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SK Choudhary
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Rajesh Kumar AH
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

SK Gupta
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Correspondence
SK Choudhary
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

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Integrated farming system (IFS) is possible way out for double farmer's income

SK Choudhary, Rajesh Kumar AH and SK Gupta

Abstract
The Government of India in annual budget of 2016-17set a policy for achieving the target of doubling farmer's income by 2022 and also our prime minister have dream project to how farmers income double by 2022. Nearly 72.2% population of India is living in 6.38 lakh villages, mostly dependent upon agriculture and livestock for their livelihood. Crops productivity is largely restricted by uncertain and erratic rainfall, scarcity of water for irrigation and deterioration of soil-health. For this context in the last five decades or so, increasing agricultural production, productivity and ensuring food security was the main focus for agricultural development. 90% farmers are marginal hold 0.5 to 1.0 ha of land. Per capita total land availability was 0.32 ha in 2001 (world average of 2.19 ha), 0.23 ha in 2025, 0.19 ha in 2050. (DAC, Agriculture Census Division 2010-11). Integrated farming system (IFS) is only possible way out to increase the farmer's income and also full fill the need of food for increasing population. In IFS systems all agricultural enterprises including animal husbandry, fishery, bee keeping, goat rearing, cropping systems, fruits, vegetable and others are setup into a single unit of land and hence better recycling of resource or input occurs. Ultimately increase the farmer's income. On the basis of sources income this article discusses the pathway and strategies for doubling the income by integrated farming system (IFS) by 2022, a major food security crop accounting for about 35% of total food grains produced and being cultivated in 30.6million ha by around 25 million farmers.

Keywords: IFS, crop, fruit, vegetable, diversification, farmer, income

Introduction
In India, the farmers maintain different enterprises for their complimentary and supplementary nature and for ensuring sustainable livelihood from time immemorial. After the advent of green revolution inlate-1960s and economic liberalization in early-1990s, the farmers gradually started focusing on a few enterprises due to several imposing factors including shrinking farm sizes, fluctuating commodity prices, livelihood diversification and shortage of labour during peak agriculture season (Ponnusamy and Devi, 2017) [17]. To achieve doubling farmer's income might require novel strategies and some change in the policy stance. The conclusion is that 70%of the farmers in India have annual per caput income less than Rs. 15,000. Only 10% of them earn more than Rs. 30,000. (Kumar and Chahal 2018) [12]. Land size and income are identified important correlate. Since more than three-fourths of the low income farmers (<Rs. 15,000) are marginal farmers who cultivate landholdings less than or equal to one hectare. Only 7% of the marginal farmers fall in the high-income class (>Rs.30,000) might be due to a more diversified income portfolio in terms of the number of income sources accessed and the intensity of engagement.
It had a severe impact on food and nutritional security of millions of poor farm households. The Government of India has made an announcement about Doubling Farmers' Income by 2022and also Honourable Prime Minister of India who is challenging the status of all involved stakeholders. Production and productivity increase in agriculture alone will not ensure doubling farmers' income (Srinivasan, 2017). Honourable Prime Minister of India gave a call to the nation of doubling farmers' incomes by 2022 by spelling out six points strategy. The budget for the year 2017-18 allocated Rs. 1,87,223/- Crores for agriculture and rural development, which is 24 per cent higher than last year (Anonymous. 2017a).

The doubling, farmers' income would involve massive investments in agricultural research and development irrigation, fertilizers, agricultural market infrastructure including development of Agricultural Produce Market Committee (APMC) and agriculture value chains, supported by adequate and timely availability of bank credit, implementation of a number of schemes for revival of agricultural growth and farmers' welfare (Jadhav, 2017) [10]. Experts are judging the options and strategies for achieving this enviable target. This National Round Table given a total of 40 recommendations for increasing incomes of farmers have been divided into five major parts which among these IFS approaches will play a most important role (Khan 2016) [11]. i.) Increasing incomes by improving productivity, ii.)Water and agri-input policies, iii.) Integrated farming system, iv.) Better market price realization and v.) Special policy measures. One of the options is to evaluate the potential of age-old integrated farming system (IFS) in enhancing income of farm families within the reasonable time period. To overcome obstacles and establish a direction for rural poverty in India, the members of NITI Aayog, ICAR and Scientists jointly hosted a meeting to brainstorm the idea of doubling farmers' income. Delegates from the Department of Agriculture, GOI, national research institutions, central/state agricultural universities, the private sector, international research centers, and NGOs were also convened to develop a strategy for meeting the PM's challenge (Wani *et al.,* 2017) [24]. However, experts are engaged in searching the options and strategies for achieving this enviable target. One of the options is to evaluate the potential of the IFS approaches to enhancing the income of farm families within a reasonable time period.

Some of the Integrated Farming System models demonstrated with success are discussed here. These are integrated rice–wheat-dairy-goatery farming system in sabour, Bihar, Integrated farming model at Bihar Agricultural University in Sabour, Bhagalpur districts; Makhana was integrated with fish and water chestnut to enhance farmers in comeas compared to makhana alone at ICAR Reseach Complex for Eastern Region, Patna and NRC, makhna, Darbhanga, Bihar etc. For doubling of the farmer's income some strong strategies need to be adopted considering the basic requirement of the farmers. These strategies might be massive investments in agricultural research and development, adaption of GAP, conservation agriculture technology, implementation of farmers friendly policies, judicious use of available resources and inputs, along with improved market and transportation facility, MSP reform, supported by adequate and timely availability of bank credits. It has been reported that a rise in the MSP will raise farmer income by 13-26 per cent (Sodhi, 2017) [20]. India is also the world's largest and fastest growing market for milk and milk products. On average, livestock contributes about 12 per cent of farmers' income in India (Chand 2017) [4]. Smart farming and credit supporting smart farming are one of another possible strategy for doubling farmers' income. Diversification can prove as a game changer, involving high value crops.

Why Double Farmers' Income

Today, around 138 million Indian farmers' facing problem about declining the farm income and increasing cost of inputs like seed, fertilizers, herbicide, insecticide, irrigation, labour and tractor etc. A recent study by the National Institute of Agricultural Economics and Policy Research (NIAP) has shown that around 70% farmers in the country have annual per captain come less than Rs. 15,000 (around USD 250). Most of the states in our country there are lack the required infrastructure for agricultural income growth. And around 70% farmers are marginal (owning less than one hectare), and 77% of them earn income of Rs. 6,067 per capita a year. Further, about 40million farmers have just around 500 m^2 of land, which is not sustainable. Keeping in view for small and marginal farmers has drawn specific policy. The Hon'ble Prime Minister, considering this as a national priority, rightly called for doubling the farmers' income by 2022. IFS Approaches is holistic, multidisciplinary, dynamic, problem solving, location specific and farmer needs oriented, which make a vital contribution to sustainable development by adding consideration of economic, ecological and social objectives to the essential business of agricultural food production. The well-being of farmers can be improved by bringing together the experiences and efforts of farmers, scientists, researchers, and students at different locations with similar eco-sociological system. In addition to this, proactive government policies and institutional support are the needs of the hour to make IFS approach successful for small and marginal farmers of developing countries like India (Kumar 2013) [13].

Broad strategies for doubling income of farmers

i). Enhancing Production through yield Increase

Increase in yield or productivity of crops by various way *viz*. timely supply of good quality of sufficient seeds prior to season, timely availability of good quality of inputs, applying short duration high yielding varieties, increase hybrid seeds, by promoting farm mechanization, application integrated nutrient management, application integrated pest management, by increasing irrigation facilities and adoption of DSR/zero tillage/SRI and other enterprises is the single most important factor that can increase income. Since the area cannot expand much, either through increase in net sown area or through increase in cropping intensity, enhancing the productivity is the only route available to enhance production. Bridging yield gaps through adoption of recommended agronomic practices, planning profitable crop mix that can maximize aggregate income, and reducing crop losses through integrated weed and pest management are short/ medium term options that can bring in additional income.

ii). By increasing cropping intensity

According to land situation, irrigation and other facilities farm plan should be prepared for *Kharif*, *Rabi* and *Garma* for 03 years e.g. Paddy - wheat/pulses/Maize, Maize – Wheat/Pulses/Maize, Maize – Wheat/Pulses/Maize – Mung, Vegetable (cauliflower) - potato - onion – mung, Maize/Vegetable – Potato-Potato-Onion-Mung, Paddy (short duration) - vegetable - onion – maize, Paddy - vegetable – maize, use of rice fallow land, and rice- makhana cropping system

iii). Leveraging water resources for enhancing farm incomes

Water resources are very scarce in relation to size of arable and population. By 2050 the global agriculture sector needs to produce 60 per cent more, while developing countries need to produce 100 per cent more. This target can be met only by improving water productivity. This apart, there is a need for a paradigm shift in water management in rain fed areas. Here

the emphasis should be on securing water for bridging dry spells and on improving agricultural and water productivity through new technological water management options. Micro-irrigation (drips and sprinklers) was one technological option which increases the water productivity. As per one estimate drip irrigation can help save water enough to irrigate 10 times more area

iv). Special focus on dry land areas
Water management interventions for dry lands consist of: i) adopting an efficient water shed management approach, ii) reducing vulnerability through rainwater harvesting and storage, iii) recharging depleted groundwater and aquifers and strictly regulating groundwater extraction, iv) pricing water and power to reflect their opportunity costs, v) enlisting government support for water saving options, vi) specifying and enforcing clearly defined water rights in watershed communities, vii) enabling stronger collective action for community development in agriculture and resource management, and viii) enhancing the scientific and technological support to water shed programmes.

v). Reducing cost through smart nutrient management:- Indian soils are increasingly deficient in micronutrients and the NPK balance has shifted away from the ideal/norm ratio of 4:2:1 and is skewed towards nitrogen. The widespread secondary and micronutrient deficiencies have led to deterioration in soil health leading to low fertilizer response and crop yields in rain fed areas of India. The degrading soil health trend can be reversed through adoption of soil test based application of deficient secondary and micronutrients to harness existing productivity potential on a sustainable basis. The introduction of soil health cards across the country addresses this issue.

vi). Reducing costs through the farming systems approach
Complementary relations that could exist among farm enterprises are rarely exploited as farmers have been increasingly depending on purchased inputs and preferring solo enterprises rather than a mix of them. Integrated farming system (IFS) is an innovative and unique approach to promote efficient land use and animal management techniques based on biophysical resources, particularly of small and marginal farmers. In spite of the advantages of farming systems, their adoption by farmers is not high due to limitation of available production technologies, biophysical or geophysical constraints, labour and input market constraints, financial and credit constraints, social norms, inter-temporal trade-offs, policy constraints, and constraints to knowledge or skills.

vii). By reducing cost of production:- Income can be increase by reducing the cost of production by various way like Provision of subsidy on farm inputs, Provision of subsidy on diesel, Provision of subsidy on HYV/ hybrid in light of market price, mechanization cost and diesel, Provision of subsidy on HYV/ hybrid seeds, Subsidy on mechanization in light of market price, Use of green manuring e.g. Dhaincha, Moong, Cowpea, Sunhemp etc., Use of bio fertilizers:-*e.g.* Rhizobium, PSB, Azotobactor, Azolla, Blue green Algae, Mycorrhiza etc., Subsidy on transport, Use of renewable energy sources *i.e.* Solar energy, Gobar/Bio gas etc., Promotion of DSR/Zero tillage technology, Promotion of custom hiring system, Promotion of integrated farming system: Synergise blending of crops/horticulture, dairy, fishery, and poultry to provide regular income.

viii). Reducing costs through low input agriculture
The cost of cultivation has been on the rise eroding the profits Lowering the costs without compromising on the output can increase the net income It is possible to do so as there is a general tendency on the part of farmers to apply overdose of fertilizers and pesticides expecting higher yields' Organic farming, low external input, sustainable agriculture precision farming, etc. are being promoted with a view to reducing chemical use these intervention, have, however, remained sporadic and limited to a few geographies.

ix). Income enhancement through diversification with inclusion of new varieties and high value crops
Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value added crops with complementary marketing opportunities. Crop diversification and inclusion of the new varieties can be one of the important technologies in increasing the farmers' income to a certain extent. The introduction of new cultivated species and improved varieties of crop is a technology aimed at enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses. It reduces the risk of total crop failure and also provides alternative means of generating income, as different crops will respond to climate scenarios in different ways. Crop diversification in India is generally viewed as a shifting from traditionally grown less remunerative crop(s) to more remunerative crop(s). Crop diversification includes lot of promises in alleviating the problem of low productivity, sustainability, soil health, low income, etc. through fulfilling the basic needs and regulating farm income, with standing weather aberrations, controlling price fluctuation, ensuring balance food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, environmental safety and creating employment opportunity. Strategic diversification of crops and enterprises is needed to provide higher inclusive development. Evidence on diversification have shown that the ratio of gross returns to cereals in high value crops in the state was 2.07 in fruits, 1.08 in vegetables and 1.55 in flowers (Saxena *et al.,* 2017). In order to mitigate the adverse effect of climate change on agricultural crops, improve soil health and to increase the farmer's income, following crop diversification models need to be promoted.

i) Cash crops: Sugarcane, Betel leaf and Vegetables etc.
ii) Spices: Turmeric, Ginger, Dhania, Garlic, Ajwain and Saunf etc.
iii) Medicinal Plants:-Sadabahar (*Catharanthus roseus*), Sarpgandha (*Rauvolfia serpentine*), Kalmegh (*Andrographis paniculata*), Brahmi (*Centella asiatica*), Buch (*Acorus calamus*), Pippli (*Piper longum*), Shatawari (*Asparagus racemosum*) etc.
iv) Aromatic Plants Suitable: Lemon grass (*Cymbopogon Flexuosus*), Palma Rosa (*Cymbopogon martinii*), Java citronella (*Cymbopogon winterianus*), Mentha (*Mentha arvensis*), Tulsi (*Ocimum basilicum*), Vetiver (*Vetiveria zizanioides*) etc. (Singh 2013).
v) Flowers: Inclusion of floriculture/ flowers in peri-urban area of Bihar is one of the biggest opportunities to create income throughout the years for farmers.

x). Income Enhancement through Professionalization
Since farming in India is almost always the hereditary occupation of a family, learning how to farm is nearly always limited to traditional practices passed on through generations. But can modern agriculture be practiced without proper skilling and professionalization of the farmers who have to organize resources, collect and leverage information, take crucial decisions and bear the risks? Farming is increasingly transforming into a skilled job with agricultural markets evolving in the digital space, consumer preferences going global, all entrepreneurial functions demanding technical and managerial skills and value chains becoming sophisticated.

xi). Stabilizing Income and risk management:- Farmers face three basic risks: yield, price, and idiosyncratic risks. The yield risks are: weather and input risks. Weather risks include late onset of monsoon, low and untimely rainfall. Major input risks are on account of fertilizer, pesticides, labour, farm machinery, irrigation, credit, information, and seed. The price risks are related to output marketing which include price volatility, non-operational Minimum Support Price (MSP) system, and discrimination in price realization. Idiosyncratic risk sare farmer related, such as health issues of the farmers, access to non-farm employment opportunities, access to public distribution, and employment guarantee programmes. Farmers have managed risks traditionally through ex-ante adaptation strategies such as investing in wells mixed farming, sharecropping, stocking grains and/or ex-post strateg iesadopted during risky situations, which include replanting, changing input use and thinning the standing crop among others. Often, community support was counted on to survive the risks. Price stabilization mechanisms such as building bonds with commission agents/traders, entering into contracts, and income stabilizing mechanisms, such as insurance and credit, are other strategies followed by farmers to offset risks.

Major Challenges and issues in Agriculture:-Marginal and poor farmers have major challenge for successful growing of crop and if this challenge overcome farmers can easily achieve the double income in 2022. The few major challenge in agriculture is as fallows. i). 90% farmers of state are marginal 0.5 to 1.0 ha of land, ii). India climate are unpredictable. Only 60% area is under irrigation, iii). In some state there is no any canal system of irrigation only private based diesel engine system irrigation which is too costly, iv). Rice-wheat is major cropping system and prevailed only in *Kharif* season, v). Less use of rice fallow land due to lack of irrigation facilities, vi). Elay sowing of wheat because of delay harvesting of rice, vii). High cost of hybrid variety seeds, viii). Lack of short duration high yielding varieties, ix). High cost of cultivation as a result high cost of production, x). Lack of storage and processing facilities, xi).Market fluctuation in cropping and off season, xii). High use chemical fertiliser and pesticide, xiii). Lack of marketing facility and xiv). Occurrence of flood, drought and hail storm.

Problems of present agriculture
There are various problems in agriculture to face the farmers in which some are as fallows *viz.* i). Decline in agriculture growth rate ii). Decline factor productivity iii).Static or decline in food production iv). Increasing malnutrition v). Shrinkage of net cultivable area vi). Increasing environmental population vii). Depleting ground water table viii). Increasing cost of production ix). Low farm income and x). Problems of farm labour due to large scale migration this problem can solve in single units like by adopting the integrated farming systems (IFS). IFS is a biologically integrated farming system which integrates natural resources and regulation mechanisms in to farming activities to achieve maximum replacement of off-farm inputs; secures sustainable production of high quality food and other products through ecologically preferred technologies.

Farming system and its components
The main objective of the farming system is sustainability where, production process is optimized through efficient utilization of inputs without infringing on the quality of environment with which it interacts on one hand and attempt to meet the national goals on the other (Suhas and Singh, 2017). Farming systems concept is a combination of one or more enterprises with cropping especially for small and marginal farmers. There are various component of Integrated farming system *viz.* crop production, vegetable crops production, fruit cultivation, poultry farming, livestock integration, biogas plant, mushroom cultivation, bee keeping, agro forestry, aquaculture, duckery, goatery, vermicomposting and miscellaneous enterprises like seriand lac culture.

i). Crop production
The cropping system should provide enough food for the family, fodder to the cattle and generate sufficient cash for domestic and cultivation expenses. These objectives could be achieved by adopting intensive cropping (multiple cropping and intercropping). Intensive cropping may pose some practical difficulties such as shorter turnaround time lapse for land preparation before the succeeding crop and labour shortage at peak periods of agricultural activities. These practical handicaps can easily be overcome by making modifications in the cropping techniques. Alteration of crop geometry may help to accommodate intercrops without losing the base crop population (Rana, 2013).There are various cropping system fallowed in India *viz.* Rice-based cropping system, Sorghum-based cropping system, Pearl millet-based cropping system and Wheat and gram-based cropping system etc.

ii). Animal husbandry / livestock
Dairy farming is an important source of income to farmers. Besides producing milk and/or draft power, the dairy animals are also good source of farm yard manure, which is good source of organic matter for improving soil fertility. The farm byproducts in turn are gainfully utilized for feeding the animals. Though the total milk productions in the country as per current estimates have crossed 90 million tonnes/annum, the per capita availability is still about 220 g/day against the minimum requirement of 250 g/day as recommended by Indian Council of Medical Research. The dairy sector in India is characterized by very large number of cattle and buffaloes population with very low productivity. Around 70% of Indian cows and 60% of buffaloes have very low productivity. This sector is highly livelihood intensive and provides supplementary incomes to over 70% of all rural and quite a few urban households. The sector is highly gender sensitive and over 90% of the households dairy enterprise is managed by family's women folk.

iii). Goat and sheep rearing
The system of sheep and goat rearing in India is different

from that adopted in the developed Countries. In general, smaller units are mostly maintained as against large scale in fenced areas in the developed countries.

Goat Rearing: In India, activity of goat rearing is sustained in different kinds of environments, including dry, hot, wet and cold, high mountains or low lying plains. The activity is also associated with different systems such as crop or animal-based, pastoral or sedentary, single animal or mixed herd, small or large scale. Goat is mainly reared for meat, milk, hide and skin. Goat meat is the preferred meat in the country. A goat on hoof (live goat) fetches a better price than a sheep on hoof.

Sheep Rearing: Sheep are well adapted to many areas. They are excellent gleaners and make use of much of the waste feed. They consume large quantities of roughage, converting a relatively cheap food into a good cash product. Housing need not be elaborate or expensive. However, to protect the flock from predatory animals, the height of the fencing should be raised to two meters.

iv). Fisheries

Ponds serve various useful purposes, *viz*., domestic requirement of water, supplementary irrigation source to adjoining crop fields and pisciculture. With the traditional management, farmers obtain hardly 300-400 kg of wild and culture fish per ha annually. However, composite fish culture with the stocking density of 5000-7500 fingerlings/ha and supplementary feeding can boost the total biomass production. Some strategies are adopted for fisheries development such as establishment of fish hatchery in aquaculture and use of seasonal and perennial pond for stocking and throughout availability of good quality fingerlings and yearlings, to start the integrated fish farming cum refine aquaculture technology etc.

The state government has supported installation of fish feed mill and construction of fish seed hatching on subsidies rate. To facilitate fish marketing, the scheme of distribution of moped-cum-icebox has been introduced. Two or three-wheeled vehicles have also been introduced on subsidies rates for fast movement of fish to the market.

v). Sericulture

Sericulture is defined as a practice of combining mulberry cultivation, silkworm rearing and silk reeling. Sericulture is a recognized practice in India. India occupies second position among silk producing countries in the world, next to China (Anonymous. 2017b). Currently, 2.82 lakh ha area of mulberry plantation produces about 1.27 lakh tons of reeling cocoons and 0.14 lakh tons of raw silk. The total area under mulberry is 188 thousand ha in the country. Sericulture is practiced both in tropical and temperate climates. It plays an important role in socio-economic development of rural poor in some areas. India exports silk mainly to USA, Germany, United Kingdom, France, Italy, Singapore, Canada, UAE, Switzerland, Netherlands, Spain, Japan, Thailand etc. (Anonymous, 2013). In India more than 98% of mulberry-silk is produced from five traditional sericulture states, *viz*., Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu, and Jammu and Kashmir. The climatic conditions in India are favorable for luxuriant growth of mulberry and rearing and silkworms throughout the year. The temperature in Karnataka state, major silk producing state in India, ranges from 21.2 to 30 ^{o}C. Climatic conditions in Kashmir are favorable to silk worm from May to October.

vi). Piggery

Pigs are maintained for the production of pork. They are fed with inedible feeds, forages; certain grain byproducts obtained from mills, meat byproducts damaged feeds and garbage. Most of these feeds are either not edible or not very palatable to human beings. The pig grows fast and is a prolific breeder, farrowing 10 to 12 piglets at a time. It is capable of producing two litters per year under good management conditions. The carcass return is high at 65-70% of the live weight.

vii). Poultry

Poultry is one of the fastest growing food industries in the world. Poultry meat accounts for about 27% of the total meat consumed worldwide and its consumption is growing at an average of 5% annually. Poultry industry in India is relatively a new agricultural industry. Till 1950, it was considered a back yard profession in India. In the sixties, the growth rate of egg production was about 10% and it increased to 25% in the seventies. The growth rate came down to 7-8% by1990 due to price-rise in poultry feed. By 2000, the total egg production may reach up to 5000cores. Broiler production is increasing at the rate of 15% per year. It was 31 million in 1981 and increased up to 300 million in 1995 (Singh, 1997). Nearly 330 thousand tons of broiler meat is currently produced. The average global consumption is 120 eggs per person per year and in India, it is only 32-33 eggs per capita year. As per the nutritional recommendation, the per capita consumption is estimated at 180 eggs/year and 9 kg meat/year.

viii). Duck Rearing

Ducks account for about 7% of the poultry population in India. They are popular in states like West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Tripura and Jammu and Kashmir. Ducks are predominantly of indigenous type and reared for egg production on natural foraging. They have a production potential of about 130-140 eggs/bird/year. Ducks are quite hardy, more easily brooded and resistant to common avian diseases. In places like marshy riverside, wetland and barren moors where chicken or any other type of stock do not flourish, duck rearing can be better alternative.

ix). Apiculture (Beekeeping)

Apiculture is the science and culture of honeybees and their management. Apiculture is a subsidiary occupation and it is an additional source of income for farm families. It requires low investments and so can be taken up by small, marginal and landless farmers and educated unemployed youth. Bihar is enriched with highly diversified, abundant bee-flora and favourable ecological condition. The honey production potential is about three times (60-65 kg) higher than the national average (20 kg) and very high than any state of India, *viz*., Punjab (30kg), H.P (35 kg) and Haryana (20 kg) per hive per year (Dalwai 2017) [6]. The litchi honey produced in Bihar has better taste, colour and flavour than the honey produced in other states due to variation in ecological condition. Litchi honey is very popular and has high demand nationally and internationally. Honey bees act as excellent pollinators and therefore improve the yield of various agricultural crops. In Bihar, migratory beekeeping was developed by AICRP (Honeybee), Pusacentre since 1993 which have been proved beneficial for producing different types of honey in different

areas, which resulted in considerable increase in yield and colony existence. By adopting of migratory beekeeping, beekeepers may harvest different honey flows as well as their income.

x). Mushroom production

Mushroom is an edible fungus with great diversity in shape, size and colour. Essentially mushroom is a vegetable that is cultivated in protected farms in a highly sanitized atmosphere. Just like other vegetables, mushroom contains 90% moisture with high in quality protein. Mushrooms are fairly good source of vitamin C and B complex. The protein have 60-70%digestibility and contain all essential amino acids. It is also rich source of minerals like Ca, P, K and Cu. They contain less fat and CHO and are considered good for diabetic and blood pressure patients.

Nutritional level of poor farmers can be improved by increasing mushroom production. There is considerable demand of medicinal mushrooms in addition to edible mushroom species. Straw is being better utilized by promoting mushroom production. For this, the availability of mushroom seeds and quality compost is important. So far, 7 mushroom span units have been established in the state to overcome the shortage of its seeds. The production is being encouraged by setting up a group of mushroom producing farmers, especially the women farmers. The production is being linked to market. The government has also targeted to setup 20 mushroom production units and 10 mushroom span units by 2022.

Species: There are three types of mushrooms popularly cultivated in India. They are (i) *Oyster mushroom – Pleurotus sp.* (ii) Paddy straw mushroom – *Volvariella volvacea* (iii) White *bottom mushroom – Agaricus bisporus*

xi). Agro-forestry

Agriculture and forest are always vulnerable to unfavorable climatic condition. Natural calamities, such as floods, drought, water logging etc. occur almost every year, combined with the effects of deforestation, forest degradation and erosion. Agroforestry is a collective name for land use systems and technologies, in which woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately combined on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or in a temporal sequence *i.e.* Agroforestry is an integrated self-sustained land management system, with introduction of various component like timber, pulp, pole, fuel wood, food and medicine with agricultural crops on the same unit of land, meeting the ecological and socio-economic needs of farmers. In agroforestry systems, there are ecological and economical interactions among different components. That implies that: (i) agroforestry normally involves two or more species of plants (or plants and animals) at least one of which is woody perennials;(ii) an agroforestry system always has two or more outputs; (iii) the cycle of an agroforestry system is always more than one year; and (iv) even the simplest agroforestry system is structurally, functionally, and socio-economically more complex than a mono cropping system. Agroforestry is very important for conserving soil and water, maintenance of soil fertility, controlling salinity and water logging, positive environment impact and alternate land use for marginal and degraded lands. Selection of proper land use systems conserve biophysical resources of non-arable land besides providing day-to-dayneeds of farmer and livestock within the farming system. This system also provides to varied needs of the farmer enhance employment opportunities by spreading labour needs which otherwise are concentrated in the farming system (Anonymous. 2013). The perennial characteristic of trees helps to make the best use of crop land through plantation on corner boundaries with well managed.

The different type of agro-forestry systems commonly followed in India are: (1) Agri-silviculture (crops+ trees), which is popularly known as farm forestry (2) Agri-horticulture (crops + fruit trees); (3) Silvi-pasture (Trees + pasture + animals); (4) Agri-horti-silviculture (crops + fruit trees + MPT_S(Multipurpose trees) + pasture); (5) Horti-silvi-pasture (fruit trees + MPTs+ Pasture); (6) Agri-silvi-pasture (crops +trees + Pasture); (7) Homestead agroforestry (multiple combination of various components); (8)Silvi-apiculture (trees + honey bees); (9) Agri-pisci-silviculture (crops + fish + MPT_S); (10) Pisci-silviculture (Fish + MPTs) etc.

xii). Biogas

A biogas unit is an asset to a farming family. It produces good manure and clean fuel and improves sanitation. Biogas is a clean, unpolluted and cheap source of energy, which can be obtained by a simple mechanism and little investment. The gas is generated from the cow dung during anaerobic decomposition. Biogas generation is a complex biochemical process. The celluloitic material is broken down to methane and carbon dioxide by different groups' of microorganisms. It can be used for cooking purpose, burning lamps, running pumps etc.

Family farming model for nutrition and round the year income

A one hectare area with 5 member family farming model comprising of diversified cropping systems (0.78 ha) + horticulture(0.14 ha)+ dairy (2 cows) + goat(11 no's) + fish (0.1 ha) + ducks (25 no's)+ boundary plantation (Subabul, 225 plants & Moringa, 50 plants) developed for the South Bihar Alluvial Plain zone (BI-3) in Middle Gangetic Plains region provides round the year income which ranges between Rs 13,160 (September) to 51,950(April)/ha/month. The diversified cropping systems [rice - wheat –greengram(grain + residue incorporation), rice - maize + potato - cowpea (fodder), rice - mustard -maize (grain) + cowpea (fodder), sorghum + rice bean – Berseem / oat- maize + cowpea(fodder) and seasonal vegetables (brinjal, tomato, cauliflower, cabbage, vegetable pea, okra, lettuce) grown in 0.78 ha area could meet the full family requirement of 1100, 95,125, 185 & 640 kg of cereals, pulses, oilseeds, fruits (guava & papaya) and vegetables and livestock requirement of 29.5 & 6.6 t of green and dry fodder per annum. The model also meets the milk, egg and fish requirement of 550 litres, 900 no's and 120 kg respectively. Besides meeting the family and livestock requirement, the model produced marketable surplus of 4810, 986 and 35 kg of cereals, vegetables and fruits with surplus of milk, egg and fish of 4243 litres, 950 numbers & 124 kg respectively which resulted in round the year income. The model also ensured fuel wood availability of 4 t/year for the family and could add 4 t of enriched vermicompost and 2.3 t of manure to improve the soil health. The value of recycled products and by-products model works out to be Rs1.29 lakhs which reduces the total cost (Rs 3.1 lakhs) of the model by 42%. The family labour (730 man

days) contributed to save 37% of cost. Hence, only 21% (Rs 0.68 lakhs) of total cost is involved in the form of inputs purchased from the market. A total netreturn of Rs 3.14 lakhs which is 3.2 times higher than existing pre-dominant crop+dairysystem of the zone (DARE, 2015).

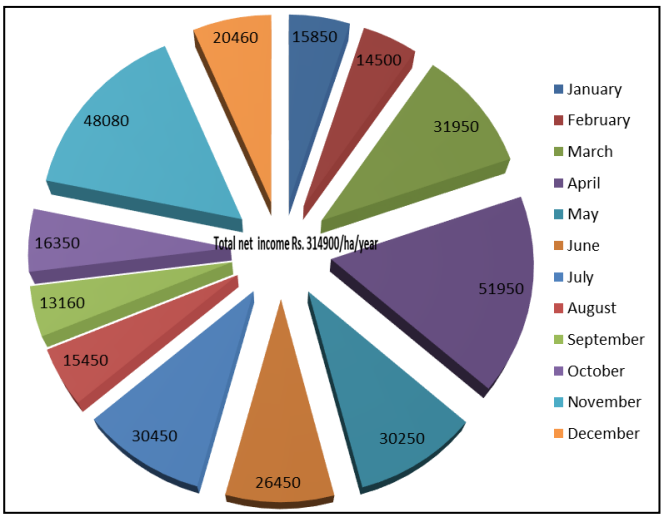

Fig 1: Round the year net income (Rs/ha) for the family from crop (0.78 ha) + horticulture (0.14 ha) + dairy (2 cows) + goat (11 no's) + fish (0.1 ha) + ducks (25 no's) + boundary plantation (subabul & moringa) farming system model at Sabour (Bihar) Fruit and vegetable (F&V) production and processing (Source: Panwar *et al*, 2018)

Ricecum fish culture

Paddy cum-fish culture is a traditional integrated fish-rice production system. The earliest practices can be traced back to more than 2,000 years ago. The system of farming is most prevalent in China, Japan, Indonesia, India, Thailand and the Philippines. China is the largest producer of fish and rice in the world. Many researchers suggest that integrated rice-fish farming is ecologically eco-friendly sound because fish enhance the fertility of soil by increasing the availability of nutrients such as nitrogen and phosphorus (Giap *et al*., 2005; Dugan *et al*., 2006). In it, the fish species selected for cultivation should have a faster growth rate. Species such as *Labeorohita, Catlacatla, Anabas testudineus, Oreochromis mossambicus, Clarias batrachus, Clarias macrocephalus, Channa striatus, Channa punctatus, Channamarulius, Chanoschanos sp.* etc. have been most commonly cultured in rice field. Rice-fish culture is now one of the most important aquaculture systems in India. While making significant contribution to rural livelihood and food security, development of rice-fish culture is an important approach for environment friendly holistic rural development, and epitomizes an ecosystems approach to aquaculture. Rice-fish culture in India utilizes a range of production systems and practices, but all contribute to eco-environmental benefits and sustainable development. Many factors have contributed to these developments, but equally and still, there are challenges that need to be addressed for up-scaling these production systems and practices. Fish play a significant role in controlling aquatic weeds and algae that carry diseases, act as host for pests and struggle with rice for nutrients. Moreover, fish eat flies, snails, and insects, and can help to control mosquitoes causing malaria and water-borne diseases (Matteson, 2000). The bio-control of rice pests is one of the prominent features of rice–fish farming which further minimize the use of pesticides for production of rice crop i.e. minimizes the cost of production because insects and pests are consumed by the fish.

Integration of Makhana with fish and Singhara (water chestnut)

Makhana was integrated with fish and water chestnut to enhance farmers' income as compared to Makhana alone at ICAR Research Complex for Eastern Region, Patna. The technology was demonstrated in an area of 50 ha with 96 beneficiaries in Darbhanga Sadar Block. The results revealed that makhana gave a total net profit of Rs. 7,90,636 with an employment generation of 9,437 man-days peryear; fish showed an additional net income of Rs. 4,65,677 with an employment generation of 889man-days/year whereas water chestnut generated an additional net income of Rs. 25,010 with an employment generation of 335mandays/year. In India the total production of makhana is about 50,000 tons out of which the state of Bihar contributes about 80 per cent of the production. The makhana market is of about 400-500 crores in the state which has a high export potential and can be exported to Middle East countries. Beside of this, there are vast investment opportunities in Bihar for establishment of makhana processing unit (e.g. unit for producing makhana pops, making flavoured and/or roasted makhana snacks, RTC Kheer, baby food, etc.). (Srivastava, 2018).

Role of farming system approaches

Food security

Food security can be defined as the balanced food supply and effective demand for food, ensuring food security to the individual wards off to the gender based ntra-household discrimination. Thus food security needs to be redefined as 'livelihood security for the household and all member within which ensure both physical and economic asses to balanced diet, safe drinking water, environmental sanitation, primary education and basic health care.

Provides balanced food

There is need of farming system which has several components like dairy, poultry, goatry, fisheries etc. along with crop production. In this way, farming system would not only meet the food demand but also cater the need of protein, fat, vitamins and minerals required for good health. Incorporation of horticulture and agroforestry with cropping would ensure seasonal access to fruits, fuel, fodder and fiber.

Quality food basket

As the living status is improved, the requirement of cereals will be decreased and supplemented by other items *viz*. milk, egg, meat, fruit etc. Integration of allied enterprises with cropping increases the nutritive value of the products.

Higher productivity and enhanced farm income

Integration of fish in rice system decreased rice grain yield due to the presence of fish trenches occupying 10% of the rice area; however, additional income increases. The profit can be increased more when fish, vegetables and livestock are included in rice-rice farming system. (Chaubey *et al.*, 2018).

Effective recycling of resources

The effective recycling of farm resources is possible by adoption of farming system research. Crop by-product is utilized as fodder for animals, and animal by-product i.e. milk, and dung may be utilized for increasing income and soil fertility, respectively.

Minimize environmental pollution

In Punjab, Haryana, western Utter Pradesh and Bihar burning of rice residue is common practice, which increased the concentration of greenhouse gases in atmosphere, in addition to huge amount of nutrient loss. Such situation could be avoided by introduction of some more enterprises like animal husbandry on the farm. Rice straw may be used as animal feed.

Employment generation

Since crop based agriculture is highly season specific and time bond, the intensity of labour requirement increases during sowing and harvesting time of crops. For rest of the time, farmers sit idle if they do not have off-farm activities. This leisure time could be utilized effectively by adoption of farming system, which keeps the whole family busy throughout the year.

Summary

Low level of farmers' income can cause serious adverse effect on the present and future of agriculture and farmers health in the country. For that purpose Government of India announce how to double the farmers income for that purpose the interventions in Integrated Farming System model covering Introduction, adaption and acceptance of new varieties and cash crops as well as new and upcoming production technologies can potentially strengthen farmers' cropping systems by increasing yields, improving drought resilience, boosting resistance to pests and diseases and also by capturing new market opportunities by which farmers fulfil the target of doubling farmers' income. Diversification of activities which yields better remuneration (region specific) should be the ideal strategy and easy to increase the farmers income.

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