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Foreword

Rainfed agriculture is predominant in arid, semi-arid and sub-humid regions of the country. These regions are home to about 81% of rural poor in the country. At present, about 55% of the net sown area is rainfed contributing 40% of total food grain production and supports 2/3rd of the livestock population. Hence, rainfed agriculture has a crucial role to play in sustaining the economy and food security of India. Though, impressive gains were noted in some of the rainged crops in recent years, the gap between attainable and farmers' yields still remains high. Small and marginal farmers who are the backbone of rainfed farming are resource poor and risk averse. In addition to the small holder dominance, rainfed agriculture also faces new challenges of climate variability.

The farming systems approach is considered as important and relevant especially for the small and marginal farmers as location-specific integrated farming systems will be more resilient and adaptive to climate variability. The IFS approach also has the potential to overcome multifarious problems of farmers including resource degradation, declining resource use efficiency, farm productivity and profitability. Traditionally, farmers in rainfed regions practice crop-livestock mixed farming systems, which provide stability during drought years, minimize their risk and help them to cope with weather aberrations. However, these traditional systems are low productive and cannot ensure livelihood security now. Hence, it is imperative to improve the existing farming systems to enable adequate employment and income generation, especially for small and marginal farmers who constitute more than 80% of the farming community.

Keeping in view the importance of farming systems approach for enhancing the productivity and profitability of rainfed farming systems, an attempt was made to improve the existing farming systems of small and marginal farmers in Anantapur and Adilabad districts of Andhra Pradesh. The results obtained from the study (2009-2012) are presented in this bulletin. I hope the publication would be very useful to researchers, teachers and extension personnel working on integrated farming systems.

B. Venkateswarlu

Background

Rainfed agriculture is predominant in arid, semi-arid and sub-humid regions of the country. These regions are home to about 81% of rural poor in the country. Hence, rainfed agriculture has a crucial role to play in sustaining the economy and food security of India (CRIDA, 2012). At present, about 55% of the net sown area is rainfed contributing 40% of the total food production, supports 40% of human and 2/3rd of livestock population. However, aberrant behaviour of monsoon rainfall, eroded and degraded soils with multiple nutrient and water deficiencies, declining ground water table and poor resource base of the farmers are major constraints for low and unstable yields in rainfed areas. In addition, climate variability including extreme weather events resulting from global climate change poses serious threat to rainfed agriculture.

Farmers make decisions in an environment that lead to complex farming systems. 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). Traditionally, farmers in rainfed regions practice crop-livestock mixed farming systems, which provide stability during drought years, minimize their risk and help them to cope with weather aberrations. However, these traditional systems are low productive and cannot ensure immediate livelihood security. The decline in size of land holdings, eroded and degraded soils with multiple nutrient deficiencies, aberrant weather and low investments pose a challenge to the sustainability and profitability of farming. In view of the decline in per capita availability of land from 0.5 ha in 1950-51 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 imperative to develop strategies and agricultural technologies that enable adequate employment and income generation, especially for small and marginal farmers who constitute more than 80% of the farming community (Jha, 2003).

During the last 4–5 decades of agricultural research and development in India, major emphasis has been given to component- and commodity-based research involving development of crop varieties, animal breeds and farm machinery, mostly conducted in isolation and at the institute level (Behera *et al.*, 2008). This component-, commodity- and discipline-based research has not proved wholly adequate in addressing the multifarious problems of small and marginal farmers (Jha, 2003). Following such approaches, it has been argued that several problems have appeared in Indian farming such as declining resource use efficiency and declining farm profitability and productivity (Sharma and Behera, 2004).

It has been widely 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 farmer centric research and development efforts, is desirable (Jha, 2003). To meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability, several researchers have recommended a farming systems approach (Norman, 1978; Byerlee *et al.*, 1982; Gurbachan-Singh, 2012). No single farm enterprise is likely to be able to sustain the small and marginal farmers without resorting to integrated farming systems (IFS) for the generation of adequate income and gainful employment year round. Hence, it is necessary to integrate different enterprises like livestock, poultry, duckery, apiary, field and horticultural crops, etc. within the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable.

A common characteristic of integrated farming systems is that they invariably have a combination of crop and livestock enterprises and in some cases may include combinations of poultry, agro-forestry, horticulture, apiary etc. Further, there are synergies and complementarities between different enterprises that form the basis of the concept of IFS (Lightfoot and Minnick, 1991; Jitsanguan, 2001; Radhammani *et al.*, 2003). Integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs by another within the context of the farming system. The difference between mixed farming and integrated farming is that enterprises in the integrated farming system are mutually supportive and depend on each other (Csavas, 1992). The synergy between enterprises increases with on-farm diversity and is fundamental to the IFS concept. Diversification of farming activities improve the utilization of labour, reduce unemployment in areas where there is a surplus of underutilized labour and provide a source of living for those households that operate their farm as a full time occupation.

The term "farming systems research (FSR)" has been applied to a wide variety of activities (Byerlee *et al.* 1982). In its broadest sense, FSR is any research that views the farm in a holistic manner and considers interactions in the system (CGIAR, 1978). Research with a farming systems perspective can have various objectives ranging from increasing the body of knowledge about farming systems to solving specific problems in the farming system (Byerlee *et al.*, 1982). Expectations are highest in its problem-solving role where the aim is to increase productivity of the farming system by generating new technologies appropriate for farmers. This research is often further divided into location-specific research with a short-term objective of developing improved technologies for a target group of farmers and research conducted with a long-term perspective to overcome major, widespread constraints in farming systems.

Farming Systems Research - An efficient strategy

Byerlee *et al.* (1982) have outlined the following points for improving the efficiency of FSR:

- 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.
- An efficient research strategy, therefore, should focus on a very few – perhaps two to four – research opportunities that offer potential to increase resource productivity in a way acceptable to farmers
- The identification of these research opportunities and their development into technologies acceptable to farmers should be done using a farming systems perspective
- On-farm research with farming systems perspective (OFR/FSP) programmes are most efficiently implemented for identified strata or relatively homogenous group of farmers
- Socio-economic criteria may be just as important as agro-climatic variables in delineating recommendation domains

Several kinds of innovations/interventions can be identified for enhancing the productivity of farming systems (adapted from Simmonds, 1986). They are:

1. Costless interventions: a new variety, proper plant spacing, cultivation across slope, performing operations on time etc
2. Interventions that cost cash: special seed (hybrid), chemical inputs etc
3. Interventions that cost both cash and efforts/manpower: an extra crop in the sequence, an additional enterprise etc

4. Complex interventions that demand several inputs: a complete package of improved practices for different enterprises

Generally, the adoption rate will be more if the interventions are simpler and cheaper.

Farming Systems Research: Approaches

There are several approaches to FSR that are sometimes presented as different entities (Carberry, 2001). In all these FSR approaches, a participative approach is recommended, though the activity may differ on degree of participation, and also on how farmer-directed research is managed. While all approaches assume the participatory component to be essential, there is no prescriptive approach for the right way or combinations of participation (Dalal-Clayton and Bass, 2002). The diverse activities included in FSR in the broad sense fall into three categories (Simmonds, 1986). They are:

1. Farming systems research in the narrow sense (FSR): It involves the study of farming systems as they exist. Typically, the analysis goes deep, technically and socio-economically, and the objective is academic or scholarly rather than practical. The view taken is nominally 'holistic' and numerical system modeling is a fairly natural outcome if a holistic approach is claimed.

2. On-farm research with farming systems perspective (OFR/FSP): It starts from the percept that only farmer-experience can reveal to the researcher what farmers really need. Typically, the OFR/FSP process isolates a sub-system of the whole farm, studies it in just sufficient depth to gain the necessary FSP and proceeds as quickly as possible to on-farm experiments with farmers' collaboration. There is an implicit assumption that stepwise change in an economically favourable direction is possible and worth seeking. Farmer participation is ensured at different stages of technology generation and transfer processes such as system description, problem diagnosis, design and implementation of on-farm trials, and providing feedback through monitoring and evaluation (Rhoades and Booth, 1982).

   In addition to OFR/FSP, on-station research with FSP is also conducted at the research stations by taking into consideration the farmers' problems, resource availability with farmers such as land, labour, capital etc. and farm constraints (physical and bio-physical) (Rangaswamy *et al*., 1996; Behera and Mahapatra, 1999).

3. New farming systems development (NFSD): It takes the view that many farming systems are already so stressed that radical restructuring rather than stepwise change is necessary. Therefore, the objective is invention, testing and exploitation of new systems. OFR/FSP is mostly concerned with unit changes or simple packages while NFSD has to face the problems of multiple changes in complex packages.

Worldwide, a number of studies on IFS have shown several advantages of adopting farming systems approach. Some of the advantages include: food security to the farm family, higher farm productivity and enhanced income, employment generation particularly during off-season, impart stability to farm income, efficient recycling and reuse of resources, and sustainability of the system. Furthermore, the farming systems approach is considered as important and relevant especially for the small and marginal farmers as location-specific integrated farming systems will be more resilient and adaptive to climate variability. Keeping in view the importance of farming systems approach for enhancing the productivity and profitability of rainfed farming systems, an attempt was made to improve the existing farming systems of small and marginal farmers in Anantapur and Adilabad districts of Andhra Pradesh. The results obtained from the study (2009-2012) are presented in this bulletin.

Identification of Rainfed Farming Systems: Process

The process of identification of the study area and dominant traditional farming situations (climate, soils, cropping patterns) at district level are presented in this Chapter.

Study Area

Andhra Pradesh (AP) is the fourth largest state in the country covering an area of 2,74,40,000 ha of which 37.6% is under cultivation, 22.6% is under forests, while 22.5% is under permanent pastures and 10.3% is under current fallows (Kareemulla *et al.,* 2007). The cropping intensity in the state is 121%. The state receives an average rainfall of 940 mm with southwest monsoon contributing the major share. However, more than 50% districts of AP are drought prone with high incidence of poverty and unemployment. AP is divided into seven agro-climatic zones out of which northern Telangana zone and scarce rainfall zone of Rayalaseema are largely rainfed. The study area was selected in these two regions viz. Adilabad district in northern Telangana zone and Anantapur in scarce rainfall zone of Rayalaseema (Fig 1). These districts represent drought-prone Telangana and Rayalaseema regions and are sufficiently diverse in terms of cropping pattern, agro-climatic conditions and farmers' socio-economic conditions. This offers immense opportunity for an in-depth analysis of different farming systems and testing of different technologies/ interventions under distinctly varied agro-climatic and socio-economic conditions.

Fig. 1 : Location of the study area in Andhra Pradesh

Anantapur district

Climate: Anantapur is the only arid district of Andhra Pradesh with about 536 mm annual rainfall with a standard deviation of 200 mm. This district lies in the rain shadow area of the state and suffers from frequent droughts. The rainfall was near and above average for 19 out of 40 years (1971-2010). In another study, an analysis of monthly rainfall over 94 years (1911 to 2004) indicated an annual mean rainfall of 568.5 mm with a coefficient of variation of 28% (Rukmani and Manjula, 2009). That the coefficient of variation of rainfall is higher than the threshold level of 25% for annual rainfall suggests variability and lower degree of dependability on rainfall in the district. Further, in more than one-half of the years studied, the actual rainfall was below the annual mean rainfall of 568.5 mm. That is, 51 out of 94 years have experienced below mean rainfall in the district. On average, the district experiences drought conditions once in every five years. Eighteen out of 94 years are classified as drought years, as the annual actual rainfall in these years has been 75% below the annual mean rainfall. Fourteen out of these 18 years are moderate-drought years while 4 may be classified as severe-drought years. Occurrence of rainfall during first flowering and pod development stages is very crucial for higher productivity of groundnut (Bapuji Rao *et al.*, 2011).

Soils: The major soils group of the district is red earths with loamy sub soil and red sandy loams classified under Aridisoils (Fig 2). The surface soils are loamy sand to sandy loam and sub soils are sandy clay loam to sandy clay. The soils are gravelly, shallow to moderately deep, well drained and slopy with rolling topography. Large areas in the district have coarse soil-surface texture, are poor in water and nutrient retention, and are prone to wind and water erosion.

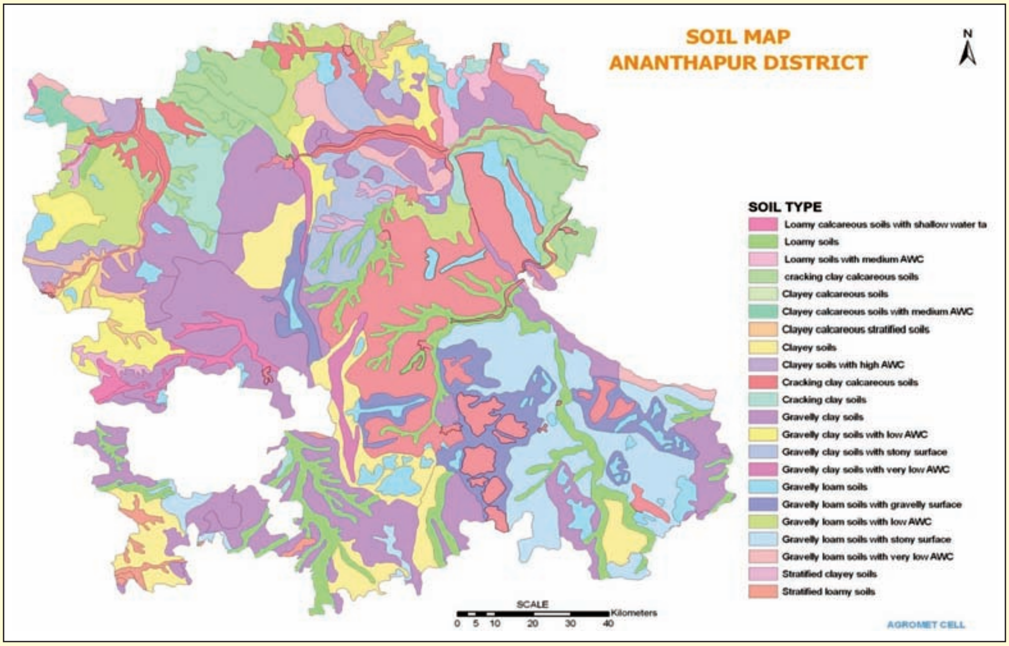

Fig. 2 : Soil map of Anantapur district (Source: NBSSLUP, Regional centre, Bangalore)

Land use: Anantapur has geographical area of 19,13,000 ha with only 10.3% of the district's area under forests. Gross cropped area is 11,54,000 ha, and the net sown area accounts for 56.6% of the total geographical area (Table 1). About 6.3% of the area is under non-agricultural land uses while permanent pastures constitute 0.5%. The per capita cultivated land in the district is 0.29 ha (Kareemulla *et al.*, 2007) and the average size of holding is 1.93 ha.

Table 1 : Land use pattern in Anantapur and Adilabad districts (2008-09)

Land use category	Anantapur	Adilabad	Andhra Pradesh
Geographical area (000 ha)	1913.0	1620.0	27504.0
Forests (%)	10.3	42.8	22.6
Barren & uncultivable (%)	9.6	2.7	7.5
Non-agricultural uses (%)	6.3	3.8	9.6
Permanent pastures (%)	0.5	0.9	2.1
Cultivable wastes (%)	2.8	0.9	2.4
Other fallows (%)	4.7	4.1	5.4
Current fallows (%)	8.8	7.1	9.5
Net sown area (%)	56.6	37.1	39.5
Area sown more than once (000 ha)	72.0	94.0	2962.0
Gross cropped area (000 ha)	1154.0	691.0	13830.0
Cropping intensity (%)	107.0	116.0	127.0

Farming situations: The predominant farming situation in Anantapur district (Table 2) is rainfed red soils (74%) followed by rainfed black soils (8.3%).

Table 2 : Farming situations in Anantapur district

Farming situation	Area (ha)	%
Canal irrigated black soils	7799	0.81
Canal irrigated red soils	21117	2.17
Tank irrigated black soils	4835	0.49
Tank irrigated red soils	18432	1.90
Well irrigated black soils	7921	0.81
Well irrigated red soils	80540	8.30
Rainfed black soils	110047	11.3
Rainfed red soils	718335	74.1
Problematic soils	190	0.01

Source: ANGRAU, Hyderabad

Cropping pattern: The district has only 11% of area under irrigation with groundnut occupying maximum area under rainfed condition accounting for over 75% of the cropped area. The cultivation of groundnut is preferred in this region as the crop can withstand dry spells of 4 to 6 weeks duration during its vegetative growth phase. Other important crops are chickpea (6.3%), rice (4.2%), sunflower (3.7%), pigeonpea (3.0%) and sorghum (1.2%). The productivity of the major crops is less than half a tonne per hectare reflecting the harsh production environment in the district. The district has a cropping intensity of 107%. The district had over 21,000 ha under horticulture in 2000-01, which has increased to nearly 85,500 ha in 2008-09 with its share growing from 4.3% to 9.7% of the total area under horticulture in the state. However, area under vegetables has marginally declined, while that in spices has drastically declined from about 16,600 ha to 5,198 ha during this period (Table 3).

Table 3 : Area under horticultural crops in the districts

District	Area (ha) TE 2000-01	% share	Area (ha) TE 2008-09	% share
		Fruit crops		
Anantapur	21022	4.3	85581	9.7
Adilabad	3344	0.7	52225	5.9
AP (Total)	483645	100	879861	100
		Vegetables		
Anantapur	8572	3.5	4003	1.4
Adilabad	3501	1.4	17990	6.4
AP (Total)	241782	100	279713	100
		Spices		
Anantapur	16626	4.3	5198	1.6
Adilabad	18714	4.8	11258	3.5
AP (Total)	389558	100	322998	100

Socioeconomic setting: The district has a population of 36,40,478 with 5,89,465 rural households. About 14% of the total population belongs to Scheduled Caste while 3.49% belongs to Scheduled Tribes. The rural literacy rate is 51.6% with over 67% of the work force engaged in agriculture and the rest in non-agricultural activities (Table 4). The district has the largest livestock population (15,74,110) next only to Mahabubnagar with a grazing pressure of 10.6 adult cattle units (ACUs) per hectare of available grazing area. The district has a large number of small ruminants (4,81,849). The per capita income of the district was ₹ 16,939 during 2003-04 at constant prices.

Table 4 : Demographic features of Anantapur and Adilabad districts (Census, 2001)

Feature		Anantapur	Adilabad
No. of households	Rural	589465	389854
	Urban	189587	134795
	Total	779052	524649
Population	Male	1859588	1250958
	Female	1780890	1237045
	Total	3640478	2488003
SC population		514896 (14.14%)	461214 (18.54%)
ST population		127161 (3.49%)	416511 (16.74%)
Population density/km^2		191	155
Literacy – Rural (%)	Male	64.6	59.6
	Female	37.9	33.0
	Total	51.6	46.3
District literacy (%)		56.1	52.7
Workers engaged in agricultural activities (%)		67.5	61.0
Cultivators (%)		29.8	30.4
Agricultural labourers (%)		37.7	30.6
Workers engaged in non-agricultural activities (%)		32.5	39.0

Adilabad district

Climate: The climate of the district is characterized by hot summer and in general dry except during south-west monsoon season. About 85% of the total rainfall is received during south-west monsoon. Despite receiving higher annual rainfall (1103 mm), Adilabad has suffered from major agricultural droughts during the past two decades. The average annual rainfall during 2000-2011 was 983 mm. During the period, the annual rainfall was less than 750 mm in 2002, 2004 and 2009.

Soils: Black soils are predominant in the district covering about 85% of the cultivated area. About 10% of the soils are categorized under red soils. More than 50% of the district is underlain by hard rocks and the rest by the semi-consolidated sedimentary rocks and unconsolidated alluvial deposits (Fig 3).

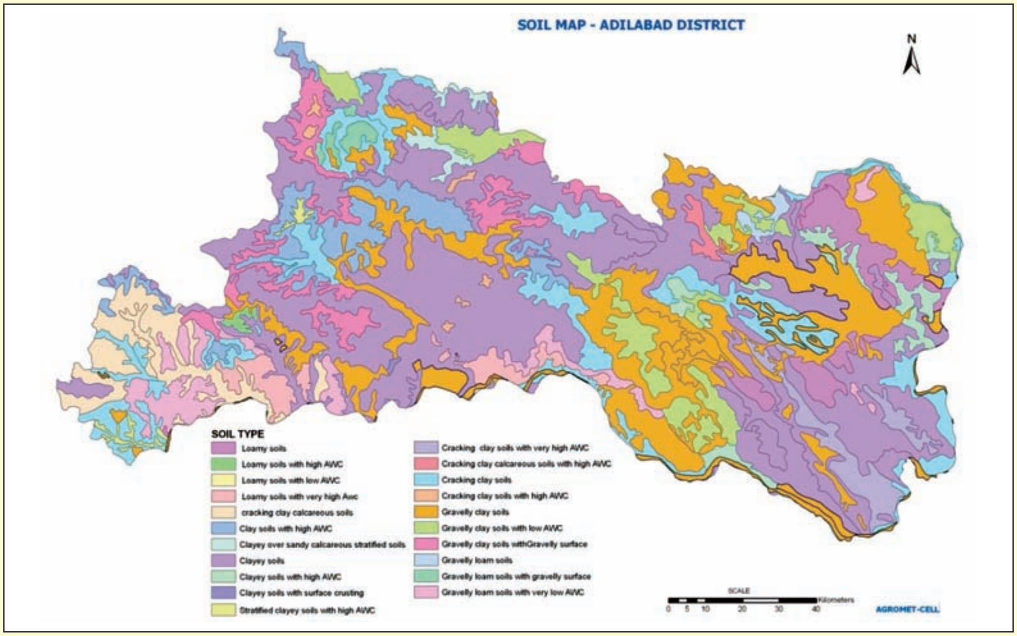

Fig. 3 : Soil map of Adilabad district (Source: NBSSLUP, Regional centre, Bangalore)

Land use: Adilabad is spread over an area of 16,20,000 ha with nearly 43% of the area under forests. While gross cropped area is 6,91,000 ha, the net sown area is 37.1% of the total geographical area. Only 4% of the area is under non-agricultural uses, while permanent pastures constitute 0.9% (Table 1).

Farming situations: The predominant farming situations in Adilabad district are given in Table 5. About 74.5% of the cultivated area in the district is under rainfed conditions.

Table 5 : Farming situations in Adilabad district

Farming situation	Area (ha)	%
Rainfed black soils- high rainfall	289928	56.81
Rainfed black soils- medium rainfall	52488	10.29
Rainfed red soils- high rainfall	12856	2.52
Rainfed red soils- medium rainfall	25100	4.92
Tank irrigated areas	19823	3.88
Canals irrigated areas	45440	8.90
Well irrigated black soils	30232	5.92
Well irrigated red soils	34292	6.72
Saline soils	162	0.03

Source: Adapted from Vijay Kumar (2007)

Cropping pattern: Sorghum has been continuously losing area to cotton, maize and black gram. Presently, cotton represents maximum share (40.4%) followed by rice and sorghum. But the productivity of this crop is low (375 kg/ha during 2008-09 against the state average of 434 kg/ha). The district has a cropping intensity of 116%. Fruit crops area in the district increased from 3,344 ha in 2000-01 to 52,225 ha in 2008-09. The district contributes 5.9% to the total area under fruit crops in the state. Similarly, gain in area under vegetables has been noted (from a mere 3,500 ha in 2000-01 to 17,990 ha in 2008-09). This district contributes over 6.4% of the total area under vegetables in the state. However, area under spices (chillies and turmeric) has decreased from 18,714 ha in 2000-01 to 11,258 ha in 2008-09 (Table 3). The district had a per capita income of ₹ 18581 in 2003-04, considerably less than the state average. The district has 16 Agriculture Produce Marketing Committees @ 3.2 per lakh ha of net sown area.

Socioeconomic setting: The district has the per capita land availability of 0.65 ha of geographical area due to lower population and the average size of holding is 1.54 ha. This district is having a significant tribal population (16.74%), second only to Khammam district. The density of population is less (155/km^2). Over 46% of the rural population is literate with a work participation rate of 61%. Agricultural labourers and cultivators constitute just about 30% each with 39% of the workers engaged in non-agricultural activities (Table 4). Adilabad has 13,13,985 adult cattle units (ACU) of livestock with over 8,00,000 cattle and 3,00,000 buffaloes. It has a high grazing pressure with over 12 ACUs per hectare of grazing area available in the district.

Participatory Farming Systems Development

Two representative clusters (villges) each from Anantapur and Adilabad were selected viz. Pampanur from Atmakur Mandal in Anantapur district and Seethagondhi cluster from Gudihatnoor Mandal in Adilabad district. In the two selected clusters, benchmark survey, farming systems analysis, focused group discussions and farmer-scientist interactions were conducted to finalize the interventions of farming systems and their implementation in a participatory mode. The salient findings are presented in this chapter.

A. Benchmark survey of selected villages

Pampanur cluster, Atmakur Mandal, Anantapur district

In this cluster, three villages/hamlets viz. Y. Kothapalli, Pampanur and Pampanur *Thanda* were selected for the benchmark survey. The cluster is located at 21 km from the district headquarters and 7 km from mandal (Atmakur) headquarters. About 50% of the households were selected for the survey. The selection of sample households was done by adopting random sampling technique. However, care was taken to include the households of different categories like marginal, small, medium, large farmers and landless labourers. The pre-designed questionnaire that consisted of data requirement both from primary and secondary sources was administered simultaneously in both districts. Cross verification was carried out with available secondary data wherever required. The survey involved a total of 297 households. The total geographical area of the cluster is 2110.9 ha out of which the cultivable area is 1431.5 ha. More than 90% of the cultivated area (1293 ha) is rainfed. The average annual rainfall of the cluster is about 500 mm. The cluster has 576 households with majority under small and marginal farmers category. Majority (93%) of the soils in the cluster are red soils (alfisols). The extent of soil loss was estimated at 6 tons/ha/year.

Family size and literacy: The average family size in the cluster was 4.2 and the number of members was more (5) in large farmers' category. In general, male population was slightly more than female population in the cluster. The overall literacy rate in the cluster as reflected by the survey was only 33%.

Land holding: The average land holding was 3.24 ha in the cluster. About 70% of farmers in the cluster belonged to marginal (12%), small (22%) and medium (36%) categories. On the other hand, large farmers possess about 59% of total cultivated area in the cluster (Table 6).

Table 6 : Land holding pattern in Pampanur cluster

Category	Number of households	Area operated (ha)	Average holding size (ha)
Landless	1 (0.3)	0	0
Marginal (0-1 ha)	37 (12.5)	28.1 (2.9)	0.76
Small (1-2 ha)	64 (21.5)	87.9 (9.1)	1.37
Medium (2-4 ha)	107 (36.0)	275.6 (28.7)	2.58
Large (>4 ha)	86 (29.0)	571.1 (59.3)	6.64
Others	2 (0.7)	0	0.00
Total	297	962.7	3.24

Figures in parentheses are percentages

Cropping pattern: The cluster is predominantly a sole crop belt with *kharif* as the major cropping season. Groundnut is the major oilseed crop occupying 76% of the cropped area followed by paddy (7%). Other crops like different vegetables, sunflower, pigeonpea and mango are grown to a limited extent (Table 7). Small and marginal farmers grow groundnut as sole crop on 85-87% of their lands. On the other hand, large farmers follow crop diversification and grow several crops including groundnut (74%), paddy (8%), vegetables (6%), pigeonpea (3%) and sunflower (2%). This could be due to better availability of irrigation facilities for large farmers. The overall cropping intensity in the cluster was 100% under rainfed conditions and 150-176% under irrigated conditions. On average, the groundnut productivity under rainfed conditions was 6.5 q/ha in the cluster.

Groundnut- a major crop in the cluster

Table 7 : Area (ha) under major crops in Pampanur cluster

Crop	Farmer category				Total
	Marginal	Small	Medium	Large	
Groundnut	26.1 (87)	69.2 (84.5)	200.7 (77.1)	410.2 (73.6)	706.2 (75.9)
Paddy	1.6 (5.3)	1.8 (2.2)	14.2 (5.5)	45.3 (8.1)	62.9 (6.8)
Vegetables	0.8 (2.7)	2.3 (2.8)	16.3 (6.3)	32.1 (5.8)	51.5 (5.5)
Sunflower	1.2 (4)	0	3.2 (1.2)	12.6 (2.3)	17 (1.8)
Pigeonpea	0	0	0	14.6 (2.6)	14.6 (1.6)
Mango	0	0	0.8 (0.3)	10.9 (1.9)	11.7 (1.3)
Groundnut + pigeonpea	0	2 (2.4)	0	0	2 (0.2)
Cotton	0	0	0.8 (0.3)	0	0.8 (0.08)
Sorghum	0	0	0.6 (0.2)	0	0.6 (0.06)
Green gram	0	0	0.6 (0.2)	0	0.6 (0.06)
Other crops	0.3 (1)	6.6 (8.1)	23.1 (8.9)	32 (5.7)	62 (6.7)
Total	30	81.9	260.3	557.7	929.9

Figures in parentheses are percentages

Cost of cultivation: The average cost of cultivation for groundnut in the cluster was ₹ 13845/ha. Among the cost components, labour cost accounted for about 61% of total cost of cultivation followed by seed (27%) (Fig 4). All the farmers in the cluster follow manual and mechanical methods of weed control resulting in higher labour requirement. Further, most of the farmers employ labour for groundnut harvesting.

Manual labour engaged in groundnut harvesting

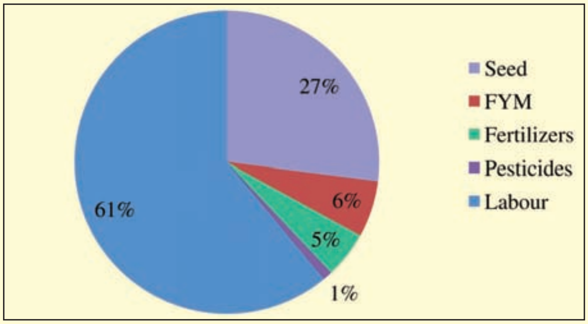

Fig 4 : Share of different inputs and labour in the total cost of groundnut cultivation

Livestock possession: The average livestock ownership of the households ranged from 5 to 8 in the selected cluster villages. Among the farmer categories, large farmers possessed more number of livestock compared to others. The sheep and goat population was more in the cluster compared to draught and milch animals.

Small ruminants are preferred over bovines

Farm mechanization: Tractor was used by 31% of the farmers for performing different agricultural operations, followed by MB plough (29%). Use of plant protection equipment was limited to less than 18% of the farmers. Limited use of threshers, winnowers and motor pump was also noticed in the cluster.

Tractor drawn 'Anantha planter' for groundnut sowing

Membership in organizations: More than 80% of the respondents had membership in SHGs. Regarding membership in *Rytu mitra* groups, the percentage of membership was more in case of large farmers (80%) followed by small (75%), marginal (65%) and medium farmers (60%). Similarly, membership in cooperative society was more in case of large farmers (50%) followed by medium farmers (35%).

Wage earnings: The average number of wage earners in a household was 2.5. It was highest among landless and marginal farmers. The average on-farm income/year/household through wages ranged from ₹ 17765 (large farmers) and ₹ 33960 (marginal farmers). The on-farm income from wages decreased with increase in the size of holdings. The average off-farm income/year/household was ₹ 11430. It ranged from ₹ 8599 (large farmers) to ₹ 30038 (other farmers). On average, labour in this cluster get employment for about 130 days in a year of which 105 days are through on-farm employment within the cluster. The employment opportunities outside the cluster are very meager with just 16 days/year. About 28% of the cluster families were in the habit of seasonal migration with an average employment of 71 days/year for each such migrating member. The income from migration for the concerned migrating member was to the tune of ₹ 6329.

Seethagondhi cluster, Gudihatnoor Mandal, Adilabad district

In this cluster, eight villages/hamlets were selected for survey. The cluster is located at 13 km from the district headquarters and 7 km from mandal (Gudihatnoor) headquarters. The total geographical area of the cluster is 1913 ha, of which 1296 ha (68%) is under cultivation. About 23.3% of the land in the cluster is reported as degraded land. Majority of the soils of the cluster are black soils while red soils are found in isolated patches. The cluster received an annual rainfall of over 1100 mm during 2006 and 2007. The cluster has a total population of 1983 (as per 2001 census). There are 575 households in the cluster with majority under the small and marginal farmer category. Only four out of eight villages in the cluster have adequate drinking water facility. There exists only one commercial bank branch in the cluster. The cluster has one Primary Health Centre to cater to the needs of the people. On the other hand, there is no Veterinary Health Centre within the cluster boundaries. Out of the eight villages of the cluster, five villages have proximity (< 10 km) to the agricultural market yard.

Family size and literacy: The average family size of the cluster was 4.8 with large farmers having more members (5.7) compared to other categories. The male population was marginally higher than females across all the household categories. The literacy rate in the cluster was 59%. Among the literates, those with primary school education were the largest single group.

Land holding: The average land holding per household was 2.58 ha in the cluster. More cultivated area (52%) was possessed by large farmers followed by medium farmers (37%). Small and marginal farmers cultivated about 11% area in the cluster.

Cropping pattern and intensity: The cluster is predominantly a sole crop belt with *kharif* as the major cropping season. Cotton + pigeonpea intercropping and cotton cultivation occupied about 67% of the cultivated area during 2006-07. The next major crop was sorghum that occupied one-fourth of the gross cropped area in the cluster (Table 8). There was a distinct difference in the crop area allocation across different land holding categories. Small and marginal farmers had greater allocation of cultivable area under sorghum compared to their counterparts (large farmers) who had larger area under

Cotton + pigeonpea intercropping is predominant in the cluster commercial crops like cotton. The cropping intensity under rainfed conditions was about 100% in the cluster.

Table 8 : Area (ha) under major crops in Seethagondhi cluster

Crop	Farmer category				Total
	Marginal	Small	Medium	Large	
Cotton + pigeonpea	1.6 (18.6)	39.8 (46.3)	116.8 (60.2)	258.9 (59.7)	417.1 (57.8)
Sorghum	3.0 (34.9)	37.0 (43)	25.3 (13.1)	126.5 (29.2)	191.8 (26.6)
Cotton	2.8 (32.6)	6.2 (7.2)	26.4 (13.6)	30.0 (6.9)	65.4 (9.1)
Pigeonpea	0.8 (9.3)	3.0 (3.5)	24.0 (12.4)	10.0 (2.3)	37.8 (5.2)
Green gram	0	0	0	2.4 (0.6)	2.4 (0.3)
Paddy	0	0	0	0.8 (0.2)	0.8 (0.1)
Chickpea	0	0	0	0.8 (0.2)	0.8 (0.1)
Other crops	0.4 (4.6)	0	1.3 (0.7)	3.8 (0.9)	5.5 (0.8)
Total	8.6	86.0	193.8	433.2	721.6

Figures in parentheses are percentages

Crop productivity: The productivity of cotton intercropped with pigeonpea varied between 11-18 q/ha across the farmer categories. Similarly, the intercropped pigeonpea yielded about 1.9 q/ha. The sorghum yield was in the range of 7.4-11.8 q/ha in the cluster (Table 9).

Table 9 : Productivity (q/ha) of major crops grown in Seethagondhi cluster

Crop	Farmer category				Mean
	Marginal	Small	Medium	Large	
Cotton + pigeonpea - cotton	18.2	13.0	11.1	11.9	12.0
- pigeonpea	3.1	3.2	1.7	1.5	1.9
Sorghum	7.4	7.4	11.8	8.5	10.0

Cost of cultivation: The cost of cultivation for cotton + pigeonpea intercropping was ₹ 14770/ha (₹ 12000-16000/ha across different categories). Labour accounted for the largest cost component (61%) followed by fertilizers (17%) and seed (13%) (Fig 5). Similarly, the cost of cultivation for sorghum was ₹ 8883/ha (₹ 8000-9500/ha across different categories). The composition of the cost components was similar as that of cotton + pigeonpea intercropping, with labour component comprising the largest share (Fig 6). The major reason for more spending on labour was due to reliance on manual and mechanical methods of weed management.

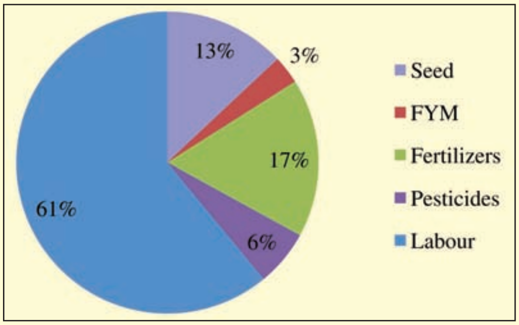

Fig. 5 : Share of different inputs and labour in the total cost of cotton + pigeonpea cultivation

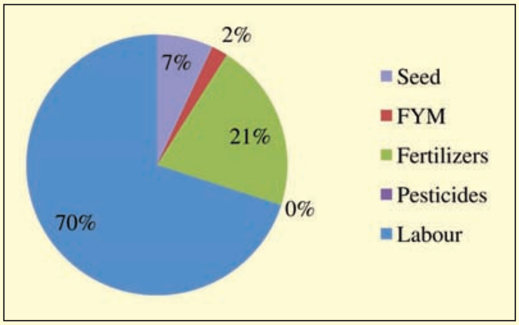

Fig. 6 : Share of different inputs and labour in the total cost of sorghum cultivation

Livestock possession: The average livestock holding in Seethagondhi cluster ranged from 2 to 7. Among the farmer categories, small farmers had relatively large number of livestock compared to others. The population of draught animals was more in the cluster followed by goats.

Farmers prefer cattle over small ruminants in the cluster

Farm mechanization: Among different farm implements/machinery, tractor was commonly used by all categories of farmers in the cluster. On average, about 40% of farmers in the cluster used tractor for performing different agricultural operations. Among the other farm implements, mould board plough was more popular among 1/3rd of the farmers of the cluster. Other farm machinery including cultivators, sprayers, etc. are used by very few farmers (<10%).

Agricultural extension: A large proportion of farmers obtain extension advice from the Extension Wing of Agricultural University followed by State Agriculture Department and input dealers.

Membership in organizations: There were about 22 village level community based organizations like SHGs and *Rythu Mitra* groups in the cluster. Thus, the average number of such village level institutions works out to one per every 100 persons. The membership of large farmers was more in these organizations compared to other categories of farmers. *Rythu Mitra* membership was similar among all the categories of farmers, while membership in cooperatives was dominated by medium farmers.

Wage earnings: The average number of wage earners per household was 2.2. The average income earned through on-farm wages was ₹ 29932/household/year compared to off-farm earning of ₹ 26180. The average number of employment days obtained by a labour on the farm was 113 days in a year compared to 13 days from off-farm activities and another 5 days outside the cluster. About 3% of households in the cluster migrate during off-season in search of employment. On an average, 1.7 persons went on migration in the regularly migrating families. The annual income of such migrating members was ₹ 39400.

B. Selection of farm families

The study was conducted in the farmers' fields in selected villages of Anantapur and Adilabad districts. A total of 6 target farmers were selected in each district based on the following criteria: a) farm size: (small and marginal), and b) type of farming system: [crops alone, crops + livestock (crop production is a major enterprise), and crops + livestock (size of livestock component is relatively more)]. Hence, the study involved a total of 12 farm families in two districts. The list of selected farmers in each district, along with area owned by each farmer, the cropping systems and the livestock owned by them is given in Tables 10 and 11.

In Anantapur district, all the six farmers were selected from village Y. Kothapalli. All the selected farmers follow groundnut + pigeonpea intercropping (Table 10). Among the livestock, farmers usually rear cow, sheep and goat. In Adilabad district, the farmers were selected from three villages viz. Seethagondhi, Chinna Malkapur and Pedda Malkapur. The selected farmers in different villages follow cotton + pigeonpea intercropping (Table 11). Among the livestock, farmers usually rear cow, bullocks and goat.

Table 10 : Details of selected farmers in Y. Kothapalli (Anantapur)

Farmer	Area (ha)	Cropping system	Livestock
Marginal farmers			
H. Peddanna	0.8	Groundnut + pigeonpea	-
M. Kullayappa	0.8	Groundnut + pigeonpea	Cows (2)
Ramanjaneyulu	1.0	Groundnut + pigeonpea	Sheep (90), Goat (30)
Small farmers			
B. Ravishankar	1.6	Groundnut + pigeonpea	-
Narasimhulu	2.0	Groundnut + pigeonpea	Cows (2), Sheep (2)
B. Ramakrishna	2.0	Groundnut + pigeonpea	Cows (2), Sheep (100)

Figures in parentheses are numbers

Table 11 : Details of selected farmers in Seethagondhi cluster (Adilabad)

Farmer	Village	Area (ha)	Cropping system	Livestock
Marginal farmers				
N. Dharmaji	Seethagondhi	1.0	C + P	-
N. Rajanna	Seethagondhi	1.0	C + P	Bullocks (2)
B. Kistu	Seethagondhi	1.0	C + P	Bullocks (4), cows (3), buffalo (1)
Small farmers				
M. Mothiram	C. Malkapur	2.0	C + P	-
S. Manku	P. Malkapur	2.0	C + P	Bullocks (2)
K. Manthu	Seethagondhi	2.0	C + P	Bullocks (2), cow (1), goats (40)

C: cotton; P: pigeonpea; figures in parentheses are numbers

C. Farming system analysis (FSA)/diagnosis of existing farming systems

An understanding of existing farming systems of selected farmers is an essential prerequisite for formulating sensible location-specific interventions. It also helps in diagnosing the principal constraints to improve farm productivity. Hence, a detailed farming system analysis was done for the selected farming systems.

Y. Kothapalli, Anantapur

Diagnosis of existing farming systems was carried out involving six selected farmers. Regarding the analysis of crop production component, the row-ratio for the groundnut + pigeonpea intercropping ranged from 6:1 to 12:1 (Table 12). All the six farmers were using 'TMV 2' and 'LRG 30' varieties of groundnut and pigeonpea, respectively and followed a row spacing of 30 cm. Regarding nutrient management, one farmer was not using any organic manure/chemical fertilizer for crop production. The remaining 5 farmers were using both organic manure (through FYM/sheep penning) and chemical fertilizers. However, no farmer was applying fertilizers as per the recommendation. All the six farmers were following manual and mechanical methods (harrowing) for weed management. The farmers were using various pesticides including fenvalerate, monocrotophos etc for pest management. There were large variations in terms of crop yields ranging from 4.5 – 10 q/ha for groundnut and 0.5-2.0 q/ha for pigeonpea.

Table 12 : Analysis of existing farming systems: Crop production

Particulars	Name of the farmer					
	Peddanna	Kullayappa	Ramanjneylu	Ravishankar	Narasimhulu	Ramakrishna
Cr. system	G + P (6:1)	G + P (10:1)	G + P (6:1)	G + P (12:1)	G + P (7:1)	G + P (11:1)
Variety	G: TMV 2 P: LRG 30	G: TMV 2 P: LRG 30	G: TMV 2 P: LRG 30	G: TMV 2 P: LRG 30	G: TMV 2 P: LRG 30	G: TMV 2 P: LRG 30
Spacing	30 cm	30 cm	30 cm	30 cm	30 cm	30 cm
Nutrient use (NPK kg/ha)	---	FYM 2.5 t/ha 14:35:0 1 top dress	Sheep penning 55:23:30 1 top dress	FYM 1.5 t/ha 11:30:20	FYM 1 t/ha Sheep penning 12:29:38	FYM 2 t/ha 14:35:45
Weed control (No.)	Manual (1) Manual (1)	Harrowing (1) Manual (1)	Harrowing (1) Manual (1)	Harrowing (1) Manual (1)	Harrowing (2) Manual (1)	Harrowing (1)
Plant protection	-	Fenvalerate Monocrtophos 2 sprays	Monocrtophos Dithane M-45 2 sprays	Fenvalerate 1 dusting	Fenvalerate 1 dusting	Monocrtophos 1 spray
Yield (q/ha)	G: 4-5 P: 0.3-0.5	G: 5-6 P: 0.25-0.3	G: 8-10 P: 1-1.2	G: 5-6 P: 0.3-0.5	G: 5-6 P: 0.5-0.7	G: 4.5-5.0 P: 1.5-2.0

G: groundnut; P: pigeonpea

Small ruminants- a major source of income

Regarding the analysis of livestock component, all the farmers use groundnut and pigeonpea residues for feeding the livestock (Table 13). In addition, green fodder from field bunds and crop fields was also used. The purchased feeding material includes paddy straw, maize stover and rice bran. In general, all farmers reported abundant fodder availability (green fodder from field bunds, residues of groundnut and pigeonpea, and grazing) during July to February. But they were facing scarcity of fodder during March to June (grazing in fields and wastelands, purchase of paddy straw). While there was no healthcare for cows, deworming was done once in 3 months for sheep and goat.

Table 13 : Analysis of existing farming systems: Livestock

Particulars	Name of the farmer			
	M. Kullayappa	Ramanjaneyulu	B. Narasimhulu	B. Ramakrishna
livestock numbers	Cows (2)	Sheep (90) Goat (30)	Cows (2) Sheep (2)	Cows (2) Sheep (100)
Feeding material	Own: G & P residues Purchase: paddy straw & rice bran	Own: G & P residues, grazing	Own: G & P residues, green fodder from field bunds Purchase: paddy straw	Own: G & P residues, grazing Purchase: maize stover & concentrates
Healthcare	Nil	Deworming once in 3 months	Nil	Deworming once in 3 months
Output	Milk 6 liters/day	20 sheep/yr 15 goat/yr	Milk 6 liters/day	Milk 4 liters/day 15 sheep/yr
Sale	4 L/day @ ₹ 15/L	₹ 1500/young ₹ 2500/adult	4 L/day @ ₹ 12/L	3 L/day @ ₹ 12/L ₹ 2500/sheep

G: groundnut; P: pigeonpea

Seethagondhi cluster, Adilabad

Heavy weed infestation in crop fields

In this cluster, all the six selected farmers followed a row-ratio of 8:1 for the cotton + pigeonpea intercropping (Table 14). All the farmers had adopted Bt-cotton hybrids ('Brahma', 'Mallika' etc). The predominant pigeonpea varieties were 'Asha' and 'Nirmal durga'. A spacing of 90x90 cm was mostly followed for cotton + pigeonpea intercropping. However, with the adoption of Bt-cotton hybrids, the farmers have reduced the spacing to 75x75 cm. Regarding nutrient management, one farmer was using only chemical fertilizers for crop production but other 5 farmers were using both organic manures and chemical fertilizers. However, no farmer was applying fertilizers as per the recommendation. All the six farmers followed manual and mechanical methods (harrowing) for weed management. The farmers were using various pesticides including imidacloprid, monocrotophos, endosulfon etc for pest management. The yield levels ranged from 8.75-20 q/ha for cotton and 1-2.5 q/ha for intercropped pigeonpea in different farmers' fields.

Table 14 : Analysis of existing farming systems: Crop production

Particulars	Name of the farmer					
	N Dharmaji	N Rajanna	B Kistu	M Mothiram	S Manku	K Manthu
Cr. system	C + P (8:1)	C + P (8:1)	C + P (8:1)	C + P (8:1)	C + P (8:1)	C + P (8:1)
Variety	C: Brahma P: N. durga	C: Brahma, P: N. durga	C: Mallika P: N. durga	C: Mallika S: JK-22	C: Mallika P: Asha	C: Mallika P: Asha
Spacing	75x75 cm	75x75 cm	75x75 cm	75x75 cm	75x75 cm	75x75 cm
Nutrient use (NPK kg/ha)	123:60:60 2 top dress	FYM 15 q/ha 187:113:75 2 top dress	FYM 15 q/ha 80:25:62	FYM 10 q/ha 65:20:50	FYM 8 q/ha 40:13:25	FYM 50 q/ha 40:17:25
Weed control (No.)	Harrowing (6) Manual (1)	Harrowing (5-6) Manual (1)	Harrowing (6) Manual (1)	Harrowing (2) Manual (1)	Harrowing (4) Manual (2)	Harrowing (7) Manual (2)
Plant protection	Endosulfon Acephate 2 sprays	Imidacloprid Monocrotophos 3 sprays	Acetamiprid Monocrtphos Endosulfon 3 sprays	Monocrtphos 1 spray	Monocrtphos 1 spray	Monocrtphos Imidacloprid Chlpyrphos
Yield (q/ha)	C: 17 -20 P: 2.0-2.5	C: 10-12 P: 1.0-1.75	C: 16-18 P: 1.5-2.0	C: 12.5-15 P: 2.5	C: 8.75-10 P: 1.25	C: 12.5 P: 2.0

C: cotton; P: pigeonpea

Regarding the analysis of livestock component, all the farmers use sorghum and pigeonpea residues for feeding the livestock (Table 15). In addition, green fodder from field bunds and crop fields was also used. The purchased feeding material includes paddy straw and groundnut cake. While there was no healthcare for cows and buffaloes, deworming was done once in 3 months for goats.

Table 15 : Analysis of existing farming systems: Livestock

Particulars	Name of the farmer			
	N Rajanna	B Kistu	S. Manku	K. Manthu
Type of livestock & numbers	Bullocks (2)	Bullocks (4) Cows (3) Buffalo (1)	Bullocks (2)	Bullocks (2) Cows (1) Goat (40)
Feeding material	Own: green fodder from bunds, P residues, grazing	Own: P & sorghum residues, grazing Purchase: groundnut cake	Own: P & sorghum residues Purchase: rice straw	Own: green fodder from bunds, P & sorghum residues, grazing Purchase: rice straw
Healthcare Output	Nil Draft 60 days/yr @ ₹ 300/day	Deworming Draft 60 days/yr @ ₹ 300/day Milk 1 L/day	Nil Draft 50-60 days/yr @ ₹ 300/day	Deworming for goats Draft 60 days/yr @ ₹ 300/day Goats 6-8/yr @ ₹ 2000-3000/goat

P: pigeonpea

D. Design of interventions in a participatory mode

After the analysis of existing farming systems, suitable interventions were identified in consultation with the farmers. Byerlee *et al.* (1982) have reported that 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. With this in view, we tried to focus on very few and most important interventions, which can maximize the farm productivity and profitability, in a way acceptable to selected farmers. Most of the farmers were of the opinion that weed management is labour-intensive and is not done at the right time due to shortage of labour. They were willing to use suitable herbicides for weed control. Similarly, imbalanced fertilizer use was another major constraint limiting crop productivity in both districts. Hence, the following interventions were identified for addressing the diagnosed constraints.

Y. Kothapalli, Anantapur

- T_1: Herbicide use (pendimethalin) for weed control
- T_2: Use of recommended NPK (20:17.5:41.5 kg NPK/ha) for groundnut + pigeonpea intercropping system
- T_3: Use of both herbicide and recommended NPK
- T_4: Farmers' practice (as in Table 12)

Seethagondhi cluster, Adilabad

- T_1: Herbicide use (pendimethalin) for weed control
- T_2: Use of recommended NPK (120:26.2:33.3 kg NPK/ha for cotton and 20:26.2:33.3 kg NPK/ha for pigeonpea) for cotton + pigeonpea intercropping system
- T_3: Use of both herbicide and recommended NPK
- T_4: Farmers' practice (as in Table 14)

Farmers managed the control plots as well as the non-experimental variables on the treatment plots. On-farm trials were conducted at selected 12 farmers' fields during 2010 and 2011. The technical and economic performance of technologies/ interventions as influenced by varied agro-climatic, socio-economic and management conditions were monitored. On-farm participatory action research was adopted as a broad methodological framework.

The large ruminant production system, primarily dairying was found to be complex in the cluster villages. Animals are basically local, non-descriptive breeds of very low genetic potential for milk production. Cows and buffaloes are generally reared on traditional practices with socio-economic considerations, mainly guided by available feed resources both at household level and grazing areas. Long calving interval, low productivity, high disease incidence, low technology uptake, insufficient market facilities, infrastructure and inability of the livestock holder to invest on livestock component were major constraints in both districts. Hence, the following livestock interventions were promoted in both clusters:

- Farmers in Anantapur cluster feed livestock with groundnut haulms in large quantity without mixing it with any other roughage. As a result, much of the protein available in groundnut haulms is not digested fully in the rumen of the animal. Hence, farmers were educated on the importance of mixing groundnut haulms with appropriate quantity of non-legume fodder.

Groundnut haulms and paddy straw stored together

- Chopping of sorghum stover, which is available in large quantity in Adilabad district, was promoted to reduce wastage (by at least 50%) and improve its digestibility.

Chaff cutter for drudgery reduction and efficient utilization of fodder

Chaffed crop residues as livestock feed

- Habituation of mineral mixture supplementation: Majority of the reproductive problems in livestock are basically due to deficiency of micro- and macro-minerals. This has been evidenced by the metabolic profile results of the study.

In order to meet the required micro- and macro-minerals for better production and reproduction, supplementation of mineral mixture (50 g per day per adult cattle or buffalo) was promoted in the villages.

- Conduct animal health camps in both districts to raise awareness among the farmers about the incidence of various diseases in livestock. 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 professionals and service providers (para workers) was established in reporting any epidemics and timely implementation of prophylaxis measures with community cooperation. Based on consultations, schedules were drawn for vaccinations and de-worming in cooperation with village organizations.

De-worming in small ruminants (Anantapur)

Animal health camp in Adilabad

In addition, all the selected farmers were encouraged to adopt improved composting techniques for efficient recycling of on-farm resources to reduce the dependence on chemicals or off-farm inputs, reduce cost of production and to improve the sustainability of farming systems.

Unlike other pesticides, farmers should exercise more caution in selecting the dose, method and time of herbicide application. Because, any deviation from the recommended practice may either damage the crop or result in poor weed control. Hence, before start of the sowing season, the selected farmers were trained regarding method of herbicide application, selection of suitable nozzle for herbicide application, calibration of sprayer etc. Further, demonstrations were also conducted on herbicide application.

Training and demonstration on herbicide application

Impact Assessment

Field trials were conducted at each of the selected farming systems (six each in Anantapur and Adilabad districts) during 2010 and 2011 to evaluate the performance of different interventions at farmers' fields. One acre field was selected in each of farmers' fields and it was divided into four blocks (1000 m^2 each). The three interventions (herbicide use, use of recommended fertilizers, and use of both herbicide and recommended fertilizers) were imposed in each of the block while farmers' practice was imposed in the fourth block. Pendimethalin was applied @ 0.75-1.0 kg a.i./ha on the same day of sowing using a knapsack sprayer fitted with flat-fan nozzle, in both Anantapur and Adilabad districts. The salient findings of the trials are presented in this chapter.

A. Crop productivity

First year (2010-11)

In Y. Kothapalli of Anantapur district, the sowing of groundnut + pigeonpea was done during second week of July, 2010. The rainfall received during the crop season is given in Table 16. Although the total rainfall during the crop season was about 257 mm, its distribution was uneven during the season. The rainfall during one month after crop sowing was better in terms of both amount and distribution. However, during the mid-season (1st September to 10 October), the crops suffered due to dry spells. As a result, the farmers harvested very low groundnut yields (Table 17) while pigeonpea failed completely.

Table 16 : Rainfall during crop season, 2010 in Pampanur cluster

Week	Rainfall (mm)	Week	Rainfall (mm)
12-18 Jul	6.7	6-12 Sep	6.9
19-25 Jul	6.1	13-19 Sep	4.6
26 Jul-01 Aug	18.8	20-26 Sep	-
2-8 Aug	4.2	27 Sep-3 Oct	-
9-15 Aug	21.7	4-10 Oct	1.45
16-22 Aug	38.2	11-17 Oct	26.5
23-29 Aug	13.7	18-24 Oct	67.2
30 Aug-5 Sep	4.5	25-31 Oct	36.2

Table 17 : Effect of different interventions on groundnut yield (kg/ha) in Y. Kothapalli

Name of the farmer	Intervention			
	Farmers' practice	Herbicide use (T_1)	Rec. NPK (T_2)	$T_1 + T_2$
B. Ravishankar	150	175	180	420
B. Ramakrishna	140	180	190	540
H. Peddanna	50	80	100	150
M. Kullayappa	160	140	180	680
K. Narasimhulu	140	160	230	550
Ramanjaneylu	200	300	350	680

The groundnut yield, averaged across six farmers' fields, was only 140 kg/ha in the plots under farmers' practices (Fig 7). Application of pendimethalin for weed control gave about 24% higher yield while use of recommended NPK gave 46% higher yield than farmers' practice. However, the yield increased by more than 3.5 times when both pendimethalin and recommended NPK were applied compared to farmers' practice.

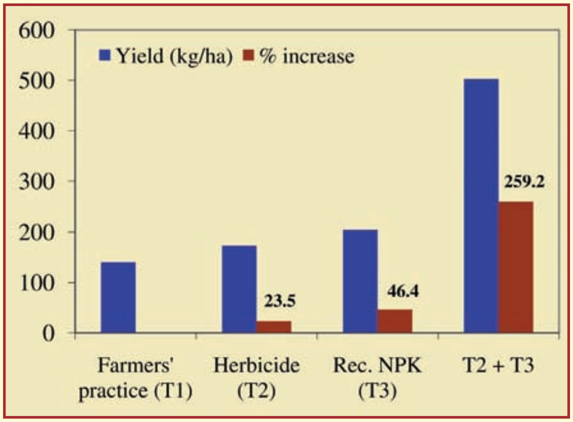

Fig. 7 : Response of groundnut to different management practices

Similarly in Seethagondhi cluster of Adilabad district, the interventions identified for addressing the diagnosed constraints were a) use of herbicide for weed control, b) use of recommended NPK, and c) use of both herbicide and recommended NPK in cotton + pigeon pea intercropping. These interventions were evaluated during *kharif* 2010 to test their performance at selected six farmers' fields. The crops received about 1145.8 mm rainfall in 36 rainy days during June-November, 2010 and there were no dry spells during the crop season (Table 18).

Table 18 : Rainfall pattern in Seethagondhi cluster during crop season, 2010

Particulars	Month						Total
	June	July	August	September	October	November	
Rainfall (mm)	156.4	385.5	365.3	189.6	39	10	1145.8
Rainy days	5.0	10.0	8.0	8.0	3	2	36.0

On average, the cotton equivalent yield (CEY) increased by 22.4% with the use of herbicide for weed control and 32.8% with application of recommended NPK compared to farmers' practice (Fig 8). Use of both herbicide and recommended NPK enhanced the CEY by 39.8% compared to farmers' practice.

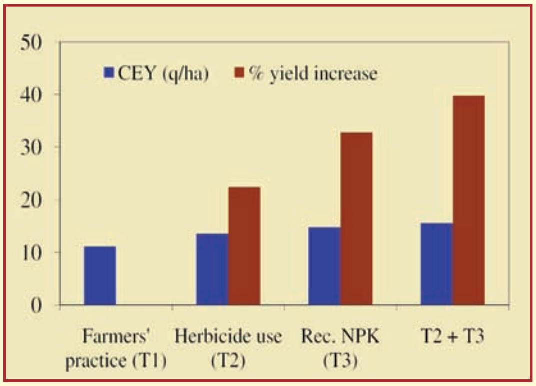

Fig. 8 : Effect of different interventions on cotton equivalent yield (CEY)

Herbicide use in cotton + pigeonpea

Studies on utilization of cotton and pigeonpea residues as livestock feed

The nutrient composition (Fig 9) of shredded cotton and pigeonpea stalks signify the value of these residues as feed for livestock along with other ingredients. The *in vitro* digestibility studies without or with 1% jaggery or 1% urea or 1% of the both (jaggery + urea) at 0, 1, 2 and 6 hours of treatment revealed the inevitability of addition of some easily fermentable carbohydrate and nitrogen sources and also incubation time on better digestibility of these stalks (Fig 10 and 11) as animal feed.

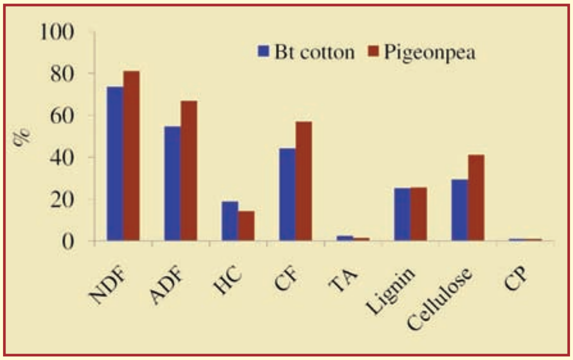

Fig. 9 : Nutrient composition of shredded cotton and pigeonpea stalks (NDF: Neutral detergent fibre; ADF: Acid detergent fibre; HC: Hemicellulose; CF: Crude fibre; TA: Total ash; CP: Crude protein)

Adilabad being cotton and pigeonpea growing area, the residues of these crops seem to be good by-products and could offer livestock producers an excellent feed stuff for drought survival of livestock or feeding during summer.

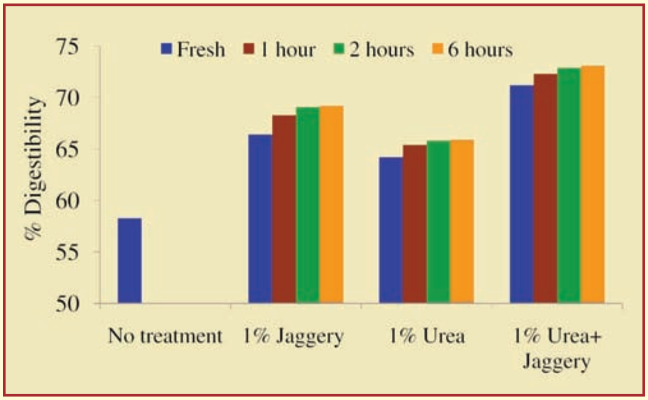

Fig. 10 : ***In vitro*** **digestibility of treated and untreated cotton stalks with different incubation times**

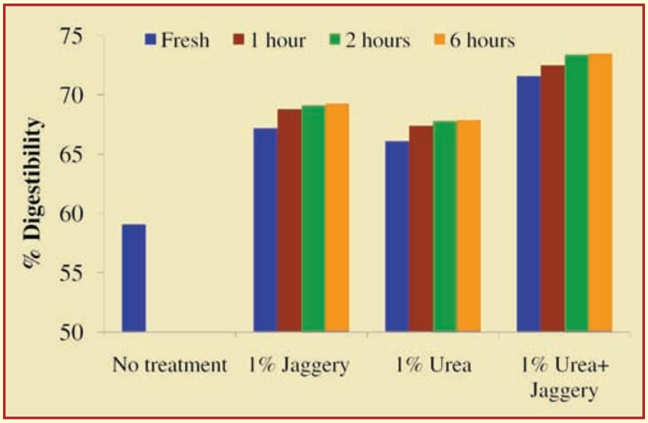

Fig. 11 : ***In vitro*** **digestibility of treated and untreated pigeonpea stalks with different incubation times**

Second year (2011-12)

In Y. Kothapalli of Anantapur, the groundnut + pigeonpea intercropping suffered heavily due to prolonged dry spells during flowering and pod formation. The crops received only 261 mm of rainfall in 12 rainy days during June-September, 2011 (Table 19). There was no rainfall after 16th September forcing the farmers to harvest intercropped pigeonpea at vegetative/flowering stage for feeding the livestock.

Table 19 : Rainfall pattern in Pampanur cluster during crop season, 2011

Particulars	Month						Total
	June	July	August	September	October	November	
Rainfall (mm)	121.5	73.5	37.0	29.0	0	0	261.0
Rainy days	5.0	3.0	3.0	1.0	0	0	12.0

The farmers harvested very low groundnut yields while pigeonpea failed completely (Table 20). The groundnut yield, averaged across six farmers' fields, was only 248 kg/ha in the plots under farmers' practices (Fig 12). Application of pendimethalin for weed control gave about 20% higher yield while use of recommended NPK gave 53% higher yield than farmers' practice. However, the yield increased by more than 2 times when both pendimethalin and recommended NPK were applied compared to farmers' practice.

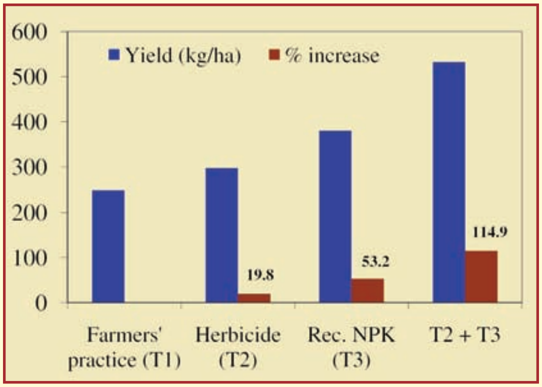

Fig. 12 : Response of groundnut to different management practices

Table 20 : Effect of different interventions on groundnut yield (kg/ha) in Y. Kothapalli

Name of the farmer	Intervention			
	Farmers' practice	Herbicide use (T_1)	Rec. NPK (T_2)	$T_1 + T_2$
B. Ravishankar	330	360	520	590
B. Ramakrishna	320	400	490	540
H. Peddanna	260	300	320	620
M. Kullayappa	100	150	200	300
K. Narasimhulu	290	330	400	480
Ramanjaneylu	190	240	350	470

On average, groundnut pod yield under farmers' practice was 194 kg/ha (Fig 13). The increase in groundnut yields due to different interventions was 21.1% with herbicide use, 51% with use of recommended NPK, and 155% (5.2 q/ha) with use of both herbicide for weed control and recommended NPK compared with farmers' practice.

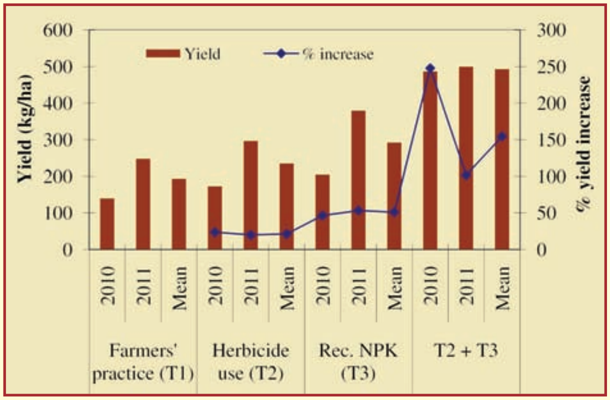

Fig. 13 : Response of groundnut to different management practices in farmers' fields of Y. Kothapalli, Anantapur

In Seethagondhi cluster of Adilabad district, the rainfall during later period of crop season was almost nil (Table 21) resulting in very low yields of both cotton and pigeonpea. The amount of rainfall and number of rainy days during crop season, 2011 were 47.2 and 47% lower compared to that of 2010. As a result, both cotton and pigeonpea yields were reduced by about 60% in 2011 compared to that of 2010.

Table 21 : Rainfall pattern in Seethagondhi cluster during crop season, 2011

Particulars	Month						Total
	June	July	August	September	October	November	
Rainfall (mm)	44.5	266.0	240.0	54.0	0	0	604.5
Rainy days	3.0	8.0	7.0	1.0	0	0	19.0

On average, the CEY increased by 7% with the use of herbicide for weed control and 18% with application of recommended NPK compared to farmers' practice (Fig 14). Use of both herbicide and recommended NPK enhanced the CEY by 27% compared to farmers' practice.

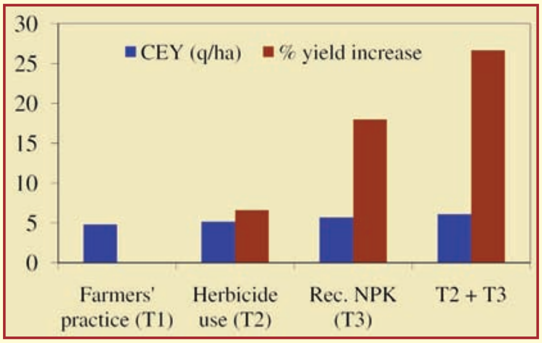

Fig. 14 : Response of cotton + pigeonpea to different management practices

In this cluster, averaged across six farmers' fields and two crop seasons, the CEY of cotton + pigeonpea intercropping was 7.99 q/ha with farmers' practice (Fig 15). All the management practices gave higher CEY compared to farmers' practice. The CEY increased by 17.5% due to herbicide use for weed control, 28.3% with application of recommended NPK, and 35.8% with use of both herbicide and recommended NPK compared to farmers' practice.

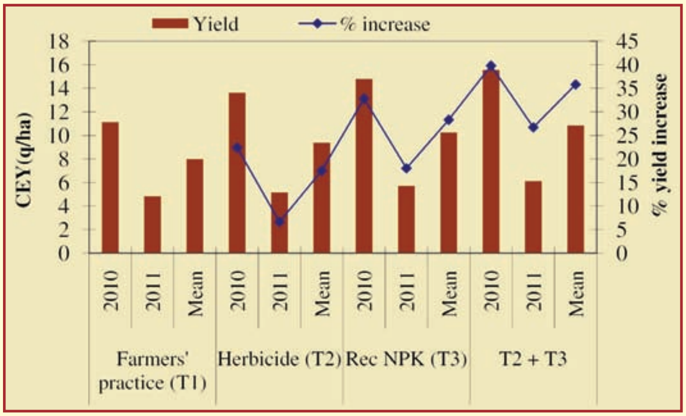

Fig. 15 : Response of cotton + pigeonpea intercropping to different management practices in Seethagondhi cluster, Adilabad

B. Resource flow between different components of farming systems

In Y. Kothapalli of Adilabad district, the crop component (groundnut + pigeonpea intercropping) contributed about 1.91 to 2.07 tons of livestock feed, comprising groundnut haulms, pigeonpea stalks and green fodder from crop field and bunds, in the farming systems of marginal farmers (Fig 16 & 17). Most of the intercropped pigeonpea was harvested as green fodder due to drought in both years. The livestock component produced about 4.2 to 12.8 tons of manure/year which was used for manuring crop fields. However, the contribution of crop component to total income was negative (₹ -1824 to -2865) due to poor yields of groundnut and complete failure of pigeonpea as a result of prolonged dry spells during crop season in both years. The employment generation ranged from 243 to 550 man-days/year. Similarly, the crop component contributed 2.65 to 3.12 tons of livestock feed, and about 4.5 to 10.7 tons of manure was generated from livestock component in the farming systems of small farmers (Fig 18 & 19). The contribution of crop component to total income was negative (-8.8 to -93.7%). Integrated farming system involving crop (2.0 ha) + dairy (2 cows) + small ruminants (100 sheep) generated the highest employment (725 man-days/year) compared to other farming systems.

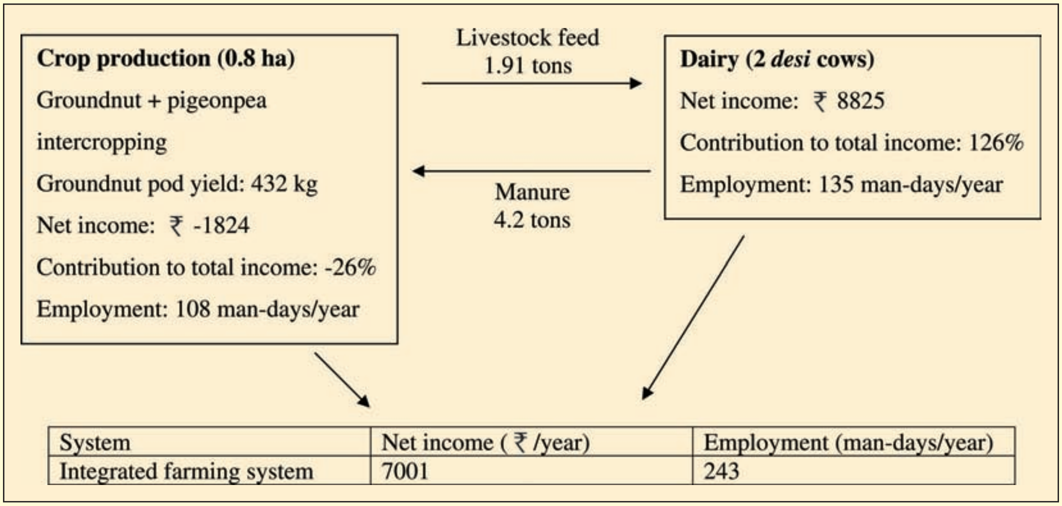

Fig. 16 : Resource flow in integrated farming system (crop + dairy) of a marginal farmer (M. Kullayappa) in Y. Kothapalli, Anantapur

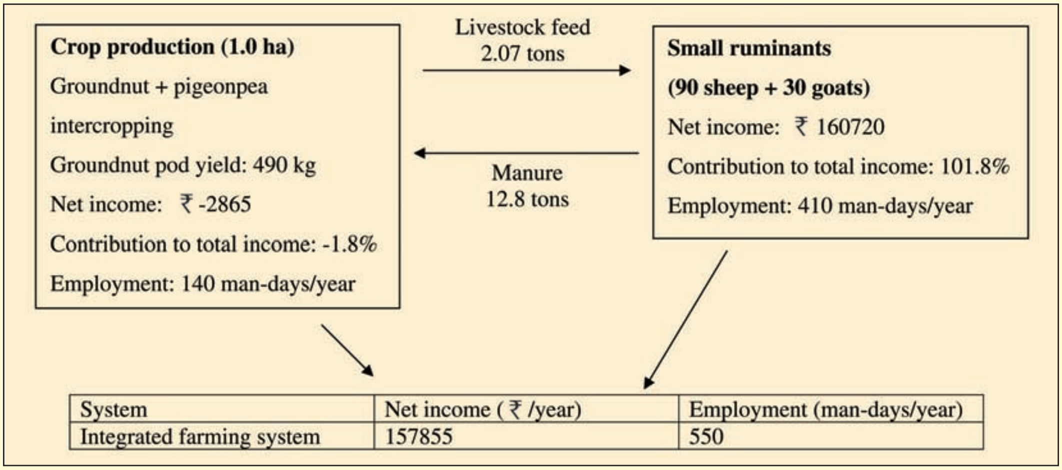

Fig. 17 : Resource flow in integrated farming system (crop + small ruminants) of a marginal farmer (Ramanjaneyulu) in Y. Kothapalli, Anantapur

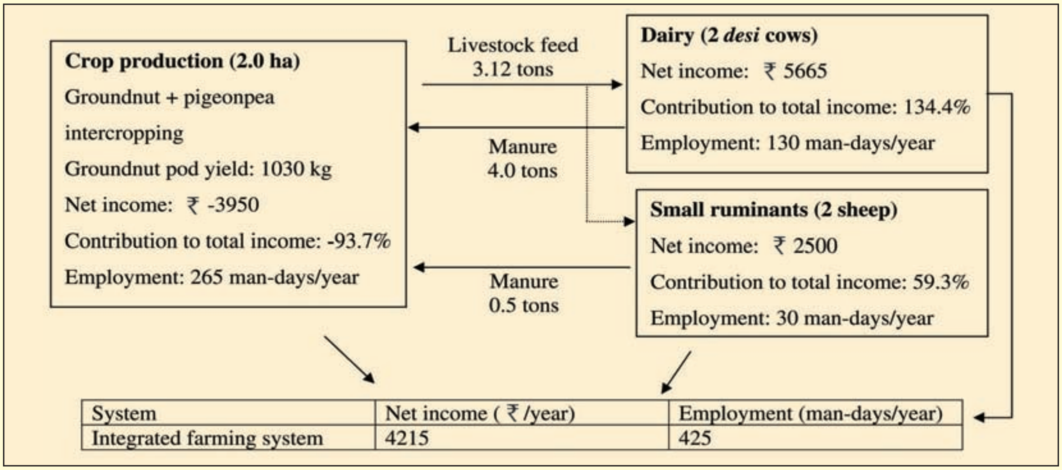

Fig. 18 : Resource flow in integrated farming system (crop + dairy + small ruminants) of a small farmer (Narasimhulu) in Y. Kothapalli, Anantapur

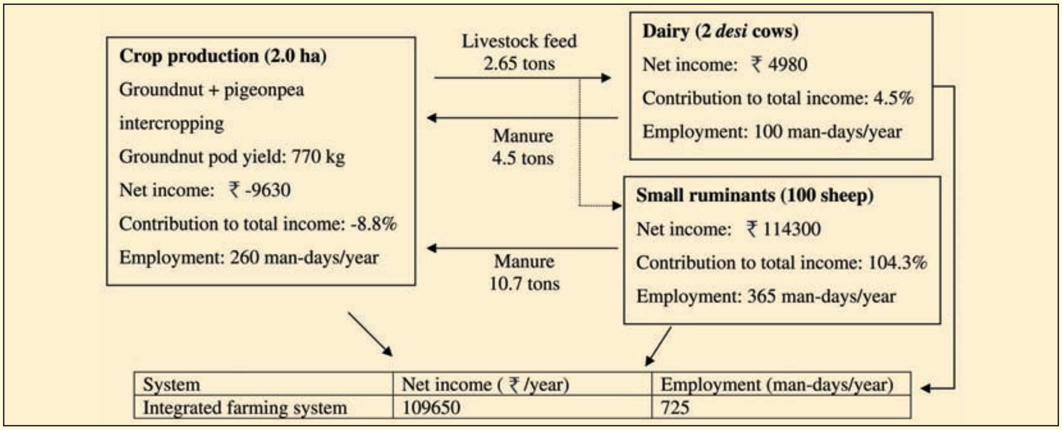

Fig. 19 : Resource flow in integrated farming system (crop + dairy + small ruminants) of a small farmer (B. Ramakrishna) in Y. Kothapalli, Anantapur

In Seethagondhi cluster of Adilabad district, the cotton equivalent yield was 921 to 1115 kg/ha and contributed 35 to 47.3% to total net income of marginal farmers. In addition, about 1.5 to 1.7 tons of livestock feed (pigeonpea stalks and green fodder from crop field and bunds) was harvested from crop component in farming systems of marginal farmers (Fig 20 & 21). The major share of net income (52.7 to 58.6%) was from livestock component in addition to generation of about 4.4 to 7.5 tons of manure. among the farming systems of marginal farmers, the employment generation was highest (482 man-days/year) with integrated farming system involving crop + dairy + draught animals. Among the farming systems of small

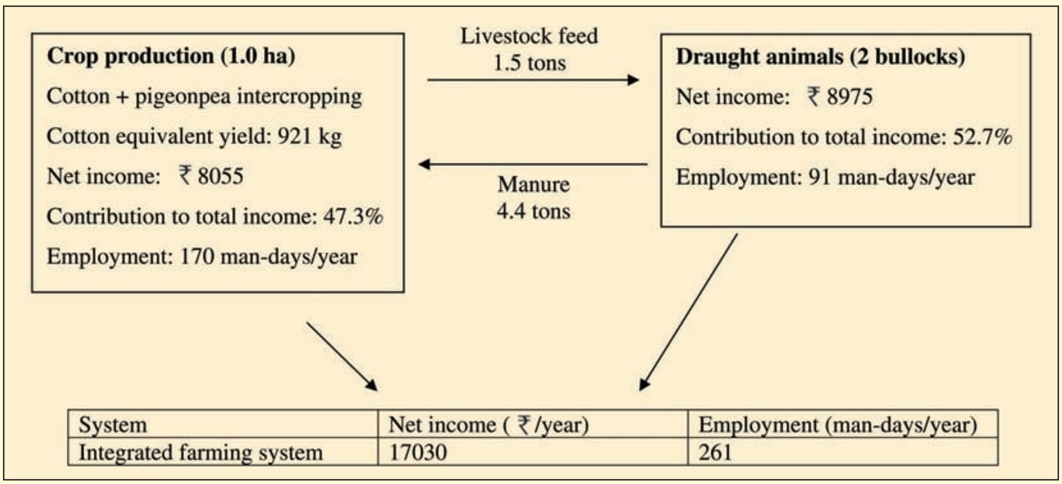

Fig. 20 : Resource flow in integrated farming system (crop + draught animals) of a marginal farmer (N. Rajanna) in Seethagondhi, Adilabad

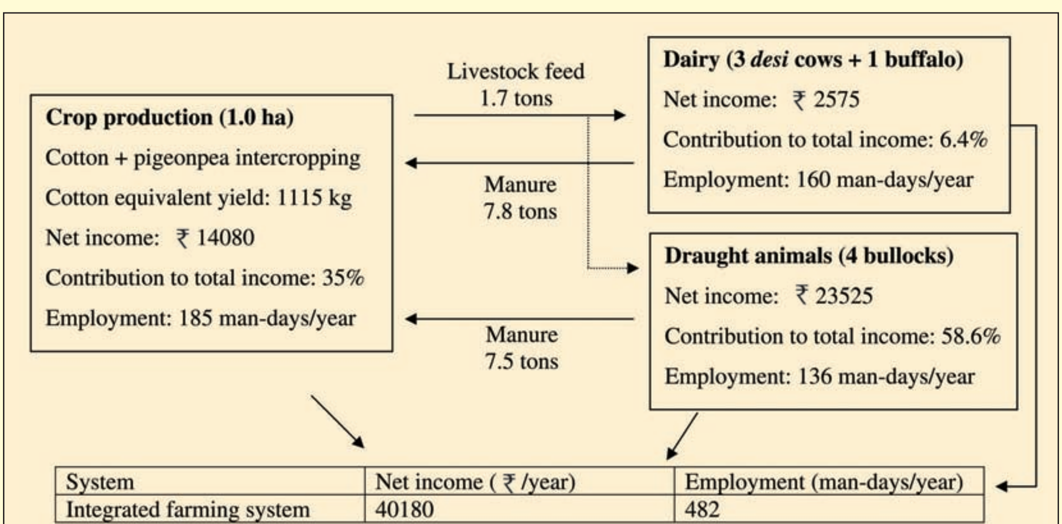

Fig. 21 : Resource flow in integrated farming system (crop + dairy + draught animals) of a marginal farmer (B. Kistu) in Seethagondhi, Adilabad

farmers, the crop component produced cotton equivalent yield of 1882 to 2390 kg, and contributed 2.6 to 2.8 tons of livestock feed and 32.7 to 56% to total net income (Fig 22 & 23). The livestock component generated about 4.4 to 10.4 tons of manure which was used for manuring crop fields. Integrated farming system involving crop (2 ha) + draught animals (2 bullocks) + dairy (1 cow) + small ruminants (40 goats) generated the highest employment (672 man-days/year) compared to other farming systems.

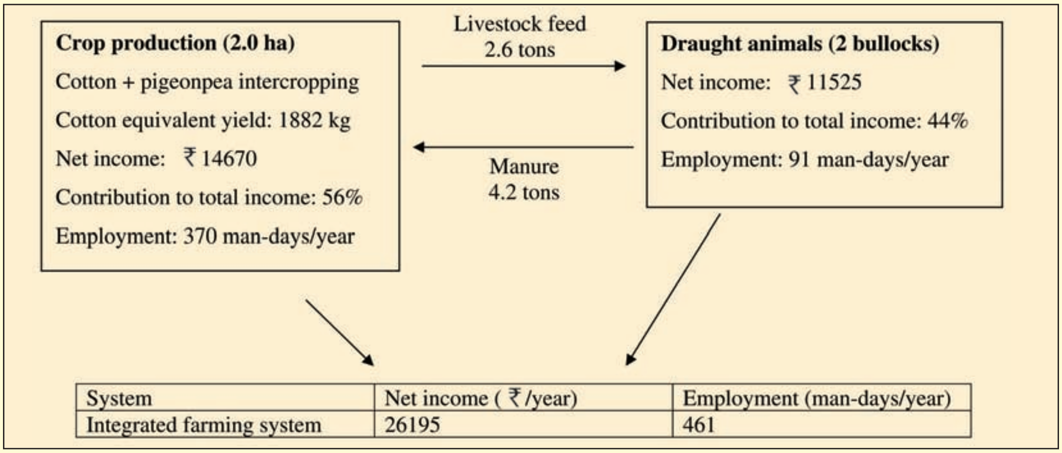

Fig. 22 : Resource flow in integrated farming system (crop + draught animals) of a small farmer (S. Manku) in P. Malkapur, Adilabad

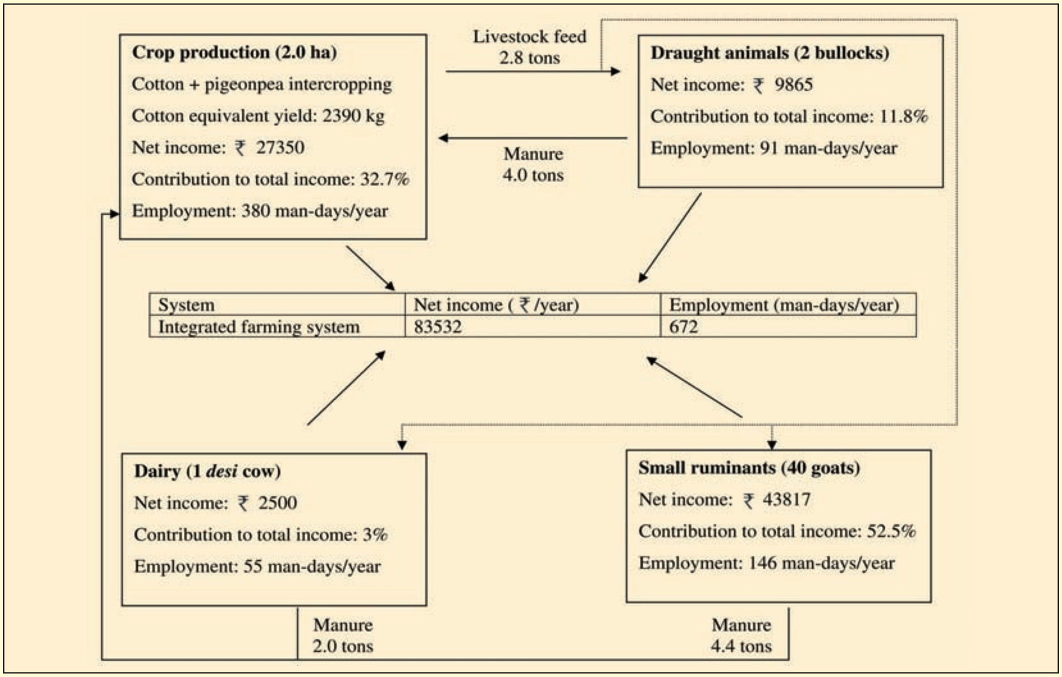

Fig. 23 : Resource flow in integrated farming system (crop + draught animals + dairy + small ruminants) of a small farmer (K. Manthu) in Seethagondhi, Adilabad

C. Economics of different farming systems

Y. Kothapalli, Anantapur

The groundnut yield, averaged across six farmers' fields and two years, ranged from 1.9 to 5.2 q/ha under different treatments. The cost of cultivation was ₹ 15900/ha with farmers' practice. However, herbicide use for weed control reduced cost of cultivation by ₹ 1300/ha. It was highest (₹ 16500/ha) with use of recommended NPK (Fig 24). The gross returns ranged from ₹ 7000/ha with farmers' practice to ₹ 15100/ha with use of both herbicide and recommended NPK. However, the net returns from groundnut + pigeonpea intercropping system were negative in all the treatments (₹ -190 to -8800/ha) due to complete failure of pigeonpea and poor groundnut yields in both years.

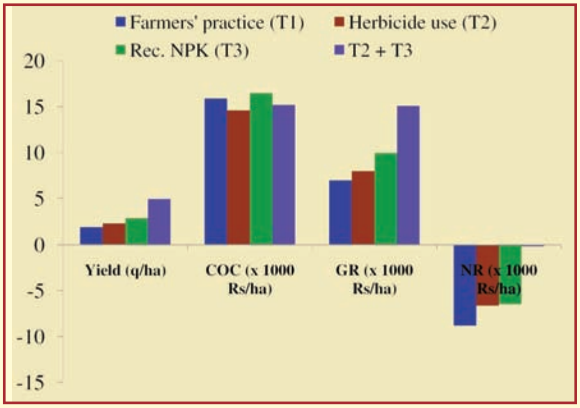

Fig. 24 : Economics of groundnut + pigeonpea cultivation in Y. Kothapalli, Annatapur (mean of 2010 and 2011); COC: cost of cultivation; GR: gross return; NR: net return

Among the livestock components in Y. Kothapalli, the expenditure involved for livestock rearing ranged from ₹ 9475/year for two *desi* cows to ₹ 49200/year for 2 *desi* cows and 100 sheep (Table 22). Higher net income (₹ 160720/year) was realized from sheep (90) and goat (30) followed by rearing of 2 *desi* cows and 100 sheep (₹ 119280/year).

Table 22 : Economics (₹/year) of livestock rearing in Y. Kothapalli, Anantapur

Particulars	Name of the farmer			
	M. Kullayappa	Narasimhulu	Ramanjaneylu	B. Ramakrishna
Livestock	*Desi* cows - 2	*Desi* cows - 2 Sheep - 2	Sheep – 90 Goat - 30	*Desi* cows - 2 Sheep - 100
Gross income	18300	17640	206000	168480
Expenditure	9475	9475	45280	49200
Net income	8825	8165	160720	119280

The economics of different farming system models were worked out for marginal and small holdings in Y. Kothapalli. Both marginal and small farmers having crop production alone incurred losses due to complete failure of pigeonpea and poor groundnut yields as a result of drought in both years (2010 and 2011). The monetary loss ranged from ₹ 5268/year for a marginal farmer (0.8 ha) to ₹ 12299/year for a small farmer (1.6 ha). Integration of livestock rearing with crop production gave higher net returns/year compared to crop production alone for both marginal and small farmers (Table 23). Further, improved farming systems gave higher net returns/year compared to existing farming systems involving farmers' practice. Interestingly, marginal farmers got higher returns/year than small farmers due to: a) crop failure due to drought resulting in more losses from crop component, and b) more reliance of marginal farmers on livestock component.

Table 23 : Economics of different farming system modules in Y. Kothapalli, Anantapur

Farmer	Area (ha)	Cropping system	Livestock	Net income (₹/year)	
				Farmers' practice	Improved FS
Marginal farmers					
H. Peddanna	0.8	Groundnut + pigeonpea	-	-5268	1316
M. Kullayappa	0.8	Groundnut + pigeonpea	Cows (2)	505	7001
Ramanjaneyulu	1.0	Groundnut + pigeonpea	Sheep (90) Goat (30)	148445	157855
Small farmers					
B. Ravishankar	1.6	Groundnut + pigeonpea	-	-12299	-480
Narasimhulu	2.0	Groundnut + pigeonpea	Cows (2) Sheep (2)	-13185	4215
B. Ramakrishna	2.0	Groundnut + pigeonpea	Cows (2) Sheep (100)	94520	109650

Figures in parentheses are numbers

Among the farming systems of marginal farmers, integrated farming system involving crop production (groundnut + pigeonpea intercropping) and rearing of small ruminants (90 sheep and 30 goats) was found better with a net return of ₹ 157855/year compared to other farming systems. Similarly, among the three farming systems of small farmers, integrated farming system involving crop production (groundnut + pigeonpea intercropping) and livestock rearing (2 *desi* cows and 100 sheep) gave higher net return (₹ 109650/year) compared to other farming systems.

Seethagondhi cluster, Adilabad

The CEY, averaged across six farmers' fields and two years, ranged from 7.9 to 10.1 q/ha under different management practices. The cost of cultivation under farmers' practice was ₹ 21200/ha. It was lowest (₹ 19500/ha) with the treatment involving use of pendimethalin for weed control. Similarly, the cost of cultivation was less (₹ 19900/ha) with use of both herbicide and recommended NPK. However, use of recommended NPK alone resulted in higher cost of cultivation (₹ 21700/ha) compared to farmers' practice (Fig 25). Both gross and net return from cotton + pigeonpea intercropping were less (₹ 23800 and ₹ 2600/ha, respectively) under farmers' practice compared to improved management practices. Use of herbicide for weed control coupled with application of recommended NPK gave higher gross return (₹ 30300/ha) and net return (₹ 10300/ha) compared to other management practices.

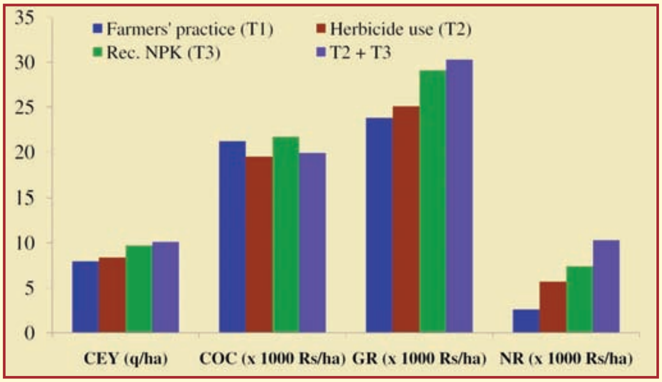

Fig. 25 : Economics of cotton + pigeonpea cultivation as affected by different agronomic practices (mean of 2010 and 2011); COC: cost of cultivation; GR: gross return; NR: net return

Among the livestock components in Adilabad, the expenditure involved for rearing livestock ranged from ₹ 6475/year for two bullocks to ₹ 31393/year for maintaining bullocks (2), *desi* cow (1) and goat (40). The net income was highest (₹ 56182/year) due to rearing of both bovine (bullocks and *desi* cow) and small ruminants (goat). Rearing of a pair of bullocks gave a net income of ₹ 9025-11525/year through their hiring for draught purposes (Table 24).

Table 24 : Income (₹/year) from livestock component in Seethagondhi cluster, Adilabad (mean of 2 years)

Particulars	Name of the farmer			
	N. Rajanna	S. Manku	B. Kistu	K. Manthu
Livestock	Bullocks- 2	Bullocks- 2	Bullocks- 4 *Desi* cows-3 Buffalo-1	Bullocks- 2 *Desi* cow-1 Goat-40
Gross income	18000	18000	40575	87575
Expenditure	8975	6475	14475	31393
Net income	9025	11525	26100	56182

The economics of different farming system models were worked out for marginal and small holdings in Seethgondhi cluster of Adilabad. Improved farming systems gave higher net returns/year compared to existing farming systems involving farmers' practice for both marginal and small farmers. Further, farmers having crop production alone realized less income/year compared to those having integrated farming systems (Table 25).

Table 25 : Economics of different farming system modules in Seethagondhi cluster, Adilabad

Farmer	Area (ha)	Cropping system	Livestock	Net income (₹/year)	
				Farmers' practice	Improved FS
Marginal farmers					
N. Dharmaji	1.0	Cotton + pigeonpea	-	1100	10125
N. Rajanna	1.0	Cotton + pigeonpea	Bullocks (2)	10750	17080
B. Kistu	1.0	Cotton + pigeonpea	Bullocks (4) *Desi* cows (3) Buffaloe (1)	30580	40180
Small farmers					
M. Mothiram	2.0	Cotton + pigeonpea	-	9186	17460
S. Manku	2.0	Cotton + pigeonpea	Bullocks (2)	10755	26195
K. Manthu	2.0	Cotton + pigeonpea	Bullocks (2) *Desi* cow (1) Goats (40)	64502	83532

Figures in parentheses are numbers

Among the farming systems of marginal farmers, integrated farming system involving crop production (cotton + pigeonpea intercropping) and livestock rearing (4 bullocks, 3 *desi* cows and 1 buffalo) was found better with a net return of ₹ 40180/year compared to other farming systems. Similarly, among the three farming systems of small farmers, integrated farming system involving crop production (cotton + pigeonpea intercropping) and livestock rearing (2 bullocks, 1 *desi* cow and 40 goats) gave higher net return (₹ 83532/year) compared to other farming systems.

Operationalization of the Rainfed Farming Systems

In rainfed regions, risk resilient approaches like farming systems approach play a greater role for enhancing the farm productivity and income, and further the livelihoods of small and marginal farmers. Therefore, it is necessary to characterize the dominant traditional farming systems for improvement and to develop economically viable and location-specific farming system models for different categories of farmers in general and small and marginal in particular. Further, already developed integrated farming system models need to be validated and replicated in respective areas. However, small and marginal farmers with capital scarcity, risk avoidance objectives, and a cautious learning process rarely make drastic changes in their farming systems. Rather, they proceed in a step-wise manner to adopt one and sometimes two new inputs or practices at a time (Byerlee *et al.*,1982). Hence, an efficient research strategy should focus on a very few-perhaps two to four-research opportunities that offer potential to increase resource productivity in a way acceptable to farmers. Furthermore, for successful and sustainable adoption of different multi-enterprise farming systems in rainfed areas, the following activities should be undertaken by researchers, extension personnel and policy makers (adapted from Venkateswarlu *et al.*, 2012):

- Characterization of existing farming systems for better understanding of productivity and constraints.
- Emphasis on improving the existing farming systems in a phased manner rather than recommending drastic changes to the traditional farming systems.
- Farming System Research through system modelling: Understanding of farming systems, prioritization of enterprises, risk assessment, development of whole farm models etc.
- Rainwater harvesting and its efficient utilization should be promoted on a priority basis. Efforts should be made to provide incentives to farmers owning groundwater sources to share water with other rainfed farmers to provide protective irrigation during *kharif* season. Similarly, pooling/leasing of bore wells or taking over rights on bore wells (at least for *kharif* season) may be possible if packaged with right incentives. Subsidized energy or renewable energy systems may also be used as an incentive for water sharing and social regulation.

The rainwater management interventions either *in situ* or *ex situ* may be converged with Integrated Watershed Management Programme (IWMP), Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS). National/State Horticulture Mission (NHM/SHM) and relevant central/state govt. programmes.

- The supply of inputs of various components including improved seed, fertilizers, improved breeds of livestock, seed/fingerlings of fish, farm implements etc. may be converged with the relevant programmes like mega seed project of GoI, National Food Security Mission (NFSM), Integrated Scheme on Oilseeds, Pulses, Oilpalm and Maize (ISOPOM), subsidy schemes on farm implements etc.

- Community level seed banks with buffer stocks of seed material of diverse crops appropriate for the village/area need to be maintained. These seed banks should be considered as a necessary common infrastructure particularly for rainfed areas supported by the government on a regular basis. Seed banks should be controlled and maintained by organized farmer groups.

- Programmes promoting farming systems should have a built in component of improving soil organic matter. Composting methods with high biomass-to-dung ratio should be targeted to overcome the limitation of availability of dung. A regular subsidised transport (preferably through bullock carts) for manures to the distant agricultural fields should be provided. There is scope for integrating this service with MNREGS. Further, provision of a power operated biomass-shredder as a common utility at the village level would help in cutting the biomass for faster decomposition in manure pits. Such a facility would also increase the fodder supply many fold by reducing wastage and chaffing the hard stumps.

- Isolated patches of forest land under ownership of the forest department within the villages / watersheds needs special consideration. Regenerating these lands with people's participation for providing biomass for livestock and livelihoods should be the core purpose of managing these forest areas. The community land in the villages, which is accessible for better use, must be used for productive purpose. Therefore, adoption of concepts like social forestry, water harvesting and recycling, fishery and stall-bed feeding to the animals (goatry/piggery) will add to the profit margin with other numerous indirect benefits of employment and to improve the ecology of the area.

- A specific and viable system has to be put in place for developing feed and fodder banks at strategic places in the rainfed areas. Biomass intensification specially targeting the small ruminants should receive highest priority; much of the shrub/tree-biomass for goats and sheep can be enhanced easily with little effort/resources. Development of cost-effective technologies to improve the nutritive quality of crop residues would ensure efficient utilization of existing feed resources. Similarly, adequate investments should be made on community-managed livestock health care systems with strong linkages with animal husbandry departments.

- Post-harvest 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. With the growth in Self Help Group (SHG) movement across the country, options for collective marketing and value addition are opening up. This unique opportunity should be harnessed by dovetailing required processing infrastructure and technologies. A special area based planning exercise for mapping the requirements of processing/value adding infrastructure need to be taken up. The infrastructure should include common storage places for seeds and other agriculture inputs and agriculture produce within the village and at the bulking points.
- Establishment of agro-service centers in the villages can save the cost of inputs and can also get timely farm advisory services for higher profitability. An effective rural knowledge society and ICT system involving various stakeholders; farmers, development agents and agencies, knowledge generators and distributors (universities, and public and private institutions) should be established for bridging the information and knowledge gaps on production and marketing of different commodities.
- Formation of commodity groups and self-help groups of farm women can help to promote off-season income generation activities which lead to livelihood improvement. Imparting training in emerging skills and crafts as per diversified demands in the market will go a long way for realizing all inclusiveness of landless, asset-less, small and marginal farmers.
- 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.
- Greater emphasis has to be laid down by the extension department for upscaling exposure visits, trainings and demonstration of location-specific farming system models, for creating greater awareness and capacity building of the farming community and also the stakeholders from line departments.

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भारतीय कृषि अनुसंधान परिषद

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Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad – 500 059, Andhra Pradesh
Phone : 040-24530177, Fax : 040-24531802
Email: director@crida.in Website: www.crida.in