Farming Systems in Rainfed Areas of Karnataka

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Introduction

Rainfed Agro-Ecosystem (AES) occupies an important place in Indian Agriculture, covering 68 per cent of the cultivated area (96 m ha) supporting 40 per cent human and 60 per cent livestock population and producing 44 per cent of the food requirements, thus playing a critical role in India's food security. The human population in this system is likely to reach 600 million by 2025 from the present 500 million. The area under rainfed Agro-ecosystem may decrease to 85 million ha by 2025 AD. The population in our country below poverty line (BPL) is about 44 per cent and dominates rainfed based production system. The average size of farm holding has declined over time and more than 85 million out of 105 million operational holdings are less than 1 ha and pose a serious threat to food security (Mahapatra and Bapat, 1992). It is estimated that 1.2 million people worldwide live in poverty and 79 million are suffering from malnutrition and depend on crop based activity from a significantly reduced rainfed cultivated area. The overall crop productivity has to be enhanced from the present 0.82 to 2.0 t/ha by 2025 to meet the basic needs of the growing population. However, the productivity of lands continues to be low and unstable due to aberrant behavior of monsoon, frequent droughts, resource poor farmers, low investments, eroded and degraded soils with low water holding capacity and multiple nutrient deficiencies, declining ground water table etc., (Singh et al., 2002).

Critical Elements of Sustainable Rainfed Farming

Soil, water and vegetation are the basic resources sustaining human beings and the animal population. Hence, their conservation and proper use is of paramount importance. The approach to soil and water conservation structures in recent years has been favouring construction of check dams, bunds, etc., involving high investment, neglecting low-cost agronomic practices which serve the same purpose. Dryland

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farming has become a neglected enterprise because of the high risk and meager profits. However, the compelling need to provide increased food, fuel, fodder, fibre to the farm family and the absence of alternative sources of income have resulted in the virtual mining of these land resources. The direct result of this disturbing trend is soil erosion, nutrient loss, diminished stream flow and water scarcity.

These in turn have led to decline in crop yields and lack of food security among the rural households. An unbalanced ecosystem will have an adverse effect in the long term on the living conditions of the rural population. The annual production loss due to land degradation is estimated to be 4.0 to 6.3 per cent of the total agriculture GDP.

Of the ten agro-climatic zones in Karnataka, five are classified as dry zones covering 63 per cent of the geographical area and 71 per cent of the net sown area. With only about 25 per cent of the net sown area under irrigation, a substantial contribution to agricultural production of the state comes from drylands. For example, during 2000-01, of the total food grain production of 109.6 lakh tonnes, 62.52 lakh tonnes (57 per cent) came from rainfed areas. Most of the pulses (97 per cent) and oil seeds (80 per cent) were produced in dryland areas. It is noteworthy that a semi aquatic crop like rice is grown as a rainfed crop and as much as 20 per cent of the total area under this crop in hill, coast and transition zones is rainfed. The estimated requirement of grain during 2000-01 was 88.30 lakh tonnes whereas the production was 109.6 lakh tonnes (Hegde and Gajanana, 2005).

Relevance of Integrated Farming System

Integrated farming system (IFS) is an innovative and unique approach to promote efficient land use and animal management technologies as well as resource management capabilities of the farmers, particularly small and marginal farmers of rural populace. It is a micro approach and the entire holding of an individual farmer is considered as a unit. This approach calls for concerted educational efforts with primary focus of maximizing the net income of farmers over a period of time. This is closely related to realistic planning of farms in order to generate maximum family employment and to get sustained and stable net income. Such planning and implementation requires identification of potential for development, needs, interests and capabilities of farmers, availability of resources and also training them in farm management techniques. The different enterprises not only compete for scarce resources such as land, labor and capital on the farm but also exhibit interdependence due to supplementary or complementary relationship. This

also helps in recycling of the farm wastes and residues without polluting the environment and degrading the resource base.

Alternative Farming Options in Rainfed Agriculture

Traditionally farmers have been following mixed farming practices in order to spread the risk and produce various commodities required for family consumption. With evolution of market oriented farming, most of the earlier production systems gave way to monoculture of arable crops. Single crop based farming makes the farmer dependent on the market for other essential inputs like fodder, fiber, fuel wood and timber. With appropriate farming systems, majority of the needs of the farmers can be met within the production system. Livestock forms an integral part of the farming systems in most rain fed areas. The neglect of fodder production resulted in acute fodder scarcity leading to poor livestock health and quality. Introduction of top feed species and perennial grass/ legume as a component of the farming system can fill this gap to a large extent.

In general, rainfed areas are cropped for 3-4 months and the land remains fallow during the remaining part of the year. Nearly 30 per cent of annual rainfall in rainfed agro-eco system is received in the off-season i.e. during November to April southwest monsoon areas. The rainfall, which otherwise goes waste, can be utilized if some perennial vegetation like trees or grasses are introduced as a component in the farming system. The perennial species can also be grown as hedgerows on soil conservation structures and the bio mass if not required as fodder can be incorporated into the soil as green manure. Cropping systems that include perennial trees and grasses maintain the vegetative cover during the off-season and contribute to reduce soil erosion and improve the microclimate for crop growth (Rao et al., 1991). Recycling of tree bio mass improves soil fertility and tree roots facilitate nutrient flow from deeper soil layers to the surface in the form of litter fall (Korwar and Patibha, 1998). Ley farming (grass-arable crop 3-4 year rotation) substantially contributes to maintaining and upgrading soil quality.

Some of the promising alternative land use systems as options for rainfed cropping systems are:

- Alley cropping
- Silvipasture
- Tree farming
- Dryland horticulture
- Agro-horticulture
- Medicinal and aromatic plants
- Pastures and ley farming

Farming System Models

Cropping Systems

A good cropping system for dryland should have the ability to reap the benefits of a good cropping season to minimize the risk of erratic rainfall. In order to achieve this dual aim, suitable component cropping systems have to be developed which are more productive and less risky than sole cropping.

The crop combination depends on climate, local preferences and other site specific factors. The crop components should posses differences in duration, plant morphology, root system, stress tolerance, density response, resistance to pests and pathogens and yield stability (Shankar and Shivakumar, 2005).

Groundnut based production system

Table1: Net income generation in Groundnut based Production System as documented in the survey of Eastern and Central Dry zones of Karnataka during 2008.

Sl. No	Particulars	Marginal Rs.	Small Rs.	Medium Rs.	Large Rs.
I	**Rainfed Agriculture**				
	Crops only	5,059/-	11,154/-	7,199/-	
II	**Rainfed Agriculture + Other Enterprises**				
	1. Crop (1 ha.) + Dairy (1 animal)	14,048/-	12,102/-	18,339/-	23,100/-
	2. Crop (1 ha) + Sheep (8–10)			28,570/-	
	3. Crop (1 ha) + Sheep (8 –10) + Diary (1 animal)	22,000/-		-	
III	**Rainfed Agriculture + Irrigated**				
	Crops only	10,000/-	-	15,000/-	15,000/-
IV	**Rainfed Agriculture + Irrigated + Other Enterprises**				
	Crop (1 ha) + Dairy (1 animal)	15,000/-	14,125/-	17,676/-	10,242/-
	Crop (0.8 ha) + Dairy (1 animal) + Sericulture (0.2 ha)	19,833/-	24,745/-	37,000/-	-
	Crop (0.8 ha) + Dairy (1 animal) + Areca nut (0.2 ha)	-	-	-	25,000/-

- The net income from rainfed groundnut based production system ranged from Rs.5059/ha with crop alone to Rs. 22,000 with groundnut + Dairy (animal) + sheep (8-10) system in respect of marginal farmers. The crop + dairy generated a net income Rs.14, 048/ha.

- With respect to small farmers under rainfed agriculture, crops alone recorded a net income of Rs.11,154/ha as compared to Crop + Dairy which recorded a net income of Rs.12,102/ha, whereas in respect of medium farmers of rainfed agriculture the net income ranged from Rs.7199/-ha with crop alone to Rs. 28,570/ha with crop + sheep. The crop + dairy generated income of Rs.18,339/- ha with respect to medium farmers and was found to generate net income Rs.23100/ha with respect to large farmers.
- The net income of rainfed + irrigated agriculture ranged from Rs.10,000/ha with crops alone whereas Crop + Dairy generated Rs.15,000/-ha as compared to crop + Dairy + Sericulture which generated Rs.19,833/- ha.
- With respect to small farmers a net income of Rs.14,125 was generated with Crop + Dairy followed by Rs.24,745/- with Crop + Dairy + Sericulture.
- With respect to medium farmers a net income with Crop + Dairy was found to be Rs.17,676/-ha as compared to Rs.37,000/- Crop + Dairy + Sericulture.
- With respect to large farmers Crop + Dairy generated an income of Rs.10,242/ha as compared to Crop + Dairy + areca which recorded a net income of Rs.25,000/- ha.

Finger millet based cropping systems

Table2: Net income generation in finger millet based production system as documented in the survey of Eastern Dry zones of Karnataka during 2008.

Sl. No	Particulars	Marginal Rs.	Small Rs.	Medium Rs.	Large Rs.
I	**Rainfed Agriculture**				
	Crops only	7,500/-	9,231/-	-	-
II	**Rainfed Agriculture + Other Enterprises**				
	1. Crop (1 ha.) + Dairy (1 animal)	15,701/-	12,873/-	11,384/-	-
	2. Crop (0.8 ha) + Dairy (1 animal) + Horticulture (0.2 ha)	24,850/-	-	-	-
III	**Rainfed Agriculture + Irrigated**				
	Crops	-	10,000/-	-	15,000/-
	Crops + Banana	-	37,500/-	-	-
IV	**Rainfed Agriculture + Irrigated + Other Enterprises**				
	Crop (1 ha.) + Diary (1 animal)	-	24,000/-	24,500/-	-
	Crop (0.8 ha) + Dairy (1 animal) + Horticulture (0.2 ha)	-	-	-	34,230/-

- Under rainfed agriculture three systems were identified viz., namely crops alone, crop + Dairy and crop + Dairy + Horticulture, where as under rainfed + irrigated condition three sub-systems namely crops alone, crops + Dairy, Crop + Horticulture + sheep were identified.
- In rainfed and irrigated agriculture crops like finger millet inter mixed with field bean, fodder, Jowar, cowpea, pigeon pea, mustard, Niger and castor were grown, whereas under irrigated agriculture maize, paddy, vegetable and flowers, banana were grown. Mango was generally raised as a dryland horticulture crop in rainfed agriculture.
- Under rainfed agriculture improved varieties of finger millet like GPU-28, MR-1 were raised, among pulses cowpea, C-152, Redgram TTB-7 were used. For other crops local varieties were generally raised.
- Farm yard manure was applied to a limited extent to rainfed crops where as for irrigated crops FYM was generally used in adequate quantity. Among chemical fertilizers only DAP and Urea were used without application of potassium fertilizer leading to imbalanced application of fertilizers.
- Plant protection measures were generally taken up for pulse crops to a limited extent.
- Majority of the farmers used local cow breeds for draft and milk purposes. Few farmers owned cross Breed cows for mulching purpose and local breeds of sheep were generally reared.
- Under rainfed agriculture where crops were raised alone the family labour was used only for six months in a year whereas in irrigated agriculture the family labour utilization was slightly higher by large farmers.
- Raising crops alone under rainfed agriculture generated a net income of Rs.7500/-ha with respect to marginal farmers as compared to small farmers who were able to generate Rs.9231/-ha, Crop + Dairy generated a net income of Rs.15,701 with regard to marginal farmers as compared to small and medium farmers where a net income of Rs.12,873 and Rs.11384 was generated. Crop + Dairy + Horticulture systems generated a net income of Rs.24,850 under rainfed agriculture systems.

Cropping Sequence

Pearl millet – chickpea	Sunflower - chickpea	Black gram – rabi sorghum
Black gram – safflower	Green gram - safflower	Soybean – safflower
Sorghum – cowpea/horsegram	Cowpea – finger millet	Cowpea – chilli/tomato

Intercropping

Groundnut + pigeonpea	Seteria + pigeonpea	Pearl millet + pigeonpea
Sorghum + pigeonpea	Groundnut + Rabi sorghum	Green gram + safflower
Safflower + Pearl millet (4:2)	Rabi sorghum+Chick pea (2:1)	Pearl millet + pigeonpea

Livestock Maintenance: a tool for Alternative Livelihood System

Animals on the farm establish contributory relation with all other farm enterprises. They play a very important role in the present socio-economic conditions of farmers. Indeed, they require considerable labour for attending as well as a year round source of feed. Livestock convert grains, hay, greens and agricultural by-products into valuable food products like milk, meat and eggs. The residues are incorporated into the soil to make it more fertile and productive. Livestock production is well suited to the farmers in the scarcity areas, as the demand for water for maintaining animals is lesser as compared to that of crop production. Moreover, it provides a stable income and keeps the members of the family, particularly women folk, employed throughout the year. In addition, the products enhance the nutritional status of the family members. Further, it is a well known fact that, they also tend to add stability to the farming system, as their productivity generally does not fluctuate widely in response to the impact of weather which is not so with the field crops. However, cropping patterns must be adjusted to meet these needs.

Dairy Farming

Dairying, as a subsidiary source of income, is a real relief to most of the weaker groups in society (small, marginal land holding farmers) who maintain an average herd of one or two milk animals, comprising cow and or buffaloes, often one or two which enable these farmers to generate sufficient additional income to break the vicious subsistence agricultural debt cycle. Dairying is an economic activity, which evens out cash flow to households, in contrast to income from crops, which comes only at the end of a season. Further, dairy provides for an indirect income insurance against risks from crops, such as crop failure due to drought or pests (Prabhat et al., 2005).

Dairying for the farmers of drought-prone areas can be made more profitable by

1. Upgrading the local unproductive/low productive stock of cattle by introduction of exogenous germplasm through artificial insemination.
2. Improving existing crossbred animals through nutrition management programmes like feeding of balanced rations, mineral mixtures, available green fodder, tree leaves and proper health care management. With the above combination, the milk yield can be enhanced to the extent of 5 litres/animal/day.

Moreover, during the last two decades both population and food grain production grew at around 2 per cent, while milk production grew at more than double the rate of growth of the population, increasing per capita availability of milk from 112 gm/day in 1970/71 to 231 gm/day in 2003-04.

Goat and Sheep Farming

Goat and sheep rearing activities are very important in the developing zones. Generally, these activities are taken up by nomadic tribes and weaker sections of the farming community. Livestock farmers raise their flocks due to its cash reserveness for the household during drought or to conduct some of their family functions as and when the occasion arises. It is also an important economic activity that allows the farmer to have some milk (after the household need is met) and its derivatives in addition to meat. The young males and adult females that are not pregnant during the year are sold. Flocks are usually medium-sized, mixed with a predominance of goats than sheep because goats are less demanding in food requirements.

In any Indian farming community the family income is supplemented with off-farm activities. As a matter of fact, the households that depend solely on animal rearing are very rare.

Poultry Farming

Poultry is well developed in the dry areas, on a small and medium scale. Traditional rearing is combined with various farming activities. The expansion of modern farms was semi-intensive throughout the area. Some of the producers managed to put their production directly in the local market, whereas others signed production contracts with large enterprises. The income generated out of the activity is considered the primary income of the household. Farming labour is accessible however permanent labour is needed.

Crop + Goat + Silviculture Farming System

A farming system involving crop, animal and tree components 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 the farmer. The manure can aid in improving soil fertility.

Radhamani (2001) studied integrated farming systems involving three cropping systems with *Ailanthus excelsa* + crop + goat, *Ceiba pentandra* + crop + goat and *Emblica*

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 the system (Table 3).

Table 3: Productivity contribution of different components under Rainfed conditions

Farming system of 1 hectare		Component productivity (sorghum grain equivalent, tonnes)		
		Crop	Goat	Total
Sorghum sole cropping (grain))		6.34	-	6.34
Ailanthus excelsa + crop + goat	CS1	6.55	-	31.59
	CS2	3.24	-	
	CS3	3.45	-	
	Goat	-	18.35	
	Total	13.24	18.35	
Ceiba pentandra + crop + goat	CS1	6.02	-	30.59
	CS2	3.15	-	
	CS3	3.43	-	
	Goat	-	18.35	
	Total	12.60	18.35	
Emblica officinalis + crop + goat	CS1	6.81	-	32.10
	CS2	3.49	-	
	CS3	3.45	-	
	Goat	-	18.35	
	Total	13.75	18.35	

(Radhamani, 2001)

CS1 - Sorghum + cowpea (grain) : 0.33ha
CS2 - Sorghum + cowpea (fodder) : 0.33ha
CS3 - Cenchrus glaucus : 0.33ha
Goat : 0.01ha

Pig Farming

Pigs are the most efficient converters of inedible feed into valuable nutritious meat. Most of these feedstuffs are not palatable and acceptable to other farm animals. The breeds of pigs commonly reared are Yorkshire, Landrace and Saddleback.

Pigs are versatile farm animals and are capable of adopting to varied agro-climatic conditions, feeds and managerial practices. Pigs are fast growers and gain weight from 200-250 grams per day. They are also prolific breeders, which mature in 8-9 months, and become mothers by 12-14 months. Gestation period is about 112-118 days. Pigs farrow 8-12 piglets at a time with two farrowings per year.

Pigs do not require any specialized housing system except protection against scorching sun in summer and extreme cold in winter. Each adult animal requires a minimum of 12-15 sq.ft. of floor space. Pigs are voracious and versatile eaters. They feed on a variety of feedstuff comprising agro-based by-products, fruits and vegetables, market waste, industrial by-products, kitchen, hostel and hotel wastes, tamarind seeds and dehydrated poultry droppings in small quantity. Each adult pig should be given 1-2 kg of balanced feed.

Problems

1. Traditional customs restrict the adoption of piggery.
2. Unscientific rearing and constant breading of genetically degraded pigs.

Solutions

1. To educate the farmers about importance and profitability of piggery.
2. To show the worthiness in recycling of agricultural waste.

Table 4: Economics of Piggery (With 2 females and one male)

(in rupees)

1. Investment (Bank Loan)	
a) Construction cost of pig shed (10 ft X 10ft=1100sq. ft @ Rs.100/sa.ft.)	10,000
b) Cost of 3 piglets @ Rs.650 each (3 months old)	1,950
c) Cost of equipment	150
Total investment	**12,100**

2. Expenditure (for two years)	
a) Concentrate feed @ one kg/pig/day @ Rs.6/kg	13,140
b) Transportation cost of hotel waste @ Rs.10/day	7,300
c) Animal health care @ Rs.50/pig/year	300
d) Insurance coverage @ 5%	195
e) Interest on capital @ 12% per annum	2,880
f) Cost of family labour @ 50 mandays per annum @ Rs.50/mandays	2,500
g) Miscellaneous expenditure	185
Total Expenditure	**26,500**
3. Gross income (after two years)	
a) Sale of 40 piglets @ Rs.1000 each	40,000
b) Sale of FYM (2 tonnes) @ 500 per tonne	1,000
c) Sale of plastic bags (50X3/-)	150
Gross income	41,150
4. Net income (3-2)	**14,650**
Repayment of loan (50% of principal)	6,050
5. Net profit @ Rs.4300 per annum	**8,600**

Note: 1) Parent stock of pigs will remain as it is.
2) Cost of family labour includes the cost of marketing also.

Average Productivity of Farming Systems

The net income from individual and combined enterprises among different category of farmers in rainfed area of 120 sample farmers is presented in Table 5.

Farming system is aimed at the efficient use of resources to maximize the income. It also minimizes the production risk by spreading the risk to various enterprises instead of one activity. The details of net farm income derived from the existing farming system are furnished in Table 5.

The small farmers realized maximum net income of Rs.31,000 from crop + dairy + dryland horticulture + sheep system followed by Rs.27,210 from crop + dairy + dryland horticulture systems. With respect to medium farmers and large farmers crop + dairy + sheep + dryland horticulture gave a maximum net farm income of Rs.49,250 and

Rs.1,05,000, respectively, followed by crop + dairy + dryland horticulture which was Rs.42, 800 and 1,00,900 respectively (Table 5).

Table 5: Net farm income (Rs.) from the existing farming systems among different categories of farmers

Sl. No.	Farming system	Small farmers	Medium farmers	Large farmers
1	Crop + Sheep	6250	9000	-
2	Crop + Dairy	10,400	17,125	22,938
3	Crop + Dryland Horticulture	19,000	-	43,000
4	Crop + Dairy + Sheep	12,500	20,667	26,000
5	Crop + Dairy + Piggery	20,000	-	-
7	Crop + Dairy + Dryland Horticulture	27,210	42,800	1,00,900
8	Crop + Dairy + Dryland Horticulture + Sheep	31,000	49,250	1,05,000

(Nagaraja et al., 2004)

Employment Opportunities and Income Generation from Diverse Activities

Most of the rainfed farmers are hardly able to make both ends meet with the income from crop production alone and the most affected are small and marginal farmers. This calls for evolving suitable strategies to fulfill the additional needs of the population while reducing the pressure on land. Alternative employment and income generation to make them self-supporting and attain a reasonable standard of living are the immediate needs to augment rural prosperity and prevent migration to urban areas.

Integration of various farm enterprises to ensure effective utilization of available resources is an important approach for enhancing the economic stability of farming. Promoting various land-based subsidiary enterprises like dairy, poultry, sheep, sericulture, inputs, agro-processing, post-harvest and value addition, contract farming, etc., through evaluation can go a long way in improving rural prosperity. Self Help Groups (SHGs) have proved to be very successful in improving income. In a nutshell, activities specific to the region should be designed and supported in rural areas to provide farmers with a better standard of living.

Integration of some selected on-farm enterprises like agriculture, horticulture, animal husbandry, tree species and other related activities under Integrated Farming System (IFS) are proving to be successful. IFS with agro forestry has the potential to ensure the basic necessities of life, viz., food, fuel, fodder, flowers, fruit, fibre and fish, besides shelter and clothing as well as year round employment for small and marginal farmers. The vertical growing common bush/tree species like casuarina, silver oak, calliandra, drumstick,

acacia poles and small timber trees supplement the farm income. These tree crops can be grown on field bunds with grain crops as supplementary/complementary to each other. The field bunds can be stabilized with fodder legumes and grasses to yield nutritive fodder for grazing for small ruminants. Besides, some trees with economic value like neem, pongamia, jack, mango, tamarind and medicinal herbs can be established in the field corners or wastelands. A storage water pond designed for collecting surplus runoff water on the farm helps in providing protective watering for high-value vegetable/flower crops, besides facilitating fish culture.

The availability of fodder would support the rearing of one or two buffaloes, cows, a few sheep, rabbits and poultry birds. Poultry and fisheries using farm ponds could provide employment opportunities on the farm. Animal and crop-plant wastes and cattle manure will facilitate the working of biogas plants to provide cooking gas and lighting and at the same time yield enriched sludge-manure. Traditional farming system comprising of agriculture, horticulture, forestry species, animal husbandry, fisheries and other activities on the farm could be strengthened to make farming self-supporting. An Integrated Farming System (IFS) model in an area of one acre (0.40 ha) has been initiated at ARS, Bavikere, UAS, Bangalore, under rainfed conditions during 1999-2000. The model has proved that agriculture can be "eco-friendly" and need not be commercial by specialized farming as in developed countries, and can still be an economically viable enterprise. Farming is the largest private sector enterprise in India with nearly 60 per cent of the working population depending on it for their livelihood and it has the potential to provide gainful employment to all. Specialization has its limitations in agriculture and the complementary relationships between agriculture and other enterprises need to be harnessed through IFS for reducing unemployment.

New economic opportunities are being created by liberalization of the economy. These opportunities are being created by "biological software" for sustainable agriculture through development of biofertilizers, bio-processing, vermicompost, eco-foods, herbal medicines, recycling of agricultural and urban wastes and agro-processing. A proper blend of traditional IFS with need-based modernization is the essential strategy to be adopted for augmenting livelihood opportunities. Poverty alleviation is closely linked to livelihood opportunities at both the Farm Sector and Non-farm sector levels.

Policies and plans of the Government of India have been addressing these issues from time to time but most of them have their own deficiencies and some cater to the unskilled farm or labour-oriented livelihoods such as Drought-Prone Area Programme (DPAP), Integrated Rural Development Programme (IRDP). Any improvement in livelihood of the farm sector would have to depend on development of skills, lifting the

rural masses out of illiteracy and concerted efforts in vocationalization of learning and training in diversified fields.

A planned approach in both public and private sectors to absorb these trained personnel and to make them earn their livelihood through value-added avocations is the need of the hour. One of the best examples is sericulture development though World Bank assistance. Small-scale farmers have benefited by these developments making them employ the rural poor and provide livelihood to them. Similar activities in other diversified fields need a Central Budget of at least Rs.100 to Rs.200 crores for each category.

The farming system practice also enhances employment generation throughout the year. Crop + dairy + sheep system provided maximum employment of 319 mandays, 190 woman days and 17 bullock days, in case of marginal farmers (Table 6). In case of small farmers, crop+dairy+dryland horticulture + sheep system provided maximum employment.

Table 6: Employment generation in the farming systems among different categories of farmers

Farming system	Marginal Farmers			Small Farmers			Medium Farmers		
	M	W	BP	M	W	BP	M	W	BP
C + Sh	240	215	11	209	120	9	------	------	-----
C + D	131	160	8	197	131	14	259	264	22
C + H	75	59	12	-----	-----	-----	264	134	-----
C + D + Sh	319	190	17	320	235	10	370	500	31
C + D + Pi	193	174	12	-----	----	-----	-----	-----	-----
C + D + H	212	123	10	376	317	19	498	465	30
C+D+H+Sh	300	220	15	483	481	23	470	610	33

Note: C: crop; Sh: Sheep; D: Dairy; H: Dryland Horticulture; Pi: Piggery; M: Men; W: Women and BP: Bullock pair (Nagaraja et al., 2004)

Farming Systems in Dryland Orchards

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, groundnut or horsegram, 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 main cause for depletion of 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 orchards, crop + piggery can be thought of. The benefit-cost analysis for mango based farming system has been worked out (Table 7) using the same criteria as used for the other crop-based systems presented earlier.

Similar to mango orchards, a vast number of coconut orchards can be brought under sustainable farming systems in Deccan Plateau with careful selection of the 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.

Net annual revenue realized per acre from most cropping systems is generally low and not commensurate with the present level of cost of living to maintain a family of 2+2. If such systems can be raised by adding an animal component, the income generated could be doubled. However, feed cost would proportionately be a burden. At the same time, additional quantity of animal manure is generated. This would absorb extra cost on feed to some extent. By increasing the animal component by 1 cow and 2 sheep, economic sustainability can be augmented. Even this level of income may not sustain a rural agrarian family. Therefore, it is imperative to examine whether a one-hectare farm is more sustainable than a one-acre farm (Bhaskar, 2005).

Table 7: Benefit – Cost analysis of Mango based Farming System

Costs		**Returns**	
A. 1 acre crop + 1 cow + 2 sheep + 10 birds			
Particulars	**Rs**	**Particulars**	**Rs**
Mango orchard maintenance	3,000	Fruits 3 t @ 1,000	30,000
Crop cultivation	2,500	Grain 10 q @ Rs. 400/-	4,000
		Mixed crops	2,000
Dairy {dep. cost of animal (1) + concentrate feed (1) + Vety. Med (1)}	7,075	Sale of milk 2500 litres/year @ Rs. 9.00	22,500
Sheep (2 ewes + 1 ram)	4,500	Sale of sheep 2 @ Rs 1500/-	3,000
Poultry birds – Giriraja (10)	500	Sale of eggs or aged birds	2,000
Total	**17,575**	**Total**	**63,500**
Net returns		**45,925**	

B. 1 acre crop + 2 cow + 4 sheep + 10 birds			
Mango orchard maintenance	3,000	Fruits 3 t @ 1,000	30,000
Crop cultivation	2,500	Grain 10 q @ Rs. 400/-	4,000
		Mixed crops	2,000
Dairy {dep. cost of animal (2) + dry fodder (1) + green fodder (1) + concentrate feed (2) + vety. Med (2)}	18,546	Sale of milk 5000 litres/year @ Rs. 9.00	45,000
Sheep (4 ewes + 1 ram)	7,500	Sale of sheep 4 @ Rs 1500/-	6,000
Poultry birds (10)	500	Sale of eggs or aged birds	2,000
Total	**32,046**	**Total**	**89,000**
Net returns		**56,954**	
C. 1 hectare crop + 1 cow + 2 sheep + 10 birds			
Mango orchard maintenance	7,500	Fruits 7.5 t @ 1,000	75,000
Crop cultivation	6,250	Grain 25 q @ Rs. 400/-	10,000
		Mixed crops	5,000
Dairy {dep. cost of animal (1) + concentrate feed (1) + vety. Med (1)}	7,075	Sale of milk 2500 litres/year @ Rs. 9.00	22,500
Sheep (2 ewes + 1 ram)	4,500	Sale of sheep 2 @ Rs 1500/-	3,000
Poultry birds (10)	500	Sale of eggs or aged birds	2,000
Total	**25,825**	**Total**	**1,17,500**
Net returns		**91,675**	
D. 1 hectare crop + 2 cow + 4 sheep + 10 birds			
Mango orchard maintenance	7,500	Fruits 7.5 t @ 1,000	75,000
Crop cultivation	6,250	Grain 25 q @ Rs. 400/-	10,000
		Mixed crops	5,000
Dairy {dep. cost of animal (2) + concentrate feed (2) + vety. Med (1)}	14,150	Sale of milk 5000 litres/year @ Rs. 9.00	45,000
Sheep (4 ewes + 1 ram)	7,500	Sale of sheep 4 @ Rs 1500/-	6,000
Poultry birds (10)	500	Sale of eggs or aged birds	2,000
Total	**35,900**	**Total**	**1,43,000**
Net returns		**1,07,100**	

Figures in parenthesis against dairy indicate the number of animals for which cost is included.

Farming system model for small farmers (1 acre) – Bavikere Model

A sustainable model for small and marginal farmers is being developed at the Agricultural Research Station, Bavikere of the University of Agricultural Sciences Bangalore. This model has given a clue to sustainability as a bottom-up programme, with many observations on the catchment approach. These are being incorporated in the model in that it does not have any rigidity and can be adopted to different locales without sacrificing the importance of natural-resource management and increased production on a sustainable basis.

The land is laid out suitably to impose all the treatments and concepts of the Integrated Farming System. Following are the common features adopted in the model.

In order to ensure harvesting and effective use of rain water, land is laid out into five or six sub-plots by putting bunds across the slope, forming waterways leading to an on-farm reservoir (farm pond) through a silt trap. This would also ensure recharging of ground water. Thus, in situ moisture conservation is practiced and the surplus water stored in the farm pond is used for vegetable cultivation in the kitchen garden and for protective irrigation when needed. In addition, fish farming could be taken up if adequate rainwater is available.

The field boundary is planted with suitable plant species like Casuarina, silver oak, rain tree, albizzia, neem, pongamia, bamboo, champaka, soapnut, antawala, glyricidia, sesbania, etc., which provide many products such as timber, fuel-wood, fodder, fruit, fibre and green-leaf manure. Bunds are also planted with grasses and green-leaf yielding plants like glyricidia and sesbania, to get sufficient green fodder for farm animals and to give stability to the bunds.

Crops and Cropping Systems

Crops and crop combinations (mixed cropping) are selected in such a way that farm family can get cereals, pulses, oilseeds, vegetables, fruits, etc. While doing so, suitable crop combinations prevailing in the zone are selected with due consideration of the farming situation (micro-climate) in a given agro-ecological situation. Crops are raised in such a way that the farmer gains both in time and in space.

Subsidiary enterprises

Dairying, apiary, poultry, pisiculture, sheep farming, mushroom production, etc are all practiced in the system. The farmhouse is provided with a latrine connected to the

biogas plant that takes care of the fuel requirement. Biogas slurry with farm wastes and branches lopped from border plants ensure sufficient organic manure besides what is obtained through vermicompost. Kitchen garden pandals are erected on the manure production vats and climber vegetables like gourds are raised. Climber vegetables are also raised on the top of the farmhouse, cattle shed, etc. A few very important medicinal plants also find place in the model (Rudraradhya and Pandurangaiah, 2005).

Technological Options for Farmers in Rainfed Areas

These technologies can be included in the dryland based farming system.

1. Integrated Nutrient Management (INM)
2. Integrated Pest and Disease Management (IPDM)
3. Dryland Horticulture
4. Improved green fodder crops
5. Farm forestry in dryland
6. Upgradation of sheep
7. Introduction of Giriraja birds
8. Fish rearing in farm ponds
9. Nutrition garden
10. Value added products.
11. Mechanization

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