservation structures are carried out considering the peak runoff. In this context, the watershed concept is of practical significance. Also, the entire development needs are to be taken up on topographic considerations from ridge to valley.

Resource Conservation Measures

Details about conservation measures adopted in cultivated lands have been delineated by Katyal et al., (1995) and Sharma and Mishra (1995). Based on the nature and type of barriers and their cost, the conservation measures in arable lands can be divided into three categories: (i) Hardware treatments (ii) Medium software treatments and (iii) Software treatments.

Farming system approach

Of late, it has been increasingly recognized that unlike irrigated areas, it is difficult to develop profitable technologies for heterogeneous agro-ecological and socio-economic conditions of small holders in arid and semi-arid regions (Osten et al., 1989). Since, the problems are complex ,addressing only a component of the farming system, e.g crop variety, fertilizer use or even crop husbandry per se is not expected to bring about a significant increase in the productivity as witnessed in irrigated areas. The extension strategy should be such as to match this challenge.

The farming systems perspective, dovetailed on watershed approach therefore can be the appropriate management strategy for such regions (Chambers, 1991).

The following steps constitute the farming systems mode for research, both on-station and on-farm (Watershed)

- PRA and assessment of socio-economic conditions of people.
- Identification of ITK (indigenous technical knowledge)
- Collection of available technological knowledge on various components of the farming system – arable farming, animal husbandry, water harvesting, management of wastelands and alternate land use systems etc.
- Focus group (farmers) interaction to identify appropriate technology for different categories of farmers.
- Identification of lead farmers to function as facilitator in technology application and adoption.
- Identification of points of synergy among systems components.
- Structuring of technological components with maximum synergy.
- Phasing of program over the project period

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ADOPTION AND IMPACT OF INTEGRATED PEST MANAGEMENT IN COTTON AND PIGEONPEA

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Introduction

The new agricultural technologies such as improved crop varieties, use of chemical fertilizers have led to substantial productivity gains. Another factor associated with the growth in productivity is the substantial increase in the use of chemical pesticides, both in terms of area covered by plant protection and quantity of chemicals applied per unit of cropped area (David, 1986; Birthal *et al*, 2000). The use of chemical pesticides was widely adopted, especially by better endowed farmers and in the case of commercial crops, as farming became more market oriented. However, high and indiscriminate use of pesticides has led to problems such as pest resurgence, resistance, health and environmental hazards (Armes *et al*., 1992) on one hand and increased dependence of farmers on external inputs on the other. The market imperfections, as reflected in poor quality of pesticides, high interest rates on borrowed capital, unfavourable out prices etc., also contributed another dimension to the 'crisis' associated with the indiscriminate use of pesticides (Chowdry *et al*, 1998). In response to such a scenario, researchers have been trying to develop alternative means of pest management which are known as Integrated Pest Management (IPM) practices (Pedigo, 1991).

Spedding (1988) defined IPM system as a group of interacting components operating together for a common purpose – to keep the pest populations below the economic threshold levels. These components include cultural, mechanical, physical, biological and lastly chemical measures. The IPM basically involves application/use of a variety of means that aim to manage pest populations below the economic threshold level (Smith and Reynolds, 1966; FAO, 1971). The input requirements, managerial skills and information needs of IPM therefore vary from those of chemical pest control and hence need to be examined more closely. The need for IPM is even more in rainfed agriculture characterized by poor biophysical and socioeconomic environment (Kanwar, 1999).

There are several definitions for IPM. The main motto of IPM is to minimize the use of synthetic pesticides and to maximize the natural regulatory mechanisms to maintain pests below the levels at which they cause economic damage (Perfect, 1992). A review of available literature reveals that substantial progress has been made in developing a range of IPM practices for cotton (Jayaraj *et al*, 1992; Venugopala Rao, 1995) and pigeonpea (Girradi et al ,1994, Shanover *et al*, 1999 and Srinivasa Rao ,2001). It is however to be noted that these practices have to be adapted to the specific needs and resources of the given situation.

Adoption of technologies has attracted attention of researchers (Feder *et al*, 1984). Adoption is a logical end to the process of technology development. Unless the technology is adopted by the farmers, the gains from the innovations can not be realized and the investments that go into the technology development, can not be justified. Adoption of technologies is a function of many factors related to the technology itself, farmers' managerial abilities and the enabling socioeconomic environment.

Here, we present the factors affecting adoption of IPM and the farm-level impact in case of two crops, cotton and pigeonpea. This is based on the data collected from farmers in Guntur and Rangareddy districts of Andhra Pradesh.

Analytical methods

Factors influencing adoption of IPM

Adoption can be defined in two ways. First, it can be considered as a dichotomous measure when the number of farmers following a particular technology is considered. Secondly, it can be considered as a continuous variable when viewed as a degree of use (quantity of fertilizer per hectare, percentage of farmers using a technology, percentage of area where IPM is followed). In this paper, we attempted to assess adoption in both 'whether' and 'extent' terms. We first attempted to analyze the factors that influence the adoption decision. Then, we tried to measure the extent of adoption of the technology, the IPM in this case, by the adopters.

The decision to adopt or not to adopt the IPM essentially takes the form of a binary variable and therefore can be analysed with logit or probit models. These models relate the dependent and the independent variables nonlinearly. The multivariate logistic regression models have been used to analyse the farmers' adoption decision with respect to different technologies.

The decision of a farmer to adopt or not to adopt a technology is influenced by a variety of factors related to the farmer (decision maker) and the farm. In this study, the decision to adopt IPM was regressed on a set of independent factors viz., farmers' age (X_1), education (X_2), family labour availability (X_3), participation in social groups (X_4), ability to recognize the pests and natural enemies (x_5), farm size (X_6), proportion of area under the pigeonpea (X_7), and access to irrigation (X_8). The specification of these variables and the descriptive statistics are given in table I. Since the dependent variable, the adoption of IPM, is a binary variable, and the independent variables are a mix of qualitative and quantitative variables, the multivariate logistic regression as given below was used to examine the influence of these factors on the adoption decision.

$$Y = Ln (P/(1-P)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_5 X_5 + \beta_6 X_6 + \beta 7 X_7 + \beta_8 X_8$$

where P is the probability that the farmer adopts IPM and (1-P) is the probability that the farmer does not adopt the IPM and the βs represent the regression coefficients estimated by the maximum likelihood method. These coefficients represent the change in the log of odds of adoption of IPM for a unit change in the corresponding independent variable. We computed the

e^{β}, which gives the odds ratio, associated with change in the independent variable. The analysis was done using SPSS12.0.

Measuring the extent of IPM adoption

The adoption can be measured as an extent or degree of adoption also. IPM is a continuum spanning from complete dependence on chemical insecticides at on end to a combination of a wide range of cultural, mechanical, biological and chemical means at the other end. In order to understand the extent of IPM adoption, we attempted to measure IPM adoption as a weighted score. The weighted scores were computed as follows: First, a list of all the plant protection practices followed by the IPM farmers was developed. Then, these practices were divided into four categories – cultural, mechanical, biological and chemical. These categories were given different weights considering their importance in IPM. Thus these four categories were given weights of 0.30, 0.20, 0.35 and 0.15, respectively. These weights were arrived at in consultation with the entomologists working on pest management in the selected crops. Then, the number of practices followed in each category was multiplied by the respective weight and summed over all the categories to obtain a weighted score of IPM adoption for the farmer. Thus, the IPM score, Z, of a farmer is given by

$$\mathbf{Z = \Sigma w_j n_j}$$

where w= weight of the j'th category (j=1 to 4)

n= number of practices belonging to the jth category adopted by the farmer

After computing the individual IPM scores, farmers were divided in to three categories – low, medium and high adoption – by taking the 35 and 70 percentile scores as cut-off points. Thus, farmers whose score were equal to or below 35 percentile were categorized as low adopters, those falling between 35 and 70 percentile were categorized as medium adopters and those scoring greater than 70 percentile were classified as high adopters.

Farm level Impact of IPM

The impact of adoption of IPM technologies is examined by following a 'with and without' approach where in the mean values of the key parameters such as the use of plant protection chemicals, cost of cultivation, yield, net returns, of the 'IPM' farmers were compared with those of the non-IPM farmers. The differences were tested for their statistical significance applying t-test for continuous variables (inputs use, yield etc.) and χ^2 test for categorical variables (number of sick events).

Findings

Cotton

Table 1 lists different components of IPM recommended for cotton and the frequency of adoption of each practice. It can be observed that erecting pheromone traps in the crop was adopted by all the IPM farmers. Topping was adopted by 93 per cent and spraying of Neem Seed Kernel Extract (NSKE) and neem oil by as many as 87 per cent. Adoption of biological means of pest management such as NPV and *Bacillus thuringiensis* is not as popular with only 24 per cent adopting because of the constraints in availability. In order for these components of IPM to be effective, time and method of application (e.g. NPV is to be applied during the cooler hours of the day and with adjuvants to reduce photodegradation and enhance efficacy) are very critical. Since many farmers are not aware of these finer aspects of use of biorationals, they often do not obtain the potential benefits. Only 30 per cent of adopters collected the larvae mechanically as it is a labour-intensive practice.

Table 1. Adoption of different components of IPM in cotton, Guntur district

PRACTICE	**ADOPTERS (NO)**	**ADOPTERS (%)**
Pheromone traps	90	100
Topping	84	93
Botanicals (Neem oil, SKE)	78	87
Trap and border crops	59	66
Bird perches	62	69
Resistant variety (Bt)	54	60
Mechanical collection	27	30
Biorationals (NPV, Bt, *Trichogramma*)	22	24

Factors influencing adoption

The characteristics of IPM farmers and non-IPM farmers are presented in table 2. It is seen from the table that the IPM farmers were relatively younger, had more years of schooling, had more family labour availability in terms of adults per house hold and were members in some social organizations such as farmers' clubs, user groups, self help groups etc. The IPM farmers also could identify a more number of pests and natural enemies than the non-IPM farmers. However, the IPM farmers have sown about 49 per cent of land to cotton compared to 75 per cent in case of non-IPM farmers. The average farm size of IPM farmers was about 5.1 ac compared to 6.6 ac in case of non-IPM farmers. Further, as many as 59 per cent of IPM adopters also grew chillies, another important commercial crops requiring investments in plant protection, compared to 39 per cent in case of non-adopters.

Table 2. Characteristics of IPM adopters and non-adopters in cotton in Guntur District

VARIABLES	UNIT	COTTON	
		IPM	Non –IPM
Age	Years	39(10)	45 (12)
Literacy	%	70	53
Adults	No/HH	3(0.97)	2 (1.3)
Children	No/HH	0.8(1.0)	0.6 (1.1)
Membership	%	64	30
Pest recognition ability	Score	6.2(1.9)	5.1 (2.1)
Farm size	Ha	5.1(2.5)	6.6(4.7)
Cotton	%	48.8(19.9)	74.5 (17.6)
Irrigation	%	18.6 (25.6)	12.8 (21.5)
Chillie	%	59	39

Figures in parentheses are standard deviations.

The maximum likelihood estimates of the logistic regression model obtained with SPSS 12.0 are presented in table 3. The table gives the estimated regression coefficients along with the significance levels, the odds ratio and the model fit statistics in the form of Negelkerke R^2, log likelihood and the percent correct classification. The model estimated was found to be a significantly good fit as can be seen from all the three criteria mentioned. The Negelkerke R^2 was about 0.66 and the log likelihood (-2 log LL) of 124.71 was significant at one per cent. The model predicted about 83.7 per cent of the cases correctly as either adopters or non adopters. Further, the model predicted 83.1 per cent of adopters and 84.3 per cent of non-adopters correctly.

The results from logistic regression analysis showed that all the variables except irrigated area included in the model significantly influenced the decision to adopt IPM technologies. The farm size, proportion of area under cotton and age of the farmer influenced the adoption decision negatively whereas the other variables influenced positively. As can be seen from the table, as the farmers' age increases by one year, chances of adoption will decrease by about 4 per cent the odds ratio being 0.94. Similarly, an illiterate farmer has only 44 per cent chances of adoption of a literate farmer. Participation in community based organizations such farmers' clubs also enhanced the probability of adoption of IPM. The IPM technologies require more labour compared to the dependence on chemical insecticides alone. Thus the bigger farms and larger acreage under cotton are less likely to attract IPM, which is reflected in the negative coefficients of the farm size and the area under cotton. The significantly positive coefficient for labour endowment as measured by the number of adults per household only reinforces this observation. Further, chillies is an important commercial crop grown in the area and requires considerable efforts in plant protection against pests and diseases. Farmers are being supported with knowledge on ways of plant protection (including IPM) and the necessary inputs such as pheromone traps. There is a possibility of chillie growers also apply the knowledge and use of IPM to cotton as well. The significantly positive coefficient for the variable 'chillies' confirms such a hypothesis.

Table 3. Logistic regression results for adoption of IPM in cotton, Guntur district, AP

VARIABLE	B	SE	WALD	OR
Constant	4.37*	1.56	7.80	
Age (yrs)	-0.06*	0.02	7.58	0.94
Education (yrs)	-0.82@	0.51	2.61	0.44
Adults (No/HH)	0.67*	0.25	7.34	1.94
Membership (0,1)	2.05*	0.51	15.89	7.77
Ability (score)	0.22@	0.12	3.45	1.25
Farm size (ha)	-0.27*	0.09	9.58	0.76
Crop (%)	-0.08*	0.02	31.63	0.92
Irr (%)	0.01	0.01	0.94	1.01
Chillie	1.22*	0.50	6.01	3.41

*and @ indicate significance at 1 and 10%, respectively .
Nagelkerke R^2 :0.66 -2log LL:124.71 Corr.class:83.7%

Extent of adoption

In the above analysis a farmer was considered to be an IPM adopter if he or she adopts at least four different components of IPM. However, there can be variations in the extent of adoption of different components of IPM. In order to measure the extent of adoption, scores were computed for all the IPM farmers. The findings are presented in table 4. Twenty four different components of IPM were observed to be followed by the IPM farmers. As many as fourteen were cultural practices, five were chemical, three biological and two mechanical. A farmer adopting all these twenty four practices in his effort to manage pests below the economic threshold levels, he or would get a score of 6.4. The scores of the farmers were found vary between 2.8 and 3..8 with an average score of 3.3. About 37 per cent of farmers scored below 2.8 (35.5 percentile) and were classified as low adopters. Only 28 percent of farmers were found to achieve high adoption scores (>3.85, the 70 percentile). The remaining 35 per cent of farmers were classified as medium adopters with scores between 2.8 and 3.85. Thus there was observed variation in adoption within the adopters.

Table 4. Extent of IPM adoption in Cotton in Guntur district, Andhra Pradesh

CATEGORY	WEIGHT	NO. OF PRACTICE FOLLOWED
Chemical	0.15	5
Cultural	0.3	14
Biological	0.35	3
Mechanical	0.2	2
Max score		6.4
Avg score (range)		3.3 (2.8-3.8)

Groundnut

Table 5 lists different components of IPM recommended for pigeonpea and the frequency of adoption of each practice. It can be observed that ploughing during summer before sowing the crop is the most adopted component of IPM adopted by the farmers. A majority of IPM farmers (about 90%) also rotate crops such as sorghum, maize, pearl millet with pigeonpea in order to break the pest build up. Spraying of Neem Seed Kernel Extract (NSKE) and neem oil was found to be adopted by as many as 75 per cent of the sample farmers. Adoption of biological means of pest management such as NPV and *Bacillus thuringiensis* is not as popular because of the constraints in availability. In order for these components of IPM to be effective, time and method of application (e.g. NPV is to be applied during the cooler hours of the day and with adjuvants to reduce photodegradation and enhance efficacy) are very critical (Ravindra and Jayaraj, 1988). Since many farmers are not aware of these finer aspects of use of bio-rationals, they often do not obtain the potential benefits.

Table 5. Adoption of different components of IPM by farmers in pigeonpea in Rangareddy district (n=90)

PRACTICE	ADOPTERS (%)
Spraying NPV	7
Spraying NSKE or neem oil	75
Spray of conventional insecticides	72
Spray of profenophos	15

Spray of spinosad	30
Pheromone traps	17
Summer ploughing	97
Crop rotation	90
Intercrops	27
Border crops	22
Use of resistant variety	92
Clipping tender tips	53
Erecting bird perches	47
Hand picking	63

Factors influencing adoption

The characteristics of IPM farmers and non-IPM farmers are presented in table 6 It is seen from the table that the IPM farmers were relatively younger, had more years of schooling, had more family labour availability in terms of adults per house hold and were members in some social organizations such as farmers' clubs, user groups, self help groups etc. The IPM farmers also could identify a more number of pests and natural enemies than the non-IPM farmers. However, the IPM farmers have sown about 83 per cent of land to pigeonpea compared to 87 per cent in case of non-IPM farmers. The average farm size of IPM farmers was about 10.9 ac compared to 9.1 ac in case of non-IPM farmers.

Table 6. Characteristics of adopters and non-adopters of IPM in pigeonpea, Rangareddy district

CHARACTERISTIC	UNIT	ADOPTERS		NON-ADOPTERS	
		Mean	SD	Mean	SD
Age	Years	42	12.6	43	13.6
Schooling	Years	6.7	11.4	2	3
Adults	No HH^{-1}	3.9	1.6	3.8	1.9
Children	No HH^{-1}	1.2	1.1	0.9	1.2
Membership	1,0	47		41	
Ability	Score	6	1.6	4.4	2.0
Farm size	Ha	10.9	8.5	9.1	8.3
Crop area	%	82.6	19.6	86.7	18.9
Irrigated area	%	6.4	13.9	4.8	13.2

HH: Household

The maximum likelihood estimates of the logistic regression model obtained with SPSS 12.0 are presented in table 13. The table gives the estimated regression coefficients along with the significance levels, the odds ratio and the model fit statistics in the form of Negelkerke R^2, log likelihood and the percent correct classification. The model estimated was found to be a significantly good fit as can be seen from all the three criteria mentioned. The Negelkerke R^2 was about 0.46 and the log likelihood (-2 log LL) of 115.31 was significant at one per cent. The model predicted about 75 per cent of the cases correctly as either adopters or non adopters. Further, the model predicted 72 per cent of adopters and 78 per cent of non-adopters correctly.

An examination of the logistic regression coefficients indicates that age of the farmer, schooling, participation in social groups and ability to recognize the pest and natural enemy species influenced the adoption decision significantly. As can be seen from the table, each year of schooling increased the odds of adoption of IPM by 37 percent. Similarly, as the age of the farmer increased by one year, the odds would decrease by two per cent. Thus, younger and educated farmers are more likely to adopt IPM technologies. This inference is not surprising because the younger farmers are more ambitious and more receptive to the newer technologies and the education will place them in a better position to obtain the relevant information and the necessary inputs. The participation in social groups also influenced the adoption decision significantly. A farmer who is a member in some social group is 3.77 times more likely than a farmer who is not a member. The participation of a farmer in social groups enhances his or her social capital in terms of access to information and resources. Further, various development programmes are also emphasizing the technology transfer through self-help groups, user groups etc. to quicken and broad base the uptake of the technologies. Thus, the highly positive and significant influence of the social capital as represented by participation in social organizations is tenable. The IPM technologies require more labour compared to the dependence on chemical insecticides alone. Thus the bigger farms and larger acreage under pigeonpea are less likely to attract IPM, which is reflected in the negative coefficients of the farm size and the area under pigeonpea. The positive coefficient for labour endowment as measured by the number of adults per household though not significant only reinforces this observation. It may be of relevance to note that farmers with larger farms and more area under the crop concerned are more likely to adopt chemical plant protection measures as observed in case of castor (Rama Rao et al., 1997). Further, access to irrigation is highly correlated to the access and use of other purchased inputs such as fertilizers, which may influence IPM adoption positively. The relatively more assured returns from irrigated crops may also attract more managerial attention of the farmers as a result of which rainfed crops like pigeonpea might 'suffer' in which case the access to irrigation discourages IPM adoption. The observed non-significant coefficient indicates that the variable acted both ways.

Thus, the variables associated with the human and social capital (age, education, pest recognizing ability and participation in social organizations) and the relative resource endowments (farm size and human labour availability) influenced the IPM adoption decision significantly. It is acknowledged that the IPM components are more knowledge-intensive (CGIAR, 2000) and more labour using. Thus, any effort to transfer IPM technologies should address the communication aspects – giving the right information at right time and in a right way.

Table 7. Logistic regression results for adoption of IPM in pigeonpea, Rangareddy district

VARIABLE	β	SE	WALD	ODDS RATIO
Constant	-2.72^{*}	1.82	2.24	
Age	$-0.02^{@}$	0.02	1.27	0.98
Schooling	0.32^{*}	0.08	16.84	1.37
Adults	0.17	0.15	1.15	1.18

Membership	1.33*	0.53	6.16	3.77
Ability	0.54*	0.13	16.19	1.72
Farm size	-0.04@	0.03	2.32	0.96
Crop area	-0.02	0.01	1.13	0.98
Irrigated area	-0.002	0.02	0.01	0.99
Negelkerke R^2	0.46			
-2log likelihood[a]	115.31*			
Percent correct classification[b]	74.8			
Sensitivity[c]	71.7			
Specificity[d]	78.0			

* and @ indicate significant at 1 and 10 percent, respectively.
a Follows χ^2 distribution with 9 df.
b Based on a 50-50 classification scheme
c Prediction of farmers adopting IPM who were classified correctly
d Prediction of farmers not adopting IPM who were classified correctly

Extent of adoption

In the above analysis a farmer was considered to be an IPM adopter if he or she adopts at least four different components of IPM. However, there can be variations in the extent of adoption of different components of IPM. In order to measure the extent of adoption, scores were computed for all the IPM farmers. The findings are presented in table 8. Thirteen different components of IPM were observed to be followed by the IPM farmers. As many as seven of these thirteen were cultural practices, three were chemical, two biological and one mechanical. A farmer adopting all these thirteen practices in his effort to manage pests below the economic threshold levels, he or would get a score of 3.6. The scores of the farmers were found vary between 1.5 and 3.3 with an average score of 1.98. About forty five percent of farmers scored below 1.85 (35 percentile) and were classified as low adopters. Only 20 percent of farmers were found to achieve high adoption scores (>2.15, the 70 percentile). The remaining 35 per cent of farmers were classified as medium adopters with scores between 1.85 and 2.15. Thus there was observed variation in adoption within the adopters.

Table 8 Extent of IPM adoption in pigeonpea, Rangareddy district

CATEGORY	WEIGHT	NO. OF PRACTICES FOLLOWED
Chemical	0.15	3
Cultural	0.30	7
Biological	0.35	2
Mechanical	0.20	1
Total	1.00	13
Maximum possible score	3.6	
Average score	1.98	
Range of scores	1.5 - 3.3	
Low adopters* (%)	45	
Medium adopters* (%)	35	

High adopters* (%)	20

* With scores less than 1.85 (low adopters), 1.85-2.15 (medium adopters) and >2.15 (high adopters)

Farm level Impact of IPM

Cotton

As mentioned earlier, the farm-level impact of the IPM was observed by comparing the key variables of IPM farmers with those of non-IPM farmers (Table 9). As a result of adoption IPM components, there was observed a steep decline in the use of chemical insecticides from about 18 l ha^{-1} in case of non IPM farmers to about 6.5 l ha^{-1} in case of IPM farmers. This also resulted in the saving on expenditure on plant protection chemicals. It is interesting to note that IPM farmers also applied more organic manures compared to the non-IPM farmers. The IPM adopters also harvested more kapas (23 q/ha) compared to 19 q/ha by non-adopters. The cost savings together with the increased yields resulted in obtaining significantly higher net returns (by 370%) from IPM farms compared to non-IPM farms. The cost of production also fell by about 42 per cent in IPM farms compared to non-IPM farms. Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. It was observed that about 48 per cent of farmers reported incidents of falling sick due to exposure to insecticides. This figure was only 17 per cent in case of IPM farmers. These health hazards would further lead to expenditure on health care as well as loss of wages during the period of illness. Thus, the adoption of IPM also had a desirable effect on the family or hired labour engaged in the application of chemical insecticides.

Table 9. Farm-level impact of adoption of IPM in Cotton in Guntur district, Andhra Pradesh

PARAMETER	UNIT	IPM FARMS	NON-IPM FARMS	CHANGE (%)
Farm Yard Manure	t ha^{-1}	13.71	9.46	44.86
Chemical nutrients	kg ha^{-1}	20.14	20.89	-3.55
Chemical insecticides	l ha^{-1}	6.48	3217.99	-63.99
Yield	q ha^{-1}	22.92	19.38	18.30
Expenditure on insecticides	Rs ha^{-1}	4244.42	12950.2	-67.225
Cost of cultivation	Rs ha^{-1}	19622.4	28386.3	-30.87
Net returns	Rs ha^{-1}	18076.2	3796.83	376.09
Cost of production	Rs q^{-1}	856.12	1464.72	-41.55
Incidence of sick events	%	17	48	

Pigeonpea

As mentioned earlier, the farm-level impact of the IPM was observed by comparing the use of chemical insecticides and yields of IPM farmers with those of non-IPM farmers. As a result of adoption IPM components, there was observed a steep decline in the use of chemical insecticides from about 9 l ha^{-1} in case of non IPM farmers to about 5 l ha^{-1} in case of IPM farmers (Table

10). This also resulted in the saving on expenditure on plant protection chemicals. It is interesting to note that IPM farmers also applied more organic manures compared to the non-IPM farmers. The adoption of IPM could protect the crop as can be observed from marginally higher yield levels obtained by the IPM farmers. The cost savings together with the increased yields resulted in obtaining significantly higher net returns (by 160%) and lower cost of production (by 37%) from IPM farms compared to non-IPM farms.

Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. It was observed that about one half of farmers reported at least one incident of falling sick because of exposure to insecticides compared to three out of 60 IPM farmers. These health hazards would further lead to expenditure on health care as well as loss of wages during the period of illness. Thus, the adoption of IPM also had a desirable effect on the family or hired labour engaged in the application of chemical insecticides.

Table 10. Farm-level impact of adoption of IPM in pigeonpea, Rangareddy district

PARAMETER	UNIT	IPM FARMS	NON-IPM FARMS	CHANGE (%)
Farm Yard Manure	t ha^{-1}	5.4	3.7	45.9
Chemical nutrients	kg ha^{-1}	67	61	9.8
Chemical insecticides	l ha^{-1}	5	9	44.4
Yield	q ha^{-1}	13	11	18.2
Expenditure on insecticides	Rs ha^{-1}	2500	5400	-53.7
Cost of cultivation	Rs ha^{-1}	12340	16580	-25.6
Net returns	Rs ha^{-1}	6268	2400	161.2
Cost of production	Rs q^{-1}	949	1507	-37.0
Incidence of sick events	%	3	30	-90

The differences are significant at 5 per cent probability at least.

Summary and conclusions

Research on and extension of IPM is a response to the changing ecological, economic and biological environment that the farming community is confronted with. In spite of the increasing emphasis on research and extension of IPM technologies, there are still some knowledge and information gaps that need to be filled for enhancing the adoption of IPM technologies. Farmers growing the three target crops, viz., cotton and pigeonpea, were found to follow a wide range of practices to manage the pests. The adoption of different components of IPM was found to be varying. On the whole the cultural components of IPM such as summer ploughing (more than 90% of IPM farmers), intercropping were adopted by more farmers. The adoption of biological components such as NPV, Bt was observed to be limited because of the constraints in availability as well as the lack of proper understanding on the application methods and efficacy of these components. All the IPM farmers were found to use pheromone traps in case of cotton. Apart from age and education of the farmers, the ability to recognize the insect pests and participation in CBOs were found to influence IPM adoption positively. Adoption of IPM was observed to be more in case of cotton where the incidence of insect pests is high compared to other two crops. The adoption of IPM was found to lead to reduction in use of insecticides, reduced cost of cultivation and increased net returns. Another important benefit associated with adoption of IPM was the reduction in incidence of sick events arising from exposure to insecticides. Use of new generation insecticides was found to discourage IPM adoption as farmers find them more effective. The adoption of IPM was found to have desirable impact on plant protection expenditure, use of chemical insecticides and profitability of crops and more importantly on the incidence of health hazards to farm labour.

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IMPORTANCE OF MICRONUTRIENTS IN DRYLAND CROPS: EXPERIENCES FROM ON-FARM TRAILS UNDER NAIP

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Plants require 16 nutrients for proper growth and development. Nitrogen (N), phosphorus (P), and potassium (K), are needed in large quantities (macronutrients). Others, such as calcium (Ca), magnesium (Mg) and sulfur (S), are required in small quantities (secondary nutrients). Plant nutrients, like zinc (Zn), boron (B), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo) and chlorine (Cl), are required in very small quantities (micronutrients). In rainfed regions of the country, declining soil fertility and nutrient imbalances are major issues affecting agricultural productivity (Srinivasarao 2011). Organic matter levels have declined sharply in intensively cropped regions, leading to stagnant yields of major food crops in India. In addition to universal deficiency of nitrogen, deficiencies of potassium, sulphur and micro nutrients are emerging as constraints for sustaining and or enhancing productivity under intensive crop production systems. Zinc, Sulphur and Boron deficiencies are widespread across the vast Dryland tracts of India. It is estimated that 29.4 m ha of soils in India are experiencing decline in fertility with a net negative balance of 8-10 m t of nutrients per annum. Poor nutrient use efficiency is another cause of concern. So far soil fertility issues have been addressed mainly in irrigated agriculture, but recent studies indicated that drylands are not only trusty but also hungry. Most of the soils in the rainfed regions are low in organic carbon and available N, and these soils are showing multi-nutrient deficiencies including secondary and micronutrients also.

Soil organic matter, being the storehouse of many plant nutrients has a significant effect on productivity besides improving water retention and soil microbial diversity. However, due to competing usages of organic resources, application of organic manure and crop residues has declined over time. Considering the growing nutrient imbalance in soils and crop plants, even if we use all organic manures available in the country, we will still have a large deficit of essential plant nutrients (Srinivasa Rao et al. 2009a, b). Use of chemical nutrients to some extent therefore, is inevitable to sustain agricultural productivity and food security of the country.

Fertilizers contribute about 50% of the increased yields as a component of improved technology**.** The dramatic increases in the yields of crops like wheat and rice have occurred because of high yielding varieties and higher fertilizer use. The yield potential of many dry land crops has not been tapped much despite the introduction of high yielding cultivars because of low nutrient use. About 80% of the fertilizer is consumed in irrigated areas while only 20% is used in the rainfed areas that constitute 65% of the cropped area. Hence, apart from several other reasons, low nutrient use in rainfed agriculture is one of the important causes of low yields (Srinivasarao et al. 2010). Efforts therefore need to be made to redefine the fertilizer doses by synchronizing with the crop nutrient demand water availability in the soil particularly in drylands.

The target area for this study comprised of eight backward and tribal dominated districts of Andhra Pradesh covered under the Component 3 sub project "Sustainable rural livelihoods through enhanced farming systems productivity and efficient support systems in rainfed areas" under NAIP, which is being implemented by a consortium led by the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad since September 2007 (Fig. 1). It aims at improving the livelihoods of the rural poor by improving the overall systems productivity by following good agricultural practices, better natural resource management and addressing the issues of profitability and sustainability through efficient institutional and support systems. The project sites are selected based on the criteria of dominance of rainfed farming, SC and ST population, low household income and poor infrastructure. General description of the study sites are given in Table 1.

Figure 1. Target districts where 84 villages were identified for demonstrations

Table 1. Details of study sites/villages selected in the target districts

District	Villages	No of villages	No. of House holds	Area (ha)	Characteristics of the cluster	Soil Type	Crops
Adilabad	Seethagondi, Garkampet, Arkapally, Old Somwarpet, Pedamalkapur, Chinamalkapur, Kotwalguda, New Somwarpet	8+2*	575	1296	High tribal population (70%) and close to forests, very low productivity and technology adoption. VSS are active.	Black	Cotton Pigeonpea Chickpea vegetables
Nalgonda	New banjara hills, Jamal kunta thanda, Seetamma thanda, Yellapa kunta	9+9	621	500	Highly drought prone area, off season employment and high	Red	Groundnut Pigeonpea greengram Sorghum vegetables Horticulture crops

	thanda, Chinagore kunta thanda, Pedagore kunta thanda, Peda seetharam thanda, China Seetharam thanda, Lalsingh thanda				migration rates, small hamlets/ tandas with more than 80% tribes.		
Khammam	Bheemavaram, Koremvarigumpu, Kurvapally Kothuru, Mamillavai, Ramavaram, Thummalacheruvu Venkatapuram	7+4	650	1000	High tribal population assigned and forest lands, poor communication and market facilities, and high indebtedness.	Red and black	Cotton, Sorghum Maize
Mahabub Nagar	Zamistapur Telugugudem Kodur Thanda	3+4	734	756	Highly drought prone area, more landless families, degraded lands, high livestock population, fodder scarcity, high migration and, limited livelihood opportunities.	Red and black	Castor, Sorghum, Groundnut
Anantapur	Pampanoor, Pampanoor Thanda, Yennamkothapally	4+4	576	1430	Most drought prone area, extensive monocropping of groundnut, re-peated crop failures and water shortages, limited livelihood opportunities.	Red (gravelly)	Groundnut
Kadapa	B.Yerragudi, Kapu Palli,	8+5	216	1060	Drought prone area	Red and	Groundnut Sunflower

	BA. Nagireddy Palli, Madhiga Palli, Moodindla Palli, Puttakarla Palli, Puttakarla Palli Colony, Konampeta				with predominance of small and marginal farmers with maximum erodable lands. Lacks proper credit and agricultural market facilities.	black	vegetables
Warangal	Jaffer gudem, Kusumbai Thanda and Satynarayana Puram, Jal Thanda, Ramanna Gudem, Vepalagadda thanda, Cherla thanda, Lokya thanda	7+3	689	2070	Village with high tribal population, degraded soils with good potential for water harvesting and drought proofing measures.	Red and black	Cotton Rice Pigeonpea
Ranga Reddy	Ibrahimpur, Dhadi Thanda, Roopsing Thanda, Malkaypet Thanda	4+3	409	346	Village with high migration rates and lack of irrigation facility, more forest land, high use of chemical inputs and indebtedness.	Red sandy	Maize Pigeonpea vegetables

*****Extended villages

With several interactions, meetings with farmers in these villages, farmers were sensitized to go for soil testing. Soil samples from 1850 farmers' fields covering 84 villages of the eight districts were collected during 2007-2010 with farmer participation in soil sampling. After conducting farmers' meeting in each village and depending upon soil type, crop, slope and management, about 30 per cent of farmers' fields were selected for sampling using stratified random sampling methodology. The identified farmers were made into groups for demonstration of soil sampling procedure. Collected soil samples were labeled with cluster, village and farmer's names. In most of the clusters, village sarpanch or village head was involved in participatory soil sampling. Collected soil samples were analyzed in the soil chemistry laboratory at the CRIDA.

During 2007-11, a total of 265 on-farm trials were conducted with different test crops in Adilabad (*kharif* cotton and *rabi* chickpea), Khammam (cotton), Warangal (cotton), Anantapur and Kadapa (groundnut), Mahabubnagar (Cotton, castor and rabi groundnut), Rangareddy (Maize and pigeonpea) and in Nalgonda (groundnut, green gram and vegetable crops like tomato and Bhindi) districts with the objective to demonstrate the comparative evaluation of SSNM including micro and secondary nutrients and farmers practice. Crops were grown on selected farmers' fields with known fertility status and SSNM based nutrient application.

Some of the villages in the districts (Warangal, Adilabad, Nalgonda, Khammam and Rangareddy) P build up in the soils were determined. In these farmer's fields, P dose was reduced to hulk (Srinivasarao et al., 2008 a, b. c). At present K application was no practiced. However, K deficient fields were found in all the districts and K fertilizer was introduced in these fields. Similarly sulphur, zinc and boron were applied depending upon soil test data. SSNM package for individual farmers' field was developed based on crop grown and soil test data. Nitrogen in invariably low in all the villages and recommended N was used for the crops.

Micronutrients in SSNM were compared with the farmers' practice in an area of half acre in each of the farmers' fields. The balanced nutrition included a recommended dose of fertilizers (90 kg N and 50 kg P_2O_5 for cotton, 20 kg N and 40 kg P_2O_5 for chickpea, groundnut and green gram, 150 kg N and 80 kg P_2O_5 for tomato and 120 kg N and 60 kg P_2O_5 for Bhendi) along with basal application of micro-nutrient mixture of 2.5 kg agribor/5 kg borax (0.5 kg B ha^{-1}), 50 kg zinc sulphate (10 kg Zn ha^{-1}) and 200 kg gypsum/elemental sulphur (30 kg S ha^{-1}) per hectare. Farmer's practice in each trial was documented, which included suboptimal dose of N and P. Entire dose of N and P was applied as basal. Besides other crop management practices like weeding and pest and disease control measures were followed.

Development of micro and secondary nutrient based fertilizer recommendations

Soil test data and deficiency of various nutrients in each farmer field tested was discussed with farmers and Department of Agriculture, line department experts and in the farmers meeting and field visits. Based on soil test data and crop grown in each field, nutrient recommendations sheet was developed. Site Specific Nutrient Management (SSNM) sheet were developed for various crops based soil test data.

Benefits to Farmers due Micronutrients

- **Adilabad:** In Adilabad district, the benefits of balanced nutrition were much higher. This could be due to continuous cotton-based system with a mean yield of 2.37 t ha^{-1} of seed cotton (SSNM) compared to mean yield of 1.66 t ha^{-1} in FP, registering 43.1% yield increase (Fig. 2). Low levels of fertilizer application to cotton, chickpea or cotton-pigeonpea intercropping system over the years resulted in mining of soil nutrients. Though, these villages are with 100 per cent tribal population, the cotton is grown for the last 10-15 years without much nutrient inputs. This is one of the reasons for higher cotton response to balanced nutrition. Among the *rabi* crops, chickpea (variety JG-11) showed significant response to SSNM in Seethagondi cluster of Adilabad district. Mean seed yield increased from 0.89 to 1.21 t ha^{-1} due to balanced nutrition, registering 35.1% yield increase. Being a pulse crop, its S requirement is met from added sulphur in the form of gypsum besides application of other nutrients. However, the variation in the crop response to balanced nutrition was wide among farmers' fields. The improvement in chickpea yield with balanced nutrition varied from 15 to 58% over farmer's practice. This indicates that with improved varieties of chickpea (JG-11), a well nourished crop can yield up to 1.5 t ha^{-1} on deep black soils of Adilabad district.

- **Khammam:** Soils in Tummalacheruvu cluster in Khammam district are fine textured red soils with multi-nutrient deficiencies . Cotton yields (Bt) ranged from 0.9 to 2.5 t ha^{-1} in farmers' practice with an average yield of 1.9 t ha^{-1} and yield levels improved in the range of 1.3 to 3.2 t ha^{-1} in SSNM with an average yield of 2.4 t ha^{-1}, showing 13.6-53.0% increase in yield (Srinivasarao et.al. 2008c).
- **Nalgonda:** In other crops like groundnut and green gram in Dupahad cluster of Nalgonda district, mean seed/pod yield increased from 1.08 to 1.41 t ha^{-1} and from 0.54 t ha^{-1} to 0.75 t ha^{-1}, respectively due to balanced nutrition, registering 31.1 and 39.6% yield increase (Fig 3). Similarly, greengram and groundnut response also varied from 33 % to 47% and 18% to 44%, respectively. Among vegetable crops, tomato and bhindi mean yield increased from 21.6 t ha^{-1} to 30.4 t ha^{-1} and 8.7 t ha^{-1} to 11.6 t ha^{-1}, registering 41% and 33% increase in yield, respectively in Nalgonda district.
- **Warangal:** In Jaffergudem cluster of Warangal, balanced nutrition improved cotton yields significantly in many farmers' fields. In some of the farmer's fields, cotton yields reached to 1.6 t ha^{-1} with balanced nutrition, registering the increase in yields from 5 to 30 per cent over farmers practice.
- **Kadapa:** In Kadapa groundnut yield increased from 0.65 t ha^{-1} to 0.82 t ha^{-1} due to balanced nutrition, registering the yield increase to the extent of 15 to 18%.
- **Anantapur:** Like in Kadapa, in Anantapur also groundnut yields were increased from 0.67 to 0.88 t ha^{-1} due to balanced nutrition. The response of groundnut to balanced nutrition ranged from 20 to 50%, but generally it was around 25%.
- **Mahabubnagar:** Castor and cotton and *rabi* groundnut responded significantly to micronutrient application. Among crops, response of cotton was the highest (26%) followed by castor (19 %) and groundnut (18%).
- **Rangareddy**: Maize and pigeonpea in light - textured sandy loam soils of Parigi cluster reponded to micro and secondary nutrient application. Maize being an exhaustive crop and soils are deficient in Zn, S, B and Fe, crop response was conspicuous due to nutrient applicaiton to the extent of 15-25 per cent among farmers' fields.

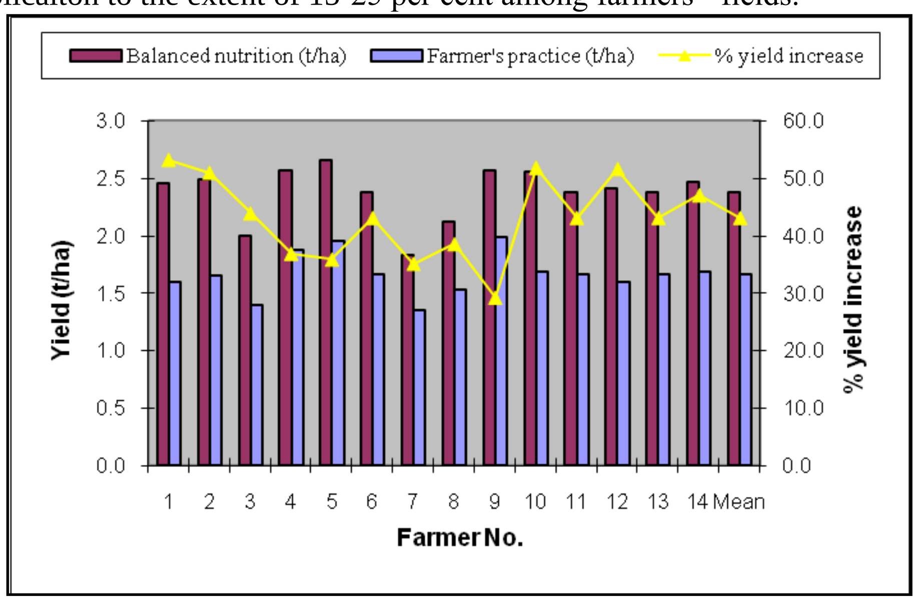

Figure 2. Effects of balanced fertilization on cotton yield in farmers' fields of Seethagondi cluster, Adilabad district, Andhra Pradesh, *Kharif* 2009-2010. (CD (P=0.05) 0.19).

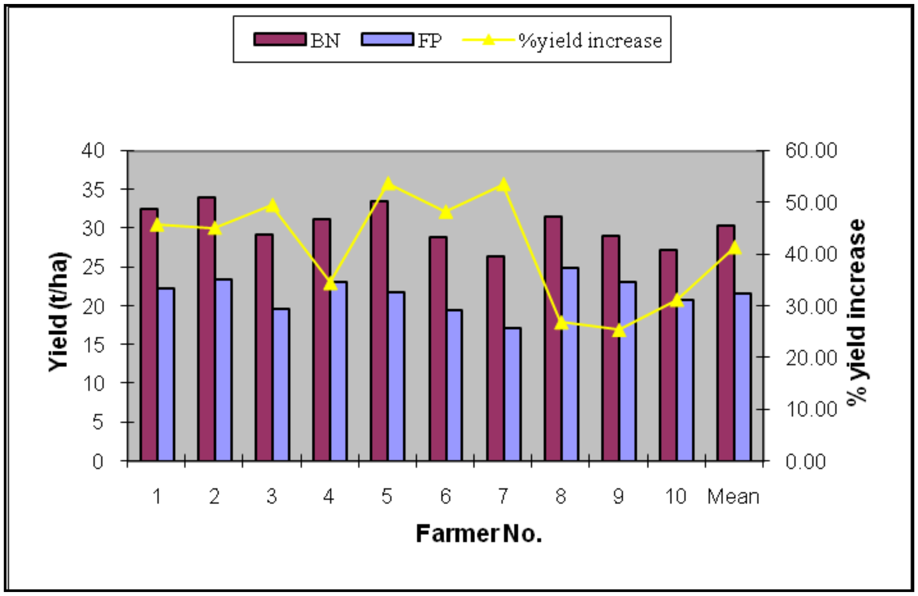

Figure 3. Effects of balanced fertilization on tomato yield in farmers' fields of Dupahad cluster, Nalgonda district, Andhra Pradesh, 2009-2010 (CD (P=0.05) 0.9)

Impact of micro nutrients on farm income

The economic viability of balanced nutrition over the farmers' practice was calculated depending on the prevailing prices of input and output costs. The additional cost incurred in the balanced nutrition as compared to farmers' practice was mainly due to micro and secondary nutrients and additional N and P. Net income and return per Re investment improved substantially through balanced nutrition (Srinivasarao et al. 2010, 2011).

Adilabad: In cotton, net income obtained varied from Rs. 30780 to 55530 ha^{-1} in Adilabad through balanced nutrition. Similarly, in other crops, net returns obtained was Rs. 5560-14210 ha^{-1} in chickpea in comparison Rs. 19210-38110 ha^{-1} in cotton Rs. 2230-8110 ha^{-1} in chickpea through farmer's practice at Adilabad. Mean value of return per Re investment was 2.97-3.05 and 1.78 in cotton, chickpea, respectively through balanced nutrition compared to 2.34-2.68 and 1.62, in farmer's practice.

Khammam: In cotton, the net income obtained varied from Rs. 15,030 to 70,530 ha^{-1} through balanced nutrition in comparison Rs. 5710-53710 ha^{-1} in cotton at Khammam.

Nalgonda: In Nalgonda net income obtained varied from Rs. 8380 to 13840 ha^{-1} in groundnut, Rs. 4207-8995 ha^{-1} in greengram, Rs. 47530-78330 ha^{-1} in tomato and Rs. 15570-38370 ha^{-1} in Bhendi through balanced nutrition in comparison Rs. 2600-8900 ha^{-1} in groundnut, Rs. 2375-

4895 ha^{-1} in greengram, Rs. 12926-43726 ha^{-1} in tomato and Rs. 4570-24370 ha^{-1} in Bhendi through farmer's practice. Mean value of return per Reinvestment was 1.60, 1.55, 2.09 and 1.78 in cotton, chickpea, groundnut, greengram, tomato and Bhendi, respectively through balanced nutrition compared to 1.39, 1.35, 1.55 and 1.42 in farmer's practice.

Warangal: In Warangal, net profit was in the range of Rs. 9033 to 22533 due to balanced nutrition compared to Rs. 10210 to17710 in farmers practice in cotton cultivation. Mean B: C ratio was also improved to the extent of 1.70 due to balanced nutrition.

Kadapa: In groundnut, net profit increased to Rs. 6300 due to balanced nutrition in comparison to Rs. 3530 in farmers' practice.

Anantapur: Similarly in Anantapur also, net profit was increased from Rs. 5200 to Rs. 6340 due to balanced nutrition. BC ratio was also improved from 1.51 to 1.67 due to balanced application.

Promotion of soil health cards in the villages

About 1500 farmers were provided soil health cards indicating the identification of the particular farmers' fields, nutrient status, deficiency or sufficiency, and recommendations to different crops and cropping systems. Soil health cards were made in local language (Telugu) also. Interaction meetings with farmers, field workers and line departments were organized and discussed the importance of soil health cards; soil test based nutrient application and productivity enhancement. The soil test results and various nutrient management practices for location specific crops were loaded in Information Communication Technology (ICT) Kiosk both in English and Telugu in the Village Resource Centre established in 8 clusters of 8 districts . Farmer can interact with touch screen system and voice based interaction helps in understanding the balanced nutrition and soil test and crop based nutrient recommendations.

Acknowledgement

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INTENSIFICATION OF LIVESTOCK PRODUCTION SYSTEMS FOR OFF-FARM LIVELIHOODS: OPPORTUNITIES AND CHALLANGES

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Smallholder livestock keepers represent almost 20% of the world population and steward most of the agricultural land in the tropics. In India, livestock is an important livelihoods providing segment of traditional farming systems and about 546 million people are involved in livestock related livelihoods (McDermott et al., 2010). It contribution is substantial (about 23%) to the agricultural gross domestic product in the country. Traditional, resource-driven and labour intensive ruminant sector, which produces a multitude of services to subsistence agriculture in general and multi-faceted contributions to socioeconomic development of the dryland areas in particular. Livestock are consistently and widely owned by small farmers for a variety of advantageous reasons (Devendra, 1983; Chantalakhana, 1990):—

- Diversification in the use of production resources and reduction of socio-economic risks
- Promotion of linkages between system components (land, crops and water)
- Generation of value-added products (e.g. meat, milk, eggs and skins)

- Income generation, investment, insurance and economic security when aberrant weather conditions prevail
- Supply of draught power for crop cultivation, transportation and haulage operations
- Contribution to soil fertility through nutrient cycling (dung and urine)
- Contribution to sustainable agriculture, and environmental protection
- Prestige, social and recreational values, and
- Development of stable farm households.

Further, increased human population growth and increasing urbanization, will significantly drive the demand for animal foods. Over the last two decades, the country evidenced with significant increase in expenditure share (from 10.01 and 3.43 in 1972-73 to 15.03 and 5.22 in 1993-94, respectively) towards milk and meat consumption. This trend is also consistent with the fact that consumers have been obtaining an increasingly greater share of calories and protein from animal food products.

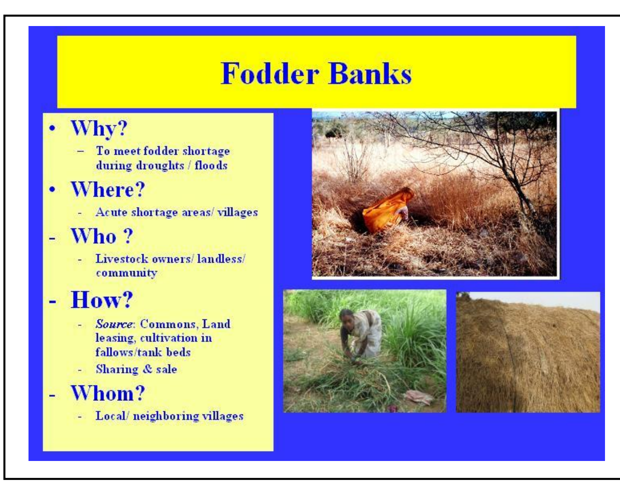
OPTIONS FOR INTEGRATION OF LIVESTOCK IN RURAL AREAS:

Feeding and nutrition are the major constraints to animal production in drylands. Animal production within the mixed farming systems is predominantly dependent on the efficiency of use of the available coarse crop residues and grazing resources. The level of efficiency will dictate to a very large extent improved per animal performance and increased productivity from different livestock resources. Hence, inorder to increase the productivity and profitability from livestock the feed and fodder base both

at village and household level should be strengthened by the concept of fodder bank with the following possible options.

Increasing feed and fodder base in the village

The necessity for green fodder arises during rabi (post-rainy season) when the green fodder availability ceases. Hence, the idea of participatory evaluation of perennial and annual fodder species on farmers' fields was introduced to sustain productivity of livestock even during rabi and summer. It aimed at increasing fodder supply through identifying and disseminating new varieties of fodder or dual-purpose crops in addition to conservation and efficient utilization of available feed and fodder resources. This involved participatory selection of fodder options with an emphasis on genetically improved varieties and newer supplementary feed resources. Small fodder banks were established with the surplus fodder collected at monthly intervals from the common lands during rainy season. Encouraged to cultivate fodder crops like maize, lucerne, cowpea, horsegram, sunhemp etc., on tank bed areas at the end of winter season. Stylo hamata was sown on the available bunds in the village for strengthening of bund and also as leguminous fodder source for livestock**.**



Fodder production from arable lands: Non-availability of arable land has been severely affecting the area under fodder cultivation. As a result, the green fodder availability both qualitatively and quantitatively is much lower than requirement and leading to many nutritional deficiencies ranging from energy, protein to micronutrients like minerals and finally lowered production from livestock. Hence, each farmer should at least allocate 10% of their land for fodder production. The surplus fodder should preserved in the form of hay or silage as fodder to the lean season requirements of the livestock in the village itself or for neighboring villages.

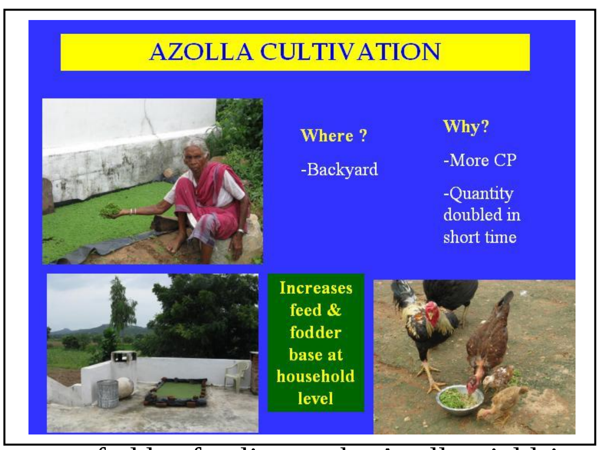
Fodder production from Tankbeds: Due to silt deposition, tank beds are fertile and retain adequate moisture in the soil profile for cultivation of short season fodder crops like sorghum and maize fodder. Cholamarri village, Anantapur District has several tanks (45 tanks) but remained unfilled and was in the grip of severe drought during 2002 resulting in distress sale of livestock. This motivated the youth and organized the community for cultivation of fodder on the tank bed of Cholamarri village in early 2003. The farmers could produce substantial biomass worth Rs. 4.75 lakh by cultivating 184 ha of tank bed area and the fodder produced could support the livestock for entire summer (Ramana et al, 2007).

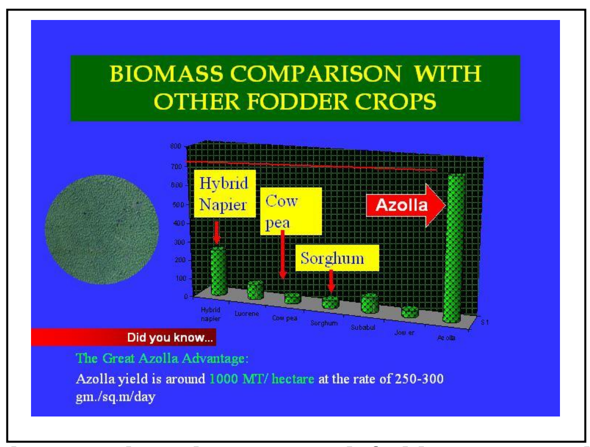
Development of integrated production systems: It is an efficient and integrated land use management system of agricultural crops, horticultural/forest tree species and or livestock simultaneously on the same unit of land like silvopastoral , hortipastoral systems, which results in an increase of overall production. Future development of these integrated systems will require policy support concerning land use and also to encourage the introduction of ruminants and to increase unit land productivity.

Annual and perennial crops: Relatively more attention will need to be given to mixed (crop-livestock) farming systems that involve annual crops, not only because of the importance of rice and wheat as food staples, and the opportunity to integrate annual legumes into the cereal cropping to develop food–feed systems.
Trees: The decreased availability of arable land in many areas and the need for more food from animals could encourage further integration of ruminants with trees in the form of silvopastoral (Forestry + Pasture + Livestock), agrisilvipastoral (Agriculture + Forestry + Pasture + Livestock) and hortipastoral systems (Orchards+ Pasture+ Livestock).

Alley Cropping: Alley cropping is a system in which food/fodder crops are grown in alleys formed by hedgerows of trees or shrubs (*Leucaena leucocephala, Gliricidia, Calliandra, Sesbania etc*.). The essential feature of the system is that hedgerows are cut back at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. The main objective of alley cropping is to get green and palatable fodder from hedgerows in the dry season and produce reasonable quantum of grain and stover in the alleys during the rainy/cropping season. This necessarily calls for cutting back (lopping) of hedge rows during the dry season fodder requirements. A welcome feature of alley cropping is its ability to produce green fodder even in years of severe drought. At Rajkot in 1985, rainfall received during the season was only 30% of normal precipitation. There was total failure of 3 legume crops tried in the system. In sole crop plots, production was limited to 0.5 – 1.7 t/ha of green fodder. However, in alley cropped plots, *Leucaena* hedgerows produced over 5t/ha of green fodder (Table 4). Similar was the experience at the Anantapur Centre in 1984. The cropping season rainfall was only 144 mm as against normal of 495 mm. All crops (groundnut, pigeonpea and sorghum) failed, and even stover production was severely affected. However, the *Leucaena* hedgerows produced 2t/ha of dry leaf material. Thus, alley cropping systems if properly planned, can remove a part of the risk faced by the small farmer in India.

Increasing feed and fodder base at household level: *Azolla*, a blue green algae which is having more than 25 % CP and can be doubled in quantity with in 5-7 days was encouraged to establish in pits at backyard depending on the number of milch animals of the farmer (Table 5). Large-scale production trials were taken up across the cluster villages to demonstrate the *Azolla* as alternative nutritious supplementary





green fodder for livestock. Azolla yield is much more than the perennial fodder varieties like APBN-1/CO-3 etc and is around 1000 MT per hectare at the rate of 300 gm./sq.m/day even after taking into account wastage space between two Azolla beds. It is more nutritious than the leguminous fodder crops like lucerne, cowpea , berseem etc and can be fed to cattle, buffalo, sheep, goat and also poultry after mixing with concentrate mixture at the ratio of 1:1.

Efficient utilization of available feed resources

Efficient utilization mechanism was strengthened through supply of chop-cutters to the custom hiring centers. Custom hiring centers are promoted in the cluster of villages to encourage mechanization of agricultural-operations. Farmers hire the implement by paying user charges. Experimental learning exercises were organized

on the need of chopping feed/fodder especially the sorghum stover, which is the major rainfed crop residue available to feed livestock in most of the districts under study. Further stakeholders were encouraged urea molasses treatment of paddy straw and preservation of surplus green fodder as silage.

Capacity building of the rural youth as livestock service providers (paravets)

In order to address the day-to-day minute health problems in livestock and poultry, a participatory approach was adopted in the cluster villages. Two local youth from the cluster of villages were selected and trained at office of the Joint Directorate of Animal Husbandry, Mahabubnagar for about 45 days as Para worker. The methodology involved more of hands on training in first aid, animal hygiene, feed and fodder management, deworming, common diseases and vaccination schedule, etc. The para-vets were provided with a simple veterinary kit along with necessary literature after the programme so that they can be provide simple veterinary services in their native village on nominal payment charges (Rs 1 and Rs 2 for treating each small and large ruminant, respectively) and the help of local veterinary doctor whenever required. This way they are expected to serve the local

farmers and also earn a livelihood for themselves. The previous attempts to develop a cadre of para-vets to aid the on-going development programmes have not produced the desired results. Studies indicate that lack of post-training handholding support has resulted in many trained Para-vets loosing interest. In order to prevent this, CRIDA has been implemented the following measures like assuring a minimum monthly income and incentives for better performance to the para-vets and also provide the required support and time for them to settle down as useful resource persons for the community.

Streamlining animal health services as community activity:

Animal health services were streamlined in the cluster villages through the trained Para workers. Strong integration and linkage (both forward and backward) among the stakeholders, animal husbandry (AH) professionals and service providers (para workers) was established in reporting any epidemics and timely implementation of prophylaxis measures with community cooperation. Livestock owners were organized into common interest groups (CIG) like milch animal rearers, goat rearers etc. Meetings with local Veterinary Assistant Surgeon (VAS), Para workers, sheep/goat/milch animal CIG groups were held at monthly intervals to discuss their problems and finalize vaccination/deworming schedule. The CIGs were encouraged to procure enmass all the required vaccines and deworming drugs well in advance by utilizing the revolving fund available with the community. Based on consultations, schedules were drawn for vaccinations and deworming in cooperation with Village Organizations (VO). The Para workers were deployed to carry out periodical vaccination and deworming in livestock under the guidance of the local Veterinary Assistant Surgeon.

Enabled Institutional Mechanisms: One member from each community was selected and formed as Salaha Samithi after taking consensus in grama sabha. The local line department officer i.e., Veterinary Assistant Surgeon (VAS) and village organization (VO) were also included as officiating members in Salaha Samithi. The Salaha Samithi discusses about all the issues once on last Thursday of every month. With the help of local NGO and scientific staff of the CRIDA, the Salaha Samithi prioritizes the activities to be implemented in their villages and also suggests the members for involving in the interventions. Similarly common interest group (CIG) of small ruminants was formed and made responsible for all production enhancement activities of sheep and goat in that cluster.

Capacity Building of Livestock Keepers: A participatory evaluation methodology was tailored to strengthen the capacity of livestock rearers. The CIG members, who are interested in livestock rearing were selected. Training programmes were organized to educate them on scientific management practices of different species of livestock and poultry, essentially about the advantage of regular deworming, timely vaccination against

endemic diseases and supplementation of mineral and concentrate mixture during lean period. The group members including small ruminant rearers do exits in the cluster village were trained through specially designed training programmes and demonstrations related to ram lamb rearing or production, fodder production, preservation and its efficient utilization and also urea molasses mineral bricks (UMMB) preparation (Table 6). All the small and large ruminant rearers were enabled to mark different activities like deworming, vaccination, shearing, supplementation etc., on the monthly calendar for ready reminder. Every second Thursday in a month, CIG members along with the para worker met the VAS and finalize the activities to be taken for control of various diseases and or improvement of productivity. Further , the para worker and shepherds were imparted with the skills of using drenching gun for deworming and shearing machine for wool cutting.

Provision of Revolving Fund: Revolving fund of about Rs.200000 (Rupees two lakhs only) was made available from the project fund to the Salaha Samithi for providing loans to the selected members for purchase of livestock/vaccines/feed/fodder seed etc well in advance through CIG.

Regular Screening of Faecal Samples of Different Flocks: Faecal matter from each flock was collected by one CIG member on rotational basis at monthly interval and got examined the same at district animal husbandry department.

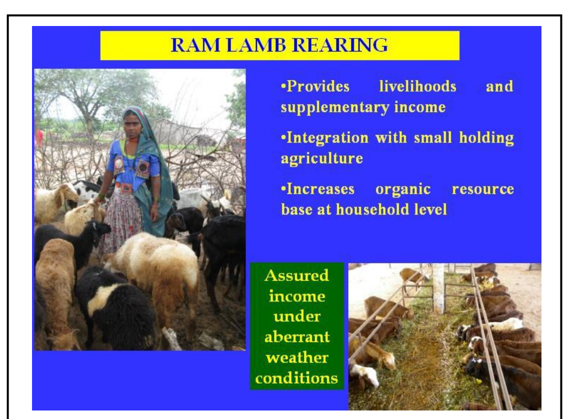
Judicious Use of Deworming Drugs: Para worker undertakes mass deworming of a particular flock depending on the faecal examination report. Deworming will be carried with the help of drenching gun, which prevents wastage of valuable drugs.

Timely Immunization: In every cluster village, the CIG was made responsible for indenting well in advance for required quantity of vaccines and deworming drugs in consultation with the local VAS, which was facilitated by the project staff. This resulted in timely availability of vaccines and vaccination of large (HS, BQ and FMD) and small ruminants (BT, PPR and FMD) and also poultry (Ranikhet disease).

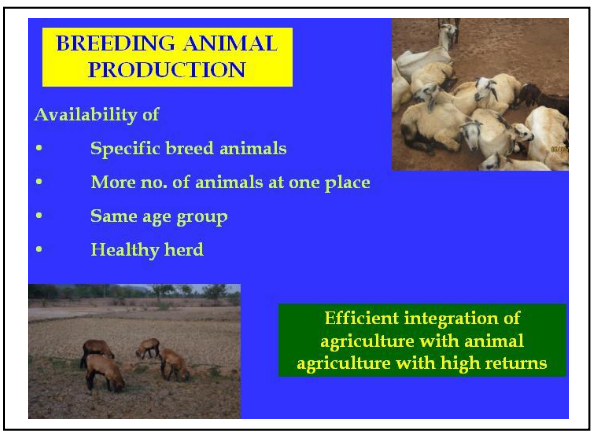
Ease of Access for Cost Effective Concentrate Mixture*:* During the crops harvesting season, one SHG was encouraged and trained to procure the locally available feed ingredients and prepare concentrate mixture sufficient to supplement small ruminants in their village during lean period by making use of revolving fund. The SHG sells the same in the village during lean period after charging one rupee extra on cost to cover preparation of the mixture.

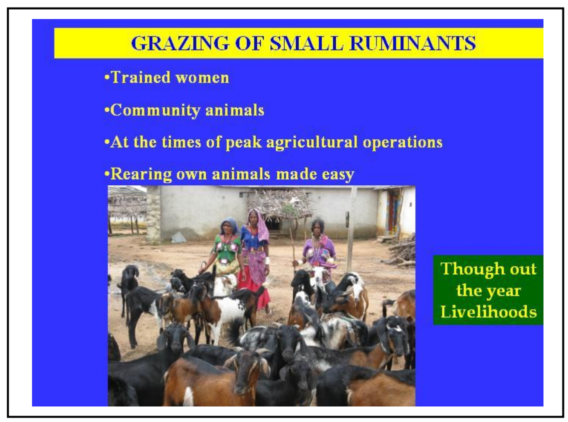
Intensification of small ruminant based livestock production systems

Initially women from SHGs who are otherwise engaged as daily labour were selected and trained through specially designed programme on ram lamb rearing or production as livelihood activity. Nellore ram lambs aged 3-4 months were procured from near by villages, insured under *Jeevarakshanidhi* a state sponsored scheme and distributed to the women on 50 : 50 cost sharing basis. The agreement was that the women would return the remaining 50% share when they dispose off the animals. All the small ruminant rearers were enabled to mark different activities



like deworming, vaccination, shearing, supplementation etc., on the monthly calendar for ready reminder. Every second Thursday in a month, small ruminant user group members along with the para worker met the VAS and finalize the activities to be taken for control of various diseases and or improvement of productivity. Faecal matter from each flock was collected by one UG member on rotational basis at monthly interval and got examined the same at district animal husbandry department. Para worker undertakes deworming depending on the faecal examination report. During the harvesting season, one SHG was encouraged and trained to procure the locally available feed ingredients and prepare concentrate mixture sufficient to supplement small ruminants in their village during lean period making use of revolving fund. The SHG sells the same during lean period after charging one rupee extra on cost to cover preparation of the mixture. The ram lambs were reared for about 6 months on semi-intensive system of management with



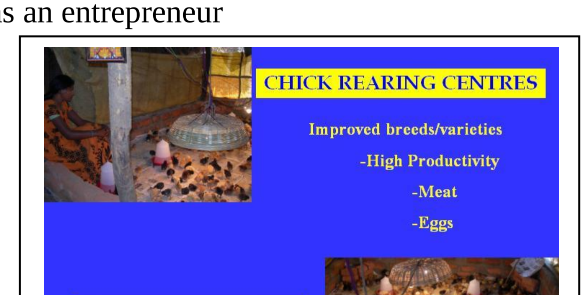


supplementation of concentrate mixture as per the recommendation of the project staff and VAS. An agreement was made with in the group that only one member on rotational basis should take all the animals for grazing everyday. The SHGs were closely monitored by the project staff with respect to feeding and health management practices from time to time. Effect of supplementation of concentrate mixture on daily average gain and final weight gain in Nellore ram lambs was evaluated under village situation to demonstrate the advantage of supplementation especially during lean period.

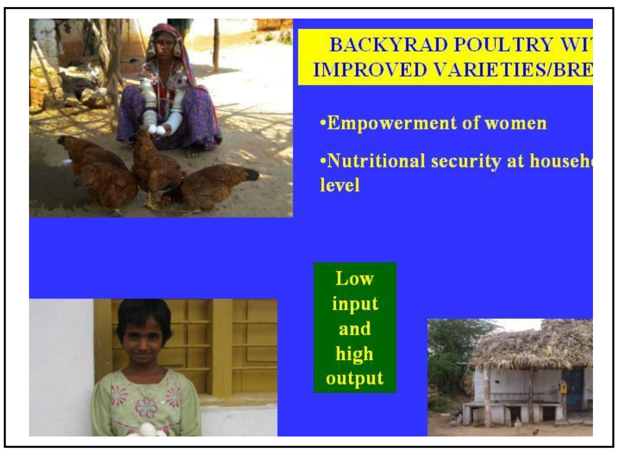
Empowerment of rural women through backyard poultry with improved breeds:

A participatory action research was conducted with proven high producing backyard poultry breeds like *Vanaraja*, *Rajasree*, *Grama Priya* etc., in cluster villages. It was designed to create additional employment opportunities and income generation

for empowerment of rural women besides aiding family nutritional security. Identified one or two interested self help group (SHG) members as an entrepreneur



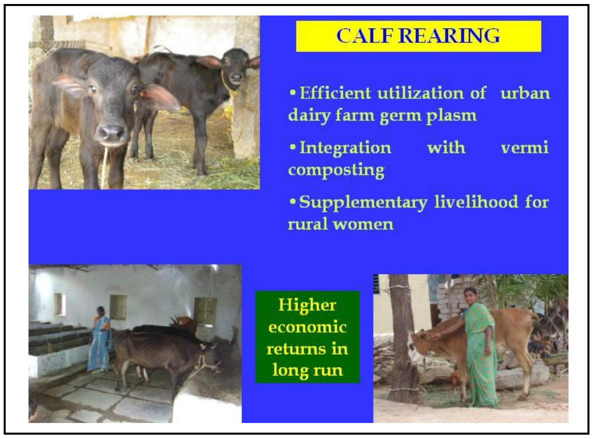
for chick rearing in each village and organized training program on chick rearing including vaccination. SHG members established chick rearing centers in one cluster villages to rear day old chicks for 6 weeks. Vaccination against all the major endemic diseases was completed during this period either by trained women or para worker with the help of VAS. The chick rearing SHG members agreed to charge a
minimum Rs.5 per chick over and above the maintenance (feed, medicines, vaccination etc.,) expenditure towards the services they offered during the 6 weeks period.

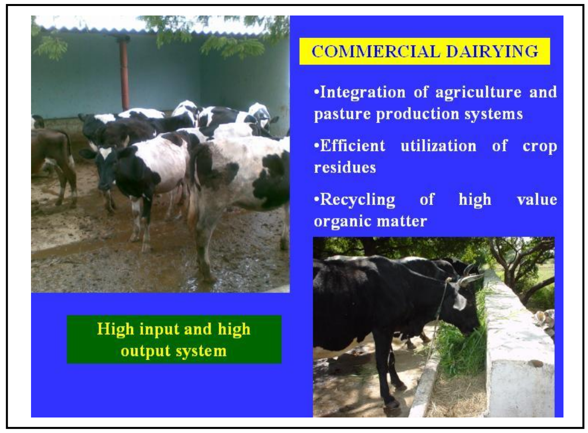


The 6 weeks old chicks were sold to the trained women farmers in the same village and performance of the chicks was regularly monitored. Some of the fertile eggs produced from these birds were hatched with *Desi* (local non-descript type) hen. Further, vaccination and day to day health care services were streamlined through the para worker under the guidance of the local VAS.

Exploitation of genetic potential in milch animals through supplementation
After assessing the nutrient intake at individual farmer level and depending on the production potential of the animal, supplementation was provided in the form of mineral and concentrate mixture/Azolla especially during the lean period when there are no green fodder. Some of the crossbred cows and graded Murrah buffaloes are fed increasing quantity of feed challenging them to produce at their maximum potential. It is starting the concentrate mix (about 500 gm) feeding before 2 weeks expected date of calving (EDC) and increase it gradually to a level of 500 -1000 g for every 100 kg body weight. This challenge feeding will condition her digestive

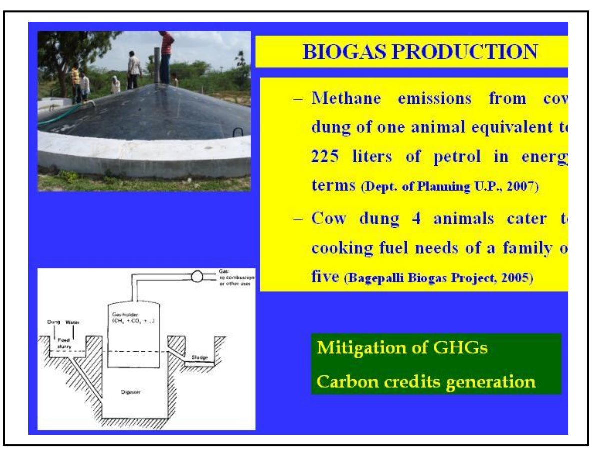
system for the increased quantity of feed to provide sufficient nutrients to initiate lactation on a higher plane. This effect has been found to have higher total milk yield in the lactation.





Dairy animals with low energy and protein intake were offered with at least 2-3 kg green fodder and 1-3 kg concentrate mixture for a period of 5-6 months depending on the breed. Reproductive camps were conducted to create awareness about identification of silent heat in buffaloes especially in summer and importance of timely insemination. Farmers were educated in managing heat stress by providing proper housing to the animals and early morning and late evening grazing during summer and feeding roughages during night etc. Supplementation of mineral mixture and regular deworming practice was encouraged by making available with subsidized products from AH department. Synchronization of oestrus (with PGF_2 alpha hormonal injections) was implemented in anoestrus and repeat breeders. Further the impact of mineral supplementation in mitigating anoestrus problem in dairy animals was demonstrated.

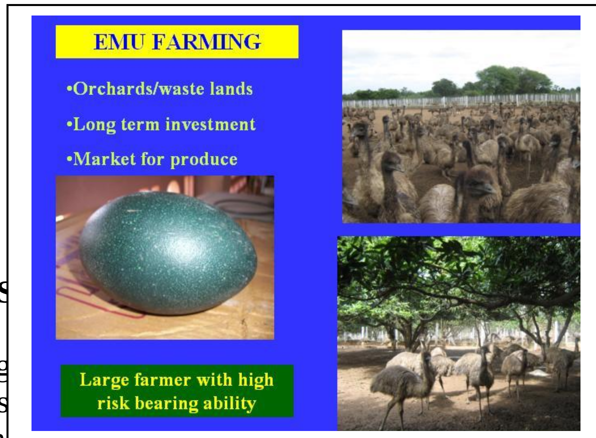
Exploitation of available dung for biogas production: It is estimated that around 3.5tonnes of dung from each large ruminants (cattle and buffalo) and 0.3 tonne from small ruminants (goat and sheep) is available in every village for biogas production. About two cubic foot of gas may be generated from one kg of dung at a temperature 28°C. This biogas consists 55-65% methane, 30-35% carbon dioxide, with some



hydrogen, nitrogen and other traces. This is enough gas to cook a day's meals for 4-6 people in India. Its heating value is around 600 B.T.U. per cubic foot. After biogas this slurry can be used as organic fertilizer which contains 1.8-2.4% nitrogen (N_2), 1.0-1.2% phosphorus (P_2O_5), 0.6-

0.8% potassium (K_2O) and 50-75% organic humus. Exploitation of dung not only provides the bio-energy, but also prevents the GHGs accumulation in the atmosphere.

***Emu farming*:** This enterprise is suitable for large farmers who can put lot of investment and wait for returns for at least 2 years.



CONCLUSIONS

Capacity building rs while streamlining the animal health services as ontainment of animal diseases in rural areas. Animal health camps and on-farm trials creates awareness among farmers regarding availability of basket of options for productivity enhancement in livestock. Further, use of technological advances along with appropriate management practices would help in providing healthier livelihoods and income from large and small ruminants. Improved cultivars along with efficient fodder utilization practices and integrated systems would augment fodder resources substantially in rural areas and reduces distress sale of animals during lean season. Improvement in services and delivery system along with creation of market linkages and better polices would drive the stake holder for adoption of livestock based technologies. Thus results in higher productivity, more stable livelihoods and income.

SUSTAINABLE RURAL LIVELIHOODS: NAIP EXPERIENCES

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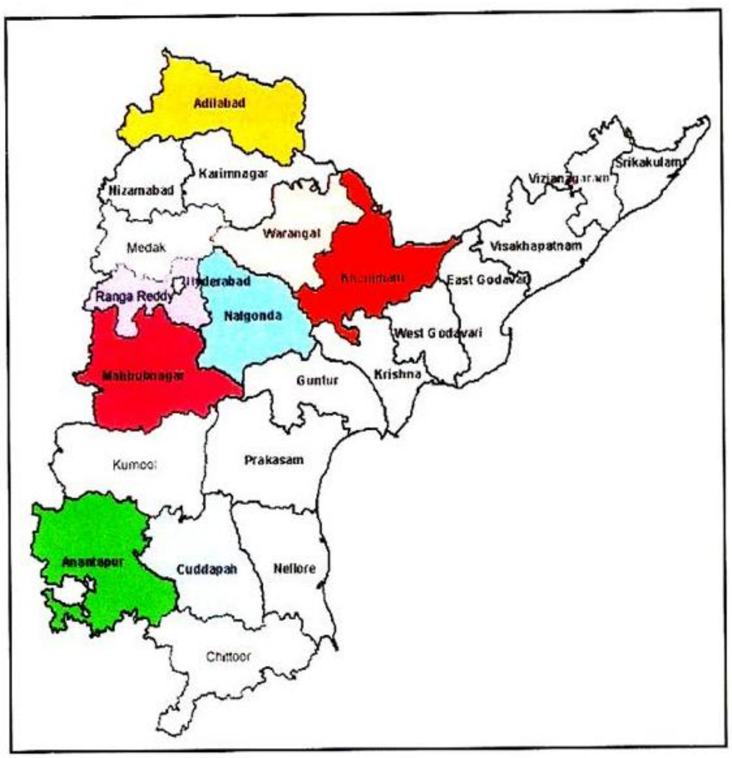
BACKGROUND

The National Agricultural Innovation Project (NAIP), Component 3 Sub project on "Sustainable Rural Livelihoods through Enhanced Farming Systems Productivity and Efficient Support Systems in Rainfed Areas" is being implemented across 8 districts of Andhra Pradesh (A.P.) with a view to improving the livelihoods of the rural poor by adopting strategies of sustainable natural resource management, productivity and profitability enhancement, building support systems and institutions, and converging on development agenda of different development agencies. In other words, it is aimed at testing a new model of sustainable rural livelihood (SRL) strategy, which is focused on innovations in ***technology transfer, support systems*** and ***collective action*** with the overall goal of improving the ***income*** and ***livelihoods*** of people. The SRL strategy is considered most relevant to the target area as it is only through the improvement of **farming systems productivity** and **enabling institutions** in most disadvantaged areas the goal of poverty reduction can be achieved.

The project is conceived with the overall objective of addressing rural livelihoods holistically by piloting innovations to optimize the use of **natural** and **human capitals** and by building institutional capability to sustain the gains through convergence of expertise at watershed/cluster level. The specific objectives however, are:

- To improve the livelihoods of the rural poor through efficient management of natural resources and increased productivity, profitability and diversity of the farming system.
- To facilitate agro processing, value addition and market linkages for enhanced on farm and off-farm income and employment generation.
- Capacity building and skill development of primary and secondary stakeholders through knowledge sharing, collective action and use of modern ICTs.
- To build a policy framework, institutional mechanisms and support systems for scaling up of the successful approaches.



Location and Project Sites

Target Area

The target area for the project includes eight predominantly rainfed clusters of villages in 8 districts of Andhra Pradesh identified as backward by the Planning Commission of India. Each cluster covers 3-4 villages/hamlets falling under one Gram Panchayat (GP) and is contiguous with a homogenous production system. It was ensured that adequate population of scheduled castes and scheduled tribes, the landless and poor households are represented in the selected villages so that the interventions and their outcomes will be useful for replication in other parts of the district/state. A profile of project clusters is given in Table 1.

Table 1: Profile of project clusters in the target districts

District	Mandal	Cluster	***Villages/Hamlets***	Area (ha.)	Households (no.)
Adilabad	Gudihath-noor	Seetha-gondhi	Old Somwarpet, New Somwarpet, Garkampet, Arkapalli, Chinna Malkapur, Peda Malkapur, Kotwalguda	1913	575
Pampanur, Anantapur	Atmakur	Pampanur	Pampanur, Pampanur Thanda, Y.Kothapalli	2111	576
Kadapa	Lakki Reddy Palli	B.Yerra-gudi	Brahmana Yerragudi Kaspa, V.N. Palli, Mudindla Palli, Kapu Palli, Konampeta, P.V. Palli, Puttakarlavary colony, Madhigapalli	1354	516
Khammam	Ashwa-puram	Tummala-cheruvu	Tummala Cheruvu, Bandla Pullaiah Gumpu, Kurvapalli Kotturu, Koremvari Gumpu, Ramavaram, Mamillavai, Venkatapuram, Bheemavaram	6934	629
Mahabub-nagar	Mahabub-nagar	Jamista-pur	Jamistapur, Telugugudem, Kodur Thanda	1217	739
Nalgonda	Penpahad	Dupahad	Jalamalkunta, Seetamma Thanda, Yellappa Kunta Thanda, China Gorekunta, Peda Gorekunta, China Seetaram Thanda, Peda Seetaram Thanda, Lalsing Thanda	800	621

Ranga Reddy	Parigi	Ibrahim-pur	Ibrahimpur, Ibrahimpur Thanda, Roopsing Thanda, Dhadi Thanda, Malkaipet Thanda	898	409
Jaffergudem , Warangal	Raghuna-thpally	Jaffar-gudem	Jaffergudem, Satyanara-yanapuram, Ramannagudem, Kusumabai Thanda, Chakal Zal Thanda, Lokya Thanda, Vepula Gadda Thanda, Cherla Thanda	2070	689

Innovations and Learnings

Coping with Drought

One of the major challenges faced in project implementation is frequent spells of drought. Such periods, though challenging, offered opportunities to enhance the capacity of the communities to cope with intermittent droughts. With climate change becoming a reality, it is all the more important for developing a response system that could address the livelihood needs of the poor. In this direction, the project spurred into action and worked with the community to draw contingency plans and implement them with fair amount of success. The major component of contingency plan was to identify water resources and common land resources for raising feed and fodder resources in a big way. The following were some of the significant interventions taken up during drought.

- Identifying common land in public or private domain for fodder cultivation.
- Raising of small ruminants as an enterprise.
- Transplantation of pigeonpea as a contingent strategy.
- Horse gram as a contingent crop.
- Discouraging water demanding crops like paddy and encouraging to save groundwater for providing life saving irrigation to the existing rainfed crops.
- Persuasion of bore well owners to share the water with neighbouring farmers for saving the crop.
- Training livestock keepers in preparation of urea-molasses mineral mixture blocks for tiding over nutrient deficiency and feeding of loppings of subabul and other fodder trees.
- Mobilizing the landless community to participate in construction of water harvesting structures through NREGS by coordinating with the block and district level officers.

Village Seed Banks: Need for Institutionalization

During the first year of the project, efforts were made to identify and develop farmer capacity to graduate into a seed grower. This was also followed up by simultaneous diffusion of improved seed in the clusters. This attempt was particularly made in groundnut to a large extent and pulses to a limited extent. While promoting village seed self sufficiency among the farmers of the cluster, three models seemed to be emerging. The first one was promoted with a buy back arrangement with the agricultural research stations (ARS, Kadiri and Anantapur). The second one involved buying of the seed by a community based organization (Salaha Samithis in Anantapur and Mahbubnagar) with the support of revolving fund. The third one was to encourage seed growers to retain seeds for themselves and selling to other farmers.

Learnings: The first two models were generally liked by the farmers, while the third one could not be practiced by many seed growers owing to their cash needs. Keeping in view the long term sustainability of a village based seed production and distribution system, an alternate model is being tried during rabi 2009. Farmers have been encouraged to come together as a producer company who will then be supported with storage and revolving fund support for carrying out transactions.

Hybrid castor seed production

High yielding varieties of castor are popular as seed material among castor growers in Jamisthapur cluster, Mahbubnagar. However, farmers are not used to growing hybrid castor in this area. Due to poor soils and frequent droughts, the yield of castor generally remains very poor here and hence low income. Keeping this in mind, an attempt was made to build the capacity of farmers for taking up hybrid seed production. A few farmers showed interest and came forward to undergo training in hybrid seed production at Directorate of Oilseeds Research (DOR), Hyderabad during rabi 2008. Finally, only one farmer could plant male and female lines of DCH-519 supplied from DOR, Hyderabad. Due to initial delay and certain issues, irrigation supply was impaired. As a result, the crop did not give expected levels of yield. However, still the economics of growing hybrid castor was an attractive proposition for the farmer. More farmers are coming forward to take up hybrid castor seed production.

Table __: Profitability of hybrid castor seed production (per ha)

Particulars	Hy. Seed crop		Bulk crop	
	Potential	Achieved	Potential	Achieved
Cultivation cost (Rs.)	24550	20275	19863	16013

Yield (kg)	750	250	1750	875
Net income (Rs.)	110450	24725*	20288	4113**

**Rs.180/kg; ** Rs.23/kg*

Large Scale Vermi composting: Profitability and Sustainability Issues

Backyard vermi compost units promoted for individual households have been suffering with poor scalability due to its labour intensive nature. Therefore, there is a high rate of discontinuity by households. In order to address the scalability issues, the project encouraged large scale vermi composting by farmer groups and women self help groups in select clusters. In Dupahad cluster (Nalgonda), large sheds were erected for vermi composting. Groups of youth were trained to prepare vermi compost by using decomposable biomass and dung. The farming community was encouraged to cart semi/undecomposed material from their backyards to the community vermi compost units. These farmers would get fully decomposed vermi compost in return to the raw material supplied by them. Thus, vermi composting was elevated to a specialized service providing enterprise from being a mere backyard activity. In addition to this, a community biogas unit was installed at the community vermi composting unit. This biogas unit uses dung slurry for biogas production and passes on the same for vermi compost unit. The biogas unit has been connected to a generator (15 kva) which can produce and supply electricity to about 100 houses. These add-on features will ensure the viability of vermi compost unit besides contributing to clean manure and energy production. This innovation has a high degree of scalability besides having implication in the climate change scenario.

In Pampanur (Anantapur) and B.Y.Gudi (Kadapa), women self help groups have been producing and marketing vermi compost as a community enterprise. In Pampanur, another group of women have taken up calf rearing as an enterprise which supplies dung as input to the group that is engaged in vermi composting. In both the cases, the SHGs were facilitated by the project staff to access abandoned private/public asset to take up the enterprise. For instance, in B.Y.Gudi cluster the SHG members were provided with access to an abandoned poultry shed belonging to farmer on rent basis. In Pampanur, the women approached the Project Director, District Rural Development Agency (DRDA) to gain access to a building owned by the DRDA for setting up the vermi composting and calf rearing enterprises.

Learnings: Backyard vermi composting can be replaced by enterprise model of vermi composting by training and capacity building of farmers and women self help groups. It can be strengthened by adding complementary enterprises like calf rearing or biogas unit. The group needs to be linked with market by providing initial hand holding.

Enhancing rainwater use efficiency

One of the major emphases of the project is on augmenting water availability through judicious use of rainwater by various means. Each cluster representing a unique agro-ecology presents different kinds of opportunities for rainwater harvesting and its efficient use. The rainfall ranges from just around 500 mm (in Pampanur cluster Ananthapur) to over 1100 mm (Thummalacheruvu cluster Khammam). Similarly, soil types vary too from deep Vertisols (Seethagondi, Adilabad) to medium and shallow Alfisols (Pampanur, Ananthapur). Hence, the runoff and infiltration capacity and therefore the water harvesting potential also vary. In high rainfall Vertisol areas (Adilabad) runoff is harvested in farm ponds for tiding over mid season droughts. In low rainfall shallow Alfisols (Anantapur and Mahbubnagar) the runoff is harvested in percolation ponds, trench cum bunds and CCTs for facilitating infiltration and re-charging of groundwater resources.

The Seethagondi cluster of Adilabad is blessed with fairly high rainfall (above 1000 mm) and deep black soils. Besides these, the undulated topography in this area provides ideal opportunity for harvesting the runoff, storing and reusing the same for tiding over brief spells of drought during cropping season. The technical and economic feasibilities of runoff harvesting through farm ponds for profitable crop production and diversification has been proved during the last year. However, emphasis this year was on up-scaling farm ponds through convergence with NREGS as an option for enhancing productivity (Annexure-1).

The Pampanur cluster of Anantapur being very arid prefers to harvest rainwater through percolation ponds and recharge groundwater. The groundwater is then judiciously used through sprinklers and drip irrigation systems which have been deployed across the cluster by converging with development programmes such as Andhra Pradesh Micro Irrigation Project (APMIP) and National Horticulture Mission (NHM). Besides, the custom hiring centers at Pampanur and Y.Kothapalli have been equipped with good number of sprinkler sets and pipelines which are in great demand among farmers.

In B.Y.Gudi cluster of Kadapa, attempts were made to augment water availability through de-silting of the Gajulakunta tank near Konampeta village. This work was undertaken in which the participation of the households of the clusters was ensured. The entire work was undertaken after a report on the detailed survey of the entire area was submitted to the DWMA which is the nodal agency for implementing the scheme. This work involved removal of 1250 m^3 silt costing an amount of Rs.25,000/-. Besides this, large scale contour bunding was also undertaken by mobilizing support from NREGS to the extent of 380 man days worth Rs.80,000/-

Thummalacheruvu cluster of Khammam has unique features. The rainfall is around 1100 mm and the topography is undulated with good forest cover. There are a number of tanks across the villages which cater to the needs of the farmers. However, a long standing demand of Bheemavaram was to have an aqueduct constructed across the Bandlavagu cheruvu (tank) so that the spill away water could be effectively used for irrigating an additional 120 acres. This dream was realized when the Bandlavagu aqueduct work was executed by empowering the local *Rythu Mithra* group to construct the aqueduct (Annexure-2).

Jamisthapur cluster of Mahbubnagar is highly drought prone with an average annual rainfall of just around 600 mm. The soils are shallow Alfisols with poor water holding capacity. The rainwater harvesting strategy here comprised of digging a series of percolation ponds, trench cum bunds and repair of old check dams and other water harvesting structures. Besides, promotion of nursery and plantation activities to green the barren hillocks in the ridge area was pursued during the year. An old check dam which was leaking without being able to arrest the runoff and store water, was repaired at a cost of Rs.38,000/- with people contributing their labour towards the repair. In B.Y.Gudi, Kadapa 850 m long contour bunding was taken up creating a rainwater storage capacity of 400 m^3 utilizing 380 mandays from NREGS. Continuous contour trench of 621 m length was dug in rocky hillock abetting the watershed by partly using machinery in Jamisthapur cluster, Mahbubnagar. These trenches created an additional rainwater storage space of 621 m^3. Two percolation tanks were dug in the cluster to enhance groundwater resources. Local youth have been trained to monitor the groundwater level periodically. The custom hiring center is equipped with efficient groundwater using systems like sprinklers. The farmers are being motivated to go for irrigated dry crops in place of paddy during rabi season. Zero till maize is being promoted in paddy fallows by careful training and capacity building activities.

Dupahad cluster, Nalgonda is one of the most drought-prone areas of Andhra Pradesh. The groundwater resources are meager and soils are porous and shallow. There are large tanks and open wells which cater to water requirement of farming operations. However, the tanks are highly silted up while the open wells are dry. Two strategies were adopted to augment water resource in the cluster. The Jalamalakunta (kunta meaning tank) was de-silted by mobilizing people's participation under NREGS. A detailed survey and the estimate of the work was carried out by the project staff and submitted for including this work in the shelf of works of NREGS. An amount of Rs.2,50,000/- amounting to 2500 man days was sanctioned for completing this work. The work was taken up during the summer of 2009. Though there was severe drought during kharif 2009, the rains at the end of the season helped harvest some runoff which in turn pushed the water table up. Secondly, the large number of open wells (around 50) which were abandoned due to their drying up posed a great challenge to the project staff right from the beginning. After a detailed topo survey five open wells were selected for recharging by using low cost techniques. The technique involved diverting the runoff from a nearby water way into a silt trap and then leading the clear water into the open well through a PVC duct. The initial results have been encouraging, as farmers were able to take up short duration vegetable crops by lifting the harvested water from the open wells.

An entirely different approach was adopted in the Ibrahimpur cluster of Rangareddy which is abetting the peri-urban areas around Hyderabad. The intervention involved increasing the use efficiency of available groundwater by networking six bore wells belonging to different farmers and distributing the same to about 18 farmers (45 acres) with the help of sprinklers. The detailed process involved in linking and networking the bore wells is provided in Annexure-3.

Jaffergudem cluster, Warangal is progressive in terms of agricultural practices adopted by farmers. However, the shallow and gravelly soils have poor water holding capacity and need protective irrigation support for better productivity. Thus, the farmers resort to groundwater for irrigation support. The strategy for rainwater harvesting and use in this cluster is mainly through farm ponds and percolation ponds, appropriate cropping options. The entire soil conservation and rainwater harvesting interventions in this cluster are being carried out in convergence with NABARD funded watershed project. The farmers owning bore wells generally cultivate paddy in kharif and rabi as well leading to the impairment of water balance. While the technical support for watershed activities were provided to the NABARD project, simultaneous training and capacity building initiative were launched for educating farmers to maintain water balance. The farmers who were taking two crops of paddy, one each in rabi and khairf, were engaged over time and convinced for practice change at least during rabi season. Of the group of 5 farmers who initially agreed to take up zero till maize in paddy fallow during rabi, one was able to finally sow zero till maize in rabi 2007. A sustained campaign and farmer to farmer training and interaction facilitated by the project team resulted in this practice spreading to 20 farmers during rabi 2008. Now zero till maize has been accepted as not only a viable water conservation option but also a remunerative alternative.

Crop-based Interventions

Major crop based interventions included strengthening of seed system in groundnut and pulses, zero tillage maize, refinement of spacing in cotton, crop diversification and contingency cropping (Annexure-4). The need for contingency crop planning arose as a result of severe drought across all the clusters (except Adilabad and Khammam where the situation was relatively better). In clusters like Jamisthapur (Mahbubnagar) and Dupahad (Nalgonda) no kharif crop could be sown, as there was no rainfall until the end of August. In other clusters, drought affected the initial growth phase and the crop wilted for want of moisture. Due to better soils however, the crops in Seethagondi (Adilabad) and Thummalacheruvu (Khammam) managed to survive and give some yield. During the kharif crop planning, it was planned to promote transplanted pigeonpea in Jamisthapur (Mahbubnagar) and Ibrahimpur (Rangareddy) clusters and considerable quantity of pigeonpea plants were raised in the nurseries. These came in handy when drought eased by the end of August. The performance of transplanted pigeonpea trials is summarized in the Table-2. Though the drought was challenging, it was nevertheless an opportunity to try and organize the community to take measures for coping with it. The following were some of the measures that were taken up across the clusters.

Table 2: Performance of transplanted pigeonpea under different planting patterns

Spacing (cm)	Pods/plant	Seeds/pod	100-seed weight (g)	Seed yield (kg/ha)
150x90	596	4.1	11.89	1100
120x90	425	4.1	11.76	902
90x60	208	3.9	11.73	916
90x20 (direct sown)	94	3.2	11.02	832

Intercropping of cluster beans in cotton (Seethagondi, Adilabad), mulching with dhaincha in cotton (Jaffergudem, Warangal), pigeonpea transplantation during late kharif (Jamisthapur, Mahbubnagar and Ibrahimpur, Rangareddy) were some of the significant interventions. Expansion of area under zero tillage maize after its initial success in Jaffergudem was systematically attempted in two phases (Annexure-5). Groundnut was promoted as alternative crop to rabi paddy in Malkaipet thanda, Ibrahimpur cluster after the networking of bore wells was completed. Select farmers were encouraged to convert their lands into horti pastures in Telugugudem, Jamisthapur cluster and B.Y.Gudi (Kadapa).

Livestock interventions

After creating wide spread awareness about preventable livestock diseases and sensitizing the community about prophylaxis, the focus during the year was shifted to better management of feed and fodder resources. The communities were engaged on several trainings, workshops and exposure visits for understanding the need to augment feed and fodder resources. Cultivation of azolla as a feed supplement to cattle was intensified with renewed focus on cultivation practices. A training session was organized for select farmers and project staff on best practices of azolla cultivation.

The project also engaged in sustain campaign for keeping up the interests of livestock farmer through preparing and displaying posters and pamphlets within the cluster. A focused training programme was organized for the para workers. Hands on training on the use of drenching guns and power operated wool shearing machines was given to the para workers before deploying these in the clusters.

Emphasis was laid on rearing sheep units with stress on deworming, vaccination and insurance. Sheep units are the most favorite intervention among the landless across the clusters. Kuroiler birds were found to perform better both in terms of disease resistance and incremental body weight at Thummalacheruvu cluster, Khammam. A comparative study with Kuroiler and other backyard poultry birds is on at Jaffergudem cluster, Warangal to assess the advantages. A solar power operated poultry incubator was procured especially to promote decentralized hatching facility different clusters. Studies are on to assess its performance.

ICTs for Knowledge Empowerment

During the year, the ICT equipment installed at all clusters during the last year was made operational. Kiosk operators were appointed, trained and deployed in all the clusters. The activities of ICT operators were regularly reviewed at the cluster level. Internet connectivity was established at all centers by using internet USB data cards. Interactive Voice Response System (IVRS) was established at all the centers. Each village resource center was strengthened by equipping with audio CDs and DVDs on various relevant subjects. Besides, facilities like drinking water dispensers, carpets for spreading in the VRCs and washroom facilities were also developed.

Institutional Innovations

The focus on developing the capacity of peoples institutions for spearheading the process of livelihood improvement even after the completion of the project was maintained all through the year. Community based organizations like Self Help Groups, Salahasamithis, Cluster Action Teams, Village Action Teams, Rythu Mitra Groups, Navakalpana Society were strengthened by empowering them to articulate the needs of the community and develop proposals for seeking project help. Such proposals were scrutinized by subject matter specialists and if found suitable, project assistance was delivered to implement the proposals. During the year, the project considered proposals such as setting up of roof water harvesting system, ram lamb and sheep rearing enterprises, heifer rearing, development of horti pasture etc. These proposals were successfully completed by the technical guidance and support of lead center budget. The sustainability fund developed at the clusters was leveraged as revolving fund which was used by the community as loan for supporting interventions like heifer rearing, sheep unit purchase and development of mango orchard (Annexure-6).

Annexure-1

Farm Ponds: Upscaling and Converging with Ongoing Initiatives

Like NREGS

The success of farm pond in Adilabad generated a lot of interest among farmers as well as line departments in the district. Mr.Namdev who was till then not known to many became a household name in the surrounding villages. Several farmers who were earlier reluctant to agree for digging farm pond in their fields, started approaching the project staff. This was due to a systematic awareness programme undertaken by the project. The programme included inviting key officials of the development departments and encouraging them to arrange for farmer exposure visits to the site of farm pond in Garkhampet in the cluster. This success story was widely shared with the media and posted on project as well as ICAR website and shared during many discussions, meetings and seminars. This effort resulted in many more farmers showing willingness to adopt farm ponds on their fields. Taking advantage of the changed attitude of farmers towards farm ponds, a detailed ground survey was carried out in all villages of the Seethagondi cluster and a proposal was prepared identifying 30 suitable sites for farm ponds. The proposal was later submitted to the nodal agency (District Water Management Agency; DWMA) that processed NREGS works through Gram Panchayat. The proposal was closely monitored by the project staff and the community, which was favourably considered and 30 farm ponds worth Rs.20.00 lakhs were approved by DWMA.

Under the NREGS, most of the work is carried out manually and farm ponds of 10 m x 10 m x 2.5 m are generally dug by labour. But the experience of the project has shown that there is a better rainfall potential in the district and hence the ponds need to be almost double the size prescribed under NREGS. However, manual labour is inadequate to dig the farm ponds of bigger size (say 17 m x 17 m x 4 m). This matter was dealt in a separate proposal seeking permission to enlarge the manually dug farm ponds to the desired size by using machines. After obtaining the permission to use machines, 5 farm ponds were enlarged into bigger ponds of 17 m x 17 m x 4 m so as to harvest more rainwater. Once this was successfully demonstrated, the DWMA was once again approached with a proposal to permit use of machines for enlarging all the remaining 25 farm ponds and sanction funds for the same.

Annexure-2

Farmers Build Aqueduct to Augment Water Availability

Bheemavaram tank in Tummalacheruvu cluster (Khammam) serves as a source of irrigation for about 120 acres. However, the excess water that flows out of the tank every year during the rainy season goes as waste since it flows down into a drain without becoming accessible to the fields downstream. Therefore, one of the first demands of the community when the project team interacted with them through PRA was construction of aqueduct across the *Bandlavaagu* drain. In order to make this dream come true, project team along with a group of consulting engineers took up the issue and started planning for a low cost aqueduct across the drain to help farmers utilize the over flowing tank water.

The group after careful study, recommended for construction of an aqueduct across the stream and discussed with the farmers if they could take the responsibility of laying the aqueduct under the guidance of project staff and engineers. Since the area is very remote and generally no contractor takes up work in such a hinterland, the farmers agreed to take up the laying of aqueduct on their own. The farmers were encouraged to formulate a user group and open a joint account in the bank so that financial assistance could be directly delivered to the group without much delay. The farmers contributed labour and a committee of the user group and project staff monitored the construction of aqueduct under the guidance of engineers. This approach involved empowering user group to take up construction of assets required by the community under expert guidance with the financial support of the project. Besides, the construction also involved latest low cost technology involving continuous HDPE pipes supported by steel columns instead of cement pipes and RCC columns which brought down the cost almost by 40%. Since the rainfall during the kharif this year was inadequate, the Bheemavaram tank did not overflow. As a result, the efficacy of the structure could not be ascertained during the year. The farmers however, are upbeat and are working to dig distribution channels downstream so that the entire potential of the overflowing water could be harnessed.

The facility was dedicated to the farmers of Bheemavaram in a special event on 10th July 2009 by Shri. R. Kanta Rao Hon'ble Member of Legislative Assembly of Pinapaka constitution.

Annexure-3

Increasing Groundwater Use Efficiency through Social Regulation

The project, right from the beginning, is committed to judicious use of scarce resources such as groundwater by investing in technology as well as community capacity. The efforts in this direction started in the Ibrahimpur cluster, Rangareddy district as soon as the project began. It involved a series of consultations with the bore well owning farmers and the neighbouring ones who did not have water source to irrigate their lands. Initially, the two tube well owning farmers did not like the idea at all. The project then got a defunct bore well repaired as a goodwill gesture and again approached the farmers who had mellowed down by then and agreed to share water, provided the project assisted the community for digging a few more bore wells so that there was enough water to share it across a large area. This time, the project contacted NABARD for assistance who came forward with financing the digging of two tube wells in that area under their comprehensive land development programme (CLDP). This raised the hopes of several farmers including those who owned bore wells initially because with the pooling of water they could now irrigate other patches of their dry fields where they could not have reached water. Thus, the one year long negotiations with the community to implement social regulations for groundwater usage finally yielded results. Over 60 acres of land belonging to 18 households was brought under protective irrigation by laying out a network of pipelines and bore wells at Malkaipet thanda in Ibrahimpur cluster, Rangareddy district. The entire group of farmers has agreed not to cultivate rabi paddy but to share bore water among themselves for growing ID crops.

Annexure-4

Altered Spacing for Higher Profitability in Cotton

Generally cotton is sown at a spacing of 90 x 90 cm. After farmers switched over to Bt cotton, they continued the same spacing even in poor soils despite its small canopy size. While discussing ways and means of increasing productivity of cotton in Jaffergudem cluster during kharif 2008 planning workshop, an idea of reducing intra row spacing in cotton came up. This was later discussed with farmers and 18 farmers came forward to take up trials with modified spacing (90cm x 60cm) in cotton in one acre each. The results were encouraging. Farmers could use their inter-cultivation devices between the rows while the plant population was intensified within the row. This resulted in an increase of plant population from 12346 to 18519 per ha. The increased spacing cost the farmers half a kg of more seed per ha while the other inputs remained more or less the same. As a result of increased plant density, the average yield of cotton recorded was 1450 kg as against 1875 kg/ha in the plots with conventional spacing. The details of particulars in the modified spacing are provided in the table below.

Particulars (per ha)	Spacing	
	90cm x 90cm	90cm x 60cm
Plant density	12346	18519
Seed rate	1.1 kg	1.6 kg
Seed cost (Rs.)	1833	2708
Yield (kg)	1450	1875
Income (Rs.)*	43500	56250
Cultivation cost (Rs.)	24010	24885
Profit (Rs.)	19490	31365

** @ Rs.30/kg*

The economics of increasing plant density was very attractive. As a result, over 150 farmers adopted modified spacing over an area of 104 ha during kharif 2008.

Impact: The average increase in yield per ha due to higher plant density was 4000 kg. This translates to a total higher income of over Rs.12,000/ha. This practice can be followed in mediocre soils with medium to low fertility levels. However, cautioned needs to be exercised during over cast conditions, as the chances of multiplication of pests/diseases will be higher under high density cropping. This simple practice change brought an additional Rs.12, 48,000/- for the cluster.

Annexure-5

Upscalling of Zero Till Maize

The zero till maize introduced during rabi 2007 was upscaled within the cluster and outscaled beyond the Jaffergudem cluster during the year. This was systematically attempted through well designed training and exposure visits for the farmers of the cluster and other clusters. Rabi 2008 saw the zero till maize spreading to 20 farmers in Jaffergudem cluster. Cultivation of rabi paddy by using scarce groundwater is also a common practice in Nalgonda, Mahbubnagar and Rangareddy districts. Keeping this in mind, farmers from Dupahad, Nalgonda; Jamisthapur, Mahbubnagar and Ibrahimpur, Rangareddy were brought to Jaffergudem for exposure visit when the crop was in cob formation stage. The farmers were taken to the best zero till maize plots in Jaffergudem and were allowed to discuss with the zero till maize farmers. Thus, a few master trainers were developed in Jaffergudem for diffusing zero till maize practice. The visiting famers were quite impressed with zero till maize and some of them expressed desire to try out zero till maize on their farms during rabi 2009. Such farmers were pursued later and once again brought back to Jaffergudem during November, 2009 when zero till maize was sown. Later, these farmers were facilitated to take up zero till maize back in their own farms. As a result, this year, two farmers each in Dupahad, Ibrahimpur and Jamisthapur have taken up zero till maize in their fields.

Annexure-6

Rich Dividends from Ram Lamb Rearing: Leveraging Revolving

Fund to Upscale the Enterprise

Small ruminants viz., sheep and goal play an important role as supplementary source of income for the landless and resource poor farmers. Considering this, the project is promoting interventions involving small ruminants, especially fattening of ram lambs for sale during peak demand period. This intervention is very popular across the clusters and particularly so in the dry districts. Two of the most drought prone districts of the state, Mahbubnagar and Anantapur where the project is being implemented, the anchoring partner BIRD-AP is adopting a novel method of leveraging the revolving fund for upscaling the intervention. The households were selected from the landless, marginal farmers and the poor women headed families. The capital required for procuring the ram lambs was provided through a revolving fund vested with the *Salaha Samithi* which is the project implementation body at both the clusters. The loan amount availed by participants ranged from Rs.2,000/- to Rs.5,000/-. These households contributed 10% of the cost as margin money for buying the lambs. So far, 91 households have availed benefit through this intervention at Anantapur in three phases (40+21+30) and 58 households in

Mahabubnagar in one phase. The interest rate on borrowings was decided by the *Salaha Samithi* as 3% per annum. Ram lambs were reared till the age of 6-7 months and were sold at an average of Rs.4,500/-. The average net returns was Rs.2,500/- per animal. The end use of profit from the enterprise was not only for continuity, but also for substitution, such as switching over to large ruminants or buying agricultural assets or investing in petty trade, etc. Considering the availability of fodder, some of the participants have also invested the returns temporarily in agriculture and are likely to continue rearing ram lambs to coincide sale during the peak demand period.

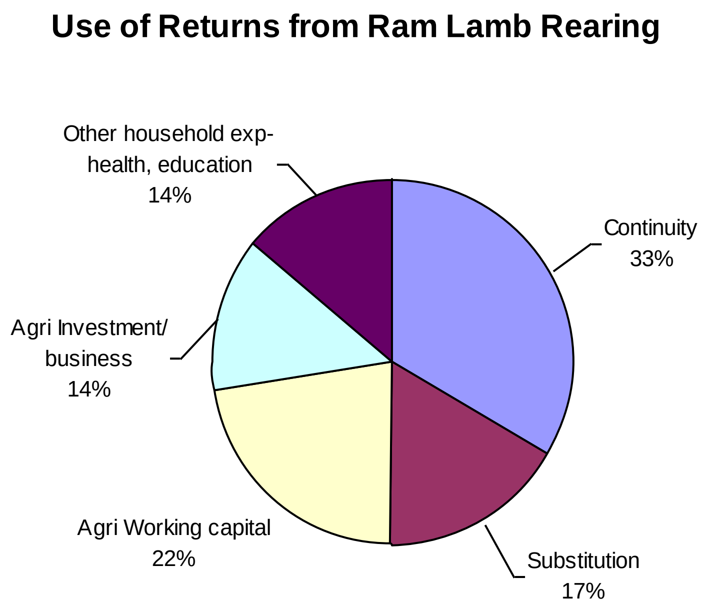
During the II Phase, the households were encouraged to avail insurance for their animals in convergence with the Department of Animal Husbandry through its *Pasu Kranti Scheme*. One year's experience has shown that sustainability is directly linked to opportunities for lucrative market. Therefore, promoting of Common Interest Groups for collective procurement of ram lamb for collective marketing to make this intervention more profitable. The unit size of 4-5 animals is considered more ideal as per the feedback given by the participants.

A study was carried out to trace the flow of earning out of small ruminant rearing among select families at Anantapur. It was found that $^{1/3}$ of the households continued with ram lamb rearing, while a fifth of them used the ploughed back the profits as working capital for their agriculture needs (see Table). Other households spent it on household expenses such as health and education, petty business and buying large ruminants (see fig.). The rate of returns was over 90% in Pampanur and Kothapally while, it was only 16% in Pampanur Thanda. The low rate of returns in thanda was due to the initial mortality of the animals. Due to this, half of the beneficiaries discontinued ram lamb rearing while the other half switched over to other enterprises.

Utilization of returns from ram lamb rearing

Village	Continuity	Substitution	Agri Working capital	Agri Investment/ business	Other purpose - health, education
P Thanda	0	2	1	0	1
Pampanur	1	3	4	2	1
Y Kothapalli	11	1	3	3	3

Total	12	6	8	5	5



INTE

R SUSTAINING

REAS

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During the last 4-5 decades of agricultural research and development in India, major emphasis has been given to component- and commodity-based research projects involving developing new crop varieties, animal breeds, pest management, nutrient management etc mostly conducted in isolation and at the institute level. Researchers often do not address the location-specific, socio-economic issues in their agricultural research and technology development framework. Consequently, this component-, commodity- and discipline-based research has not proved wholly adequate in addressing the multifarious problems of small farmers (Jha, 2003). The problems of Indian agriculture are suited to a holistic approach to research and development efforts. It has been recognized that a new vision for agricultural research in the country, one that allows the commodity- and component-based research efforts at an institute level to be shifted to farmercentric research and development efforts, is desirable (Mahapatra & Behera, 2004). In view of the decline in per capita availability of land from 0.5 ha in 1950 to 0.15 ha by the turn of the century and a projected further decline to less than 0.1 ha by 2020, it is important to develop strategies and agricultural technologies that enable adequate employment and income to be generated, especially for small and marginal farmers who constitute more than 80% of the farming community (Jha, 2003). No farm enterprise is likely to be able to sustain the small and marginal farmers without resorting to integrated farming systems (IFS), i.e., a system in which different enterprises (e.g. fishery, dairy, crop etc.) are included in farm activities in an integrated manner with a major focus on bio-resource recycling within the system, for generation of adequate income and gainful employment year round (Mahapatra, 1994).

A farming system adopted by a given farming household results from its members allocating the four factors of production (land, labor, capital and management), to which they have access, to three processes (crop, livestock and off-farm enterprises) in a manner which, within the knowledge they possess, will maximize the attainment of the goals for which they are striving (Norman, 1978). Indian farmers generally practice mixed farming in which crop and animal production constitute about 70-90% of the agricultural enterprises. Because of the complex interactions with the environment, research with a farming systems perspective is a unique approach to increase the body of knowledge about existing farming systems and to solve specific problems in the farming systems of small and marginal farmers (Norman, 1978; Behera et al., 2008). The approach aims at increasing income and employment from smallholdings by suitable integration of various farm enterprises and efficient utilization of by-products of each enterprise within the farm. Such farming systems give an opportunity to the farmer to get a basket of multiple choices comprising alternate but matching, location specific and socio-economic specific enterprises.

The farming system models can be adopted in rainfed agriculture on a watershed basis or with a farmer centric approach.

1. Watershed based farming systems

Farming systems approach on a watershed basis is a method designed to understand the farmers' priorities, strategies and allocation of enterprises and decision-making. It should start with analysis of farmers' knowledge, problems and priorities in a given hydrological unit. This approach should relate to the land use that results in an efficient, optimum and sustainable use of natural resources including biotic, socio-economic and related infra-structural resources. Farming systems model in a watershed should address arable, non-arable, common pool resources and private property resources integrating the components of soil and water conservation measures, crops, parkland systems, trees on bunds, wind breaks, silvi-pasture systems, agri-horticulture systems, block plantations, high value low volume crops and live fences in a holistic manner. In this approach, the focus is more on managing natural resources viz. soil, water and biodiversity in a topo-sequence, prioritizing the farming systems decisions in an area basis.

In regions with rainfall of 500 to 700 mm, the farming systems should be based on livestock with promotion of low water requiring grasses, trees and bushes to meet fodder, fuel and timber requirements of the farmers. In 700 to 1100 mm rainfall regions, crop, horticulture and livestock based farming systems can be adopted depending on the soil type and the marketability factors. Runoff harvesting is a major component in this region in the watershed based farming system. In areas where the rainfall is more than 1100 mm, integrated farming systems integrating paddy with fisheries is ideal. There are several modules of rainfed rice cultivation along with fisheries in medium to low lands of rainfed rice growing regions of the eastern states of India.

A model farming system for small holders with 1.15 ha area in an Alfisol watershed has been developed by CRIDA covering arable crops, green manuring, bushes on bunds, economic fruit yielding plants on the lower side and grasses on the upper topo-sequence of the micro-watershed. Economic analysis of the model after a 3-year period (2005-08) indicated that the module covering arable crops on 0.4725 ha, agro-forestry on 0.3496 ha, vegetables on 0.1150 ha, grasses on 0.1256 ha and bushes on 0.0890 ha gave the highest gross income of Rs.16080/-, and net income of Rs.9793/- and a BC ratio of 2.38. The individual enterprises of arable cropping, agro-forestry, vegetables, grasses and bushes contributed 38.2, 10.3, 27.2, 7.1 and 17.2 %, respectively to the total net income (CRIDA, 2008).

Under the technology assessment and refinement programme of the NATP, an IFS module comprising 35.4% area under cereals, 25.7% under pulses, 21% under oilseeds, 17.3% under commercial crops and 1.2% area under fodders along with backyard poultry (6 birds per household) was found to be ideal for small and marginal farmers in Dharwad region of Karnataka (TAR-IVLP, 2005). The poultry component played a major role in stabilizing the farmers' income during drought years. Similarly, in Arjia region of southern Rajasthan, an IFS module of maize, pulses, oilseeds and forage grasses combining with in-situ rainwater management and bio-fencing gave 22.37% higher profitability than sole maize (AICRPDA-Arjia, 2006).

2. Farmer/family centric farming systems

In this system, the focus is on the individual households particularly of small and marginal farmers and their livelihood security. In this approach, the strengths and weaknesses of the traditional farming systems being followed by the farmers need to be assessed based on which selective productive enhancement and enterprise diversification interventions should be introduced. This calls for a detailed analysis of each household for their resources, investment capacity, labour availability and so on through participatory farming systems analysis tools. This can be done through focused group discussions, household level surveys and assessing local market needs.

Based on the income derived from each enterprise by the family (>50%), the family centric farming systems can be grouped into crop, agroforestry and livestock based systems (Subba Reddy and Ramakrishna, 2005).

2.1 Crop based Farming Systems

In this system, crops are the main source of livelihood. Animals are raised on agricultural wastes, and animal power is used for agricultural operations and the dung is used as manure and fuel. In low rainfall areas, agri-sheep farming involving cotton production in one ha of marginal lands and rearing of 10 lambs gave the net returns of Rs. 27500/ha as compared to growing cotton alone (Rs. 8700/ha) at Warangal in Andhra Pradesh (TAR-IVLP, 2003). The integrated farming system model in dryland vertisols at Kovilpatti (Tamil Nadu) showed that Crop + Goat + Poultry + Sheep + Dairy recorded the highest gross income (Rs. 35301) followed by Crop + Goat + Poultry + Dairy (Rs. 30807), while the conventional system having crop cultivation alone gave only Rs. 5860/acre as gross income. The animal waste from cow (20-22 kg/day/animal), sheep and goat (400-450 g/animal/day) and poultry litter (40 kg/batch of 20 broilers) were collected and applied to the IFS field, which resulted in improved soil fertility and crop yields. Employment increased from 75 man-days in conventional cropping system to 272 man-days in IFS model (AICRPDA-Kovilpatti, 2006). At Chattisgarh, a model having 2 bullocks + 1 cow + 2 buffaloes + 15 goats + 20 poultry and 20 ducks along with the crops in 1.3 ha gave the net income of Rs.58456/year against arable farming alone (Rs.18300/ year) and employment generation of 571 man-days (Rama Rao *et al*, 2005). Integration of sheep rearing in groundnut based farming system offered a gainful employment in rainfed areas. In scarce rainfall zone of Andhra Pradesh at Anantapur, the highest net returns were recorded with groundnut cultivation (2 ha) + poultry (Rs. 43360) followed by groundnut cultivation + dairy (3 buffaloes) (Rs. 40606) while sole crop of groundnut (2.6 ha) recorded the net returns of Rs. 14872/ha (Reddy, 2005).

In high rainfall areas crop based farming systems will include fisheries. In rainfed rice-based production system at Orissa, conserving excess water in the refuges at the down stream of rice field and rearing of fish recorded the highest net returns (Rs. 21,197/ha) with BC ratio (2.78) as compared to the growing of rice alone (Rs. 15294/ha) (James *et al.*, 2005). In Jharkhand, improved rice (IR-64) + fish (mixed carps) – wheat (PBW-443) enhanced the net returns (Rs.58557/ha) as compared to the farmers practice of rice-fallow system (Rs. 2770/ha). Also in Jharkhand, Fish-cum-pig rearing (2:3) along with paddy increased the net returns (Rs. 53100/ha) with a B: C ratio of 4.12 as compared to farmers practice of rearing fish alone in the ponds (Rs. 12125/ha) (TAR-IVLP, 2004).

The hilly terrain of NE hill region is suitable for sustainable multi-enterprise system. The Tripura center of this region has developed a farming system model combining agriculture with horticulture, forestry and livestock rearing on one ha land. The enterprises taken are: cereal crops, pulses, oilseeds, horticultural crops such as mango and pineapple, vegetables, and livestock components of duckery, piggery and fishery in the water harvesting structures. The results indicated that the multi-enterprise system is nearly five times more profitable than traditional monocrop rainfed rice cultivation, which gives maximum production of 10 q/ha of rice.

2.2 Agro-forestry based Farming Systems

Perennial components like trees and grasses imparts stability to farming due to less effect of yearly variation in rainfall on these components besides protecting crops from water and wind erosion and improvement of soil fertility. Several studies carried out at CAZRI, Jodhpur showed higher benefit cost ratio from tree based farming systems as compared to pure arable cropping. Agri-pasture and silvi-pasture systems were found to be more stable and profitable than arable farming. The agri-silviculture system is recommended for land capability class IV with annual rainfall of 750 mm. Short duration dryland crops such as perarlmillet, blackgram and greengram combined with widely spaced tree rows of *Faiderbia albida* and *Hardwickia binata* have been found compatible in semi-arid tropical areas (Korwar, 1992). At CRIDA, the horti-pastoral system involving *Cenchrus/Stylos* in rainfed guava and custard apple, *Cenchrus* yielded dry forage of 7 t/ha during the first year while *stylos* recorded 5.6 tons of dry fodder during the second year of plantation. In ber based agri-horti system, pearlmillet + pigeonpea (Solapur), pigeonpea + blackgram (Rewa), castor (Dantiwada) and clusterbean (Hyderabad) showed promising results in rainfed environment.

In the black and red soil region, the land scape is often undulating. The canals run on the ridge. The seepage water travels through the porous *murrum* layer to areas at lower elevation, picking enough salts on the way to salinize lands on the slopes or in the valley. A belt of agro-forestry plantations involving trees capable of transpiring large amounts of water can effectively intercept such saline seeps and protect highly productive valley lands. *Acacia nilotica* and *Dalbergia sissoo* account for about 86 and 84% interception of the seepage over the control, respectively (Patil, 1994).

However, the popularity of tree-based systems is largely governed by the market infrastructure and price trends. *Eucalyptus tereticornis* based agro-forestry became quite popular in early eighties and large scale plantations came up as boundary plantations and block plantations. By the time these plantations became ready for harvest in early nineties, the prices crashed to all time low. The farmers harvested Eucalyptus and sold at through away prices. This markedly affected farmers' interest in agro-forestry. The same scenario happened with *Kinnow* and grapes in Punjab. The recent price trends of the most dominant poplar based agro-forestry in Punjab, Haryana and western UP is a reflection of what happened with Eucalyptus in ear1y nineties. To promote adoption of such diversified agro-forestry systems, policy initiatives like assured procurement, post-harvest and value addition are needed.

2.3 Livestock based Farming Systems

The livestock based farming systems in rainfed agriculture are complex and generally based on traditional socio-economic conditions. An understanding of production factors (livestock, capital, feed, land and labour) and processors (description, diagnosis, technology design, testing and extension) that effect animal production is pre-requisite for livestock integration. The productivity of livestock in farming systems in rainfed agriculture can be improved by increased fodder production as an intercrop with cereals, relay and alley cropping, forage production on bunds, improving the feed value of stover by chopping, soaking with water, urea treatment, strategic supplementation of concentrate, urea molasses etc. Establishment of fodder banks in areas where surplus fodder is available, artificial insemination with semen approved bulls, removing low grade animals through castration and adoption of preventive measure like vaccination and de-worming through health camps improve the productivity of milch animals (Mishra, 2002). At CRIDA, field studies indicated that urea treated straw increased the milk yield by 0.47-1.2 l/day in IVLP villages of Ranga Reddy district (Andhra Pradesh). The paddy straw consumption was also increased with 1-1.2 kg/animal due to this intervention. Urea molasses mineral block (UMMB) enhanced quality and quantity of milk by 25-30% in cows and buffaloes. It also helped in maintaining the overall health and productivity of animal particularly when fodder scarcity was acute in drought period. Mineral supplementation gave higher milk yield (58%) and net returns (Rs. 6816) compared to the farmers' practice of grazing alone (Rs. 2156).

2.4 Multi-enterprise farming systems for deep water rice growing areas

There are large areas of waterlogged fertile alluviums in eastern India (3.28 M ha) where water stagnates above ground for over six months in a year. The adverse physical conditions allow only one anaerobic paddy crop with a very low yield potential of less than 1.0 t/ha. A number of farming models integrating fish and prawn culture, cultivation of paddy, vegetables, fruits, poultry, duckery, piggery, rabbitry and cattle were evaluated at different locations. The systems based on multiple recycling of carbon, energy and nutrients from biomass to livestock/poultry/piggery/fishery etc also minimized environmental loading with pollutants (Samra et al., 2003). The average net return of Rs. 69,275/ha/year from integrated farming system were higher than the traditional rice cultivation. Such enterprising ventures need to be promoted in Orissa, Bihar, Assam, West Bengal and Eastern Uttar Pradesh for enhancing livelihood and land quality.

A multi-enterprise option is generally followed in coastal wet1and areas. Integrating rice and fish culture in these ecologically disadvantaged environments helps improve the farm productivity through recycling of nutrients. Among the rice-based mu1ti-enterprise options tried, rice-rice-azolla and rice-azolla-calotropis+fish farming gave higher grain yield of 10.57 t/ha and 10.13 t/ha, respectively. The results indicate that on an average 173 kg/ha fish was harvested from rice-rice-azolla-calotropis+fish farming (Shanmugasundaram and Balusamy, 1993).

Adding further value to Farming Systems approach

Post harvesting, processing and establishing market linkages add further value to the farming systems approach. Collective procurement and marketing if directly handled by the producers will significantly enhance the profitability. Establishment of agro-service centers in the villages can save the cost of inputs and can also get precise farm advisory services for higher profitability. Formation of commodity groups and self-help groups for farm women can help to promote off-season income generation activities which lead to livelihood improvement in villages.

Conclusion

Although the advantages of farming system approach are well established, there are still several constraints in upscaling the approach. The most important is the location specificity of the models and declining family labour availability for farming. While efforts are being made to replicate/popularize established farming system models, another approach would be to improve the existing farming systems of farmers through some simpler and cheaper interventions such as introduction of a new variety, an extra crop in the sequence or as intercrop, efficient resource recycling and utilization etc. Because small and marginal farmers with capital scarcity, risk avoidance objectives, and a cautious learning process rarely make drastic changes in their farming system. Rather, they proceed in a step-wise manner to adopt one and sometimes two new inputs or practices at a time. The impact of market need to be studied on a continued basis. Instruments like preferential credit should be designed for those farmers who adopt farming systems approach in view of their contribution to sustainability of agriculture as an enterprise.

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CONTINGENCY CROP PLANNING

G. Ravindra Chary and Ganesh Kute

Agriculture is the source of livelihood for nearly two-third of the population in India. The sector currently accounts for 14.2% of the GDP and employs 55% of country's total workforce. Weather plays an immense role in agriculture. Timely onset and good distribution of rainfall are critical for achieving optimum crop yields by farmers, particularly during *kharif* season (June-October) along with other factors like inputs (seeds, fertilizers etc), labour and technology. Temperature plays a key role during *rabi* season. Rainfall during the monsoon season not only determines the success of rainfed crops but also influences water availability to irrigated agriculture as most rivers in India are fed by rainfall.

Due to aberrations in monsoon behaviour in terms of onset, distribution and withdrawal; any deviation from normal monsoon pattern affects crop production, fodder availability to livestock and causes huge losses to farmers, impacting the livelihoods of farmers particularly small and marginal farmer in rainfed region. Farmers are facing hardships in agricultural operations and often experience huge crop losses. Climate change and climate variability are likely to further aggravate this erratic behaviour. Every year, droughts and floods are playing havoc with agriculture sector resulting in loss of production and infrastructure. The ministry of agriculture and different state Governments has evolved contingency strategies which are implemented during droughts. Rainfed areas constitute nearly 58% of the net cultivated area and account for 40% of the country's food production and support 40% of human and 60% of the livestock population and are the most vulnerable to monsoon failures. It has been estimated that even after full irrigation potential is realized, nearly 70 million ha of cultivated area will continue to be under rainfed farming. For this reason, performance of rainfed agriculture is key to achieve growth, equity and sustainability of agricultural production in the country. The demand for water from agriculture and allied sectors is ever increasing. Insufficient rainfall and the growth disregard for prudent use of water resources within the renewable limits has computed the problems of water shortage which is being felt even in the irrigated regions. Increase of variability in precipitation being witnessed at the regional levels is forcing us to enhance our preparedness to face monsoon aberrations even in the irrigated regions.

In addition to the drought, extreme weather events like heat wave, cold wave, untimely and high intensity rainfall, hailstorm and frost are increasingly being experienced in different parts of the country. Some of the extreme events in the recent past are:

- 20 day heat wave during May 2003 in Andhra Pradesh
- Extreme cold winter in the year 2002-03
- Abnormal temperatures during March 2004 and Jan 2005
- Floods in 2005 , Cold wave 2005 - 06
- Floods in arid Rajasthan & AP and drought in NE regions in 2006
- Abnormal temperatures during 3rd week of Jan to 1st week of Feb 2007
- Floods in eastern part of India – 2008, High temperature during *rabi* 2008-09 in major parts of the India

- 2009 floods

The extreme weather events (heat wave, cold wave, frost, hailstorm and cyclone) are climatic anomalies which have major impact on food, commercial and horticultural crops. In recent times the frequency of these events is increasing causing enormous damage not only to agriculture but also to other sector like livestock, poultry and fisheries. Proper documentation of occurrence, impacts and traditional coping mechanism is crucial for developing contingency strategies for such events at different crop stages viz., seedling / nursery stage, vegetative stage and reproductive stage and at harvest.

What is a Contingency Crop Plan?

- Contingency Crop Plan (CCP) is an emergency plan with information on crop, soil and water management strategies that help in minimizing crop and yield losses and assures some income to farmers during weather aberrations such as drought, floods, unusual rainfall events, heat wave, cold wave, frost, hailstorm etc.
- CCP help the administrative mechanism particularly agricultural departments to advise the farmers for alternatives and facilitate advance planning in respect of inputs, infrastructure etc.
- CCPs help in efficient utilization of natural resources for enhancing the crop productivity and income

Contingency Crop Planning is needed for drought both for rainfed and irrigated situation, delayed onset of monsoon normal onset followed by long dry spell, mid-season drought (vegetative / reproductive stages) and terminal drought. The suggested contingency measures which are recurrent in rainfed agriculture focus on **c**hange in crop, variety, appropriate agronomic measures, soil and water conservation measures and implementation, linkage issues, sources of seed / inputs etc.

For drought under irrigated situation, the CCP should focus on the condition with: Delayed / limited release of water in canals due to low rainfall; non-release of water in canals under delayed onset of monsoon in catchments; lack of inflows into tanks due to insufficient / delayed onset of monsoon and insufficient groundwater recharge due to low rainfall.For situation like untimely (unseasonal) rains, CCP should focus on the situations like continuous high rainfall in a short span leading to water logging and heavy rainfall with high speed winds in a short span. For Flood prone areas, the CCP has to focus on transient water logging/ partial inundation, **c**ontinuous submergence for more than 2 days and sea water inundation.CCP has to be developed keeping in view of the major farming situation (soil type) and major crops of the region.

Some of the strategies during Contingency Planning for drought in rainfed situation

a) Delay by 2 weeks:

- Direct seeding with seed drill, Weed free condition up to 40 days in Paddy
- Preparation of conservation furrows for moisture conservation
- Hoeing at critical stages of weed competition
- Sowing on ridges in case of Maize

- Prefer early cultivars
- Opening of conservation furrow in between crop rows for moisture conservation
- *In*-situ rain water conservation.
- Bed & furrow system of planting geometry.
- Application of full P&K & 20% N at basal along with FYM at seed row (paddy)
- Defer the sowing date in the nursery beds.
- Strengthening field bund

b) Delay by 4 weeks:

- Direct seeding with seed drill in case of Paddy
- Weed free condition at critical stages of crop growth
- Split application of recommended dose of nitrogen
- Prefer drought tolerant varieties
- Sowing at wider spacing specific to the crop and variety
- Seed hardening (Soak the seeds in 2% potassium di-hydrogen phosphate for 10 hours)
- Soil test based fertilizer application
- In wide as well as close spaced line sown crops, complete hoeing, weeding followed by ridging to the base of the crop rows at 20 days after sowing for *in-situ* moisture conservation.
- Adopt higher seed rate by 20% with wider spacing

c) Delay by 6 weeks

- Thinning of crops
- In case of paddy, seedlings from nursery may be used
- Adopt *In situ* soil and water conservation measures like cover cropping, bunding, trenching, terracing, and ridge and furrow method of planting.
- Seed treatment and proper plant protection measures should be taken to avoid germination failure and crop loss.
- Withhold N fertilizer (top dressing) application up to receipt of rainfall.
- Adopt seed hardening and wider row spacing specific to crop

d) Delay by 8 weeks

- Sow the crops at narrow spacing as soon as rain received
- Prefer short duration varieties/hybrids
- Adopt closer spacing
- Select early maturing cultivars.
-

Once the crops are sown, standing crop experience long dry spell affect growth, flowering, fruiting etc. depending on the stage of the crop. The seasonal drought is categorized in to early seasonal drought, mid season drought and terminal drought. Some of the strategies once given below:

a) Early season drought (Normal onset followed by 15-20 days dry spell after sowing leading to poor germination/crop stand etc.)

- Optimum population maintenance by gap Filling with seed priming

- In case of less than 30 % germination, take up re-sowing with wider spacing of 45 cm with sufficient soil moisture.
- Thinning of the seeding in the row.
- Crop residue mulching between the crop rows.
- In case of intercropping sequential sowing may be followed
- Manual weeding from the inter rows.
- Transplanting of old seedlings with higher nitrogen and potash application so as to induce fast growth after rain.
- Stand by nursery should be prepared to get ready for complete crop failure
- Broadcasting sprouted seeds of short duration varieties.
- Chemical weed control specific to crop.
- Reseeding of nursery beds.
- Re-sowing in severely damaged field with >50% mortality.

b) Mid season drought

1. At vegetative stage
- Protective irrigation and thinning
- Stripping of old & nonfunctional leaves.

2. At flowering / fruiting stage
- Protective irrigation,

3. At maturity:
- Protective irrigation or harvest at physiological maturity
- Protective irrigation, In case of poor grain filling harvest for fodder
- Adopt soil moisture conservation measures like ridges and furrows in *kharif*
- Supplemental irrigation with harvested rain water in ponds (10 mm depth.) by using micro-irrigation (Sprinklers)
- Foliar application of 2% urea at pre-flowering and flowering stage
- Topping and desuckering
- Harvesting of mature leaves
- Harvest non flowering plants for fodder purpose if water is not available

c) Mid season drought (long dry spell, consecutive 2 weeks rainless (>2.5 mm) period)

1. At vegetative stage
- Hoeing/Weeding
- Spray 8 % kaoline
- Spray 2 % urea
- Opening of conservation furrows in between two crop rows
- Thinning in the row
- Harrowing and earthing up
- Apply irrigation in alternate furrow
- Give supplemental irrigation ,if available

2. At flowering/ fruiting stage
- Use of anti transpirants @ 8 % kaoline,
- Mulching

- Hoeing/Weeding
- Use of 8 % kaolin spray
- Foliar spray of 2 % urea
- Harvesting for fodder
- Provide irrigation at critical stages at flowering and grain filling stage

d) Terminal drought

1. At maturity:

- Plan for *rabi* crops
- Utilization of residual moisture for early sowing of pre-*rabi* crops like cowpea horse gram (Urmi), green gram blackgram, Niger to be sown to conserve soil moisture.
- Provide life saving irrigation from harvested rain water at reproductive stage and conserve soil moisture.
- Harvest the crop at physiological maturity stage.

The basic principles of dryland farming like *in-situ* moisture conservation (specific to soil type and rainfall situation) like compartmental bunding, ridge and furrow system, mulching, cover cropping, conservation furrow etc are to be adopted. Other practices include rainwater harvesting and storage in farm ponds and recycling / utilization for life saving / supplementary irrigation during dry spells. Location specific soil, crop and water management practices recommended by agriculture universities / agriculture and line departments are available for adoption. Preparation of contingency crop plans for floods, cyclones, heat wave etc. in progress and made available in due course of time.

Suggestions:

- There is a need to prepare resource inventories of weather, crop and soils information at micro level for better agricultural planning in managing weather based risks
- Dissemination of weather based advisories through village knowledge centers / mobile network should be taken up on priority basis
- Capacity building of the stakeholders for implementing CCPs

SILVIPASTORAL SYSTEM FOR FODDER PRODUCTION

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Abstract:

Introduction

Land degradation refers to decreases in soil productivity inducing its present and potential capabilities through deterioration of physical, chemical and biological features. Human induced degradation can be either displacement of soil material, mainly by water and wind, or soil deterioration resulting from salt accumulation, loss of nutrients or through physical processes including water logging. Out of the total geographical area of 329 m ha, 187.7 m ha representing 57% presently suffers from various kind of degradation problem (Paroda, 1998). Water erosion is the major cause contributing to loss of top soil (132.4 m) and terrain deformation (16.4m ha), wind erosion is dominant in western region resulting in 13.5 m ha degraded lands. Water logging is the major physical deterioration process, which accounts for degradation of 11.6 m ha land area. Soil deterioration due to chemical process is estimated to affect 13.8 m ha which includes accumulation of excess salts i.e. salinisation (10.1 m ha) and loss of organic matter and plant nutrients (3.7 m ha). Degraded lands such as ravine, shallow gravelly red soils and rocky areas of semiarid region, hot desert and sand dunes, cold desert, cho and riverbed area, swampy and wet lands etc. are not suitable for annual crop cultivation. Therefore, it is very essential to develop these lands through perennial vegetation so that further degradation can be checked. Silvipastoral systems have been found as an ideal alternative for development of such degraded lands in our country.

The current demand and supply gap is difficult to bridge in case of 150 M CUM of non commercial wood, 147 M t of dry fodder and 1464 M t of green fodder in the country. The acute fodder shortage (quantity and quality) is the major cause of low productivity of livestock, especially in hills and semi-arid areas. Fuelwood, the primary source of energy for more than 70% population, is obtained progressively from collecting dead wood or from the lopping of live trees, felling of trees and eventually to the uprooting of the stumps. In fact in many areas the mining of wood (from stumps) has become the principal source of for landless people to earn their livelihood. It is further coupled with the diversion of the crop residues and animal dung to the fuel use to the detriment of soil structure and fertility.

Considering these, the silvipastoral technology has been found as the most viable alternative to protect land resources, soils, environment and provide the vital needs of fodder, firewood, timber and the related non-wood forest products.

The resource needs

The arid and semi-arid regions under the effect of monsoon produce savanna type vegetation. Functionally in most of the degraded forests and new plantations, the early colonizers like grasses, legumes and weed provide a rich resource for herbivores, which under uncontrolled grazing continue to degrade the system. The degraded area in semi-arid and arid states (Table 1) shows 79.6 M ha available land waiting improvement. The grazing demands as per higher animal productivity and economic returns from the animal can be expected as 1156 and 1253 M t dry matter annually by 1995 and 2000 AD comes to 949 and 1136 M t respectively. As against these, the present availability is 198.9, 215, 15 and 11 M t of dry fodder and concentrate respectively by 2000 AD. Thus, there is a vast gap in demand and supply.

Table 1: Semi-arid areas in India and Wastelands

State	Area (km2)	% of total semiarid area	Area under wastelands (m ha)
Maharastra	189580	19	12.0
Karnataka	139360	15	7.1
Andhra Pradesh	138670	15	7.2
Rajasthan	121020	13	18.0
Tamilnadu	95250	10	3.4

Gujarat	90520	9	6.1
Uttar Pradesh	64230	7	6.6
Madhya Pradesh	59470	6	13.0
Punjab	31370	3	1.1
Haryana	26880	3	2.4

Similarly, by 2000 AD the fuelwood demand is likely to vary between 200 to 385 M cum for which about 40 M ha additional land area would be needed to produce fireword for the increasing human population. The scarcity of firewood also forces people to burn dried cow dung to meet the demand for energy in terms of fuel.

The Silvipastoral Systems

Silvipastoral system is commonly defined as growing ideal combination of grasses, legumes and trees for optimizing land productivity, conserving plants, soils and nutrients and producing forage, timber and firewood on a sustainable basis. This involves replantation , substitution or intervention in the existing vegetation by desirable species. This approach is close to nature where trees, grasses, shrubs and legumes grow together in an integrated manner. They are utilized either through cut and carry or in-situ grazing system. It involves I) trees which are valuable as conserver of land for amelioration of climate specially in arid and semi arid regions besides their fodder, fuel and timber value, ii)grasses and legumes with animals feeding on them and the man with management options and turning this practice into a highly economic system even involving rainfed cash crops occasionally.

Basic assumptions before planning a silvipastoral project are:

1. The silvipastoral projects are suitable for degraded lands for development along with forage production
2. This programme should be considered as a supplementary activity for providing green and dry forage to the animals through out the year.
3. It should help the areas with acute forage shortage specially the dry arid zones.
4. It can be taken as a supplementary activity to the agriculture and not the sole activity
5. The borrower should have the reasonable income from the agriculture crops and should not fully depend upon this for his subsistence.

STEPS FOR DEVELOPMENT OF DEGRADED LANDS*(The Silvipastoral technique)*

The choice of species

A knowledge of suitable species of grasses, legumes and trees is a pre – requisite before initiating any development programme. Ours is a vast country with a great diversity of climate and variable in topography and soils. Therefore, any blanket recommendation can not be made. One has to choose the right species that can adopt to a given environment.

Measures for protecting the area from animals

Overgrazing has been responsible for the degradation of land. Simple closure of the area would help rapid regeneration of grasses, legumes and trees already available in that area. Protection may be done either by barbed/woven wire with angle iron/stone/wooden poles or cut thorny shrub materials, loose stone wall, cattle proof trench, live hedge etc. For live fencing species like *Carrisa carandus, Lantana camera, Agave sislana, A. americana, Lowsonia alba, L. inermis, Euphorbia tirucalli, Opuntia species, Prosopis juliflora, Ipomea fistula, Parkinsonia aculeata etc.* may be effectively used which is economical also. By simple protection, production from natural vegetation, recorded at the tune of 3.5 t/ha as compared with only 0.08 t/ha from unprotected area (Shankarnarayan et. al. 1974)

Eradication of unwanted Bushes

Under Indian climatic condition, closure of an area leads to bush formation, which occupies over 30% area, and this causes a reduction in the productivity of grasslands. Therefore, unwanted woody perennials such as Lantana , Karonda etc. should be eradicated to get higher production. Eradication may be done either manually by uprooting the bush/trees or chemically by application of 0.8% 2,4,5-T solution on freshly cut stumps or broad cast weedicide pcloram at 10-15 kg/ha around bushes. Application of weedicide showed good kill of bushes and prevented resprouting (Shankarnarayan, et. al., 1974).

Suitable soil and water conservation measures

Soil and water conservation measures are one of the most important factor for improvement of degraded lands especially on sloppy lands. On such type of lands the first step to check the run off improve the water percolation and increase soil moisture status of the soil. Staggered contour bunds/trenches (3x0.5x0.5m) are made to arrest the water flow. The soil is deposited along with contour and the trenches are dug facing the slope. 500-600 trenches/ha are recommended for semiarid region with rainfall upto 1000 mm. They retain 95% of the run off even from the rain storms of high intensities. On the soil mounds, seeds of legumes such as *Stylosanthes hamata*, *Macroptilium atropurpureum* etc. are sown to enrich soil and optimizing the soil moisture availability.

Establishment of grasses, legumes and trees

Just by protection of the degraded lands, the regeneration of natural vegetation starts. This is often time consuming process. Therefore, establishment of suitable grasses, legumes and trees of that area is desirable. After selection of suitable species planting and sowing may be done at the onset of monsoon. Pits of 45 cm3 size at 5x5m or 6x4 m spacing should be dug during May-June for weathering of soil so as to minimize the attack on seedlings by insects and pests. At the time of plantation of saplings, in each pit a mixture of urea, SSP and murate of potash (125 g in the ratio of 1:4:1) along with 40 to 50 per cent farm yard manure of the total volume of the pits and may be given. 10 to 15 g BHC powder per pit may be given besides 15 to 20 kg/ha at the time of soil working to save the saplings from termite attack. 5-11 months old tree seedlings may be planted during monsoon in the pits depending the growth of saplings of tree species.

Immediately after tree plantation, the interspaces are sown with grasses at the rate of 4-5 kg/ha at 100 cm spacing. In between two rows of grass, small seeded legumes such as Stylo or Siratro should be shown at the rate of 5 to 6 kg/ha. The seeds of grasses and legumes, pelleting should be done with clay soil and farm yard manure for better establishment. For quick growth and production of grasses and legumes 40 kg P2O5 and 20 kg N/ha at the time of land preparation followed by split application of 20-60 kg N/ha annually depending on the rainfall and its distribution has been recommended (Rai and Kanodia, 1981). In arid zones, complete soil working after removal of unwanted bushes etc. followed by sowing of perennial grasses resulted better establishment and higher productivity (Chakravarty and Verma, 1970).

Ecological assessment of the production function

Under the silvopastoral system of land management the broader aims are the production of forage, firewood, grazing, seed and land improvement of the environment. These are analysed as under:

-Forage production:

The systematic studies on established that depending upon soil moisture and nutrients the yield differences from 2 to 10 t/ha could be obtained per year from the grasses. After five years growth of trees the canopy effect on pasture yield becomes apparent. This depends upon the tree species, canopy architecture and density.

-Firewood

Production of fuelwood at 8 years of growth under silvipasture on wastelands was attempted on A. tortilis and A. amara. The former gave a yield of 28 t/ha and the latter 38 t/ha, which could be 3.5 and 4.75 t/ha/yr. on an average. For most of the short rotation species on such lands on a cycle of 10 years one could expect from 4-6 t/ha/yr. fuelwood production at a tree density of 500 plants/ha in Jhansi conditions.

-Grazing

After harvesting the grass in the 4th year when growing animals were allowed to graze between December to June, it was found that they not only maintained their body weight but showed growth without any additional concentrate or salt (Ramana et al., 2000). The growth and production of grasses during the next monsoon was found to be normal. The leaf litter of trees, legume component in the pasture and trees, legume component in the pasture and occasional tree leaf provided the balanced ration along with the dry tussocks grazed. Thus 75 kg/ha/yr. animal weight gain was observed in the silvipastoral system.

-Land improvement:

The analysis of soils after 6 years of silvipasture establishment indicated increase in the nutrients like N, P, OC, and K in time even when grasses were harvested and removed every year. Mishra et. al. (1988) also observed improvement in soil physical properties, pH, N and OC with 4 years silvipasture plantation on a calcareous soil. From these studies it was amply indicated that poor soils on the wastelands could restore their fertility under such systems.

-Overall gains

From the foregoing it could be seen that depending upon their edapho-climatic situations these could produce the annual harvestable herbaceous biomass in the range of 7-8 t/ha at varying levels of management. The removal of harvestable biomass further leaves about 15-20% of it, which is not harvested and could be utilized by grazing animals. Table 3 provides an analysis of such gains in the terms of their energetics and compares with other systems of land use.

The perusal of Table 2indicates that the current level of production from grazing/wastelands could be doubled under managed pasture situation, which could further be improved by 3 times under silvipastures. The rainfed cropping is also compared with these systems to indicate the value of these high input technologies.

Table 2: Comparative estimate of the energy fixation (in harvestable biomass) by different systems of land use

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Land use system	Aerial biomass	Energy

	(t/ha/yr.)	(Kcal/m2/yr)
1. Grazing lands	2.8 - 8.0	250 - 960
2. Managed pastures	3.5 - 5.5	1120 - 2000
3. Rainfed agriculture (with inputs & management)		
Sorghum (105 days)	5.9	2591
Pearl millet (67 days)	7.5	3197
Maize (diara)	1.7	782
4. Silvipasture (with intensive management possibilities)	7.0- 15.0	3040 - 6511

Production potential of various silvipastoral systems

Forage production from pasture under silvipastoral system is directly influenced by its initial establishment, subsequent management, edaphic and climatic conditions, tree density and canopy manipulation etc. Long term studies conducted at different climate and edaphic condition in India revealed that total biomass production (forage + leaf fodder + fuel wood) obtained through silvipastoral system are many times higher than the natural or seeded pastures alone. The suitable species and their production from silvipastoral systems in different types of degraded lands of India are given below.

Shallow gravelly red soils areas of semiarid region.

On the basis of more than 20 years studies in shallow gravelly red soils, Pathak et. al. (1996) reported that the 20 ha degraded lands producing hardly up to 1t/ha/yr have been improved to produce up to 10 t/ha/yr. at a10 year rotation through silvipastural system. Besides yield improvement by 8-10 times, the quality of forage has also improved by 6-7 times. Studies were conducted with woody component of *Albizzia amara*, *Dichrostachys cineria* and *Leucaena leucocephala* in association with *Chrysopogon fulvus* as grass and *Stylosanthes hamata* + *S. scabra* as pasture legumes at NRCAF for evaluation of silvipastoral system and natural grassland from 1990 to 1996. The maximum total biomass of 10.4 t/ha (5.63 t from grasses and legumes + 1.15 t from leaf fodder and pods + 3.62 t as fuel wood) was recorded during 4th year of establishment of silvipasture. The production of natural grassland varied from 2.06 to 3.16 t/ha during different year (Rai,1998).

Ravine Areas

Ravines present the worst form of erosion, which completely destroy the land. About 4 m ha area is ravinous confined largely to the state of UP, MP, Gujarat and Rajasthan. These lands are far below their economic utilization. Although ravine lands are potential for producing, fuel, fodder and fibre and generation of additional employment. Small to medium gullies of these ravines can be put to silvipasture or hortipasture or silvihortipasture. Suitable MPTs for ravine areas are *A. nilotica, A. catechu, A. tortilis, Dichrostachys cineria, D. sissoo, Azadirachta indica, Dendrocalamus strictus, Albizzia species, Eucalyptus tereticornis, Grewia tenax, Zizyphus nummularia, Z. mauritiana, Capparis zeylanica, Aegle marmelos,E. officinalis, Limnosia acidissima, Ficus species, Prosopis species.* In addition to MPTs, grasses (*Cenchrus species, Dicantheum annulatum, Eulalopsis binata, Pennisetunm pedicellatum,Panicum antidotale etc.)* and legumes (*Macroptilium artopurpureum, Rhynchosia minima, Clitoria ternatea, Alysicarpus monilifer, S. hamata* etc.*)* to be sown for getting higher biomass as well as controlling the soil erosion loss in these areas.

Chos and Riverbeds affected area

The shallow hill torrents (Streams) along the foot hills have seasonal flows which are popularly known as "Chos" in Punjab "Raos" in Doon valley. These areas are largely observed in the sub mountain regions of Himalaya. Besides, there are large riverbed affected areas, which are created due to shifting of major rivers of spillover river sections. These lands are known as "Bet" , "Khadder", "Chaur", "Diara" etc. This type of affected area is found in eastern states of our country (UP, Bihar etc.). In India the total area affected by this problem is 2.73 m ha (Miahra et. al. 1988). These lands area can be developed through plantation of MPTs (*A. catechu, A.. nilotica, D. sissoo, Salix sp., Bauhinia purpurea, L. leucocephala, Grewia optiva, A. lebbeck, Agave spp., Z. mauritiana, Psidium guajava, Morus sp.*) along with grasses (*Eulalopsis binata, Arundo donax, Saccharum munja, S. spontanium, P. purpureum, C. fulvus, P. pedicellatum*) and legumes (*Calopogonium muconoides, Stylosanthes guianensis, Pueraria tuberosa, P. hirsuta, P. phasedoides, P. lobata*). The productivity of such lands can be increased and adopting such systems can minimize soil erosion.

Mines affected areas

In our country lot of areas are available which has been badly affected by mining for coal, limestone, marble and other building materials. Mine-spoils area has been rehabilitated by engineering conservation measures like construction of series of gabion structures and loose rock filled check dams (Mishra et. al., 1988). In between structures, quick growing MPTs like

Bauhinia ratusa, L. leucocephala, Lanea grandis, Grewia optiva, Erythrina suberosa, Acacia species, Albizzia species, Salix tetrosperma, Eucalyptus hybrid, D. cinerea, D. stictus, Ipomea carnea, Agave spp., Vitex negundo, A. indica, Z. mauritiana along with grasses (*Chrysopogon fulvus, E. binata, Bothriocola persuta, D. annulatum,, P. purpureum, Arundo donax, S. spontaneum*) and legumes (*M. artopurpureum, S. hamata, Pueraria hirsuta, P. tuberosa, P. labata*) can be successfully introduced and maximum benefit can be obtained from such areas.

Swampy and Wet Lands

The extent of wetlands is more than 6 m ha apart from the permanent water bodies passing different kind of problem in our country. Marsh lands and swamps are usually found in southern and eastern India. Such type of affected areas can be improved by growing of suitable MPTs like *Barringtonia acutangula, Salix tetrasperma, Bischiffia javanica, Lagerstroemia flosreginae, Eucalyptus robusta, E. rudis, D. Latifolia, Glyricidia maculata, Populus euphratica, Syzigium cumini.* To get higher production from these areas in addition to MPTs, suitable grasses (*Brachiara mutica, B. decumbens, Iseilema laxum, Dicanthium caricosum, Paspalum nolatum*) and legumes (*Sesbania microcarpa, Latononis bainesli, Glycine wightii*) to be established and 20 to 40 t/ha green forage yield can be obtained (Patil and Pathak, 1981).

Saline and Alkali Soils

In India about 8 million hectare area is infested by saline alkali soils and in Uttar Pradesh alone about 1.2 m ha area is lying as "Usar". Hence, to increase the total forest cover and to reclaim such type of lands plantation of suitable MPTs (*Prosopis juliflora, Acacia nilotica, A.. catechu, A.. tortilis, Cassia siamea, Albizzia lebbeck, A. procera, Butea monosperma, D. sissoo, Casuarina equisetifolia, Tamaris articulata, Emblica officinalis, Pongamia pinnata, Salvadora spp., E. hybrid, S. cumini, T. arjuna, L. leucocephala, T. indica, Z. mauritiana* etc.) along with grasses (*Leptochloa fusca, B. mutica, C.. gayana, B.intermedia, Sporobolus marginatus, Paspalam spp.* etc.) and legumes (*Atripex spp., Sesbania spp., Rhynchoisa minima, Clitoria ternatea, Desmanthus virginatus* etc.) have been found beneficial for increasing the productivity of such lands.

Arid Desert and Sand Dunes

About 30 m ha area under arid zone of the hot thar desert is sandy hummocks and sand dunes, which is mostly covered the states of Rajasthan, Gujarat and Haryana. Indian desert is one of the most thickly populated deserts of the world having a population of over 19 M people with an average density of 61 persons/km2 as against 3 persons/km2 in other deserts (Paroda et. al. 1980). These areas can be developed with plantation of suitable MPTS, grasses and legumes as well as the productivity of the grasses can be enhanced many times with improved management practices. On an average, forage production of *C. ciliaris* when grown in association with *A. tortilis* was 0.88t/ha while yield with *C. mpane* and *H. binata* were0.8 to 1.0 t/ha, respectively when these trees planted at the spacing of 10 x 10m (Deb Roy, 1993). Forage production under 14-18 years old plantation of 4 desert trees (*P. cineraria, T. undulata, A. lebbeck and A. senegal)* was recorded maximum 1.5 t/ha with *P. cineraria* and *T. undulata* and minimum was 0.6t/ha with *A. senegal* (Ahuja, 1980). Sharma et. al. (1994) reported that the productivity of Kailana arid land can be increased 2-3 times by replacing natural grass cover with *C. ciliaris* and introduction of top feed spp. (*Z. nummularia and Grewia tenax)* under silvipastoral system.

Conclusion

The package of practices such as protection of area from biotic interference, adaptation of proper soil and water conservation measures, method of establishment as well as suitable grass, legume and tree species for different type of wastelands such as saline alkali soils, ravine areas, mines affected soils, cho and riverbed affected areas, swampy and wet lands, shallow gravelly red soils and rocky areas in semi arid regions and desert and sand dune areas has been discussed in the text. The results on production of biomass through various silvipastoral systems on different degraded lands revealed that the silvipastoral systems are very much beneficial for getting higher biomass (forage, top feed, fuel, minor timber) production from the same land on sustainable basis.

Future Research Needs

- Very few pasture legumes have been identified to be adaptable and useful in mixture with grasses. Further research on their germplasm collection testing and improvement are essential to select them to use in diverse habitat.
- Cultural practices for tree multiplication, their management and utilization for higher productivity.
- Tree lopping studies and understanding their growth and regrowth patterns is essential to advise the higher leaf fodder production
- Use of biofertilizers and moisture conserving chemicals for improving establishment of plants on degraded lands.
- Interactive mechanisms of grasses, legumes and trees at different stages of growth should be studied to advise suitable management principles for optimum production on sustainable basis.
- Studies on age of trees to start pruning/lopping, frequency, intensity and season of pruning.
- Soil improvement capacity of various silvipastoral systems.
- Economics of silvipastoral systems.

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Alternate land use systems for better soil and water resource utilization

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The population explosion has brought marginal rainfed lands in to cultivation, posing a serious threat to natural eco system resulting in low and un economical yields. Inappropriate arable cropping systems often lead to rapid degradation of arable land, besides holding little promise of coping with ever increasing needs of human and livestock population. At present nearly 70% of the area is affected by wind erosion. If destruction of natural vegetation and over use of marginal lands continues, up to 9% of the additional land may be affected by wind erosion by 2020. Rehabilitation of the degraded lands and enabling more food and biomass production from these lands is the priority in the immediate and medium term.

Alternate land use systems with perennial tree/ bush/ grass systems are better alternatives for such regions. Development of perennial based systems for different agro ecological regions can meet the requirements of ever growing population of both human and livestock. With the development of Indian economy and growing per capita incomes, there is a growing requirement of products such as animal products, fruits, bio fuels, paper and environmental friendly packaging material, etc. besides fodder and fuel. These products can be obtained from perennial systems, which can be grown under rainfed conditions. Systems like agri horticulture, silvipasture, hortipasture, dye yielding, medicinal and aromatic plants not only meet diversified requirements of the economy but also enhances income to rainfed farmers. Further processing of these products could emerge as an important source of income and employment.

Fuelwood: The rural population in India relies heavily on traditional biomass-based fuels (fuelwood, crop residues, and animal dung) for meeting its energy needs. Approximately 96% of rural households are estimated to be using these fuels. These fuels dominate the domestic sector and are primarily used for cooking. Fuelwood is the primary energy source for cooking used by rural households (78%). Use of wood for industrial purpose also has gone up remarkably in recent years. In the state of Andhra Pradesh alone, 67 biomass based power projects of 404 MW capacity are in operation and one of the problem faced by these plants is availability and procurement of biomass raw materials. Development of biomass based projects with co firing in existing coal fired power plants are increasing due to the emphasis on reducing CO_2 emissions from the power plants and also the emerging opportunities under Clean Development Mechanism (CDM) of Kyoto protocol. During 2000 the gap between the sustainably produced fuelwood and the consumption was about 200 m cum. The gap between consumption and recorded production of fuelwood has, however, been increasing, indicating the seriousness of the fuelwood problem in India. This gap is widely believed to be met from illicit and unsustainable exploitation of biomass resources.

Pulpwood: In India, the rapid increase in the population lead to a rapid increase in paper consumption (news print, printing paper, packaging material as a substitute for polythene, value added paper etc.). The rate of annual production is about 4.1% where as the growth in the consumption was at an average rate of 5.1% a year. The consumption has far exceeded the production every year and the gap has widened over time. In India, the annual per capita consumption of paper and paperboard was only 4.5 kg, compared to 42 kg in China and 55 kg worldwide. It is estimated that India's annual per capita consumption of paper and paper board will rise to 8 kg by 2010. Due to the inability of forests to meet the raw material requirements, industry to a great extent depends on the imported pulp. The imports were to the tune of 768 thousand tons costing about US $ 435m. during the 2002-04. It is estimated that the consumption is expected to double by the year 2010-11 and likely to increase substantially by the year 2015-16.

Table 1. Average annual production, consumption and imports of paper and paperboard, 2002-04.

Category	**Production (Thousand tones)**	**Consumption (Thousand tones)**	**Imports (Thousand tones)**
News print	700	1249	555
Printing & writing	1530	1539	106
Household & sanitary	40	43	3
Other paper & paper board	1861	1920	104
Total paper & paper board	4131	4751	768 (US $ 436m)

(Source: FAOSTAT 2006)

Timber: Rapid urbanization and intensive construction activity in the country lead to large gap between domestic demand and supply. The wood demand has increased by over 60% in the last decades, where as the output from the forests has halved in the same period. Our forests are at the optimum level of conservation and further improvement in productivity may not be possible. It is obvious that government owned forests cannot meet the requirement of the country, let alone the future. The overall annual imports are to the tune of 2 million m^3 a year valuing about US$550 million a year. It is estimated that the requirements of various categories of wood will increase by 40% by 2013-2013. Now more than 50% of industrial timber is being contributed by agroforestry in private sector. With forests under increasing pressure, agroforestry is the only segment that can record growth in production in timber, fuelwood, industrial wood, fodder and grass and medicinal plants and farmers in rainfed regions should seize this opportunity in the years to come in a big way.

Table 2. Demand and supply of wood (in million cu.m)

Particulars	**1985**	**1996**	**2001**	**2006**
Wood demand for domestic furniture, agriculture, industries	50	64	73	82
Output from forests	24	12	12	12
Output from plantations, production from social and farm forestry	-	41	47	53
Deficit	26	11	14	17

(Source: Report of National Forestry Commission 2006, MOEF)

Agroforestry Systems for wood production:

In India many fast growing plants were screened for their suitability for pulp and paper making. This includes a large number of annuals and perennials. Some of them are Populus, Bamboo, *Casuarina equisetifolia, Eucalyptus globulas, Eucalyptus grandis, Sesbania aculeata, Moringa oleifera, Prosopis juliflora, Leucaena leucocephala, Grevillea robusta, Pinus taeda, Sesbanea aegyptica, Acacia auriculiformis, Gmelina arborea, Pinus radiata,* and *Hibiscus sabdariffa*. Due to their adaptability to climate, soil and environmental conditions, rapid biomass accumulation, high quality of pulp, ready market and multiple uses such as poles, wood etc. The following tree species are grown widely by farmers in one or other parts of the country and the tree species are well integrated in to the existing land use systems.

Poplar (*Populus deltoids*)**:** Poplar is the most widely grown tree cash crop in north and north western parts of India. Poplars due to their fast growth, ease in vegetative propagation and multiple uses such as plywood, match splints, pulp, veneer, fibre board, fuel, fodder etc. resulted in wide acceptance with the farming community for the last so many years. With the systematic shrinkage of forest land in India and expanding human population, poplars have gained tremendous importance in meeting the demand of wood products so much so that 80% of plywood production in north India depends on poplar wood.

By and large poplar is grown above 28^0 N latitude in the country. With the introduction of new clones and release of new clones through breeding among well adapted land races, it has been possible to grow them successfully well before this latitude in Maharashtra, Madhya Pradesh, Eastern UP, Bihar etc. it is estimated that around one million hectares of agricultural land is under poplar cultivation in one or other form of agroforestry. The total area planted annually works out to be about 23,000 ha (Rawat, 2001).

Due to the importance and utility attached to poplars, a large number of exotic poplars were introduced in India. The most widely planted species among them is *Populus deltoides*. It is grown on a large scale in Tarai regains of UP, plains of Punjab, Haryana, U.P., Himachal Pradesh and Arunachal Pradesh. Some of the new clones, introduced recently, which have shown promise in agroforestry systems, are S7C4, S7C8, S7C15, S7C20 etc. WIMCO seedling ltd. Rudrapur has also developed some clones such as Udai, Kranti and Bahar, which are being planted by farmers. Some of these poplars produce a mean annual increment of up to 50 m^3/ha/year, the overage is being 20m^3/ha/year against a maximum of 4.5m^3/ha/year available from forest plantations. The growth habit of poplar tree with straight and cylindrical bole, moderate conical crown, mostly deciduous during winter months helps to keep the tree-crop competition to a minimum.

Poplar is generally planted either at 3 to 4m spacing in linear rows on one or more bunds of agricultural fields or at 5x4m spacing throughout the agricultural field. Poplar has been successfully integrated with agricultural crops and several agroforestry models, which are ecologically and economically viable, are available. Field crops such as wheat, sugarcane, sunflower, mustard, oat, maize and pulses are grown extensively with poplar either in irrigated or rainfed conditions (Sharma & Dadhwal 1996). However when grown under marginal lands without irrigation the growth rates and biomass accumulation is quite low. A variety of inter crops were tested with poplars for their suitability and performance. Some of them are lettuce, beet root, pineapple, yams, including essential oil yielding annuals viz. tagetes, etc. Among them pineapple and yams have shown promise of cultivation as an inter crop with poplars. Lettuce, beet root perform well with poplar and registered yields as high as 275q/ha and 150 q/ha, respectively. Among the essential oil yielding crops picholi and tagetes hold promise (Chandra 2001).

Eucalyptus sps***.:*** - Extensive plantations of eucalyptus is being taken up by government and non government agencies in the recent past because of the economic gains associated with shorter rotation cycle of Eucalyptus. In Punjab & Haryana during 80's farmers adopted wide scale plantation of eucalyptus at a closer spacing keeping in view the demand for local pulp mills. However the development of high yielding and disease resistant clones has revolutionized eucalyptus cultivation in many parts of India. The productivity of these clones under rainfed conditions ranges between 12-44 m^3/ha/yr. In certain trials the productivity of best clones has been more than 10 times the productivity of seedlings control treatment or the worst performing clone (Piare Lal, 2001). The plantation of eucalyptus in India has increased tremendously during the last decade through various forestry and agroforestry programs. Over 0.62 m. ha of land is covered by this genus (Singh and Kohli, 1992).

Due to short rotation cycle i.e. 4-5 years and high returns associated with clonal plantations, they became popular among the farming community. An average yield of 40-50 ton/ha/3yrs. is not uncommon in deep soils. Besides that the coppicing ability of eucalyptus makes it suitable to take up 3-4 harvests continuously without any additional expenditure. Supply of improved plant material at subsidized rates, continuous advisory services and guaranteed minimum support price offered by the state government are some of the other contributory factors encouraging the cultivation of eucalyptus in large areas in the vicinity of paper industries. Due to the non availability and high cost associated with labour and risky nature of the commercial crops such as chillies, tobacco and cotton and guaranteed returns associated with eucalyptus, large number of farmers are growing eucalyptus in their agricultural lands.

Unlike poplar much of the eucalyptus cultivation is confined to rainfed areas. Areas receiving high rainfall are particularly suitable for eucalyptus cultivation. Better yields of eucalyptus can be obtained in sandy loam soils with good drainage. The best time of planting eucalyptus is the break of monsoon in June-July when the seedlings become 1m long and fit for planting in pits of size 45x45x45 cm. It is planted it a spacing of 3x2m. It has been grown not only as monoculture plantation but also as field bund plantation in agricultural fields. A large number of crops such as chickpea, lentil, wheat, mustard, berseem, blackgram and greengram are commonly grown with eucalyptus.

Leucaena leucocephala: *Leucaena leucocephala,* a leguminious multipurpose tree thrives well in neutral to alkaline soils where the annual rainfall ranges from 600-1700mm. It is an excellent source of fuelwood with high calorific value and produces large quantities of forage. The forage is highly palatable, digestive and nutritious. Foliage is very rich in nitrogen and can used as green manure. Besides above, leucaena is having good copping ability and ability to fix atmospheric nitrogen and can be successfully grown in marginal and sub marginal lands with less difficulty.

Several *Leucaena leucocephala* cultivars and *Leucaena diversifolia* were tested in India, Indonesia and other SE Asian countries as a raw material for pulp and paper. It was clearly established that they have the potential to produce high biomass and the cellulose content of the pulp was high indicating their suitability for pulp production. Pulp contains high amounts of alpha-cellulose (92-94%) with low ash content (0.05-0.06%). Experiments conducted in India revealed that plant growth and yield parameters were found to be minimum in the closest spacing i.e. 100x100 cm and maximum with wide spacing i.e.

200x200 cm. However, maximum dry matter production was obtained in the closest spacing i.e. 160 t/ha by the 5th year and minimum biomass yield was obtained in the widest spacing i.e. 45 t/ha by 5th year. With the increase in population the biomass yield per unit area was also increased (Saikia & Sharma 1994). The plant height, diameter and yield of biomass increased with the increase in nitrogen application and the trend was found to be linear (Saikia and Sharma 1994). Manivachakam et al. (1998) reported that the above ground biomass production of *L. leucocephala* at the age of 5 years amounted to 128.4t/ha in a sandy loam soil where as it is 49.8 t/ha in clay soil of Coimbatore. Farmers in the districts of Nagpur and Wardha of Maharashtra went for massive plantations of leucaeua during 1980's. Large area in the districts of Prakasam, Guntur, Krishna of AP is under Leucaena cultivation. Farmers generally adopt high density plantations. The spacing ranges from 1x1m to 3x0.6m. These plantations are distributed in areas receiving an annual rainfall of 500-900mm. Leucaena is generally harvested in 3.5 years and allowed to re sprout. 3-4 rotations can be taken up successfully. Agricultural crops such as cowpea, blackgram, green gram and cotton are grown during the first year of each rotation. There is tremendous scope to increase its cultivation in sloppy areas of watersheds and it is particularly suitable for class III & IV lands of watersheds which are characterized by undulating topography, high intensity run off, shallow and light soils and whose ideal land use is to bring such lands under perennial vegetation.

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MICRO-IRRIGATION SYSTEM: DESIGN, INSTALLATION AND MAINTENANCE

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In traditional irrigation methods, the wastages occurring through storage, conveyance and distribution ultimately result in delivering 30 to 35 % of stored water for plant uptake. The traditional flood or ridge and furrow method of irrigating field suffers from numerous problems such as considerable seepage, conveyance and evaporation loss; higher energy cost; lower water productivity; irrigation induced soil erosion, leaching of costly agricultural inputs causing sub-surface water pollution. Moreover, this method is supply driven rather than crop-demand driven causing mismatch between need of the crop and the quantity of water supplied.

The recent advances in irrigation technology have made inroads in the cultivation of vegetables and horticultural crops. The frontier technology of micro-irrigation system (MIS) not only provides higher water productivity but also minimize the problems associated with the traditional irrigation system. Application of micro-irrigation system enhances the water use efficiency to 90-95%. In MIS, the water is applied at low rate in the root of the plants more frequently. The major components in successful operation of MIS include design, installation and maintenance.

Design:

The design of MIS include water balance (accounting gain, loss and change in water storage at particular condition at particular time), estimation of water requirement, operation and frequency of MIS, stages of different crops, roots characteristics etc.

Irrigation methods for vegetables

Type of irrigation method: The different type os irrigation method is presented in figure 1.

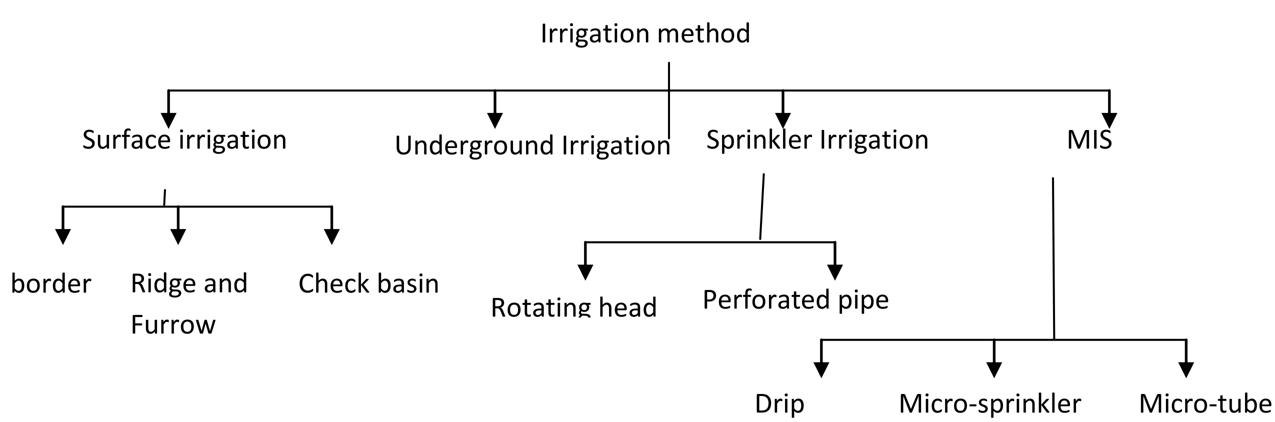

Fig. 1 Types of irrigation method

Surface irrigation method: Water is applied directly to the field using field channels, flooding in check basin using field bunds and ridge and furrow.

Underground irrigation: The water is applied under the ground beyond the root of plant.

Sprinkler irrigation: The water is applied through high pressure nozzle that causes sprinkling of water droplets in the air simulating the rain.

Drip Irrigation or MIS: The water is applied at the root of the plant at low rate and more frequent. Figure 2 presents the different components of standard MIS.

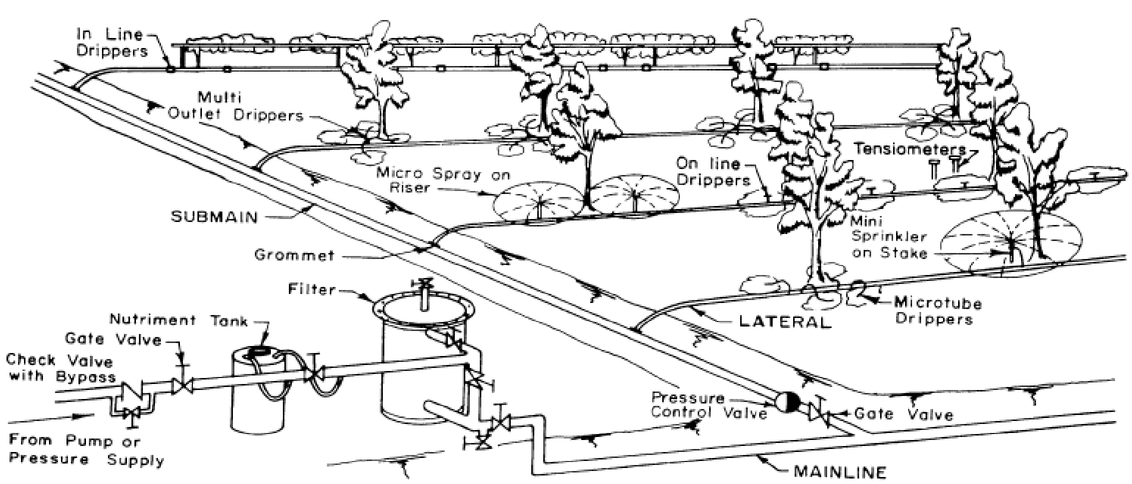

Figure2. Components of standard MIS

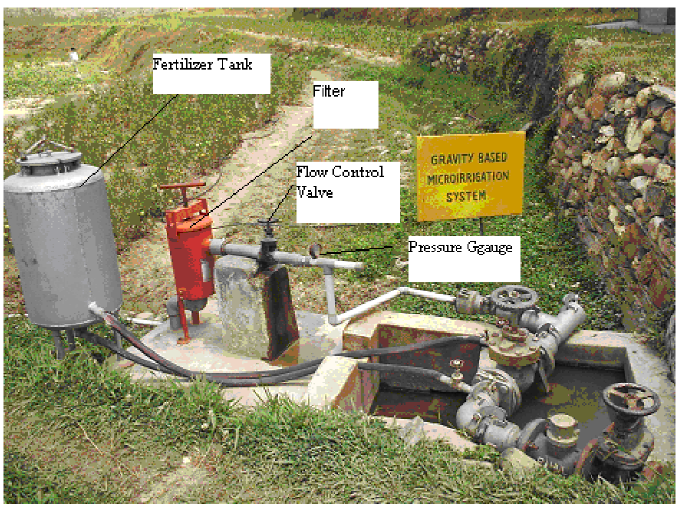

Fig.3 Major components of MIS

In MIS the water is applied at frequent interval in small quantity. The proper management helps in maintaining the adequate moisture and air in the root zone of the plant throughout the crop season. The water conveyance pipe (main and submain and lateral) and water application devices (dripper, emitter and micro-tube) are the integral components of micro-irrigation system. Main and Submain pipes are usually made from PVC or HDPE. Lateral pipes have the diameter of 12 and 16 mm and is made from LDPE. The water application devices are mostly made from PVC. Since all these are made from plastics, these pipes are chemically inert. The irrigation system has fertigation tanks as accessories. Figure 3 presents the major components of MIS.

Main pipe: The main pipe has the diameter of 50mm or more and is buried under the ground.

Submain pipe: The submain pipe diameter is lesser than the main pipe and is also buried under the ground. If the field is small less than (1 acre) and crop is same, then submain pipe is not needed.

Lateral pipe: The lateral pipe that attached the water application devices are kept over the ground. The attachment of water application devices are fixed as per the crop geometry.

Joiner and accessories: These are used to customize the irrigation system according to the field conditions. These includes tee, elbow, reducer, connector and end cap.

Filter is one of the major components of MIS, which is used to separate the foreign material from the water to prevent the MIS from frequent clogging. These are classified as media filter and screen filter. The media filter has higher filtration capacity as compared to screen filter.

Advantage of MIS over traditional irrigation system

Table 1: Advantage of MIS over flood irrigation system

SN	**Description**	**MIS**	Flood
1	Water Saving	Significantly (40-60% higher than flood irrigation)	Water consumption is more due to higher evaporation and seepage.
2	Conveyance loss	Almost nil	Significantly higher
3	Irrigation efficiency	80-90%	30-50%
4	Expenditure	Less on labour, fertilizer and chemicals	Comparatively more
5	Problem of weeds	Almost nil	Significantly higher
6	Disease and pest	less	more
7	Fertilizer use efficiency	more	less
8	Control on water	Can be achieved easily	Difficult to control

	supply		
9	Benefit:cost ratio	1.3 to 13.0 (excluding water saving)) 2.8 to 30.0 (including water saving)	1.8 to 3.9
10	Increase in productivity	20-100% as compared to flood irrigation	Significant less than MIS

Table 2. Irrigation efficiency under different irrigation methods

Irrigation efficiency	**Irrigation methods**		
	Surface	**Sprinkler**	**MIS**
Conveyance efficiency	40-50% (canal) 60-70% (well)	99%	99%
Application efficiency	60-70%	70-80%	90 %
Surface moisture	30-40%	30-40%	20-25%
Overall efficiency	30-35%	50-60%	80-90%

Biosecurity issues in Poultry Production

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Introduction

Biosecurity has become increasingly important with the intensification of poultry production. The success of the poultry industry as a reliable source of animal protein worldwide has been due to the implementation of a biosecure production system to prevent the spread of infectious disease among farms (Nespeca, 1997). Poultry industry looses crores of rupees in revenue annually due to infectious diseases. Disease loses represent a significant component in the overall cost of poultry production. Impact of diseases is one major impediment for increased productivity. Total loses caused by specific diseases not only include mortality, decreased egg production and condemnations but also costs of vaccination, chemotherapy.

Biosecurity is the protection of living organisms from any type of infectious organism. Thus, biosecurity in poultry production is the protection of poultry from infectious (viral, bacterial, fungal or parasitic) agents. Designing an effective biosecurity programme requires an understanding of the poultry operation and general principles of disease transmission. Mortality due to diseases or decreased feed efficiency and/or decreased growth rates and egg production due to infectious processes are major factors for economic loss in poultry production. In addition, the number of birds per unit area of space within a house, the size of a house, the number of houses within a farm and the concentration of farms within geographical areas has increased considerably in modern poultry industry. This has encouraged rapid and effective spread of infectious agents between birds within a house, between houses within a farm or between farms in a geographical area. This paper briefly highlights some of the major principles and practices of biosecurity for poultry production operations.

Prevention is the approach of choice because the cost of medication is relatively high and because once disease has appeared it is likely that productivity will have been affected such that profit margins are reduced or eliminated despite effective treatment. There are a number of choices for prevention which include biosecurity, vaccination and chemoprophylaxis, eradication of the infection from the population, adoption of good management and breeding for resistance to disease. Biosecurity measures are aimed at infectious agents outside the host. Other disease preventive and control approaches, immunization, chemo prophylaxis and chemotherapy, are aimed at infectious agents that enter inside the host. Further, the use of antibiotics and has raised public concern over emergence of resistant microbes in the food chain.

Means of disease spread

Disease transmission occurs when infectious material travels from sick or recovered birds to susceptible ones. How this material gets from one place to another is a function of the disease agent itself. Some infectious agents can be passed from infected breeding stock through eggs. Some can be carried by the wind on loose feathers and in dust. Some are transmitted through contaminated water supplies. Most are transmitted by fecal material carried on everything from equipment to shoes and hands. Sometimes vermin like rodents, wild birds, skunks, raccoons, and even cats, and dogs can carry the infectious agents and never show any signs of sickness. Without question, the superior way in which disease moves from farm to farm is people.

The chain of infection

The aim of biosecurity plan is to reduce the risk of disease exposure and transmission. An understanding of how infections develop and factors that influence this outcome is crucial for implementing biosecurity and other disease prevention strategies. Diseases which can be transferred from one host to another are called infectious diseases. Infectious diseases result from the interaction of agent, host, and environment. A specific chain of events must occur before an infectious disease can be spread. Components, or "links" in the chain of infection include a) an infectious agent capable of infecting poultry, b) a source: an infected host, a reservoir of infection, c) a portal of exit from the source, d) a suitable means of transmission, e) a portal of entry into a new host and f) a susceptible host. This chain must be complete for an infection to occur. If the process of infection is stopped at any component or link in the chain, an infection is prevented. If a pathogen successfully enters a susceptible host the chain is completed, the host becomes a new source of infectious microorganisms and the process of infection continues. For an infectious disease to occur, each link in the chain must be connected. If even one link of the chain is missing, it interrupts the process, and no infection will occur. Biosecurity measures (isolation, traffic control and disinfection) can stop the infection by interrupting the process at all the links that are outside the susceptible host. The chain at the point of susceptible host can be disrupted by other measures of disease prevention and control, which include proper vaccination, good management practices and medication.

Three "STOP" Biosecurity Plan

The objectives of biosecurity are to STOP the entry of infectious organisms into poultry operation, to STOP buildup and spread of infectious agents within a poultry operation, and to STOP the escape of microorganisms from an infected poultry operation. Biosecurity is a team effort, a shared responsibility, and an on-going process to be followed at all times. From the breeder to the hatchery, to growout operators, biosecurity measures have to be observed to contribute to the success of the industry. The major components of biosecurity, as practiced by the poultry industry, include: isolation, traffic control, sanitation, and rodent and insect control. The purpose of these practices is to prevent the introduction of pathogens and to provide the best living conditions for the health of the birds. In this way, the industry can minimize the risk of disease and insure the production of a clean food product.

1. ***STOP entry of Infectious agents into the farm.***
    - **Proper location and design of farm**
    - **Isolation of facilities**
    - **Cleaning and Disinfection of Vehicles/Equipment**
    - **Limiting access to the farm**
    - **Showering at the entrance of the farm**

- **Purchasing stock from know source**
- **Avoid borrowing equipment, feed, litter, etc. from another farm.**

2. ***STOP buildup and spread of infectious agents within poultry operation.***

- **Using separate vehicle for handling feedstuffs and handling manure.**
- **Limiting vehicle and foot traffic within the farm boundaries.**
- **Travel from the youngest group on the farms to the oldest.**
- **Proper cleaning and disinfection of sheds, equipments etc.**
- **Rodent, wild bird and pest control**
- **Separating the sick birds from the healthy ones**
- **Proper disposal of dead birds**
- **Sanitizing Water Lines**
- **Checks on feed and water quality**

3. ***STOP escape of infection agent off the farm***

- Self quarantine
- Adopting enhanced biosecurity
- Suspending all unnecessary traffic
- Disposal of dead birds on-farm
- Reporting suspicion of a highly infectious disease
- Alerting neighboring poultry farms

Disinfectant use in biosecurity

Disinfectants play a key role in biosecurity program. Disinfectants are chemical agents that kill pathogens on contact. Disinfection is the destruction of all vegetative forms of microorganisms, but the spores may not be destroyed. In poultry industry disinfectants are used in footbaths, for disinfecting equipment, vehicles and to disinfect poultry premises. The lethal action of disinfectants for various pathogens (viruses, bacteria, fungi, protozoa) depends on the chemical composition of the disinfectant and the organism. Factors to be considered while choosing a disinfectant are cost, efficacy (killing efficiency against viruses, bacteria, fungi), activity with organic matter, toxicity (relative safety to animals), residual activity, effect on fabric and metals, activity with soap, solubility (acidity, alkalinity, pH), contact time and temperature.

There are some basic principles to consider for disinfection. An important point to remember is "hard" water can neutralize the activity of some disinfectants. Disinfectants will not work if the surface to be disinfected is not clean. Cleaning the premises refers to the physical removal of organic matter, thus exposing the pathogens to the killing power of the disinfectant. Organic matter interferes with the action of disinfectants by: coating the pathogen and preventing contact with the disinfectant; forming chemical bonds with the disinfectant, thereby making it inactive against organisms; or reacting chemically with and neutralizing the disinfectant. Also, some disinfectant solutions may only be active for a few days after mixing or preparing. Sufficient concentration and contact time may overcome some of these problems with certain classes of disinfectants, but often increasing the concentration or contact time makes use of the product impractical, expensive, caustic, or dangerous to the users or to the birds. Disinfectants also vary considerably in their activity against the assorted bacteria, viruses, fungi, and protozoa about which poultry producers may be concerned. It is important to select a disinfectant that will be active against a wide spectrum of pathogenic organisms. It is also important to keep solutions clean and freshly made as per the manufacturer's directions. Temperature and concentration of disinfectant influence the rate of killing of microorganisms. The activity of many disinfectants improves markedly if the temperature is increased. All disinfectants, whether they are sprays, foams, aerosols or fumigants, work best at temperatures above 65ºF. Temperatures for chlorine and iodine based disinfectants should not exceed 110ºF. Disinfectants must have sufficient contact time with the surfaces to which they are applied in order to allow them to kill the pathogens concerned. The amount of contact time needed will vary with the product used and the pathogen. Rotation of disinfectants is more effective than continuous use of the same disinfectant to reduce the possibility of microbial resistance. The most commonly used disinfectants can be divided into the following classes based on their chemical composition.

For routine use in biosecurity programs at the farm level, producers should consider the major risks they are concerned about, consider the type of surfaces to be disinfected, the conditions under which the disinfectant will be used, and then select a disinfectant that best suits their needs. Information about activity in hard water or in the presence of organic debris, contact time needed, what pathogens are reliably killed, human use and environmental concerns, and other details are usually on the label or can be obtained from the company. Above all, producers should remember that disinfection is just one aspect of their biosecurity program.

Hazard Analysis Critical Control Point (HACCP) Biosecurity Plan

HACCP techniques have been applied for many years to develop food safety plans and form the basis for poultry meat inspection programmes. HACCP provides an organized framework to identify hazards and develop monitoring and control procedures at critical points with some objectivity. The following steps may be followed for developing and implementing HACCP plans.

1. Form a HACCP Team and define the scope of the HACCP Plan
2. Describe the Products
3. Construct a detailed Flow Chart of the production process and conduct onsite verification
4. List all the potential Hazards associated with each stage of the production process, conduct a Hazard Analysis and consider any Control Measures to control Hazards
5. Determine Critical Control Points (CCP)
6. Establish Critical Limits for each CCP
7. Establish a Monitoring System for each CCP
8. Establish Corrective Action Plans for CCP Deviations
9. Establish Record Keeping and Documentation
10. Establish Verification Procedures
11. Train staff for HACCP implementation
12. Commence Monitoring the CCP's

Limitations of Biosecurity

Although biosecurity is an important tool in disease control, there are certain technical and financial limitations to it. We do not have hygienic systems, however well defined they may be, that can fully prevent infectious diseases entering the farms. There is no way we can have full control on all feed delivered to the farm, all means of transportation, all people, on all the drinking water and all the air entering the house. There are no systems that, under practical conditions, can assure the total absence of rats, etc. Also, cleaning and disinfection of barns, although quite useful tool in diminishing infection risks, do not produce absolutely sterile poultry houses.

As the poultry industry is a business, it has to make profit, like any other type of business. The financial benefits derived from a biosecurity program can be projected by comparing the annual costs of installations and preventive measures with economic losses arising from an outbreak of a disease, assuming a specific risk of exposure. A mathematical model has been developed to evaluate biosecurity in a broiler parent flock within a range of given situations (Shane, 1995).

Benefits of Biosecurity

Biosecurity programs and plans are an important part of health control measures to protect poultry flocks from harmful infectious organisms, pests and diseases. By implementing biosecurity precautions, the flock can be protected from the entry of potentially devastating diseases. Biosecurity can reduce the risk of introducing disease (Shane, 1993) and can reduce the magnitude of the financial losses that may occur following infection (Gifford et al., 1987). With good biosecurity programme, probiotics and other antibiotic alternatives work better and optimum growth can be reached by minimizing the negative effects of bacterial infections. Good biosecurity has helped eliminate mycoplasma infections in primary breeding flocks and can help exclude virus infection, fowl cholera and the cycling of respiratory viruses (Stewart, 1987). Therefore, biosecurity is an important determinant for poultry health, welfare and food safety.

Disease prevention is a critically important part of rearing poultry. Healthy poultry are more productive and require less feed and other resources to maintain productivity. Animal health in agricultural production is also crucial for protecting our nation's food supply and maintaining public health. This is especially important when looking at emerging public health concerns such as the Avian Influenza pandemic in Asia. Intensive poultry rearing, integrated production practices, and high regional farm density make biosecurity and disease prevention concerns even more critical. Many advances have been made by the poultry industry to promote high biosecurity standards. Yet, there is still more that can be done to protect individual poultry facilities as well as the poultry industry and food supply as a whole.

Future

It is difficult to predict what the future will bring. However we may assume that the poultry industry will face several major changes. Biosecurity will be probably the most important tool in preventing poultry diseases as well as zoonoses. This implies not only that in the near future much has to be invested in improved farm conditions, improved management, better control of feed and water, etc.,, but probably even more important: a change in structure and mentality in the poultry industry. The only way to have full control over the total production chain, which is essential in the biosecurity concept, is by having fully integrated operations. The people involved have to understand the importance of biosecurity, support the concept and be willing to invest in it.

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Participatory approaches in Soil and Water Conservation: Planning and Management

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The natural resource base in Dryland areas has undergone degradation over years because of neglect and over exploitation. There is an urgent need to restore this resource base to sustain agriculture and animal production. Besides, most of the poor people living in semi arid rural areas depend heavily on natural resources to earn their livelihoods. Management of natural resources in ways that are sustainable and ensure fair and free access to the poor will have a bearing on the quality of life of these people. Among the major resources available in the country, the most important are soil and water and associated agricultural components like crops, livestock etc,. involving the total eco-system. One of the principal reasons for low productivity in agriculture in certain parts of the country is the progressive deterioration of soil & water resources due to erosion. It has been estimated that about 200 million acres of land, that is, almost a one fourth of the country's land surface is suffering from soil erosion.

An insight into the rainfed regions reveals a grim picture of poverty, water scarcity, rapid depletion of ground water table and fragile ecosystems. Land degradation due to soil erosion by wind and water, low rainwater use efficiency, high population pressure, acute fodder shortage, poor livestock productivity, underinvestment in water use efficiency, lack of assured and remunerative marketing opportunities and poor infrastructure are important concerns of enabling policies. The challenge in rainfed areas, therefore, is to improve rural livelihoods through participatory watershed development with focus on integrated farming systems for enhancing income, productivity and livelihood security in a sustainable manner. (Common guidelines 2008). However the planning and implementation of conservation programmes for restoration of deteriorating resources at grass root level needs immense participation of the local village people. This calls out the spirit of conducting participatory exercises like PRA, (Participatory Rural appraisal,) PLA (Participatory learning Action), PRCA (Participatory Rural communication appraisal) etc,. at field level to elicit the issues and priorities by villagers.

Rapid rural appraisal or RRA developed as a methodology in the 1970s, influenced by Farming Systems Research (FSR) and other methods.

RRA was developed for quick field – oriented results with objectives as follows:

(i) Appraising agricultural and other needs of rural community;
(ii) Prioritizing areas of research tailored to such needs;
(iii) Assessing feasibility of developmental needs and action plans;
(iv) Implementing action plans, monitoring and evaluating them.

Rapid Rural Appraisal or RRA is a way of organizing people for collecting and analyzing information within a short time span. It can be defined as any systematic process of investigation to acquire new information in order to draw and validate inferences, hypotheses, observations and conclusions in a limited period of time .It has flexibility to adjust to situations because it does not imply or recommend a standard set of methods to be applied in each case.

Participatory Learning Processes

Participatory Rural Appraisal

- **PRA is a process of involving local people in the analysis and interpretation of a rural situation.Participatory Rural Appraisal (PRA) is a methodology for interacting with**

villagers understanding them and learning from them. It involve a set of principles , a process of communication and a menu of methods for seeking villagers participation in putting forward their points of view about any issue and enabling them do their own analysis with a view to make use of such learning.

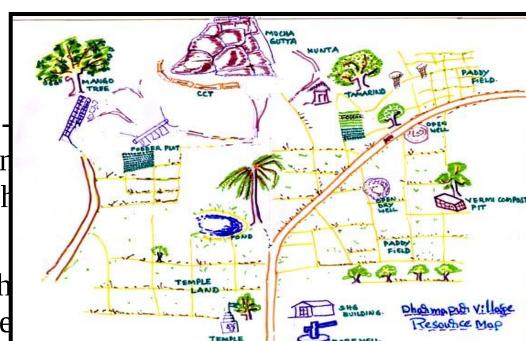
Analyzing information through People participation during PRA exercise

PRA initiates a participatory process and sustains it .Its principles and the menu of methods help in organizing participation.

- **Objectives of PRA**
  - To develop capabilities of a group/groups of people for critical analysis and assessment of their rural situations
  - To build up village profile on different aspects based on perception of the local people
  - To develop a system of information about the rural situation within the shortest possible time
  - To ensure people's participation in programme development
  - To make bureaucracy sensitive to the needs of the people

Techniques of PRA

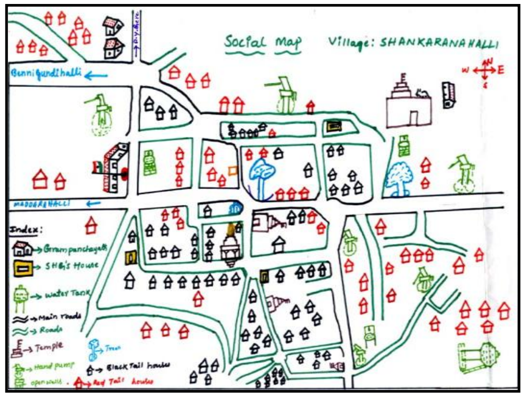
- *Resource Map:* This indicates both the natural resources like vegetation, soil type water bodies available etc,.and man made resources needed for development of agriculture.



- *Agro-ecology Map:* Agro- between agriculture and environment which in ll, temperature, RH including fragmentation of h

- *Technology Map*: The tech decision behavior of the farmers with reference ologies in terms of cropping pattern, varieties , Plant protection measures and nutrient management followed etc,. giving a totality of crops situation in the village.

•*Social Map*: This is to depict the social-structure of the village like local bodies, caste structure, housing pattern Institutions organizations etc,.



• *Matrix Ranking:* Matrix ranking will indicate the reasons for technology decision behavior of the farmers., preferences of the farmers in making choice of technology etc,.

• *Mobility Map:* This will indicate the purpose for which the farmers go out for agriculture purpose.

•*Time line:* This indicates the major events remembered by the villagers and provides the past history of the village.

•*Time trend:* This indicates the change in past few years related to variables / technologies concerned with agriculture.

•*Seasonal analysis:* This indicates the month wise situation/ work operations from January to December with regard to agriculture and animal husbandry.

•*Impact diagram :* This indicates the changes that have occurred either for individual or for the society due to adoption of a technology.

•*Wealth Ranking:* Wealth ranking means placing people on the different places of social ladder according to the villagers criteria with reference to wealth status categorized by rural people themselves.

•*Livelihood analysis:* Indicates the way in which farmers belonging different category of wealth make their livelihood including the crisis management mentioning their income sources , expenditure pattern etc,.

•*Farm household Map* : This map depicts the way in which the surrounding of a typical household appears without going into the details of its inside structure .

•*Bio resources Flow Diagram* : this indicate the degree of the village household members utilize and recycle the various resources in and around the farm house to suggest remedial measures.

•*Transect* : Transact is making a long walk inside the village and locating the various items that are found in the village like soil, crops, animals, problems, etc.

•*Daily routine diagram :* This daily routine diagram depicts the way in which farmer or farm women spends his or her time from morning to night.

•*Basic information about the village :* This will indicate the data regarding the population to area under crops, number of families, yield of animals and crops, mortality related to animals etc.

•*Venn diagram :* This indicates the importance of the various individuals and the institution in and outside the village with regard to a phenomenon related to agriculture. For example getting loan for agriculture purpose.

Villagers depicting important linkages through Venn diagram

Problem tree: The problem tree will indicate various resources responsible for the specific problem related to agriculture. This will also indicate the intervention for the various causes which will help in problem identification related to a discipline.

•*Preference ranking :* This is to found out the perception of farmers regarding the magnitude of the problems of agriculture found in the village.

•*ITA :* This is the indigenous technology adopted in village with reference to agriculture
•*Action Plan :*This indicates the systematic working out in board line of what needs to be done for the problems identified in the village.

- **Limitations of PRA**

  - The availability of a team with number of specialists in different disciplines and team building with the local people may be a problem
  - Perception of the job as exhaustive and time consuming, together with role reversal of learning from the local people, may develop unfavorable attitude in the specialists and officials towards the whole process.
  - The process requires expert handling by the group leader, having good field experience and knowledge of group dynamics.

- Lack of suitable accommodation in the village; vehicles for transport; equipments like camera, slide projector, video etc.; secretarial assistance may hinder the work.
- The work itself requires a good amount of fund and in spite of all efforts it may not be possible to cover more than a few villages in one season

Conclusion

Evaluation reports have shown that SWC projects cannot succeed without full participation of project beneficiaries and careful attention to issues of grass root level. "People's participation is imperative in soil and water conservation programme through watershed approach. It is a collective and cooperative effort by the local people for sharing common benefits. Participation of local people at the time of preparing a watershed development programme is very much needed to take decisions because the programme should according to the basic needs of local people. The local people are the ultimate beneficiaries of any programme. Therefore, the programme should be for the people, by the people and of the people.

The best people to plan and implement soil & water conservation programmes are those who use the resources as the community's demand for food, energy and many other needs has to depend on the preservation and improvement of the productivity of this natural resource. participation is the key to halting degradation of soil and water and conserve them at field level. Encouraging land users to participate in conservation programmes will not be easy, however, unless those involved could participate right from analyzing rural situation through participatory processes like PRA, planning programmes, implementing and see positive gains in doing so. Hence participatory approaches play a crucial role in harnessing social capital for common commitment to explore livelihood strategies at grassroot level.

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PREPARATION OF DETAILED PROJECT REPORT: BASELINE CHARACTERIZATION OF WATERSHEDS

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1.0 Introduction

Drylands, in India are generally characterized by highly variable rainfall, poor soils, low yields and poor development infrastructure. The fragile eco-systems of these rainfed areas suffer from degradation. The economic conditions of the farmers are miserable and deplorable. Biological resources of watersheds vary with time and space. There is need for undertaking a comprehensive study of their assessment, quantification, mapping and appraisal through diverse techniques and modalities for successful venturing of watershed development programmes.

As watersheds have multiple uses, the nature and extent of characterization of these resources will depend upon the very purpose of watershed management. As the human and animal pressure on these resources is increasing, their proper management and use without their deterioration is essential for providing sustainable livelihoods to the rural people who are dependant on these resources. As the watershed conditions keep changing over time, these basic surveys and resources characterization serve as the baseline. Potential change on economic, ecological and social system need monitoring using baseline data set. A baseline survey is therefore, a pre-condition in assessing the project impacts and to justify investments.

2.0 Physiographic Features of Watersheds

Drainage basin or a watershed is the area of land where all of the water that is under it drains off into the same place. Watersheds come in all shapes and sizes. The size of watershed is dependent on the size of the stream, river, the point of interception of stream or river, the drainage density and its distribution. They cross taluks, districts and even state boundaries. Physiography refers to the natural features of the earth's surface. These are divided into general groups and then subgroups containing features such as uplands, hills, ridges, plains, valleys, etc. Delineation of watersheds at various levels of hierarchy based on drainage network is necessary. Water quality is affected through water runoff by physiography.

Survey of India toposheets (1:50,000 scale) provides location, drainage network and contour and surface water bodies and drainage can be derived from them. Satellite imageries will be useful in updating information on water bodies, drainage, etc. Slope, aspect and altitude are important terrain parameters from land utilization point of view. All India Soil and Land Use Survey has prepared guidelines for preparation of slope categories which can be safely adopted for deriving slope classes on 1:50,000 scale, which are given below:

Slope categories	Slope (%)
Nearly level	0 - 1
Very gently sloping	1 - 3
Gently sloping	3 - 5
Moderate sloping	5 - 10

Strong sloping	10 - 15
Moderate steep to steep sloping	15 - 35
Very steep sloping	> 35

New science tools like Geographic Information System (GIS) and remote sensing can help make better assessments of the watersheds at varying scales, at better temporal scales economically. The use of GIS in watershed management becomes more relevant where multidisciplinary efforts are the key to the development of the community and the ecosystem as a whole. Assessment and characterization of the natural resources of the watershed being the prime activity before any implementation efforts start; GIS will facilitate these tasks and help provide more information to take proper decisions.

The first and foremost task is the creation of a spatial database of the watershed through primary and secondary survey. A primary survey may involve using a GPS/differential GPS (for precise altitude) to record features /phenomena or events at specific locations. Also remote sensing data will serve as another source of primary data since it records the data on a required/available date.

Elevation data will be of prime importance for hydrological modelling. This data can be obtained either from large-scale topographic sheets (1:25,000) if available for that area, or stereographic data from remote sensing or aerial photography. First hand data can be generated from topographic survey using total station survey equipment or differential GPS.

3.0 Soil Resources of Watersheds

Mapping of the spatial distribution of soils and their properties is the basic requirement for proper utilization of soils and for implementing soil and water conservation practices in a watershed. It is achieved through various types of soil surveys coupled with remote sensing to classify soils into units using uniform system of classification and uniform nomenclature in order to correlate them with those in other areas; prepare the map of their distribution in field; and define their adaptability for crops, grasses and trees, their management requirements and yields of individual crops under different systems of land use and management.

Productivity enhancement, in addition to resource conservation is one of the main objectives of watershed management. This requires an assessment of the soil fertility status, i.e., the amounts and availability of essential plant nutrients in the soil to support crop production. Based on the soil fertility analysis, the application of nutrients from various sources is recommended to achieve balanced nutrition of crops to increase and sustain crop production on soils in a watershed. Our experience has shown that most soils in rainfed areas are deficient in secondary (S) and micronutrients (B and Zn) in addition to the already prevailing deficiencies of N, P and K, which need to be corrected. It is advisable to issue soil health card to individual farmers indicating limiting nutrients for enabling site specific nutrient management (SSNM) based on crops and cropping system.

4.0 Climatic Resources of the Watersheds

Knowledge on agroclimatology is a valuable tool in assessing the suitability of a watershed for rainwater harvesting and crop planning. Importance of climate assumes greater importance in the semi-arid rainfed regions where moisture regime during the cropping season is strongly dependent on the quantum and distribution of rainfall *vis-à-vis* the soil water holding capacity and water release characteristics. A thorough understanding of the climatic conditions helps in devising suitable management practices for taking advantage of the favourable weather conditions and avoiding or minimizing risks due to adverse weather conditions.

Most important input for agroclimatic characterization of a watershed is the daily rainfall data. Other weather parameters like temperature, relative humidity, solar radiation, wind speed and direction are also required for a complete characterization process. Particularly, temperature and solar radiation can be limiting factors for the *rabi* crops in the central and northern parts of India. Moreover, data on all these parameters are required for computing the water balance of watersheds. Long-period daily data of a location near the watershed representing the general climatic conditions are to be collected, quality checked, compiled and a database is created. Data in various formats like daily, weekly, monthly, seasonal and yearly can be retrieved from the database. Either a manual or an automatic weather station is established in the watershed for continuous monitoring of weather conditions. The India Meteorological Department (IMD), State Department of Statistics, State Agricultural Universities and ICAR institutes are some of the major sources of weather data. Readily usable data on monthly basis for several locations in India is available in the publications of IMD (1985, 1995).

5.0 Water Resources Appraisal

The four waters namely rainwater, soil water, surface and ground water are interlinked and interdependent. In watersheds, budgeting of water resources and planning for harvesting and recharge plays a major role in the success of programme. Water acts as triggering mechanism for motivation and for different interventions.

At the very outset, all open dug/bore wells need to be geo-referenced and few need to be monitored continuously for water levels at least at monthly interval. These wells should represent the ridge, middle and lower portion of watershed. Well hydrographs can be prepared for comparison of watersheds from the available data with respect to rainfall and water use. The water levels in open wells during pre- and post- watershed development will serve as an indicator of water resources development. Remote sensing and GIS can be employed as a tool for geo-referencing the water bodies and the area under irrigated crops, particularly during *rabi* and summer period. Any increase in the number of water bodies and area under irrigation need to be monitored for evaluation at later stages. Further, by employing remote sensing and GIS tools, it is possible to demarcate low, medium and high groundwater potential aquifers/areas for exploitation by integrating thematic information like topography, soil type, parent material, etc.

Potential for rainwater harvesting and recycling/recharging

The concept of 'Water Balance' analysis need to be adopted for detecting the potential for water harvesting and recharge of groundwater. Water balance analysis need to be carried out for the whole year as well as the cropping season for assessing the surplus or deficit during the year to estimate the changes in available water in the wells through rainfall and atmospheric requirements through evaporation and changes in temporal availability of rainfall and plant water requirement, respectively. Actual rainfall, normal rainfall and normal potential evapotranspiration will be used from available database.

The FAO water balance analysis for the cropping season for individual crops provides the information on the surplus and deficit periods during crop growth season (Thornthwaite and Mather, 1955). This analysis helps in building alternative arrangements for alleviating the moisture deficits during the crops season especially when it occurs during the critical stages of plant growth. With the provision of the supplemental irrigation at those stages, it is possible to mitigate drought and enhance productivity.

6.0 Characterization of Production Systems

6.1 Annuals

Crops and cropping systems

Land use statistics comprising existing farming systems i.e. traditional crops and cropping systems (before and after watershed development) need to be recorded at regular interval while the drivers influencing changes in cropping pattern and cropping systems i.e. improved farming systems such as, agronomic and market interventions, water availability, access to inputs/technology, rise in level of income, after the implementation of Watershed Development Programme need proper documentation.

Spatial distribution of crops in rainy and post-rainy season

In a watershed, with availability of high-resolution data and ground-truthing using GPS, it is now possible to have baseline information on land uses, acreage under different crops/plantations/CPRs, etc and its status on a cloud free day for both *kharif* and *rabi*. This information can be integrated with other thematic layers in a GIS environment and possibility exists for identification of land use for each farmers based on survey numbers. The maps thus generated will help in participatory technology development (PTD) and refinement of existing practices. Also scope exists for linking with site-specific nutrient management and preparation of integrated soil health card and land use plan. Area under cultivation of crops/plantations/pasture prior to and after treatment for arable and non-arable land will be useful for estimating change in land use/ land cover and cropping intensity.

6.2 Perennials / vegetative cover

The land use and land cover can be studied using the state of-the-art remote sensing technology (through satellite images) to assess the impact of various interventions made on these parameters. The change in green cover due to mounting of perennial systems like agroforestry, farm forestry, horticulture, pasture, biofuel plantations, etc can be estimated using Normalized Difference Vegetation Index (NDVI) during pre- and post- project implementation period.

7.0 Characterization of Livestock Endowment

Livestock is an integral component of the conventional and integrated farming systems. Small ruminants like, sheep or goats are the best source of regular cash income throughout the year for rural poor without much investment. They form a major component in a tree-crop-livestock diversification/integration paradigm. Optimal use of the manure produced by small ruminants forms a part of essential criteria in striving towards sustainability. The selection of appropriate livestock species (breed) matters much in improving the productivity of livestock, which is an important consideration in the development of an integrated farming system.

An integrated crop-dairy farming system is a viable and profitable proposition to the farmers, therefore, data of large ruminants like crossbred cows, graded buffaloes, etc. is essential. However, data on change in composition of livestock breed (using pre and post-watershed) and outputs (milk, meat, wool, etc.) is essential for quantifying the impact of watershed on livelihoods of landed and landless people. Social fencing and stall-feeding are interlinked and the success of programme lies in effective implementation of both. Apart from the above, bio-physical parameters, there is a need for collection of socio-economic parameters to achieve equity.

8.0 Budgetary Breakup:

One per cent of the budget has been earmarked for the preparation of detailed project report. The activities related to remote sensing and GIS can be outsourced. The budget earmarked for livelihoods has been reduced from 10 per cent to 9 per cent and collection of contribution is must. The amount collected towards contribution needs to be deposited in the watershed development fund (WDF), which is 20% in case of general category and 10% for SC/ST communities. The upper limit per household is Rs. 12,000/- for integrated farming systems and livelihood interventions. In case of NRM works on private lands, it is 10% for general category and 5% for SC/ST, small and marginal farmers.

Budget component	Existing provision (% of total project cost) as per the guidelines	Amendments recommended (% of total project cost)

▪ Administrative costs ▪ Monitoring ▪ Evaluation	10 1 1	10 1 1
Preparatory phase, including: ▪ Entry point activities, ▪ Institution and capacity building, ▪ Detailed Project Report (DPR)	4 5 1	4 5 1
Watershed Works Phase: ▪ Watershed development works, ▪ Livelihood activities for the asset less persons, ▪ Production system and micro enterprises	50 10 13	56 9 10
Consolidation phase	5	3
Total	100	100

Summary and Conclusion

Various Central Ministries (MoA, MoRD and MoEF), and departments/NGOs are implementing watershed programmes for the development of rainfed areas to convert them from grey to green. The objective of watershed programme is conservation, augmentation and sustainable utilization of natural resources for enhancing productivity, profitability and economic viability of rainfed agro-ecosystem. Over a period of time watershed programmes have evolved from purely technical to community-owned. But, to strike a balance and evaluate tangible and intangible benefits, baseline characterization is must. The chapter has dealt with various parameters that need consideration and active involvement of R&D institutions for evolving an action plan acceptable to both primary and secondary stakeholders. With the advancement made in space, dryland and information technologies, it is now possible to demystify science in a more people-centric manner. The pre-requisite is collection of baseline information to appreciate the change over space and time due to watershed programmes and justify the investments made.

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CRITERIA FOR SELECTION OF WATERSHED PRJECTS

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As per the new common guidelines the watershed programme is implemented nationwide from April 2008. To make the programme operational the selection of watersheds and their prioritizations are of prime importance. This would provide early socio-economic/livelihood benefit to the people staying in the fragile watersheds and needing immediate natural resource management interventions for sustainable agricultural development. All this need some understanding of the purpose of watershed development and management as discussed below.

Why is the watershed approach?

A watershed is an appropriate unit of development as it allows measurement, conservation and judicious utilization of water, a critical input for agricultural production.

The concept of participatory integrated watershed management was later emerged to involve local community to manage natural resources (soil, water, vegetation etc.) for sustainable production and livelihood security – a holistic approach for overall development.

Broad objectives:

The specific objectives of the watershed project are:

- Harvesting maximum rainwater as possible for the purpose of supplemental irrigation, drinking water availability, plantation including horticulture and floriculture, pasture development, fisheries etc. to create sustainable sources of income for the village community. This leads to conservation, development, and sustainable management of natural resources including their use.
- Ensure overall development of rural areas through employment generation, poverty alleviation, community empowerment, and development of human and other economic resources.
- Mitigating the adverse effects of extreme climatic conditions such as droughts and floods, desertification on crops, human and livestock population.
- Restoring ecological balance by harnessing, conserving and developing natural resources of land, water and vegetative cover especially plantations.
- Encouraging village community towards sustained community action for the operation and maintenance of assets created and further development of potential of the natural resources in the watersheds.
- Promoting use of simple, easy and affordable technological solutions and institutional arrangements that make use of, and build upon local technical knowledge (ITK) aqnd available materials.
- Enhancing agricultural productivity and production in a sustainable manner.
- Reduction in regional disparity between irrigated and rainfed areas.

Each watershed development project is expected to achieve the following results.

- All the planned works/activities (DLT, arable and non-arable land) are completed with the active participation and contribution of UGs and community at large.
- The UGs/GPs have willingly taken over the operation and maintenance of the assets created and made suitable administrative and financial arrangements for their for their maintenance and further development.
- All the members of the WC and staff have been properly trained to discharge their responsibilities on withdrawal of WDT.
- SHGs have been properly formed on sustainable basis.
- The increase in cropping intensity and agricultural productivity reflected in overall increase in agricultural production.
- Increase in income of farmers/landless labourers in the project area.

- Increase in groundwater table due to enhanced recharge by watershed interventions.

Watershed development programme projections

FYP	Area to be covered (lakh ha)	Unit cost (Rs/ha)	Total cost (Crore Rs.)	Cost sharing (centre:state:community)
XI Plan (2007-2012)	200	6000-8000	14000	40:30:30
XII Plan (2012-2017)	250	7500-9500	21250	30:30:40
XIII Plan (2017-2022)	285	9000-11000	28500	25:25:50

Changes in approach and strategies of watershed development over time – from technical to socio-technical mode:

- Approach shifted from "soil conservation" to "watershed management" supporting the entire livelihood system of the local people."
- "Line department" and "top-down" oriented planning got replaced with "participatory watershed development" following "bottom-up" approach – empowerment of community and stakeholders.
- Project funding mode shifted from solely "government grant" to "government grant – cum user contributions" mode.
- Natural resource conservation from national environmental perspective is being linked to livelihood issues.
- Social auditing of the watershed programmes ensures transparency at all levels.
- Targeting benefits of the programme especially to resource poor people and women groups.
- The guidelines changed from generalities to specific to meet the needs of time and space.

Key features of the common guidelines

Based on the requirements and shortcomings of the previous programmes and guidelines of different implementing agencies the common guidelines were framed with following key features.

- Delegation of power to states
- Dedicated institutions for implementing the programme at various levels
- Duration of the programme enhanced in the range of 4-7 years depending upon the nature of activities spread over 3 phases, viz; preparatory phase, works phase and consolidation phase
- Productivity enhancement and livelihood given priority along with conservation measures. Livestock and fisheries management as central intervention and encourage dairying and marketing of dairy products.
- Envisages geo-hydrological units normally of average size of 1000 to 5000 ha comprising of cluster of micro-watersheds.
- Special efforts to be made to utilise IT, RS and GIS technology for planning, monitoring and evaluation of the prograamme
- Capacity building and training of all functionaries and stakeholders with definite action plan and requisite professionalism and competence
- A multi-tier ridge-to-valley sequenced approach covering the higher reaches predominated by forests and where the water resources originate, the intermediate slopes to be treated by best possible options including horticulture and agro- forestry, and the plains and flat areas mostly under agricultural crops
- The watershed development process would be synergized with employment generating programmes such as NREGS, Backward Regions Grant Funds (BRGF) etc.

Broad criteria for selection and prioritization of watershed development projects

While prioritizing the watershed for the purpose of implementation the following criteria ware followed by giving variable weightage to different parameters.

- Acuteness of drinking water scarcity
- Extent of over exploitation of ground water resources
- Preponderance of wastelands/degraded lands
- Contiguity of another watershed that has already been developed or treated
- Willingness of village community to make voluntary contribution, enforce equitable social regulations for sharing of CPRs, make equitable distribution of benefits, make arrangements for operation and maintenance of assets created
- Proportion of SC/STs in the watershed
- Area of the project should not covered under assured irrigation
- Productivity potential of the land

The weightage systems followed in Andhra Pradesh and Orissa as examples are given below.

Criteria for watershed selection in Andhra Pradesh

Sl.No	Particulars	Extent	Marks	Max. marks (100)
1	No. of small & marginal farmers	< 25%	5	
		>25 & < 50%	10	
		>50%	15	15
2	SC/ST holdings out of total	< 10%	3	
		>10 & < 25%	5	
		>25%	10	10
3	Women organized in SHGs in the habitation and participating in the programme	< 20%	3	
		>20 & < 50%	5	
		>50%	10	10
4	Status of groundwater below ground level	< 10m	2	
		>10 & < 15m	3	
		>15m	5	5
5	APSRAC (Andhra Pradesh State Remote Sensing application Centre)	Very low	6	
		Low	12	
		Medium	18	
		High	24	
		Very high	30	30
6	Livestock	< 1000 nos.	2	
		>1000 & < 2000	3	
		>2000	5	5

7	No. of families affected/involved in migration and landless people involved in wage employment	< 50 >50 & <100 >100	3 5 10	10
8	Contiguity and macro-watershed for saturation	No Yes	0 5	5
9	Availabilityof fallow/waste/CPR for the poorto utilize and willingness of community to permit usefruct to landless	< 10% >10 & < 20% >20%	3 5 10	10

WATERSHED PROJECT MANAGEMENT

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Project Management[1]:

The major activities of the watershed development projects will be sequenced into

1. Preparatory,

2. Works, and 3. Consolidation and withdrawal phase.

In view of the expanded scope and expectations under the watershed development programme, the project duration could be in the range of four to seven years depending upon the activities and ministries/departments. The DPR should mention the detailed justification for the proposed project duration. The project duration may be spread over 3 different phases as decided by the Nodal ministry and is given below:

Phase	Name	Duration
I.	Preparatory phase	1-2 years
II.	Watershed works phase	2-3 years
III.	Consolidation and withdrawal phase	1-2 years

I. Preparatory phase

The major objective of this phase is to build appropriate mechanisms for adoption of participatory approach and empowerment of local institutions (WC, SHG and UG). Watershed Development Team, (WDT) will assume a facilitatory role during this phase. In this phase, the major activities will include:

a. Taking up entry point activities to establish credibility of the watershed development team and create a rapport with the village community. The entry point activities *inter-alia*, will include:
   - i) Works based on the urgent needs of the local communities such as revival of common natural resources, drinking water, development of local energy potential, augmenting ground water potential etc.

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   - ii) Repair, restoration and upgradation of existing common property assets and structures (such as village tanks) may be undertaken to obtain optimum and sustained benefits from previous public investments and traditional water harvesting structures.
   - iii) Productivity enhancement of existing farming systems could also be an activity that helps in community mobilization and building rapport.

b. Initiating the development of village level institutions such as Watershed Committees (WCs), Self Help Groups (SHGs) and User

Groups (UGs) and capacity building of different stakeholders on institutional and work related aspects.

c. Environment building, awareness generation, undertaking of intensive Information Education and Communication activities, creating involvement and participatory responses.
d. Baseline surveys needed for preparation of Detailed Project Report (DPR), selection of sites and beneficiaries. Every effort must be made to collect gender-disaggregated data to adequately reflect the situation and priorities of women.
e. Hydro-geological survey of the watershed to map out zones of potential ground water recharge, storage and sustainable groundwater utilization.
f. Building up a network of technical support agencies.
g. Preparation of DPR, including activities to be carried out, selection of beneficiaries and work-sites and design and costing of all works, ensuring that the interests, priorities of women, dalits, adivasis and the landless are adequately reflected in the DPR.
h. Working out detailed resource use agreements (for surface water, groundwater and common/forest land usufructs) among User Group members in a participatory manner based on principles of equity and sustainability.
i. Participatory monitoring of progress and processes.

Preparation of DPR: DPR preparation is a crucial activity at the district level, which is to be facilitated by the WDT for an identified project area. The technical inputs in the form of resource maps and cadastral maps have to be made available at local level. It is necessary to capture the entire database of DPR in a systematic manner as a structured document at the initial stage itself.

DPR preparation requires a strong PRA exercise and comprehensive beneficiary level database separately for private land and community land development with linkages to the cadastral database. This will facilitate spatial depiction of the action plan. DPR should include, among other things, the following:

a. Basic information on watershed including rainfall, temperature, location including geographical coordinates, topography, hydrology, hydrogeology, soils, forests, demographic features, ethnographic details of communities, land-use pattern, major crops & their productivity, irrigation, livestock, socio-economic status etc.

b. Details of expected/proposed User groups & self help groups, master tables for private land/common land activities, contribution to watershed development funds, information on soil and land-use, existing assets related to water harvesting recharging and storage etc. needs to be provided plot-wise.
c. Problems typology of the watershed including an account of the major problems requiring intervention from the perspective of enhancing livelihood potential/carrying capacity as well as conservation and regeneration of resources.
d. Description of proposed interventions (physical and financial, including time-table of interventions) along with technical details and drawings certified by the WDT.
e. Detailed mapping exercises.
f. Institutional mechanisms and agreements for implementing the plan, ensuring emphasis on participatory decision-making, equity and sustainability of benefits, and post-project sustainability.
g. Expected outcomes and benefits, especially with respect to livelihoods for different segments, benefits to women and regeneration/conservation of resources etc.

The DPR will be prepared by the WDT for integrated development of the watershed area with active participation of the Watershed Committee (WC). The WDT should utilize various thematic maps relating to land and water resources in the preparation and finalization of the DPR. This DPR shall necessarily include the clear demarcation of the watershed with specific details of survey numbers, ownership details and a map depicting the location of the proposed work/activities for each year.

The DPR for the watershed shall be in tune with the District perspective plan. The permissible works relating to soil and moisture conservation under NREGS, BRGF, and Artificial Ground Water Recharge must complement the micro watershed plan. District agricultural plans may also be consulted while formulating the district perspective plans.

This DPR will be a part of the MIS from which details will be arranged into various layers on GIS as a monitoring, management, accounting and analytical tool besides serving as a source of information and a link to the state level data cell in the State Level Nodal Agency (SLNA) and national data center in the NRAA. The DPR may be summed up using a standard tool such as Logical Framework Analysis (LFA) that includes goals, purpose, outputs, activities, inputs, challenges and measurable indicators of progress.

The overall responsibility for the preparation of a technically sound and high quality DPR would lie with the Project Implementing Agency (PIA). After approval by the Gram Sabha, the PIA shall submit the DPR for approval to the DWDU/DRDA/DP. Alternatively, the mechanism of approval and implementation of projects by district level committee/collector may continue to prevail.

Each watershed has unique characteristics and problems. Its treatment and management would therefore require careful consideration of various site specific factors like topography, nature and depth of soil cover, type of rocks, water absorbing capacity of land, rainfall intensity, land use etc. All works must be planned in a location-specific manner, taking into account the above factors along with local demands and socio-economic conditions of the watershed.

The ridge-to-valley principle with multi tier sequenced approach has been indicated in detail at preface on Para 9 (IX).

II. Watershed works phase

This phase is the heart of the programme in which the DPR will be implemented. Some of the important activities to be included in this phase are:

a. Ridge area treatment: All activities required to restore the health of the catchment area by reducing the volume and velocity of surface runoff, including regeneration of vegetative cover in forest and common land, afforestation, staggered trenching, contour and graded bunding, bench terracing etc.
b. Drainage line treatment with a combination of vegetative and engineering structures, such as earthen checks, brushwood checks, gully plugs, loose boulder checks, gabion structures, underground dykes etc.

c. Development of water harvesting structures such as low-cost farm ponds, nalla bunds, check-dams, percolation tanks and ground water recharge through wells, bore wells and other measures.
d. Nursery raising for fodder, fuel, timber and horticultural species. As far as possible local species may be given priority.
e. Land development including in-situ soil and moisture conservation and drainage management measures like field bunds, contour and graded bunds fortified with plantation, bench terracing etc.
f. Crop demonstrations for popularizing new crops/varieties, water saving technologies such as drip irrigation or innovative management practices. As far as possible varieties based on the local germplasm may be promoted.
g. Pasture development, sericulture, bee keeping, back yard poultry, small ruminant, other livestocks and micro-enterprises.
h. Veterinary services for livestock and other livestock improvement measures.
i. Fisheries development in village ponds/tanks, farm ponds etc.
j. Promotion and propagation of non-conventional energy saving devices, energy conservation measures, bio fuel plantations etc.

III. Consolidation and withdrawal phase

In this phase the resources augmented and economic plans developed in Phase II are made the foundation to create new nature-based, sustainable livelihoods and raise productivity levels. The main objectives under this phase are:

a. Consolidation and completion of various works.
b. Building the capacity of the community based organizations to carry out the new agenda items during post project period.
c. Sustainable management of (developed) natural resources and
d. Up-scaling of successful experiences regarding farm production systems/ off-farm livelihoods.

An indicative list of various activities during this phase is given below:

A. Consolidation of various works

a. Preparation of project completion report with details about status of each intervention.
b. Documentation of successful experiences as well as lessons learnt for future use.

B. Management of developed natural resources

a. Improving the sustainability of various interventions under the project.

b. Formal allocation of users right over Common Property Resources (CPRs);
c. Collection of user charges for CPRs;
d. Repair, maintenance and protection of CPRs;
e. Sustainable utilization of developed natural resources;
f. Involvement of gram panchayat/corresponding institutions (as a governance body) in addressing the above aspects.

C. Intensification of farm production systems/off-farm livelihoods

a. Up scaling of successful experiences related to above aspects through revolving fund under the project as well as credit and technical support from external institutions.
b. Promotion of agro-processing, marketing arrangements of produce and similar off -farm and informal sector enterprises.
c. Farmers may also be encouraged to develop non-pesticidal management, low cost organic inputs, seed farms with wider markets to fetch competitive price.

D. Project management related aspects

a. Participatory planning, implementation and monitoring of activities to be carried out during consolidation phase;
b. Terminal evaluation of project as per the expected outcomes.

Federations could be formed at the level of a cluster of villages in order to support economic activities at scale. These would further strengthen and activate the linkages established with external resource agencies for knowledge, credit, input procurement, sale of local produce, carrying on processing activities to the point of exports. In these activities, bankability of activities will be attempted. At the same time, local-level institutions are expected to reach maturity and exit protocols become operative for the PIA. The watershed committees may use the watershed development fund for repair and maintenance of structures created in Phase II.

The classification of activities in the three phases must not be understood in a rigid manner. Many of the phase III activities may even start in many watersheds during phase I and/or II itself. Phasing of activities needs to have an internal logic and integrity that must flow through the entire action plan. This will depend on a host of factors such as the prevailing initial conditions, needs and possibilities in each village, response of the community etc. Such flexibility must be built into the action plan and is to be seen as a distinguishing feature of these guidelines.

Conclusion

Watershed management basically involves harmonising the use of soil and water resources between upstream and downstream areas within a watershed toward the objectives of natural resource conservation, increased agricultural productivity and a better standard of living for its inhabitants. Identifying and addressing the significant externalities associated with watershed is critical for these objectives to be achieved in a sustainable manner. All of the successful watershed projects have some characteristics in common — emphasis on social issues, social mobilisation, clear direction to the Government to accept principles of participatory management, transparent project monitoring and a strong sense of ownership by the local community.

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[1]Common Guidelines for Watershed Development Projects (2008). Government of India. Published by National Rainfed Area Authority, Govt. of India, NASC Complex, D.P. Shastri Marg, New Delhi.

Agricultural Risk Management through Weather Based Insurance[♣]

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Introduction

Climate has always presented a challenge to those whose livelihoods depend on the weather. Even though a drought (or flood, or a hurricane or cold wave or heat wave) may happen infrequently, the threat of the disaster is enough to block economic vitality, growth and wealth generation during all-years- good or bad. The risk of drought and flooding can keep people in poverty traps, as risk-adverse behavior limits productivity and willingness of creditors to lend to farmers, for example. Lack of access to financial services, especially in rural areas, in turn restricts access to agricultural inputs and technologies, such as improved seeds and fertilizers. At the national level, when disaster strikes, many developing countries rely on humanitarian aid, whose delay can led to higher human and economic costs. Climate change is one of the most important global environmental challenges facing by human beings, which affects food production, property, natural ecosystems, freshwater supply and health sector. The Intergovernmental Panel on Climate Change (IPCC) projects that the global mean temperature may increase between 1.4 and 5.8 °C by 2100 (IPCC, 2007). At the same time, the Intergovernmental Panel on Climate Change's fourth assessment report has warned us that climate change is likely to reduce food production potential, especially in some already food-short areas. It further states that there is now higher confidence in the projected increases in droughts, heat waves and floods, as well as their adverse impacts which will be hardest felt by the most vulnerable, who are often in the weakest economic position.

Climate change will greatly exacerbate this situation; and developing countries, which are least responsible for climate change, face its greatest impacts. New tools are urgently needed to help vulnerable people deal with climate change, and the uncertainty that accompanies this. It is not only the poor who need such tools. After a climate-related disaster, governments struggle to finance relief and recovery efforts and maintain essential government services. Disaster response can be delayed for several months as humanitarian aid trickles. One innovative response to enable poverty reduction through better climate risk management is weather insurance.

Climate Risk management and agriculture

[♣] Lecture delivered during Training Course on "Sustainable Agriculture Production through Innovative Approaches for Enhanced Livelihoods" held at CRIDA during 2-15 September,2011

Climate risk is a particular challenge for the hundreds of millions whose livelihoods depend on rainfed agriculture in marginal, high-risk environments. Climate risk is not a new phenomenon, and climate risk management in the broad sense has long been practiced. Farmers anticipate the rains, using indicators,and time their planting and inputs based on their best estimates; they install irrigation system if they can; and they reduce risk exposure by diversifying their livelihoods as far as possible (Decron,1996; Ellis,2000). Scientists have also sought ways to help manage the risk that climate presents. Agriculture research has developed crop varieties that are drought tolerant, for example, and soil management practices that increase soil moisture-holding capacity. Weather forecasts have been a major advance in helping people plan appropriately. Rainfed agriculture is often characterized by high variability of production outcomes, that is, by production risk. Unlike most other entrepreneurs, agricultural producers cannot predict with certainty the amount of output their production process will yield, due to external factors such as weather, pests, and diseases. Agricultural producers can also be hindered by adverse events during harvesting or collecting that may result in production losses. In discussing how to design appropriate risk management policies, it is useful to understand strategies and mechanisms employed by producers to deal with risk, including the distinction between informal and formal risk management mechanisms and between ex-ante and ex-post strategies. The-ex ante or ex-post classification identifies the time in which the response to risk takes place: ex-ante responses take place before the potential harming event; ex post responses take thereafter. Ex-ante informal strategies are characterized by diversification of income sources and choice of agricultural production strategy. One strategy producers employ is risk avoidance. Extreme poverty, in many cases, makes producers very risk-averse, pushing them to avoid high-risk activities, even though the income gains to be generated might be far greater than those gotten through less risky choices. This inability to accept and manage risk respectively reflected in the inability to accumulate and retain wealth is sometimes referred to as the "the poverty trap" (World Bank 2001).

According to Clarkson *et al*., (2001), there are six requirements that must be met if rainfed farmers are to manage risks related to climate extremes, variability and change. These include:

- Awareness that weather and climate extremes, variability and change will impact on farm operations
- Understanding of weather and climate processes, including the causes of climate variability and change
- Historical knowledge of weather extremes and climate variability for the location of the farm operations
- Analytical tools to describe the weather extremes and climate variability
- Forecasting tools or access to early warning and forecast conditions, to give advance notice of likely extreme events and seasonal anomalies
- Ability to apply the warnings and forecasts in decision-making

Agriculture Insurance Company of India Ltd. (AIC)

Agriculture Insurance, including livestock insurance has been practiced in the country for over 25 years. Prior to 2002-03 General Insurance Corporation of India (GIC) was implementing National

Agricultural Insurance Scheme (NAIS**)**. Recognizing the necessity for a focused development of crop insurance program in the country and an exclusive organization to carry it forward, Government created an exclusive organization - Agriculture Insurance Company of India Limited (AIC) on 20th December 2002 (www.aicofindia.org). AIC commenced business from 1st April 2003. AIC introduced rainfall insurance known as 'Varsha Bima' during the 2004 South-West Monsoon period. Varsha Bima (Varsha Bima covers anticipated shortfall in crop yield on account of deficit rainfall. Varsha Bima is voluntary for all classes of cultivators who stand to lose financially upon adverse incidence of rainfall can take insurance under the scheme. Initially Varsha Bima is meant for cultivators for whom National Agricultural Insurance Scheme (NAIS) is voluntary) provided for five different options suiting varied requirements of farming community. These are – (i) seasonal rainfall insurance based on aggregate rainfall from June to September, (ii) sowing failure insurance based on rainfall between 15th June and 15th August, (iii) rainfall distribution insurance with weights assigned to different weeks between June and September, (iv) agronomic index constructed on the basis of water requirement of crops at different pheno-phases and (v) catastrophe option, covering extremely adverse deviations of 50 percent & above in rainfall during the season. Varsha Bima has been piloted in 20 rain gauge areas spread over Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. During 2005, Varsha Bima was fine-tuned and extended to 120 locations in 10 States during *kharif* 2005, and further to 150 locations in 15 States during *kharif* 2006 AIC also introduced weather insurance pilots on wheat insurance, mango insurance, and coffee insurance during 2005-06, and is looking ahead for expansion. Thanks to the sustained efforts and launch of innovative insurance products in the past 6 to 7 years, the number of farmers and the cropped area covered under crop insurance has seen spectacular growth. For the year 2009-10 as many as 27 million farmers growing crops on over 38 million hectares were insured under various crop insurance programs of AIC. The numbers seem very impressive, yet a great majority of farmers who actually need insurance protection are still outside its purview.

Crop Insurance

The idea of crop insurance emerged in India during the early part of the twentieth century. Yet it was not operated in a big way till recent years. J.S. Chakravarti proposed a rain insurance scheme for the Mysore State and for India as a whole with view to insuring farmers against drought during 1920s. Crop insurance received more attention after India's independence in 1947. The subject as discussed in 1947 by the Central Legislature and the then Minister of Food and Agriculture, Dr. Rajendra Prasad gave an assurance that the government would examine the possibility of crop and cattle insurance. In October 1965 the Government of India decided to introduce a Crop Insurance Bill and a Model Scheme of Crop Insurance in order to enable the States to introduce, if they so desire, crop insurance. In 1970 the draft Bill and the Model Scheme were referred to an Expert Committee headed by Dr. Dharm Narain. Different experiments on crop insurance on a limited, ad-hoc and scattered scale started from 1972-73. The first crop insurance program was on H-4 cotton in Gujarat. All such programs, however, resulted in considerable financial losses. The program(s) covered 3110 farmers for a premium of Rs. 4, 54,000 and paid claims of Rs. 3.79 millions. It was realized that programs based on the individual farm approach would not be viable in the country. Obviously, "individual farm approach" would reflect crop losses on realistic basis and hence, most desirable, but, in Indian conditions, implementing a crop insurance scheme at "individual farm unit level" is beset with problems, such as:

(i) Non availability of past record of land surveys, ownership, tenancy and yields at individual farm level (ii) Large number of farm holdings (nearly 116 millions) with small farm holding size (country average of 1.41 hectares) (iii) Remoteness of villages and inaccessibility of farm-holdings (iv) Large variety of crops, varied agro-climatic conditions and package of practices (v) Simultaneous harvesting of crops all over the country (vi) Effort required in collection of small amount of premium from large no. of farmers (vii) Prohibitive cost of manpower and infrastructure

Weather Insurance

As the name suggest, weather insurance is an insurance coverage against the vagaries of weather. Many agrarian economies owe their strength to favourable weather parameters, such as rainfall, temperature, relative humidity etc. Around sixty five percent of Indian agriculture is heavily dependent on rainfall, and, therefore, is extremely weather sensitive. Many agricultural inputs such as soil, seeds, fertilizer, management practices etc. contribute to productivity. However, weather, particularly rainfall has overriding importance over all other inputs. The reason is simple - without proper rainfall, the contributory value of all the other inputs diminishes substantially. An analysis of Indian Crop Insurance Program between 1985 and 2003 reveals that rainfall accounted for nearly 95 percent claims – 85 percent because of deficit rainfall and 10 percent because of excess rainfall (AIC, 2006). Reducing vulnerability to weather in developing countries may very well be the most critical challenge facing development in the new millennium. One of the most obvious applications of weather risk management products, weather insurance or weather derivatives. Weather impacts on many aspects of the agricultural supply and demand chain. From the supply side, weather risk management can help to control both production risk and quality risk. Weather events like warmer than normal winter or a cooler than normal summer can impact all sorts of companies like utilities, food and agricultural groups and even retailers.The basic idea of weather insurance is to estimate the percentage deviation in crop output due to adverse deviations in weather conditions. There are statistical techniques to workout the relationships between crop output and weather parameters.

Advantages of weather insurance over traditional crop insurance

There are many shortcomings in the traditional crop insurance. The important ones are: (a) adverse selection (b) multiple agencies and their huge administrative cost (c) lack of reliable methodology for estimating and reporting crop yields (d) delays in settlement of claims (f) program limited to growers (farmers). Majority of these shortcomings could be overcome in the weather insurance, as follows:

(i) Trigger events (like rainfall) can be independently verified & measured.

(ii) Compared to yield based insurance, weather insurance is inexpensive to operate. Since very few agencies would be involved in implementation, the aggregate administrative cost would be far lower.

(iii) Unlike traditional crop insurance where claim settlement can take up to a year, quick payouts in private weather insurance contracts can improve recovery times and thus enhance coping capacity.

(iv) Scientific way of designing product and transparency.

(v) Individual farmers are generally unable to influence the weather index value.

Weather-Index

Index-based weather risk insurance contracts in agriculture have emerged as an alternative to traditional crop insurance. These are linked to the underlying weather risk defined as an index based on historical data (for example, for rainfall, temperature, snow, etc.) rather than the extent of loss (for example, crop yield loss). Weather insurance is a creative product that can be used for situations ranging from sales promotions to income stabilization, unlike regular insurance, which would only cover physical damage, weather insurance protects against additional expenses or loss of profit from a specific weather event. Insurance generally pays based on actual damages, while weather insurance pay based on the difference between a negotiated "strike price" and the actual weather (or the total of weather related index). As the weather index is objectively measured and is the same for all farmers, the problem of adverse selection is minimized. Weather-indexed insurance can help farmers protect their overall income rather than the yield of a specific crop, improve their risk profile enhancing access to bank credit, and hence reduce overall vulnerability. Some of pilot schemes and delivery models operated in India are:

1. ICICI Lombard pilot scheme for groundnut in Andhra Pradesh
2. KBS pilot scheme for soya farmers in Ujjain
3. Rajasthan government insurance for orange crop
4. IFFCO-TOKIO monsoon insurance
5. AIC Varsha Bima Yojana (rainfall insurance scheme)
6. AIC Sookha Suraksha Kavach (drought protection shield)
7. AIC coffee rainfall index and area yield insurance
8. ICICI Lombard loan portfolio insurance

Weather Insurance Pilots in India

ICICI-Lombard was the first general insurance company in India to introduce rainfall insurance pilot based on a 'composite rainfall index' in 2003. It implemented a pilot project in Mahabubnagar district of Andhra Pradesh for groundnut and castor. Though participation was limited, it held out valuable lessons for future programs. The rainfall index insurance and other weather-based insurances have since been extended to other areas and crops beginning with *kharif* 2004 season.

IFFCO-Tokio General Insurance Company (ITGI) piloted rainfall insurance by the name – 'Baarish Bima' during 2004 in nine districts of Andhra Pradesh, Karnataka, Gujarat & Maharashtra. The product is based on rainfall index compensating farmers for deficit rainfall. The policy pays for deviations in actual rainfall exceeding 30 percent. The claims are paid on graded scale, with 100 percent claims payable when adverse deviation in rainfall reaches 90 percent. This pilot again is expanded to more crops and areas after *kharif* 2004 season. After analysing the impact that temperature has on wheat cultivation, ICICI Lombard had designed a weather insurance product for wheat cultivators which addresses the dual risks of extreme temperature fluctuations and unseasonable rainfall

Conclusion

In India around 61 % of cultivable area is under rainfed cultivation, which is most vulnerable to vagaries of weather. Economic status of farmers of this region is very poor and the ability to overcome the crop failure due to adverse weather events is abysmal. Weather insurance will continue to be the dominant insurance concept as the coming years will experience more frequent extreme weather events like heavy rains, droughts heat and cold waves etc. Food security and weather risk management are inextricably linked: weather risk management or the lack of it determines the level of systematic risk in the food security system. At the farm level, weather based index insurance allows for more stable income streams and could thus be a way to protect people's livelihood and improve their access to finance. Weather based insurance is an upcoming strategy that has proven its worth in places such as India and it is important that it has given the attention as it deserves to improve the food securities of communities especially the resource poor. The lack of historical data is more difficult to overcome, presenting a real obstacle to scaling up the weather insurance program. Finally, climate change needs to be treated as a major economic and social risk to national economies, not just as a long-term environmental problem.

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