Integrated Farming System: An Approach for Sustainable Management of Natural Resources

D.K. Sharma
ICAR-Central Soil Salinity Research Institute, Karnal, Haryana, India
Corresponding author E-mail: dk.sharma@icar.gov.in

ABSTRACT
Integrated farming system (IFS) is a multidisciplinary approach that fulfills all the sustainability criteria, including social, economic, and environmental, and has good relevance to smallholder farmers. It has greater significance and relevance than the individual approach of managing soil, water, nutrients, crops, pests, and farm energy needs. Development and emergence of region-specific IFS models can revert the current alarming rate of degradation of natural resources and biodiversity due to intensive agricultural practices. It can sustainably counter the challenging issue of food security for the burgeoning world population. Successful implementation of IFS can take care of the social equity concerns which have great potential in doubling or maintaining a regular income for farmers and their families through on-farm employment opportunities. This review provides a comparative analysis of IFS to the current monoculture-based agricultural scenarios with particular reference to smallscale farmers.

Keywords: Integrated farming, soil health, resource conservation, sustainability, smallholder farming, diversification.

CURRENT AGRICULTURE SCENARIO IN INDIA
The second half of the 20th century, characterized by the Green Revolution in many African, Asian, and Latin American countries, witnessed a remarkable growth in food production but still, a large population in many developing and underdeveloped countries did not have access to sufficient food (Godfray et al., 2010). Substantial increase in food production and a multitude of environmental problems co-evolved during this period primarily due to the heavy and indiscriminate use of agrochemicals in rice and wheat crops (Sinha, 1997). Despite impressive gains in food output, Green Revolution was thus seen to lack concerns for social equity and environmental sustainability (Conway and Barbie, 1988) and thus required a paradigm shift in means and ways of agricultural development with emphasis on socially just and environment-friendly approaches of food production and distribution (Sinha, 1997).

Indian agriculture contributes 8 percent of the global agricultural gross domestic product to support 18 percent of the world population on only 2.3 percent of the world’s geographical area. Agriculture continues to be the mainstay of the Indian economy by providing livelihood to 54.6 percent population; contributing 17.4 percent of the gross value addition, 12 percent of total exports with a growth rate of 4.1 percent in agricultural production during 2016-17. The agricultural sector grew at the growth of around 4 percent per year during 2004-05 to 2014-15 and the growth was quite impressive as compared to 2.2 percent per annum during the previous decade.

In the past, an increase in food production was mainly achieved by bringing additional lands into intensive cultivation through the use of improved seeds, heavy input use, and liberal irrigation. In changing scenario, this approach does not seem feasible as land and freshwater are not only becoming scarce due to competition from housing and industrial sectors, but different forms of land degradation such as soil erosion, desertification, soil
salinization, and unsustainable cropping practices are turning many productive lands into barren patches (Godfray et al., 2010). The current alarming rate of natural resource degradation, spanning about 25 percent of the earth’s soil and water resources and biodiversity, could adversely affect the food security of a burgeoning world population in the changing global scenario (FAO, 2011).

**CHANGING SCENARIO CONCERNING NATURAL RESOURCE BASE**

Indian agriculture is facing second-generation problems comprising shrinking and degradation of natural resources, declining average size of landholding, multi-nutrient deficiencies, soil fatigue due to intensive cultivation, yield plateau in most of the crops, continuous decrease in the input use efficiencies, low total factor productivity, declining water table and a virtual halt in further expansion of the irrigated area have posed a major challenge to maintain sustainable production levels without endangering the environment. Several measures such as ecologically sensitive intensification, focus on soil quality and soil organic carbon sequestration, and enhancement of biota activity and diversity need to be integrated to achieve sustainability (Bhardwaj et al., 2019, 2020, 2021; Lal, 2020). Climate change is now a reality, and it is challenging the farmer’s ability to adopt adaptation measures that are warranted. It is manifesting as an increase in mean temperature, changing pattern of monsoon (floods, droughts, more dry spells, high-intensity rains in a short time, etc.), shortening of winter period (terminal heat stress), change in pest dynamics, increased heat waves, shifting of cropping zones, etc. The annual mean temperature for the country as a whole has risen by 0.560 C during 1901-2009 (Attri and Tyagi, 2010). It is estimated that crop production loss in India by 2100 AD could be 10-40 percent despite the anticipated beneficial effects of increased CO₂ on crop growth. The agroecosystems have become more vulnerable to climate change and the availability of resources especially water has considerably decreased. The per capita availability of water will decline to 1140 m³ by 2050 from 1820 m³ in 2001. The groundwater table in the most productive Punjab, Haryana, and western Uttar Pradesh states is depleting by a rate of around 0.5 meters per year.

**EFFICIENT UTILIZATION OF NATURAL RESOURCES**

It is high time to develop and promote region-specific IFS models for the variable resource base of farmers. The concept of integrated farming system (IFS) has great significance and relevance than the individual approach of soil, water, nutrient, crop, pest and energy management. It combines all good agricultural practices like integrated nutrient management (INM), conservation agriculture (CA), integrated weed management (IWM), integrated water management (IWrM), integrated pest management (IPM), integrated disease management (IDM), integrated energy management (IEM), integrated post-harvest management, etc. (Fig. 1). In the current scenario, the deteriorated soil-water-plant continuum and climate change are direly indicating the urgent need to follow IFS principles in the agrarian sector, especially in vulnerable areas. IFS is particularly beneficial for small and marginal farmers because it aims to minimize dependence on purchased inputs while utilizing on-farm resources. This has the potential to enhance the productivity of crops without a commensurate increase in cost, thus increases farm profitability substantially. There is a need to shape up our research and development curriculum with redesigned IFS practices to address the emerging matrix of agricultural problems in a holistic manner and to tackle production-, resource- and climate-vulnerability issues of the farm sector while integrating soil, water, nutrient, crop, pest and energy management practices for improving system productivity and profitability.

**BENEFITS IN TERMS OF PRODUCTION AND PROFIT IMPROVEMENT OVER EXISTING SYSTEMS**

Integrated farming system (IFS) promotes a multi-disciplinary whole-farm approach which represents multiple crops and multiple enterprises in a single farm to achieve sustainable farming (Fig. 2). It optimizes various farm components and farm resources, and their integration for multi-enterprise farming systems in a given set of the agro-ecological regime for enhanced soil health, resource use efficiencies, factor productivity, profitability, and regular employment to farmers. IFS is an economically and environmentally sound diversified production system that has great potential in
Figure 1. Integrated farming systems model for smallholder farmers with around two-hectare land area

Figure 2. Various components of integrated farming system for ensuring high resource use efficiency
doubling farmers’ income with careful planning and scientific intervention under the Indian context. Integration of horticultural crops, dairy, fishery, goatry, poultry, duckery, and piggery with existing farming systems enhance income manifold (200 to 450% or more). Recycling and intermittent use of products and by-products within the system could save costs to the extent of 45 percent and even more. Besides diversification of crops and enterprises, there is a need to introduce agroforestry options to give resilience to the production system, varietal cafeteria approach, increased seed replacement rate, and pesticide rotation shall be followed because it enhances resistance in all types of pests resulting in higher rate application of pesticides or no effect of costly inputs in managing pests, etc. To harness the benefits of agricultural diversification, there is a need to link it with the market, contract farming system, strengthen the Govt./registered agency procurement network to procure all the diversified produce at MSP/ reasonable price at village level to eliminate the middle man and strengthen the value addition and processing industry with access to farmers.

Keeping in view the specific requirements of small and marginal farmers in the post-reclamation phase, an integrated multi-enterprise model consisting of diverse components (field and horticultural crops, fishery, cattle, poultry, and bekeeping) has been developed for a 2 ha area for ensuring sustainable resource use efficiency, high and regular incomes and employment generation (Sharma and Chaudhari, 2012; Singh, 2009). This model substantially reduces the production costs by synergistic recycling of resources among different components. Similar models are also being standardized for waterlogged sodic soils in Uttar Pradesh, highly saline black soils in Gujarat and coastal saline soils of West Bengal Multi enterprise farm pond based system for coastal degraded lands has been developed. Harvesting of rainfall and surface runoff from the surrounding area is the major objective of a farm pond to recycle the water for crops, animals during the dry season. In the process, a multi-enterprise farm-pond-based production system can be developed to ensure multiple uses of water and income from components. Due to the factors of soil salinity and backwaters in coastal areas, especially in the light of predicted scenarios of climate change where changes are expected via sea-level rise and seawater intrusion, the farm ponds in coastal/degraded lands are expected to have either fresh or brackish water. In brackish-water-based farming systems, apart from salt-tolerant lines of rice with salinity tolerance up to an extend of 6 dS/m of electrical conductivity, ducks can serve as an important component as no mortality was observed when introduced gradually to saline water of different concentrations up to 15 ppt. The body weight recorded at different week intervals did not show much difference in different concentrations of salinity for a period of one, two, and three-week intervals. Additional return of 4000/- from 600 m² pond can be obtained from the duck component within four months through the sale of eggs for ensuring the rotational livelihood of farmers especially in the disadvantaged areas having coastal salinity as a constraint. Saline tolerant fodders can also be grown on the bunds of farm-pond to support livestock production (cattle & goat). Brackish water prawns can be reared in the ponds. After testing the water quality in the pond, water can be utilized for irrigation during the dry period (Ambast et al., 2011). Economics of various land shaping models at CSSRI, RRS, Canning town (West Bengal, India) were calculated and the farm pond model emerged as the most profitable with the highest B:C ratio of 2.41 followed by deep furrow (DF) and paddy cum fish (PCF). All the land shaping models have been generating higher net returns over the control plot

Long term experiment conducted at Central Soil Salinity Research Institute (CSSRI), Karnal revealed that the highest system productivity in terms of rice equivalent yield (REY) was recorded with rice-wheat-moongbean cropping system (12.2 t ha⁻¹) followed by rice-wheat (11.1 t ha⁻¹) and maize-wheat-moongbean (7.0 t ha⁻¹). The average net income from crop and subsidiary components together was ₹ 348595/-, out of which ₹ 72020/- came from cereal crops (including fodder), ₹ 35880/- from vegetables and fruits, and ₹ 195650/- from subsidiary components, from an area of 2.0 ha, which was substantially higher than a conventional rice-wheat cropping system (₹ 302250/-). Among all the systems, fruits and fisheries production were found more remunerative with a B:C ratio of more than 4, whereas, vegetable production system generated lowest B:C ratio (1.9) due to the involvement of higher input cost and labor in this system. The economy of the integrated farming system at village Kashrawan in Raibareli district of Uttar Pradesh, India, was evaluated in terms of cost-benefit analysis.
of the individual cropping systems. The B:C ratio of the various components under study varied from 1.70 in fruit-based system to 2.63 fish farming system. The whole system B:C ratio came to 2.21.

CONCLUSION

The diversification of existing farming systems with change in crop (s), cropping systems, addition and improvement of livestock components, inclusion of horticulture, primary and secondary processing, and boundary plantations is essential to improve the on-farm income of small lead holders in India. Integration of diversity of components also paves way for meeting the household demand for balanced food, improved recycling of nutrients and water besides increasing the on-farm employment opportunities for family members. Various integrated farming models have clearly demonstrated the advantages. A productivity gain of 2 to 3 times and an increase of 3 to 5 times in the net returns is possible with improved systems. Further, resource-saving of 40 to 50% can also be ensured besides raising the income of the household to the level of at least ₹ 400 to 500 per day. An increase to the extent of 70 to 80% in additional employment generation is also possible. Improved diversified systems also ensure household nutritional security. Under extreme weather events also, farm households following multiple farming components have better resilience than the single commodity-based production systems.

REFERENCES


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