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Rice-Based Integrated Farming System for Sustainable Coastal Agroecosystem of India

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Abstract

In comparison to industrial expansion, agriculture growth in recent years has been extremely slow. Future food demand is being impacted by the declining production of primary crops. Due to a modest shift of acreage for other purposes mainly industrialization and urbanization, net sown area in India has slightly declined in last two decades. A holistic approach is urgently required to generate positive growth rates in agriculture, particularly in coastal ecosystems. Sustainable agriculture aims to preserve the basis of natural resources, safeguard the environment, and promote wealth over a longer period. A farming system is a collection of agro-economic activities that interact and are connected in a specific agroecosystem. The term "Integrated Farming Systems" (IFS) refers to a strategic combination of one or more enterprise with crop production that produces complementary results through efficient waste and crop residue recycling and generates extra sources of income for farmers. The interdependent, connected, and interlinking production systems based on crops, animals, and related ancillary professions are what make up the IFS activity. Abundance of species diversity aids in improving soil health especially organic carbon, besides enhances ecological conditions, both of which are necessary for long-term sustainability of production system. Additionally, it inhibits the spread of pests and improves soil nutrient cycling. IFS approach with site-specific models offers gainful employment and is extremely profitable and sustainable in all environments. Along with IFS, other practices that promote fertilizer use efficiency include agroforestry, integrated nutrient management, and soil and water conservation.

Keywords: Ecosystems, Integrated Farming Systems, Rice, sustainability.

Introduction

Despite India fast economic growth, the rate of agricultural growth remained around 3 to 3% in last 20 years. This has been mirrored in the fact that major crop productivity is either stagnant or decreasing in majority part of India. With the espected population of over 1.6 billion and annual food demand of 400 Mt by 2050, the country requires minimum 4% annual growth in agriculture. The changing macro and micro-economies will also impact the demand and behavioral changes for food. There would be substantial increase in demand for quality products of fruits/vegetables and livestock. The challenges of environment protection and globalization shall put tremendous pressure on Indian agriculture. Climate change induced impacts on agricultural productivity pose the most imminent of such challenges.

Over 85 million out of 105 million of India's working farms are smaller than 1 hectare, and this number is falling (Paramesh et al., 2022). There is essentially no scope for horizontal growth of land for agriculture due to the country's declining per capita available land and ever-increasing population. The only way to expand vertically while providing farm families with decent returns is to integrate farming components that require less space and time. In order to increase farm output, lessen environmental degradation, enhance the quality of life for resource-poor farmers, and ensure sustainability, the Integrated Farming Systems (IFS) gain more relevance. A holistic approach is essential if agriculture is to maintain a positive growth rate. Conservation of the natural resource base, environmental protection, and increased prosperity over an extended period of time are the three main objectives of sustainable agriculture. A farming system is a collection of interconnected agroeconomic activities that interact with one another in a specific agrarian setting. The term "farming system" refers to a collection of farm businesses to which farm families allocate resources in order to effectively use the businesses already in place for the productivity and profitability of the farm. Crop, livestock, aquaculture, agroforestry, and agri-horticulture are the types of farms involved (Paramesh et al., 2019). Although crop and other enterprises coexist in such diversified farming, the main goal is to reduce risk, whereas in IFS, a thoughtful combination of one or more enterprises along with cropping has a complementary effect through efficient recycling of wastes and crop residues, which includes an additional source of income for the farmer. The primary focus of IFS activity is on a small number of interconnected, interrelated, and interlinking production systems based on plants, animals, and related auxiliary occupations. According to Paramesh et al. (2020b), the IFS would naturally produce more sustainably because residue from one sector becomes the input for another, virtually eliminating waste as a source of environmental pollution.

Rice varieties suited for lowland situations of west coast region

The farmers select the rice varieties depending upon the suitability to the ecology and local needs. In general farmers prefer coarse grain rice varieties due to their suitability to parboiling and milling in local mills (Manohara et al. 2020). ICAR CCARI has developed four salt tolerant rice varieties *viz*., Goa Dhan 1, Goa Dhan 2, Goa Dhan 3 and Goa Dhan 4 which are medium duration rice varieties, coarse grained, with yield potential ranging from 30-35 q/ha. These improved salt tolerant rice varieties giving 80-100 % more grain yield compared to traditional rice variety like Korgut and inturn increasing the net returns of the farmer (Manohara et al. 2019). Similarly, in rainfed shallow lowland ecology/medium lands, farmers mostly grow varieties *viz*., Jaya and Jyothi. The Jyothi rice variety is fetching premium price in market due to its red colour, and suitability for parboiling.

Table 1. Salient features of the four salt tolerant rice varieties developed at the Institute

Variety	Year of release	Duration	Grain type	Grain yield
Goa Dhan 1 (KS 12 / IET 25055 / IC629221)	2017 (SVRC release)	130-135 days	Short bold	Under high salinity condition - 30-35 q/ha Under normal condition- 40-45 q/ha
Goa Dhan 2 (KS 17 / IET 27825/ IC629222)	2017 (SVRC release)	125-130 days	Long bold	Under high salinity condition - 28-30 q/ha Under normal condition - 40-45 q/ha
Goa Dhan 3 (GRS 1 / IET 25051 / IC629223)	2019 (SVRC release)	120-125 days	Long bold	Under high salinity condition- 30-35 q/ha Under normal condition- 55-60 q/ha
Goa Dhan 4 (JK 238 / IET 27840 / IC629224)	2019 (SVRC release)	125-130 days	Long slender	Under high salinity condition - 30-35 q/ha Under normal condition - 50-55 q/ha

Integrated farming system in coastal ecosystem

Rice-based integrated farming systems

The wetland ecosystem that includes rice fields in the coastal region provides a variety of important ecological and economic activities that are advantageous to mankind. Diversified cropping is constantly on the rise, largely due to economic factors. Crop diversification is a useful strategy to boost crop productivity under various circumstances. It is meant to provide a larger range of options for production in a specific area to increase production-related activities on different crops (Manjunath et al., 2018). The frequent approach of expanding the system's base by including more crops in it is known as horizontal diversification. With a 300–400% increase in cropping intensity, this multiple cropping has allowed realizing a production potential of up to 30 t/ha/year (Varughese *et al*., 2007). The factors that influence crop diversification: I resource-related factors, such as irrigation, rainfall, and soil fertility; (ii) technology-related factors, such as seed, fertilizer, storage, processing, and marketing; (iii) household-related factors, such as the need for self-sufficient food and fodder as well as investment capacity; and (iv) institutional and infrastructure-related factors. The above is additionally impacted by farm size, tenancy agreements, research and extension programs, marketing strategies, and government regulatory laws. Farmers have long-established cropping systems for various agro-climatic zones based on factors like soil compatibility, profitability, market accessibility, and water control (irrigation/drainage) (Paramesh et al., 2020a). Relay cropping, intercropping, mixed cropping, reduced tillage, weed control, and the use of chemical inputs are just a few of the techniques that have assisted in cutting production costs while ensuring sustainability over a longer period. By enhancing the physical, chemical, and microbiological properties of soil and boosting soil fertility, scientific cropping techniques can raise soil productivity.

Integrated farming system for enhancing farm income, productivity, and employment

IFS offered scope to improve farm productivity by crop-livestock intensification and diversification in a small and marginal landholding. Differences concerning farm productivity between control systems and IFS were mainly due to higher crop intensity and livestock productivity. The IFS establishes linkages between components such as livestock, fishery, mushroom cultivation, apiary, and further leads to synergisms resulting in greater production efficiency. the IFS is a potential option in resource-deprived small and marginal land holdings to increase the system productivity and to meet the food and nutritional requirement of the farm family. Bringing crop diversification including cereals (energy), pulses (proteins), oilseeds, fruits and vegetables, and animal diversification in a small piece of land at the same time is imperative for achieving family needs.

IFS is considered a potential approach for rural bio-entrepreneurship and also an important tool to double the farmer's income in India. It attracts rural youth to adopt IFS as a potential entrepreneurship option (Behera and France, 2016). The IFS model involving different land-based enterprises generated net returns of INR 3,78,784 with about 3 times higher employment (628 man-days) than the conventional rice-wheat system. The by-products/ wastes of one component in the system served as an input for the other which reduced the reliance on off-farm inputs aiding in strengthening sustainability. Rautaray et al. (2005) reported that the rice-fish model under lowland ecologies of Assam with vegetables, fruits, ornamental plants, and agroforestry components in dyke area produced 2.8 times higher income than rice alone. Nayak et al. (2018) observed structural variation in soil microbial diversity due to nutrient recycling (organic manures) with the production of planktons and macro-benthos in rice-fish-duck, rice-duck, and in the rice-fish system over conventional rice production system. In IFS, farm activities are continued around the year, thus the farm family is effectively engaged in farming. The adoption of such systems avoids the migration of farmers and rural youth to nearby cities and towns for the search of contractual employment. The specialized agriculture practices and mono-cropping increased production costs, risk of crop failure, and lower market price (Manjunath et al., 2017). Due to this, the small and marginal farmers migrated to neighboring cities in search of jobs and livelihood. In this scenario, IFS will be a solution to reduce economic risk with improved employment generation. Das et al. (2018) reported significant improvement in employment generation, income, and livelihood of the farmers in crop-fish-pig (pig-based IFS) and crop-fish-duck systems over crop alone.

Conclusion

It is concluded that the productivity of major crops is either static or declining in many parts of the country owing to various reasons. To sustain food security the approach of IFS is positive and will conserve the resource base through efficient recycling of residues within the system. Therefore, a farming system is a set of agricultural practises that are coordinated to preserve the ecological stability and desired degree of biological diversity while also protecting the productivity of the land and the quality of the environment. Sustainable agriculture would boost farm income, maintain ecological balance, make food easily accessible, provide social benefits, and improve the quality of life for agricultural communities through the efficient use of natural resources for higher productivity and production. The success of sustainable agricultural systems may be understood and strategies to increase production, profitability, and resource usage efficiency can be found by using an agro-ecological approach. The IFS models developed on ecosystems and sub-systems can be fine-tuned through farmer participatory trials with multilevel interventions of experts. The dissemination of such models will help in anchoring sustainability in agriculture.

Future thrusts

- Measurement of the amount of biomass produced by Integrated Farming Systems and its general effectiveness in achieving sustainability.
- Finding effective cellulolytic microbes for recycling crop waste.
- The effect of IFS on carbon sequestration and carbon buildup.
- The advancement of local farming communities' existing indigenous technology know-how (ITK), as well as its scientific validation and popularisation.
- Creation of on-farm research to find and use technology to address site-specific issues.
- Investment in community soil and water conservation; research and development of organic farming; establishment of small-scale companies; development of rural youth and farm women's skills

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