RAINFED AGRICULTURE: STRATEGIES FOR LIVELIHOOD ENHANCEMENT

B. Venkateswarlu, Director, Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad – 500 059

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

References

CRIDA-IVLP 1996. Progress Report of Technology Assessment and Refinement through Institute Village Linkage Program, CRIDA, Hyderabad.
CRIDA-ORP 1997. Progress Report of Operation Research Projects of All India Co-ordinated Research Project on Dryland Agriculture. Pp: 519
CRIDA-QRT report, 1996. Report of the third Quinquennial review team on Dryland Agriculture, CRIDA, Hyderabad submitting during November, 1996. pp: 55-61
CRIDA Vision 2020, 1997, Perspective Plan of the Central Research Institute for Dryland Agriculture, Hyderabad, India.

Government of India 1994. Agricultural Statistics at a Glance. Ministry of Agriculture, Government of India, New Delhi, pp.140.

Katyal, J.C. and Das, S.K. 1993. Transfer of Agricultural Technology in Rainfed Regions. Fertilizer News 38(4): 23-30

Katyal J.C. and Das S.K.1994. Rainwater Conservation for Sustainable Agriculture. Indian Farming. Pp: 65-70.

Katyal, J.C., Das, S.K., Korwar, G.R. and Osman. M 1994. Technology for Mitigation stresses: Alternate land uses. Stressed Ecosystems and Sustainable Agriculture eds. Pp. 291-305 (Virmani S.M., Katyal J.C., Eswaran H and Abrol I.P eds. Publisher)

Mayande V.M and Katyal J.C.1996. Low Cost Improved Seeding Implements for Rainfed Agriculture. Technical Bulletin. 3, CRIDA, Hyderabad p. 26.

Singh, R.P., 1988. Dryland Agriculture Research in India. Pages 136-164 in 40 years of Agricultural Research and Education in India, New Delhi, India : ICAR.

Singh .H.P., Sharma , K.L., Venkateswarlu B and Neelaveni .K., 1998. Prospects of Indian Agriculture with Special Reference to Nutrient Management under Rainfed Ecosystems. National Workshop on Long Term Soil Fertility Management through Integrated Plant Nutrient Supply System. IISS, Bhopal, April 2-4.

Singh R.P. and Das S.K. 1984. Timeliness and Precision Key Factors in Dryland Agriculture. Project Bulletin 9, CRIDA, Hyderabad , pp, 1-29.

Venkateswarlu. J, 1986. Efficient Resource Management for Dryland. In: 15 Years of Dryland Agriculture Research, Souvenir, CRIDA, Hyderabad, pp. 42-58.

Vishnumurthy, T. 1995. Analysis of Constraints in Transfer of Dryland Technology: An Operational Research Experience. Research for Rainfed Farming Process. Joint ICAR-ODA Workshop held at CRID, Hyderabad, 11-14 Sept., 1995, pp 33-44.

SUSTAINABLE RURAL LIVELIHOODS: NAIP EXPERIENCES

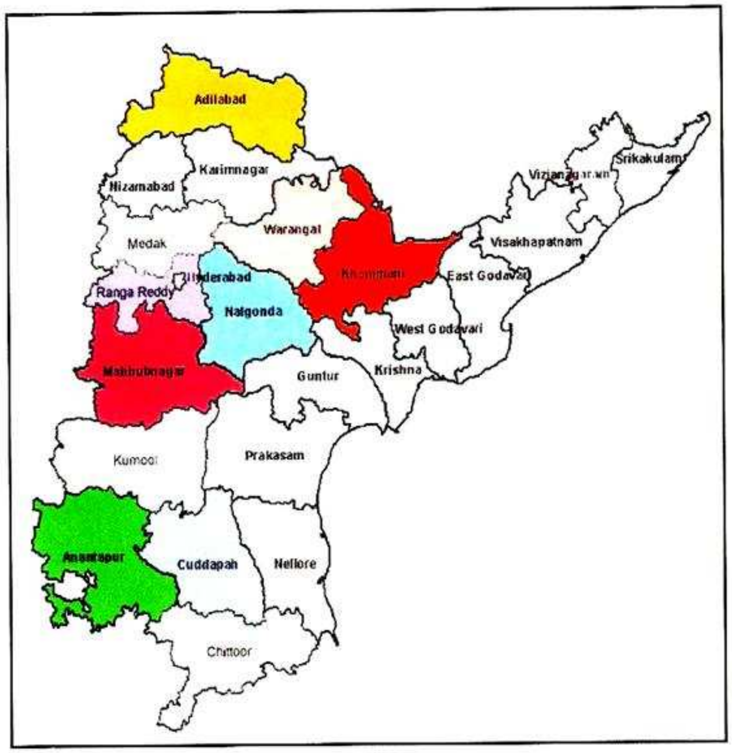
Dr. Sreenath Dixit, Principal Scientist, Central Research Institute of Dryland Agriculture, Santoshnagar, Hyderabad – 500059.

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.

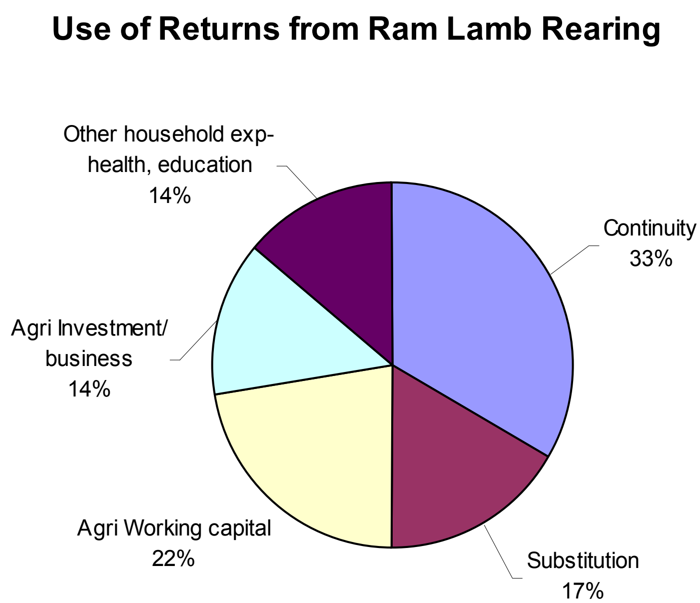
During the II Phase, the households were encouraged to avail insurance for their animals in convergence with the Department of Animal Husbandry through its *Pasu Kranti Scheme*. One year's experience has shown that sustainability is directly linked to opportunities for lucrative market. Therefore, promoting 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



WATERSHED PLUS APPROACH AS PLATFORM FOR LIVELIHOOD ENHANCEMENT

Mohammed Osman, Principal Scientist (Agronomy) ,Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad - 500 059

1.0 Introduction

India, which has an agrarian economy, is blessed with a monsoon regime that is more or less regular in its cycle of onset, spread and withdrawal over the country. The southwest monsoon experienced by India is a part of the larger Asia monsoon circulation and provides a major portion of the annual rainfall of the country. India on an annual basis receives about 4 x 10^3 km^3 (400 M ha m) of precipitation (FAI, 1993) out of the 5 x 10^5 km^3 precipitation received globally (Lal, 1994). India's share, thus, is about one percent of the global precipitation. Tamil Nadu, parts of Andhra Pradesh, Karnataka and Kerala, also receive rainfall during northeast monsoon period. The rainwater availability in different monsoon periods (**Table 1**) indicates that major contribution is from the southwest monsoon (74%). In comparison, the contribution is less from northeast monsoon (10%). However, this is the main source of water availability to the extreme south and southeastern parts of Peninsular India. The rainfall during winter (3%) and pre-monsoon (13%) season is also significant and helps in some of the agricultural operations in Northern India.

Table 1 Rainwater availability: India

Season/Period	M ha m*	Percent
Winter (Jan-Feb)	12	2.6
Pre-monsoon (Mar-May)	52	13.3
Southwest monsoon (Jun-Sep)	296	73.7
Northeast monsoon (Oct-Dec)	40	10.4
Total for the year	400	100

* Million hectare metres [Source: FAI, 1993]

The distribution of mean annual rainfall has direct relationship with (i) net sown area and (ii) percent of gross area. Obviously, net sown area has increased from as low as 4.0 m. ha in case of annual rainfall of less than 300 mm to as high as 73.1 m. ha with more than

1000 mm. Similarly, percent of gross area has ranged between 2.8 and 51.1 in case of mean annual rainfall of less than 300 mm and >1000 mm, respectively (**Table 2**).

Table 2 Distribution of mean annual rainfall

Rainfall (mm)	Percent of gross area	Net sown area (m. ha)
Very low <300	2.8	4.0
Low 300-500	6.8	9.7
Moderate 500 – 1000	32.7	46.7
High > 1000	51.1	73.1
Data not available	6.6	N.A.

Source: Mandal and Mandal (1999)

In order to achieve overall development of agriculture in the country, it is essential to bridge the yield gaps, enhance the productivity and profitability, minimize risk and improve the livelihoods of millions of people dependent on rainfed agriculture. Although a large number of technologies have been generated by the NARS, their impact on the livelihoods of those living in rainfed regions has been limited and the recent slow down in agricultural growth has resulted in further widespread distress in this sector. The Govt. of India has accorded due priority to agriculture, however, the "green revolution" era by-passed rainfed agriculture.

Rainfed Farming in Relation to Rainfall

Based on the resource availability, broad guidelines for natural resource management on watershed mode are given below:

For regions with rainfall less than 500mm: Priority should be given for ensuring drinking water facility even during lean season. In *situ* conservation coupled with farm/field boundaries should be given emphasis. Deep soils only should be encouraged for cultivation. Livestock based farming system should be encouraged. Fodder needs can be met by growing grasses in soils with low to medium soil depth. Runoff harvesting can be possible only if watershed receives runoff from upstream areas.

Rainfall (500-700mm): Crops can be grown in medium to deep soils with high available water content. Runoff harvesting could be possible in few cases for critical/ supplemental irrigation. Horticulture can be promoted to a larger scale. Land capability based land use planning with emphasis on alternate land use need to be promoted.

Rainfall (700-1100 mm): Various farming systems involving cropping and livestock can be promoted. Runoff harvesting is possible on small farms also. *In-situ* conservation with water harvesting for supplemental irrigation can be planned within watershed. In few cases, residual moisture within fields or pre sowing irrigation for *rabi* crop is also possible and there is a need to explore the possibilities based on location specificity.

Rainfall (>1100 mm): Areas receiving more than 1100 mm rainfall through South West monsoon, integrated farming system with fisheries in medium to low lands of rainfed rice can be encouraged.

2.0 Watershed as Platform for Rainfed Agricultural Activities

Water is the driver of nature and watershed programs are implemented across the country in rainfed areas to boost productivity and profitability. These programmes are being operated on area basis. In the past, there have been different guidelines adopted by different ministries (MoRD, MoA, MoEF). To overcome this constraint, the National Rainfed Area Authority (NRAA) has come up with new common guidelines w.e.f, 1st April 2008. The details on area treated and the expenditure incurred on these watershed programmes till the end of 10th Plan period are given in **Table 3** (Sharda et.al., 2008). So far, the investment made by various agencies on watershed implementation is Rs. 194706 million and the area treated is about 56.5 m ha, with an average investment of Rs. 3444/- per ha.

Table 3 Physical and financial achievements under various watershed development programmes in India (upto March, 2007)

Sl. No.	Ministry/Scheme and year of start	Physical achievement (Area, ha)	Financial achievement (Lakhs Rs.)
A) Ministry of Agriculture (Department of Agriculture & Cooperation)			
1.	NWDPRA (1990-91)	8845911	278743.17
2.	RVP/FPR (1962 & 81)	5991736	205031.46
3.	WDPSCA (1974-75)	392017	29415.00

4.	RAS (1985-86)	735660	11851.16
5.	WDF (1999-00)	97726	4613.24
6.	EAPs	1458345	224410.59
	Sub Total	**17521395**	**754064.62**
B) Ministry of Rural Development (Department of Land Resources)			
1.	DPAP on Watershed basis (1995-96)	13719500	244301.00
2.	DDP on Watershed basis (1995-96)	7873000	183779.00
3.	IWDP on Watershed basis (1995-96)	10722304	226852.93
4.	EAPs	581700	84610.00
	Sub Total	**32896504**	**739542.93**
C)	**Ministry of Environment and Forests**		
1.	NAP (1989-90	959864	203142.00
	Sub Total	959864	203142.00
D)	Planning Commission		
1.	HADP (V Plan)	29075	12774.00
2.	WGDP (V Plan)	806285	50349.47
	Sub Total	**835360**	**63123.47**
E)	**Other Watershed Schemes Operating in Different States**		

	EAS, State Schemes, APHM RIDF, SLUC, SFSRLPGS, KAWAD, CWP, INVDA, CAD, Adarsh Gaon etc.	4328271	187184.22
	Total (A+B+C+D+E)	**56541394**	**1947057.24**

(Source: Sharda et.al. 2008)

2.1 Impact of Watershed Programs on Productivity of Crops

Watershed programs in India have shown a significant enhancement in productivity of crops in most of the regions they were implemented. Studies show that watershed programs in rainfed regions on an average, recorded a mean B:C ratio of 2.0 and internal rate of return (IRR) of 27 %, (Joshi et al. 2004,2005; Ramakrishna et al. 2006; Wani et al. 2006 and 2008) and had proved to be beneficial for sustainable development of rainfed regions (Joshi et al. 2008, Wani et al. 2008). It is, however, of concern to note that even though only 1% of the watersheds performed below B:C ratio of 1, a large number (65%) of projects performed below B:C ratio of 2.0. Only a limited number of watersheds recorded B:C ratio above 2.0 (Wani et al. 2006). There is thus, a need to have a closer look at these programs for successful up-gradation and implementation to achieve the higher success.

A comparison of the differences in yield of selected crops between major watershed and non-watershed areas show that yield was generally more in adopted areas of watershed in a study by CRIDA (Sastry et.al., 2004). However, in some cases (as in case of maize, green gram and groundnut), there were no differences (**Table 4**).

Table 4 Changes in productivity due to watershed programme

Crops	Average yield (kg/ha)		% increase/ decrease
	Watershed	Non-watershed	
Cereals			
Sorghum	1120	940	19.1
Pearl millet	1220	940	29.8
Finger millet	1420	1030	37.9
Maize	2260	2300	-1.7

Rice	2200	2030	15.0
Wheat	2350	1880	25.0
Oilseeds			
Groundnut	1040	1060	-1.9
Soybean	1420	620	129.0
Pulses			
Greengram	890	890	0.0
Blackgram	890	590	50.8

(Source: Sastry et. al., 2004)

A positive benefit observed in watershed areas has been that often, the soil conservation activities/measures undertaken at watershed areas were performed in an interactive and participatory mode which create enthusiasm of the farming community and they are immensely benefited from the awareness created through these programs. Singh et al. (2006) discussed at length the viability and acceptability of these programs. However, the farmers are still reluctant to leave the traditional methods and opt more for field leveling and field bunding than contour bunding. Inspite of these impediments, the overall improvements in physical parameters in watershed projects, under various agro-climatic conditions are set out in **Table 5.**

Table 5 Improvements due to watershed programmes

Parameters	Arid	Semi-arid	Humid
Rise in water table (m)	1.05	1.57	1.38
Reduction in runoff (%)	35.0	33.2	30.5
Reduction in soil erosion (%)	15.0	28.8	25.6
Surface water resource developed (%)	9.0	18.0	20.5
Increase in afforestation (%)	10.0	11.3	21.7
Increase in cropping intensity (%)	6.0	16.0	18.3
Increase in employment (%)	12.5	25.0	20.8

(Source: Sastry et. al., 2004)

Another flagship programme that is of importance to rainfed areas is NREGS (National Rural Employment Guarantee Scheme). However, the response to this scheme again is mixed.

2.2 Components of Watershed Management

Several components of watershed programme are discussed in detail, which needs special emphasis to have desired gains in terms of productivity, profitability and sustainability (Osman et. al., 2006).

i) Rainwater Management

Rainwater management is the key to the success of rainfed agriculture. Although water is a renewable resource, it is in perpetual motion through hydrological cycle. Anthropogenic activities such as large number of (oversized) rainwater harvesting structures constructed in the watershed programmes helped in impounding of water flow and positively influenced the cropping intensity. The major concerns, however, are lowering of water table, water quality deterioration and industrial pollution of groundwater in peri-urban areas. *In situ* moisture conservation, harvesting of runoff and efficient water use, again, are important issues in rainfed agriculture. Transforming *ex-situ* water harvesting systems for more groundwater recharge at micro basin level and increasing water productivity become priorities for any further sustained development of agriculture in rainfed areas. However, the major policy issues related to rainwater management in rainfed regions in the country were thoroughly discussed by Sharma (2002).

Integrated Watershed Management Programme: New Guidelines

There are 35 basins, 500 sub-catchments and more than 3200 watersheds of various sizes in India. Watershed management approach has been evolved vigorously, over the last three decades and the technologies are in the process of achieving perfection with advancement of socio-economic and bio-physical processes. The emphasis has now shifted from mere bio-physical - soil & water conservation measures to empowerment of rural communities for increasing productivity through improved access to natural resources. The top-down approach followed earlier has now been replaced with bottom-up with focus on knowledge empowerment and emphasis on owning of programme right from the day one and post project management, for sustainability. The roles of institutions have been modified, from implementers to facilitators. More emphasis has now been laid also on building the capacity of the formal and informal rural institutions. The focus is now on improving the natural capital- rainwater, soil health and vegetation for enhancing livelihoods of landed and landless. So far, watershed programmes concentrated on landed but now adequate allocation has been made for the landless who largely depend on common pool resources. Also, government is planning to provide a boost to watershed based rainfed agriculture, through offering incentives specific to rainfed farmers which can help them in digging small farm ponds to enhance their chances for drought mitigation and for biomass generation and incorporation to improve their soil fertility, besides better access to quality seed and other inputs, better market linkages and crop insurance. If these incentives come up, it can enhance the enthusiasm among rainfed farmers and can usher in the second green revolution through the rainfed areas.

ii) Rainwater Harvesting and Recycling for Improved Livelihoods – A case study

The farm pond dug of 900 m^3 capacity in the village Garkampet, Gudihatnoor mandal of Adilabad district has proved to be a boon for tribal farmers. The water was retained long time without lining even after cessation of monsoon during 2008-09, even after utilization of water for supplemental irrigation to tomato grown on 0.5 acre plot. The total cost of cultivation of tomatoes in 0.5 acre land was worked out to be Rs. 23,600/-. The gross returns accrued from 4460 kg production of tomatoes from 27 pickings in 0.5 acre land was found to be Rs. 1,30,450/-. The benefit-cost ratios (BCRs) based on total cost of cultivation of tomatoes and based on total cost of cultivation of tomatoes including cost of pond were calculated as 5.53 and 2.23, respectively (**Table 6**). The case study has come out with conclusive evidence of livelihood improvement in terms of five capitals formation namely natural, social, human, financial and physical of the farmer, Mr. Namdev, belonging to the village Garkampet, Seethagondi Gram Panchayat in Gudihatnoor mandal of Adilabad district in Andhra Pradesh. The farmer has come out of the debt trap and now making a decent living. The impact has been enormous and 30 more such sites have been identified by the farmers themselves within the *Gram Panchayat* and were taken up with assistance from the line department.

Table 6 Impact of farm pond on net returns accrued from production of tomatoes (in 0.5 acre land) during 2008

S.No.	Particulars	Amount (Rs.)
1	Gross returns	1,30,450
2	Total cost of cultivation of crop (a)	23,600

	Cost of digging of pond (b)	35000
3	Net returns accrued from production of tomatoes (1-2a)	107,350
	Net returns accrued after recovering cost of farm pond [1-2 (a+b)]	72,350
4	(a) BCR based on total cost of cultivation of crop	5.53
	(b) BCR based on total cost of cultivation including cost of pond	2.23

Impact of rainwater harvesting on diversification of rainfed agriculture – tomato, marigold and rearing of fish

2.3 Sustainable Rural Livelihoods through Integrated Watershed Management Programme

A wide variety of technological solutions have been suggested to address some of the above problems. The mismatch between the promise of available technologies and their actual performance in rainfed agriculture is due to risk persistence, inadequate communication and knowledge empowerment, lack of economic viability and compatibility with client needs and resources, poor credit facility and inadequate market infrastructure support geared to their capabilities. The central issue of rainfed farming is not necessarily of package of technologies but of building the capacity of farmers to support a decent livelihood through enhancement in their economic conditions by adopting diversified land use and farming systems approach and an appropriate market linkage that provides them adequate returns. Thus, development of appropriate riskminimizing technologies and promotion of enabling institutional arrangements hold the key to improve the rural livelihoods. Rural livelihoods depend heavily on agriculture and allied enterprises. Sixteen typologies based on economic activities were identified in the districts with more than 70% rainfed area. Of these typologies, about 2/3rd are closely associated with dairying. In addition, agro-forestry, horticulture etc, cut across typologies. These diverse agro-based activities need to be integrated in a farming systems mode on watershed platform for risk distribution and sustainable livelihoods.

3.0 Conclusions

In the light of changing agriculture scenario in the country, the areas that are going to influence the future of rainfed agriculture are: climate change and its impact; bridging of yield gap through improved rainwater and soil management; drought management through risk resilient farming systems and contingency planning; improved profitability of rainfed agriculture through farm mechanization and post-harvest value addition; necessary support systems through training, HRD, consortium approach and convergence of schemes and use of information technology tools considering watershed as the main platform. Government incentives to rainfed farming mainly for field work and cost intensive interventions like digging of farm ponds, tank silt and biomass addition to farm lands are needed to enhance production capabilities. Such incentives will enhance the confidence of rainfed farmers to work with new vigor to reduce their risk proneness and improve their productivity and profitability.

References

FAI. 1993. Fertilizer Statistics 1992-93. Fertilizer Association of India, New Delhi, India, III-21 to IV-76

Joshi, P.K., A.K. Jha, S.P. Wani, Laxmi Tiwari and Shiyani, R.L. 2004. Meta analysis to assess impact of watershed program and peoples participation. Global Theme on Agro-Ecosystems Report No. 12, ICRISAT, Patancheru 502 324 Andhra Pradesh. 20pp.

Joshi, P.K., A.K. Jha, S.P. Wani, Laxmi Tiwari and Shiyani, R.L. 2005. Meta analysis to assess impact of watershed program and peoples participation. Research Report No. 8, Comprehensive Assessment of Watershed Management in Agriculture, ICRISAT, Patancheru 502 324 Andhra Pradesh and Asian Development Bank. 21pp

Joshi, P.K., A.K. Jha, S.P. Wani, T.K. Sreedevi and Shaheen F.A.. 2008. Impact of watershed program and conditions for success: A meta-analysis approach. Global Theme on Agro-ecosystems Report No. 46. Patancheru 502 324, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. 24 pp.

Lal, R., 1994. Water management in various crop production systems related to soil tillage. Soil and Tillage Research, 30: 169-185

Mandal, C. and Mandal, D.K. 1999. Agro-Demographic Zones of High Rainfall Regions of Eastern India, Agricultural situation in India, Vol. 55, No.11, February, 1999, p.675-680.

Osman, M., Venkateswarlu B., Prasad Y.G., Desai S. Balloli, S.S. and Shaik Haffis. 2006. CRIDA VISION – 2025, Central Research Institute for Dryland Agriculture, Hyderabad, 194 P.

Ramakrishna, Y.S., Y.V.R. Reddy and B.M.K. Reddy 2006. Impact assessment of watershed development program in India. In K. Palanisami and D. Suresh Kumar (eds.), Impact Assessment of Watershed Development- Issues, Methods and Experiences (India: Associated Publishing Company), pp. 223-238.

Sastry, G., J. Venkateswarlu, Y.V.R. Reddy, Om Prakash and K.P.R. Vittal. 2004. Evaluation of Watersheds in India. Scientific Pub., Jodhpur, pp:231

Sharda,V.N., Juyal, G.P. and Naik, B.S. 2008. Watershed Development in India – Status and Perspective, CSWCR&TI, 218 Kaulagarh Road, Dehradun, pp:219

Singh, S.N., Jyothirmai V.K.K., Anil Kumar, B. and Reddy, Y.V.R. 2006. Economic evaluation of watershed management in semi-arid region of India: Viability and acceptability. The Asian Economic Review 48(3):387-404.

Wani, S.P. Pirara Singh, K.V. Padmaja, R.S. Dwivedi and T.K. Sreedevi. 2006. Assessing impact of integrated natural resource management technologies in watersheds. In K. Palanisami and D. Suresh Kumar (eds.), Impact Assessment of Watershed Development - Issues, Methods and Experiences (India: Associated Publishing Company), pp. 38-58.

Wani S.P., P.K. Joshi, K.V. Raju, T.K. Sreedevi, J.M. Wilson, Amita Shah, P.G. Diwakar, K. Palanisami, S. Marimuthu, A.K. Jha, Y.S. Ramakrishna, S.S. Meenakshi Sundaram and D'Souza Marcella. 2008. Community watershed as a growth engine for development of dryland areas. A comprehensive assessment of watershed programs in India. Global Theme on Agroecosystems Report No. 47. Patancheru 502 324, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Ministry of Agriculture and Ministry of Rural Development. 156 pp.

WATERSHED PROJECTS AND LIVELIHOOD ENHANCEMENT IN RAINFED AREAS

P.K.Mishra, Project Coordinator (Dryland Research),

AICRPDA, CRIDA (ICAR), Hyderabad

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 >10 & < 15m >15m	2 3 5	5
5	APSRAC (Andhra Pradesh State Remote Sensing application Centre)	Very low Low Medium High Very high	6 12 18 24 30	30
6	Livestock	< 1000 nos. >1000 & < 2000 >2000	2 3 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

Criteria for watershed selection in Orissa

Sl. No.	Parameters	Source	Range	Marks	Weight
1.	i) % of wasteland and degraded land ii) Drainage density	ORSAC	Priority - I Priority - II Priority - III	20 12 8	20
2.	Frequency of drought in the village/watershed (review data for last 20 years).	Block	< 5 times 5 - 10 times > 10 times	3 6 10	10
3.	Irrigated area	Revenue/ Line Departments	< 15% 15% - 30% > 30%	10 6 3	10
4.	Contiguity of treated/proposed watersheds	ORSAC/ Soil Conservation	No Yes	10 0	10
5.	% of SC/ST population	Census/ Village Statistics	< 30% 30% - 50% > 50%	3 6 10	10
6.	No. of small and marginal farmers	Agriculture Department/ Village Statistics	< 25% > 25 - <50% > 50%	2 5 8	8
7.	% of Landless HHs	Census/ Village Statistics	< 30% 30 - 50% > 50%	3 6 10	10
8.	IMR (Per thousand live births)	ICDS/ PHC	< 40% 40 – 60% > 60%	2 4 7	7
9.	Problem of Drinking Water	RWSS/ ORSAC	Low High Acute Shortage	1 3 5	5
10.	Availability of common land	Tahasil	< 100 Ha 100 – 250 Ha > 250 Ha	3 6 10	10

WATER RESOURCES PLANNING FOR SECURING LIVELIHOODS IN RAINFED AGRICULTURE

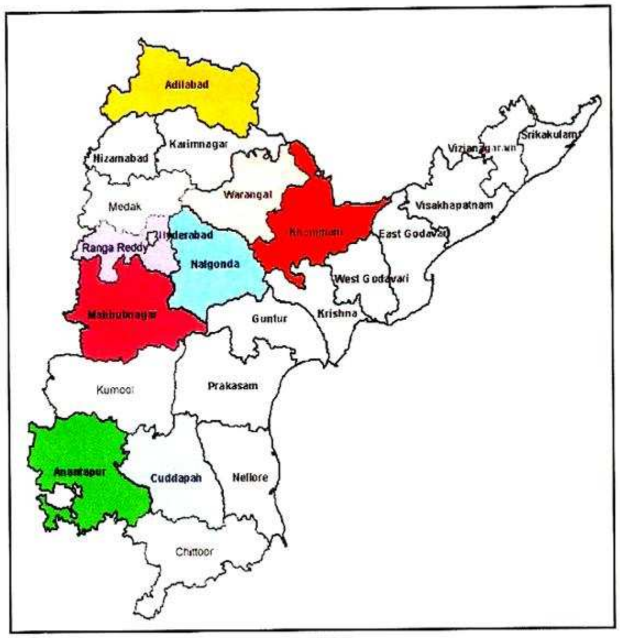
KV Rao, Senior Scientist (S&WCE) CRIDA, Hyderabad-59
Central Research Institute for Dryland Agriculture, Hyderabad

ABSTRACT
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" has employed many engineering interventions for enhancing the systems productivity and thereby improving the livelihoods of the rural poor. The paper illustrates cases of successful resource conservation interventions that provide employment opportunities during their implementation and revitalize rainfed agriculture through sustainability and cropping intensity enhancement. These interventions include rainwater harvesting and reuse, water resource development/augmentation, demand management of water at micro level in the predominantly rainfed areas of Andhra Pradesh. The project has followed a participatory action research framework and used community mobilization techniques for sensitizing the rural poor about resource conservation. Finally, it demonstrates how a well designed and implemented intervention could have a significant impact on the capacity of the rural community to conserve and use precious resource like rainwater.

Introduction

The National Agricultural Innovation Project (NAIP) deals with research on sustainable rural livelihoods under its component 3. One of the sub projects of component 3 titled "Sustainable Rural Livelihoods Through Enhanced Farming Systems Productivity and Efficient Support Systems in Rainfed Areas" is being implemented across 8 districts of Andhra Pradesh (see map) 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.



Location and Project Sites

One of the major strategies for improving rural livelihoods on a sustainable basis is through enhancing the overall systems productivity which aims at improving the capacity of harvesting and utilizing rainwater at the community level. This strategy involves measures that aim at scientifically designing and executing rainwater harvesting structures. Besides, interventions that promote improving water productivity and timeliness of agricultural operation are also pursued as part of the productivity enhancement strategy. The following cases explain how specific engineering interventions made an impact on augmenting rainwater availability and thus increasing systems productivity.

Case 1: Rainwater harvesting through farm ponds: Emphasis on topo survey and runoff analysis

Water is most crucial resource for sustainable agricultural production in the dry land/rain fed areas. However, the major part of the rainwater goes away unused as runoff washing away precious top soil. Recent analysis of the rainfall pattern shows that there is an increase in the number of high intensity rainfall followed by long spells of drought. This calls for taking measures to harvest the excess runoff during the high rainfall events and reuse the same for life saving irrigation during drought spells. A location specific rainwater harvesting method through farm ponds was standardized to address this problem. Besides, the project has evolved a process for up-scaling this technology in convergence with on-going programmes like NREGS.

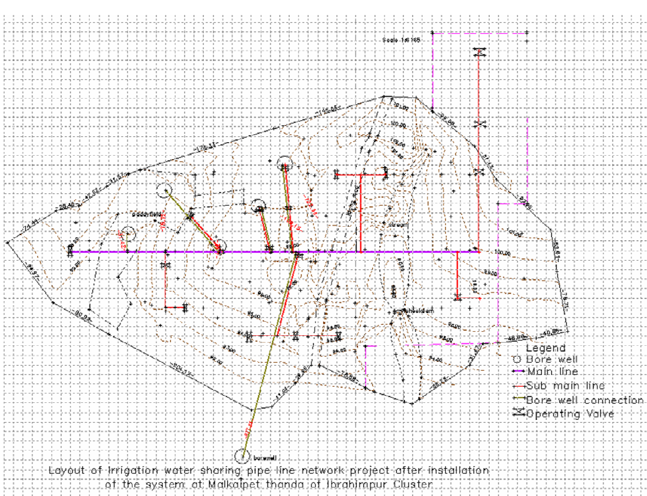
The Seethatgondi cluster of Adilabad district is predominantly populated with tribals who are engaged in subsistence agriculture despite receiving an average rainfall of 1050 mm annually and fairly deep black soils. The topography here has good potential for harvesting runoff. Considering the slopes of the fields, an appropriate location was identified after a detailed topo survey of the location for a dug out pond (17m x 17 m x 4.5 m) involving a group of farmers as stakeholders. By highlighting the benefits of the proposed intervention, the farmers were persuaded and agreed to get the Farm Pond dug in their land.

Soon after the farm pond was dug (July, 2008), there were good rains leading to complete filling. The rainwater filled to the brim of the pond got the farmers enthused. They hired diesel engine to irrigate half acre area where they grew tomatoes. Overwhelmed by this response, the NAIP project has facilitated inclusion of digging work in the NREGS shelf of works. Consequently the district authorities of Adilabad had visited this successful farm module and have allocated an amount of Rs.20.00 lakhs for up scaling this intervention. This intervention, while creating the employment under NREGS, facilitated for intensive cultivation of crops/vegetables and to overcome the intermittent dry spells with supplemental irrigation.


Farm pond dug under NREGS being widened and deepened

Case 2: Sustainable use of groundwater: Pipeline networking and social engineering for participatory management

Cultivation of rice using precious groundwater is a common practice in the rainfed areas of Andhra Pradesh. Malkaipet thanda in Ibrahimpur cluster, Rangareddy district, one of the driest regions of Andhra Pradesh, is not an exception to the practice. This area has been categorized as "over exploited" in terms of groundwater resources. NAIP staff, keeping this in view started working on promoting better water management through a water sharing arrangement among farmers. The efforts in this direction were initiated by WASSAN, the cluster anchoring partner 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. The project then got a defunct bore well repaired as an incentive 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 lands where they could not have provided water. Thus, the one year long negotiations with the community to implement social regulation 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. For the first time an area of 25 acres came under groundnut with protective irrigation during rabi 2009 where no second crop was possible earlier. **Groundnut was generally cultivated in kharif with an average yield of 400 kg/acre. With this intervention, groundnut could also be cultivated in rabi with much higher yield level (550 kg/acre).** This intervention helped increase cropping intensity besides creating additional employment, income for the farm families. Next year, the area under protective irrigation through the pipeline networking will increase to its full potential i.e. 18 ha.



Layout of irrigation water sharing pipe line network project after installation of the system at Malkaipet thanda at Ibrahimpur Cluster

Case 3: Enabling farmers for augmenting water availability

Bheemavaram tank in Tummalacheruvu cluster (Khammam) serves as a source of irrigation for about 120 acres. However, the command area is divided into two parts by a drainage channel flowing across the area. As a result, the entire command area did not get the benefit of irrigation by the tank. Therefore, the farming community had been desiring for long for construction of an aqueduct across the drainage channel so that irrigation water could be transported from one side the command area to other side. But it did not materialize due to local problems. In the absence of such an arrangement, half of the designed command area remained un-irrigated.

However, the excess water that flows out of the tank every year during the rainy season goes waste since it flows down into a drain without becoming accessible to the fields on the other side of the command. 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.

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 would take up work in such a hinterland, the farmers agreed to lay the 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. The construction employed 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%. The farmers are very happy with their dream coming true and are working to dig distribution channels downstream so that the entire potential of the overflowing water could be harnessed to irrigate about 120 acres.

Schematic diagram of the aqueduct before (above); aqueduct after completion

The table below illustrates the rainwater harvesting and storage potential of various interventions and the resultant increase in protective irrigation potential, cropping intensity apart from additional income that could be generated in one season.

Table 1: Impact of Interventions Aimed at Rainwater Harvesting and Use

Cluster	RWH and use strategy	Rainwater storage capacity created	Man days gene-rated	Protective irrigation potential created (acre)	Increase in cropping intensity (%)	Additional income Potential per season

		(cu m)				**(Rs)**
Seethagondi, Adilabad	Farm ponds	3238	600	7.0	200	84010
Pampanur, Anantapur	Farm ponds Percolation ponds	3611	1938	7.8	150	31200
B.Y.Gudi, Kadapa	Contour Bunding	425	380	NA	NA	NA
Thummala-cheruvu, Khammam	Aqueduct	NA	50	120	150	720000
Jamisthapur, Mahbubnagar	Farm ponds, check dams and Percolation ponds	4850	1378	10.5	150	41945
Dupahad, Nalgonda	Tank deepening and de-silting	3695	2500	8.0	200	95867
Ibrahimpur, Rangareddy	Networking of bore wells with social regulation	NA	500	45	250	630000
Jaffergudem, Warangal	Farm ponds, percolation ponds,	5100	3700	11	150	66160
	Total	**21419**	**11046**	**209.3**	178.5*	**16,69,182**

**Average cropping intensity*

Conclusion

Engineering interventions have a very significant role in the areas of resource conservation, value addition and promotion of mechanization for timely agricultural operations. The mechanization needs of rainfed agriculture vary widely depending on the local needs, resources and cropping pattern. Engineering interventions can have remarkable impact on improving the livelihoods of the rural poor, as they are shown to improve yield levels by 15% and reduce costs up to 30% besides improving timeliness of operations. Therefore, there is a strong need to consider a carefully thought out strategy involving need based engineering interventions in any productivity enhancement programme. However, these need to be taken up in participatory mode by involving the community so that they have a long lasting impact. Other stakeholders like rural artisans, entrepreneurs need to be involved in building a support system for promoting mechanization at village level. Further, a constant capacity building initiative must go hand-in-hand. This can be achieved by involving the community right from the planning stage. This will inculcate a sense of ownership by the community resulting into sustainable improvement of rural livelihoods.

References

1. CRIDA (Central Research Institute for Dryland Agriculture), 2010. Sustainable Rural Livelihoods Through Enhanced Farming Systems Productivity and Efficient Support Systems in Rainfed Areas, Annual Report 2009, Hyderabad, A.P., India: CRIDA p. 34

2. Hardikar, J 2008. Vidarbha distress: 'Relief' irrigation increasing worried for farmers. India Together. Available at http://www.indiatogether.org/2008/may/env-vidwater.htm

3. Singh, H.P., B. Venkateswarlu and Sreenath Dixit (2000). Sustainable land use practices for combating desertification, CRIDA, Hyderabad. Draft National Action Plan. P.80

MODELLING MICROWATERSHED HYDROLOGY: WATER YIELD AND ITS ECONOMICS IN CROP PRODUCTION

K.S. Reddy, Principal Scientist (SWCE)
Central Research Institute for Dryland Agriculture
Santhoshnagar, Hyderabad-500 059

Introduction

Surface runoff from a watershed is a result of interaction between the rainfall and watershed parameters. There have been a great deal of attempts in the past to predict a runoff by using simple two variable regression approach or by using complicated modeling procedures (Sharma, 1983, Verma, 1987 and Selvarajan, 1990). Simpler approaches suffer from inaccuracy and have extremely scope of application. The most sophisticated and elaborate modeling approaches are advantageous but they require large amount of input information along with the time distribution of some of the data. Hydrologic monitoring of the watersheds is seldom done in the country though the watershed yield is a major parameter of interest for various works such as reservoir design, irrigation planning, adopting in situ moisture conservation techniques, estimation of drainage requirement etc.

The hydrologic soil cover complex method (SCS, 1964) is considered to be an efficient method for runoff prediction. This is a semi empirical method, which uses a number of qualitative attributes of watershed parameters and predicts the runoff as a resultant interaction of watershed parameters with rainfall. The qualitative attributes of the watershed were expressed in the number scale (0 to 100) and these numbers are called curve numbers. The list of curve numbers corresponding to set up watershed parameters is available in the standard tests. For Indian conditions, handbook of hydrology (MOA, 1972) has given the appropriate curve numbers, which can be used to predict the runoff for given rainfall. Some studied have indicated the necessity of fitting appropriate curve numbers suitable to the local conditions to have a better prediction of runoff (Hawkins, 1990). The main objective of the present study is to develop a suitable water yield model of a watershed by establishing appropriate curve numbers and its validation over selected micro watersheds of upper Damodar Valley in the Chota Nagpur region of the Bihar. The generated information on the availability of storage water in the reservoirs of micro watersheds was used for estimating the economic benefits by selecting locally grown crops like paddy, maize and pigeon pea.

MATERIALS AND METHODS

Study Area

The study area (Latitude $24^0 2'$ N and Longitude $85^0 43'$ E) comprised of five micro watersheds of sizes varying from 1.212 to 22.27 ha, lying in the sub watershed number 8/5 in the village Urgi of Upper Damodar Valley (Fig. 1). Some of the important land use and morphological characteristics of the study area are forest, agriculture and bare land with no canopy to thin canopy. The average slope of the watersheds ranges from 2 to 4.5 per cent. The drainage density of watershed varied from 5.2 to 15.8 km^{-1}.

Methodology

The estimation of water yield was done by a modeling approach primarily the hydrologic soil cover complex method. The necessary input data for using this method are the rainfall, land cover, land treatment, antecedent moisture condition and hydrologic soil group. The AMC values was calculated using the recorded daily rainfall data. The hydrologic soil group was obtained from the relevant reports of DVC, Hazaribagh (Anonymous, 1985). In addition, the five selected reservoirs of the study area was surveyed to develop relationships of storage volume versus depth of storage and water spread area versus depth of water. The rainfall runoff process was studied at the site for about one and half months during June to July in the year 1992. Pan evaporation data were needed to divide the evaporation lass from the total water loss due to seepage and evaporation from the reservoirs and obtained from the literature (Rathore and Bishwas, 1989).

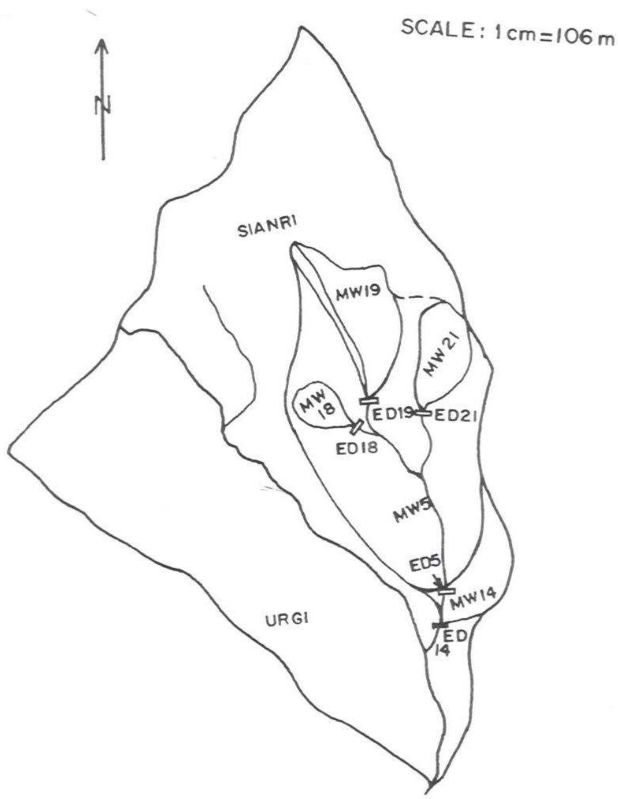


Fig 1. Location map of micro watersheds along with small reservoirs in sub watershed 8/5

The analysis in the model development has been done in two parts. In the first part the runoff from a given rainfall was estimated by using the equations:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad (1)$$

where, Q = Runoff depth, mm

P = Rainfall depth, mm

S = Maximum potential retention, mm and

$$S = \frac{(25400 - 254XCN)}{CN} \qquad (2)$$

where, CN = curve number.

A computer program was developed integrating soil cover complex method with water budgeting equation as given below:

PVOL (I) = TRNVOL (I) – SEEP (I) X APOND (I) – EVAPO (I) X APOND (I) (3)

The program was made user friendly for entering curve number value for AMC-II condition for different land uses available in the micro watersheds. The weighted curve number was used to calculate the value of S and Q is calculated by using eq. (1) for given rainfall and S. If on a particular day P<0.2S, Q is taken as zero. In the second part of the program the calculated runoff depth is converted into runoff volume by multiplying with the watershed area. The volume of runoff is then used along with discreetised weighting curve and the updated depth of reservoir was obtained. For this depth the water spread area was estimated using the corresponding rating curve. The information of water spread area is then used to estimate seepage and evaporation losses. The seepage loss as step function of various ranges of water spread area was established by monitoring the water level decline during the periods of no rain after adjusting for evaporation lass which was taken as the pan evaporation value. Thus, the operation of second part results in a new value of water level as a consequence to runoff accumulation or water level decline in a non rainy day. The flow chart of the model is given in Fig. 2 and 3.

Economic benefits of water yield for crop production

The methodology involves the assessment of water availability in the storage reservoirs to meet the soil moisture deficit for different crops like paddy, maize and pigeon pea, commonly grown as rainfed crops in the study area. The long term (20 years) daily rainfall data was used to study the possible utilization of water for crop production and the economic benefits were worked out for the above crop activities in the micro watershed. The gross water deficits were calculated by using the water balance equation as follows:

$$R + S_p = WR_0 + ET_c + PERCO \pm \Delta S \qquad (4)$$

Where, R = rainfall, mm

S_p = absorbed spill depth, mm

WR_0 = weighted runoff, mm

ET_c = crop evapotranspiration, mm

PERCO = deep percolation, mm

ΔS = surplus / deficit

The gross deficits of the crops thus calculated on weekly basis at 75 % probability level were matched with total water availability in the storage structures.

Optimization of maximum crop returns

Based on the information available on crop production, cost of product and cultivation and the gross deficits in different weeks of crop season (Kharif) , the maximum crop return was estimated by using the linear programming model as given below:

Objective function

$$\text{Maximize } z = \sum_{j=1}^{4} C_j X_j \qquad (5)$$

Subjected to,

$$\sum_{j=1}^{4} a_j x_j \leq 19.02 \qquad (6)$$

$$\sum_{j=1}^{4} D_{ij} X_j \leq V_i \qquad (7)$$

(I vary from 1 to 17 with respect to water constraints)

$$X_j \geq 0 \qquad (8)$$

where,

Z = Maximum net crop return, Rs.

C_j = Return over net of cultivation cost (in which irrigation cost was not included) of j^{th} crop, Rs/ha.

X_j = J^{th} crop activity, (j=1 for paddy, j=2 for maize, j=3 for pigeonpea and j=4 for rainfed crop)

a_j = Land required per unit of j^{th} crop activity, ha.

D_{ij} = Gross deficit per unit of j^{th} crop in i^{th} week, mm

V_i = Total water availability in i^{th} week, ha mm

i = 28^{th} to 40^{th} week i.e. , 1 to 13 for paddy

= 25^{th} to 39^{th} week i.e., 1 to 15 for maize

= 25^{th} to 41^{st} week i.e., 1 to 17 for pigeon pea.

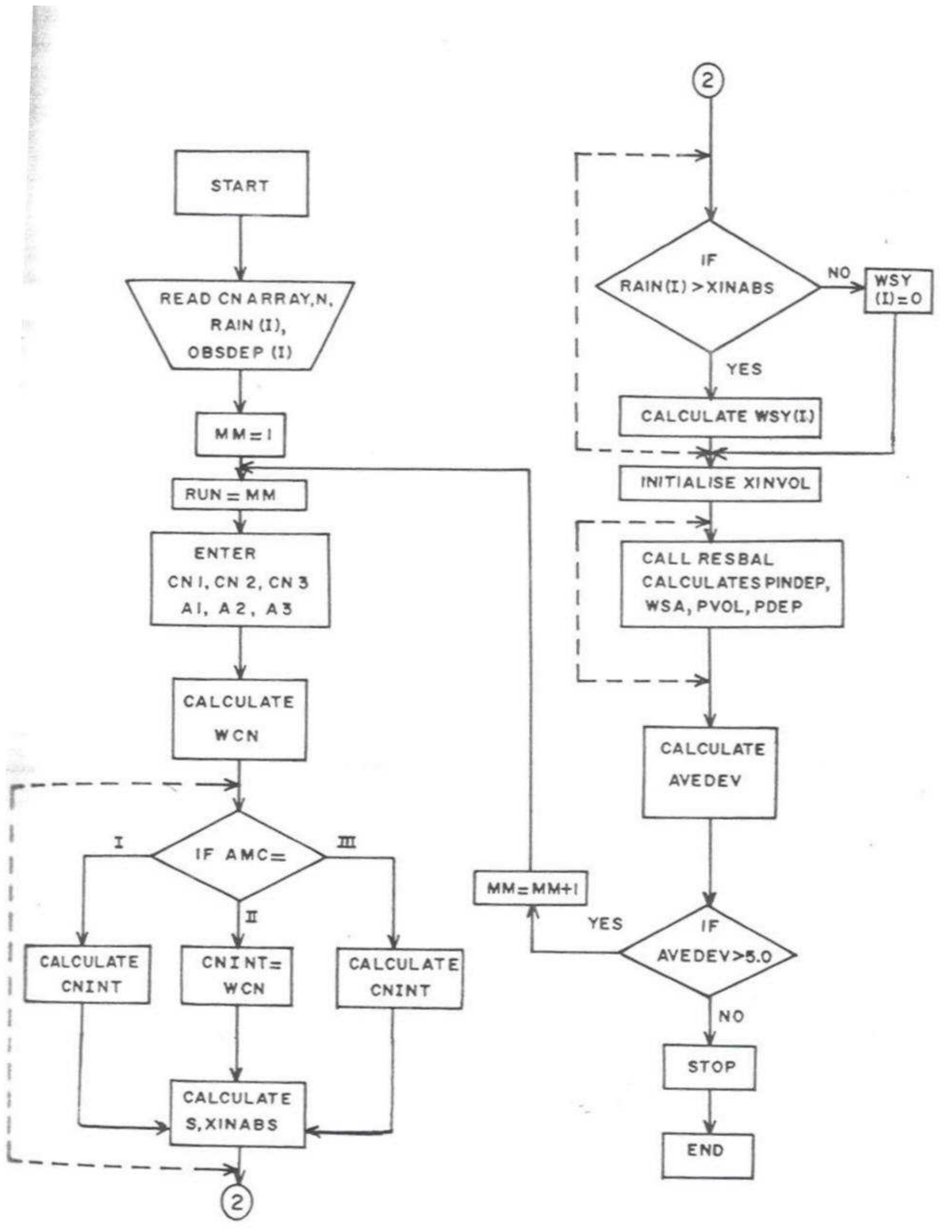


Fig 2. Flow chart showing different operation in SWYMOD

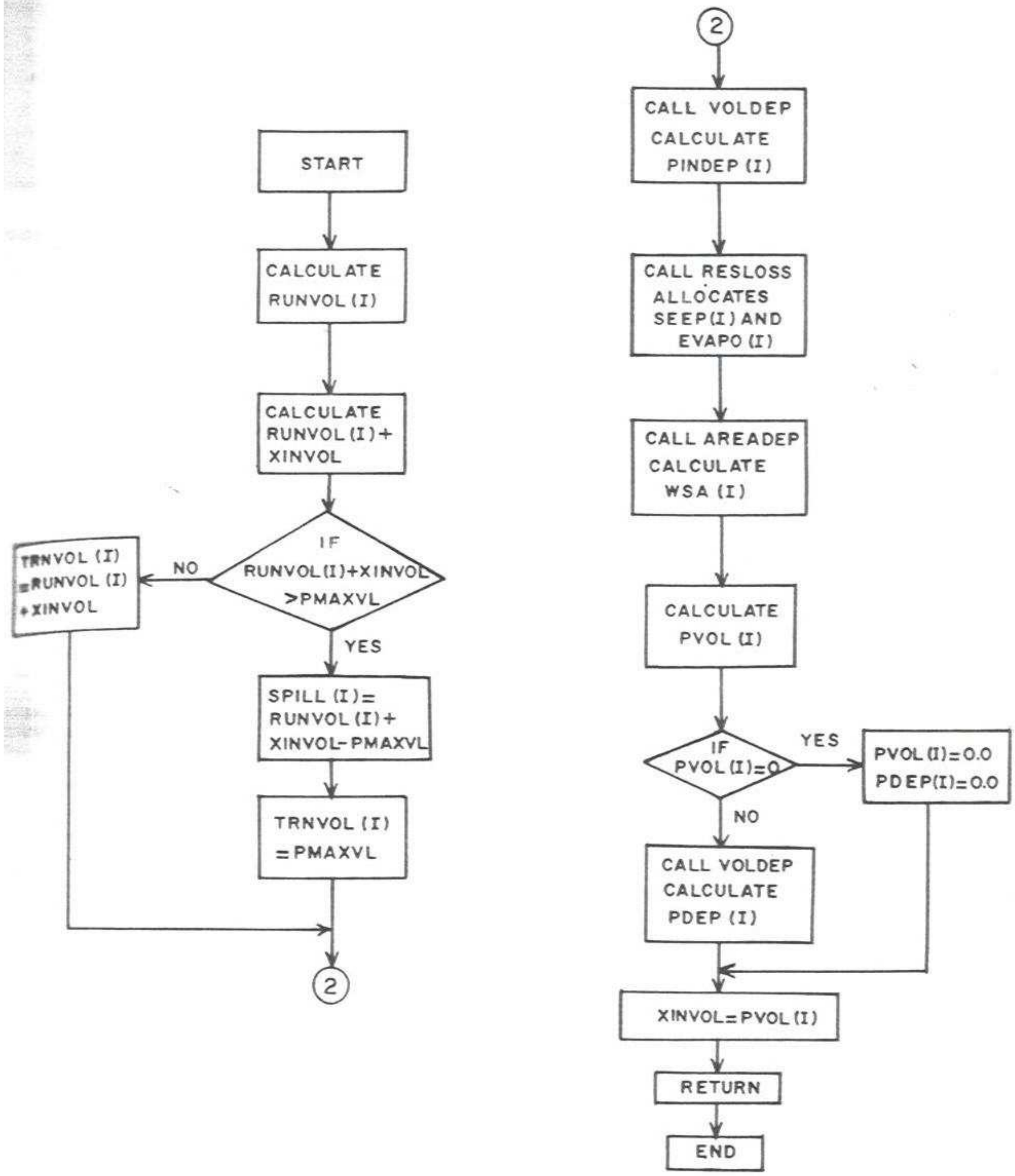


Fig 3. Flow chart showing different operations in water budgeting of reservoirs

In the above formulation the rainfed crop is taken as little millet with local name Gundli in the project area. The above model was used for two optimal crop plans. One was imposing no restriction on 4 crop activities selected and second was with restriction of paddy to an extent of 2.83 ha area. The optimal crop plans were obtained with the maximum net crop returns. For these two optimal crop lands, the economic feasibility of irrigation in the project area for different amortization periods was worked out based on the current market prices of the inputs and the produce.

Results and Discussion

Some preliminary investigations were done to establish the relationships between reservoir water spread area and storage volume as functions of strorage depth; establishment of reservoir losses due to seepage and evaporation as functions of storage depths and establishment of the test criteria in the form of tolerance limit of the reservoir water level to be used for model validation over the selected micro watersheds. The representative relationships for water spread area and storage volume versus storage depth for reservoir number ED 18 and ED 19 are given in Fig.4. To estimate the seepage losses preliminary infiltration tests were conducted at the bottom of the reservoir and the infiltration curves for ED 5 and ED 18 are given in Fig. 5. The soil texture of the reservoir ED 5 is similar to ED 14 and the soil texture of ED 18 is similar to ED 19 and ED 21 and hence the infiltration tests were done in two reservoirs only (Table 1). The basic infiltration rates obtained were 6 mm/hr and 10 mm/hr for ED 5 and ED 18 respectively. These values correspond to 144 mm/day and 240 mm/day respectively. However to ascertain the agreement between the basic infiltration rate and the actual reservoir seepage loss, observations on the decline of water depth in the selected reservoirs were made during non rainy days within the observation period from June to July 1992. the maximum water depths of runoff accumulation recorded was 2.03 m, 2.13 m, 0.63 m, 1.13 m and 0.6 m and the recorded water losses at these depths were 25 mm/day, 25 mm/day, 150 mm/day, a50 mm/day and 175 mm/day in the reservoirs ED 5, ED 14, ED 18, ED 19 and ED 21 respectively. A comparison of above water losses with the basic infiltration rate reveals that the former or lower than the latter and one may inform that assumption of basic infiltration rate as a seepage loss in the reservoirs would give erroneous results during water budgeting calculations. Under these circumstances the values for seepage loss from the reservoirs are estimated from the field observations as given in the Table 2.

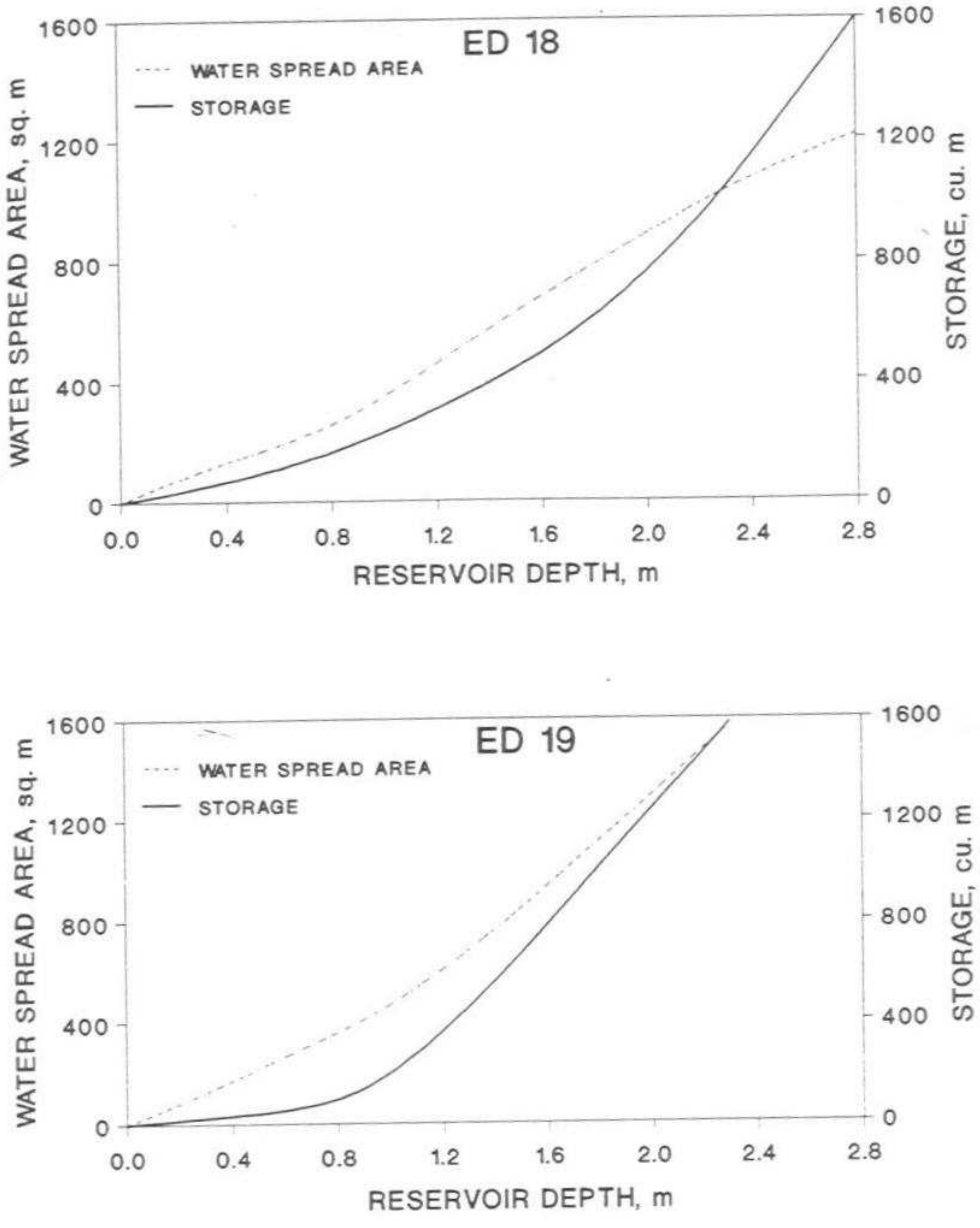
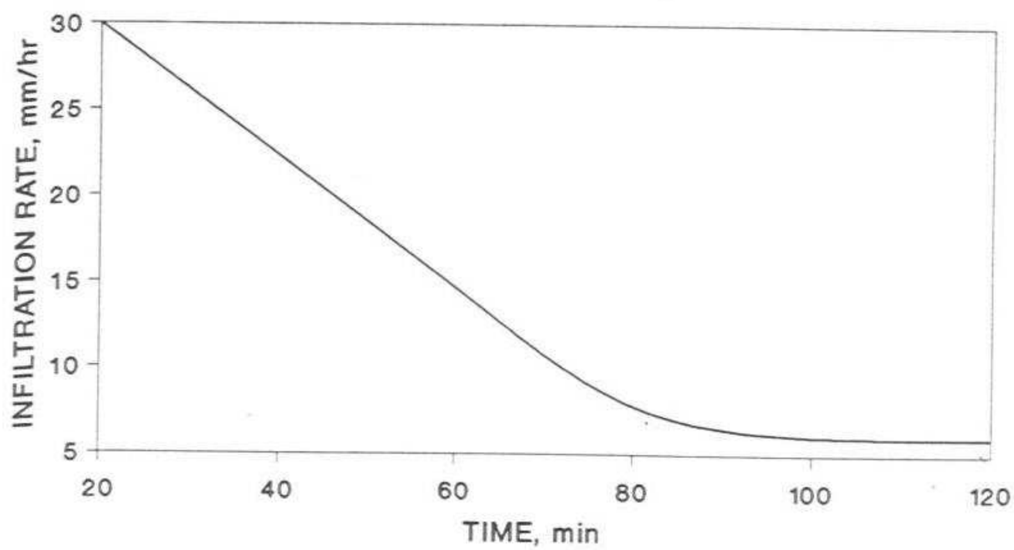
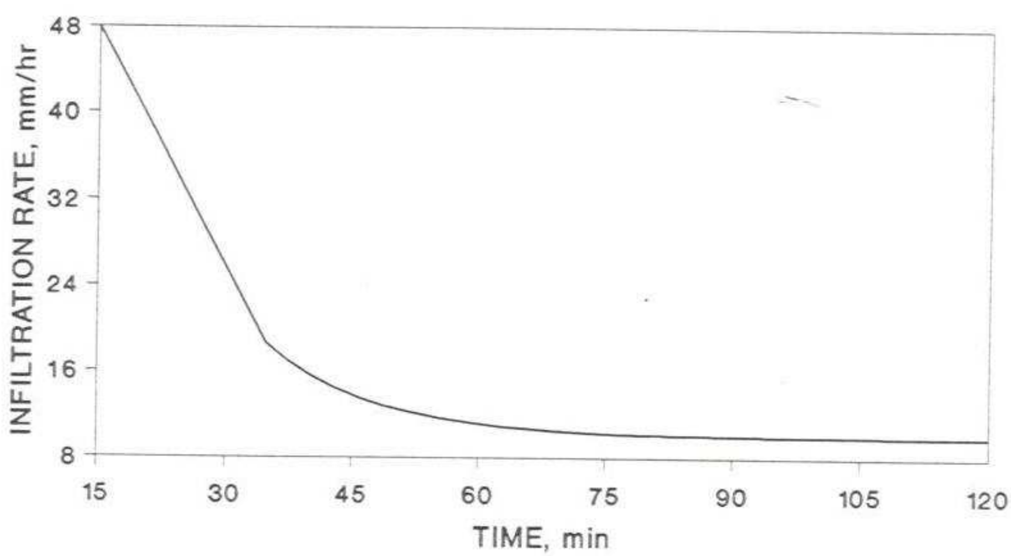


Fig 4. Water spread area and storage volume versus storage depth relationships for ED18 and ED19 reservoirs


30
25
20
15
10
5
INFILTRATION RATE, mm/hr
20
40
60
80
100
120
TIME, min

ED 5


48
40
32
24
16
8
INFILTRATION RATE, mm/hr
15
30
45
60
75
90
105
120
TIME, min

ED 18

Fig 5. Infiltration curves for the soils of the representative reservoirs of ED 5 and Ed18

Table 1: Textural composition of reservoir soils

Reservoir identification	Reservoir soil texture		
	Sand (%)	**Silt (%)**	**Clay (%)**
ED 5	55.0	17.5	27.5
ED 14	53.7	22.9	23.4
ED 18	68.3	13.3	18.4
ED 19	65.6	14.8	19.6
ED 21	64.2	16.3	19.5

Table 2: Observed water losses in the reservoirs and their projected values for different ranges of storage depths

Reservoir identification	Depth of storage (m)	Observed seepage +Evaporation loss (mm/day)	Range of storage depth (d), (m)	Assumed seepage + evaporation for the indicated depth range (mm/day)
ED 5	≥ 2.03	25.0	0 < d ≤ 2.5	25.0
	3.4	75.0	2.5 < d ≤ 3.4	50.0*
	4.3	125.0	3.4 < d ≤ 4.3	100.0*
ED 14	≤ 2.13	25.0	0 < d ≤ 2.5	25.0
	3.7	75.0	2.5 < d ≤ 3.7	50.0*
	4.8	125.0	3.7 < d ≤ 4.8	100.0*
ED 18	≤ 0.3	25.0	0 < d ≤ 0.3	25.0
	0.475	100.0	0.3 < d ≤ 0.48	62.5
	0.625	150.0	0.48 < d ≤	125.0

			0.63	
Ed 19	≤ 0.35	0.0	0.63 < d ≤ 2.8	125.0*
	0.40	25.0	0 < d ≤ 0.4	12.5
	0.93	100.0	0.4 < d ≤ 0.93	62.5
	1.13	150.0	0.93 < d ≤ 1.13	125.0
			1.13 < d ≤ 2.3	125.0*
Ed 21	≤ 0.08	25.0	0 < d ≤ 0.13	37.5
	0.13	50.0	0.13 < d ≤ 0.33	62.5
	0.33	75.0	0.33 < d ≤ 0.60	125.0
	0.60	175.0	0.60 < d ≤ 1.80	125.0*

Note: The values marked with * are the extended values from the observed depths to spill level of storage for the later use of SWYMOD with long term daily rainfall data.

The reservoir water losses given in Table 2 include both seepage and evaporation components. The reservoir water budgeting requires both seepage and evaporation losses separately as rate variables corresponding to the depth of storage resulting from a given inflow of runoff into the reservoir. To accomplish this the separate sub-routine or RESLOSS was developed which supplies both seepage and evaporation as inputs to water budgeting on each time step of computation. The pan evaporation values obtained for a nearby area were used to separate the seepage loss.

The test criterion used in the model to develop curve numbers on iterative process for prevalent land uses in the micro watersheds of project site, was a statistical parameter, average absolute deviation. It is calculated between the observed and predicted water levels of accumulated runoff in the storage reservoirs in each run of the model. The model operates in various runs for each selected curve numbers for the forest (CN1), agricultural lands (CN2) and bare land (CN3) conditions and their corresponding percent areas A1, A2 and A3 respectively (Fig. 2 and 3). If the average absolute deviation between the observed and predicted storage depths is more than a pre assigned value called tolerance limit, the model picks another set of curve numbers.

The tolerance limit chosen for model validation was 50 mm based on the results of reduction in the irrigated area as given in Table 3.

Table 3: Maximum reduction in the irrigated area at the three tolerance limits of predicted reservoir water depth.

Tolerance limit (mm)	Max. volume reduction (cu. m)	Reduction in irrigated area (ha)	
		Paddy *@ 5 cm per application	Maize / pigeonpea *@ 2 cm per application
10	35.0	0.02 (0.1)	0.18 (0.9)
50	190.0	0.38 (2.0)	0.95 (5.0)
100	380.0	0.76 (4.0)	1.90 (10.0)

Note: (1) The values within the parentheses are percentiles of total area of 19.02 ha available for agriculture in micro watersheds.

(2) *Assumed application rates.

The model was first verified during the observation period from June to July 1992 on micro watershed MW 21, which has 100 per cent forest. In MW 21 the model was verified by selecting curve number starting from 80 and increasing with an increment of 5 in each run of the model. In this case the curve number for agricultural land and bare land were assigned to zero as there were nil area under these two land uses. It was found that CN-1 of 90, resulted in the average absolute deviation between the observed and predicted reservoir water levels to be 40.5 mm which was below the pre assigned tolerance limit of 50 mm. In an attempt to estimate for the small increment of CN-1 were tried out in the vicinity of 90 and CN-1 of 91.2 resulted in the minimum average absolute deviation of 38 mm. The final output from the model is given in the Fig. 6. Similar procedure was used in developing curve numbers for other land uses like agricultural land and bare land in the remaining watersheds. The curve numbers were compared with USDA (SCS, 1964) and the results were presented in Table 4. the statistical test of Wilcoxons' Matched Pairs Signed Ranks Test was used to test the agreement between the predicted and observed water depths of the reservoirs in the selected micro watersheds. The results of the above test indicated that the model predictions now the selected reservoirs are acceptable because there was no significant difference between the observed and predicted water depths at 5 % of the rejection region for all the cases.

Economic benefits of water yield for crop production

Based on the basic information like average yield, cost of the produce, cost of cultivation collected from the farmers of the study area, an economic analysis was done by assuming the lift irrigation project with 5 hp diesel pump set for irrigating the locally grown crops like paddy, maize, pigeon pea and little millet (*gundli*). The linear programming model was tried for two imposed conditions of crop activities namely no restriction on the area under any of the four crops and with restriction on the area under paddy crop. Table 5 reveals that between the two imposed conditions the crop plan comprising maize and pigeon pea gives the maximum return when compared to the crop plan comprising paddy, pigeon pea and rainfed crop. The difference in the return between the two crop plans is Rs. 6,511/- per ha. A comparison between Table 5 and 6 reveals that the annual running cost of Rs. 600/- per ha is much less in crop plan comprising maize and pigeon pea as compared to Rs. 1298/- per ha of the crop plan comprising paddy, pigeon pea and little millet as rainfed crop. It is because the total pumping period and hence the pumping cost is much higher when paddy is grown, which faces water deficit in every week during its growth period. The benefit cost ratios in both the options of including and excluding reservoir cost are more than one with increase in trend as amortization period increased (5 to 15 years) in the crop plan comprising maize and pigeon pea (Table 5). The benefit cost ratio is less than one for all amortization periods when the paddy is grown (Table 6) indicating the compulsory inclusion of paddy is not economically beneficial to the farmers.

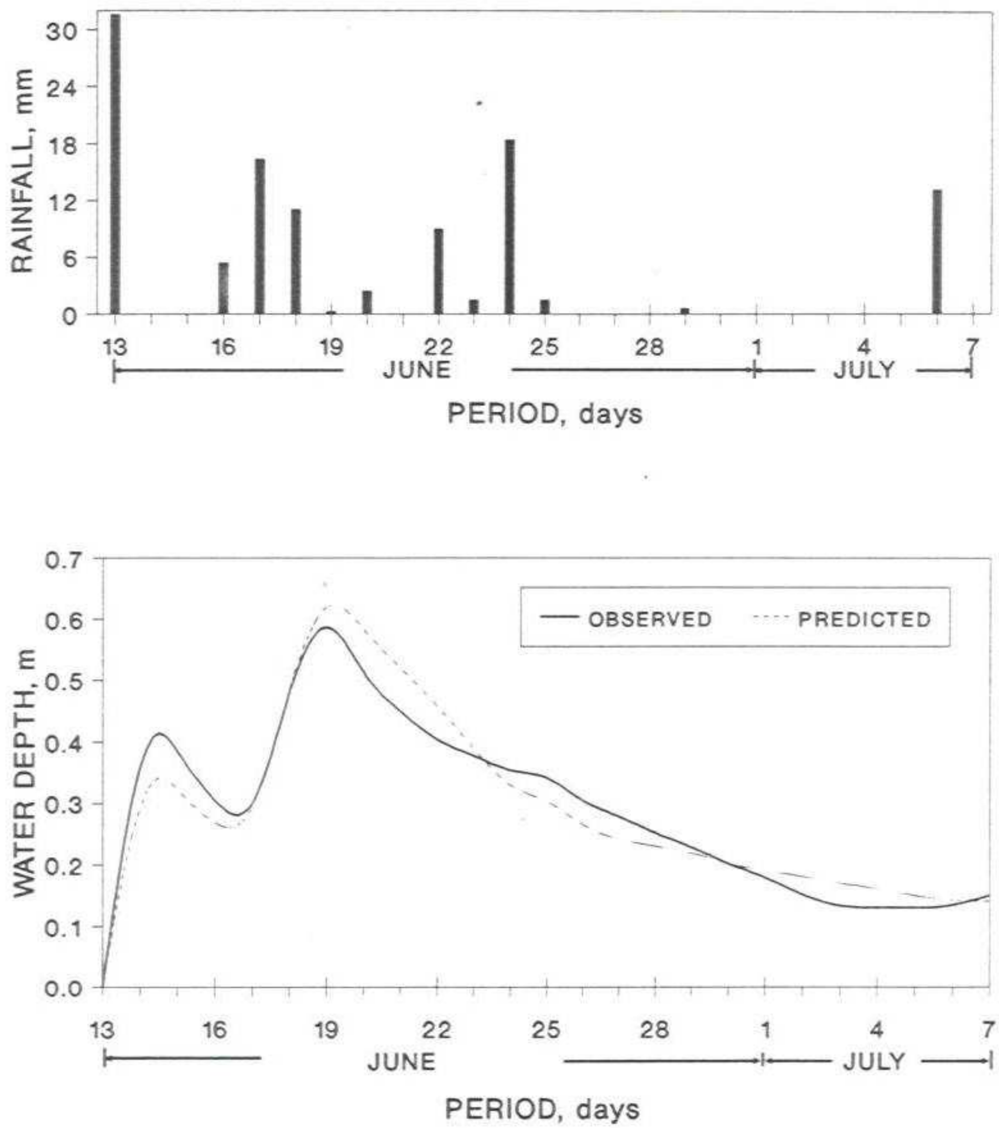


Fig 6. Predicted and observed water depths in the reservoir ED18

Table 4: Comparison of curve numbers for AMC II condition and XINABS = 0.2S.

Land use	Treatment	Hydrologic condition	Hydrologic soil group B	
			Curve numbers from SCS USDA (1964)	Curve numbers obtained by SWYMOD
Forest or Woods	--------	Poor	66	90.5 to 91.2

		Fair	60	
		Good	55	
Agriculture or Row crops	Straight row	Poor	81	79.3
		Good	78	
	Contoured	Poor	79	
		Good	75	
	Bare land	Fallow	86	94.5

Note : XINABS = Initial abstraction, mm

S = Potential maximum retention, mm

AMC = Antecedent moisture condition.

Table 5: Benefit-cost ratio for crop plan comprising maize and pigeon pea for different amortization periods

Amort--ization period (year)	Annual capital cost (Rs./ha)		Annual running cost Rs./ha	Annual capital and running cost (Rs./ha)		Annual benefit (net of cultivati--on cost) (RS./ha)	Annual net benefit (Rs./ha)		Banefit-cost ratio	
	A	B		A	B		A	B	A	B
5	996.93	707.54	599.72	1596.65	1307.26	8685.33	7088.68	7378.07	4.4	5.6
10	640.89	454.85	599.72	1240.61	1054.57	8685.33	7444.72	7630.76	6.0	7.2
15	534.07	379.04	599.72	1133.75	978.76	8685.33	7551.58	7706.57	6.7	7.9

A: Inclusive of reservoir cost.

B: Exclusive of reservoir cost.

Table 6: Benefit-cost ratio for crop plan comprising paddy, pigeon pea and little millet for different amortization periods

Amort--ization period (year)	Annual capital cost (Rs./ha)		Annual running cost Rs./ha	Annual capital and running cost (Rs./ha)		Annual benefit (net of cultivati- -on cost) (RS./ha)	Annual net benefit (Rs./ha)		Banefit-cost ratio	
	A	B		A	B		A	B	A	B
5	659.65	370.26	1297.76	1957.41	1668.02	2174.60	217.19	506.58	0.10	0.30
10	424.06	238.02	1297.76	1721.82	1535.78	2174.60	452.78	638.82	0.26	0.42
15	353.38	198.35	1297.76	1651.14	1496.11	2174.60	523.46	678.49	0.32	0.45

A: Inclusive of reservoir cost.

B: Exclusive of reservoir cost.

Conclusions

A surface water yield model (SWYMOD) integrated with reservoir water budgeting has been found to simulate watershed rainfall-runoff process reasonably well as evidenced by the comparison of the model predicted and the actually observed reservoir water levels in all the cases of five selected micro watersheds. The results of non-parametric statistical test showed that there is no significant difference between observed and predicted reservoir water depths of all the five selected micro watersheds of Upper Damodar Valley. Hence, the fitted curve numbers in the present study can be used to estimate the runoff in the similar micro watersheds. If paddy is to be grown on the maximum possible area based on water availability alone, the return reduces drastically. The benefit-cost ratio for all the three considered amortization periods (5 to 15 years) and for the two cases when reservoir cost included and excluded from the analysis is always greater than one for the crop plan in which paddy is excluded. For all the amortization periods considered, the benefit-cost ratios are less than 1.0, corroborating the infeasibility of the adoption of paddy as an economic option.

References

Anonymous (1985). Annual report of soil conservation department, DVC, Hazaribagh.

Hawkins, R.H. (1990). Asymptotic determination of curve numbers from rainfall-runoff data. Draft paper presented in symposium of Institution of Engineers at Hyderabad, Andhra Pradesh.

Ministry of Agriculture (1972). Hand book of Hydrology, Ministry of Agriculture and co-operation, New Delhi.

Rathore, L.S. aand B.C. Bishwas (1989). Pan evaporation over India. Workshop on Evaporation from Open water surfaces, Vadodara, 7-14 November, pp. 61-68.

Soil Conservation Service, USDA. (1964). Hydrology, section-4, National Engineering Handbook, Washington, D.C. Revised Edition.

Sharma, S.D. (1983). Development of efficient drainage systems for canal command areas in Monsoon dominated rainfall regions. Ph.D. Thesis, IARI, New Delhi.

Selvarajan, M. (1990). Studies on ground water recharge through percolation ponds. Ph.D. Thesis, IARI, New Delhi.

Verma, N.H. (1987). Studies on efficient use of rainwater for rainfed crops. Ph.D. Thesis, IARI, New Delhi.

CONCEPT OF FARMING SYSTEMS FOR RISK MITIGATION IN RAINFED AGRICULTURE

K.A. Gopinath, Senior Scientist (Agronomy),
Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad

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.

References

AICRPDA- Arjia, 2006. Annual Progress Report of All India Coordinated research Project for Dryland Agriculture, Arjia, MPUA&T, Udaipur.

AICRPDA- Kovilpatti, 2006. Annual Progress Report of All India Coordinated research Project for Dryland Agriculture, Kovilpatti, TNAU, Tamil Nadu. p. 31-38.

Behera, U.K., Yates, C.M., Kebreab, E. and France, J. 2008. Farming systems methodology for efficient resource management at the farm level: a review from an Indian perspective. *Journal of Agricultural Science*, 146: 493-505.

CRIDA, 2008. Annual Report 2007-08. Central Research Institute for Dryland Agriculture, Hyderabad, India. 119p.

Ganesan, G., Chinnasamy, K.N., Bala Subramanian, A. and Manickasundram, P. 1990.

Jha, D. 2003. An overview of farming systems research in India. Annals of Agricultural Research, 24: 695-706.

James, B.K., Mishra, A., Mohanty, A., Rajeeb, K., Brahmanand, P.S., Nanda, P., Das, M. and Kiannan, K. 2005. Management of Excess Rainwater in Medium and Lowlands for Sustainable Productivity", Research Bulletin No. 24, Water Technology Center for Eastern Region l(ICAR), Bhubaneswar, India, 24p.

Korwar, G.R. 1992. Alternate land use systems. In: LL Somani (Ed) Dryland Agriculture in India- State of Art of Research in India. Scientific Publishers, Jodhpur, India. pp. 143-168.

Mahapatra, I.C. 1994. Farming system research – a key to sustainable agriculture. Fertilizer News, 39: 13-25.

Mahapatra, I.C. and Behera, U.K. 2004. Methodologies of farming systems research. In: Recent Advances in Rice based Farming Systems (Eds D. Panda, S. Sasmal, SK. Nayak, DP. Singh and S. Saha), pp. 79–113. Cuttack, Orissa, India: Central Rice Research Institute.

Mishra, A.K. 2002. Integration of livestock in land use diversification. In: Summer School on "Land Use Diversification in rainfed Agro-Ecosystem during 15 April – 5 May 2002, Central Research Institute for Dryland Agriculture, CRIDA.

Norman, D.W. 1978. Farming systems research to improve the livelihood of small farmers. American Journal of Agricultural Economics, 60: 813-818.

Osman, M., Venkateswarlu, B. and Singh, R.P. 1989. Agroforestry research in the tropics of India- A Review. In: RP Singh., IPS Ahlawat and Ganga Saran (Eds) National Symposium on Agroforestry Systems in India. Indian Society of Agronomy, New Delhi. pp. 18-35.

Patil, 1994. Annual Report of All India Coordinated Research Project on Salt Affected Soil and Use of Saline Water, Central Soil Salinity Research Institute, Karnal.

Rama Rao W.Y., Tiwari, S.P. and Singh, P. 2005. Crop Livestock Integrated farming system for augmenting socio-economic status of smallholder tribal farmers of Chhatisgarh in Central India. Livestock Research for rural Development 17(8): 1-4.

Reddy, M.D. 2005. Predominant farming systems and alternatives in Andhra Pradesh. In: AK Singh., B Gangwar and SK Sharma (Eds) Alternative Farming Systems. Farming Systems Research and Development Association, Modipuram. pp. 217-227.

Samra, J.S., Sahoo, N., Roy Chaudhary, S., Mohanty Rajib, K., Jena, S.K. and Verma, H.N. 2003. Sustainable integrated farming system for waterlogged areas of Eastern India. Research Bulletin No 14, WTCER, Bhubaneshwar, Orissa, 24p.

Shanmugasundaram, V.S. and Balusamy, M. 1993. Rice-fish-azolla - An integrated farming system in lowlying wetlands. Farming systems 9: 105-107.

Singh, H.P., Sharma, K.D., Subba Reddy, G. and. Sharma, K.L. 2004. Dryland Agriculture in India. In: "Challenges and Strategies for Dryland Agriculture"

CSSA special publication No. 32. Crop Science Society of America and American Society of Agronomy 671S. USA. p 67-92.

Subba Reddy, G. and Ramakrishna, Y.S. 2005. Farming Systems Modules in Rainfed Agriculture. In: AK Singh., B Gangwar and SK Sharma (Eds) Alternative Farming Systems. Farming Systems Research & Development Association Modipuram. pp. 250 110.

TAR-IVLP, 2003. Annual report of technology assessment and refinement through institute village linkage program (TAR-IVLP) under rainfed agro-ecosystem. Central Research Institute for Dryland Agriculture, Hyderabad, 94p.

TAR-IVLP, 2004. Annual report of technology assessment and refinement through institute village linkage program (TAR-IVLP) under rainfed agro-ecosystem. Central Research Institute for Dryland Agriculture, Hyderabad, 90p.

TAR-IVLP, 2005. Completion report of technology assessment and refinement through institute village linkage program (TAR-IVLP), Central Research Institute for Dryland Agriculture, Hyderabad.

BIOAGENT PRODUCTION LIVELIHOOD ENTERPRISES FOR SMALL FARMERS

Suseelendra Desai,
Principal Scientist, Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad 50059, A.P., India

Introduction

Crop plants are attacked by several foliar- and soil-borne organisms resulting in huge economic losses. Currently, the most widely used control measure for suppressing these diseases is the use of fungicides. However, pollution of our immediate environment due to repeated application of these chemicals and development of resistance by pathogens are major concerns that have given impetus to alternative disease management measures such as use of "biologically based disease management strategies". One approach to such biologically based strategies is use of environmentally safe biocontrol agents (BCAs) in conjunction with integrated pest management (IPM) strategies. In addition, BCAs also play a predominant role in organic agriculture where there is no scope for use of chemical pesticides.

Biological control could either be through enrichment of native BCAs by adopting cultural practices such as organic amendments or by introducing BCAs. Introduction of BCAs for the control of plant diseases has been practiced in agricultural fields since at least 1927 (Millard and Taylor, 1927). Over the intervening years, from hundreds of biological control agents identified as potential candidates, by even late 80's, only about 5% of BCAs have actually achieved their commercial targets (Justum, 1988). However, due to increased awareness building efforts on one hand and inability of fungicides to manage burning soil-borne pathogens has led to increased dependence on some products based on *Trichoderma* spp. or *Pseudomonas* spp. in recent years.

While the demand for these products increased, proportionate increase in availability of quality products did not take place resulting in spurious products occupying the market and thereby shattering the hopes of desperate farmers.

To bridge this gap between demand and supply, there is a very good scope for new entrepreneurs who would like to make it as their career. However, to run the enterprise successfully, there is a need to have a complete understanding of the whole system from research through extension.

An in-depth analysis of a candidate BCA brings out its strengths, weaknesses, and opportunities, thereby aiding in proper selection and deployment of BCAs for exploitation of their potential. The three major steps involved in the development of a successful BCA are research, development and extension. Testing must begin with the identification of the BCA and continue to the commercial product. In this chapter, an effort has been made to give an overview of entrepreneurship development for production of biocontrol agents.

Identification of promising strains

The BCAs exhibit different modes of action and hence, a good testing program should elucidate all the mechanisms involved in the biocontrol activity of the BCA. Apart from biocontrol ability, the BCAs possess other traits such as rhizosphere competence, tolerance of fungicides, saprophytic competitive ability, ability to tolerate high- and low-temperatures, adaptability to different edaphic conditions etc. These traits are useful for an otherwise good BCA as they help in the establishment of the BCA in a given agro-ecological region. Several protocols have been developed for the identification of a BCA that could be broadly classified as *in vitro* and greenhouse and field tests.

Fungal BCAs exhibit several modes of biocontrol ability such as mycoparasitism, competition, production of hydrolases and antibiosis. All the *in vitro* tests have been designed for identification/selection of potential BCAs, and elucidate biocontrol mechanisms of known BCAs. For instance, methods such as dual culture, sclerotial parasitization and soil tube methods are useful for identifying the mycoparasitism and competition phenomena. Under simulated conditions BCAs are checked for volatiles and non-volatiles to comprehend the production of cell wall degrading enzymes and antibiotics. Testing for rhizosphere competence and competitive saprophytic ability, and ability to tolerate fungicides will help in characterizing the BCAs for their other desirable traits. These *in vitro* tests have been successfully used against all groups of BCAs. Some BCAs are known to induce resistance and plant growth. In addition to the above traits, testing the BCAs for other desirable traits such as growth on different substrates, production of different survival structures (chlamydospores, sclerotia, spores, hyphal fragments), tolerance of different ambient, and edaphic conditions (high and low temperatures; soil-moisture-deficit stress, soil salinity, soil alkalinity, soil acidity, water-logged conditions) could be useful for not only their characterization but also their need-based deployment.

Evaluation of BCAs

The performance of a BCA could be specific either to location and or a pathogen. Alternatively, a few BCAs can perform across locations and against more than one pathogen. In both situations, tests must be conducted thoroughly to assess the actual potentiality of a BCA so that it can be maximally exploited and several methods are available for such evaluation. Out of several isolates of a BCA, only a few may qualify for greenhouse and field-testing. The main objectives of greenhouse and field-testing are

To select active BCAs which control a spectrum of plant pathogens

To evaluate selected BCAs under a set of environmental conditions and

To evaluate test formulations and application methods

Once the objectives of screening are clear, screening in greenhouse and field should ensure enough and known plant pathogen population to induce sufficiently high disease pressure. These tests are also influenced by choice of BCA, testing environmental conditions, choice of cultivars, type of formulation, application method, and method and time of disease assessment. Simulation of testing situations gives an opportunity for the effective evaluation of a BCA. In all these cases, the BCA can be applied as seed treatments or directly to the soil. Soil application would be highly effective and cost effective in cases of transplanted crops where the nurseries would be protected and during which time the BCA could establish on the roots, thus protecting the crop even after transplanting. The method of application of a BCA depends on the type of pathogen to be managed, stage of crop to be protected, nature and spread of disease in a region, and the climatic conditions of the region. An attempt has been made here to discuss the principle behind testing of a BCA.

Commercialization of BCA

The commercialization of a BCA is significantly influenced by the consistent performance, persistence, safety, stable formulation, application method, viable market size, preferably low costs of production, and preferably low capital costs. Testing is required for large-scale multiplication of the BCA, development of formulations, evaluation of their efficacy, demonstration of the benefits of using biopesticides to the end users, and assessment of the performance of the technology and its refinement back in the laboratory. For undertaking these activities, a strong network of scientist-industry-extension-farmer is required.

For industries to commercialize BCAs, they need model studies for the large scale multiplication, type of formulation, nature of filler material, delivery systems, optimum storage conditions of the product and information on shelf life. Often, dusts contain about 5-10 per cent colony forming units (cfu) of BCA by weight, wettable powders might have 50-80 per cent cfu by weight, granular formulations might contain 5-20 per cent cfu by weight and liquid formulations contain about 10-40 per cent cfu by weight. The testing protocols hence, must consider the optimum formulation type as well as concentration of BCA. Certain specific conditions might increase efficacy of a formulation. Addition of organic acids to *T. koningii* formulations and polysaccharides and polyhydroxyl alcohols to *T. harzianum* increased the activity of the BCAs. Several researchers reported a variety of substrates for multiplication, and formulation. However, the most popular technology for formulation remains to be talc based formulation. Of late, farmers are demanding for liquid formulations as they are easy to transport and equally good.

Quality control and quality assessment

One of the major bottlenecks for the wide spread adaptation of the BCAs in production systems is development of reasonable quality control steps. Biological control is a very complicated natural phenomenon and it requires a thorough understanding of the process for maintaining required order of quality and to design required regulations. A number of criteria have to be fulfilled to develop a high quality BCA product such as maintenance of a pure culture, good mass multiplication facilities, optimum formulation practices and appropriate storage conditions. Contaminated cultures, bad fermentation and formulation conditions would lead to growth other microbes thus reducing the final optimal population counts of the BCA. For instance, solid-state fermentation, though simple and easy, is a potential source of cross contamination as it is often difficult to maintain sterile conditions. Products formulated using such biomass fail to give expected results and also show variations between batches. On the contrary, liquid fermentation can offer production of pure biomass for formulation. Another concern to the maintenance of quality is the emergence of a lot of small time entrepreneurs who do not possess required facilities and so market spurious products in the name of biocontrol agents. Though, biological control helps in managing some pathogens, such practices will lead to loss of faith of farmers in biological control. These problems could be overcome if, proper care is taken to establish good fermentation and formulation facilities and stringent regulatory systems are in place.

Extension approaches

For each of the BCA formulations developed, its utility has to be demonstrated under field conditions. Such demonstrations need a good team of subject matter specialists who can interact with the growers and get a feed back so that the technology is assessed for its impact and refined to suit the exact needs. For acceptance and wide spread use of a technology, a proven BCA should be demonstrated among progressive farmers who are generally enthusiastic. Where, the technology has been useful, it has been accepted straight away by the farmers. These beneficiaries are imparted training at the research centers and also on their own fields. These farmers transfer the technologies to their colleagues. In addition, there is a need for awareness building about the beneficial effects of BCAs among the farmers on regular basis to keep their interest in the products.

Regulatory requirements

With the growing demand for use of biopesticides, several nations including the USA, Canada and India have developed guidelines for the regulated use of the biopesticides. At the regulatory level, testing protocols should emphasize the criteria for the registration of BCA as biopesticides, the legal aspects of the registration, safe handling of the antagonists and mechanisms to monitor the introduced microbes. Strains of BCA would be treated as pesticides and thus while processing for registration, a special care has to be given to the generation of only need based toxicological data to reduce costs. All along, the emphasis on BCAs has been that they are eco-friendly. Hence, while considering the registration of the biopesticides, care must be given to show that the formulations are not going to be harmful to mammals over time. For instance, *Trichoderma* has been one of those considered to be an opportunistic human pathogen. Larson et al (1996) reported that *T. viride* spores at relatively high concentrations (0.1-2 mg/ml) triggered histamine release from bronchoalveolar lavage cells.

Registration of BCAs

A range of BCAs including fungi as active ingredients are now commercially available in many countries for control of fungal and bacterial diseases. The regulatory requirements have been generally favorable and less stringent to BCAs than chemicals. Registration of BCAs with a federal or central regulatory agency is mandatory before its release to end-users. While in the Europe OECD norms are followed for biopesticides (OECD, 1996). In the United States, the US Environmental Protection Agency (EPA) regulates biological pesticides or biopesticides (U.S. EPA, 1989). The generic and product-specific data requirements for biological pesticides appear in Title 40, Part 158, of the Code of Federal Regulations (CFR). A complete description of all data requirements and study protocols for biological pesticides is presented in the Pesticide Assessment Guidelines, Subdivision M: Guidelines for Testing Biorational Pesticides. The Government of India in its notification of 8-15/99-CIR, dated 02.08.1999 has allowed for the registration of two types of biopesticides under section 9(3) of the Insecticides Act of 1968, provisional and regular.

Environmental risk assessment studies

While assessment of environmental impact of a chemical molecule may take about 7-8 years and cost a few million dollars, the information required for the registration of BCAs is relatively less, as they are primarily considered bio-safe as opposed to chemicals. This evaluation cost is one of the major factors in commercialization of BCAs. A well-designed regulatory process prevents introduction of such BCAs or their products that are potentially dangerous to environment thus allowing release of all useful products without any unwarranted delays and develops on its own based on past experience. The environmental impact studies vary depending on whether the BCA is indigenous or not; natural isolate or genetically modified; a known pathogens of crops, humans and other mammals; and activity spectrum of the BCA. For instance, Agriculture and Agri-Food Canada have given a detailed account of the efforts being made in Canada for developing a four-tier testing procedure used for the assessment of risk of the microbial pesticides and their products.

Compatibility testing

The success of a BCA depends on its compatibility with other disease management systems. This requires a holistic testing of BCA in combination with other disease management practices in a systems approach. Once the BCA is found to be compatible, it can successfully be integrated with the integrated disease management modules for each of the cropping systems. Sankar and Jeyarajan (1996) found that *Gliocladium* and *Trichoderma* were compatible with *Azospirillum. T. harzianum*, *Rhizobium* and carbendazim were successfully integrated for the management of stem rot of peanuts caused by *S. rolfsii* (Muthamilan and Jeyarajan, 1996). Addition of *T. harzianum* up to 5% resulted in 92% protection without affecting nodulation. Integration of *T. harzianum* with a sub-lethal dose of methyl bromide (300 kg/ha) and soil solarization yielded a maximum control of *Fusarium* crown and root rot of tomato caused by *F. oxysporum* f.sp. *radicis-lycopersici* (Sivan and Chet, 1993). Application of *Bacillus subtilis, Bradyrhizobium japonicum* and *Glomus fasciculatum* either used alone or in combination increased shoot dry weight, number of nodules, phosphorus content, and reduced nematode multiplication and wilting index (Siddiqui and Mahmood, 1995). The BCAs earlier identified were integrated into an IDM module for the management of leafspots and rust (Ghewande et al., 1993) in which one spray of either colony forming units of *Penicillium islandicum* or *Verticillium leccanii* or their culture filtrates was both beneficial and compatible with other components such as a spray each of fungicides and 2% neem leaf extract.

Conclusion

Entrepreneurship development in biofungicide production has a very good scope provided qualified graduates take it up as a career as they can appreciate the nuances of quality in production, formulation and storage. Qualified entrepreneurs can reduce the risk of propagating wrong organisms as BCAs. For instance, both *Trichoderma* and *Aspergillus flavus* produce green color colonies. However, the former is a beneficial organism while the latter is a serious mycotoxigenic fungus. By undergoing 'hands on' training, the young entrepreneurs can learn the techniques and develop unto successful entrepreneurs.

Selected Readings

Millard, W.A. and Taylor, C.B. 1927. Antagonism of microorganisms as the controlling factor in the inhibition of scab by green manuring. Ann. Appl. Biol. 14: 202.

Justum, A.R. 1988. Commercial application of biocontrol: status and prospects. Philosophical Trans. Royal Soc. London, series B, 318:357-373.

OECD. 1996. OECD Data requirements for registration of Biopesticides in OECD member countries: survey resutls. Environment Monograph No. 106, Paris, France.

U.S. EPA. 1989. U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Subdivision M of the Pesticide Testing Guidelines: Microbial and Biochemical Pest Control Agents. Document No. PB89-211676. National Technical Information Service, U. S. Department of Commerce, Springfield, VA.

Sankar, P. and Jeyarajan, R. 1996. Compatibility of antagonists with *Azospirillum* in sesamum. Indian Phytopathol. 49: 67-71.

Muthamilan, M. and R Jeyarajan, R. 1996 Integrated management of Sclerotium root rot of groundnut involving *Trichoderma harzianum*, *Rhizobium* and carbendazim. Indian J. Mycol. Pl. Pathol. 26: 204-209.

Sivan, A. and Chet, I. 1993. Integrated control of *Fusarium* crown and root rot of tomato with *Trichoderma harzianum* in combination with methyl bromide or soil solarization. Crop Prot. 12:380-386.

Siddiqui, Z.A. and Mahmood, I 1995. Biological control of *Heterodera cajani* and *Fusarium udum* by *Bacillus subtilis*, *Bradyrhizobium japonicum* and *Glomus fasciculatum* on pigeonpea. Fundamental Applied Nematol. 18:559-566, 1995.

Ghewande, M.P. Desai, S., Prem Narayan and Ingle, A.P. 1993. Integrated management of foliar diseases of groundnut (*Arachis hypogaea* L.) in India. Intl. J. Pest Mangt. 39:375-378.

Larsen, F.O., Clementsen, P., Hansen, M., Maltbaek, N., Gravesen, S., Skov, P.S., and Norn, S. 1996. The indoor microfungus *Trichoderma viride* potentiates histamine release from human bronchoalveolar cells. APMIS 104:673-679.

ALTERNATE LAND USE SYSTEMS IN CPR'S AND PPR'S FOR IMPROVING LIVELIHOODS

GR Korwar, Head (DRM)
Central Research Institute for Dryland Agriculture
Santoshnagar,Hyderabad – 500 059

Introduction

"Agroforestry (AF) is a collective name for land-use systems in which woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between trees and other components of the system" (Lundgren, 1982). This definition implies that: **agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is woody perennial;**

an agroforestry system always has two or more outputs;

- the cycle of agroforestry system is always more than one year; and
- even the simplest agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a monocropping system.

The practice of trees and arable crops together on the same piece of land is an age-old practice with the Indian dry land farmers. Agroforestry results in multiple products, increases income, reduces runoff and soil loss, utilizes off-season rainfall and radiation and gives stability to dry land agriculture. Further it makes the future generation farmers to inherit not only the land of their predecessors, but also the wealth of standing biomass of trees. Several studies have been carried out on oilseeds as intercrops in agroforestry systems. The oilseed intercrops can be grown in alley cropping system, intercropping with nitrogen fixing trees, agrisilviculture, agrihorticulture and other agroforestry systems (Singh et al, 1987)

Agro Forestry Based Systems

The agri-silviculture system is recommended for land capability class IV with annual rainfall of 750 mm. A large number of tree-crop combinations, particularly of N fixing trees with sorghum, groundnut, castor and pulses were evaluated in Alfisols and Vertisols. Short duration dryland crops such as pearl millet, black gram and green gram, combined with widely spaced tree rows of Faiderbia albida and Hardwickia binata, have been found compatible in semi-arid tropical areas (Korwar, 1992).

In Andhra Pradesh agroforestry with Leucaena + sheep based AF system gave better returns than Leucaena + arable crops based AF system.

Grass component in agri-pasture and silvi-pasture systems was more profitable than the arable farming. Economic evaluation of the above alternate land use enterprises vis-à-vis dryland crop cultivation was carried out by CAZRI, Jodhpur, taking 18 years as an effective period. The entire tree based systems showed higher benefit-cost ratio over the pure arable farming.

At CRIDA, the horti-pastoral system with Cenchrus / Stylos in rainfed guava and custard apple, Cenchrus yielded dry forage 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 Pearl millet + pigeon pea (Solapur), Pigeon pea + black gram (Rewa), Castor (Dantiwada) and Cluster bean (Hyderabad) showed promising results in rainfed environment. Ber on an average gave 40 kg fruits/tree along with the 100 kg of horse gram and 450 kg of cowpea cultivated in interspaces (Osman et al., 1989). Radhamani (2001) reported the additional employment gains (314 man-days / year) through integrated farming system with crop + goat under rainfed vertisols.

In 21st Century, stability in crop production and income is likely to occur because of land use diversification. A matrix of possible land uses as influenced by the resource carrying capacity is recommended for future.

The Agri-horti-silvi-duckery-fishery system studies North East India showed that multi enterprise model comprising cereal crops, pulses, oil seeds, horticultural crops such as mango and pineapple, vegetables crops and livestock components of duckery, piggery, and fishery with harvesting structures in 1 ha land gave 5 times more profitable than traditional mono crop rice cultivation which gave maximum production of 1t/ha of rice (Rs.5000-6000/ha/year).

The studies were conducted by BAIF in Navsari and Valsad districts of South Gujarat. A farming systems approach is followed in the Wadi programme. Hence the sources of income include orchards and other on-farm enterprises of the family **(**Table 1).

In most of the project villages, potable drinking water availability is round the year. Availability of water, fuel and fodder has substantially increased. Hence the time required for women to fetch drinking water, fuel and fodder is reduced by 50%. This reduces the drudgery of women who are generally responsible for fetching water, fuel and fodder. Another impact is availability of gainful self-employment opportunities within the watershed.

Other major impact is environmental conservation. Soil conservation, increase in vegetation cover and diversity, crop diversity and several other direct and indirect impacts are created contributing to enrich the ecosystem health.

Tree Based Farming

The marginal lands or the lands, which are not capable of supporting the field crops, can be best converted into the tree-based farming. With the treatment measures, soil fertility and moisture level can be enhanced. With the availability of water for protective irrigation orchards, agri-horti-forestry becomes viable option in such area.

A typical model developed by BAIF over a period of two decades, consists of establishing drought tolerant fruit crops such as mango, cashew, Indian- gooseberry, tamarind, custard apple or ber on marginal land covering 0.4 to 1.0 ha by the family.

The interspaces are used for cultivating arable crops grown by them earlier. Hardy shrubs and trees useful for fodder, fuel, timber and herbal medicines are established on the field bunds and borders while some thorny species are planted on the outer boundary to serve as a live hedge-cum-windbreak.

Each component in the system has been developed thoughtfully and tested in the field. Below is a brief description of the interventions in the farm of a family:

- The soil conservation measures within and around plot are taken up to improve the nutritional and moisture status of the soil for better productivity.
- Water resource development is a key activity, for nurturing fruit trees. Integrated area development approach is adopted for developing the water resources. The planning is done in such way that at least the orchards get assured water supply. In addition it also provide support for two crops. In this process, the basic requirement of clean water for human and livestock consumption is also met, reducing the incidences of illness and drudgery of women.
- Fruit trees are established over a period of five years start yielding thereafter and remain the source of income for a long duration. Minimum two species of these tress are planted to ensure the production of at least one, even if the other fails due to unpredictable natural conditions.

The forestry plants along the border of the plot are selected to ensure the assured availability of fuel wood for domestic use and fodder for the livestock. There is also enough income from the timber through this intervention. Along with bushes, it serves the purpose of live fence.

- Since the gestation period of fruit trees is five to six years, the intercrop in the plot continue to suffice the dietary needs of family. Rather the crop production increases between 25 to 80% due to improved availability of water and better soil moisture and nutrients. Farmers are advised to use improved seeds and adopt eco-friendly agricultural practices such as green manuring, vermicomposting and mulching to improve soil productivity. Integrated Pest Management practices are also adopted, while utilising traditional knowledge to protect the crops.

While developing their own plots, families are trained in the skills of nursery raising and grafting. This skill acquired gives them opportunity to develop the nurseries and grafts and sale it in the market.

Systems with multiple Enterprises (Crop + Goat + Silviculture)

A system involving crop, animal and silviculture has been the right combination of enterprises that existed even in early periods of agricultural development. An animal like the goat, which feeds on all types of vegetation, is a hardy species that can withstand the adverse climatic conditions of drylands. Besides it can provide additional returns to farmer. The manure can aid in improving the soil fertility.

Radhamani (2001) studied integrated farming systems involving three cropping systems with *Ailanthus excelsa* + crop + goat, *Ceiba pentandra* + crop + goat and *Embica officinalis* + crop + goat to identify the most suitable component linkage. Integration of sorghum + cowpea (grain or fodder) and *Cenchrus glaucus* intercropped in *Emblica officinalis* with goat had highest productivity and economic returns under Coimbatore conditions. The highest B: C ratio and employment generation was also found in this system.

In drylands of Karnataka, mango orchards are very suitable for adopting sustainable farming system with cattle or sheep or goat along with intercrops of ragi or groundnut or horse gram, which is extensively followed in traditional mango belts of

Srinivaspur, Mulbagal and Chintamani taluks of Karnataka. Some more components like bamboo can also be added to make the system more sustainable. Even cashew and tamarind trees are commonly interspersed with mango trees. In Bijapur and other places of North Karnataka, grapes, which are fast depleting ground water resources, need to be replaced with pomegranate, ber and amla along with regular crop components and goat as an animal component. In Bellary, along with dryland orcharding + crop, piggery can be thought of.

Similar to mango orchards, a vast number of coconut orchards can be brought under sustainable farming systems in Deccan Plateau with careful selection of right combination of enterprises. However, established orchards do not permit cultivation of sun-loving crops. But fodder crops can be successfully cultivated in the monsoon period.

There are many Silvipastopral systems involving trees, pastures and or animals, their description and main characteristics are listed in Table 2. Similarly Agrosilvopastoral systems (trees + crops + pasture / animals) are listed in Table 3. In rainfed lands of arid and semiarid regions raising shelter belts, wind breaks; growing NFTs in field, raising woodlots (NFTs) on degraded lands would be priority agroforestry systems (Table 4)

Table. 1 Annual Income (INR) Through Agri-horti-forestry Programme at Various Stages

S.No.	**Source of Income**		**Age of Orchard**	
			6-7 Years	**14-15 Years**
I	Income from Core Wadi activities			
	a	Fruit Trees (Cashew and Mango)	2,700	13,500
	b	Intercrops in Orchards	5,000	6,000
	c	Forestry		4,400
	d	Livestock		7,200
	Sub-Total I		7,700	31,100
II		Other Enterprises* (Fruit Nursery, Forest nursery, Vermicompost, etc.)	1,400	12,000
	Sub-Total II		1,400	12,000

**Other Enterprises: This includes average income from other enterprises promoted through the Wadi program. It is observed that about 40% families take-up such enterprise.*

Table 2. Silvopastoral systems (trees + pasture and/or animals)

AF Practice	**Brief Description of arrangements of components**	**Major groups of components**	**Agroecological adaptability**
1. Trees on rangeland or pastures	Trees scattered irregularly or arranged according to some	w: multipurpose; of fodder value	Extensive grazing areas

	systematic pattern	f: present a: present	
2. Protein banks	Production of protein rich tree fodder on farm/rangelands for cut-and-carry fodder production	w: leguminous fodder trees h: present	Usually in areas with high person: land ratio
3. Plantation crops with pastures and animals	Example: cattle under coconuts in south-east Asia and the south pacific	w: plantation crops f: present a: present	In areas with less pressure on plantation crop lands

Table 3. Agrosilvopastoral systems (trees + crops + pasture/animals)

AF Practice	Brief Description of arrangements of components	Major groups of components	Agroecological adaptability
1.Homegardens involving animals	Intimate, multistory combination of various trees and crops, and animals, around homesteads	w: fruit trees Predominate; also other woody species a: present	In all ecological regions with high density of human population
2. Multipurpose woody hedgerows	Woody hedges for browse, mulch, green manure, soil conservation, etc.	w: fast-growing and coppicing fodder shrubs and trees h: (similar to alley cropping and soil conservation)	Humid to subhumid areas with hilly and sloping terrain
3. Apiculture and trees	Trees for honey production	w: honey producing (other components may be present)	Depending on the feasibility of apiculture
4. Aquaforestry	Trees lining fish ponds, tree leaves being used as 'forage' for fish	w: trees and shrubs preferred by fish(other components may be present)	Lowlands
5. Multipurpose woodlots	For various purposes (wood, fodder, soil protection, soil reclamation, etc.)	w: multipurpose species: special location-specific species (other components may be present)	Various

W= woody; h= herbaceous; f = fodder for grazing; and a = animals

Table 4. Main Characteristics and Agroforestry Emphasis in the Arid and semi-arid region of India

Characteristics	Details
Climate	Dry-humid to very hot, sub-humid; rainfall in arid 40-65 cm; in semi-arid 70-125 cm
Geographical spread	Spreads over Rajasthan, Gujarat, Punjab, Haryana, parts of U.P., M.P., A.P., Maharashtra, Karnataka and T.N.
Soils and vegetation	Sandy to clay loam; xerophytic thorny scrub forests and woodlands and pasmophytic scrub vegetation, grazing lands
Main land-use systems	Trees and shrubs in crop fields and along boundaries permanent grazing lands having trees and shrubs with stunt growth
Main land-use and ecological problems	Drought, overgrazing, salinity, extension of sand dunes, low water table, soil erosion, degraded lands
Major Agroforestry emphasis	Raising shelter belts, wind breaks; growing NFTs in field, trees on pasturelands, raising woodlots (NFTs) on degraded lands

References

Korwar, GR (1992). Alternate land use systems. In LL Somani, et al., (Ed) Dryland Agriculture in India State of Agricultural Research in India. Scientific Publishers, Jodhpur, India p. 143-168.

Osman, M., Venkateswarlu, B. and Singh, RP. (1989). Agroforestry research in the tropics of India a Review. In Natyional Symposium on Agroforestry Systems in India. CRIDA. Hyderabad.

Radhamani, S. (2001). Sustainable integrated farming system for dryland vertisol of Western Zone of Tamil Nadu PhD. (diss) Tamil Nadu Agricultural University, Coimbatore.

Singh Gurubachan, (2005). Farming Systems Options in sustainable management of natural resources. Published in Alternate Farming Systems: Enhanced Income and Employment Generation Options for Small and Marginal Farmers (Ed) Singh, AK. Gangwar, B. and Sharma, SK. Farming Systems Research & Development Association

Modipuram 250 110, Meerut, UP, P. 80-94. Proc. Of a Symposium 16-18 September, 2005.

Singh RP, Vijayalakshmi K., Korwar GR and Osman M (1987). "Alternate land use systems for drylands for India". Research Bulletin No. 6. CRIDA, Hyderabad.

Subba Reddy, G., and Ramakrishna, YS (2005). Farming Systems Modules in Rainfed Agriculture, Published in Alternate Farming Systems: Enhanced Income and Employment Generation Options for Small and Marginal Farmers (Ed) Singh, AK. Gangwar, B. and Sharma, SK. Farming Systems Research & Development Association Modipuram 250 110, Meerut, UP, P. 65-71. Proc. Of a Symposium 16-18 September 2005.

SEED VILLAGE – CONCEPT AND PRACTICE

V.MARUTHI, Principal Scientist (Agronomy),
Central Research Institute for Dryland Agriculture
Hyderabad

Seed is the major contributing factor (15-20%) in realizing sustainable yields especially from Drylands. In order to produce sufficient food to the rising population, provision of quality seed and at appropriate time is critical for the producers. Though GOI has realized the importance of quality seed and its availability, set the mechanism of seed improvement, seed multiplication, certification, processing and storage at all the area levels, occurrence of extreme weather events upset the balance we achieved. Therefore, as a forward contingent plan of supplying quality seed at relevant time does have contingent measures.

A village, wherein trained group of farmers are involved in production of seeds of various crops and cater themselves, fellow farmers of the village and farmers of neighboring villages in appropriate time and at affordable cost called "a seed village".

Concept

- Organizing seed production in clusters
- Replacing existing local varieties with the alternate high yielding varieties
- Increasing the seed production
- To meet the local demand, timely supply and reasonable cost
- Self sufficiency and self reliance of the village
- Increasing the seed replacement rate

Features

- Seed is available at the door steps of farms at an appropriate time
- Seed availability at affordable cost
- Increased confidence among the farmers about the quality because of known source of production
- Producer and consumer are mutually benefited
- Facilitates fast spread of suitable cultivars of different kinds

Seed production of different crops

Seed village concept is to promote the quality seed production of foundation and certified seed classes.

Selection of area

The area with the following facilities will be selected.

1. Irrigation facilities
2. Suitability of climatic conditions to raise the crop for more than one season
3. Labour availability
4. Knowledge of local farmers on that particular crop
5. Occurrence or out break of pest and diseases
6. Past history of the area for suitability to raise seed crop
7. Average rainfall and distribution
8. Closeness to an urban area for easy movement of seed and other inputs

Seed supply

Suitable area for seed production (Rice, Pulses and Oilseeds) will be identified by the Scientists. The foundation / certified seeds will be supplied by the University through Krishi Vigyan Kendras (KVKs) and Research Stations to the identified farmers in the area. The farmers will use these quality seeds and take up their own seed multiplication in a small area (1acre) for their own use.

Capacity building

In order to harness the synergy between technologies and the community participation, special emphasis is to build farmers' capacity to produce quality seeds. Training on seed production and seed technology to farmers for the seed crops grown in the seed villages will be given for technology empowerment of farmers.

Training on Isolation distance, sowing practices, seed treatment, Identifying offtypes and removal, maintenance of seed plots measures durinfg flowering, maturity status and harvesting methods. After harvest, Seed cleaning, grading, seed treating, bagging and storage, sampling and sending to seed testing laboratory for analysis etc.

A seed grower forum will be organized for further empowerment of technology and marketing.

Establishing seed processing unit

Post-harvest seed handling is a vital component of the total technology in marketing available good quality & improved varieties. If the seeds are not processed and handled properly, all the past efforts in production make seed processing and packaging a very important aspect in seed production.

Seed processing centers is based on the available infrastructure and convenience. Each seed processing centre will have the following infrastructure.

- Seed garden cum cleaner
- Bag closer, trolleys, scales and furniture
- Building to house equipment
- Seed storage structure
- Seed threshing and drying yard
- Information centre

The information centre will have internet facility to provide access to information on seed demand and agriculture market index, weather forecast, plant protection measures etc.,

Advantages of seed village concept approach:

1. Solve the problem of isolation. Mainly in cross pollinated crops like maize, sunflower where the required distance is the problem will be solved by raising a single variety in a large area.
2. Mechanization is possible from sowing to harvesting
3. Post harvest handling of seed is easy
4. Because of a single variety, the problem of varietal admixture during processing, drying will be avoided
5. Seed certification official will cover large area per unit time
6. Totally it reduces the cost cultivation
7. Seed will be with high genetic, physical purity

Practice in Anantapur District

Groundnut Seed (K6) was obtained on loan basis from the State Agricultural University (SAU) with a Buy Back Agreement for Pampanur village of Anantapur district and distributed to 13 farmers for 25.6 ha. Further farmers agreed to return 1.5 times the quantity of seed originally received as seed material. Therefore, seed material for 334 ha was produced for the ensuing season.

LIVESTOCK INTEGRATION FOR IMPROVING LIVELIHOODS OF RURAL POOR

D.B.V.Ramana, Sr. Scientist (LPM), Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad-500 059

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.

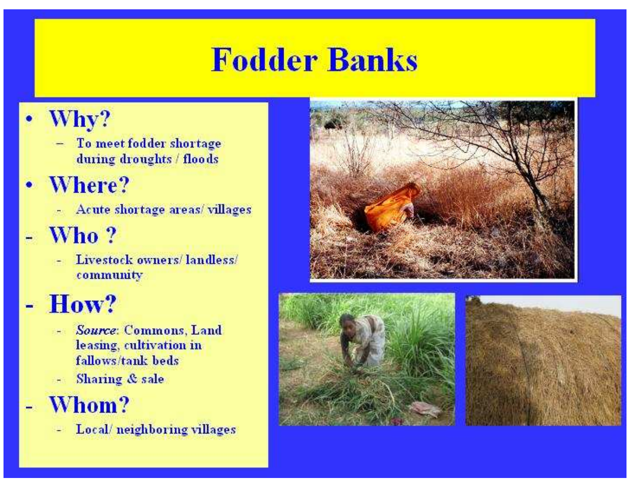
Further, increased human population growth and increasing urbanization, will significantly drive the demand for animal foods. Over the last two decades, the country evidenced with significant increase in expenditure share (from 10.01 and 3.43 in 1972-73 to 15.03 and 5.22 in 1993-94, respectively) towards 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.

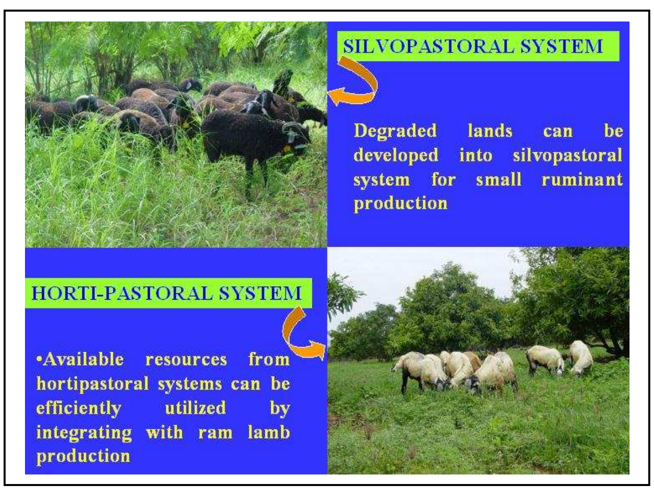


Fodder production from arable lands: Non-availability of arable land has been severely affecting the area under fodder cultivation. As a result, the green fodder availability both qualitatively and quantitatively is much lower than requirement and leading to many nutritional deficiencies ranging from 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).

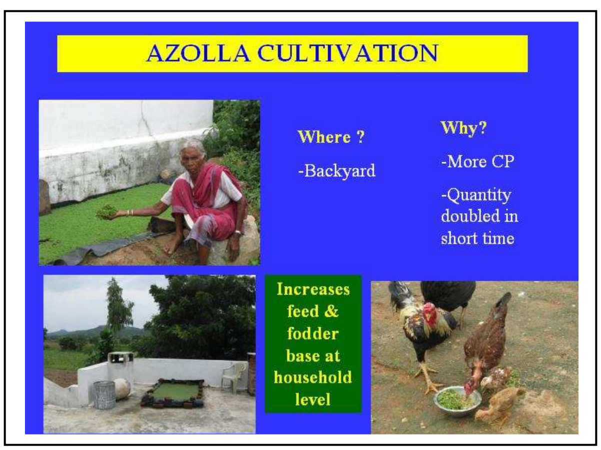
Development of integrated production systems: It is an efficient and integrated land use management system of agricultural crops, horticultural/forest tree species and or livestock simultaneously on the same unit of land like silvopastoral , hortipastoral systems, which results in an increase of overall 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.

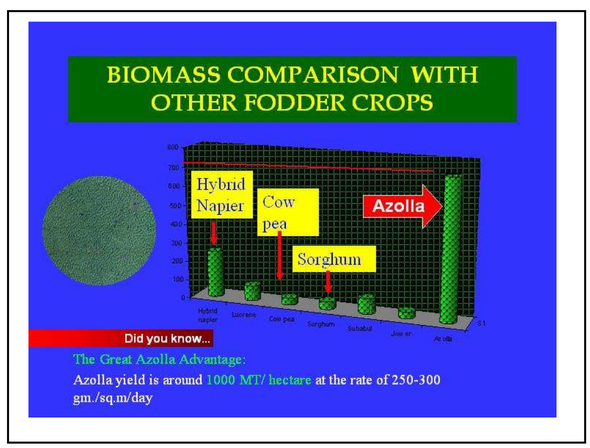
Annual and perennial crops: Relatively more attention will need to be given to mixed (crop-livestock) farming systems that involve annual crops, not only because of the importance of rice and wheat as food staples, and the opportunity to integrate annual legumes into the cereal cropping to develop food–feed 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.

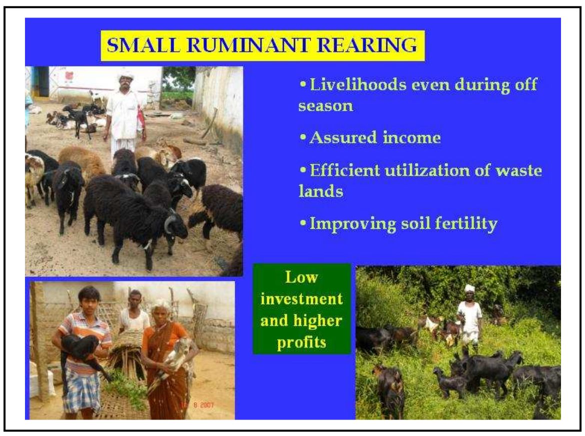
Judicious Use of Deworming Drugs: Para worker undertakes mass deworming of a particular flock depending on the faecal examination report. Deworming will be carried with the help of drenching gun, which prevents wastage of valuable drugs.

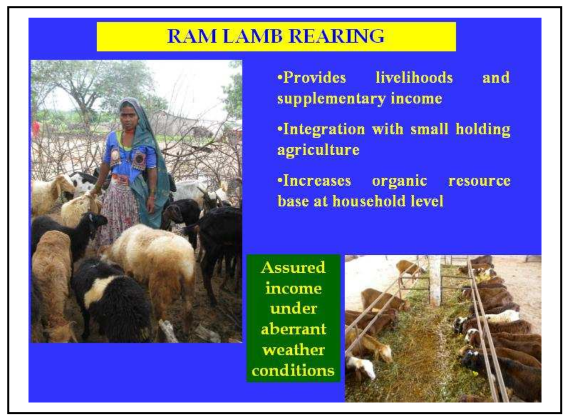
Timely Immunization: In every cluster village, the CIG was made responsible for indenting well in advance for required quantity of vaccines and deworming drugs in consultation with the local VAS, which was facilitated by the project staff. This resulted in timely availability of vaccines and vaccination 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.

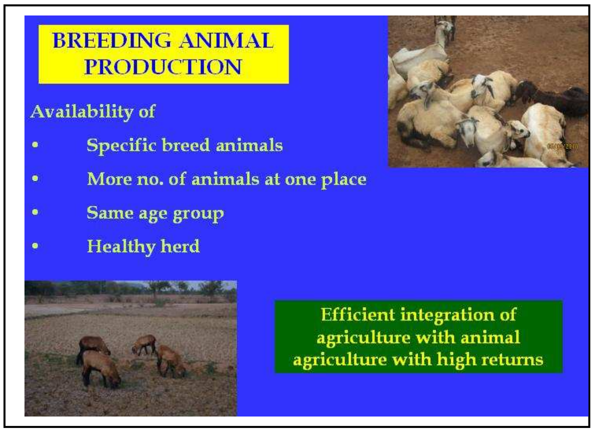
Intensification of small ruminant based livestock production systems

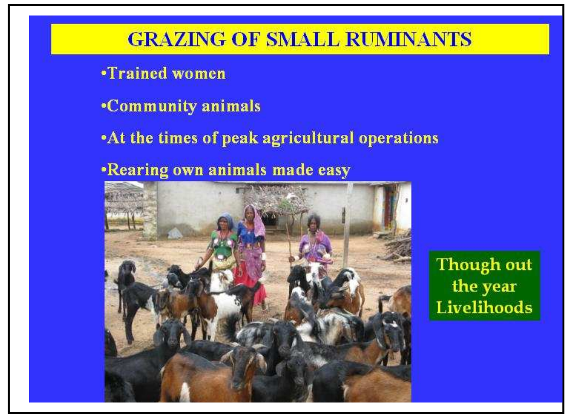
Initially women from SHGs who are otherwise engaged as daily labour were selected and trained through specially designed programme on ram lamb rearing or production as livelihood activity. Nellore ram lambs aged 3-4 months were procured from near by villages, insured under *Jeevarakshanidhi* a state 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

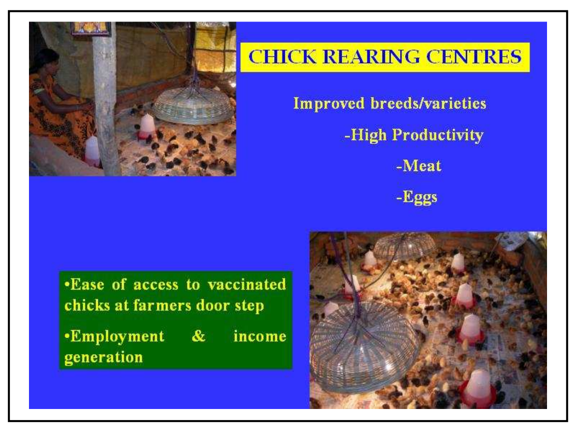




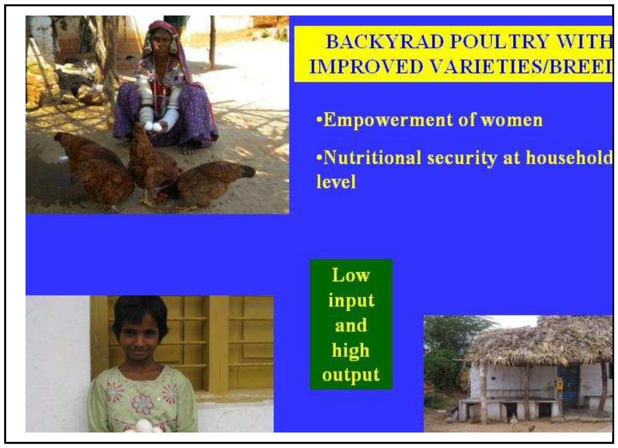
supplementation of concentrate mixture as per the recommendation of the project staff and VAS. An agreement was made with in the group that only one member on rotational basis should take all the animals for grazing everyday. The SHGs were closely monitored by the project staff with respect to feeding 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



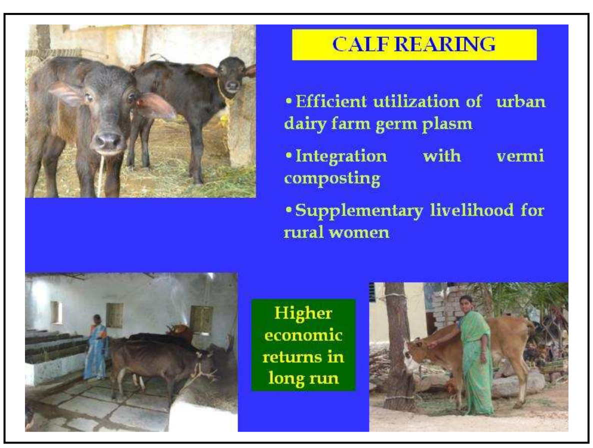
for chick rearing in each village and organized training program on chick rearing including vaccination. SHG members established chick rearing centers in one cluster villages to rear day old chicks for 6 weeks. Vaccination against all the major endemic diseases was completed during this period either 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.

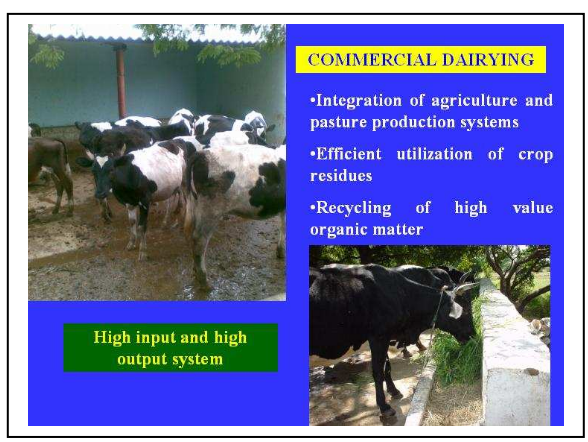


The 6 weeks old chicks were sold to the trained women farmers in the same village and performance of the chicks was regularly monitored. Some of the fertile eggs produced from these birds were hatched with *Desi* (local non-descript type) hen. Further, vaccination and day to day health care services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

Exploitation of genetic potential in milch animals through supplementation

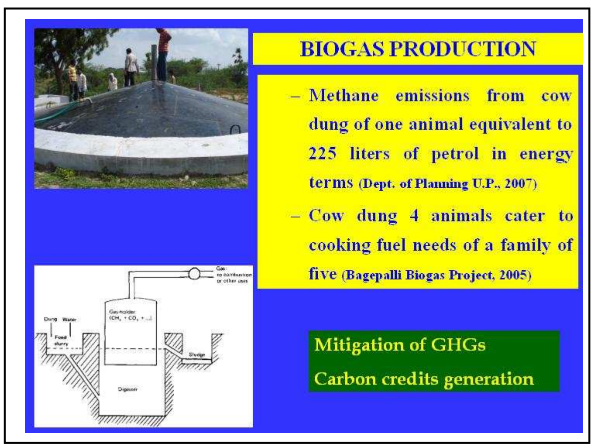
After assessing the nutrient intake at individual farmer level and depending on the production potential of the animal, supplementation was provided in the form of mineral and concentrate mixture/Azolla especially during the lean period when there are no green fodder. Some of the crossbred cows and graded 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.





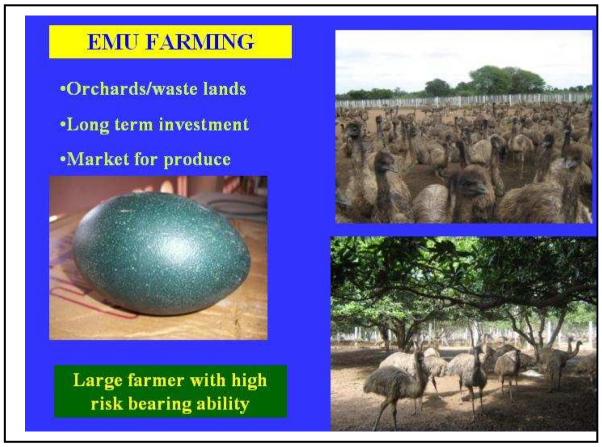
Dairy animals with low energy and protein intake were offered with at least 2-3 kg green fodder and 1-3 kg concentrate mixture for a period of 5-6 months depending on the breed. Reproductive camps were conducted to create awareness about identification of silent heat in buffaloes especially in summer 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 and participatory involvement of stakeholders while streamlining the animal health services as community activity would better facilitate containment 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.

YIELD, INCOME AND EMPLOYMENT EFFECTS OF TECHNOLOGY ADOPTION

C A Rama Rao
Principal Scientist (Agricultural Economics)

India is a vast country rich in diversity. The biological, geographic, climatic, social, cultural and economic diversity gives us the name Indian Subcontinent. Yet, if one were to describe India in a single phrase, one should call it an 'agrarian country'. While it is true that the contribution of agriculture to GDP declined over time from more than 50% at the time of independence to less than 20% now, the number of people dependent on agriculture refused to fall below 60% even now. That means a skewed distribution of income and low levels of incomes on average to the people dependent on agriculture. This is one of the most important reasons why agriculture should continue to deserve the attention of the decision makers in the country and its various channels of governance and administration.

A livelihood, as defined by Robert Chambers and Gordon Conway, "comprises the capabilities, assets (including both material and social resources) and activities required for a means of living". The DFID's livelihoods framework identifies five types of capital – the natural capital, the human capital, the financial capital, the technological capital and the social capital. Any individual or a region – a person, a family, a village, a district or a country – is endowed with different levels of the capital assets and undertakes an activity which will have a livelihood outcome. While strengthening of one capital will have a complementary effect on levels of other forms of capital and hence on livelihood outcomes, identifying and strengthening the critical capital holds the key to enhancing livelihoods in a sustainable way. In a country like us where agriculture is a 'way of life' for a majority of rural population, it goes without saying that strengthening natural capital is the key to livelihood development as agriculture is essentially a biological process (plant and animal growth) which is dependent on natural capital (soil, water, vegetation and climate). Other forms of natural capital such as minerals also have a bearing on livelihood outcomes.

Slowdown in agricultural growth and productivity, changing cropping patterns, increase in distress migration, changing consumption patterns, government policies favouring industrial houses, among others have seriously undermined the food and livelihood security of the poorer households.

Persistent poverty, especially in drought prone ecologically fragile areas is a result of vicious cycle that operates from the poor resource base, which in the absence of adoption of technologies, generates low productivity and (hence) income levels which then lead to low savings and investments leaving the resource and capital base unimproved and thus completing the cycle of poverty. This vicious cycle of poverty is to be broken if people are to escape from the poverty trap. Obviously, the cycle can be broken at any one link but breaking this cycle at more than one link will be more effective.

Strengthening the capital base is one way of improving livelihoods and adoption of technologies is an important component in doing so. Technologies will help improve the natural resource base (e.g. NRM technologies) as well as improve the productivity of the resources (production enhancing technologies such as improved seed, fertilizer application, etc). Adoption of technologies is also a logical end to the process of technology development for only when the technologies are adopted, will investments that go into that process be justified. Other ways of strengthening livelihoods are augmenting the financial capital by making credit available.

In addition to technologies in the form of improved seed, nutrient management and plant protection, management of natural resources, especially soil and water, are important technologies that will have a bearing on livelihoods of farmers. These technologies will have effects on yield (and hence income), cost and employment.

Apart from technology adoption, diversification is another strategy for improving livelihood options. The word 'diversification' has different connotations. Diversification in general means growing importance of secondary and tertiary sectors at the economy level. Within agriculture, it means a shift in the importance of non-crop activities such as livestock, fisheries and others. Within the crop sector, it means a shift in cropping pattern in favour of commercial crops and non-food crops. At the micro level, diversification is also seen as a contrast to specialization. In a farm that is more diversified, more number of commodities/crops are produced as against one or two crops in a specialized form. In such cases generally, the goals of diversification are risk minimization and meeting multiple family and farm needs.

At the household level, farm size and family size were found to be more associated with diversification in addition to access to irrigation. Small farmers grew more number of crops as inter and mixed crops to meet the family requirements of pulses. Maintaining a couple of milch animals was also found to be a common practice contributing to income diversification. Wage earnings were also a significant share of house hold income in case of small farmers and marginal farmers.

How adoption of different technologies affect yields, incomes and employment of labour is illustrated in the following pages:

Farming systems and income composition

In a study on farming systems in western Uttar Pradesh, Singh et al (2009) showed that on an average, households in the region received Rs 170863/farm as farm-family income out of which 48.87 per cent was from crops, followed by non-farm income (salary and wages) (39.35%). Farming system-wise analysis has indicated that crops contributed a major share to farm-family income in vegetable- and sugarcane-based farming systems, while non-farm sources contributed the major income in livestock- and cereal-based farming systems. The share of livestock was recorded highest (24%) in livestock-based farming system and lowest (about 8 %) in sugarcane-based farming system. In the sugarcane-based farming system, the farmers were found earning lower income in absolute as well as percentage terms from livestock. On this basis, the hypothesis that farmers grow sugarcane for their fodder requirement for animals was rejected. The family labour was often surplus on marginal holdings, necessitating them to supplement their income by working out side the farms.

Annual input cost under different farming systems in Western Plains of Uttar Pradesh

Particulars	Livestock-based farming systems	Vegetable-based farming system	Cereal-based farming system	Sugarcane-based farming system	All farming systems
Cost on crop production					
Seed	2526	4251	1081	4286	3999
Fertilizer	2563	2025	1645	3547	3292
Plant protection	101	112	9	279	245
Irrigation charges	1567	1807	1310	1493	1509
Labour	3903	4228	3601	4085	4057
Machinery	3713	3682	2980	4117	4008
Transport/MC	1482	1214	213	3451	3014
Gross cost	15855	17320	10838	21259	20122
Gross income	37221	63678	30507	45911	45384
Livestock maintenance					
Concentrate	8573	4180	4078	1808	2482
Dry fodder	2101	1614	1101	591	763
Sugarcane top	1208	690	617	321	413
Green fodder	2839	2475	2319	778	1051
Mineral mixture	2193	1103	1483	297	510
Labour	5379	2924	2940	1379	1794
Medicine	907	644	727	238	321

Gross cost	23200	13631	13267	5413	7334
Gross income	29030	17983	14068	7131	9631
Overall cost	39055	30951	24105	26672	27456
Gross farm income	66251	81661	44575	53042	55015

Singh et al (2009) Agricultural Economics Research Review

Table Composition of family income in different farming systems in western UP (Rs/farm)

Farming system	Crops	Livestock	Non-farm income*	Total
Livestock based farming systems	27916 (31.04)	21773 (24.21)	40237 (44.75)	89926 (100)
Vegetable based farming systems	132451 (62.76)	37406 (17.72)	41188 (19.51)	211045 (100)
Cereal based farming systems	40575 (38.39)	18711 ()17.70)	46400 (43.90)	105686 (100)
Sugarcane based farming systems	99169 (50.69)	14503 (7.87)	81065 (41.43)	195637 (100)
All farming systems	83507 (48.87)	17722 (10.37)	69634 (40.76)	170863 (100)

Figures in the parentheses are percentages to total included miscellaneous incomes like sale of family assets, gift received in cash or kind, etc.

Seed cost reduction in groundnut cultivation through use of shrivelled seed:

Anantapur cluster is dominated by monocropped groundnut, which is also intercropped with pigeonpea, cowpea and castor at 20:1, 8:1 and 8:1 , respectively. The groundnut seed is expensive and seed per unit area is high because of the seed boldness. About 100 kg kernels ha-1 costs around Rs.3000/ha. Generally, the farmers store the previous year's seed (variety TMV-2) for the coming season, but during continuous drought years, the small and marginal farmers are forced to sell the entire crop without retaining the produce for seed purpose. Besides, local production of bold seed is less. Promoting shrivelled seed as a substitute for the bold seed may help farmers, because of the inexpensive seed cost (25/-kg-1) and lower seed rate (85 kg ha-1). Eight male farmers tried this technology and their average yields obtained using shrivelled seed are given in It is shown that the use of shrivelled seed has given almost equal yield as compared to using assorted/bold/medium bold and small seed. Rs. 2300/- per hectare (cost of bold seed is Rs. 3500/- per hectare) was saved without affecting the yields. This technology was promoted especially to the small and marginal farmers to save the seed cost.

Table 4. Effect of seed size on yield and economics in groundnut, Anantapur

Seed size	Pod yield (kg/ha)	Haulm yield (kg/ha)	Cost of seed (Rs/ha)	Net returns (Rs/ha)
Assorted	1097	2135	3125	6105
Bold	1180	2302	3500	7032
Medium	1169	2229	2300	8014
Small	1001	1801	1440	7100
Shrivelled	987	1958	1200	1211

Source: http://www.crida.ernet.in/DFID/Crida%20Technical%20Report%202002-05PDF.pdf

Soil-testing based fertilizer application

From each of the three villages in the cluster, soil samples from 20 farmers' fields were collected and tested at ICRISAT. Soil test based fertilizer recommendations were provided. The soils were acidic to neutral in pH; non-saline; medium to high in potassium; low to medium in organic matter, nitrogen and phosphorus; and low in sulphur, zinc and boron. It was found that some farmers were applying more than required phosphorus to groundnut crop. Simple experiments were conducted on eight farmers' fields to demonstrate the usefulness of soil test based fertilizer application, which not only reduced the cost of fertilizers by Rs. 110 per hectare but also increased the pod yield of groundnut by 200 kg per hectare.

Table . Comparison of farmers' practice and soil test based fertilization

FERTILIZATION	**Fertilizer applied (kg/ha)**	**Cost of**	**Pod yield of**

	Diammonium phosphate	Muriate of potash	fertilizer (Rs/ha)	groundnut (kg/ha)
Farmers' practice	62.5	62.5	825	2111
Soil test based	50.0	62.5	715	2311

IPM in Groundnut

The farm-level impact of the IPM was observed by comparing the use of chemical insecticides, cost of cultivation, nutrient use 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 16 l ha^{-1} in case of non IPM farmers to about 6 l ha^{-1} in case of IPM farmers (Table). Consequently, expenditure on plant protection chemicals fell from Rs. 3619 to Rs. 1084 ha^{-1}. It is interesting to note that IPM farmers also applied about 84 per cent more organic manures compared to the non-IPM farmers. The IPM farmers harvested about 9.8 q ha^{-1} of groundnuts compared to 9.2 q ha^{-1} in case of non-adopters. The reduced cost of cultivation and marginally higher yields together resulted in higher net returns from IPM farms (Rs. 7246 ha^{-1}) compared to non-IPM farms (Rs. 3651 ha^{-1}). Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. About five per cent of farmers reported pesticide-related health hazards compared to 17 per cent in case of non-IPM farmers. Such a reduction is due to the less number of chemical sprays as well as due to the relatively safer insecticides used by the IPM farmers.

Table . Farm-level impact of adoption of IPM in groundnut in Anantapur District, Andhra Pradesh, 2004-05

Parameter	Unit	Non-IPM farms	IPM farms	Change (%)	t statistic
FYM	t ha^{-1}	10.6	19.4	83.5	2.13
Nutrients (N,P,K)	kg ha^{-1}	88.0	77.3	-12.2	6.09
Insecticides	l ha^{-1}	15.7	5.8	-63.2	7.67
Yield	q ha^{-1}	9.2	9.8	6.4	4.04
Expenditure on insecticides	Rs^{-1}	3619	1084	-70.1	8.72
Cost of cultivation	Rs ha^{-1}	11791	9366	-20.6	2.34
Net returns	Rs ha^{-1}	3651	7246	98.5	2.66
Incidence of sick events	%	16.7	5.5		5.62*

The differences were found to be statistically significant at 5 per cent, at least.

* χ^2 statistic.

Impact of farm ponds

Impact of farm-ponds on cropping pattern and cropping intensity

The percentage increase in crop productivity was considerably high with farm-pond. The change in crop yield over without farm-pond was significance in case of maize (7.43 q/ha) followed by paddy (4.60 q/ha) indicating that paddy and maize were highly responsive for water and overall change in crop yield which vary from 16 per cent to 41 percent. Household average net income generated (Table 3) with farm-pond (Rs. 16,748.85) was found to be relatively higher than that of without farm-pond (Rs. 11,300.65). In percentage terms, the corresponding increase in total average net income was 48.21 per cent and was high in case of Agriculture (57.16).The employment generation in with farm-pond (343.33) was high compared to without farm-pond (329.85) with a percentage increase of 4.08 per cent. From different sources of employment, agriculture (5.59 %) followed by animal husbandry (1.66 %) generated more number of man-days with farm-pond.

S.No.	Season/crop	With farm pond		Without farm pond	
		Area	Percentage for gross cropped area	Area	Percentage for gross cropped area
A.	Kharif				
1.	Paddy	31.42	28.55	28.02	31.15
2.	Cotton	22.27	20.23	18.62	20.7
3.	Jowar	6.07	5.52	7.69	8.55
4.	Maize	4.13	3.75	11.34	12.6
5.	Soybean	8.1	7.36	5.26	5.85
6.	Groundnut	4.85	4.41	7.29	8.1
7.	Fallow	0.97	-	1.62	-
	Total kharif cropped area	76.84	69.82	78.22	86.95
B.	Rabi				
1.	Rabi jowar	8.91	8.1	2.43	2.7
2.	Greengram	24.29	22.08	9.31	10.35
3.	Fallow	44.61	-	68.1	-
	Total rabi cropped area	33.2	30.18	11.74	13.05

	Gross cropped area	110.04	100	89.96	100
	Net cropped area (hectares)		77.81		79.84
	Cropping intensity (%)		141.42		112.67

Desai et al (2007) Karnataka Journal of Agricultural Sciences 20:426-427

Impact of farm ponds on productivities of major crops (q/ha)

Crops	With farm pond	Without farm pond	Change in yield (qtls)	% change
Paddy	24.82	20.22	4.6	22.74
Cotton	11.95	9.88	2.07	20.95
Jowar	11.68	9.53	3.15	22.56
Maize	32.03	24.6	7.43	30.2
Soybean	15.75	13.12	2.63	20.04
Groundnut	17.33	14.92	2.41	16.15
Rabi jowar	10.17	8.32	1.85	22.23
Greengram	3.8	2.69	1.11	41.26

Desai et al (2007)

Average net income of sample households from different sources

S.No.	Source	With farm pond	Without farm pond	Change in average net income	% change
1.	Agriculture	12,887.09	6,427.85	6,459.24	57.16
2.	Horticulture	911.03.	876.66	34.37	0.31
3.	Animal husbandry	1,880.32	1,692.26	188.06	1.66
4.	Labour	643.2	1,955.20	-1,312.00	-11.61
5.	Others	427.21	348.68	78.53	0.69
6.	Total average net income	16,748.85	11,300.65	5,448.20	48.21

Desai et al (2007)

Employment from different sources of the sample households

S.No.	Source	With farm pond	Without farm pond	Change in average net income	% change
1.	Agriculture	287.34	268.89	18.45	5.59
2.	Animal husbandry	27.38	16.53	10.85	3.28
3.	Labour	18.08	37.6	-19.52	-5.91
4.	Others	10.53	6.83	3.7	1.12
5.	Total employment	343.33	329.85	13.48	408

Desai et al (2007)

Farm ponds

The primary use for which farm ponds were constructed varied from cluster to cluster. In Tumkur cluster, the farm ponds were mainly used for percolation and recharging. Hence, the farmers decided not to pump water from farm ponds for irrigation purpose. The water was used sometimes for manually watering a few plants planted around the farm ponds using pots filled from the pond. In the case of Anantapur, some of the farm ponds were used as supplementary irrigation by pumping water. In Mahabubnagar, two farmers decided to use the ponds for rearing fish.

Cost and returns from farm ponds used for fish rearing:

The estimated cost and benefits from this activity based on the information provided by the two farmers is given in Table 3.3. Farmers need to invest around Rs. 9,300/- (in addition to the construction cost of farm pond) and can expect around Rs.34,000/- net income in 8 months. Thus, the farm ponds in the farmers fields is profitable, if the harvested rainwater can be supplemented to prevent drying of the pond.

Size of farm pond : 10 m x 10 m x 3 m; Cost of farm pond : Rs.8,000 (dug as project activity)

A.	**Input Cost**	(Rs)
i)	Cost of 3000 seed fish	300-00
ii)	Cost of transport	50-00
iii)	Feed cost:	
a)	Rice bran 320 kg (10 kg/wk for 8 months) @ Rs.3/kg	960-00
b)	Sorghum flour 256 kg (8 kg/wk for 8	2560-00

	months) @ Rs.10/kg	
iv)	Cost of labour for feeding 60 days (2 hr/day for 8 months) @ Rs.30/day	1800-00
v)	Cost of harvesting 16 labour @ Rs.40/day	640-00
vi)	Transport cost and packing material	3000-00
	Sub total	9310-00
Fixed Cost	Amortized farm pond cost (based on 5 years life)	1600-00
	Total cost	**10910-00**
GR	Yield 2250 kg @ Rs.20/kg	**45000-00**
NR		**34090-00**

Optimizing cropping pattern

Table gives total returns over working costs for a 3 acre farm from both kharif and rabi seasons. Farmers usually grow rice in both seasons provided there is no constraint on water availability, which gives them a total return of Rs. 36600. Some farmers also grow groundnt during rabi from which the returns are higher compared to rice. However, availability of quality seed sometimes constrains farmers from growing groundnut. In years of poor rain fall, farmers are forced not to grow any crop in which case the total returns fall to Rs.24400. Considering the water requirements, the project promoted chickpea and maize during rabi. Considering that farmers would be reluctant to do away with rice completely, it is more likely that farmers would replace two acres of rice with either chickpea or maize. Between these two options, growing one acre of rice with two acres of maize appears to be more profitable. However, growing chickpea will also have soil-enriching effect. Further, wild boars are a menace in this area and damage the crops badly. Chickpea is observed to be less attractive to wild boar compared to maize and groundnut. Thus, taking into consideration these factors in addition to the crop profitability, growing chickpea along with rice during rabi emerges as an alternative to cope with growing limitation of water.

Table . Net returns and water use efficiency of different cropping systems based on water requirements during *kharif* and *rabi* for a 3 acre farm

Practice / Intervention	Cropping system	Total net returns (Rs)	Water use efficiency Rs. per mm
Farmers' practice 1*	Rice (3)- Rice (3)	36000	5.00
Farmers' practice 2 **	Rice (3)-Rice (1)	24400	5.08

Farmers' practice 3 **	Rice (3)-fallow (3)	18300	5.08
Intervention 1	Rice (3) - Groundnut (3)	37560	7.83
Intervention 2	Rice (3) - Maize (3)	31854	6.64
Intervention 3	Rice (3)-Chickpea (3)	27936	6.42
Intervention 4	Rice (3)-Rice (1), chickpea (2)	30824	5.82
Intervention 5	Rice (3)-Rice (1), maize (2)	33436	5.97

Note: Figures in parentheses indicate acreage

* When sufficient water is available for cultivating all the area in both the seasons.
** When water is available for cultivating all area in *kharif* season and less area in *rabi* season.

Source: http://www.crida.ernet.in/DFID/Crida%20Technical%20Report%202002-05PDF.pdf

Participatory approaches for sustainable NRM and livelihood improvement

-Dr.K.Nagasree, Scientist (Sr.Sc), Agril.Extension, TOT, CRIDA

Email: knagasri@yahoo.com

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.

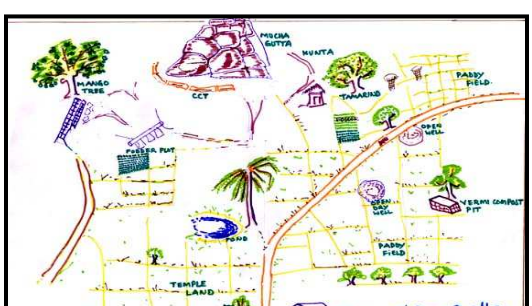
Analyzing information through People participation during PRA exercise

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

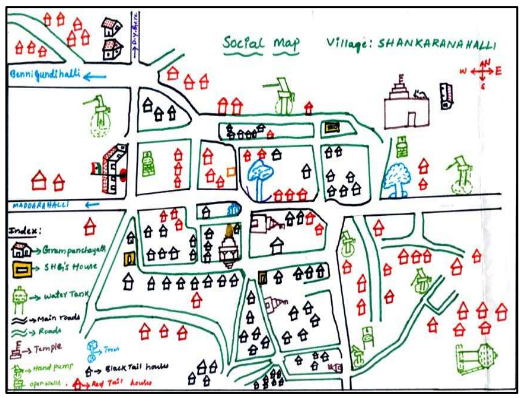
- *Resource Map:* This indicates both the natural resources like vegetation, soil type water bodies available etc,.and man made resources needed for development of agriculture.



• *Agro-ecology Map:* Agro- ecology map will indicate the relation between agriculture and environment which includes weather parameters like rainfall, temperature, RH including fragmentation of holdings, drainage system ,weeds,etc.

• *Technology Map*: The technology map will indicate the technology decision behavior of the farmers with reference to the adoption of agricultural technologies 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.

References :

Bagdi. G.L. 2005 People's Participation in Soil and Water Conservation Through Watershed Approach/ Lucknow, International Book Dis., iv, 192 p., tables, ISBN 81-8189-054-X.

Chambers Robert 1994 Participatory Rural Appraisal , Challenges, Problems ,Potentials and paradigm world development Vol 22 No.10 1437-1454

FAO 1990 Food & Agricultural Organization **The conservation and rehabilitation of African lands** Z5700/E

GOI 2008 Common guidelines for watershed development projects

PHILIP TOWNSLEY 1996 RAPID RURAL APPRAISAL, PARTICIPATORY RURAL APPRAISAL AND AQUACULTURE : IN FAO FISHERIES TECHNICAL PAPER 358

NATIONAL RURAL LIVELIHOOD MISSION(NLRM) A FRESH LEASE OF LIFE FOR THE RURAL PEOPLE LIVING BELOW THE POVERTY LINE (BPL)

(*Source: http://pib.nic.in/newsite/erelease.aspx?relid=52423)*

Backgrounder

The Ministry of Rural Development has decided to re-design and re-structure the on going Swarnjayanti Gram Swarojgar Yojana (SGSY) into National Livelihood Mission (NRLM). The idea has been conceived as a cornerstone of national poverty reduction strategy.

The objective of the Mission is to reduce poverty among rural BPL by promoting diversified and gainful self-employment and wage employment opportunities which would lead to an appreciable increase in income on sustainable basis. In the long run, it will ensure broad based inclusive growth and reduce disparities by spreading out the benefits from the islands of growth across the regions, sectors and communities.

The Mission has been designed to achieve the following 'Outputs' and 'Outcomes' by 2016-17.

Output and Outcome Targets for the NRLM : 2016-17

In Lakh

S. No.	Output/ Outcome Indicator	Target for remaining period of 11th Plan	Tentative target for 12th Plan	Total target by 2016- 17	Number of BPL families
I	Outputs*				
1	Total number of new BPL SHGs to be formed	12.25	15.75**	28	280
2	No. of SHGs to be provided Revolving Fund support	12.25	15.75	28	280
3	No. of SHGs to be provided Capital Subsidy	5.25	10.75	16	160
4	No. of SHGs to be provided Interest Subsidy	10	12	22	220
5	No. of rural BPL youth to be provided Skill Development Training	15	60	75	75

II	Outcomes*				
1	No of SHGs to be entering at Micro enterprise level	5.25	10.75	16	160
2	No. of rural BPL youth to be provided placement support	15	60	75	75

Note- Each SHG having on an average 10 members (one from each family).

* Subject to availability of resources and cooperation from other stakeholders.

The Rural Livelihoods Mission is proposed to have a three-tier interdependent structure. At the apex of the structure will be the National Rural Livelihoods Mission, under the Ministry of Rural Development, Govt. Of India. At the State level, there will be an umbrella organization under the State Department of Rural Development/ Department which is responsible for implementing self-employment/rural livelihoods promotion programs. The State level Mission with dedicated professionals and domain experts under the State department of Rural Department will be guided financially, technically and supported by the NRLM on need basis. The National and the State Mission will have a symbiotic relationship. They will have mutual access to the knowledge and services in the area of rural livelihoods.

The NRLM will be set up in the Rural Development Ministry under the overall supervision of Joint Secretary in-charge of existing SGSY Division. It is proposed to have a Governing Council (GC) and an Executive Committee (EC). A GC will be constituted under the chairmanship of the Minister for Rural Development, GOI. The Minister and Secretary of Agriculture, Women and Child Development , Labour , State Minister of Rural Development (4 on rotation basis), Adviser (RD), Planning, Land Resources(LR), Panchayati Raj Institutions(PRI), Drinking Water Supply and Sanitation(DW&S), Tribal Affair Commission, DG Indian Council Of Agriculture Research (ICAR), CMD NABARD, Financial Service, DG National Institute Of Rural Development (NIRD) and DG (CAPART), Representative of Self Help Group (SHG) Federation, (3) Experts (RD)/ NGO's (5) will be the member of the Governing Council of the Mission while Secretary (RD) will be the Convener and the Mission Director (JS) will be the Co-Convener of GC.

The Governing Council will be the policy making body setting overall vision and direction to the Mission, consistent with the national objectives. It will lay down priorities and review overall progress and development of the Mission. The GC will be empowered to lay down and amend operational guidelines. However, the subsidy norms of the NRLM as approved by the Government shall in no circumstances be changed or exceeded for any of the Mission components. It will meet at least twice a year.

The NRLM has been envisaged to perform the following functions:

(i) facilitate establishment of state level umbrella agencies by the state governments for providing institutional support for poverty elimination programs; *(ii)* support state level umbrella organizations in the design and implementation of pro-poor programs;*(iii)* provide professional and technical support an guidance to the state agencies by seeking out and disseminating pro-poor technologies and institutional innovations through research and development and forging linkages between the state agencies and the national centers of excellence; *(iv)* liaise with other Missions/departments to explore areas for convergent action and facilitate such convergence to enhance the capabilities and facilitate access to other entitlements such as wage employment, food security, education, health, etc and ; *(v)* explore and facilitate partnerships between National/State Rural Livelihood Missions and public, private, NGO and Co-operative sector partners, for diversifying and sustaining the livelihoods of the poor; *(vi)* undertake/commission studies to assess emerging self employment/skill based employment opportunities and disseminate the information to the State agencies; *(vii)* study best practices in self-employment/ micro enterprise activities across the country and support their replication in other parts of the country through workshops, cross-learning visits and exchange programs; *(viii)* develop capacity building and training modules for functionaries of the peoples institutions as well as the state agencies and district units, and other stakeholders participating in the poverty elimination programs; *(ix)* facilitate analysis and dissemination of the impact of changing economic policies on the poor and play policy advocacy role; *(x)* act as information warehouse on rural poverty statistics by accessing information from multiple sources; *(xi)* identify shortcomings in program design and implementation and facilitate debates/discussions thereof by experts for finding innovative & workable solutions and their dissemination to the state agencies. *(xii)* promote institution of comprehensive monitoring and learning systems at the state agencies and district units, including web enabled MIS and community monitoring systems; and *(xiii)* identify high quality institutions in livelihoods education and training and facilitate linkage of the state organizations with missions with such institutions for capacity building of professionals.

The need for restructuring the SGSY has arisen on account of feedback provided and recommendations made by various studies including those conducted by National Institute of Rural Development (NIRD), Hyderabad, Bankers Institute of Rural Development (BIRD), Lucknow, Centre for Management Development, Thiruvananthapuram etc. and reports of the Steering Committee constituted by the Planning Commission for the 11th Plan Further, the Ministry of Rural Development (MoRD), Government of India (GoI) has accepted the recommendation of the Committee on Credit Related Issues under SGSY *(Prof.Radhakrishna* Committee) to create a National Rural Livelihoods Mission (NRLM) to provide greater focus and momentum for poverty reduction to achieve the Millennium Development Goal (MDG) by 2015 through rapid increase in the coverage of rural poor households under self-employment.

In addition to provide self employment to the rural folks, the Mission will also help in enhancing their capabilities and facilitate access to other entitlements such as wage employment and food security and benefits of Indira Awas Yojana (IAY), drinking water, land improvement, education, and health and risk mitigation through convergence and coordination mechanism. The decision follows three major developments that have taken place in the recent years and had major impact on the rural economy especially the rural poor i.e (i) the economy experienced a robust growth (ii) National Rural Employment Guarantee Scheme (NREGS) emerged as a major program to provide additional income to the rural poor and (iii) various initiatives taken under the National Skill Development Mission (NSDM).Taking these developments into account and in order to achieve the objective of the 11th Plan of broad based inclusive growth in this perspective, the strategy paper of Ministry envisages a four pronged strategy to attack rural poverty comprising *(i)* generation of self employment in credit linked micro enterprises and salaried employment through demand driven skill development *(ii)* wage employment under National Rural Employment Guarantee Scheme *(iii)* payment of pension to elderly and vulnerable sections under National Social Assistance Program *(iv)* income generation and social security programs of other Ministries of Government of India.

NRLM programs is proposed to be implemented in all rural districts of different states excluding the districts in *Delhi* and *Chandigarh*. However, the Governing Council of the Mission based on the latest available data is empowered to include or exclude the districts for the implementation of various components of the Mission.

It is envisaged that the State Governments will transit into the NRLM mode only in a phased manner. Till such time the States do not transit into NRLM mode, the SGSY activities will continue to be implemented as per current guidelines/norms and fund releases will be made to DRDAs as per existing procedures. The revised norms of SGSY will be applicable to the States having the commitment to fulfill the following within the stipulated time period:

i. State level agencies and the district level units are set up

ii. Full complement of professional staff has been trained and placed

iii. State level poverty reduction strategy has been formulated

Funds for implementing the Mission's programs are proposed to be directly released separately to the state level agency and the DRDAs on the basis of the detailed district wise annual action plans submitted by the state agencies and approved by the EC of the National Mission, but within the overall allocation indicated for each state on the basis of the poverty ratio. The funds to state level agencies will be transferred to meet expenditure on: (i) establishing and running the dedicated state /district/sub-district level agency; (ii) organizing state level skill development and placement services (covering more than one district); and (iii) other activities such as technical services, concurrent evaluation and such other activities.

The funds to DRDAs will be transferred to the meet expenditures on: (i) subsidy to SHGs; (ii) infrastructure and marketing (district level and sub-district level); (iii) corpus for federations; (iv) interest subsidy; (v) training and capacity building of all stakeholders and (vi) engagement of NGO facilitators. The funds to district units will be released where full complement of professional staff has been placed and district poverty reduction plans have been formulated. In other case the exiting procedure of fund release will be followed.

Funds will be released in two installments based on the progress report and submission of utilization certificates by the district units under intimation to the state level agency. The State level agency will compile and consolidate expenditure details, physical progress and other details and submit to National Mission periodically. MoRD will release 75% of the approved amount to the State Government/DRDA and the State government will release the balance amount of 25%. In respect of north-eastern states, J&K, Himachal Pradesh & Uttrakhand, the GOI and state share will be in the proportion of 90:10, respectively.

As far as possible, e-banking will be used for transfer of funds to the state level agencies and to the districts. The state level agency will maintain a separate budget and prescribed accounting system for the Mission activities both at the state and district level. The district units will adhere to the accounting system and financial guidelines prescribed by the state agencies. The block units will be directed by the district units to follow similar systems and guidelines to ensure transparency and accountability.

The National Livelihood Mission will have a strong mechanism of Monitoring and Evaluation with the involvement of the state level agency and dedicated district level units. The Monitoring and Learning (M&L) specialists at the Mission and state agency levels will coordinate concurrent monitoring of the Mission activities. At the district level, the Monitoring and Learning specialist will undertake monitoring of the physical and financial targets of various Mission interventions, adopting the formats designed by the National Mission for this purpose. In addition, the district level M&L specialist will be responsible for instituting community monitoring systems including a system of self monitoring by the SHGs and their federations.

Panchayati Raj Institutions (PRIs) will be actively involved in the following activities of the Mission:

(i) identification and mobilization of BPL households into SHGs, with priority being given to the SC and ST households especially primitive tribal groups, poorest of the poor households, women headed households and households engaged in declining occupations;*(ii)* facilitating federation of SHGs at the village/gram panchayat level/ block level and providing basic facilities for the effective functioning of such federations in terms of providing accommodation for federation office and such other basic facilities;*(iii)* giving priority to the demands of the SHGs and their federations in the annual plans/activities of the PRIs by making suitable financial allocations;*(iv)* entrusting execution of panchayat activities including civil works to SHGs and their federations on a priority basis; *(v)* leasing out panchayat resources such as fishing ponds/tanks, common property resources, market yards, buildings and other properties to the SHGs and their federations for proper management and maintenance;*(vi)* entrusting responsibility for collection of panchayat revenues including house property tax to the SHGs for a small fee; and*(vii)* entrusting management and maintenance of select civic amenities to the SHGs.*(viii)* any other activity which could be taken up by the members of the SHGs or their federations.

NRLM will have multi pronged approach to strengthen livelihoods of the rural poor by promoting SHGs, improving existing occupations, providing skill development & placement and other activities thereof.. The training and capacity building, deployment of multidisciplinary experts and other initiatives will enhance the credit worthiness of the rural poor. The services of craft persons, community resource persons etc will be utilized as TOT to for capacity building and training under NRLM. The periodic interaction of Mission with Public Sector Banks and other financial institutions to enhance the reach of rural poor to the un-banked areas will ensure their financial inclusion. Further, poor have multiple livelihoods and they need multi pronged approach to strengthen it. The existing strategy of social mobilization of poor, their organization into SHGs, training & capacity building, credit linkage for micro enterprise for self employment will continued to be one of the main components of NRLM. Emphasis will be on convergence with various schemes of Rural Development along with other line departments/ministries to strengthen the exiting occupations of the rural poor, ensure their participation as beneficiary of emerging opportunities as a result of various schemes for sustainable livelihood and also introducing newer technologies in their enterprises. The multidisciplinary domain experts at various levels will coordinate with all the stakeholders for benefiting the poor in risk mitigation, food security, training and capacity building, micro financing, infrastructure development and better marketing linkages for getting appropriate prices for their products. People owned & people centered organization by federating SHGs will act as facilitators for strengthening the SHGs and thereby benefiting the rural poor. In addition skill development & placement will be the subset of the redesigned program for deploying the rural BPL poor in the sun-rising sectors of the economy. The Mission will make concerted efforts to train rural BPL to provide last tier implementation personnel as service providers, lok sevaks, etc to local bodies to implement to programs efficiently and effectively.

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AKT/ST/SAK

(Release ID :52423)

The National Rural Livelihood Mission (NRLM) and Strategies for Livelihoods Improvement in Rain-fed Areas

Dr. P. Purushotham, Professor & Head, CSE&RE, NIRD, Rajendra Nagar, Hyderabad-500 030

The National Rural Livelihood Mission (NRLM) has been launched in June 2011 with the objective of reducing poverty in rural community through promotion of diversified and gainful self-employment and wage employment opportunities to provide appreciable increase income on sustainable basis. To accomplish this, the Mission has evolved the strategies of identifying the BPL households, organising them into functionally effective, self-managed and self-governed institutions viz., self-help groups (SHGs), federate these institutions at village, block and district level to overcome the financial, technical, infrastructural, marketing and other constraints and risks that inhibit their growth and also enhance their bargaining power. For his, the members of SHGs and their leaders are trained and their capacity built. The Mission also envisages a great deal of convergence with various line departments and other development institutions and stakeholders. This paper reviews the Mission strategies in promoting livelihoods in rain-fed areas and also presents a model of farm-technology popularisation involving the beneficiary population.

Capacity building of rural households for sustainable livelihoods

- Organise poor into SHGs i.e. self-managed peoples' institutions, build their capacity to pool their own savings and thrift into common resource pool, lend the same to the needy among themselves for consumption and production purpose and manage their own intuitions
- Help them access various development support available from government and other institutions, including financial institutions for credit to reduce dependency on money lenders;
- Network them into larger institutional platforms for more bargaining power while dealing with markets - through creation of market outlets
- Up-grade their productive skills for self employment,
- Promote micro-enterprises and develop natural resources and infrastructure
- Capacity building of primary and secondary stakeholders through knowledge sharing, collective action and use of ICTs.
- Develop institutional mechanisms and support systems to internalize the development project outputs by the community.
- Encourage institutional innovations (eg: borewell water sharing in Nalgonda made possible through SHG women leadership; networking of borewells with social regulation, Ibrahimpur, RR district, AP; Fodder cultivation in CPRs or contract farming by women SHGs)
- Enlisting the needs of the community through visits and discussions.

Livelihoods through sustainable agriculture

Agriculture is the major livelihood option of majority population of the rain fed areas. Due to deteriorating soil fertility, declining yield, receding ground water level, disappearing flora and fauna, spiralling cost of chemical fertilisers and pesticides farming in these regions has turned out to be least remunerative, forcing the farm households to quit farming and migrate to cities in search of employment. In this regard, NRLM strategies are designed to:

- Organise awareness camps on practices of sustainable agriculture;
- Build capacity of the farmers for organic/bio farming, soil, water, crop and integrated pest management;
- Promote sustainable agriculture, agro-forestry, horticulture;
- Promote production of quality seed
- Train, demonstrate and expose farmers and farm labourers for more scientific, adaptable and climate friendly agriculture practices with better income through organic and bio-fertilizers and pest controllers (eg: Anebavi village, Nalgonda district, AP) ;
- Help reduce dependency on agro chemicals for fertilisers, insecticide, pesticide and weedicide; promote traditional practices of rejuvenation of soil with bio mass and organic manure (eg: CMSA of AP)

- Organise awareness camps of rural households, carry out situation analysis, identify areas of intervention for watershed development, sustainable agriculture agro-forestry, water conservation & management measures, roof water harvesting, soil fertility management, forestry development, livestock development,
- Promote enterprises for production of bio-pesticides; vermicomposting; neem oil extraction unit; quality seed availabitity; effective water management practices; less input and better output in agriculture;

- Establishment of custom hiring centers.
- Installation of post harvest machinery for primary value addition (eg: Dal mills in RR district, Nalgonda & Mahabubnagar, AP).
- Promote chipper-shredders to make best use of harvested residues/biomass for composting, animal feed and mulching
- Promotion of green leaf manuring : Gliricidia planting on the field bunds (by SHGs in Sangareddy, Medak district).
- Vermicomposting on large scale through women SHGs.
- Addressing issues of upscaling through self-managed peoples' institutions

Livelihood through Livestock Development

Livestock is the next major income generating activity for majority of population in the regions of dry land agriculture. During this decade the population of livestock in this region has drastically declined due to non availability of fodder. Cost of dairy and dairy products, meat. etc, have spiralled in recent years. On the other hand tones and tones of agro waste and/or agro by-products are getting destroyed for want of awareness and processing facilities. These agro waste also contain a number of nutrients and minerals.

- Popularise micro-enterprise activities to convert these agro waste in valuable nutrient cattle feed.
- Promote self-managed micro-enterprises among the rural households to establish processing units at panchayat level where farmers could bring in their agro waste and convert them in to nutrient cattle feed, for a nominal fee. Besides procuring agro waste from farmers producing and supplying nutrient cattle feed to the needy at affordable rate, such units could provide service to the needy.
- Train the households to enrich their animal fodder through urea treatment and mix of minerals, azolla, etc.
- Encourage women and the landless to upscale goat rearing; support their activity through insurance, de-worming, stall feeding and feed supplementation

Convergence of development programmes under NRLM

NRLM envisages convergence among various development departments/organizations for creation of livelihoods. For promoting rural livelihoods in rain-fed areas, it has identified the following opportunities of convergence.

S.No.	Area of farm sector addressed	Name of C-DAP programme into which convergence is proposed	Name of the central sector scheme
1	Land, Soil Health & Fertility	Establishment of integrated nutrient management system	Strengthening of soil health
		Setting-up of new soil testing labouratories	Project on balanced use of fertilisers
2.	Water Resource Management	Micro irrigation (sprinkler & drip)	Micro irrigation in Horticulture (80:20) & National Horticulture Mission
3	Seed and Planting Material	Distribution of seeds	Integrated scheme of Oil Seeds, Pulses, Oil Palm and Maize (ISOPOM) (75%

			Centre: 25% State)
		Establishment of seed treatment and demonstration units at gram panchayat level	Beej Gram Yojana (100% Centrally sponsored)
		Distribution of planting material	NHM (National Horticulture Mission)
4	Production Technologies	Programme on promotion of cultivation of summer/winter pulses for improving productivity	Integrated scheme of Oil Seeds, Pulses, Oil Palm and Maize (ISOPOM) (75% Centre: 25% State)
		Programme on promotion of cultivation of summer/ winter pulses for improving productivity	National Food Security Mission (NFSM)
5.	Horticulture & Plantation	Improvement of package of practices for cultivation of arid fruit crops	NHM, NWDPRA (MMA), Drought Prone Area Programme
6.	Technology Dissemination	Farmers study tour within and outside the state for exposure and outside the state for exposure	Agriculture Technology and Management Agency (ATMA)
		Farmers training and demonstration at KVK	
		Establishment of Agri Clinic	
		Farmers study tour within and outside the state for exposure and motivation towards	Farmers Welfare Scheme (Kisan Hit Yojana)
		Knowledge dissemination at farmers field level by Subject Matter Specialists (SMS)	Support to extension programmes for Extension Reforms (90% CS: 10% State)
7	Post Harvest and Marketing	Improvement and creation of new market facilities for marketing of agricultural produce practices	Backward Region Grant Fund (50% funds from RKVY and 50% from BRGF)
		Programme for quality and	Clean milk

		hygienic milk	production (100%)
		Promotion of commercial dairy farming units	Intensive Dairy Development Programme (100% CS)
8.	Dairy	Dairy training workshop for women	Mahila Dairy Project (100% CS)
		Programme for quality & hygienic milk production	Strengthening Infrastructure for Quality and Clean Milk Production
		Dairy training workshops	
9.	Fisheries	Renovation of village ponds for fish production	Mahatma Ghandhi National Rural Employment Guarantee Scheme (MGNREGS)
10.	Animal Husbandry & Veterinary	Artificial insemination	National Project for Cattle and Buffalo Breeding (NPCBB)
		Livestock disease surveillance and quick alert system	Livestock Health & Disease Control (LH & DC); Directorate of Animal Health
		Programme for year round production of green fodder	Feed and fodder development
11.	Farm Mechanisation	Establishment of farm mechanisation centres at panchayat level	Agriculture Mechanization (MMA)

Non-farm sector

Livelihood opportunities in the non-farm sector have to be promoted through technology adoption for higher productivity (eg: improved vertical kiln for charcoal making out of Prosofis Juliflora in Rajastan, Ber pulversiers in Chhattarpur), access to credit (credit for stone artisans), market, infrastructure and entrepreneurial assistance.

Community - Managed Sustainable Agriculture Model

The experience of Andhra Pradesh's Society for Elimination of Rural Poverty (SERP) through its Indira Kranti Patham (IKP) in organising the working poor into small self-help groups (SHGs), imparting them skills to manage their own institutions, and building their capacity to access the technology delivery system, and practise community-managed sustainable agriculture (CMSA), seems to be an appropriate alternative model for enhancing the farm productivity in rainfed areas (Vijaykumar *et a.l*, 2009). The institutional structure that has been evolved for this purpose consists of individual small farmers organized into SHGs which are federated at village as village organization (VO), at *mandal* (sub-block) as Mandal Samakhya and Zilla Samakhya at district level. The progressive SHG members are tied up with farmer-field schools. In this model, the self-managing institutions of poor, which are also called community institutions, have been built with the following capabilities: The guiding principles of community-managed sustainable agriculture (CMSA) are presented in the Box.

- Pooling the thrift and savings, lending them internally among the members, recovering the same and redeploying for meeting the credit needs of the members.
- Accessing various farm services such as inputs, extension, government subsidies, assistance in post-harvest operations transportion, value addition and sales collectively for realising the benefits through bulk-transaction.
- Accessing bank credit, and
- Building collective marketing strength through networks and federations.

Box: The guiding principles of CMSA

- *Observe and document pest and predator behaviour, pest incidence on the farms.*
- *Replace chemical pesticides with physical methods of pest management complemented by bio- pesticides.*
- *Manage to eliminate pest population*
- *Focus on balancing predator and pest population*
- *Enhance and maintain soil health through mulching, green manure and vermi compost*
- *Reduce usage of chemical fertilisers and subsequently phase it out.*
- *Increase diversity of crops and encourage crop rotation.*
- *Identify appropriate cropping systems; inter-cropping, multi-cropping, crop rotations, and*
- *Preserve local varieties and land resources and crop genetic diversity.*

Source: Vijaykumar *et al*.(2009).

In this model, the promotion of technology awareness is managed by community institutions which act as an end-to-end solution and service providers for small holders. The activities carried out by the members under CMSA are summarized in the Table. To begin with, the leadership capacity of SHGs and their federations is built. Gradually, they are tied up with the farmer-field schools sponsored by Agriculture Department and exposed to a wide-range of technologies. The SHGs and their federations are trained by the best practicing farmers as community resource persons (CRPs) who serve as community extension workers to upscale the activities. Table- Sustainable technologies practised by CMSA farmer

<table>
<tr><td colspan="4">Pest, soil fertility and crop management</td></tr>
<tr><td colspan="4">Stage- 1 CMSA (Non-Chemical Pest Management)</td></tr>
<tr><td colspan="2">Step-1: Observations and Diagnostics:
• Observe and document pest and predator behaviour.
• Understand pest life cycle.

Step-2: Physical Methods of Pest Management:
• Summer ploughing
• Bonfires and pheromone traps, sticker plates and bird perches

Step 3: Biological Methods of Pest Management:
• Planting trap-crops along perimeter or in rows
Step 4: Bio-pesticides
• Use of agniastram- chilli, garlic, neem and cow urine
• Brahmastram - neem leaves, custard apple, castor, papaya, bitter gourd, and cow urine</td><td>Continue use of chemical fertilisers in the initial stages.

Begin use of manure and compost

Begin application of microbial formulation

Panchagavya: cow dung, cow urine, milk, ghee and yogurt

Jeevamrutham: jaggery, sugarcane juice, cow urine and dung</td><td>Crop rotation</td></tr>
<tr><td colspan="4">Stage 2 CMSA – Sustainable Agriculture</td></tr>
<tr><td>Same as above</td><td colspan="2">Reduce and replace chemical fertilisers with soil fertility management through:
• Application of tank silt
• Green manuring
• Mulching
• Vermi composting
• Inoculation with nitrogen fixing bacteria like Azospirillum and Azotobacter
• Biomass plantation on bunds
• Azolla application for rice</td><td>Inter-cropping and multi-cropping/ mixed cropping.</td></tr>
</table>

Source: Vijaykumar *et al.*(2009).

District Federation or Zilla Samakhya

Conducts market interface, maintains MIS/IT system, Insurance call centres

Sub-district Federation or Mandal Samakhya

Supports VOs
Secures linkage with technology sources, helps the SHGs build their capacity

Village Organisation (VO)
Strengthens SHGs, arranges line of credit to SHGs,social mobilisation and supports development activities

Self-Help Groups (SHGs)
Mobilises members' thrift and credit
Participatory monitoring, poverty reduction plans, household investment plans

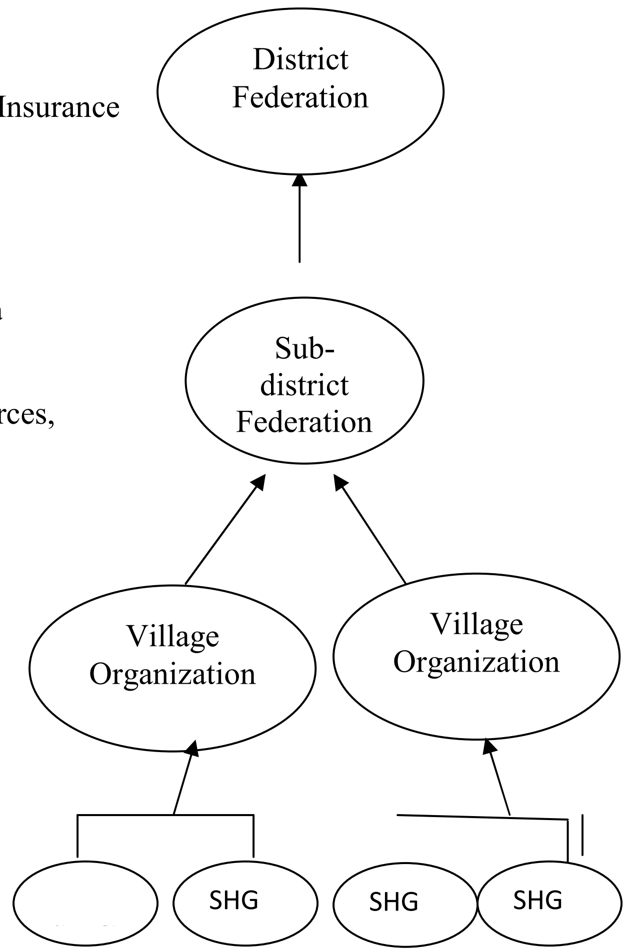

Fig.-1The institutional framework of SHG network for CSMA (Vijaykumar *et a.*., 2009)

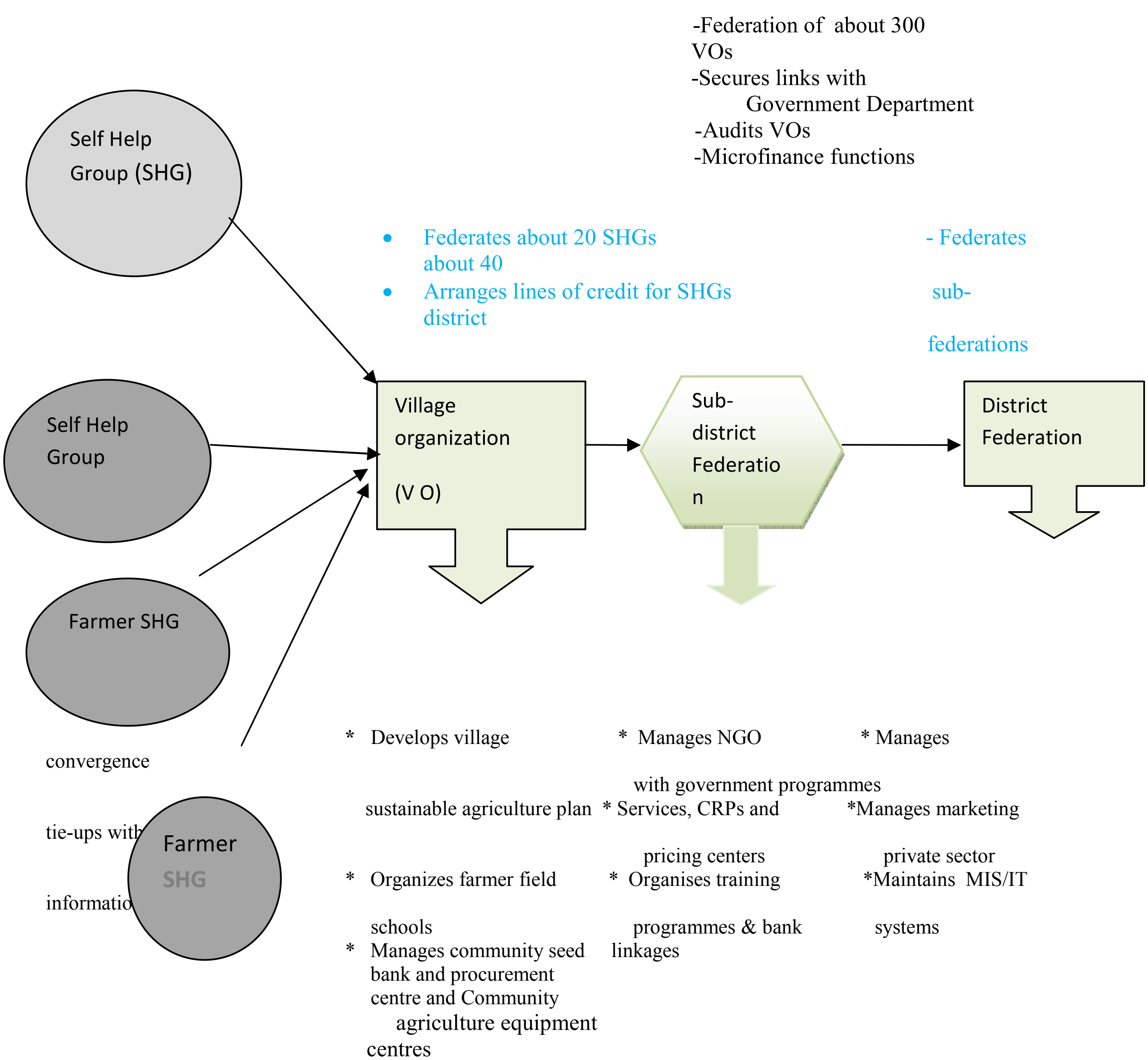

Figure 2: CMSA activities carried out by SHG federations (Vijaykumar *et al*.,2009)

These active and best farm practising farmers are trained in and exposed to the dynamics of value chain. The training and capacity building take place in several steps and tiers (Fig.1 and .2).

The village organisations (VOs) of SHGs along with the village activists, play a crucial role in mobilising the farmers towards sustainable agriculture. A group of 20 to 25 farmers form a farmer SHG (*Sasya Mitra Sangha*). A village may have as many as 4 to 5 farmer SHGs depending upon the size of farming community. The farmer SHG together with VOs develop a CMSA plan on capacity building, production, maintaining internal controls and marketing. The VO is entrusted with overall programme management at the village level and is the centre of all CMSA activities in the village. These village-level initiatives are scaled up through networking with the federations of SHGs at mandal (sub-block) level and ultimately at the district-level.

At the district level, the DRDA plays a proactive role in introducing the SHG networks to the technology developing and disseminating agencies/departments such as agriculture, animal husbandry and horticulture. Under the mentor role of DRDA, the CMSA initiatives are also converged with the other development programmes/schemes such as Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) so that the farm-related works such as excavation of compost pits and village tanks are carried out as part of the public work programme. The SHG leaders participate in the planning and operationalisation of CMSA initiatives, make regular visits to farmers field schools (FFSs) and farmer fields to monitor the progress.

The SERP at the State level provides the strategic leadership in formulating policies, programmes and encourages the district and sub-district-level teams to experiment and innovate in popularising sustainable agriculture among the members of SHGs. It has leveraged the FFSs set up by the State government as the main channel for delivery of extension services. Village activists involved in SHG movement bring together all the farmers to attend weekly workshops in their own fields, and training programmes to discuss issues related to sustainable agriculture practices. The training is provided to units of farmer-SHGs. To start with, the SHG farmers and their leaders are trained in procedures related to the application of non-chemical pesticides. Once the farmers appreciate the merits of these techniques, they are motivated to learn other domains of farm practices.

Scaling up with Community Resource Persons

The role of community resource persons (CRPs) is critical in up scaling of CMSA and making it popular. CRPs are farmers who practise CMSA and demonstrate its merits to other farmers. Each CRP adopts three villages and shares the expertise on sustainable practices with others. This activity is carried out in a phased manner - 15 days in a month. In addition, the CRPs also identify farmers who show interest in practising sustainable agriculture. Some of these farmers are short-listed to facilitate the farmer's access to high-quality inputs through a network of community seed banks and agricultural implements from community centres. Such handholding enables community to conduct value chain analysis to ensure higher quality and better prices of the produce.

As one could learn from the SERP experience, this model has enabled the illiterate, resource-poor, small/marginal farmer community - through the women members of the farm households - in a few districts in Andhra Pradesh, to learn and successfully adopt CMSA. Over 10,00,000 small farmers covering 4 million acres of farm land have adopted CMSA in AP since 2004.

References

1. Vijaykumar, T, Rayudu, D,V., Jayram Killi., Madhavi Pillai., Paramesh Shah,. Vijayasekhar Kalavakonda and Smriti Lakhey, 2009. Ecologically Sound, Economically Viable: Community Managed Sustainable Agriculture in Andhra Pradesh, India. A World Bank Report pp 1-28.
2 National Rural Livelihood Mission Guideline, Ministry of Rural Development, Govt of India