Integrated farming system: An eco-efficient sustainable practice for food and nutritional security

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Introduction

Globally, food security is a key challenge of 21st century given concerns to meet the adequate balanced food, fuel and fiber requirements of rising populations, in the eve of declining natural resources, increasing water scarcity, climate change and increasing energy costs while protecting environmental qualities. Despite great progress in increasing productivity in the last century, hundreds of millions of people remain hungry and malnourished. Further hundreds of millions don't eat the proper diet or consume the wrong sorts of food, which makes them unhealthy. The health of the community and environment suffers too, as degradation of soil, water along with outcome of the associated pollutants accompany many of the agricultural systems. This is the indicative of something wrong in our agricultural and food system? In the past, with the advent of Green revolution technologies substantial enhancements of food grain production leads towards self-sufficiency in food production in India including several developing countries, with massive application of higher inputs of fertilizer, pesticides, irrigation and machines etc. disregarding the ecological integrity of land, forests and water resources, which subsequently resulted environmental degradation and endangered biodiversity.

The intensively cultivated lands for achieving higher production without adequate replenishments threatening the very sustainability of the important traditional agricultural production systems and national food security. The declining trends in size of land holding and diversion of agricultural lands (infrastructure and industries) for other uses poses a serious challenge to the national food security. In Indian context, the average size of the landholding has been declined to 1.16 ha during 2010-11 from 2.28 ha in 1970-71; and with continued trends the average size of holdings expected would be mere 0.68 ha in 2020 and would be further reduced to 0.32 ha in 2030. From 1970, world average per capita consumption of food has increased by 17 percent to 2,760 kilocalories per day—good as an average, but still hiding the fact that many people are surviving on less per capita food consumption under 2,200 kcal

per day. The challenge remains huge in term of food security in respect to production, distribution and consumption patterns of millions of hungry and malnourished peoples. But solving the persistent hunger problem with enhancing livelihood security is not simply a matter of developing new agricultural technologies and practices as most of the small and marginal farmers are poverty ridden and cannot afford expensive technologies. A common, though erroneous, assumption about agricultural sustainability implies on a net reduction in input use, thus making such systems essentially extensive (i.e., requiring more land to produce the same amount of food). There will have to find new types of problem solving solutions based on locally available resources (land, water, biodiversity, genotypes along with social, and human resources) combined with best available technologies and ecological management practices that can able to minimize or eliminate harm to the environment, can be termed as "sustainable intensification" or "eco-efficient" agricultural practices.

Can something be done, or is the time for the expansion of an agriculture (agro-system) based more on ecological principles and in harmony with people, their societies, and cultures? Therefore, farming systems approach is a valuable approach to addressing the problems of sustainable economic growth for farming communities in India. Hence, integrated farming systems (IFS) are viewed as a sustainable alternative to commercial farming systems particularly on marginal lands with the objective of reversing resource degradation and stabilizing farm incomes.

The bottom line is very clear - agriculture in smallholder systems needs to be resilient, sustainable and eco-efficient, and at the same time yield multiple benefits to be accrued to the smallholder farmers including the futuristic provisions for ecosystem services. Integration and diversification in the IFS combined with unique resource management strategies are helpful in achieving sustainable production and economic benefits without undermining the resource base and environmental quality. Investing in such agro-ecosystem ensures the growth in agriculture and can most effectively bringing economic growth and poverty reduction.

Integrated farming system as eco-efficient agricultural systems

Eco-efficiency is concerned with the efficient and sustainable use of resources in farm production and land management's and it can be increased either by altering the management of individual crop and livestock enterprises or by altering the land-use system. Conceptually the eco-efficiency seems to be similar to ecological intensification (Dobermann et al., 2008) and

conservation agriculture (CA), which encompassing both the ecological and economic dimensions of sustainable agriculture. Additionally, the economic, social, institutional, market, and policy-related aspects will also determine the extent of eco-efficiency in agriculture (Keating et al., 2010). Future enhancements of production and productivity must be targeted in the area along with the promotion of ecological sustainability. Importantly, this greater output and efficiency has to be achieved while maintaining or restoring land, water, biodiversity, and agro ecosystems.

Considering the operational farm holding (decreasing trends) and their area sizes (majority below 1 ha area) and declining of per capita availability in India practically one can expect the vertical expansion and which is possible by integrating farming components requiring lesser space and time and ensuring reasonable returns to farm families. Therefore, IFS assumes greater importance for sound management of farm resources to enhance the farm productivity and reduce the environmental degradation, improve the quality of life of resource poor farmers and maintain sustainability.

Fig A. Rice-fish multi crop model for irrigated lowland

Fig B. Rice-fish- livestock – horticultural and agro-forestry based IFS model

Fig C. Multistory- rice- fish- horticultural and agro-forestry based IFS model

Three types of integrated farming (IFS) models have been developed at ICAR-National Rice Research Institute, Cuttack, based on resource availability and managements. The objective is to achieve economic and sustainable production of diverse products to meet farm families' needs and to cater to local market demands, while preserving the resource base and maintaining environmental quality.

The generic IFS models (Fig 1.) developed (NRRI) with integration of cropping with horticulture, fish, poultry, ducks, goat, mushroom culture, bee-keeping, and farm agroforestry woodlots, depending on agro-climatic and socio-economic conditions. The crop residues and other farm wastes including animal droppings are recycled or composted and returned to the land. Initial cost of earth works for land shaping ranges between US$ 2500 and US$3 000/ha. IFSs have been shown to stabilize crop production (especially in rainfed ecosystems); enhance resource recycling, ensure efficient use of all inputs, generate year-round employment, improve farm income, cash flow, family nutrition and maintains healthy ecosystem services in the face of biotic and abiotic stresses along with adaptation to climate-change scenario. The benefit/cost ratio increased from 1.60 in conventional system to multi crop model 2.6, multistoried model 2.85 and to combined crop-livestock model 3.2. The IFS model for rainfed medium lowland has been adopted on 200 ha of land in Orissa State, India, and the model for deepwater areas on 100 ha. These IFS systems could be expanded and adopted to other eastern region/ states for poverty alleviation and improving livelihood security of small and marginal farmers. However, the large-scale adoption would require initial financial assistance to help with the costs of land shaping, initial input costs, training and technical support to farmers. In the real sense the IFS system provides sustainability in production with employment, economic, nutritional and environmental security to the small and marginal farmers.

IFS, ecological intensification and harnessing ecosystem services for food security

Ecological intensification is based on managing service providing organisms that directly or indirectly contributing to the agricultural production. The aim is to maximize production with minimization of environmental impacts, but not necessarily exclusion of anthropogenic inputs, (such as inorganic fertilizers, pesticides, energy, and irrigation). This includes the regulating and supporting ecosystem services management in agricultural practices (Bommarco et al. 2013). The value and general understanding of provisioning ecosystem services (food, fiber, and energy) is higher and the importance of supporting (e.g., soil fertility)

and regulating (e.g., pest control and crop pollination) services are remains undervalued, however, intensively cultivated crop production systems depend heavily on supporting and regulating services that determine the productivity.

In the present contest, the ecosystem services utilization is becoming an integral part of farming system, and judicious selection of mixed farming enterprises demonstrate the economic benefits of supporting and regulating services for enhancing profitability. The landscaping of IFS delivers more services besides crop production, such as climate regulation, water regulation, and biodiversity conservation, many of which give benefits at regional or global scales. Multifunctional integrated farming system encourage farmers and land managers to adopt/ practices ecological intensification for ensure productive, profitability and environmentally friendly agriculture for maintenance of food security.

Conclusion

The rice-fish based integrated farming system is an eco-efficient land management practices with integration of crop-livestock-agro-forestry system having judicious use of farm resources and waste recycling with lesser dependence of non-renewable resources. The CLAIFS enhances the farm and water productivity, diversify and enhances the farm income with provision of biological control of weeds, pest. and addition and spreading of organic fertilizer resulting improvements of soil health. The system embodied with supporting and regulating ecosystem services which provides enhanced sustainable crop yields. The system having potentials for climate change resiliency and mitigation strategies and thus enabling the farmer's participation of climate risks managements for building a climate resilient production system for national food security.

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