



## Integrated farming system approach for enhanced farm productivity, climate resilience and doubling farmers' income

V K SINGH<sup>1</sup>, S S RATHORE<sup>2\*</sup>, R K SINGH<sup>3</sup>, PRAVIN K UPADHYAY<sup>4</sup> and KAPILA SHEKHAWAT<sup>5</sup>

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

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### ABSTRACT

Indian agriculture is plagued by several complex challenges like declining factor productivity, poor resource use efficiency, lesser share in Indian economy (14.4%); high dependence of population on agriculture and allied sectors (52%); more thrust on annual cereal crop production etc. Nearly, 86% of the Indian farmers are small and marginal (<1.0 ha) for whom agriculture has become cost-intensive due to escalating prices of agro-inputs, labour and energy. The decreasing land holding size poses another serious challenge to the profitability and sustainability of Indian agriculture. Achieving economic sustainability in such agricultural production system necessitates coherent linkage of climate-smart agriculture with the farmer's needs. In this context, integration of cropping with other farming enterprises under integrated farming system (IFS) can ensure enhanced system productivity, resource-use efficiency and more employment opportunities. Research evidences across the country clearly reveals that the complementary co-existence of farm enterprises under IFS can provide an array of benefits in meeting out the growing demands for food and nutrition rich dietary, income stabilization and livelihood upliftment while conserving ecological balance and environmental, particularly for small holders with limited resources. The present review is a synthesis of studies made in different agro-ecologies to explore the potentialities for resource integration in a systems perspective, the implementation feasibility and potential barriers in adoption of a more productive, competitive, diversified and sustainable IFS.

**Key words:** Complementarity, Doubling farmers' income, Farming system, Livestock, Resource use efficiency, Small farm holders

India is bestowed with the second highest arable land (141.0 Mha) in the world, yet the average per capita holding size remains 1.1 ha only. The small (<2 ha) and marginal (< 1.0 ha) farm holders represent more than 86% of Indian farm families which live in risk prone production conditions (Anonymous 2018). The majority of the farmers lack essential farm resources like draught animals, assured irrigation facilities, fertilizers, pesticides and farm machineries, which are crucial in harnessing high productivity. Also, the unawareness and resource poor conditions restrict these farmers to adopt the advancements made in the farming sector. The cultivation of few annual crops like rice and wheat in irrigated regions has although made the country self-sufficient in food grain production, but the second generation problems have come up, viz. resource degradation, plateauing productivity and non-profitability of agricultural entrepreneurs (Rathore *et al.* 2019). The mixed farming practiced in ancient times was subsistence in nature but the concept has become imperative in the present context

where the need has arisen to produce more and diverse for meeting the food, nutritional and economic requirement of the farm families. Thus, integrated farming system (IFS) approach is one such holistic technological package which can cater many challenges of small and marginal farmers (Singh *et al.* 2019). It has been widely reported that IFS approach increases productivity by 2-3 times, creates additional employment, save 40-60% resources and ensure 100% household nutritional security (Mahapatra 1994, Rathore and Bhatt 2008). Considering these facts, one of the flagship programme of Government of India for betterment of farming community is the "doubling farmer's income (DFI) by 2022" and in this regards many interventions have been suggested including IFS for ensuring higher farm productivity and profitability for sustainable economic growth for farming communities in India. In this review attempts have been made to compile the finding in national perspective for doubling farmer's income and employment opportunities in agriculture.

### Challenges in Indian agriculture

#### Holding size and profitability

In these states the IFS hold great promise for improving

\*Corresponding author: sanjayrathorears@gmail.com

<sup>1</sup>Head, Division of Agronomy, <sup>2</sup>Principal Scientist, <sup>3</sup>Scientist and <sup>4</sup>Senior Scientist.

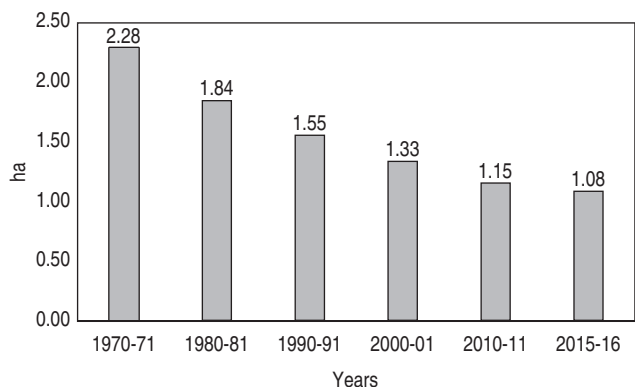


Fig 1 Average size of operational holdings in India (Government of India 2015-16).

the farmer’s income and overall livelihood. Due to increasing population, further fragmentation of land holdings is happening, and the average size of operational holding has declined to 1.08 ha in 2015-16 (Fig 1). The operational size of holding has reduced from 1.84 ha to 1.08 ha during 1980-1 to 2015-16. Looking into the average size of operational

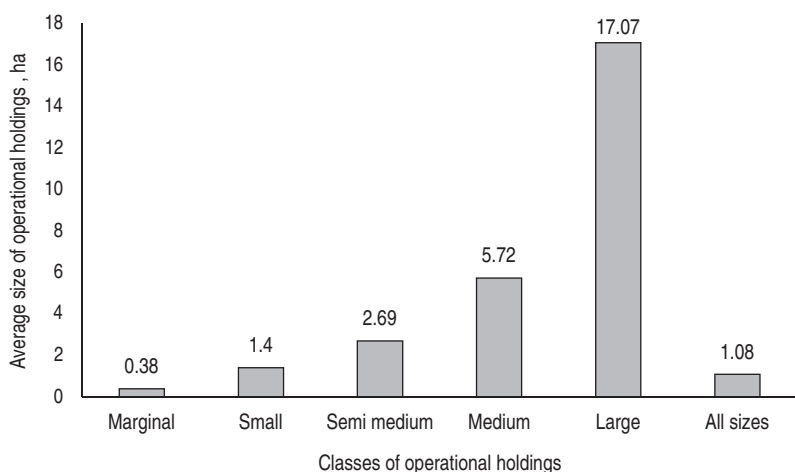


Fig 2 Average size of holdings (ha) categories wise (2015-16).

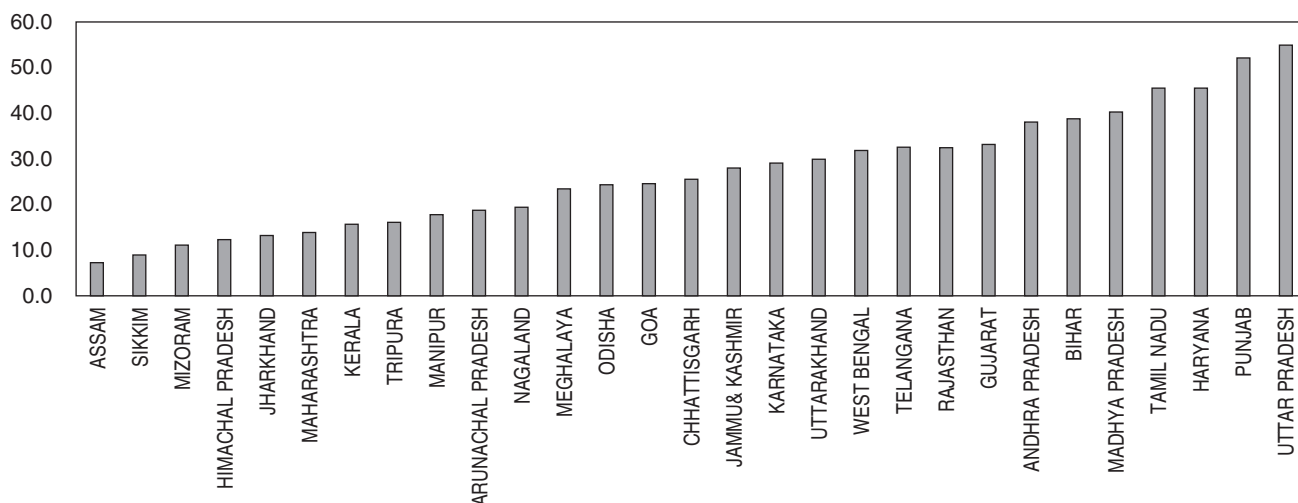


Fig 3 Percentage of net irrigated area to total cropped area, 2014-15 (Anonymous 2018).

holding category wise, it has reduced to 0.38, 1.42, 2.17, 5.76, 17.37 ha respectively for marginal, small, semi medium, medium and large farmers with average operation holding size across all categories as 1.08 ha (Fig 2).

Therefore, IFS hold great promises for enhancing farm productivity and profitability in small and marginal farmers under irrigated conditions. The irrigated areas in Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Bihar, AP states primarily dominated by few crops, and because of this reason there are more risk of different types of stresses and lower profitability. As a matter of fact, the farming is led by marginal and small farm holdings in India. The small and marginal holdings taken together (0.00-2.00 ha.) constituted 86.08% of the total holdings in 2015-16 against 85.01% in 2010-11 while their share in the operated area stood at 46.94% 2015-16 (Table1).The category-wise average size of operational holding has reduced to 0.38, 1.42, 2.17, 5.76, 17.37 ha, respectively for marginal, small, semi medium, medium and large farmers with average operation holding size across all categories as 1.16 ha (Fig 2). In our country Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Bihar, AP are the states where up to 60 % is the net irrigated area (Fig 3).

Also the proportion of marginal and small holdings taken together has increased considerably from 74.5 % in 1980–81 to 85.0 % in 2010-11. Further, states like Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Bihar, Andhra Pradesh with 60% net irrigated area are primarily dominated by few crops, mostly cereals (Fig 3).

Thus, they are more prone to different stresses and poor profitability. Designing a suitable IFS in such fragile ecologies holds a great promise to combat stress and improve farmer’s income and overall livelihood.

Researches carried out reveal that the farmers input management changes with varying holding size, and as the size of

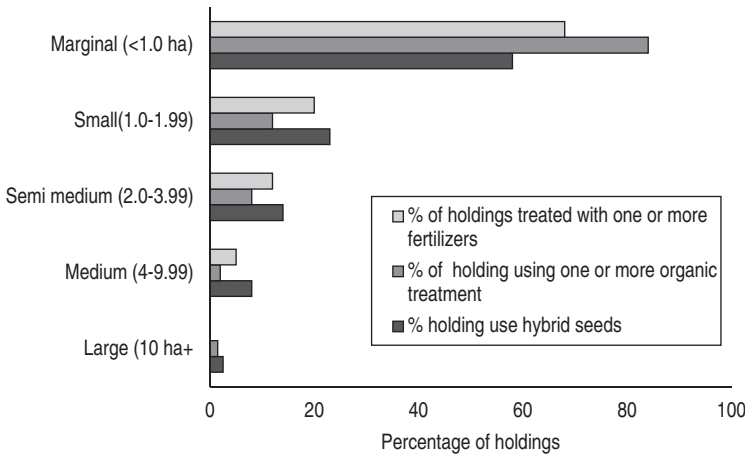


Fig 4 All India use of input and size of holdings (Anonymous 2018).

holding decline, the farmers often do better management and higher crop intensification. The farmers explore for new avenues with better management under decreased size of holding (Fig 4).

The small and marginal farmers invest more on high yielding varieties, multi-nutrient sources of fertilizers and higher nutrient doses over large farmers even under unfavorable conditions (Singh *et al.* 2015). Also, the marginal and small farms used 47% and 20% more fertilizer per unit area, respectively over large size holding and this relationship has remained intact over time (Chand *et al.* 2011). Agronomic options for such farmers including bio-intensification with suitable crop diversification and more number of enterprises open new opportunities to bring long-term sustainability and higher income. It is pertinent to mention that ecology based resource integration through enterprise diversification is relatively less risky in irrigated areas over rainfed areas as most of the farm activities are governed by assured water supply (Rathore *et al.* 2019). Hence, the input use is also governed by farm holding, available resources, agro-ecologies and enterprises under operation at farm. Excessive and imbalanced input use causes negative impact on long-term sustainability of resource base and reduces system net gain.

*Integrated Farming System: A sustainable approach*

The glorious success of “Green Revolution” in India was attributed to the expanded irrigation facilities, high-yielding varieties, intensive use of fertilizer and other inputs which was confined to a few cereal crops. Its consequences were intensive mono cropping, soil and ecological health degradation, biotic and abiotic stress and production fatigue as serious threat over a period of time. To counter these emerging issues, there is dire need to develop and adopt problem-solving

production techniques which ensure continuous supply of different commodities with complete recycling of the wastes (Tripathi and Singh 2019). Farming system represents an appropriate combination of farm enterprises (cropping systems, horticulture, livestock, fishery, forestry, poultry and many others) and the means available to the farmer to raise them for profitability. It interacts adequately with environment without dislocating the ecological and socio-economic balance on one hand and attempts to meet the national goals on the other (Jayanthi *et al.* 2000). In fact, IFS is a pro-farmer approach which confirms farmer’s active participation across all genders through use of complementary multidisciplinary approach to achieve farmers felt needs. An ideal IFS would be a perfect blend of traditional knowledge and frontier technologies with focus on adoption as per need of the specific situation. Integration of different enterprises with bottom up and dynamic approach makes IFS which provides a holistic package of practices for achieving overall sustainability on a long-term basis (Fig 5).

In IFS, resource use optimization is done by combining various enterprises which are inter-linked in such a way that the by-product from one enterprise can be utilized as inputs in another enterprise (Hendrickson *et al.* 2008). This ultimately leads to enhanced productivity, profitability and resource use efficiency. Gender issue becomes sensitive since majority of the farm operations are done by women but their participation in decision making remains inadequate. In an IFS model, many small units’ enterprises are adopted and year round activities go-on simultaneously, the deep involvement of whole farm family remains essential. The complementary use of natural, man-made resources and by-products utilization ensure efficient recycling and high use efficiency. It also reduces cost of production and adds in to the net worth of the farm family. The sustainability concern is also addressed in IFS as efficient recycling and

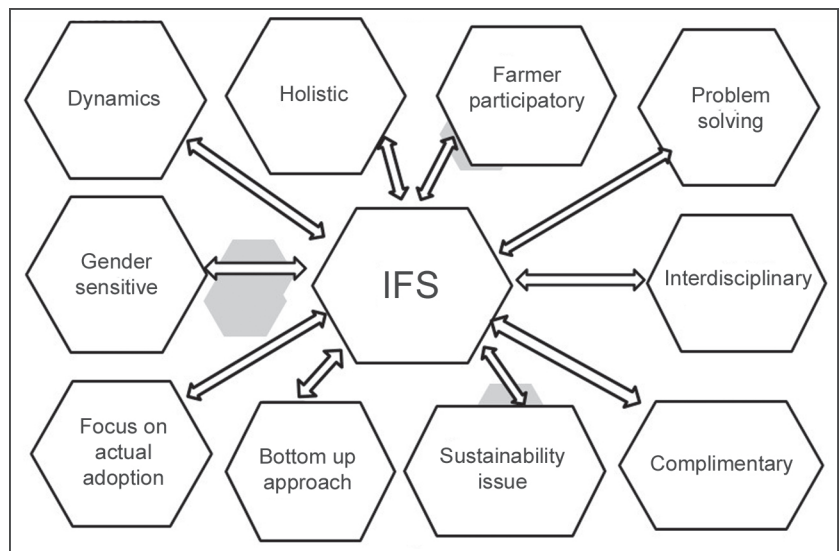


Fig 5 Core characteristics of integrated framing system approach (Behera 2013).

Table 1 Sources of income (%) of different categories of the farmers in India

Sources	Marginal + Small (%)	Medium + Semi-medium (%)	Large (%)
Wages & salaries	39.5	13.0	3.2
Non-farm business	9.2	4.8	4.4
Livestock	14.8	11.5	6.9
Crops	36.5	70.8	85.5

complementary resources use minimize the competition and reduce stress in the system. Such unique attributes of IFS determine the success and higher adaptability among the farmers. In a nutshell, majority of the emerging problems of present day agriculture like declining response to agro-inputs, lowering production, profitability, increasing cost of farming, poor resource use efficiency, hidden unemployment, and degradation of natural resource base are effectively met by various core characteristics of the IFS. The proven benefits under IFS approach are discussed here as under.

#### Livelihood security of small holders

Location specific integration of farming system resource through IFS is immensely useful for sustaining the livelihood of small holding farmers (Gangwar 2011). The socio-economic conditions, soil characteristics, farmers own preferences and above all, the availability of resource governs the adoption of IFS at farmer's field (Kumar *et al.* 2017; Rahman and Sarkar 2012). The small and marginal farmers rely on mixed farming involving crops, livestock and as the size of holding increases the dependence on cultivation of specialized crops increases (Table 1).

The wise selection of enterprises based on location-specific agro-ecological conditions, geographical terrain, soil status, availability of marketing and processing facility, socio-economic condition, risk bearing capacity, knowledge about enterprise etc. decides the success of IFS. The thumb rule of integration is that product of one enterprise should be an input for other enterprises and make them complimentary

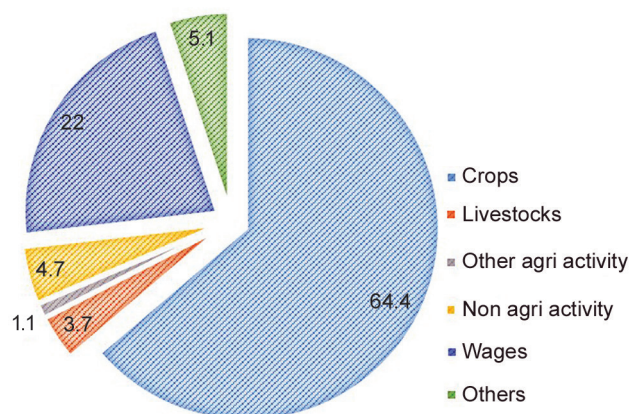


Fig 6 Percentage distribution of rural household based on source of income (NSSO 2015).

for each other (Gill *et al.* 2009). The recent researches advocate the benefits of IFS in terms of doubling productivity and employment generation depending upon the number and kind of enterprises and their management (Singh *et al.* 2011). The multi-enterprise model for small holder (1.0 ha) had annual net gain of more than ₹ 3.5 lakhs and 620 days manpower employment while sustaining soil and ecological health (IARI Annual Report 2018). The availability of critical inputs and technical know-how among the farmers' are the major constraints in adoption of IFS at on-farm situation. Studies conducted in 20 villages of New Tehri district of Uttarakhand has demonstrated that with a small intervention like quality seed, vegetables seeds/seedling for kitchen gardening, vaccination of livestock and regular technical interaction with farmers has made pronounced effect on ensuring their livelihood (Singh *et al.* 2015).

#### IFS for enhanced production profitability

A nation-wide study on the share of different enterprises in total income reveals that the sources of income differ across the regions in the country (DFI 2017). The share of crop commodities in total farmer's income ranges between 33–64 % and 14% in different states and Union Territories, respectively. The non-farm business is the predominant source of income next to cultivation in many zones; as it is about 48% in the Northern Hill zone, 41% in the Eastern zone, 32% in the Western zone, and 35% in the Southern zone. The share of non-farm business in the Union Territories is 68%. The share of livestock income in the Eastern zone remains highest at 16 %. Overall, it varies between 9–16%, with an average of about 11%. Hence, it is evident that crop cultivation and livestock rearing, along with wages are major source of income for the farmers (Fig 6). In IFS, optimum amalgamation of diverse enterprises is done to meet the farmers own requirement and market the surplus produce for getting higher employment round the year which will also check rural migration towards cities (Roy and Tarafdar 2018; Gangwar *et al.* 2011; Behra *et al.* 2012).

IFS model of 1.0 ha area involving crops, dairy, fishery, duckery, biogas plant, fruit trees and agro-forestry at IARI, New Delhi, resulted in net returns of ₹ 3,78,784/ha/year with an employment generation of 628 man-days. Studies conducted on IFS approach vis-à-vis crop alone showed multi-fold increase in production profitability at several locations of India as well as in South-East Asian countries like Philippines and Indonesia (Table 2 and 3).

This approach had enhanced resource use efficiency through recycling the waste and by-product within the enterprises. In fact, resource recycling reduces the production cost in one hand brings sustainability on the other. The small farms (up to 2 ha) hold the key to ensure food and nutritional security of India. Therefore, location specific integration of field crops, orchard, floriculture, agro-forestry, livestock such as dairy, poultry, piggery, fishery and other less land requiring activities such as mushroom, apiary, and boundary plantations are the key for improving the livelihood of marginal and small holders.

Table 2 System productivity under integrated farming system approach

Location	IFS	System productivity (t/ha)	Reference
Bihar	Cropping alone	9.21	Kumar <i>et al.</i> (2012)
	IFS (Crop + fish + duck + goat)	21.20	
	IFS (Crop + fish + cattle)	21.18	
Bihar	Rice-wheat	7.25	Kumar <i>et al.</i> (2012)
	IFS (Cropping + fish+poultry)	19.2	
Tamil Nadu	Cropping alone	13.0	Jayanthi <i>et al.</i> (2002)
	IFS (Field crops + fish + goat)	37.7	
Karnataka	Cropping alone (rice-rice)	5.6	Channabasavanna <i>et al.</i> (2009)
	IFS	35.2	

Data in Fig 6 and 7 demonstrate that state wise sources of income of the farmers mainly depends on crops and wages. While other remunerative enterprises like live-stock farming and non-farm business are almost ignored. Therefore, a majority of the states having farmer's income less than ₹ 10000/month under these situation. Inclusion of more number of self-sustaining enterprises can become a key for improving livelihood of small holders farm profitability.

#### Judicious use of resources

The basic aim of IFS is to derive a set of resource development and utilization practices, which leads to substantial and sustained increase in agricultural production (Rathore and Bhatt 2008). Liyanage *et al.* (1993) showed that the integration of legume-based pasture and dairy cattle yielded 17% more nuts and 11% more copra, while maintaining the nutrient status of the soil above the critical level, despite reduced application of fertilizer. Jayanthi *et al.* (2000) reported highest productivity of 33.5 t/ha of rice grain equivalent yield by integrating pigeon pea+ fish + mushroom and rice-based cropping applied with

Table 3 Comparative performance of over conventional cropping at different locations.

Location	Particulars	Profitability (₹/ha)	Reference
Bihar	Cropping alone	62 760.0	Kumar <i>et al.</i> (2012)
	IFS (Crop + fish + goat)	151 479.0	
Bihar	Rice-wheat	22,234	Kumar <i>et al.</i> (2017)
	IFS (Cropping + poultry + goatry + mushroom)	89413	
Uttar Pradesh	Sugarcane-wheat	74430.0	Singh <i>et al.</i> (2011)
	IFS (Crop+ dairy based farming system)	135820.0	
Uttar Pradesh (Varanasi) Eastern Plain and Vindhyan region	Cropping alone	87092.0	AICRP on IFS. (2017)
	IFS (Crop + fish + goat)	384400.0	
Punjab	Crops (rice-wheat)	81200	Gill (2004)
	IFS (Crops (rice-wheat) + dairy Fish + piggery)	154000	
Uttar Pradesh	Crops (Cereals, pulses, oilseeds, green fodder, dry fodder, sugarcane)	260078	Annual report 2017-18
	IFS (dairy, mushroom, boundary plantation, fishery, fruits)	517308	
New Delhi	Crops	93198	Annual report 2017-18
	IFS	515325	
Tamil Nadu	Crops	94586.0	AICRP on IFS Annual Report 2015-16
	IFS	292702.0	
Philippines	Rainfed rice, upland crops and cattle fattening, Santa Barbara	Without IFS: ₹ 50265	Devendra and Thomas (2002).
		With IFS: ₹ 77490	
Indonesia	Food crop, rubber and animal production system (one cow, three goats and 11 chickens), Butamarta south Sumatera	Without IFS: ₹ 4663.0	CRIFC (1995)
		With IFS ₹ 11040.0	

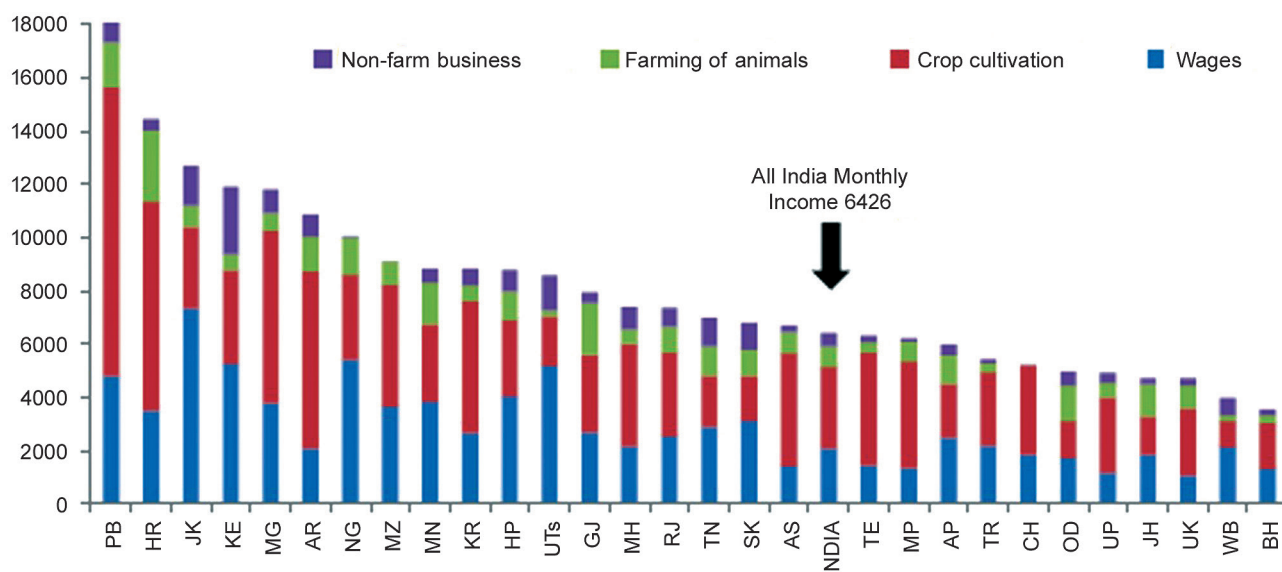


Fig 7 Farmers monthly income from different sources in various state (DFI 2017).

composted pigeon manure compared to rice alone in the cropping system. Integration of cropping with pigeon + fish + mushroom utilized 218 ha cm of water as against 182 ha cm in conventional cropping. Bio-intensification with complementary integration of different enterprises including crop, horticultural, livestock, fishery, poultry, agroforestry etc. led to higher system productivity (Dhyani *et al.* 2016; Singh *et al.* (2007). Many fold increase in the system productivity under IFS over cropping alone has been reported by Kumar *et al.*, 2012 in Lower Gangetic Plains. Output per unit land and other inputs increases substantially and have been reported widely under different locations of the country and also in abroad (Table 2).

#### Enhanced resource use efficiency

The efficiency of a system means the ratio between the output and input energy. The IFS are often less risky, if managed efficiently, they get benefitted from synergisms among enterprises, diversity in produce, and environmental soundness (Lightfoot 1990). The term 'resource use efficiency (RUE) in agriculture' may be broadly defined to include the concepts of technical efficiency, allocative efficiency and environmental efficiency (Haque 2006). Technical efficiency is the ability of a system to produce a given level of output with minimum quantity of inputs under a given technology. Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and allocative efficiency (Moreno *et al.* 2011; Olayide and Heady 1982). In other words, the efficiency of a system determines its success in producing large amount of output as possible from given sets of inputs. Poor use efficiency of natural and manmade resources in Indian agriculture is the primary reason for low profitability. It has impact from two sides, one the crops

are not able to utilize the desired level of input and on the other side wastage of resources. Ultimately poor resource use efficiency leads to enhanced loss of production as well as lowering economics.

However, there are many studies (Behra *et al.* 2012; Kumar *et al.* 2019) showing that farmers often use their resources sub-optimally. While some farmers may attain maximum farm productivity at a high cost, others achieve maximum profit per unit of inputs used. Also, in the process of achieving farm productivity and returns, generally environmental impact is being ignored in resource use efficiency, which cannot be sustainable in long run. Under IFS, farmers can allocate his land, labour, water and other resources in an optimal manner, so as to maximize his income at least cost, on sustainable basis. In fact, no farm enterprise is likely to be able to sustain the small and marginal farmers without resorting to IFS, i.e. a system in which different enterprises (e.g. fishery, dairy, crop, etc.) are included in farm activities in an integrated manner with a major focus on bio-resource recycling within the system, for the generation of adequate income and gainful employment year round (Mahapatra 1994). Resource use efficiency of IFS is always higher than the cropping system because of recycling of resources Long-term trial has been conducted by ICAR-Indian Institute of Farming Systems Research (IIFSR, Meerut) at various location through All India Co-ordinated Research Project on Integrated Farming Systems and confirmed that resource saving of the model at all location were superior over existing farmers practices (cropping alone) (Table 4).

Resource budgeting based on 06 year information on various input and output use showed that through recycling within the system, about 58% of the total cost of production can be met from the farm itself which directly/indirectly saves the worthy inputs resulting in higher resource use efficiency (Singh *et al.* 2018). The role of enterprise diversification and

Table 4 Resource saving (%) of different IFS model under various agro-climatic zone of India

Agro-climatic zone	Name of the centre	Component of IFS Model	Resource saving (%)
Western Himalayan Region	HNB, Garhwal Univ. Pantnagar (Uttarakhand)	Crops+Dairy+Horticulture+Vegetable+ Apiary + Fisheries+ Poultry+ Vermicompost	33.20
Eastern Himalayan Region	AICRP-IFS centers ICAR Research Complex, Umiam (Meghalaya)	Crops+livestock+fruit+trees+ fishery	3.15
Trans Gangetic Plains Region	AICRP-IFS, PAU, Ludhiana	Field crops (Cereals, pulses, oilseeds, green fodder)+horticultural crops (fruits and vegetables)+ Agro-forestry (Poplar with Turmeric-Wheat)+dairy+ Aquaculture (Fresh water fish production)+ Boundary plantation+ Kitchen gardening	16
	AICRP-IFS, CCHAU, Hisar	Field crops (Cereals, pulses, oilseeds, fodder, and fibre)+horticultural crops (fruits, vegetables and flower)+ animal unit (2 buffalos)+mushroom unit+vermicompost unit	21
Upper Gangetic Plains Region	AICRP-IFS, IIFSR, Modipuram, Meerut (UP)	Crop + dairy+ horti-pasture+agri-horti+ dairy + vermicompost + boundary plantation + secondary agriculture (value addition)	32.82
	CSAUA&T, Kanpur (UP)	Crop + Dairy + Horticultural crops	39.00
Middle Gangetic Plains Region	AICRP –IFS, IAS,BHU, Varanasi	Cropping systems+ Fruit crops +Vegetable+ Dairy animals+ Poultry+ Fisheries+ Mushroom	25.00
	NDUA&T, Kumarganj, Ayodhya	Crop + horticulture +dairy + Fishery	24.74
	ICAR Research Complex for eastern region, Patna	Crop + Livestock (2 Cows) + Fishery cum duckery	21.00
	BAU, Sabour-Bhagalpur (Bihar)	Cropping systems+ Fruit crops +Vegetable+ agroforestry+ Dairy + duckry + Goatry	43.30
Lower Gangetic Plains Region	AICRP-IFS Centre at Kalyani (WB)	Field crop + horticulture +dairy + Fishery	28.5
Eastern Plateau and Hills	BAU, Kanke Ranchi (Jharkhand)	Crops + Goat/ Poultry +Dairy + Fishery	39.30
Central Plateau and Hills	AICRP-IFS Centre at Jabalpur(MP)	Crop + horticulture +dairy + Fishery + poultry	19.34
Western Plateau and Hills	AICRP-IFS, Parbhani	Crop + dairy (cow and buffaloes)+ Poultry+ Apiculture Unit+ vermicomposting	21.00
	AICRP-IFS, Akola	Crops+ horticulture +value addition + poultry+ Goatry	23.43
	AICRP-IFS, Rahuri	Crop + animal+ mango orchard+Poultry+vermicomposting	30.00
Southern Plateau and Hills	AICRP-IFS PJTSAU, Rajendra Nagar, Hyderabad	Crop Components+ Horticulture Components+ 2 dairy buffaloes+ 6 goats+ 20 backyard poultry birds	26.51
	TNAU, Coimbatore	Crop + horticulture +dairy + goat+vermicomposting	21.00
	ARS, Sirriguppa (Karnataka)	Crop Components+ Horticulture Components+ live-stock unit (2 cows, 1 buffalo and goatary14 nos.)+Fish pond+Vermicomposting unit (4)+compost unit (1) +Azolla unit (1)+boundary plantation with teak and glyricidia	34.10
East Coast Plain & Hills	AICRP-IFS, Bhubneshwar (Odisha)	Crops+dairy animal (2cows)+Poultry(80 birds)+Duckery (20ducks)+Horticulture+Fishery+mushroom	18.83
Western Coast Plains & Hills	AICRP-IFS, Kerala (Karmana)	Tree crops (coconut 17 nos. mango, jackfruit)+teak+kitchen garden+poultry, 2 cows+vermicomposting	19.00
	AICRP-IFS, ICAR Research Complex, Goa	Integrated farming system models for typical lowland (rice based) situations+ livestock+fish species Plantation crop (Upland) based integrated farming system model+ piggery+poultry+vermicompost unit+compost	24.00
Gujarat Plains & Hills	AICRP-IFS Center at S K Nagar (Gujarat)	Cropping systems+ Multistoried Horticulture Fruits and Vegetables+ Boundary plantation+ Livestock+ Vermicompost, compost and nursery unit+ Water recharging	65.00
Western Dry Region	AICRP-IFS, Durgapura (Rajasthan)	Crop + horticulture +dairy + poultry+goatry	24.00
Island	AICRP-IFS, Port Blair (AN)	Plantation crops + Pig+Crop + Dairy animal cows + Fish	29.90

residue recycling was reflected in resource saving, higher employment opportunities and ultimately family savings (after meeting family consumption and production cost) in various agro-ecologies of India. AICRP-IFS report 2015 through multi-location trials indicated enhanced Resource saving (Table 4).

*Multiple uses of resources*

Multiple uses of major farm resources including land, water and human is utmost essential to encourage vertical growth in agriculture. For this, diversification of cropping systems/farming systems for maximum utilization of cultivated lands, promoting agro-horti and agro-forestry systems, use of irrigation water for raising multi-storeyed enterprises like rice+fish+poultry/piggery/duckery, use of farm products and by products for raising mushroom, preparation of vermicompost, interaction of bee keeping and flowering crops and efficient use of manpower by engaging in multifarious activities of diversified agriculture in an IFS mode may bring maximum returns per unit time per unit land area.

*IFS as a climate resilient technology*

Sole commodity based farming is always prone to natural hazards such as floods, drought, disease and epidemics. Reliance on solitary farm enterprise by the

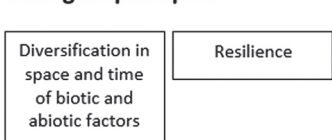
farmers is a risky affair, as it has limited resilience to cope with climate vulnerability. Diversified agricultural systems including livestock and crops (annual or perennial) is an ideal approach to build resilience in agricultural systems (Sahoo *et al.* 2019, Gill *et al.* 2009). Crop diversification within IFS helps farmer against aberrant weather conditions like early season drought, late season drought and dry spell during crop growth season. Under National Initiatives for Climate Resilient Agriculture (NICRA), IFS module was developed in NICRA village Sanora and Datia to enhance the farm income of marginal and small holders against extreme weather condition (Fig 7).

In this context, demonstration of integrated farming, having multiple component was conducted on farmer's field within one ha area against farmer's practice of single component. Components in integrated modules were field crops, vegetable crops, livestock, fisheries and poultry with compost making and biogas production. Slurry was used as a nutrient source in field and vegetable crops. Net returns from IFS model were ₹ 80000/year and increase in crop yield was noticed up to 65%/year, while an additional 130 man days/year of employment was generated. Under Island conditions with incursion of sea water due to cyclone, excess moisture during post floods, moisture stress in winter season, losses due to pests and diseases, the IFS has been identified as resilient technology (Venkateswarlu *et al.* 2012). Even

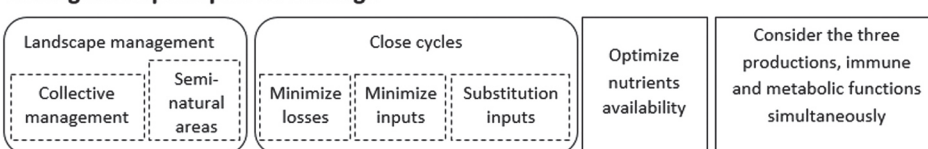
**Emergent properties**



**Ecological principles**



**Management principles for redesign**



**Practices**

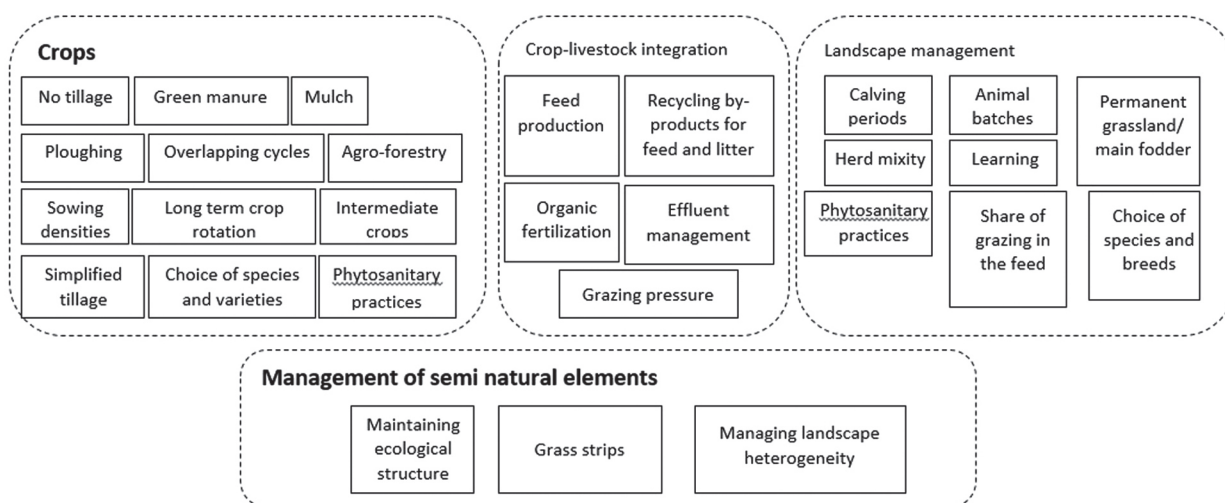


Fig 7 Better ecosystem services (Source: Bonaudo *et al.* 2014).

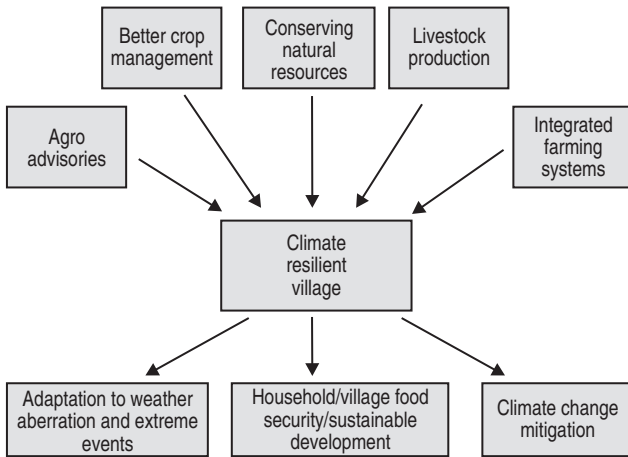


Fig 8 Integrated farming system for developing climate smart village under NICRA.

under challenged agro-ecosystem, like shifting cultivation areas, IFS ensured better ecosystem services along with higher productivity and profitability (Rathore and Bhatt 2008). Developing climate-smart agriculture through integrated approach is also an ideal solution to ensure the food security of the ever-increasing global population at a time when there are twin problems of land degradation and carbon emissions (Bhatt 2016). Through diversified crops and other enterprises, IFS provides a stable and sustainable production system, this helps in risk minimization and resilience to climate change (Ayyappan and Arunachalam, 2014; Behera and France 2016). Bonaudo *et al.* (2014) nicely explained IFS as a climate resilient practice has emergent properties like resilience, productivity, efficiency and self-sufficiency (Fig 7 and 8).

Improved integrated practices for crops, livestock's In IFS based on ecological principles ensure better ecosystem services which ultimately confirm sustainability in farming. Hence, Ministry of Agriculture and Farmer's Welfare, Govt of India has also demonstrated IFS at pilot scale on various aspects of climate change adaptation practices in agriculture in different regions of the country. For this, 5 pilot research projects have been operated in various ICAR Institutes for establishment of climate resilient IFS model in 100 Krishi Vigyan Kendra located in different zones in the country. To address the aberrant weather situations, IFS based contingency planning has been reported by many workers under different agro-ecological conditions (NICRA 2019; Srivastava 2018; Reddy *et al.* 2018; NABARD 2018). Further, advocated the multi-layered farming in IFS which opens a new door for farmers to earn round the year as there is less risk of a complete crop failure. Seven modules, *viz.* cropping systems, horti-pasture, agri-horti, dairy, vermin-compost, boundary plantation and secondary agriculture (value addition) modules are being integrated in order to develop sustainable resource management packages for climate smart integrated farming systems of small and marginal farm households (AICRP on IFS 2017).

### Conclusion and future perspectives

Integrated farming system (IFS) approach is of paramount significance to improve livelihood and enhance income of small holding farmers. IFS system are often less risky, if managed efficiently, they are benefitted from synergisms among enterprises, diversity in produce, and environmental soundness. As different components are combined in IFS, system productivity also increases by 2-4 times over sole cropping. The core characteristics of the IFS is to ensure complementarity among the enterprise. Hence, the resource use efficiency is also increasing with minimal wastage of the inputs. The response of applied inputs increases many folds under IFS. IFS has been also identified as a climate smart technology to combat the risks due to climate change in agricultural production system. In drought and flood prone areas, IFS is an ideal approach for mitigating the negative impact of adverse weather conditions. Another core feature of the IFS is on-farm recycling of by-products within the enterprises which ensures recycling of ecosystem services for improving long-term system sustainability.

Developing suitable IFS models for a resource and input diverse situations of Indian agriculture remains challenging, thus needs location-specific suitable interventions mentioned as under:

### Researchable issues

- Resource characterization at household level needs to be done for promotion of IFS in a targeted domain.
- The resource optimization through enterprise integration using various regression models would provide a long-term sustainability in terms of livelihood, economic returns, energy efficiency and soil health.
- Matrix analysis of different resources, their multiple uses within and other enterprises needs to be done to work the out input-output relationship in variable input availability situation.
- Designing a robust model which can simulate the outcome and economic stability for farmers based on the price fluctuations and market vulnerabilities would help them in decision making.
- On-farm evaluation of farming system models using critical input intervention needs to be made for real time and specific situation.

### Farmer's perspective

- A clear understanding of the benefits of IFS among farmers would promote easy adoption in target areas.
- The establishment of self-help groups (SHGs) and farmers producer company at the farmers' level will help them in building associations wherein mutual profits can be enhanced.
- Location-specific IFS models need to be developed which can cater the requirement of farming community for wider adoption of IFS.
- Initiatives may be taken for value addition and processing to make IFS more profitable and sustainable.

*Policy initiatives*

- Policy support in terms of subsidies and credits needs to be offered for small farm enterprises based bankable IFS models.
- The facilities for marketing, infrastructure, value addition and ware-housing may be developed on regional scale to benefit small and marginal farmers.
- Quality input availability and resource recycling technique needs to be ensured to harness maximum gains in IFS.

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