Farming Systems Approach – Concepts, Scope and Applicability in Rainfed Agriculture

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Introduction

Rainfed agriculture occupies 68% of India's cultivated area and supports 40% of the human and 60% of the livestock population. It produces 445 of the food requirement, thus has and will continue to play a critical role in India's food security. However, aberrant behaviour of monsoon rainfall, eroded and degraded soils with multiple nutrient and water deficiencies, declining ground water table and poor resource base of the farmers are principle constraints for low and unstable yields in rainfed areas (Singh, et al, 2004). Increasing crop productivity to meet food requirements of teaming millions in our country poses a greater challenge. In this context, there is a need to enhance the productivity of rainfed crops from at least 1 to 2 t to meet the food requirements by 2020 AD. Hence, the situation calls for efforts to intensify the production in both time and space. This could be possible by developing appropriate cropping and farming systems in rainfed agriculture.

1.0 Cropping Systems

In order to critically analyse the crop and area specific problems and potentials, the rainfed areas have been divided into five major production systems viz., Nutritious Cereals, oilseeds, Rainfed rice, Pulses, Cotton and Soybean based systems.

The guiding principles for selection of crops and varieties for efficient management of resources n rainfed areas are: land use capability concept, Water availability concept, crop substitution, quantity and distribution of rainfall, soil depth and performance of crops. Effective growing period concept is mostly used in deciding cropping systems in different agro-climatic zones. In *kharif* season, the rainfall both in terms of quantum and distribution decides the effective growing season and it becomes critical in selecting cropping systems for a given reason. A beneficial effect of 15-25% on yield was demonstrated by the crop substitution strategy, which means by replacing one crop with another appropriate crop. Soil depth and available moisture determines the selection of crops and cropping systems for a given region. In *rabi* season available moisture in soil profile at sowing time dictates the choice of crops in a given cropping system. In regions, receiving 350-600 mm of rainfall and 20 weeks effective growing season. Intercropping (150% cropping intensity) is possible in regions having 20-30 weeks of effective growing season from 650-750 mm of rainfall. In areas receiving more than 750 mm of rainfall and having an effective growing season of more than 30 weeks double cropping (2000% cropping intensity) is assured (Singh and Subba Reddy, 1986). Early planting and harvesting at physiological maturity of crops, less number of tillage operations, deep placement of fertilizers for *rabi* crops are crucial for succeeding double cropping.

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In rainfed agriculture, sustainability of yield becomes more important. While considering rainfall, and sustainable yield index it was observed that Rice + raddish (4:1) and Rice + blackgram (4:2) in Oxisols of Phulbani, pigeonpea + okra (1:1), Maize + Okra (1:1) in dry sub-humid inceptisols of Ranchi, Sorghum + cowpea (F) under delayed sowing conditions of Arjia, Pearlmillet + pigeonpea (1:2) in vertisols of Solapur, Sunflower + pigeonpea (2:1) in vertisols at Indore and Greengram + castor in semi arid entisols of Dantiwada recorded higher sustainability over the system (Vittal, *et al*, 2002).

2.0 Crop Diversification

Cultivation of crops for dyes, medicines, and aromatics is economical in rainfed lands. They also played a vital role in sustained use of degraded lands. These crops are both perennial and annuals with plants mostly of bushy nature. The advantages of bushes over larger perennial are that the former offers less competition to associated crops. The promising plants for cultivation in drylands ae dyes like Indigo (*Indigofera tinctoria* L.), Henna (*Lawsonia innermis* L.) and Bixa (Bixa *orellana* L.). Medicinal plants like Ashwagandha (*Withania somnifera* (L.). Dunal0, Senna (*Cassia angustifolia Vahl*.), Mucuna (*Mucuna pruriens* (L.), DC), and aromatics like curry leaf (*Murayya koenigii* (L.) *Spreng*), lemon grass (*Cymbopogan martini* (Roxb.) Wats), and sweet basil (*Ocimum basilium* L.).

3.0 Rainfed Farming Systems

Traditionally rainfed farmers are small subsistent land holders integrating livestock with crop production. With continuing population growth, intensifying crop and livestock systems continue to play vital role in maintaining rural livelihoods.

Farming systems refers deliberate raising of crops, forest and fruit trees, animals including fisheries, piggery and duck farming, sericulture, mushroom, on a given unit of land to increase the productivity and profitability, to upgrade natural resource base and to achieve overall improvement in the environment (Singh, 2005). The philosophy behind shifting from cropping system to the farming system mode involves (i) *in situ* recycling of organic residues including farm wastes generated at the farm to reduce the dependency on chemicals (ii) decrease in cost of cultivation through enhance input use efficiency, (iii) effective use of bye-products / wastes of one component for the benefit of other component/components (iv) upgrading of soil and water quality and bio-diversity, (v) increased water productivity, (vi) nutritional security through minimizing chemical residues in soil plant animal human chain, and (vii) environmental security by moderating flow of green house gases from the soil to environment. Farming system provides a vast canvass of livelihood gathering, a better risk coping strategy, continuous flow of income and employment throughout the year for small landholders. It involves utilization of primary and secondary produce of one system as a basic input of other system through making them mutually integrated.

3.1 Concept and principles

The modern agriculture emphasize too more dimensions viz., time and space concept. Time concept relates to increasing crop intensification in situation where there is no constraint for inputs. In rainfed areas where there is no possibility of increasing the intensity of cropping, the other modern concept (space concept) can be applied. In space concept, crops are arranged in tier system combining two or more crops with varying field duration as intercrops by suitably modifying the planting method. Income through arable cropping alone is insufficient for bulk of the marginal farmers. Activities such as

dairy, poultry, fish culture, sericulture, bio-gas production, edible mushroom cultivation, agro-forestry and agri-horticulture, etc., assumes critical importance in supplementing their farm income. It should fit well with farm level infrastructure and ensures fuller utilization of bye-products. Integrated farming system is only the answer to the problem of increasing food production for increasing income and for improving the nutrition of small scale farmers with limited resources.

3.2 Characteristics of farming systems

The farming system research activities are to be farmer oriented, system oriented, problem solving approach, inter-disciplinary, compliments mainstream disciplinary research, test the technology in on-farm trials and provides feed back from the farmers. The strategy of FSR should emphasize that the research agenda should be determine by explicitly define farmers needs through an understanding of the existing farming systems rather than its perception by the researchers. The farming systems research and extension should be dealt in holistic manner on farmers participatory mode with problem solving approach, keeping genders activity, inter disciplinary and interactive approach. IT should emphasize extensive on-farm activities and complement the experimental on-station research and acknowledges the location specificity of technical solutions and document the inter dependencies among multiple clients. Greater importance is placed on feedback to modify the content of subsequent on farm trials, if necessary, by changing research priorities focusing policy shifts based upon micro level analysis.

Thus farming system represents an appropriate combination of farm enterprises, viz., cropping systems, horticulture, livestock, fishery, forestry, poultry and the means available to the farmer to raise them for profitability. It interacts adequately with environment without disclosing the ecological and socio-economic balance on one hand and attempts to meet to national goal on others. Hence there is a need to do research on farming systems research for sustainable income along with the maintenance of natural resources. It is designed to understand farmers' priorities, strategies and resource allocation decisions.

3.3 Integrated farming system

Integrated farming system (IFS) a component of farming system research (FSR), introduces a change in farming techniques for maximum production is a cropping pattern and take care of optimal utilization of resources. The farm base is better recycling for productive purposes in the integrated farming system. Unlike specialized farming system (SFS) integrated farming systems activity is focused round a few selected, inter-dependent, inter-related and often inter-linking production systems based on few crops, animals and related subsidiary professions. Integrated farming system involves the utilization of primary produce and secondary produce of one system as basic input of other system, thus making the mutually integrated as one whole unit. There is a need to effective linkages and complementarities of various components to develop holistic farming system.

3.4 Goals of integrated farming system

The primary goals of FSR to maximize the yield of all component enterprises to provide study and stable income at higher level, rejuvenation of systems productivity and achieve agro-ecological equilibrium. Biotech stress management through natural cropping systems management and reducing the use of fertilizers and other farmful agro-

chemicals to provide pollution free, healthy produce and environment to the society. Thus farming system as a concept takes into account of components of soil, water, crops, livestock, labour and other resources with farm family at the center managing agriculture related activity.

Integrated farming system has the advantages of increasing economic yield per unit area per unit time, profitability, sustainability and provides balanced nutritious food for the farmers, pollution free environment and provide opportunity for effective recycling of one product as input to other component, money round the year and solve the energy, fodder, fuel and timber crisis, avoids degradation of forests and enhance the employment generation, increase input use efficiency and finally improve the livelihood of the farming community.

4.0 Methodology to organize farming systems under on-farm conditions

- **Farm selection**: Select the agro-ecological zone in which FSR is to be initiated. If necessary, further divide this agro-ecological zone to identify specific farming situation.
- **Selection of villages and farmers**: Select the village in each farming situation comprising marginal / small and medium / large farmers. Selection of village and farmers should be random so as to represent all farming community of the target area.
- **Diagnosis of constraints in increasing farm productivity**: Carry out survey through rapid rural appraisal. Prepare an inventory of farm resources and support services. Identify the production constraints.
- Research, design and technology generation and adoption
- Technology transfer and diffusion of improved farming systems within recommended domain.
- Impact of technology of improved farming system – productivity, economic returns, energy input – output, employment, equity (gender issue) and environment.

5.0 Predominant components in rainfed rainfed systems

5.1 Crop based farming systems

In this system, animals are raised on agricultural wastes and animal power is used for agricultural operations and voids are used as manure and fuel. In rice based production system at Orissa, *in situ* conservation of rain water by optimum wear height, conserving excess water in the refuges constructed at the down stream of rice field and rearing of fish in the refuges in the medium land enhanced the total productivity (James et al., 2005). This system recorded the highest net returns (Rs.2197/ha) with BC ratio (2.78) as compared to the growing of rice along 915294/ha). The average fish yield in this system was 1107 kg/ha in six months. The cropping intensity was increased from 100 to 131%. At Ranchi, the 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 (Rs. 2770/ha0 (TAR-IVLP, 2004).

Under nutritive cereal based production system, the cropping pattern with 35.39% of food grains and 25.71% of pulses 20.7% of oilseeds, 17.3% of commercial crops and 1.17% of fodder crops in total holdings of small farmers with backyard poultry (6 birds) helped the farmers to stabilize the farm income at Dharwad (TAR-IvLP, 2005). The animal component (poultry bird) helped the farmers during the drought year to stabilize the farm income as compared to crop alone. At Hyderabad, a marginal farmer having 0.5

ha grown cotton (Bunny) and maize + pigeonpea systems recorded the BC ratio of 3.47 and 4.43 respectively. One milch animal on an average gave the additional net benefit of Rs. 380/year. Thus, the net income from the marginal farmers could rise to the tune of Rs. 3275/ha with the investment of Rs. 1460/- in the farm (TAR-IVLP, CRIDA 2003). At Bangalore, the crop diversification involving 60% of area under fingermillet (GPU 28) and 40% area with pigeonpea (BRG-1) and 60% of fingermillet area with a combination of 40% area under drumstick gave additional net returns by 16 and 48% respectively as compared to the sole fingermillet alone (Rs. 11266/ha) (TAR-IVLP, 2003).

Agri-sheep farming with 10 lambs and growing crops and use of farm by products in one ha of marginal lands gave the net returns of Rs. 8700/ha as compared to growing cotton alone at Warangal in Andhra Pradesh (Rs. 27500/ha) under cotton based production system (TAR-IVLP, 2003). Mohammad Ali et al. (1984) showed that employment generation to the tune of 550 man-days was possible in dairy cum poultry based integrated farming system whereas cropping alone generated 245 man days in a year. In North Telangana zone, farming system with agriculture and dairy generated more than 200% additional employment over agriculture alone. The net returns were higher in agriculture and dairy followed by agriculture and poultry and agriculture and sheep (Reddy, M.D. 20050).

In Oilseed based production system, Groundnut cake is the most important by-product used as protein source and cattle feed at Ananthapur. Groundnut haulms are used for feeding cattle and sheep. Integration of sheep production in groundnut farming system offers gainful employment in rainfed areas. In this scarce rainfall zone of Andhra Pradesh, the highest net returns were recorded with farming with the poultry of broilers (Rs. 43360) followed by farming by dairy with three buffaloes having 2 ha (Rs. 40606) while sole crop of groundnut (2.6 ha) recorded the net returns of Rs. 14872/ha.

5.2 Agro forestry based farming systems

Perennial grass components, besides imparting stability to crop production in arid areas, also act as vegetative filter strips for prevention of wind and water erosion. Moreover, the grass component improves the soil organic matter and starts giving production from the establishment year onwards. Growing of grasses and legumes reveals that moth bean and mung bean in the ratio of 2:1 with grasses like *Lasiurus sindicus, Cenchrus ciliaris, Cenchrus setigerus* and *Dicanthium annulatum*, are quite promising. These crops, besides giving full yield of grass component, give the bonus yield of grain (1.3 to 2.8 q/ha) and fodder (3.5 to 6 q/ha). However, intercropping of grasses and dryland crops is often not feasible under a farmer's micro-farming situation and, hence, a strip cropping of grasses and *kharif* legumes in 1:2 ratio is recommended, with a strip width of 5 m. The grass component in agri-pasture and silvi-pasture systems was more profitable than the areable 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. All the tree based systems showed higher benefit-cost ratio over the pure arable farming.

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 N2, fixing trees with sorghum, groundnut, castor and pulses were evaluated in Alfisols and

Vertisols. Short duration dryland crops such as pearlmillet, 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 with *Cenchrus/stylos* in rainfed guava and custard apple, *Cenchrus* yielded dry forage 7 t/ha with 17.5% of crude protein during the first year while *stylos* recorded 5.6 tonnes 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. Ber on an average gave 40 kg fruits/tree along with the 100 kg of horsegram 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.

5.3 Livestock based production system

The livestock farming system in rainfed agriculture are complex and generally based on traditional socio-economic considerations. 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 feeding value of stover by chopping, soaking with water, urea treatment, strategic supplementation of concentrate, urea molasses mineral block for enhanced utilization, improvement in productivity of grasses quantum and distribution decides the effective growing season and it becomes critical in selecting cropping systems for a given reason. A beneficial effect of 15-25% in yield was and legumes in degraded lands, 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 (Mishra, A.K., 2002). At CRIDA, field studies indicated that urea treated straw increased the milk yield ranging from 0.47 1.2 l/day with an average increase of 0.8 l/ccw/day in IVLP villages of Ranga Reddy district. 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 helped in maintaining the overall health and productivity of animals particularly when fodder scarcity was acute in drought period. Mineral supplementation gave higher milk yield (58%) and net returns (Rs. 816) compared to the farmers practice of grazing alone which gave milk yield of 1.8 lit/day with net returns of Rs. 2156. Supplementation of rice bran @ 1.5% of body weight significantly improved the growth rate of sheep and goats.

6.0 Operational implications in farming systems

Farm households have great potential for experimentation, learning and exchange of experience. There is a need to recognize gender and youth roles to develop appropriate farming systems in rainfed regions. During the implementation of the

programs higher recognition for women should be given compared to the men in similar situations.

Wide spread of adoption participatory methods for planning, analysis and implementation should be linked with the relevant public sector services under decentralization, planning and implementation should be better tailored to the diverse needs of the local farming systems. Decentralization greatly facilitates assembly of interested stakeholders for the purpose of joint planning, implementation, oversight and evaluation. There is a need to identify broad range of financial organizations in order to address diverse needs of farmers particularly those associated with chronic poverty and hunger. At local level encourage promoting the use of competitive matching modalities to improve the livelihoods rainfed farmers through farming systems approach. The farming system should assess the impact of policy and institutional changes using global and national farming systems frame work.

7.0 Farmers lead learning process

Farm households have a great potential for experimentation, learning and exchange of experiences. Through this kind of innovation and learning the art of evaluation of farming system took place. There is a need to recognize gender and youth roles to develop appropriate farming systems in rainfed areas. During the implementation of the program higher reorganization for women should be given compared to the men in similar situations.

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Farming systems research has to be undertaken intensively in all rainfed production systems under varied micro-farming situations with active participation of the clientele. The inter linkages between various enterprises, recycling of organic wastes, cost-minimizing technologies under different farming situations has to be studied in a holistic manner. Coordinated multi-disciplinary approach is essential for IFS approach. The concept of farming systems approach and evolved technological base should be effectively conveyed to the agencies involved in technology transfer for dissemination to the farming community. Success of innovative farming systems will largely dependent upon how best the issues of post harvest processing, value addition and marketing are addressed.

Development of dynamic farming systems required a conductive enabling policy and environment. The structural adjustments have to be reduced, leaving urban bias in the policies. The role and impact of the state and related institutions and functioning of the farming systems expressed principally through policies, programs, institution, services and public investment in rural areas. The recent evaluation of farming systems based upon increasing specialization requires extra knowledge on the part of the farm operators. Farmers have to understand the nature of domain that they are responding to in terms of its implication for varieties, timing, packing and permitted chemicals, etc.,

and increasingly to modify their products and activities as market demand changes. The relevance of non-material capital to the farming system in terms of knowledge information and ability to assess and utilize such knowledge is required.

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