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मॉडल की प्रभावशीलता

**Effectiveness of Integrated Farming System Models for
Sustainable Livelihood**

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**Effectiveness of Integrated Farming System Models
for Sustainable Livelihood**

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LIST OF ABBREVIATIONS

AIT	Asian Institute of Technology
ATMA	Agricultural Technology Management Agency
B:C Ratio	Benefit Cost Ratio
CIFA	Central Institute of Freshwater Aquaculture
CIWA	Central Institute For Women In Agriculture
DEA	Data Envelopment Analysis
DEAP	Distributed Evolutionary Algorithms in Python
DFAC	District Farmers' Advisory Committee
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GoI	Government of India
Ha	Hectare
IAAS	Integrated Agriculture-Aquaculture Systems
ICAR	Indian Council of Agricultural Research
ICAR	Indian Council of Agricultural Research
IF&WMS	Integrated Food and Waste Management Systems
IFS	Integrated Farming System
IMC	Indian Major Carps
INR	The Indian Rupee
IRRI	International Rice Research Institute
KKU	Khon Kaen University
Km	Kilometres
KVK	Krishi Vigyan Kendra
l/ day	Litre/day
mha	million hectare
mm	Millimetre

MoA&FW	Ministry of Agriculture & Farmers' Welfare
NDDDB	National Dairy Development Board
NGO	Non-Governmental Organisation
NMR	Net Monetary Return
PBC	Perceived Behavioural Control
SAU	Standard Animal Unit
SD	Standard deviation
SN	Subjective Norm
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TE	Technical Efficiency
TPB	Theory of Planned Behaviour
VRS	Variable Returns to Scale
WTO	World Trade Organization

INTRODUCTION

Agriculture remains the mainstay of Indian economy even after six decades of planned development. But, over the past two decades, contribution of agriculture sector to Gross Domestic Product (GDP) has continued to decline from 29 per cent in 1990 to 13.9 per cent in 2016. However, agriculture sector still remains a major source of employment, accounting for about 47 per cent of the total national workforce (Ministry of Labour and Employment, 2016). Further, more than 68 per cent of the population lives in rural areas, and majority of them directly or indirectly depend on agriculture for their livelihood (Census, 2011). The total geographical area of India is 328.73 million hectare (mha), out of which 304.89 mha comprise the reported area and around 264.5 mha is under use for agriculture, forestry, pasture and other biomass production. The total reported net sown area of this country is 140.1 mha and the gross cropped area is 198.4 mha with a cropping intensity of 142 per cent. However, the net irrigated area is only 68.4 mha *i.e.* 48.82 per cent of the net sown area. (Annual Report- MoA&FW, 2017-18). India supports about 16 per cent of the total human population of the world and approximately 20 per cent of the livestock population on just 2.5 per cent of the its geographical area (Bhattacharyya *et al.*, 2015).

Indian agriculture is mainly predominated by marginal and small farmers and largely characterized by subsistence nature of farming. Marginal and small farmers who constitute more than 84 per cent of the 115 million operational holdings cultivating only 29 per cent of the arable land (Agricultural Census, 2011). In India, land fragmentation is continuing and the average size of land holding has been showing a decreasing trend from 2.28 ha in 1970-71 to 1.55 ha in 1990-91 and further to 1.23 ha in 2005-06. By 2015-16, the average of land holding size is only 1.1 ha. Correspondingly, total number of operational holdings in India increased from 71.01 million in 1970-71 to 106.6 million in 1990-91 and to 129.22 million in 2005-06 and by 2011 it further reached to 138.35 million. Low asset base and the paucity of productive resources make them vulnerable to risk and impede their coping ability. Even with the resource constraints, vulnerability and other bottlenecks, the smallholders do not lag behind other farm size categories in adopting new and

improved technologies and production inputs. Cropping intensity, which, in Indian agriculture is seen as the main source of growth, is often observed to be the highest in marginal holdings and decline as farm size increases. The inverse nature of relationship between farm size and aggregate crop productivity has been quite pronounced in recent years (Chand *et al.*, 2011). The competitive advantages of smallholders, as reported by Poulton *et al.* (2005), are their intensive local knowledge and use of family labour which lowers their transaction cost. But, it should also be noted that too small holdings are not capable of generating adequate income for the survival of farm family. Besides this, small farmers are faced with high unit transaction cost in almost all their non-labour transactions like in non-labour input markets, output markets and credit services. Moreover, vulnerabilities of smallholders to climate change related problems are quite high owing to fewer resource bases at their disposal, thereby lowering their adaptation and mitigation capacity. Under the continuous shrinkage of land holding, it is imperative to integrate various land-based enterprises like field and horticultural crops, poultry, fishery, duckery, apiary with the objective of making farming more lucrative (Behera *et al.*, 2004).

Spearheaded by the 'Green Revolution' in the 1960s-70s, the agricultural sector was able to overcome productivity stagnation with improved food grain production. This period was followed by the 'White Revolution', which transformed Indian milk production and marketing system. Over the last decade, the sector's overall performance in terms of sustainable growth has been much more modest. However, scientists, planners, policy makers and government are well acquainted with the after-effects of the Green Revolution. These included agricultural development occurring only in resource-rich regions, ignoring the need of small and marginal farmer (Mahapatra, 1994). Also, it was primarily focused only on those regions which had adequate irrigation facilities and on those farmers who were able to purchase agricultural inputs (Das, 2017). Also, the development of dairy sector remained skewed in favour of few states like Gujarat, Maharashtra, Karnataka and Tamil Nadu (NDDB, 2016-17). The states with developed infrastructure performed better in terms of growth of agricultural output and productivity (Banerjee and Kuri, 2015). However, such states are very few in number and hence the farming community especially the small farmer even in such states remains vulnerable. At the expense of degradation of natural resources, the agricultural production increased five

times (Yadav and Prasad, 1998; Singh, 2000). Many studies have reported that commercial farming system poses a threat to environment since it causes loss of genetic diversity (Ashby, 2001). Intensification of farming over time has led to the degradation of the fragile agro-ecosystem. High production cost and fluctuating returns from farming affect the socio-economic condition of farmers. Some of the adverse effects of over adoption of agricultural technologies by the farmers to make the green revolution successful include loss of soil fertility, erosion of soil, soil toxicity, underground water pollution and salinity, diminishing water resources, increased occurrence of human and livestock diseases and global warming (Rahman, 2015). Moreover, various subsidies on inputs have led to skewed and unsuitable use of inputs. For example, urea subsidies have resulted in unbalanced use of nitrogenous, phosphorus and potassium fertilizers thereby aggravating deficiency in the use of micronutrients. Even after 70 years, the regional disparity in agriculture is very much eminent.

Considering the continuous shrinking of agriculture land and increasing human population, the only effective alternative available is vertical expansion by integrating suitable farming components which ensures food security along with regular income to the farmers. Strategies for increasing the diversity of crop or animal species is frequently associated with sustainability (Hansen, 1996; Ellis, 2000). Sustainable increase in food production aims to achieve food self-sufficiency and improve the well-being of smallholder farmers under the pressure of continuous rise in population, changing food habit, economic growth, rapid urbanization and severe climate change situation. Such increase in food production has to be achieved by utilizing less land, water, labour, chemicals and by enhanced innovation (IRRI, 1998; Khush, 2001, Doss, 2006). The sustainable production of enough food needs to be achieved without further damage to natural agricultural production resources (such as soil and water), the health of the environment, or the health of people (Pretty, 2008). Therefore, farming system approach to agriculture research has been suggested by many researchers in order to meet the objectives of poverty alleviation, food and nutritional security and sustainability (Norman, 1978; Byerlee *et al.*, 1982; Shaner *et al.*, 1982). The state policy is also pushing forward sustainable agriculture through integrated farming system (IFS) and farm diversification has been sought as a key strategy to double the farmers' income by 2022 (Chand, 2017).

Farm diversification and integration of appropriate components in the farming system leads to higher productivity while using less space and time which ensures that agriculture-driven growth is inclusive, pro-poor and environmentally sustainable (Altieri *et al.*, 2012). For tackling the problems encountered in the post Green Revolution era, crop diversification and IFS are usually recommended practices (Behera *et al.*, 2007). The concepts of farm diversification and IFS are often used exclusively, even if they are conceptually different. The main difference in these concepts may not be absolute, rather it is of the degree of integration of resources in the farm system (Tipraqsa, 2006). Diversified systems consist of components like crops and livestock existing together but independently (FAO, 2001). For instance, farmers can have dairy, pigs and crops as independent units. The mixing of crops and livestock is mainly to reduce the risk and not for recycling resources. On the other hand, integration is done primarily to recycle resources efficiently. Here, crops and livestock interact generating a synergy where recycling allows the optimum use of available resources. Through integration of different farm enterprises and recycling of crop residues and by-products, this approach aims to enhance the income and employment from smallholdings (Ahlawat *et al.*, 2002; Rautaray *et al.*, 2005). Various experimental and empirical researches have shown the prospects of IFS in increasing productivity and efficiency, improving financial profitability and environmental and ecological benefits from the complementarities and synergies among the different agricultural sub-system / enterprises/ components in many parts of the world, including India (Radhamani *et al.*, 2003; Gill *et al.*, 2009).

The Integrated Farming System (IFS) is a strategy to manage resource in order to realize economic and sustained production from the farm to meet the diverse requirement of farm households while still keeping in view the importance of preserving the resource base and providing income round the year by combining different farm enterprises in a single land piece in a complementary way. The integrated farming systems give greater emphasis on the efficient management of farm resources to increase farm productivity, decrease environmental degradation, to maintain sustainability and improve the quality of life for farmers. The main difference between the IFS and commercial farming or conventional farming system is not absolute; rather it is a matter of degree of integration of resources in the farm

system (Tipraqsa, 2006). The system copes with the changes at farm level by balancing food production, profitability, animal welfare, safety, social responsibility and environmental care (Little and Muir, 2003). The IFS focus on reducing the trade-off and harnessing synergies among various agricultural sub-systems/enterprises and in so doing enhances the total productivity, sustainability and employment level.

The IFS is a very old farming system practiced for many centuries in different parts of the world. There is an extensive diversity of farming systems among a group of farms. This is true not only on a large geographic scale but also within restricted rural areas or more oriented types of these systems (Carmona *et al.*, 2010; Castel *et al.*, 2003, 2010; Van de Steeg *et al.*, 2010). In India, the IFS is practiced in different states under different agro-ecological and socio-cultural settings. Yet, a common characteristic of the IFS is a combination of crop, poultry, fisheries, apiculture, livestock and other related enterprises. The fundamental principle of the IFS concept is the synergy between enterprises which increases the on-farm diversity. It provides positive externalities to society by promoting the dimension of sustainability. It makes a crucial contribution to sustainable development by incorporating economic, social and ecological objectives to the indispensable business of agricultural food production. Like in other developing countries, in India also, extensive integrated agricultural systems are common, which is characterised by low levels of input, output and risk.

Criteria for selection of components:

The income from arable cropping by itself is inadequate for majority of the small and marginal farmers. Activities such as poultry, aquaculture, dairy, biogas production, agroforestry, edible mushroom cultivation and agri-horticulture, *etc.*, can be integrated based on the relevance and suitability of each enterprise. Choices of farm components are precursor to farmers' decisions for integration of farm components. Choice of farm components of a farm is a dynamic process and decision on what component to have and how to integrate the resources are defined by not only their socio-economic status, farm characteristic, bio-physiological condition, but also by the economic interests and their ethics and culture (Cheshire *et al.*, 2013). Some of the criteria are as follows:

- Enhancement of productivity, profitability and sustainability
- Provision of balanced food for family
- Generation of marketable surplus
- Saving energy
- Meeting the demand for fodder, fuel and timber
- Environmental safety
- Recycling of residues
- Income round the year
- Employment generation
- Agro-industries
- Increasing input efficiency
- Soil and climatic features of the study locale
- Availability & accessibility of the natural, human, financial, physical and social resources
- Present level of resources uses
- Assessing economic viability of planned integrated farming system
- Technical and managerial skill of farmer

In agronomical context, for sustainable farming, farmers should aim at minimum use of each production resource required for maximum utilization of all other resources (De Wit, 1992). An IFS improves farm productivity, reduce environmental degradation thereby improving farmers' overall quality of life and maintain sustainability by enabling sound management of farm resources. Also, the IFS has the ability to deal with with the changes at farm level by balancing food production, profitability, animal welfare, safety, social responsibility and environmental care (Little and Muir, 2003). A high degree of integration of farming components is often considered as a step towards sustainability. Every diversified farm has the capacity to integrate the various components of farm and practices sustainable resources management. The conceptual outlook for sustainable farming favours the IFS above the farm diversification.

Statement of the problem:

In India, a large number of farmers are small and marginal, often cultivating less than 1 ha or 1-2 ha of land. Approximately, 57.8 per cent of rural households are involved in agriculture in India, out of which, over 69 per cent work on marginal landholdings and 17.1 per cent possess small landholding. Near about 72 per cent of the rural households are involved as cultivators or agricultural labourers in the agriculture sector (Census, 2011). The slow agricultural growth has pressured the rural populations to move towards the non-farm sector which increased the employment in the non-farm sector by about 12 per cent between 1999-2000 and 2011-2012.

As per the Situation Assessment Survey of Farmers, 2003, conducted by the government, four out of ten farmers did not like farming and preferred another occupation if they had a choice. Further, out of these, 27 per cent were of the view that farming is not a profitable enterprise and 8 per cent felt that it is risky.

In India, small and marginal farmers face various hurdles in terms of procuring financial, technological and institutional support. Some of these issues are limited access to formal credit and insurance, short of capacity-building programmes for training them about up-to-date farm technologies, insufficient irrigation water supply, negligible scope for crop diversification and lack of marketing facilities. Both small and large farmers faced these challenges, however, the degree of access to various agricultural inputs often varies and large farmers find some sort of advantage. Though studies have shown that IFS is feasible with respect to socio-economic imperatives, the actual adoption rate is limited and unevenly spread among farmers. So, the present study was designed to examine the integrated farming systems with respect to the feasibility of integrated farming practices, techno-economic efficiencies, as well as their socio-economic and farm level impacts. As the systematic adoption of IFS is very low, the study also aimed at analyzing the factors for adoption and non-adoption and the extension strategies for promoting the IFS.

Researchable Issues:

The researchable issues related to the integrated farming systems as mentioned below, need scientific investigation.

1. What are the successful models of integrated farming system?
2. How effective are the various models of integrated farming system?

3. What are the factors responsible for the adoption and non-adoption of integrated farming system?
4. What are the various constraints the farmers faced while adopting integrated farming system?
5. What are the various farm-level impacts of integrated farming system?
6. What are the various socio-economic impacts of integrated farming system on the farming community?
7. What are the effective extension strategies for the promotion of integrated farming system?

Objectives:

To address these researchable issues, the present study was conceived with the following specific objectives:

1. To document and identify the best practices of different integrated farming system models.
2. To conduct comparative techno-economic assessment of integrated farming system models.
3. To analyse the determinants for adoption and constraints in adoption of integrated farming systems.
4. To assess the socio-economic and farm level impact of integrated farming systems.
5. To analyse the extension strategies for promotion of integrated farming system for sustainable livelihood

Expected outcome of the study

The study will help in identifying and documenting various types of IFS model. The assessment of various types of IFS in terms of economic efficiency and resources allocation trade-off will help in identifying the best IFS model, which henceforth can be recommended to the farmers. The study will trace out various kinds of socio-economic and farm level impacts that occur as a result of IFS. It will also be helpful to identify the determinants and constraints in adoption of IFS. The outcome of study could be effectively used for developing the strategies for promoting IFS.

Limitation of the study

Social science research encompasses certain assumptions and encounters various limitations. The present study was also not completely free from limitations.

- Farm records were not adequately maintained by the farmers. As the data was collected by survey method based on recalled and past experiences of the respondents, error of information is subjected to exist.
- Not all the items in the interview schedule were filled by the farmers. Some of the farmers were hesitant to answer the questions related to financial aspect. In this regard, the problem was dealt with appropriate techniques described in the Research Methodology chapter.
- Time and resource constraints were major limitations while the data were collected
- A limited size of sample (two hundred twenty two households) was taken for the study. A larger sample size would certainly have improved the reliability of the results. Hence, generalizations from the results have to be made with some reservations. However, under similar agro-climatic and socio-economic conditions, it can be extended for its productive application.

REVIEW OF LITERATURE

A brief review of literature is an essential part of any scientific study as it not only gives an idea on the endeavour done in the past but also provides the basis for interpretation and discussion of the findings. In the light of the objectives of the study, the relevant literature is reviewed and presented under the following sub-headings.

- 2.1 Challenges in current agriculture
- 2.2 Concept of integrated farming system (IFS)
- 2.3 Components of integrated farming system for different Agro-climatic zones
- 2.4 Techno-economics of integrated farming system
- 2.5 Adoption of different integrated farming system models
- 2.6 Constraints in adoptions of IFS
- 2.7 Impact of integrated farming system

2.1. Challenges in current agriculture

World Bank (2012) identified three major challenges in Indian agriculture: Enhancing agricultural productivity per unit of land per drop of water with increased yield and diversification; alleviating rural poverty through a socially inclusive strategy comprising both agriculture and non-farm employment targeting complex diverse rain-fed agriculture; ensuring that agricultural growth responds to food security needs.

Ashby (2001) emphasized that a serious threat has been imposed on environment because of commercial farming & associated inputs since it negatively impacts environment and causes loss of genetic diversity.

Sharma (2011) narrated that rain-fed agriculture would play a major role in India's food security and sustainable economic growth which emphasized food security

from water productivity improvements through water management and water uptake capacity of crops need to be achieved in the rainfed areas.

Several identification and classification of issues in agriculture is delineated like Shrinking land-base and declining access to land; Irrigation system: its expansion and utilization; Availability and access to credit; Availability and use of inputs like fertilizers, seeds and pesticides; Prices, costs and profitability; Marketing system; Agreement on Agriculture under WTO; Investment in agriculture *etc.* (E-gyankosh, 2018).

India is poised to face serious challenges to produce food grains from degraded climatic conditions, shrinking land base, scarce water resources when agri-inputs and energy costs are high. Fortunately, the opportunities for higher yields still exist because the present yield level is low (Biswas, 2009).

In economic point of view, employment is not being generated in the industry and service sector where growth is high and a majority of people are employed in agriculture wherein GDP growth is low. Hence, there has been an unbalanced approach to agricultural development in India during last decades. (Dev, 2008)

2.2. Concept of integrated farming system (IFS)

Prein (2002) explained the term “Integration” in Integrated Farming System to mean using output, especially by-products of one enterprise as inputs by another in the context of farming system. Some authors have extended the term to the use of on-farm resources and agro-industries.

Rangasamy (1999) stated that, the concept of farming systems has got more significance than conventional farming in reaping better harvests in the long run by maintaining a productive resource base. The IFS approaches have brought tremendous change in techniques of crop production and in cropping pattern in order to obtain maximum production and to ensure care of optimal utilization of resources

Köbrich *et al.* (2003) defined farming system as a set of individual farm systems having broadly similar resource bases, pattern of enterprise, livelihoods and constraints, and for which comparable development strategies and interventions would be suitable.

According to Dixon *et al.*, (2001) farming system comprises the sum of production and consumption decisions which a farm-household takes, consisting of the choice of crop, livestock and both on-farm and off-farm non-agricultural enterprises and food choice by the household in its own, unique farming system. Rao (1989) opined that uneven distribution of ownership of operational land holdings and the fragmentation of land, labour and markets leads to behavioural heterogeneity in agriculture. IFS is viewed as a multidisciplinary whole farm approach which effectively solves the problems of small and marginal farmers by enhancing income and employment from smallholding through integration of a variety of farm enterprises and recycle of crop residues (Soni *et al.*, 2014).

IFS implies agricultural systems which integrate livestock and crop production or fish and livestock and sometimes may be understood as 'Integrated Bio-systems'. In such system, an inter-related set of enterprises are used so that the "waste" from one component becomes an input for another, which eventually decreases cost and improves the production and hence, income (Soni *et al.*, 2014).

"Integrated Food and Waste Management Systems (IF&WMS)" introduced in Fiji is one version of an IFS. At present, there are numerous IF&WMS or IFS models combining agriculture, livestock, aquaculture and agro-industry in an expanded symbiotic or synergistic system. This enables the use of wastes of one process as input for another, to provide the means of production, such as fertilizer, energy and feed for optimal productivity at least costs. (Soni *et al.*, 2014)

Rodríguez (1995) reported that the IFS model has a lot of variants but the basic principles remain the same. In case of livestock, it is vital to identify local feed resources and the likings of local people for different types of livestock with due care of minimum "waste" and by-product recycling in the system.

Edwards (1997) defined IFS as an aquaculture system integrated with livestock in which fresh animal waste is used as fish feed. Okigbo (1995) defines the system as a

mixed farming system consisting of at least two separate but interdependent parts of crop and livestock enterprises.

Jayanthi *et al.* (2000) described the integrated farming systems as a mixed crop-animal system in which agricultural waste products are used to raise the animal component while the animal is used for tillage and other purposes on crop field and supply manure used as fertilizer. Agbonlabor *et al.* (2003) defined integrated farming systems as a type of mixed farming system combining crop and livestock enterprises in a supplementary and/or complementary manner. Bahire *et al.* (2010) defined IFS as the practice of raising diverse yet dependent enterprises and in cases where different enterprises are reliant they are principally complementary and supplementary to each other. IFS portray multiple crops (*eg.* cereals, vegetables, legumes, tree crops, *etc.*) and multiple enterprises (*e.g.* livestock, apiary, aquaculture, *etc.*) on a single farm in an integrated manner. The farmer, farm, resources of the farmer and farming environment together constitute a complex system, which is termed as a farming system (Behera, 2013).

Ramarao (2005) was of the view that mixed farming system of farming on a particular farm includes crop production, raising livestock, poultry, beekeeping, fisheries *etc.* which sustains and satisfies the needs of the farmers.

Rana and Chopra (2013) described that IFS is a mixing of ecological, social and economic understandings which aims at poverty alleviation through suitable scientific technology. By analyzing the dynamics and diversification, it evaluates alternate development pathways for similar groups of farmers. The basic principle of farm design in IFS is system perspective is the coexistence of different species and components working together to achieve maximum productivity with sustainability.

Biswas and Singh (2003) stated that in IFS, two or more enterprises like crop, livestock, bee-keeping, poultry, fisheries, *etc.* are integrated based on the availability of resources in order to sustain and satisfy the needs of the owner.

2.3. Components of Integrated Farming System for different Agro-climatic zones

The diversity of farming system and uniqueness of different farming system led to varying degree of practices and nomenclature. Different farming systems are practiced and defined in different countries in different ways. In other words, the definitions are varied and depend on the context.

Diversified systems consist of components such as crops and livestock coexisting independently, mainly to minimize risk and not for recycling of resources (FAO 2001). The difference between integrated farming and mixed farming is that enterprises in IFS are mutually supportive and dependent on each other (Csavas, 1992).

Moreover, there are several IFS modules but uniqueness exists in diverse IFS system which broadly classified into eight types for eight different agro-climatic zones in India. The central and southern highlands comprises millet, sorghum, cotton, pulses along with dairy cattle, goats, sheep and poultry. On the other hand, delta and coastal plains comprised rice cultivation coupled with fish culture, poultry and piggery enterprises, capture fisheries of the marine ecosystem as a specialized enterprise not mixing with cropping activity (Rana & Chopra, 2013).

According to Castel *et al.*, 2003, 2010; Carmona *et al.*, 2010; Van de Steeg *et al.*, 2010, it has been noted that huge diversity exists among the group of farms as for as farming system is concerned which is evident not only in large geographic areas but also within constrained rural areas. Lesschen *et al.*, (2005) further emphasized that every farming system is differs in some aspects and face distinct decision-making problems, whose solutions could also be unique. As a result, it is important to categorize farms in some way.

Radhamani *et al.* (2003) gave an alternative definition of IFS as a “component of farming system”, which is a whole farm approach that aims to minimize risk, increase production and profits, at the same time improving the application of organic wastes and crop residues. In order to ensure optimal utilization of resources and obtained maximum

productivity a vital change in cropping pattern and farming technique has been introduced by Integrated farming system.

World Bank (2012) encourages farmers to diversify to higher value commodities so as to contribute to higher agricultural growth, particularly in rain-fed areas with high prevalence of poverty is. It emphasizes that diversification has a huge potential for agro-processing and competitive value chains from producers to urban centers and export markets. In order to promote crop diversification, farmers and entrepreneurs should be handed the responsibilities for undertaking the initiatives for the same. However, government can provide support by liberalizing constraints of marketing, transport, export and processing.

Hosamani (1999) opined that the IFS consider interactions between the sub-systems within a whole farm setting and is designed to address the needs and goals of the farmers and society. The whole farm is viewed as a system which encompasses interacting subsystems. None of the potential enterprise are considered separately.

Lightfoot and Minnick (1991); Jitsanguan (2001); KKU (2001); Radhamani *et al.* (2003) were also of the view that crops and livestock components interact to create a synergy in an integrated system, in which recycling allows the optimal use of available resources. Thus, synergies between enterprises are fundamental to the idea of integrated farming.

Phengvichith (1998) affirmed that in order to realize the contribution of animals in a crop-animal system, the technology needs to be more system oriented and generated on-farm to ensure economic viability and social acceptability. Similar observations have been made by Devendra (1998). Senthilvel *et al.* (1998) recommended the integration of goats for rainfed areas of Tamil Nadu. The advantages of dairy integration along with cropping in farming systems have been earlier indicated by Devendra (1997 and 2000) and Dibissia and Peters (1999).

Panin and Moukhi (2000) have identified cattle enterprise as a dominant component in Botswana. Orskov (2000) observed that, on almost all small crops/

livestock farms in Asia, livestock are kept not to maximize profits but to minimize risks. Based on their study in Tamiraparani river command area, characteristics of suitable integrated agriculture-aquaculture technologies identified were that they should be of minimum risk; need low investment; give quick returns; simple and easily replicable; provide the facility to establish local fish supply capacity; and without difficulty taught to trainers and farmers (Haylor, 2003).

Legesse *et al.* (2008) reported that sheep and goats act as investment and insurance to farmers and provide income to meet seasonal purchases of food, improved seed, fertilizer and medicine during crop failure and severe decline in prices of crops. From centuries, goat production has been an integral component of farming system and a primary source of livelihood for poor farmers. Resource-poor smallholders on zero input generally rear goats in India. The system of goat production is very diverse and has been broadly divided into 6 zones based on agro-climatic conditions (Singh *et al.*, 2008).

Channabasavanna *et al.* (2009) reported that IFS with cropping involving poultry, fish and goat was highly productive and profitable. It showed around 26 per cent higher productivity over the conventional rice – rice system. It can be advocated for small and medium farmers in middle and tail end of canal where water is limiting.

Better utilization of organic manure from livestock can ensure sustainable crop-livestock intensification for poor farmers, particularly as they often are not able to afford purchasing expensive inorganic fertilizers (Bationo *et al.*, 2004). This agrees with the findings of Makinde *et al.* (2007).

Gopinath *et al.* (2012) concluded that the IFS involving crop (1 ha) + draught animals (4 bullocks) + dairy (3 desi cows + 1 buffalo) gave the highest net returns and generated employment of 482 man-days/annum compared to other combinations. The livestock component generated about 8 tons of manure which was used for as manure in the crop fields.

Rearing of buffaloes, goats, cow, *etc.* along with fish in farm ponds facilitate the farm family to have a balanced diet. Through different cropping, biodiversity, and

ecosystem services, multi-enterprise farming plays a dynamic role in making the farming system sustainable. Biodiversity has been clearly impacted by intensification of farm. (Amjath-Babu and Kaechele, 2015).

Fish production along with rice production besides helping in the control of weeds and insects and adding income, also serves as an important source of protein in the diet of farmers (Parreno-de Guzman *et al.*, 2015).

Rice-based IFS of rice + brinjal + mushroom + poultry was found to be the best in terms of rice equivalent yield (around 21 t/ha), employment generation of 392 man-days, energy efficiency and economics (Korikanthimath and Manjunath 2009).

Behera *et al.* (2014) reported that in marginal farms, the strategy of rice-wheat alone generated an income of Rs 53,221 and employment of 105-man days. However, a strategy comprising of 0.54 ha of rice-wheat, 2 cows, 0.37 ha for fishery, 20 pigs and a small poultry unit of 600 birds gave the highest annual net returns of Rs 99,113 with employment for 149 man-days.

Besides household management, women play a very vital role in household including agricultural operations as well. It is particularly more real for hilly, tribal dominated areas. With the improvement in educational status and increased participation, the role of women in agriculture and management of scarce resources will be gradually more important for sustained growth of agriculture. As such, feminization of agriculture is likely and therefore developing women-centric farming system models will be the real test considering that men are migrating to rural non-farm sectors (ICAR-CIWA Vision 2050 Document, 2015).

2.4. Techno-economics of integrated farming system

Tripathi and Rathi (2011) stated that Uttarakhand, the major components in IFS are crop + dairy, crop + horticulture +goats, crop + dairy + goats + horticulture crop +dairy + vegetables, horticulture + dairy + vegetables, vegetables + dairy and crop + dairy + companion animals are.

Mohanty *et al.* (2010) identified the IFS model in Gajapati district of Orissa. It consists of field crops (rice, maize, groundnut, pigeon pea and ragi), horticultural crops (vegetables, yam, banana, tapioca and), vermin-composting and poultry (*Vanaraja* breed)

Muir (1981 and 1986) conclude that integration of farming components with other components may be direct with activities being integrated on-site or indirect, with the components at some distance apart and connected by transport.

Pant *et al.* (2005) found that the pattern and magnitude of bio-resource flow in integrated agriculture-aquaculture systems differ between rainfed and irrigated systems. The degree of synergism through mutually reinforced linkages among crops, livestock and aquaculture was high in rainfed systems. On contrary, there were minimum synergistic relationships among enterprises in the irrigated system, as most enterprises functioned independently.

The rice-based IFS comprising of crop + dairy + poultry + fishery was the most appropriate and efficient farming system model which gave the highest system productivity and also ensured the multiple usage of water. This model generated significantly higher levels of employment compared to the rice-wheat system (Singh *et al.*, 2006).

The knowledge of linkages and complementarities will help to develop IFS in which the waste of one enterprise is efficiently used as inputs in another thus promoting effective recycling of residues/wastes. This assures regular cash flow when crop is combined with other enterprises keeping in view the environmental condition of the locale (Rana & Chopra, 2013).

The principle of combining enterprises is based on what enterprises at which level depends partly on the inter-relationships between different enterprises and the prices of the products and inputs. There are five types of enterprises, *viz.*, independent, joint, supplementary, complementary and competitive enterprises. In the integrated system, enterprise should be selected based on the principle that competition should be minimal and complementarity maximum among the enterprises (Rana & Chopra, 2013).

The IFS based on multiple uses of water, comprising of crop, duckery, fishery, piggery, poultry, agro-forestry *etc.* results in more judicious use of water resulting in higher water productivity and also improves the livelihood of resource-poor farmers (Sharda and Juyal, 2007)

Gill *et al.* (2005) reported that an IFS in Punjab under shallow water table conditions, the water productivity increased by about 56 to 86 per cent in comparison with only rice-wheat system. Integration of fishery and piggery gave maximum water productivity (net returns of Rs. 5.67/m³, 1.23 kg grain of rice/m³ of water).

Srivastava *et al.* (2004) reported that the water body has to be near the homestead for better management and security for enabling multiple uses of water, especially aquaculture, duckery and vegetables on pond embankment.

Behera *et al.*, (2008) suggested that to make farming profitable and improve the farm level resource use efficiency; the synergy among components of farming systems should be exploited. In the process of technology generation, transfer and other developmental efforts at the farm level, it is desirable to make the farmers know of the whole-farm scenario to boost efficiency and move towards sustainable farming.

Haque (2006) classified three types of efficiency *viz.* technical efficiency, allocative efficiency and overall or economic efficiency. Technical efficiency is defined as the farm's ability to produce a given level of output with minimum quantity of inputs with given technology. Allocative efficiency, on the other hand, measures the degree of success in achieving the best combination of various 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 (Olayide & Heady, 1982). Mangala (2008) revealed that in Dharwad, the farming practices adopted by respondents after implementation of IFS programme were agriculture-horticulture-forestry-dairy- vermicompost (62.14%), agriculture-horticulture-forestry-dairy-vermicompost-forage crops (21.43 %), agriculture-horticulture-dairy-forage crops (7.86 %), agriculture-horticulture-forestry dairy-forage crops (5.00 %) and agriculture-horticulture-dairy (3.57 %).

a) Crop diversification with high-value crops on resource use efficiency

Jat *et al.* (2012) opined that among different cropping systems tried, from economic efficiency point of view, rice + fenugreek + okra recorded highest production and water use efficiency followed by rice + onion + cowpea. Similar results have also been reported by Sharma *et al.* (2007). Rice + onion + cowpea generated the highest number of man-days/ha/year (486). Digging of onion in heavy black soil and picking the cowpea pods for vegetable purpose are labour intensive operations followed by rice + fenugreek + okra with 468 man-days generated/ha/year.

The maximum input energy was used in maize + black gram (2:2) – wheat – okra cropping system over all the other cropping systems tried, while minimum input energy was used in maize-wheat system. The maximum values of energy output efficiency, energy-use efficiency, energy intensiveness and specific energy were found in maize-wheat system (Jain *et al.*, 2015).

b) Crop diversification with high-value crops on economics

Sharma (2007) reported that in Himachal Pradesh during the last fifteen years, there is an increase in the area and production of vegetable crops (area 23 thousand ha in 1990-91 to 50 thousand ha in 2006-07, the production rose from 365 thousand tonnes to 1000 thousand tonnes). The results revealed that total income per household from all sources for both the small and large farmers was significantly higher in cases where crop diversification was followed extensively.

Kumar *et al.* (2008) concluded that with the inclusion of vegetable crops in rice-based cropping systems the profitability of that particular system is higher. These results were also in line with the observations of Mishra *et al.* (2007).

Among various cropping systems evaluated, net monetary returns ₹ 1,52,922/ ha was maximum in rice – toria – onion cropping system followed by ₹1,40,830/ha in rice – berseem and ₹ 1,18,809/ ha in rice - green pea – wheat cropping system. Rice – chickpea, rice – lentil, rice – mustard and rice – chickpea + linseed cropping system were not more

remunerative than rice-wheat system (Tarwariya and Maurya, 2013). These findings are in conformity with the findings of Dubey (2010).

Among the various cropping systems evaluated, rice + fenugreek + okra gave the highest net returns (₹ 96,286/ha) followed by rice + onion + cowpea (₹ 84,511/ha). The inclusion of vegetable crops like okra, fenugreek, onion and cowpea in these cropping systems not only increased the system productivity but also fetched higher market price and hence, increased the net returns (Jat *et al.*, 2012).

Among various cropping systems evaluated, maximum cost of cultivation was incurred in maize + black gram – wheat – okra followed by cluster bean – wheat – okra systems, the highest gross returns were realized from the same cropping systems in sandy loam to clay loam soils of Udaipur, Rajasthan (Jain *et al.*, 2015).

The higher net returns were realized from maize + black gram (2:2) – wheat – okra cropping system over all the other cropping systems tried, and was on a par with cluster bean – wheat – okra. This system fetched an additional income of 138.3, 107.3, 100.5 and 1.9×10^3 ₹ / ha over maize – wheat, maize – wheat – green gram, cluster bean – wheat – green gram and cluster bean – wheat – okra cropping systems respectively (Jain *et al.*, 2015).

Shah *et al.* (2015) stated that among all cropping sequences tried, hybrid rice – cauliflower- mustard – okra and rice – onion – green gram recorded the maximum rice equivalent yield compared to rice-wheat system. Inclusion of high-yielding crops led to higher production efficiencies under the existing cropping systems which were also reported by several other authors from varied agro-climatic conditions (Samui *et al.*, 2004; Kumar *et al.*, 2005).

In case of systems and techniques of farming, neglect of crop rotation, inadequate use of manures and fertilizers, use of poor-quality seeds, inadequate water supply, and inadequate use of efficient farm equipment are major issues in low efficiency in agriculture. (Suman, 2018)

2.5. Adoption of different integrated farming system models

In light of heterogeneity of farming system, Feder *et al.*, (1985) in their threshold model of adoption, characterized adoption within a community as a dynamic process in which farmers make decisions according to explicit economic decision rules. There is a relationship between farmer heterogeneity and the biological and geophysical factors that influence adoption. Mccann, 1997, Hanson *et al.*, 2004, Musshoff and Hirschauer 2008, Serra *et al.* 2008 reported that farmer attitudes, education, resource availability knowledge are important; farmers may be risk-averse toward making changes in cropping decisions or adopting new agricultural practices, or they might have very conservative attitudes toward technology or lower or higher levels of concern for the natural environment.

Loomis *et al.* (1971) and Leemans and Born (1994) revealed that biological and geophysical factors such as water availability, soil fertility, risks of floods, droughts, frost, or pest or weed infestations and also input and output market conditions were important variables impacting farmer decision-making and adoption of land use practices or technologies.

Mccann (1997) and Knowler and Bradshaw (2007) revealed that farmer's income and ability to obtain credit influence the choice of crops, farming systems, and willingness to invest in new crops or technologies.

Chavas *et al.* (2010) and Chavas and Kim (2010) reported that farmer's propensity to adopt new technologies or practices is affected by lack of knowledge and information about the costs and benefits of adopting new technologies or conservation practices or about how to implement such technologies or practices.

Binswanger and Rosenzweig (1986) emphasized that input market conditions shape farmers' production decisions in various ways. Dynamics of local and seasonal labor availability implies that it is unprofitable to grow crops with a narrow harvesting window where the overall demand for agricultural labour is high. Rogers (2003) noted that communities closer to urban centers were more likely to adopt new technologies quickly.

2.6. Constraints in adoptions of IFS

Lightfoot (1997) identified 4 main constraints in adoption of IFS in the Philippines and Ghana. The constraints were: long transition period varying from 3 to 10 years that often occurs when implementing an integrated production system. Farmers are not able to afford reduction in food production and income generation over this period; labour shortages, is another important constraints, especially in small farm family, which discourage them from adopting IFS techniques; lack of secure land rights; and lack of incentives from government in terms of subsidy, credit for adopting integrated farming.

Thamrongwarangkul (2001) in his study in Northeast Thailand reported that the need for food and immediate economic return for meeting the cash needs for schooling, medical treatment, and loan payment most of the resource-poor farmers are not able to go beyond the transition period.

Tipraqsa *et al.*, (2007) reported that high start-up costs constrain farmers from adopting integrated farming and thereby from exploiting its benefits. Banerjee *et al.* (1990) also reported that possibilities for increasing farm net returns with more allocation of resources to crop and livestock were limited due to lack of amount of capital. Similar findings were also reported by (Behera *et al.*, 2014) as pond-based farming system is capital-intensive and especially among the resource-poor groups, there is lack of sufficient funds for initial investment.

Csavas (1992) reported that in most farms studied in China depended on imported feed rather than internal recycled inputs, mainly because of poor resource among the farmers and therefore not having feedlot type systems in which to undertake livestock production. It was concluded that promotion of feedlot livestock/fish is seldom successful on small farms as such resource-poor farms are generally unable to sustain a feedlot livestock operation upon withdrawal of technical or financial project support (Edwards, 1998).

Sharma *et al.* (2008) reported the major constraint faced by the farmers who were dependent on crop, crop+dairy, crop+labour, crop+vegetable and crop+vegetable+labour were poor road to the nearest market, unavailability of effective village leader, scarcity of

technical know-how, financial crisis in the family, long and complicated loan procedure, very low support price fixed by the government, non-availability market facilities in the villages, lack of technical know-how, lack of credit facilities and higher inputs costs.

2.7. Impact of integrated farming system

Thamizoli *et al.* (2006) found that the growing of tree crops with agriculture along with other allied enterprises like dairy, goat rearing, apiculture *etc.* was very effective in managing risk and helps to deal with disasters like long drought season and heavy flood.

Mishra and Mohanty (2004) reported that the integrated fish-in-paddy field system which functions through the feeding of fish on organisms (particularly insects and other possible rice pests) and weeds, and the stirring of the sediment through their foraging action increased rice yields.

Samal *et al.* (2006) conducted a study on rural livelihood systems in rainfed rice-based farming system of coastal Odisha. It was reported that the sources of income shares in the study area fell broadly under nine heads *viz.*, rice cultivation (21.06%), other crops (1.83%), agricultural labour (4.64%), livestock (1.65%), salaried job (11.25%), remittances (25.03%), fishing in sea (5.77%) and other non-farm activities (28.77%) like, construction, transportation, small-scale industries, repairing and shop keeping.

Behera and Mohapatra (1999), in their study on rice-based IFS opined that a system comprising of crop components, dairy, poultry and fishery was the most suitable model which gave the highest system productivity and ensured multiple uses of water.

Govindan *et al.*, (1990) worked on the financial budgets of farms in Tamil Nadu by setting up an experiment with poultry and fish culture. They used financial analysis for assessing the system. It was concluded that integrating different enterprises on the farm generated higher income and on-farm labour use. Rangasamy *et al.* (1996) also conducted five years experiments in Tamil Nadu by integrating poultry, fish and mushroom with rice cultivation. They came to the conclusion that compared to conventional cropping system, such integration increases the net farm incomes and on-farm labour use. Devasenapathy *et al.* (1995) identified IFS comprising of groundnut-black gram-maize and groundnut-gingelly-ragi with integration of other enterprises *viz*

dairy, poultry, fish culture and rabbit rearing enhanced the net income as compared to conventional cropping system.

Lightfoot and Minnick (1991) concluded farmers obtain income security and ecological protection by integrating trees into farming systems. The varied plants and animals expand the income diversification. The recycling of wastes and byproducts reduces the dependence on external inputs and thus reduces the cost of cultivation in a sustainable way.

A study on Integrated Fish Farming (IFF) for food, nutritional security and economic efficiency in the mid hills of Indian Central Himalaya by Bisht (2011) reported an average net gain of Rs 36,823/ annum from IFF with an investment of Rs 11,925 by the farmer. Results also showed under rainfed conditions, such system are advantageous over conventional system of cropping.

In a study done by Mohanty *et al.*, 2010, in Gajapati district of Orissa, the IFS model identified consisted of field crops (rice, maize, ragi, groundnut and pigeon pea), horticultural crops (vegetables, yam, banana and tapioca), vermicomposting and poultry (*Vanaraja* breed). By integrating all these components, a tribal farmer enhanced the productivity and hence, the profitability as compared to the conventional farming system. By adopting this farming system module, tribal farmer earned seven times higher net returns compared to the traditional method. The benefit-cost ratio of integrated farming system model is 2.70 whereas, in traditional system it was 2.08 only ().

Gopinath *et al.* (2012) concluded that of the various livestock components, the expenditure on livestock rearing ranged from ₹ 9,475/annum for 2 desi cows to ₹ 49,200/annum for 2 desi cows plus 100 sheep. Net income (₹ 1,60,720 /year) was higher from sheep (90) and goat (30) followed by rearing of 2 desi cows and 100 sheep (₹ 1,19,280 /year).

A study was conducted in Wardha district of Vidarbha region with 120 respondents sample size from 12 villages. Data was collected with the help of pre-structured and pretested interview schedule on farming systems adopted by the farmers and on the economics of the farming systems. It was observed that all respondents had adopted agriculture and dairy farming followed by vegetable cultivation (83.33%) and fruit crops (65.0%). Integration of agriculture + dairy + vermicomposting + backyard

poultry + apiculture + forage crop + sericulture was revealed to be beneficial based on B:C ratios of complementary enterprises (Raut *et al.*, 2013).

Field crops (paddy, ragi, rajmash) + Poultry + Fishery + Horticulture system (banana) recorded profitable IFS with net income of ₹ 29,102 and B:C of 1.83 with productivity of 14.40 (t/ha) and 464-man days/ha/year over arable cropping (rice-rice) returns (₹ 14500/ha) and B:C (1.47) with less productivity (7.50 t/ha) (Sekhar *et al.*, 2014).

Rana & Chopra (2013) stated that IFS can solve the problem of increasing food production for smallholder farmers with limited resources which will increase their income and improve nutrition. Activities like agro-forestry, dairy, fish culture, poultry, sericulture, agri-horticulture, biogas production, edible mushroom cultivation *etc.*, hold critical significance for supplementing farm income. Such system should fit well with farm level infrastructure and ensure the full utilization of by-products.

Gill *et al.*, (2005) conducted a study and found that integrated farming systems on farmer's fields in Punjab conditions showed that gross profit of 1,54,000/ha/annum in crop+dairy and 1,13,200/- in fish+piggery system of farming was observed compared to ₹ 81,200/ha/annum in Rice-Wheat cropping system.

RESEARCH METHODOLOGY

Research methodology is a way to find out the results of a given problem on a specific research problem. This section articulates specific procedures for addressing research problem and what researcher intends to do to answer selected research question. After reviewing the relevant literature related to present study, a scientific and systemic procedure was developed and adopted for conducting the investigation. The adoption of the farming system is a dynamic process governed by many factors and it is difficult to get reliable data from adopter of different integrated farming system. Hence, the study was planned with a systematic approach by making use of relevant measuring instrument and statistical tools. The households who have a set of farm components at the time of survey are referred to as ‘Adopter of a particular farming system model’.

As discussed in previous chapters, concepts of mixed farming, farm diversification and integrated farming system are often used exclusively, even if there are conceptual differences. In the present study, these concepts are defined as diversified systems consisting of components such as crops and livestock coexisting independently from each other (FAO, 2001). Mixed farming is defined as a farming system where livestock enterprises are complementary to crop production and at least 10 to 49 per cent income is found from livestock. In this case, the purpose of integrating crops and livestock is to minimize risk rather than to recycle resources. However, in an integrated system, crops and livestock interact and create a synergy. Here, livestock and crops are produced within a coordinated framework and recycling allows the maximum use of available farm resources.

This chapter describes the research design, locale of the study, sampling plan, instrument done for the study, data collection, and data analysis procedures of the entire study.

3.1. Sampling design

Sampling design includes selection of the study area, *i.e.*, state, districts, blocks, and individual adopter of a particular farming system model.

3.1.1. Selection of State

Among the Eastern states, Jharkhand and Odisha state were selected purposively for the present study to represent the dry land and coastal agro-ecosystem. The agriculture and livelihood vulnerability of this region are well reported and studied (Mitra *et al.*, 2012; Oraon, 2012; Patnaik *et al.*, 2013; Singh *et al.*, 2012; Bahinipati and Venkatachalam, 2013; Mishra and Sahu, 2014; Sharma *et al.*, 2014; Paltasingh and Goyari, 2015; Vatta *et al.*, 2017; Pandey, 2016; Panda, 2017), in which integrated farming system has been seen as one of the most important tools to mitigate the challenges (Mitra *et al.*, 2012; Kumar *et al.*, 2012; Singh and Pati, 2015; Sasikala *et al.*, 2015; Singh *et al.*, 2017). Moreover, preliminary survey and secondary data showed that different location-specific integrated farming system models are well adopted.

3.1.2. Selection of Districts and blocks

Four districts of Odisha *viz.* Puri, Khordha, Jagatsinghpur, and Cuttack districts were selected randomly to represent coastal and semi-coastal region of the state. Whereas three districts of Jharkhand *viz.* Gumla, Sahebganj, Dumka districts were randomly selected to represent the dry land agriculture. From each district, one block was chosen randomly.

a) Jharkhand

Jharkhand state falls under the agro-climatic zone VII (Eastern Plateau and Hilly region), which has been further divided into three subzones. The state receives annual rainfall of 1200 – 1600 mm and the climate ranges from dry semi-humid to humid and semi-arid types. Undulating toposequence of the State and rain-fed agriculture have led to massive degradation of soil, diverse agricultural practices and low productivity. About 82 per cent of annual rainfall occurs within the monsoon season, which lasts from mid-June to September. Available moisture over the entire monsoon period determines the opportunity for the various cropping system practiced by the farmers. In general, the soils of Jharkhand are low to very low in available phosphorus and sulphur, medium in available nitrogen and potassium status and deficient in available boron. About 1.6 million ha (19% of total geographical area) is acidic. The region has a major problem of slight to moderate soil erosion as 74 per cent of the areas are located on very gentle to gentle slopes. Despite good rainfall, the cropped area and

cropping intensity are low. The level of technology adaptation is also poor leading to lower productivity. The cultivable area is estimated around 3.8 million ha but the net sown area is 2.56 million ha and only 12 per cent of cropped area is under irrigation. The total cultivable land in the State is 52 per cent as compared with 55 per cent of the country, but only 43 per cent area of this is under net sown area compared to national average of 76 per cent. The State as a whole suffers from several critical gaps in agriculture and allied sectors though a number of opportunities exist to make the state self-sufficient in agricultural production.

Table 3.1: State agricultural profile of Jharkhand

Area	79.70 lakh ha
Cultivable Area	38 lakh ha
Net Sown Area	25 - 26 lakh ha
Rainfall	1300 mm (Normal)
Irrigated Area	3.007 lakh ha
Cropping Intensity	126 %
No. of Districts	24

(Source: Department of Agriculture, Animal Husbandry & Co-operative, Government of Jharkhand, 2017)

Table 3. 2: Land use classification in selected districts (Jharkhand) (2014-2015)
[Area in hectare]

District	Sahibganj	Gumla	Dumka	Jharkhand
Reporting Area For Land Utilisation Statistics	198780	534318	377523	7970075
Forests	28316	135341	48871	2239481
Area under Non Agricultural Uses	20745	24203	32237	705788
Barren and Un Cultivable Land	10231	35945	25642	568009
Total	30976	60148	57879	1273797
Permanent Pastures and Other Grazing Lands	4343	1108	18382	113809
Land under Misc. Tree Crops and Groves not Included in Net Area	3150	2388	5895	98260

Cultivable Waste Land	8082	31463	22229	352871
Total	15575	34959	46506	564940
Fallow Lands Other than Current Fallows	34042	82275	54377	1121792
Current Fallow	42146	96919	84212	1385550
Total	76188	179194	138589	2507342
Net Area Sown	47725	124676	85678	1384515
Total Cropped Area	48177	124802	87521	1553691
Area Sown More than Once	452	126	1843	169176

(Source: Ministry of Agriculture, GoI, 2016)

Table 3.3: Area and farm harvest price under principal crops in selected districts (Jharkhand) (2014-2015) [Area in hectare and price in rupees]

Parameter		Dumka	Gumla	Sahibganj	Jharkhand
Area under <i>Kharif</i> crops	Rice	59923	49086	32750	849093
	Arhar	524	827	114	33169
	Maize	9007		1359	109194
	Niger		4182		13986
	Sweet Potato	13	1565		4456
Area under Rabi crops	Potato	1406	3120	24	38547
	Mustard	1015	170	1834	27096
	Groundnut		908		4339
	Wheat	2908	836	3348	63741
	Linseed	316	32	441	6023
Area under total food grains		82125	11038	44717	1357859
Area under pulses		4932	11038	4997	153418
Area under Oilseed		1513	5735	2301	65449
Area under total fruits and		3535	12650	805	119237

vegetables					
Cropping Intensity		102.15	100	100.1	112.2
Farm harvest price of principal crops (In Rupees)	Paddy	1050	925	1080	1158
	Wheat	1165	19797	1261	1605
	Potato	-	1194	967	992
	Mustard	2858	4894	3167	4107

(Source: Ministry of Agriculture, GoI, 2016)

b) Odisha

Agriculture as a vital sector and a key indicator of the state's economic position remains the backbone of Odisha's economy and sustenance of the life of the people. There is 61.80 lakh ha cultivated area out of which, 29.14 lakh ha, 17.55 lakh ha and 15.11 lakh ha are high, medium and low land, respectively. Agriculture is the main livelihood in Odisha. About one fourth of the total working population 76% is engaged with agriculture and agriculture related industries. Out of 87,46,000 Hectares of total cropped area in Odisha out of which 18,79,000 Hectares are under irrigation. Odisha is one of the largest producers of rice in India. The state grows almost one tenth of the total rice production of the country. The state grows one tenth of the total rice production of the country. Major crop paddy cultivation covers about 41.24 lakh ha during *Kharif* season and 3.31 lakh ha during *Rabi* season. There are four physiographic zones, viz., Coastal Plains, Central Tableland, Northern Plateau and the Eastern Ghats in Odisha. The soil pattern differs widely from highly acidic to slightly alkaline and from light sandy to stiff clays. Soils are mainly acidic with the degree of acidity varying widely. The Odisha suffers from problematic soil such as saline inundation (4 lakh ha), flooding (3.54 lakh ha) and waterlogging (0.75 lakh ha), particularly in Deltaic region. State agro-climate is tropical, characterised by high temperature, high humidity, medium to high rainfall and short and mild winters. The annual rainfall of the State is 1451.2 mm. The principal problem of Odisha agriculture is the lack of irrigation facilities in droughts prone areas create great obstacles to agriculture. Flood, cyclone, storm are regular phenomena leads to agricultural crisis in the state.

Table: 3.4. State agricultural profile of Odisha

Area	lakh ha
Cultivable Area	67.84 lakh ha
Net Sown Area	4474 lakh ha
Rainfall	1451.2 mm (Normal)
Irrigated Area	18.79 lakh ha
Cropping Intensity	164%
No. of Districts	30

(Source: Directorate of Economics and Statistics Odisha, 2016)

**Table 3. 5: Land use classification in selected districts (Odisha) (2014-2015)
[Area in hectare]**

District	Cuttack	Jagatsinghpur	Khordha	Puri	Odisha
Reporting Area For Land Utilisation Statistics	334000	172000	273000	278000	11560000
Forests	25000	2000	30000	6000	1856000
Area under Non Agricultural Uses	83000	48000	47000	51000	1318000
Barren and Un Cultivable Land	10000	1000	17000	8000	1078000
Total	93000	49000	64000	59000	2396000
Permanent Pastures and Other Grazing Lands	14000	9000	14000	15000	524000
Land under Misc. Tree Crops and Groves not Included in Net Area	10000	4000	21000	19000	211000
Cultivable Waste Land	18000	9000	18000	10000	550000
Total	42000	22000	53000	44000	1285000
Fallow Lands Other than Current Fallows	23000	4000	16000	17000	631000
Current Fallow	22000	7000	6000	28000	918000
Total	45000	11000	22000	45000	1549000
Net Area Sown	129000	88000	104000	124000	4474000
Total Cropped Area	160031	129977	126060	179262	5173003
Area Sown More than Once	31031	41977	22060	55262	699003

(Source: Ministry of Agriculture, GoI, 2016)

Table 3.6: Area and farm harvest price under principal crops in selected districts (Odisha) (2014-2015) [Area in hectare and price in rupees]

Parameter		Cuttack	Khorda	Jagatsinghpur	Puri	Odisha
Area under <i>Kharif</i> crops	Rice	119622	101193	81769	99396	3281660
Area under <i>Rabi</i> crops	Potato	559	260	1621	494	8445
	Ground nut	1404	75	291	3250	48842
Area under total Foodgrains		154687	123821	125559	171779	4847509
Area under pulses		32326	21224	40259	40489	500257
Area under Oilseed		1431	379	1648	3801	122200
Area under total fruits and vegetables		559	260	291	494	8445
Cropping Intensity		124%	121.2%	147.7%	144.5%	115.62
Farm harvest price of principal crops	Paddy	1215	1269	1222	1282	3678
	Potato	785	750	815	746	755
	Ground nut	3427	3467	3318	3200	3223

(Source: Ministry of Agriculture, GoI, 2016)

3.1.3 Selection of the Sample Households

With a view to select sample households, farmers with at least two farm components were selected randomly. In order to understand the reasons for non-diversification of farm, farmers with only crop components were also selected (four respondents from each state). The various farm components may be crop, vegetable, dairy, goat, sheep, fisheries, horticulture, poultry, duck, agro-forestry, *etc.* Farmers with unique farming components or combination of farming components were also selected purposively to comprise the different farming system models. From Jharkhand, 105 farm households were selected, 35 from each district and 117 farmers were selected from Odisha, 29, 29, 29 and 30 farmers were selected from Cuttack, Jagatsinghpur, Khorda and Puri respectively. Besides this, few successful farmers

from different districts were selected purposively for case study. Twenty officials, working in various levels at ICAR, SAUs, KVK, ATMA and NGO were also interviewed to analyse the challenges faced by the official in dissemination of IFS models and framing extension strategies for dissemination of IFS model. One farmer from coastal district Kendrapara of Odisha was also interviewed for case study.

Thus, in all a total sample of 227 farm households were considered along with 20 officials.

3.2 Data Collection

The data for the present investigation were collected from both primary and secondary sources to accomplish the set objectives of the research study. The research methodology has to be robust in order to minimize errors in data collection and analysis. Owing to this, various methodologies namely survey, interview (structured and unstructured), focus group discussion, observation and case study were chosen for data collection. The primary data were collected by personal interview/enquiry method using a semi-structured interview schedule. The detailed information required for the study was collected hold in the year 2015-16. The data collection schedule is enclosed in the Annexure section I.

The information on socio-economic and farm characteristics was collected using a semi-structured interview schedule .The description and measurement of the variable are presented in Table 3.7. Details of the farm components were collected in term of resource allocation, cost and economics of each farm components and system as a whole. Information about constraints faced in adoption of integrated farming system was also collected from the selected respondent. Information on bio-resource flow, utilization of space was also collected.

Secondary information on different aspects of farming and developments programme for related to promotion of integrated farming system were collected. Furthermore, the data on agro-climatic features of the study area, such as climate, rainfall, land utilization pattern, livestock population, cropping pattern and demographic features were collected from relevant secondary sources like Economic Surveys and Livestock Censuses.

Table 3.7: Description of socio-economic and farm characteristics

Variables	Description	Measurement
Age	Age of household-head	Number of years
Education	Educational level of household-head	Number of years of schooling completed
Family size	Number of members in a household	Numbers
Dependency ratio	Ratio of the population under 15 and over 65 years of age to the population between 15 and 64 years of age	Ratio
Primary occupation	Primary occupation of the household head	Denoted as: Agriculture and allied activities= 1, farm labourer=2, private job and business=3 and services =4
Off-farm income	Household with off-farm income	Household with off-farm income =1, otherwise 0
Food habit	Food habit of the household head	Vegetarian = 1, Non vegetarian=2
Area owned by the household	Size of landholding of household	Hectares (ha)
Lease in area	Total Cultivable area that is lease in by the household for agricultural purpose	Hectares (ha)
Leased out area	Total agricultural area that is leased out by the household for any purpose	Hectares (ha)
Total cultivable area	Total cultivable area use by the household for agricultural purpose	Hectares (ha)
Irrigation area	Proportion of irrigated area for <i>Kharif</i> and <i>rabi</i> season separately	Calculated as the ratio of the area under irrigation by Total cultivable area for <i>Kharif</i> and <i>rabi</i> season
Number of agricultural plots	Total number of separate agricultural plots	Number
Distance to nearest plot and main plot	Average distance from residence to nearest plots and main plots	Kilometres

Distance to market	Average distance from farm to market	Kilometres
Access to information	Whether has easy access to information	1 = Yes , 0 = No
Access to credit	Whether has easy access to credit	1 = Yes , 0 = No
Access to subsidy	Whether accessed to subsidy before	1 = Yes , 0 = No
Members to farmers groups of society	Whether the household head is a member of any farmers groups of society	If household head is a member = 1, otherwise 0
Access to market	Whether the household is access to marketing facilities	If access to marketing facilities= 1, otherwise = 0
Herd size	Number of animals owned by household	Measured in Standard Animal Unit (SAU) (Sirohi <i>et al.</i> , 2015)*

* conversion coefficients given in Annexure II

3.3 Analytical framework

The study employed different analytical framework to describe and answer the research questions. Case study method was used. Moreover, econometrics, parametric and non-parametric test were also used.

3.3.1 Case Study

The case study is not a specific technique but it is a way of organizing social data so as to preserve the unitary character of the social object being studied. It is an approach which views social unit as a whole includes development of that unit, which may be a person, a family or other social group, a set of relationships or processes (such as family crises, adjustment to disease, friendship formation, ethnic invasion of a neighbourhood, etc.) or even an entire culture in its real-life context. (Goode and Hatt, 1952).Typically, data are gathered from a variety of sources and by using several different methods (*e.g.* observations, interviews, *etc*). It provides a base for formulation of hypothesis and sometimes highlights extraordinary behaviour, which can stimulate new research.

3.3.2 Economics of different farming system models

Studying the cost and return of different farm components enables to comprehend the complex nature of the integrated farming system. Further, the

indicators are important for efficiency measurement and impact analysis. Descriptive statistics were employed to work out the cost and returns from different farm components. The total cost comprised of two components *viz.*, fixed cost and variable cost.

Fixed Costs

Fixed costs are that expenditure which is incurred whether or not the production is carried out. It includes interest on fixed capital and depreciation rate on buildings, cattle shed machinery/ equipment and milch animals. The depreciation was calculated as per productive life of the individual equipment and animals.

Variable Costs

By definition, variable costs are those costs that vary with the levels of farm production system. Variable costs included those recurring components in farming, which are incurred on feed, different farm inputs, ploughing, labour and miscellaneous expenses.

Labour Cost

The labour expenses comprised of hired and family labour cost. Labour cost comprised of wages paid to hired labour and value of family labour imputed at the prevailing wage rate in the study area. Total time devoted to various farm operations was taken into account while estimating labour cost.

Miscellaneous Expenses

These expenses included cost of repairs, electricity and water charges, fuel charge, *etc.* incurred by the selected households.

Gross Cost

The gross cost of milk production was computed as the sum total of fixed costs and variable costs.

Net Cost

It was obtained by subtracting the imputed value of cow dung, paddy straw, and other farm produced other inputs from the gross cost.

3.3.3 Farm efficiency in farming system models and its determinants

Modern efficiency measurement began with the work of Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs.

Generally, if we want to measure the efficiency of a production unit, output and inputs are compared. There are two commonly followed approaches for this, *viz.*, parametric and non-parametric. The former follows econometric procedure, while the latter is a mathematical programming approach. The nonparametric approach introduced as Data Envelopment Analysis (DEA) by Charnes, Cooper and Rhodes (1978) is a method of measuring efficiency of a firm through mathematical programming and does not assume any functional form and constructs production frontier as well as measure efficiency relative to the constructed frontiers.

The present study employs input oriented CRS DEA to measure technical and scale efficiency of the dairy farms by using DEAP software (version 2.1) developed by Coelli (1996).

To have an understanding of the DEA model, consider n firms producing m different output using h different inputs. Thus, Y is an $m \times n$ matrix of outputs and X is an $h \times n$ matrix of inputs. Both matrices contain data for all n firms. The Technical Efficiency (TE) measure under the assumption of CRS can be formulated as follows:

$$\begin{aligned}
 & \min_{\theta, \lambda} \theta \\
 \text{Subject to} & \quad -y + Y\lambda \geq 0 \\
 & \quad \theta x_i - X\lambda \geq 0 \\
 & \quad \lambda \geq 0 \\
 & \quad \theta \in (0, 1]
 \end{aligned}$$

This is solved for each firm in the sample. θ_i is firm i 's index of technical efficiency relative to the other firms in the sample. y_i and x_i represent the output and input of firm i respectively. $Y\lambda$ and $X\lambda$ are the efficient projections on the frontier. A measure of $\theta_i=1$ indicates that the firm is completely technically efficient.

Thus, $1-\theta_i$ measures how much firm i 's inputs can be proportionally reduced without any loss in output. However, the assumption of CRS is correct only as long as

firms are operating at an optimal scale (Coelli *et al.*, 2002). Various constraints on inputs may cause the firm to operate at a non-optimal scale.

The description of the variables used in this objective is listed below in Table 3.8.

Table 3.8: Description of Variables for Efficiency Measurement

Variable	Description	Measurement
Net income from Crop and vegetable components	Value of output of crop and vegetable	Annual income from crop and vegetable component (Rs.)
Net income from Livestock components	Value of output of animal components namely cow, bullock, buffalo, sheep, goat, poultry bird and duck	Annual income from of animal components namely cow, bullock, buffalo, sheep, goat, poultry bird and duck (Rs.)
Net income from Pond components	Value of output from pond based farming system: Fish, prawn, fruit, plantation crops.	Annual income from pond based farming (Rs.)
Outputs from miscellaneous components	Value of output of others components namely mushroom, agro-forestry, horticulture and plantation crop <i>etc.</i>	Annual income from of others components namely mushroom, agro-forestry, horticulture and plantation crop <i>etc.</i> (Rs)
Labour	Number of man-days used by the household in farming	Man-days per annum (man-days)
Land	Total cultivable area of the household	In hectares
Fertilizer cost	Value of total fertilizers used by the household in rice and wheat	Cost of fertilizers per annum (Rs)
Feed cost	Value of total feed used by the household for animal component including fish	Cost of feeds per annum (Rs)
Expenditure incurred other than fertilizer, feed and labour cost	Miscellaneous cost incurred by the farm household in management, purchase of farm inputs,	Miscellaneous cost per annum (Rs)

3.4.1 Adoption of integrated farming system model

A household's decision to adopt farming system model depends on many factors *viz.* socio-economic characteristics, farm characteristics, technology characteristics, agro-climatic factors *etc.* The study identified different categories of farmer's with respect to adoption of different sets of farm components. Reasons for adoption of each component are usually explained by a different set of explanatory variables. The study attempt to answers the research questions, firstly, why do some farmers adopt particular farming components while some do not? Secondly, why do some farmers adopt a set of farming components in total or in other word a selected integrated farming system model? The decision to adopt farming components may be simultaneous and sequential decisions.

The study employs the Logit model to identify the factors for adoption of a particular farming component. The decisions to adopt an integrated farming system model were also analyze using the same econometric model with different explanatory variable.

A logit model of the following form was used:

$$D_i^* = \alpha X_i + v_i$$

$$D_i = 1, \text{ if } D_i^* > 0 \text{ and } 0 \text{ if } D_i^* < 0$$

Case I: Where, D_i^* is a latent variable that takes the value 1 if the famer adopt a particular farming component and zero otherwise, X is a vector of explanatory variables and α is a vector of parameter.

Case II: Where, D_i^* is a latent variable that takes the value 1 if the farmer adopt a particular set farming of component or farming system models and zero otherwise, X is a vector of explanatory variables and α is a vector of parameter.

3.4.2 Adoption of intensive farming component or integrated farming system

The decision to intensify major farming component analyse using ordinary least square regression was used, with intensification as dependent variable. Intensification was measured separately for each major component vegetable and pond based farming system were analyse and system as a whole. The methodology to measure the intensification varies across the component as per kinds of outputs and

input invested. The intensification of vegetable component was measure by calculation of total net income from vegetable by unit area, whereas intensification of pond based farming is calculated by total net income from all components from pond based area by area of the of pond based farming component.

3.4.3 Explanation of choice of farm component using Theory of Planned Behaviour

Choices of farm components are precursor to farmers' decisions for integration of farm components. Choice of farm components of a farm is dynamic process and decision on what component to have and how to integrate the resources are defined by not only by their socioeconomic status, farm characteristic, biophysiological condition, but also by the economic interests, spirit of their culture and ethics (Cheshire *et al.*, 2013). The study attempt to explain the farmers' decision making processes on choice of farm components for farm diversification and integrating of the resources using the Theory of Planned Behaviour (TPB) as its conceptual framework (Ajzen, 1991).

For the promotion of sustainable farming system, understanding the determinants of behaviour for choice of farm components and management practices, such as resource integration among the farm components is necessary. In recent years the recognition of the utility of behavioural theory in understanding the determinants of behaviour has been promising. Among the several behavioural theories, Theory of planned behaviours, an extension to the 'Theory of Reasoned Action' (Ajzen and Fishbein, 1980) is well recognized. TPB captures both internal (*i.e.* psychological) and external (e.g., socio-economic, farm resources *etc.*) factors (Ajzen, 1991; Fishbein and Yzer, 2003), compared to some behavioural theory which accounts few variables in understanding, and even predicting, a given behaviour (Fishbein, 2000).

TPB described behaviour as a function of intention (Arjen, 1991), or in other words it states that a person's 'intention' to perform a particular behaviour is the best predictor of whether they actually do so (Jones *et al.*, 2015). The theory states that intention is build upon three components: attitude, subjective norm (SN) and perceived behavioural control (PBC) and these are predicted from their respective beliefs about the behaviour.

But the theories have also received criticism, particularly for their claim that all variables of relevance are taken into account (Eagly and Chaiken, 1993). Hagger *et al.* (2002) argue that the relationships proposed by the TPB will not be enough to predict human behaviour because of its complex nature. Weber and Gillespie (1998) revealed that there is a significant difference between the intention and the actual behaviour. So in agriculture decision-making process, above and beyond the intention, exploring for factors that influence behaviour and decision making is sensible. Thus, the paper aims to examine the link between intention and behaviour and identification of factors influencing farmers' decisions for choice of farm components besides intention.

108 farmers with at least two major farm components were selected to be part of the sample of farmers out of total 230 farmers. A number of farm components were the criterion to select, but the sample was not distinguished between diversified farms from the integrated farming system, as the degree of integration is not absolute rather it is a continuum which depends on many factors. Hence, farm integration being a dynamic process; governed by many endogenous variables; the difference between these concepts is difficult to differentiate at farm level.

3.4.5. Questionnaire design

The study employs indirect methods for measurement of Attitude, subjective norm and perceived behavioural control. The measures of these beliefs are calculated following the expectancy-value model (Fishbein and Ajzen, 1975), which introduces the link to the subjective expected utility model in economics (Lynne, 1995). The attitude was measured by accessible beliefs about the outcomes of the behaviour and by the evaluation of this particular outcome and belief based measure of the attitude is obtained by multiplying belief strengths and outcome evaluation and summing the products. Subjective norm was obtained from multiplying strength of normative belief with motivation to comply and summing up. In the same way, perceived behavioural control is obtained by multiplying control belief strength with power of control and summing the results.

The TPB constructs were measured on five-point scales. Following the recommendation from Ajzen and Fishbein (1980), belief strengths, motivation to comply and control belief are scaled in a unipolar manner (1 to 5) and outcome

evaluation, normative beliefs and power of control are scored in a bipolar way (-2 to +2). Five-point scale is commonly used in studies on agriculture (e.g. Bergevoet *et al.*, 2004; Lagerkvist, 2005; Gorton *et al.*, 2008). Considering the literacy level of the respondents, this type of scale will help the respondents to distinguish meaningfully between the options (Hansson *et al.*, 2012). Besides structure scales for TPB measurement, data on socio-economic and farm characteristic information were also collected.

The study faced methodological challenges as the conviction in outlining both the systems were lacking. Even though the difference in technical and management aspect of both systems have been reported in the literature but the benefits, impact and challenges in adoption of both the systems are usually reported as mutually exclusive.

The structure questions are emphasized on a theme, common to both farm diversification and integrated farming system *i.e.* farm with different farming components. The study assumed that the prerequisite in practicing both the systems is having different farm components. The main difference between the farm diversification and integrated farming system can be considered as not absolute; rather it is a matter of degree of integration of resources in the farm system (Tipraqsa, 2006). The degree of integration is subjective and the difference between the systems is difficult to outline, and even more from farmers' perspective. In this context, construct of outcome belief and control belief were measured as the possible outcomes and expected challenges in adoption of different farming components rather than separately for farm diversification and IFS in framing constructs separately for both the system.

Based on the review of literature, 17 possible outcomes of adoption of farming with different components were identified. Finally, 11 items constituted the outcome belief construct.

The normative beliefs for choice of farm components for farm diversification and for integration of farm resources were measured separately.

The items for Control belief were constructed and there were 8 items *e.g.* "I expect adoption of different farming components will induce a great commitment to farm management" on a unipolar scale with *Strongly Disagree (1)* to *Strongly Agree (5)*. On the other hand, Control Power was measured on bipolar scale *e.g.* "The

demand for greater commitment to farm management as a result of adopting different farming components is *Very Easy* (2) to *Very Difficult* (-2)".

Intention to diversify and intent to integrate the farm components with available resources were measured separately each by single statement. The intention for farm diversification was measured by the statement “I intend to diversify my farm with different farm components without much thinking of resource flows between components”, and evaluated on a unipolar scale labelled with *Very Likely* (5) to *Very Unlikely* (1). Similarly, the statement for intention for integration of farm components and resources is “I intend to choose different farm components that encourage maximum resource flow between the components and complementary and supplementary to each other”. The model was also analysed using Structural Equation Modeling

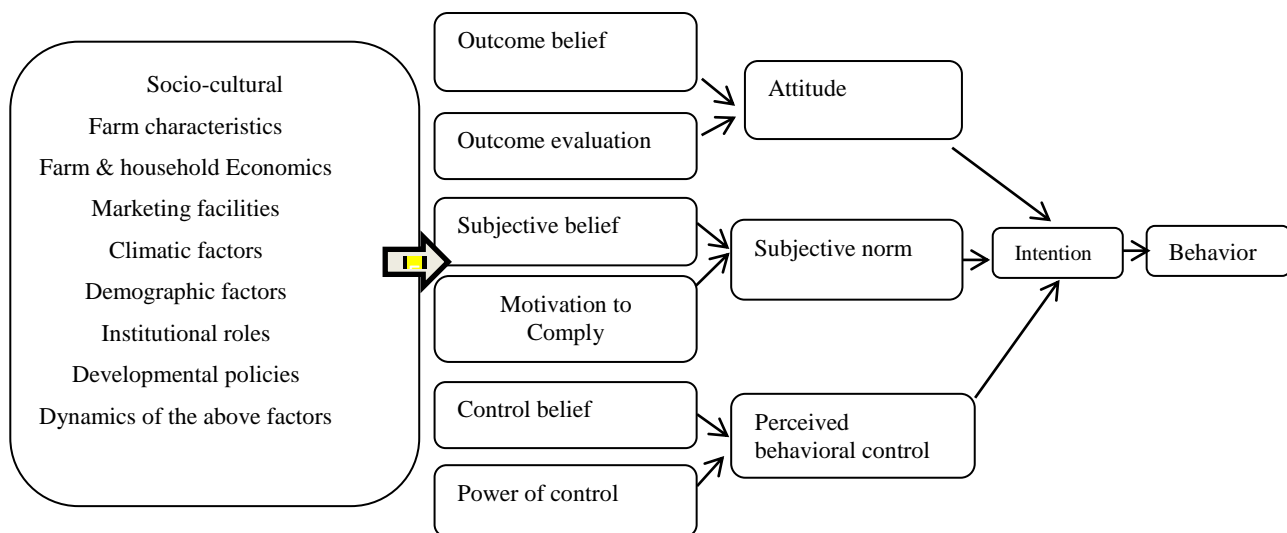


Figure 3.1. Conceptual framework of the theory of planned behaviour. (based on Ajzen and Fishbein 1980).

3.4.6. Constraints in adoption of integrated farming system and reasons for non-adoption of components

The constraint in the adoption of integrated farming system model was qualitatively assessed using open-ended questions. The study assumed that each farming system is unique so did the constraints faced. Constraint faced by the farmers for each component was also assessed. The reasons for non- adoption for various components were also asked and discussed.

Garrett's ranking technique was used to rank the constraints faced by the IFS farmers. There are certain constraints were identified in components such as cereal component in different farming system model. Constraints faced by vegetable based farmer were documented and ranked by the respondents whereas vegetable as a major component in IFS model. Similarly both fish based farming system and livestock based farming system potential constraint were elicited and prioritised by the respondents themselves with the help of Garrett's ranking technique. This technique provides the change of orders of constraints into numerical scores. This technique has obvious advantage over simple frequency distribution that the constraints are arranged based on their importance from the point of view of respondents. Garret's formula for converting ranks into percent is given by

$$\text{Per cent position} = \frac{100 * (R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} is the rank given for i^{th} factor by j^{th} respondent

N_j is the number of factors ranked by j^{th} respondent.

The percent position of each rank is converted into scores referring to the table given by Garrett and Woodworth (1969).

3.4.7. Impact evaluation

Impact of adoption of integrated farming system can be at many levels. The present study assessed the impact of adoption of integrated farming at household and farm level. At household level, the impact indicators included income, employment generation, income diversification and food security. The present study also made an attempt to assess impact at the farm level. The degree of integration among the farm components of IFS was assessed. Details of the indicators are discussed below:

Gross income: It is the total monetary returns of the economic product ssuch as agriculture or horticulture crops and their by-products like straw, fodder, fuel, *etc.* and also from various allied enterprises like poultry, dairy, goat and sheep rearing *etc.* It is expressed in terms of unit area (usually one hectare).

Net income: It is obtained by subtracting the total cost of cultivation from the gross income. Net income is the residual amount of earnings after all expenses have been deducted from Gross income. It represents the actual profit obtained by the farmers.

Employment generation: It is considered as employment status under different selected farming systems, obtained by calculating the deferential employment generated in man-days per year. On the basis of average hours put in various operations of different farm components, labour generation in different farming systems was tabulated. The labour hours were then assumed as man-days taking eight hours a day.

Income diversification: The income diversification was calculated using the Herfindahl index. The index is a measure of concentration of income shares from different farm components. This measures income specialisation and it is calculated as,

$$H = \sum(P_i^2) ; 0 \leq H \leq 1$$

Where, P_i is the proportion of income under the i^{th} farm component relative to the total farm income.

The index ranges from zero for complete diversification to one for complete specialisation.

Determinants for income diversification using Tobit analysis

The sources of income diversification differentials among farmers were identified by estimating a second-stage relationship between diversification index and suspected correlates of diversification. Since the dependent variable of diversification parameters varied between 0 and 1, the ordinary least square would produce biased and inconsistent estimates (Greene, 1993). Therefore, in this paper, the dependent variables were censored and the Tobit regression was used to analyze the data. The general formulation of the Tobit model is given by an index function:

$$\begin{aligned} y_i^* &= \beta_i Z_i + u_i \\ y_i &= y_i^* \text{ if } 0 < y_i^* < 1 \\ y_i &= 0 \text{ if } y_i^* \leq 0 \\ y_i &= 1 \text{ if } y_i^* \geq 1 \end{aligned}$$

Where, y_i^* and y_i are latent and the observed levels of income diversification respectively, Z_i is a vector of variables influencing the level of farm income diversification and β is a vector of parameters to be estimated.

Crop diversification: The crop diversification was also calculated using the Herfindahl index. It measure concentration of crop shares from of total crop area. This measures crop specialisation and it is calculated as,

$$H = \sum(P_i^2) ; 0 \leq H \leq 1$$

Where, P_i is the proportion of income under the i^{th} crop area relative to the total crop area.

The index ranges from zero for complete diversification to one for complete specialisation.

Determinants for crop diversification were also analyzed using the same methodology in income diversification.

3.4.8. Risk attitude (Risk aversion)

Farmer's willingness to take risk/Perceptions of relative risk attitude

To get insight into a farmer's perception of his or her risk attitude, five statements on a five-point Likert scale were adapted from Patrick and Musser (1997) and Meuwissen *et al.* (2001). Since all statements measure attitude towards risks relative to other farmers, the term relative risk attitude was used. Cronbach's alpha was used to test the reliability of the statement. The respondent's answers on the five statements summed up and based on this summed measure, a median split to divide was used to the respondents in a more risk-averse and a less risk-averse group (Mantel and Kardes, 1999). The score or category was used in determinants for econometrics based analysis.

Data Analysis Techniques

The collected data were analysing using descriptive statistics namely mean, standards deviation mode, frequency, percentage, regression analysis and correlation. The data were analysed using STATA and SPSS.

RESULTS

This chapter discussed the findings of the study based on the objectives stated for the present investigation. The data were collected using standardized instruments and analysed by employing appropriate statistical techniques and framework. The results of the study are presented and discussed under the following subheadings.

- 4.1. Socioeconomic profile of the respondents
- 4.2. Case study on different integrated farming system models
- 4.3. Techno-economic assessment of integrated farming system models
- 4.4. Adoption and constraints in adoption of integrated farming systems
- 4.5. Socio-economic and farm level impact of integrated farming systems
- 4.6. Extension strategies for promotion of integrated farming system for sustainable livelihood

4.1. Socio-economic profile of the respondents

The socio-economic profile of the respondents is presented in Table 4.1.1. From Table 4.1.1, it is observed that in Jharkhand majority (53 %) of farmers were in middle age group followed by age group below of below 44 years. Similarly, in Odisha 45.30 % belonged to middle age group followed by and young age group (40.17 %).

It is depicted from the Table 4.1.1 that in Jharkhand most of the farmer (42 %) had attended middle school and followed by primary education (32.38 %). About 12 per cent of farmers were illiterate and none of the respondents were graduate and above. Further, it was observed that 7.62 per cent had attended Secondary School. Whereas in Odisha, 37.61 per cent constituted middle schooled respondent followed by primary (24.79%). Nearly 13 per cent and 2.56 per cent had attended higher secondary and graduate, respectively.

From the same table, it is observed that 52.38 % had farming experiences of medium level of farming experiences (>18 – 32 years) in Jharkhand. Farmers having low (\leq 18 years) farming experience (31.43%) and high (>32 years) farming experience (16.19%) were found less. In Odisha, 47.01 per cent and 42.74 per cent of

respondents were having medium (>18 - 32 years) and low (≤ 18 years) years farming experience, respectively.

In Table 4.1.1, it was found that in Jharkhand majority of households (71.43%) were having low dependency ratio *i.e.* less working people. Similarly, medium (25.71%) and high (2.86) level was observed less. In Odisha, majority of households (70.09%) were found to have low dependency ratio. Further, it was observed that household having medium (26.50%) and high (3.42%) dependency ratio were less in Odisha. The mean dependency ratio of Jharkhand and Odisha were 0.77 and 0.76, respectively.

It was observed that 40.95 per cent Jharkhand were having land less than 1 ha. About one-fourth of the respondents were under each category of medium land holding (26.67%) and small land holding (24.76%). Relatively large farmers constituted only 7.6 per cent. In Odisha, majority of farmers (46.15%) belong to medium category of landholding. Small and marginal farmers category comprise of 31.62 per cent and 12.82 per cent respectively. Only 9.40 per cent of the respondent of Odisha was belonged to large farmers. The mean land holding of the respondent was 1.66 ha and 2.23 ha in Jharkhand and Odisha, respectively.

The mean proportions of area under *Kharif* irrigation were found to be 0.33 and 0.49 for Jharkhand and Odisha, respectively. Majority of farmers (55.24%) had low proportion of area under *Kharif* irrigation in Jharkhand. Whereas the proportion of area under *Kharif* irrigation for medium category (>0.33 – 0.66) and high category (>0.66) was found to be relatively less *i.e.* .28.57 per cent and 16.19 per cent, respectively. In Odisha, the majority of farmers were under low proportion area under *Kharif* irrigation (≤ 0.33). A similar percentage of farmers belonged to high and medium category with 31.62 and 32.48, respectively.

Table 4.1.1: Distribution of respondents according to their Socio-economic characteristic

	Variable	Jharkhand (n=105)		Odisha (n=117)	
		f	%	f	%
Age	Young (≤ 44 Years)	37	35.24	47	40.17
	Middle age (>44 –60 Years)	56	53.33	53	45.30
	Old (≥ 60 Years)	12	11.43	17	14.53

	Mean and SD	Mean=48.09; SD=8.99		Mean= 49.08; SD=10.23	
Education	Illiterate	13	12.38	2	1.71
	Primary (Class I – Class IV)	34	32.38	29	24.79
	Middle School (Class V – Class IX)	44	41.90	44	37.61
	Secondary (Completed Class X)	8	7.62	24	20.51
	Higher Secondary (Completed Class XII)	6	5.71	15	12.82
	Graduate and above	0	0.00	3	2.56
Year of farming experiences	Low (≤ 18 years)	33	31.43	50	42.74
	Medium ($>18 - 32$ years)	55	52.38	55	47.01
	High (>32 years)	17	16.19	12	10.26
	Mean and SD	Mean=22.89; SD=8.80		Mean=20.80; SD=9.05	
Dependency ratio	Low (≤ 0.86)	75	71.43	82	70.09
	Medium ($>1.42 - 1.60$)	27	25.71	31	26.50
	High (>1.60)	3	2.86	4	3.42
	Mean and SD	Mean=0.77; SD=0.59		Mean=0.75; SD=0.39	
Proportion of area under <i>Kharif</i> irrigation	Low (≤ 0.33)	58	55.24	42	35.90
	Medium ($>0.33 - 0.66$)	30	28.57	37	31.62
	High (>0.66)	17	16.19	38	32.48
	Mean and SD	Mean=0.33; SD=0.32		Mean=0.49; SD=0.34	
Proportion of area under <i>rabi</i> irrigation	Low (≤ 0.33)	99	94.29	96	82.05
	Medium ($>0.33 - 0.66$)	4	3.81	21	17.95
	High (>0.66)	1	0.95	0	0.00
	Mean and SD	Mean=0.08; SD=0.16		Mean=0.18; SD=0.17	

Distance to nearest plot from home	Low (≤ 0.56 Km)	31	29.52	46	39.32
	Medium ($> 0.56 - 1.33$ Km)	63	60.00	67	57.26
	High (> 1.33 Km)	11	10.48	4	3.42
	Mean and SD	Mean=0.78; SD=0.38		Mean=0.63; SD=0.42	
Distance to market	Low (≤ 15 Km)	50	47.62	70	59.83
	Medium ($> 15 - 25$ Km)	46	43.81	36	30.77
	High (> 25 Km)	9	8.57	11	9.40
	Mean and SD	Mean=17.28; SD=6.31		Mean=15.68; SD=6.45	
Number of plot	1	19	18.10	5	4.27
	2	52	49.52	20	17.09
	3	26	24.76	30	25.64
	4	8	7.62	22	18.80
	5	0	0.00	15	12.82
	6	0	0.00	9	7.69
	7	0	0.00	6	5.13
	≥ 8	0	0.00	9	7.69
	Mean and SD	Mean=2.22; SD=0.83		Mean=4.10; SD=2.02	
Land holding	Marginal farmer (≤ 1 ha)	43	40.95	15	12.82
	Small farmer ($> 1 - 2$ ha)	26	24.76	37	31.62
	Medium farmers ($> 2 - 4$ ha)	28	26.67	54	46.15
	Large farmers (> 4 ha)	8	7.62	11	9.40
	Mean and SD	Mean=1.66; SD=1.29		Mean= 2.23; SD=1.28	
Primary occupation	Farming	76	72.38	80	68.38
	Agricultural labor	20	19.05	5	4.27
	Private job/ Business	5	4.76	22	18.80
	Govt. services	4	3.81	10	8.55

Extension contact	Yes	19	18.10	46	39.32
	No	86	81.90	71	60.68
Credit	Yes	21	20.00	31	26.50
	No	84	80.00	86	73.50
Subsidy	Yes	1	0.95	14	11.97
	No	104	99.05	103	88.03
Training	Yes	12	11.43	34	29.06
	No	93	88.57	83	70.94
Membership	Yes	12	11.43	23	19.66
	No	93	88.57	94	80.34

A perusal of Table 4.1.1 reveals that in Jharkhand, with respect to proportion of area under *rabi* irrigation, the majority of the respondents (94.29%) belonged to low category (≤ 0.33) followed by medium (3.81%) and high (0.95%). In Odisha, similar result of Jharkhand was observed where majority of farmers (82.05%) were under low proportion of area under *rabi* irrigation followed by medium category (17.95%).

Data on the distance to nearest plot from home was also collected and was found that in Jharkhand majority of the farmers (60.00%) were having medium distance ($> 0.56 - 1.33$ Km). Similarly, 29.52 per cent farmers had low (≤ 0.56 Km) and 10.48 per cent had high (> 1.33 Km) distance from nearest plot from home. In Odisha, most farmers (57.26%) had medium ($> 0.56 - 1.33$ Km) distance from the nearest plot from home. Whereas some of the farmers (39.32%) had low distance (≤ 0.56 Km) and few farmers (3.42%) had high distance from the farm plot (> 1.33 Km).

In Jharkhand, majority of the farmers (47.62%) had relatively low distance to market (≤ 15 Km), whereas 43.81 per cent of farmers had relatively medium distance to market ($> 15 - 25$ Km) and few farmers (8.57%) had relatively high distance to

market (>25 Km). In Odisha, majority of farmers were under low distance from market (59.83%) followed by medium (30.77%) and high (9.40%) distance to market.

It was observed that in Jharkhand majority of farmers (49.52%) had 2 plots followed by them having three (24.76%) and one plot (18.10%). In Odisha, majority of farmers (25.64%) was observed having three plots followed by four plots (18.80%), two plots (17.09%), five plots (12.82%) and one plot (4.27%). Farmers having more than eight plots were also observed (7.69%).

Farmers' occupation was analysed and found that in Jharkhand majority of the respondents had primary occupation as farming (72.38%). Some of the respondents were observed as agricultural labour (19.05%). In Odisha, most of the farmers had primary occupation as farming (68.38%). 18.80 per cent and 8.55 per cent of the respondent were doing private jobs and business and government services respectively.

Majority of the respondents had no access to extension services in both the state. Only 18.10 per cent and 39.32 per cent had access to extension services in Jharkhand and Odisha, respectively. Majority of the respondent in Jharkhand (80.00) had no access to credit facility. Similarly, in Odisha majority of farmers (73.50%) had no credit facilities. In Jharkhand, majority of the respondents (99.05%) had not received any direct subsidies and in Odisha, only 11.97 per cent had received subsidy. In Jharkhand (88.57%) and Odisha (70.94%) majority of farmers had not attended any training programme in agriculture. In Jharkhand (88.57%) and Odisha (80.34%) majority of farmers did not have any membership in social organisations.

Table 4.1.2: Landholding pattern in Jharkhand and Odisha (N=222)

Parameter (ha)	Jharkhand (n=105)				Odisha (n=117)			
	Mean	SD	f	%	Mean	SD	f	%
Own land	1.71	1.28	102	97.14	2.23	1.28	117.00	100.00
Lease in	0.70	0.29	33	31.43	0.65	0.24	29.00	24.79
Lease out	1.25	0.64	19	18.10	1.28	0.70	13.00	11.11
Total crop area	1.63	0.77			2.11	0.85		

From Table 4.1.2 it is evident that, in Jharkhand, 97.14 per cent of the farmers had own land with an average of 1.71 hectare, while 31.43 percent of farmers had

land on lease in. Results also reported that 18.10 percent of farmers have leased out land with average land holding size of 1.25 hectare. Similar land holding pattern was also observed in the state of Odisha where 100 percent of farmers have own land with average land holding of 2.23 hectares. Nearly one fourth (24.79 %) of farmers had taken land on lease besides their own land, and only 11.11 percent of farmers were found to have leased out their land.

4.2. Case study on different integrated farming system models

Case study 1:

Adoption of pond-based integrated farming system

IFS Model: crop + vegetable + Dairy + Goat + poultry-Duckery + Fish + Horticulture

Shri Bipin Bihari Sethy, Sanamoolabasant village, Kendrapara, Odisha

Shri Bipin Bihari Sethy, age 36 is a farmer from Sanamoolabasant village, Kendrapara district of Odisha state. A graduate by education, he was working as a private *Amin*. He finally decided to quit the job as the earning was not sufficient to meet the demand of 6 members' family. He decided to return to his village and start farming in his 1.2 ha of land. Initially, he diversified his rice fallow with green gram, black gram and vegetables like brinjal, bottle gourd and tomato. Even though the production from farm and food grains from the public distribution system were not enough for household consumption, economically the farming was not enough to sustain the family. It was during the participation of a training programme on integrated farming system and discussion with the staff of the KVK Kendrapara, he decided to include more components and adopted the concept of integrated farming system with a pond based integrated farming system. With his saving and financial and technical help from the KVK, a pond of an area 0.6 ha was excavated. The family reside in the farm area and manage the farm by all the family members.

Farm components and its economics

From crop diversification to farm diversification, he introduced components that are synergetic and utilized space diligently. Investment in the form of pond was a crucial decision which paved the paths for other components like poultry, duck, vegetable and horticultural crop. In his word "*pond is the locus of a well-integrated*

farming systemdiversification is easy if you have a pond". Besides cultivation of Indian Major Carps (IMC) in his pond, 50 ducks of *Khaki Campbell* were pen beside the pond. Dual purpose poultry bird *Vanaraja* and *Gramapriya* were reared in a semi-intensive way. He introduced a dairy unit of one cow, after seeing the opportunity to lower the feed cost for pisciculture through resource flow. The pond also helps in providing irrigation water for the *rabi* season crops especially for vegetables, which otherwise face the problem of water scarcity. On the bunds, 20 plants of improved varieties of papaya, 30 bananas and drumsticks are planted. He also utilized the space of the bunds by growing vegetables like bottle gourd, pumpkin *etc.* Adoption of quality breeds, fingerlings, seeds and planting material has increased the production of his farm. In his word "*initially I was adopting and planting locally available seed and breeds, but adoption of quality material in the form of seed and breeds has helped me to earn extra income*". He also grows *Daincha* to enhance the soil nutrient status of his field.

Table 4.2.1: Allocation of farm components and its economics

Crop	Area (ha) / unit (number)	Cost (₹)	Net Income (₹)	Remarks
Crop and vegetable				
Rice	0.4	3500	14,000	<ul style="list-style-type: none"> • Purchase Fertilizer and replace seed annually (Swarna sub-1)
Green gram /black gram	0.2	1500	6000	<ul style="list-style-type: none"> • Replace seed biannually with locally available improved seed (PDM-54,PU-30) • No fertilizer
<i>Rabi</i> Vegetables	0.2 + pond dike	4000	40,000	<ul style="list-style-type: none"> • Use improved seed from local seed dealers' tomato, brinjal, cabbage, cauliflowers <i>etc.</i> • No fertilizer
<i>Kharif</i> vegetable	0.05+ Pond dikes	1000	15000	<ul style="list-style-type: none"> • Used saved seed for pumpkin and gourds and purchase for other vegetables
Livestock unit				
Poultry	45	8000	30000	<ul style="list-style-type: none"> • <i>Vanaraja</i> breed and <i>Khaki Campbell</i> • Feed with kitchen waste and purchase feed • For egg and sale • Sale to local dealers
Duckery	50			
Dairy	2	2000 (feed cost)	10000	<ul style="list-style-type: none"> • Cross bred • Feed with rice bran • For household Consumption of milk and sale

				<ul style="list-style-type: none"> • Produce about 4 litre/day
Goat	7	-	12000	<ul style="list-style-type: none"> • Local bred
Fish	0.60(own) + lease in ponds	20000	90,000	<ul style="list-style-type: none"> • Cultivate IMC • Purchase feed from local shop • Sale to local dealers
Horticultural crop	No of plants			
<i>Banana</i>	20 suckers	-	1000	<ul style="list-style-type: none"> • Robusta variety
<i>Papaya</i>	10 plants	-	1500	<ul style="list-style-type: none"> • High yielding variety
System miscellaneous cost		5000	-	<ul style="list-style-type: none"> • Transportation, minor equipments and materials etc
Total		46000	2,14,500	<ul style="list-style-type: none"> ❖ Cost excluding imputed family labour ❖ Labor are hired mainly for Rice: planting, weeding and harvesting ❖ Fisheries: cleaning of pond and harvesting

Residing in the farm area has helped the family to efficiently manage the farm with regular monitoring and farm activities. The farm is surrounded by rice field with no immediate neighbours. Mr. Bipin Bihari Sethy says that the location of farm has also helped to rear their hen and duck in a semi-intensive way.

High initial investment cost was the major hurdle in adoption of pond based farming system especially for small and marginal farmers. Lack of technical knowledge about fish production was also a major challenge faced.

Impact of IFS

Being in coastal district of Kendrapara has exposed his family and farm to regular extreme climate and weather aberrations. He concurred that farm diversification had helped him to cope and mitigate the challenges posed by the uncertainty of weathers in the area. The integrated farming system has helped in lowering the cost of farming with resources flow between the components and opportunities of co-management of the components. Crops, cattle, fishery, ducks and hens formed a part of the self-sustaining cycle. The units of his farm are well integrated to the best possible way and resulted to a sound sustainable integrated farming system.

Economically, the family is earning about ₹ 2,14,500 per annum from his farm. Diversification of farm has helped him to earn a stable monthly income. He sells his poultry or duck in case of any urgent need for money. The family is self-

sufficient in food grains and regularly enjoys the egg, fish, chicken and ducks besides home grown vegetable. Their children are getting better education facilities. He used his income to diversify, modernise and expand his farm. The satisfaction which he got from his farming has driven him to seek for more improved technologies and practices.

Future plan

Since majority of the income comes from pisciculture, he has decided to expand his farm through investment and hiring of ponds. He is planning to start fingerling production and prawn cultivation. He also expressed the need for proper pen house for poultry and duck to mitigate the occurrence of diseases.

Case study 2:

Intensive integrated farming system

IFS Model: Crop + Vegetables + Dairy + Poultry + Fishery + Horticultural + Flower

Shri Surendra Bhol, Indolokusiary, Balipatna, Khordha

Shri. Surendra Bhol, a matriculate, aged 53 who hails from Indolokusiary village of Balipatna block of Khordha district of Odisha has made exemplary achievement and impact by adoption of integrated farming system in commercial scale. Although he had inherited with good agricultural lands, farming was never a profitable venture until one of his rice fields of an area 1.32 acre converted into IFS farm. Under the guidance of the expert of the KVK, Mr. Bhol constructed a fish pond of 1 acre size and poultry shed with a capacity of about 2200 birds by availing financial assistance through APICOL, as he deemed to primarily focus on intensive scientific fish culture and rearing broiler poultry. He recognized the proper guidance given by KVK, Khordha and ICAR–CIFA through their regular demonstration and exposure programme. This was just the beginning of his venture. Shri Surendhra Bhol added dairy unit of 5 cross-bred cows by availing loan from State Bank of India in 2012-13. He further constructed a shed for poultry (*Vanaraja*) for egg and duck, adjacent to the poultry shed with a way to the pond for the duck unit. All the units are located to facilitate the maximum resources flow between the components. He also constructed Azolla pit for producing Azolla for dairy feed. He utilized the available

space in embankment by growing a number annual horticultural crops and seasonal vegetables, majority being papaya and banana. He also grows seasonal flowers like marigolds along the bank. The diversity of fruits and vegetable in his farm of 1.32 acre is worth to mention. Shri Bhol says *“my idea is specialized in poultry and aquaculture but I also like to have different plant types.....at least one plant of different kind should find a place on my farm”*. There were different kinds of plants like sapota, mango guava, citrus, areca nut, coconut, drumsticks *etc.* on his farm.

The farming system model was situated at the outskirts of the village, about 400 -500 metres from his house. The dairy unit is built at home. The heaps of cow dung are regularly given to fish pond and used as farm manure. To mitigate the challenges of marketing of diversified farm, he is in contract farming for poultry and milk. Mr. Bhol says *“Production is not the end of farming, marketing of the produced is equally important as production”*. He often explores the opportunities to get the best price of farm produces”.

Allocation and economics

He grows paddy as the major crop in 10 acre of land followed by cultivation of green gram and black gram in 2 acre of land. He also grows seasonal vegetables in the rice fallow in an area of 4 acres with one acre each of okra and pointed gourd and remaining area with vegetable like potato, tomato, garden pea, pumpkin, cabbage, cauliflowers, cucumber, bitter gourd, bottle gourds *etc.* Adoption of improved varieties is key to Mr. Surendra’s farming, always sought for it in local seed dealers, KVK and state agricultural officials. He earned about Rs. 160000, Rs. 35000 and Rs. 70000 from paddy, pulses and vegetables respectively and in total an annual income of about Rs. 265000/- from his conventional farming of 10 acre land.

In his pond based intensive integrated farming system; he reared about 2000 broiler birds in each production cycle (6-8 per annum). For which, he is under a contract farming, with the contract of supplies feed and chicks and purchased of broiler after about 45 days old chicken. He also reared Vanaraja bird (40) for egg and duck (50) for sale. In the pond, he adopts polyculture of prawn and fish (IMC) and produced about 800 - 900 kg of fish and 100 kg of prawn annually.

He earns about Rs. 220000/- from his poultry birds and sale of egg. The duckery unit secured him earning of about Rs. 20000. He earns about Rs 80000/- from

fisheries and prawn with an additional income from Rs 26000 from horticultural crops and flowers in the bund area. In addition to that, dairy unit earns him Rs 50000/-. He also secures Rs 10000 from vegetable grown in the area of farming system model. In total, he earns more than Rs. 406000/-.

Recognition

Mr. Bhol achievement has been recognized through various awards and position. He is a member of the DFAC of ATMA, Balipatna block. He is listed as progressive farmers of ICAR- CIFA and conferred many best farmers awards. He is often called to guide fellow farmers on various aspect of farming by KVK, ATMA *etc.*

Future plan

The future plan of Mr. Bhol is progressive and he is considering starting fingerling production of major carps. He also sights the opportunities to earn extra income through seed production of rice. Mr. Bhol is innovative and interested in adopting any new technology suitable for him in future.

Table 4.2.2: Allocation of farm and its economics (Mr. Surendra Bhol)

Crop	Area (ha) / unit (number)	Cost (Rs)	Productivity	Net Income (Rs)	Remarks
Crop and vegetable					
Rice	10 acre	55000	140- 145	1,60,000	<ul style="list-style-type: none"> • Conventional rice production with fertilizer • Basmati rice, Swarna Ajay and Hybrid rice variety of Rajalaxmi and Rambha • Adopt line transplantation in some plot
Green gram /black gram	2 acre	3500	7.5	35,000	<ul style="list-style-type: none"> • Jyoti and Pusa-105 for green gram • Pragati for black gram
Vegetables	4 acre	15000	-	70000 +10000(produce in pond area)	<ul style="list-style-type: none"> • 1acre each of okra (Hybrid okra) and pointed gourd (<i>Swarna Aluakik</i>)

					<ul style="list-style-type: none"> • Potato, tomato, garden pea, pumpkin Seasonal vegetables of cabbage, cauliflowers, cucumber, bitter gourd, bottle gourds etc. are grown
Livestock unit	Number				
Poultry	2000/ production cycle + 30 unit for egg			2,20,000	<ul style="list-style-type: none"> • Broiler 6-7 production cycle /annum • Broiler under contract farming • Vanaraja for egg
Duck	40	1500		20000	<ul style="list-style-type: none"> • <i>Khaki Campbell</i>
Dairy	5	5000		50000	<ul style="list-style-type: none"> • Cross bred Jersey • Feed with rice bran • Use Azolla for feed • Sell milk to cooperative society
Pond based farming area	1.32 acre				
Fish cum prawn	1 Acre	15000	22000	80,000	<ul style="list-style-type: none"> • Poly-culture of IMC with prawn
Horticultural crop	No of plants				
<i>Banana</i>	100	-	-	10000	<ul style="list-style-type: none"> • Robusta variety
<i>Papaya</i>	100	-	-	14000	<ul style="list-style-type: none"> • Red lady variety
<i>Flower</i>	200	500	-	2000	<ul style="list-style-type: none"> • Marigold in bunds
System misc cost		20000		-	<ul style="list-style-type: none"> • Transportation, minor equipments and materials etc
Total		115500		671000	<ul style="list-style-type: none"> ❖ Cost excluding imputed family labour ❖ Hired one permanent labour to look after all the activities ❖ Hired labour for major activities for rice, pulse, vegetable and fisheries

Case study 3:

Mushroom-based integrated farming system:

Model: Crop – Mushroom-Crop- Fisheries- Dairy- Duck- Horticultural - Vegetable

Shakhigopal, Puri, Odisha

Sanatana Behera, a rural youth, aged 27, started farming after passing matriculation. He left his education after matriculation to start farming, though his family farming was more conventional type of growing paddy followed by growing green gram and black gram with some area under seasonal vegetable. He supported his father in farming partially and gradually he involved himself as a fulltime cultivator.

After knowing about the success of mushroom growers in his locality, he decided to start mushroom cultivation by using the paddy straw from his 6 acre land. He got information from fellow mushroom growers. Paddy mushroom is one of the most demanded items in the cities of Odisha. With his savings, he built a structure with locally available material at his home. With the understanding of mushroom production, marketing aspect and its scope, he decided to expand his enterprises. He took one acre land on lease in 2010-11, where he cultivates mushroom under the shade of the trees. The input of paddy straw was utilized which otherwise got wasted. He purchased straw in bulk from local farmer after rice harvest. Mr. Behera relies on local spawn producer for mushroom spawn. As he informed about 500 spawn's packets are purchased after every 12 days.

He always wanted to own a farm, which was realised in the year 2012 through purchased of 2.4 acre agricultural land from his earning. He developed into a pond based integrated farming system. His leased in mushroom unit plot and IFS farm is around 1 km apart. He also owned a coconut and areca nut unit with 500 and 400 plants, respectively in a separate plot.

The pond based unit has two ponds with 180 x 160 ft each. He has planted 1000 banana and 400 Papaya plants. *Kharif* vegetable is grown in the bund area, pointed gourd, brinjal and gourds majorly constitute *Kharif* vegetables. In 2014, sprinkler irrigation all along the bund area has been installed for efficient utilization

of water. He also has a duckery unit of 20 *Khaki Campbell*. He cultivates Indian major carps (IMC) in the pond.

From his agricultural field, he grows paddy in 7 acre of land followed by green gram and black gram (1.5 acre combine). Winter vegetables like potato, cabbage, cauliflower, tomato, brinjal are grown in 1.5 acre where irrigation facilities are available.

He hired 10-15 persons on daily wages basis to look after the mushroom and other farm component.

Allocation and economics

From his field crops and vegetables, he produced about 50 quintals of rice and 5 quintals of pulse. He earns about 14000 from vegetables. In total, about 79000 is earned from field crops and vegetables. From his coconut and areca nut, he earns Rs. 40000 per annum

He earns about Rs. 50000- 100000/- per month depending upon the season. Mr. Behera told September- October months are the most suitable with respect to production whereas December -January gives the best price and often considers as off-season production of mushroom. Mr. Behera produces off-season mushroom and sells at a price of Rs 180-220 per kg. Normally the rate is Rs. 120- 140 / kg during peak production season. Mr. Behera told that the price of mushroom even differed in a day. During morning it fetches the best price and by evening with the deterioration of quality, the price deep up to Rs. 90-100/ kg in normal season. He usually harvests and transports twice a day during the peak season to get the best price. Mr. Behera asserted "*The perishable nature of the mushroom is a challenge Marketing is a very important aspect of mushroom cultivation*". He sells mushroom mainly to Bhubaneswar about 54 km from his farm. His brother stays at Bhubaneswar for selling of mushroom and other farm produced. Being on the Bhubaneswar- Puri highways has helped him to market the mushroom. Majority of his products is sold to hotels and restaurant. During peak month, he produced about 1 quintal of mushroom per day. Per annum, he earns about Rs. 6 lakhs from mushroom.

From his pond based farming system, he earns about Rs. 70000/- from fisheries. He earns an additional income of Rs. 15000 from vegetables, Rs. 25000/-

from horticultural crops (banana and papaya) and Rs. 6000/- from ducks. Being in the early days of pond-based farming system, the production and earning is low, which is expected to increase in the course of year. From pond based farming system he earns about Rs. 1,16,000/-.

Future plan

Mr. Behera plans to start mushroom cultivation under the shade of banana plants in his pond based farming system. He is exploring the possibilities to start mushroom processing into pickles and other product to mitigate the losses of mushroom. Fingerling production is something he wanted to start after gaining experience for a few years of fish farming.

Case study 4:

Model: Crop – vegetables – fishery (Fingerling specialization) - poultry-Duckery-Fruits-Mushroom- Flower

Mr. Prakash Chandra Nayak

Mr. Prakash Chandra Nayak, an educated (Diploma in Mechanical) rural youth of Puran Pradhan village of Baliana block in Khordha district. Mr. Prakash is one of the farmers who has benefitted from the works of KVK. With the advice of KVK, Mr. Prakash adopted fish seed rearing cum pond based integrated farming system on his farm.

Table 4.2.3: Profile of the farmer (Mr. Prakash Chandra Nayak)

Age	: 33
Education	: Diploma in Mechanical
Landholding	: 0.8 ha
Business experience	: 2 years
Products	: a. All freshwater aquaculture inputs b. Fish seed (Spawn, fry and fingerling) c. Vegetables d. Fruits e. Flowers f. Mushroom g. Vanaraja poultry
Asset value	: 4 crores
Annual turnover	: 12-15 lakhs/year
Persons employed	: Four
Social recognition	: Master trainer of KVK, recognized fish seed supplier in

	the district
Annual income	: 8,32,700
Award recognition	: Best farmer-2013, ICAR-CIFA <i>Krushak Ratna</i> , Bandipur Purushottam - An NGO, Puri

The Challenge

Previously Mr. Prakash was engaged in a job in Saudi Arabia. In 2010-11 Mr. Prakash returned to the country and started paddy and vegetable cultivation but the income from the farming was not enough to meet his family need.

Process

With the advice and guidance of KVK and his involvement in different sensitizing programmes, he added other components for better income. During the period 2014-15, Mr. Prakash earned a gross income of ₹ 8,32,700 from 0.8 ha in a pond based farming system adopting Fish – Fish Seed – Vegetables (Bitter gourd, Pointed gourd, Snake gourd, Cucumber) – Fruits (Mango, Papaya) – Flower (Marigold) – Mushroom (Paddy straw mushroom) – Vanaraja poultry. With the help of State fisheries department, he had established a ‘one-stop Aqua shop’ which provides all critical inputs related to freshwater aquaculture farming to the neighbouring villages and blocks. In addition to that, he also established a FRP hatchery for fish seed production with the support of KVK and ICAR-CIFA. He is also a recipient of a support of ₹ 1 lakh from ATMA-Khordha towards integrated farming. Continuously he tested different enterprises on a limited scale and on the basis of the experience of trial process modified the component combinations.

Initiatives

After attending a one-month long training programme supported by the State Employment Mission gross income increased from ₹ 5,19,600 in the year 2013-14 to ₹ 8,32,700 in the year 2014-15 with the same amount of land.

- In 2015, he added intensive Vanaraja poultry (a dual-purpose chicken) production system and a business of supplying critical inputs related to freshwater aquaculture in the name of Gopinath “One stop Aquashop” to the surrounding area.
- During 2015 a FRP hatchery for fish seed production was established with the support of KVK and ICAR-CIFA.

- During 2016 two Chinese hatcheries were established to meet the demand FRP hatchery.
- With this enterprising nature, he received a support of ₹ 1 lakh from ATMA-Khordha for IFS.

Lessons Learnt

- Exposure to appropriate training on improving technical skill as well as managerial skill improves the economic viability of the enterprise.
- Testing the new components in a limited basis and modification of IFS model considering the experience of trial process and market demand keep the enterprise sustainable in long-term.
- Institutional support is required for the promotion of IFS.

Case study: 5

Crop- Vegetables – Piggery- Fisheries- Dairy –Goat –Horticultural

Mr. Anup Kumar

Village-Bishunpur, District- Gumla, Jharkhand

Mr. Anup Kumar, aged 42 years, is a confident and empowered man and has name and fame in his village and nearby villages. But this was not the case before. Just three and half year before, he was an ordinary farmer just like any other farmers in his village. Anup Kumar is 42 year old and has 3 kids. He got married at a very early age and did not get ample opportunity to study further. But he was determined to do something better in his life. He has 1 hectare land where he used to grow traditional crops like rice, vegetables along with some vegetable crops and cash crops. But this much land and subsistence farming practices were not generating enough income for him so that he can support his family expenditure. Life has changed for him when he came to know about the integrated farming system practice. He received training on IFS and various models of IFS at *Krishi Vigyan Kendra*. KVK expert informed him about entrepreneurial opportunities exist in IFS and offered training for skill development and how to get access to credit.

After getting training from KVK, he started incorporating dairy, /piggery, fisheries and goat rearing along with traditional paddy and vegetable cultivation. For this purpose, he converted 0.2 ha of his land into pond and started fisheries on his

farm. He also established small piggery and goat unit on his farm. He got good response from various enterprises from first year itself and his earning increased significantly. He has got various prizes, honour, and recognition from Govt., NGOs and from other organizations for his noble work and he is often asked to share his experiences at public platform and provide advice to other fellow farmers.

Impacts and lesson learnt:

During 2011-12, Mr. Anup Kumar used to earn a gross income of Rs. 3 lakh from 1 ha of land which was dominated by paddy- vegetable cultivation. With the adoption of different farm enterprises like fisheries, dairy, along with Vegetables (Bitter gourd, Snake gourd, Pointed gourd, Cucumber) – Fruits (Mango, Papaya) – Flower (Marigold) – Mushroom (Paddy straw mushroom) farm income got substantially increased. He earned five lakh fifty thousand with the farm and crop diversification. Encouraged from this response, Anup Kumar also started rearing goat and started production of fingerlings. This again helped to earn more. In between, he was encouraged by the KVK experts to scale up his dairy business by opening up dairy and piggery unit in 2012. For this purpose, he received financial assistance from the local bank. Presently he is earning more than Rs. 8, 50,000 annually from integration of various enterprises successfully. He started a business of supplying products of milk like curd and butter in the nearby markets and is continuously expanding his business. The scale of his activities accelerated as he keeps watch of the demand. In between, he ventured into live fish sales in the market which fetched him better price and left as there were many who started practicing it. Mr. Anup Kumar is leading a network for mutually interested seed growers of fisheries. His high turnover has helped him to construct a new house and provide higher education of his kids.

Success factor:

1. His own self-belief, dedication, hard work and perseverance.
2. Guidance, training and other support provided by the team of KVK officials and
3. Follow up and proper guidance by KVK.
4. Institutional support and dedication of members of KVK
5. Interlinkage of various farm enterprises.

4.3. Techno-economic assessment of integrated farming system models

The tables 4.3.1 and 4.3.2 show the distribution of sample households across the different farming system in the state of Jharkhand and Odisha, respectively. A perusal of the tables reveals that various types of farming systems with different farm components were practiced in both states. Majority of the sample household (27.62%) practiced Crop + Dairy +Vegetable farming system followed by Crop + Dairy + Vegetable + Goat system (15.24 %). The major components in Jharkhand were crop, dairy, vegetable, goatery and piggery. Majority of the farmers have 4 numbers of different components, with maximum up to 7 components. Most of the piggery farmers adopt poultry and duckery also, whereas farmers with fish components also have Horticulture and Poultry /Duckery component. In Odisha, majority of the households (20.51 %) had Crop + Vegetable system followed by Crop + Dairy + Vegetable. Fishery is one of the major components of integrated farming system in Odisha. However the farmers with fish component also have horticulture plant, dairy, plantation crops and duckery components. Mushroom farmers were also observed in the state of Odisha. Farmers up to eight components were observed during the survey in Odisha.

Table 4.3.1: Farming systems typologies of sample household of Jharkhand

Typology	f	%
Crop	4	3.81
Crop + Goat	1	0.95
Crop + Dairy	10	9.52
Crop + Dairy + Goat	5	4.76
Crop + Dairy +Pig +Poultry/ Duckery + Goat	2	1.9
Crop + Dairy +Vegetable	29	27.62
Crop + Dairy + Vegetable + Fish + Horticulture + Poultry /Duckery	6	5.71
Crop + Dairy + Vegetable + Fish + Horticulture + Poultry /Duckery + Goat	2	1.9
Crop + Dairy + Vegetable + Goat	16	15.24
Crop + Dairy + Vegetable + Pig	3	2.86
Crop + Dairy + Vegetable + Pig + Poultry /Duckery	1	0.95
Crop + Dairy + Vegetable + Pig + Poultry /Duckery + Goat	3	2.86
Crop + Vegetable	13	12.38
Crop + Vegetable + Fish + Horticulture	1	0.95
Crop + Vegetable + Fish + Horticulture + Poultry /Duckery	1	0.95
Crop + Vegetable + Goat	2	1.9

Crop + Vegetable + Pig	1	0.95
Crop + Vegetable + Pig + Poultry /Duckery	4	3.81
Crop + Vegetable + Pig + Poultry /Duckery + Goat	1	0.95

Table 4.3.2: Farming systems typologies of sample household of Odisha

Typology	f	%
Crop	4	3.42
Crop + Fish+ Horticulture (Fruit)	1	0.85
Crop +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut)	1	0.85
Crop + Goat	2	1.71
Crop + Dairy + Goat	1	0.85
Crop + Dairy + Vegetable	14	11.97
Crop + Dairy + Vegetable + Fish	3	2.56
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit)	10	8.55
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Agroforestry	1	0.85
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Mushroom	1	0.85
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut)	7	5.98
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut) +Agroforestry	2	1.71
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut) +Mushroom	1	0.85
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut) + Poultry/Duckery	4	3.42
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) + Poultry/Duckery	5	4.27
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) + Poultry/Duckery +Agroforestry	1	0.85
Crop + Dairy + Vegetable +Fish+ Horticulture (Fruit) + Poultry/Duckery +Mushroom +Agroforestry	1	0.85
Crop + Dairy + Vegetable +Fish + Plantation (arecanut/coconut)	1	0.85
Crop + Dairy + Vegetable +Fish+ Poultry/Duckery	3	2.56
Crop + Dairy + Vegetable +Fish+ Poultry/Duckery + Goat	1	0.85
Crop + Dairy + Vegetable +Fish+ Poultry/Duckery +Mushroom	1	0.85
Crop + Dairy + Vegetable + Goat	2	1.71
Crop + Dairy + Vegetable + Horticulture (Fruit)	1	0.85
Crop + Dairy + Vegetable + Horticulture (Fruit) +Mushroom	2	1.71
Crop + Dairy + Vegetable + Horticulture (Fruit) +Plantation (arecanut/coconut)	4	3.42

Crop + Dairy + Vegetable +Mushroom	2	1.71
Crop + Dairy + Vegetable +Plantation (arecanut/coconut)	3	2.56
Crop + Vegetable	24	20.51
Crop + Vegetable +Fish+ Horticulture (Fruit)	2	1.71
Crop + Vegetable +Fish+ Horticulture (Fruit) +Plantation (arecanut/coconut) + Poultry/Duckery	1	0.85
Crop + Vegetable +Fish+ Horticulture (Fruit) + Poultry/Duckery +Agroforestry	1	0.85
Crop + Vegetable + Goat	3	2.56
Crop + Vegetable + Horticulture (Fruit)	1	0.85
Crop + Vegetable + Horticulture (Fruit) +Plantation (arecanut/coconut)	4	3.42
Crop + Vegetable +Mushroom	1	0.85
Crop + Vegetable +Plantation (arecanut/coconut)	1	0.85

Table 4.3.3: Land used pattern of the respondents

Particular	Jharkhand (n=105)		Odisha (n=117)	
	Mean	SD	Mean	SD
Net crop area (ha)	1.63	0.77	2.11	0.85
Gross crop area (ha)	2.56	1.26	3.08	1.29
<i>Kharif</i> fallow (ha)	0.33	0.16	0.00	0.00
<i>Rabi</i> fallow (ha)	0.81	0.44	1.14	0.56
Total fallow (ha)	0.69	0.55	1.14	0.56
Cropping intensity (%)				
• Small (<2 ha)	158.88	36.88	143.26	17.30
• Medium (2-4 ha)	152.29	19.32	148.30	15.07
• Large (>4 ha)	161.54	12.02	144.81	10.87
• Total	157.33	0.32	145.67	0.16

Table 4.3.3 revealed that in the state of Jharkhand average net cropped area of the respondents was 1.63 ha as compared to 2.11 hectare in Odisha. Average gross cropped area was 2.56 ha in Jharkhand while it was 3.08 hectare in Odisha. In Jharkhand, the average fallow land in *Kharif* season was 0.33 ha (20.24 % of net crop area) while no fallow land was found in Odisha in the *Kharif* season. About 49.69 per cent 54.03 per cent of net crop area were fallow land in *Rabi* season respectively in

Jharkhand and Odisha. The average cropping intensity of the respondent of Jharkhand (157.33%) is higher than Odisha (145.67%). Cropping intensity across the different landholding category in Odisha was relatively similar whereas in Jharkhand 161.54 per cent, 152.29 per cent and 158.88 per cent. Cropping intensity was found respectively for large, medium and small farmers group was in Jharkhand.

Table 4.3.4: Season wise land allocation for crop and vegetable

Crop	Jharkhand (Area in ha)		Odisha (Area in ha)	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
<i>Kharif season</i>				
Rice	1.25	0.66	1.98	0.76
Vegetable	0.32	0.14	0.25	0.11
Maize	0.27	0.12	0.16	0.05
Pulse*(Arhar)	0.24	0.09	-	-
Niger	0.25	0.07	-	-
Groundnut	0.17	0.08	-	-
Fallow land	0.33	0.16	0.00	0.00
<i>Rabi season</i>				
Wheat	0.72	0.25	-	
Vegetable**	0.28	0.18	0.52	0.24
Mustard/ toria	0.27	0.11	0.32	0.15
Moong	-	-	0.29	0.11
Urad	-	-	0.30	0.15
Chickpea	0.31	0.14	-	-
Linseed	0.13	0.05	-	-
Fallow land	0.81	0.44	1.14	0.56

* *Biennial crop*

** *Continuation in Zaid season*

Table 4.3.4 presents the season wise allocation average area under crops and vegetables. The result shows that in *Kharif* season in Jharkhand average acreage of rice crop was 1.25 ha followed by 0.32 ha for vegetables, 0.27 ha for maize, 0.24 ha for pulses, 0.25 ha for niger and 0.17 ha for groundnut. Similarly in Odisha, the average acreage in *Kharif* season for rice was 1.98 ha, followed by 0.25 ha for vegetables and 0.16 ha for maize crops. For *rabi* season, in Jharkhand average area under wheat was 0.79 ha followed by 0.31 ha for chickpea, 0.28 ha under vegetables followed by 0.27 ha for mustard/toria and 0.13 ha under linseed crops. In case of

Odisha, the table shows that in *Rabi* season, average area for vegetables was 0.52 ha, 0.32 ha for mustard/ toria crops, 0.30 ha for urad and 0.29 ha for moong.

Table 4.3.5: Economics of *Kharif* crop and vegetables

	Rice				Kharif Vegetable				Kharif Pulse (Arhar)		Kharif Maize				Kharif Niger		Kharif Groundnut	
	Jharkhand		Odisha		Jharkhand		Odisha		Jharkhand		Jharkhand		Odisha		Jharkhand		Jharkhand	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Area (ha)	1.25	0.66	1.98	0.76	0.32	0.14	0.25	0.11	0.24	0.09	0.27	0.12	0.16	0.05	0.07	0.07	0.17	0.08
Labour –Man days	83.05	21.80	77.02	10.27	45.67	8.84	51.08	15.06	26.43	5.53	28.65	6.41	37.84	10.35	29.85	4.49	29.64	7.55
Labour cost	16609.67	4359.86	15403.39	2054.76	9133.12	1768.77	10215.61	3011.55	5285.02	1105.73	5730.40	1281.65	7567.10	2069.62	5969.17	897.75	5928.00	1509.19
Fertilizer (Rs)	1785.52	810.55	2869.43	957.93														
Other cost (Rs)	4318.20	951.56	9216.63	1745.24	6341.14	2667.23	8059.82	3262.66	4324.46	1510.23	3171.21	1313.09	4229.44	1344.65	3319.41	496.23	4775.33	1387.51
Total cost (Rs)	22713.38	5201.06	27489.45	2846.54	15474.26	3768.72	18275.43	5295.16	9609.48	2273.08	8901.61	2040.93	11796.54	2792.82	9288.57	1281.67	10703.33	2670.44
Production (Qn)	39.13	3.89	43.55	4.93					7.05	0.68	16.03	1.48	17.05	1.62	2.47	0.25	6.78	0.23
Gross income (Rs)	41762.41	5891.37	56640.40	8153.93	43078.42	17796.56	59744.43	31216.52	28219.95	3369.22	13794.68	2700.23	15933.98	2676.70	8326.64	535.27	23049.80	1270.74
Net income (Rs)	19049.02	7741.65	29150.96	8196.34	27604.16	15267.58	41469.00	28508.60	13474.44	5926.31	4893.07	3079.80	4137.45	2735.40	-961.93	1127.30	12346.47	2120.96
Other Product (Straw) in Ton	5.15	0.37	5.08	0.21														

Table 4.3.5 revealed that in Jharkhand, average acreage for rice production was 1.25 ha while in Odisha it was 1.98 hectare. The average labour man-days involved in rice production was 83.05 man-days/ha in Jharkhand while it was 77.02 man-days/ha in Odisha. In Jharkhand, the average labour cost per ha for rice crop was Rs. 16609.67 while in case of Odisha it was Rs.15403.39, which was a little less as compared to Jharkhand. Result also shows that in Jharkhand, the average fertilizer cost was Rs. 1785.52 per ha, other cost was Rs. 4318.20 and total cost was Rs.22713.38 while in Odisha it was Rs 2846.43, Rs. 9216.63s. Rs. 27489.45 for fertilizer cost, other cost and total cost, respectively. Results clearly indicate that average cost per ha for rice production was more in Odisha. The average rice production was 39.13 quintal/ha In Jharkhand as compared to 43.55 quintal/ha in Odisha. It was slightly higher than Jharkhand. The average gross income from per ha rice production was Rs. 41762.41 in Jharkhand and in Odisha, it was Rs. 56640.40, while average net income/ha from rice production was Rs.19049.02 in Jharkhand and

Rs. 29150.96 in Odisha. About 5 ton of straw were obtained from one hectares of rice in Jharkhand and Odisha.

The table also shows that, in Jharkhand, average acreage for *Kharif* vegetables was 0.32 ha, while in Odisha, the average land under *Kharif* vegetables was 0.25 ha. In Jharkhand, the average labour involved in *Kharif* vegetable production was 45.67 man-days/ha, while it was 51.08 man-days/ha in Odisha. In Jharkhand, the average labour cost per ha for *Kharif* vegetables was Rs. 9133.12/-, while in case of Odisha it was Rs.10215.61 which was little more as compared to Jharkhand. Result also shows that In Jharkhand, for *Kharif* vegetable other cost/ha was Rs. 6341.14 and total cost was Rs.15474.26, while in Odisha it was Rs. 8059.82 and Rs. 18275.43 respectively. Results clearly indicate that average cost per ha for *Kharif* vegetables was less in Jharkhand as compared to Odisha. In Jharkhand, average gross income from *Kharif* vegetables/ha was Rs. 43078.42 and compare to Rs. 59744.43 in Odisha with an average net income/ha of Rs. 27604.16 and Rs. 41469.00 respectively for Jharkhand and Odisha.

Further Table 4.3.5 indicates that the average labour involved in *Kharif* pulse (pigeon pea) production was 24.63 man-days/ ha. Average labour cost per ha for *Kharif* pulse production was Rs. 5285.02 followed by other cost and total cost which was Rs. 4324.46 and Rs. 9609.48, respectively. Average production of *Kharif* pulse was 7.05 q/ha in Jharkhand, while the average gross income from *Kharif* pulse (pigeon pea) was Rs. 28219.95/ha and net income was Rs.13474.44/ha.

The results also revealed that in Jharkhand, on an average, a household has 0.27 ha land under maize cultivation and it was 1.98 ha in Odisha. In Jharkhand, the average labour man-days/ha involved in maize production was 28.65 while it was 37.84 man-days/ha in Odisha. The average labour cost per ha for maize production was Rs. 16609.67 in Jharkhand while in case of Odisha, it was Rs.37.84, which was higher as compared to Jharkhand. Result also shows that in Jharkhand, per ha average fertilizer cost was Rs. 5730.40 followed by other cost Rs. 3171.21 and total cost of Rs. 8901.61, while in Odisha it was Rs.7567.10, Rs. 4229.44, Rs. 11796.54, respectively. Results clearly indicate that the average cost per ha for maize production was more in Odisha as compared to Jharkhand. In Jharkhand, the average maize production was 16.03 q/ha, while in Odisha it was 17.05 q/ha which was slightly higher than in Jharkhand. The average gross income from maize was Rs. 13794.68/ha

in Jharkhand and in Odisha, it was Rs. 15933.98/ha. The average net income from maize production was Rs. 4893.07/ha in Jharkhand and Rs. 4137.45 /ha in Odisha.

Analysis of the result from Table 4.3.5 revealed that 29.85 labour man-days were involved in Niger crops per ha in Jharkhand. Average labour cost/ ha for production of Niger was Rs. 5928.01 followed by other cost and total cost which was Rs. 3319.41 and Rs. 9288.57, respectively. Average production of Niger crop was 2.47 q/ha. With an average gross income of Rs. 8326.64/ha and net income was Rs. 961.93/ha.

Similarly, cultivation of *Kharif* Groundnut crop in Jharkhand was also analyzed. The average size of the cultivated area for groundnut crop was 0.17 ha. On an average, 29.64 labour man-days were involved in groundnut production per ha. Average labour cost/ ha for production of groundnut in *Kharif* was Rs. 5928.00 followed by other cost and total cost which was Rs. 4775.33 &Rs. 10703.33 respectively. The average production of groundnut was 6.78 q/ha with an average gross income/ha from of Rs. 23049.80 and net income of Rs. 12346.47/-.

Table 4.3.6: Economics of *Rabi* crop and Vegetables

	Wheat		<i>Rabi</i> Pulse				Torina				Linseed		<i>Rabi</i> Vegetables			
	Jharkhand		Jharkhand		Odisha		Jharkhand		Odisha		Jharkhand		Jharkhand		Odisha	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Area (ha)	0.72	0.25	0.32	0.14	0.48	0.21	0.27	0.11	0.32	0.15	0.13	0.05	0.28	0.18	0.52	0.24
Labour – Man days	73.62	16.46	28.66	5.72	34.51	7.70	27.69	4.07	28.80	5.73	35.40	12.43	86.21	34.52	60.18	18.36
Labour cost (Rs)	1472.41	3292.10	5731.33	1144.54	6902.18	1540.20	5538.86	814.32	5760.75	1145.88	7080.67	2486.41	1724.26	6903.76	1203.54	3671.33
Fertilizer (Rs)	1698.68	766.79														
Other cost (Rs)	5234.45	1020.19	4185.10	1746.67	3310.88	884.32	4266.73	1904.01	3451.19	1149.94	2531.75	649.60	7974.83	3808.54	2272.09	1780.95
Total cost(Rs)	2165.72	2717.57	9916.43	2575.00	1021.30	1685.05	9805.59	2225.44	9211.94	1717.02	9612.42	2596.11	2521.74	1013.09	3475.63	2084.26
Production (Quintal)	30.86	2.97	5.54	1.05	7.003	0.962	6.12	1.11	5.61	0.62	0.90	0.00				
Gross income (Rs)	3983.91	4786.72	1616.75	2987.17	2540.87	3703.47	1779.81	3338.13	1648.39	2036.01	1601.38	3081.73	5197.68	2374.02	7364.23	2871.47
Net income (Rs)	1818.18	4641.22	6251.07	3835.86	1519.57	3638.29	7992.56	2417.46	7269.45	3016.63	6401.42	4455.33	2675.92	1722.04	5042.84	1773.69
Other Product	3.90	0.00														

Analysis of the result from Table 4.3.6 indicates that in Jharkhand the average size of are under wheat cultivation is 0.72 ha. In Jharkhand, the average labour man-days involved in wheat production was 73.62/ha. Average labour cost per ha for wheat production was Rs. 1472.41 followed by fertilizer cost/ha (Rs. 1698.68), other

cost/ha (Rs. 5234.4) and total cost/ha (Rs. 21675.29). Average yield of wheat was 30.86 quintal/ha which was nearly equal to the national average. In Jharkhand average gross income/ha from wheat production was Rs. 28219.95 and net income/ha was Rs. 18181.83. Production of wheat straw was about 4 ton/ha.

In Jharkhand, the average acreage for *Rabi* pulse production was 0.32 ha while in Odisha it was 0.48 hectare. In Jharkhand, average labour man-days involved in *Rabi* pulse crop production was 28.66 man-days /ha while it was 34.51 man-days/ha in Odisha. In Jharkhand, the average labour cost for pulse crop production was Rs. 5731.33/ ha while in Odisha it was Rs. 6902.18/ ha which was higher as compared to Jharkhand. Result also indicates that in Jharkhand, the average other cost was Rs. 4185.10 /ha followed by total cost Rs. 9916.43/ha, while in Odisha it was Rs. 3310.88/ ha and Rs. 10213.06/ ha, respectively. The average pulse production was 5.54 q/ha and 7.00 q/ha in Jharkhand and Odisha respectively. The average gross income from pulse production/ha was Rs.16167.50 in Jharkhand and in Odisha it was Rs. 25408.78, while average net income from *Rabi* pulse production was Rs. 6251.07/ha and Rs. 3835.86 /ha in Jharkhand and Odisha respectively.

Table 4.3.6 revealed that in Jharkhand, average area under toria production was 0.27 ha while in Odisha it was 0.32 ha. In Jharkhand, the average labour man-days involved in toria crop production was 27.69 man-days/ha, while it was 28.80 man-days/ha in Odisha. In Jharkhand, average labour cost per ha for toria was Rs. 5538.86 while in Odisha it was Rs. 5760.75 which was higher in comparison to Jharkhand. Result also indicates that in Jharkhand, other cost was Rs. 4266.73 /ha and total cost was Rs. 9805.59/ha while in Odisha it was Rs. 3451.19/ha and Rs. 9211.94/ha, respectively. In Jharkhand, 6.12 q/ha was the average yield, while in Odisha it was 5.61 q/ha which was lower than Jharkhand. In Jharkhand, average gross income from toria production was Rs. 17798.15/ha and in Odisha, it was Rs.16481.39/ha, while the average net income/ha from toria production was Rs. 7992.56 in Jharkhand and Rs. 7269.45 in Odisha.

The result from Table 4.3.6 revealed that the average size of land for linseed production is 0.13 ha. In Jharkhand, the average labour man-days/ha involved in linseed production was 35.40. Average labour cost per ha for linseed production was Rs. 7080.67 while other cost/ha was Rs. 2531.75 and total cost/ha was Rs.9612.42. In

Jharkhand average gross income/ha from linseed production was Rs. 16013.83 and net income was Rs. 6401.42.

The Table 4.3.6 revealed that in Jharkhand, average land under *rabi* vegetable production was 0.28 ha while in Odisha it was 0.24 ha. In Jharkhand, the average labour man-days involved in vegetable crop production was 86.21 man-days/ha, while it was 60.18 man-days/ha in Odisha. In Jharkhand, the average labour cost per ha for vegetables was Rs. 17242.60, while in Odisha it was Rs. 12035.42, which was lower in comparison to Jharkhand. The result also indicates that in Jharkhand, other cost/ha was Rs. 7974.83 followed by total cost of Rs. 25217.43, while in Odisha it was Rs. 22720.96/ ha and Rs. 34756.38/ ha, respectively. In Jharkhand, the average gross income from vegetable production was Rs. 51976.68/ha and in Odisha, it was Rs. 73642.35/. The average net income from vegetable production was Rs. 26759.25/ha in Jharkhand and Rs. 50428.45/ha in Odisha, which was much higher in comparison to Jharkhand.

Table 4.3.7: Distribution of respondents according to livestock component

Sl. No	Particular	Jharkhand		Odisha	
		Household Nos. (%)	$x(sd)$	Household Nos. (%)	$x(sd)$
1.	Cow	74(70.48)	7.64 (5.32)	72(61.54)	4.76 (1.93)
2.	• Total Exotic breed	12(11.43)	2.83 (0.72)	54(46.15)	4.30 (1.52)
3.	• Total Local breed	69(65.71)	7.70 (5.43)	23(19.66)	4.52 (2.05)
4.	Buffalo	17(16.19)	3.76 (1.03)	-	-
5.	Bullock	27(25.71)	2 (0.00)	15(12.82)	2 (0.00)
6.	Goat	30(28.57)	7.03(3.27)	9(7.69)	9.88(1.27)
7.	Sheep	8(7.62)	7.25(3.61)	-	-
8.	Piggery	15(14.29)	8.8(1.42)	-	-
9.	Backyard poultry	16(15.24)	15.5(5.86)	9(7.69)	16.44(6.04)
10.	Duckery unit	5(4.76)	13(4.30)	18(15.38)	16.22(5.58)

Table 4.3.7 shows the distribution of various livestock animal in the sample households in the states of Jharkhand and Odisha. It is observed from the table that the average number of cows was 7.64 and 4.76 in Jharkhand and Odisha, respectively. The number of local cows was higher than the exotic cows in both states. No buffalo was reported in Odisha in the study area while in Jharkhand, about 16 per cent of the

households recorded buffalo population with an average of 3.76 per household. Similarly, sheep and piggery were not reported in the study locale of Odisha. In Jharkhand, the average number of backyard poultry was 15.5, while in Odisha it was 16.44. Duckery unit was on an average of 13 and 16.22 nos. in Jharkhand and Odisha, respectively. The average unit of goat in Jharkhand and Odisha were 7.03 and 9.88 respectively.

Table 4.3.8: Cost and economics of dairy components

Particular	Jharkhand		Odisha	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Average milk yield of local cow (l/ day)	2.35	0.49	2.46	0.51
Average yield of exotic cow (l/ day)	5.44	1.16	7.73	1.05
Average milk yield of buffalo (l/ day)	7.56	1.31	-	-
Labour (Man days/annum)	87.24	42.57	63.38	26.06
Cost of feed of local cow (Rs./ annum)	1857.64	1324.36	1257.00	687.28
Cost of feed of exotic cow (Rs./ annum)	2728.57	678.72	8425.22	2630.05
Miscellaneous cost (Rs./ annum)	794.67	550.32	1085.44	888.52
Total cost (Rs./ annum)	17627.90	12001.78	4751.59	4559.27
Income from milk (Rs./ annum)	22766.11	18081.46	26847.14	20475.73
Income from sale of animal (Rs./ annum)	8732.00	6963.88	4927.27	2679.41
Income from ploughing (Rs./ annum)	8974.07	3061.37	8886.67	2553.67
Total net income (Rs./ annum)	28596.49	19525.71	30204.08	22324.79
Average cow dung production (ton)	34.637	20.56	31.15	18.39

The economics of dairy farming component of Jharkhand and Odisha states is presented in Table 4.3.8. The table reveals that the average yields of milk of local and exotic cows were 2.35 l/day and 5.44 l/day, respectively in Jharkhand, while in Odisha, it was higher with values of 2.46 l/day for local cows and 7.73 l/day for exotic. Buffalo was reported only in the study area of Jharkhand and not in Odisha and the average yield of milk was 7.56 l/day. The average labour utilized in dairy farming was 87.24 man days and 63.38 man-days in Jharkhand and Odisha, respectively. The cost of feed of local cows was found to be lower than that of exotic cows in both the states. Odisha reported a higher miscellaneous cost per annum compared to Jharkhand. On the other hand, total cost of milk production was much higher in Jharkhand (Rs.17627.90/annum) compared to Odisha (Rs. 4751.59/annum).

The income generated from milk production and sale averaged at Rs. 22766.11/annum and Rs. 26847.14/annum in Jharkhand and Odisha, respectively. Both incomes from sale of animal and from ploughing were higher in Jharkhand than in Odisha. The total net income was also more in Jharkhand (Rs. 28596.49/ annum) than in Odisha (Rs. 30204.08 / annum). The average cow dung produced was 34.64 ton and 31.15 ton per dairy household in Jharkhand and Odisha, respectively.

Table 4.3.9: Cost and economics of piggery component (n=15)

Piggery	<i>x</i>	<i>sd</i>
Man-days	16.8	3.32
Labour cost (₹)	3360	664.19
Total cost (₹)	9746.667	4519.62
Gross income (₹)	64273.33	20574.99
Net income (₹)	54526.67	16055.37

The cost and income of pig rearing in Jharkhand are presented in Table 4.3.9. A perusal of the table shows that the average per annum 16.8 man-days labour were involved in pig rearing. The estimated average cost of labour was ₹ 3360, while the total cost was about ₹ 9747 per annum. The average gross income and net income generated were ₹ 64273 and ₹ 54527 per annum, respectively from the average piggery unit of 8.8.

Table 4.3.10: Characterisation of fisheries component

Fisheries component	Jharkhand	Odisha
	(n=10)	(n=48)
	<i>x(sd)</i>	<i>x(sd)</i>
Pond based area (ha)	0.30 (0.18)	0.35 (0.18)
Area of the pond (ha)	0.22(0.07)	0.17(0.15)
Pond dike area (ha)	0.08(0.12)	0.18(0.09)
No. of pond (no.)	1.80 (0.63)	1.92(0.77)
Proportion of household with inherited pond	40 %	39.58
Household with fingerling production	0	5(10.42)
Household with prawn production	0	9(18.75)

Analysis of Table 4.3.10 reveals that in Jharkhand, average size of pond based area was 0.30 ha, while it was 0.35 ha in Odisha. Average area of the pond was 0.22 ha in Jharkhand, while it was 0.17 ha in Odisha which was smaller as compared to average area of the ponds of Jharkhand. Similarly, average pond dike area in Jharkhand was 0.22 ha while it was 0.17 hectare in case of Odisha. Out of the total household who had pond in state of Jharkhand, 40 percent of them were inherited from their ancestors. A nearly similar result was found in case of Odisha as well where 39.58 percent of household were found to have inherited pond. In Jharkhand, no household was involved in fingerling and prawn production while in Odisha 10.42 per cent and 18.75 per cent households were engaged in fingerling and prawn production respectively of the total fish farmers besides fish production.

Table 4.3.11: Economics of Fisheries component

Fisheries component	Jharkhand (n=10)		Odisha (n=48)	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Fish Labour (Man days)	25.40	9.40	35.88	20.940
Fish Labour cost (₹)	5080	1879.01	7175	4188.05
Fish seed (₹)	1440	497.10	2985.63	2857.28
Feed Cost (₹)	1920	902.84	4916.79	5222.83
Other cost (₹)	1420	496.21	1493.69	1350.76
Total cost (₹)	9860	2648.77	16571.10	13283.03
Fish production (Kg)	158.9	130.03	358.17	383.58
Gross income from Fish (₹)	20100	13386.98	40092.08	39607.12
Net income from Fish (₹)	10240	11112.38	23520.98	26553.23
Income from Fingerling (₹)	0	0.000	75000	28939.59
Income from prawn (₹)			11333.33	5830.95

Table 4.3.11 shows the cost of rearing fish per annum in the states of Jharkhand and Odisha. It was found that in the study area, 10 and 48 nos. of farmers in Jharkhand and Odisha, respectively had fishery as a component of their farming system. The average labour man-days was 25.4 and 35.88 in Jharkhand and Odisha, respectively. While the average labour cost incurred was ₹5080 and ₹ 7175 respectively. The total cost was higher in Odisha (₹ 16571.10 per annum) compared to Jharkhand (₹ 9860 per annum). Fish production and gross income were reported to be higher in Odisha than in Jharkhand. The net income generated was also higher in

Odisha being approximately ₹ 23520.98, while it was about ₹10240 in Jharkhand. Fingerling and prawn were found to be produced only in Odisha generating an income of ₹ 75000 and ₹ 11333.33 per annum.

Table 4.3.12: Horticulture –plantation and agro-forestry components

Horti - plantation and agro-forestry	Jharkhand	Odisha
Household with Horticultural components	10	51
Household with plantation	0	29
Household with Agro -forestry	0	6
Major horticultural plants *		
○ Banana	52.5 (22.88)	37.2(29.87)
○ Mango	23.33 (6.65)	12.55(5.03)
○ Papaya	18.67 (6.97)	12.72(11.66)
Major plantation crop *		
● Areca nut	-	22.63 (7.76)
● Coconut		19.66(10.11)
Major Agro-forestry*		
● <i>Acacia auriculiformis</i>	-	35.5 (16.60)
● Average years of <i>Acacia auriculiformis</i>		11.33 (4.17)

*mean and standard deviation in parenthesis

Table 4.3.12 reveals that in Jharkhand, 10 households were found with horticulture components while such households with horticultural component were 51 in Odisha. Likewise in Odisha, households with plantation crops were 29 and households with agro-forestry were 6. Among the major horticultural plants in Jharkhand, the average number of banana plants per banana grower was 52.5, the average number of mango plants per mango grower was 23.33 and the average number of papaya plants per papaya grower was 18.67. In case of Odisha among the major horticultural plants the average number of banana plants per banana grower was 37.2, the average number of mango plants per mango grower was 12.55 and the average number of papaya plants per papaya grower was 12.72. Analysis of the results explicitly shows there was higher number of average horticultural plants in Jharkhand as compared to Odisha.

Table 4.3.13: Characterisation of Mushroom component

Mushroom	Odisha (n=9)
Average no. of bed*	55.33(42.21)
Average production cycle (pc)**	7 (1.15)
Type of mushroom	
● Paddy mushroom	all

*Average bed size=1.5 X 1.5 feet ** production cycle =20-26 days

Table 4.3.13. reveals the status of mushroom cultivation practiced by farmers in Odisha. Farmers owned 55.33 number of bed for mushroom production. The average number of production cycle was 7.

Table 4.3.14: Economics of mushroom component

Particular	<i>x</i>	<i>sd</i>
Labour man-days	58.11	22.34
Labour cost (₹)	11622.22	4468.16
Input and other cost (₹)	15222.22	10929.06
Total cost (₹)	26844.44	15086.34
Gross income (₹)	68622.22	51841.24
Net income (₹)	41777.78	37295.37

The cost of cultivation of mushroom in Odisha is given in Table 4.3.14. The average labour engaged was about 58 man-days. While the cost incurred in labour was ₹11622, input and other cost was Rs. 15222.22. The total cost of cultivation of mushroom was approximately ₹ 26844. The per annum average gross income was ₹ 68622, while the net income generated was about ₹ 41778.

Table 4.3.15: Description of variable for Technical Efficiency

Variable	Jharkhand		Odisha	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Outputs				
Net income from Crop and vegetable components	48010.24	29038.8	95044.1	46437.06
Net income from Pond components	10240	11112.38	33323.72	51616.26
Net income from Livestock components	43932.08	29315.23	35602.9	26486.38
Net income from Miscellaneous other component Rs/annum	17390	12612.73	15040.68	16805.68
Inputs				
Labour man days per annum	236.94	91.39	253.97	101.53
Land holding (ha)	1.66	0.81	2.25	0.93
Total fertilizer cost (Rs/annum)	3229.98	2383.68	5643.19	2723.44
Total Feed cost (Rs/annum)	1820.5	1769	4167.59	5725.64
expenditure incurred other than fertilizer, feed and labour cost (Rs/annum)	13863.47	7057.15	34392.25	17484.97

The outputs and inputs used in the estimation of technical efficiency through DEA technique is summarised in the Table 4.3.15. A perusal of the table reveals that the output variables used were per annum net income derived from crop production which includes field crops and vegetable, fisheries and allied components, rearing livestock such as dairy, goat, piggery, poultry duck and miscellaneous income derived from horticulture, plantation and mushroom. The input variables were labour (man-days/annum), operational land holding (ha), per annum expenditure incurred on fertilizer, feed and expenditure incurred other than fertilizer, feed and labour cost. The table shows that the average net income derived from crop cultivation was higher in Odisha (Rs. 95044.10/annum) compared to that of Jharkhand (Rs. 48010.24/ annum). Similarly, the net income from fisheries and allied components was higher in Odisha (Rs. 33323.72/annum than that of Jharkhand (Rs. 10240.00/ annum). In case of net income from livestock component, Jharkhand recorded higher value (Rs. 43932.08/ annum) than Odisha (Rs. 35602.90/ annum). Similarly, average miscellaneous income was higher in Jharkhand.

In case of inputs, the labour man-days were slightly higher in Odisha (253.97 man days/ annum) than in Jharkhand (236.94 man days/ annum). Operational landholding averaged at 2.25 ha in Odisha and 1.66 ha in Jharkhand. The annual expenditure on fertilizer and feed were higher in Odisha compared to that of Jharkhand, while in case of others expenditure, Jharkhand reported higher value.

Table 4.3.16: Distribution of farms according to Technical Efficiency

Efficiency range (Percentage)	Jharkhand	Odisha
40-50	1 (0.95)	1 (0.86)
50-60	8 (7.62)	10 (8.62)
60-70	12 (11.43)	20 (17.24)
70-80	22 (20.95)	23 (19.83)
80-90	17 (16.19)	24 (20.69)
90-100	45 (42.86)	38 (32.76)
Total	105 (100.00)	116 (100.00)

Mean	83.31	81.34
Standard Deviation	15.10	14.89
Minimum	47.80	44.20
Maximum	100.00	100.00

Figure in parenthesis indicates percentage to total number of households

The frequency distribution of farms according to Technical Efficiency (TE) for both Jharkhand and Odisha is presented in Table 4.3.16. In both the states, majority of farm households were concentrated in the range of 90-100 per cent TE (42.86 % in Jharkhand and 32.76 % in Odisha). The minimum value of TE was 47.80 per cent in Jharkhand and 44.20 per cent in Odisha.

Table 4.3.17: Average Technical Efficiency across different landholding categories

Category	Jharkhand	Odisha
Small	83.78 (15.52)	80.35 (15.87)
Medium	81.64 (15.29)	83.43 (14.33)
Large	85.10 (11.40)	75.92 (11.77)
Total	83.31 (15.10)	81.34 (14.89)

Figure in parenthesis indicate standard deviations

The average value of technical efficiency coefficients for the farms in Jharkhand and Odisha according to landholding categories are presented in Table 4.3.17. It can be seen from the table that the overall average of all efficiency was higher in the case of Jharkhand (83.31 %) as compared to Odisha (81.34 %). In the case of Jharkhand, the efficiency was highest in large farms (85.10 %) followed by small (83.78 %) and large categories (85.10 %). However, in Odisha, it was the highest in medium group followed by small and large categories with value of 83.43 per cent, 80.35 per cent and 80.35 per cent, respectively.

4.4. Adoption and constraints in adoption of integrated farming systems

Table 4.4.1 presents the results of the logistic regression for examining the determinants of adoption of vegetable component in the farming system in Odisha and Jharkhand. The results show that owned land and proportion of irrigated area in *Rabi*

season positively and significantly influenced the probability of adoption of vegetable farming as a component of the farming system. This implies that the more the land owned by the farmer and the more the area under irrigation during *Rabi* season, the more the farmer is likely to adopt vegetable as a farming component. On the other hand, distance to market had a negative and significant effect, which means nearer the market the likelihood to adopt vegetable, is more.

The table further shows the determinants of intensive vegetable cultivation by the farmers. Intensity is calculated by dividing the net income from vegetable production per unit area. It is observed from the table that age of the household head, his education, proportion of irrigated area under *Kharif* crops and extension contact had a positive and significant effect meaning that as these factors increase, the net income generated from vegetable cultivation per unit area is also increased. The years of farming experience and distance to market, on the other hand, had a negatively significant effect. This implies that as years of farming experience and distance to market increases, the net income per unit area from vegetable farming is decreased.

Table 4.4.1: Determinants of adoption of vegetable components and intensity of adoption (n=222)

Dependent variable	Adoption of Vegetable cultivation			Intensity of Vegetable cultivation		
	Coef.	Std.	p	Coef.	Std.	p
Age	0.002	0.051	0.975	415.763*	247.526	0.095
Education	0.043	0.091	0.635	1069.796**	413.642	0.010
Farming Experience (Year)	-0.043	0.054	0.433	-502.458*	268.875	0.063
Own area (ha)	0.881**	0.351	0.012	1573.324	1203.766	0.193
Proportion of irrigated area in <i>Rabi</i> season	8.567**	3.558	0.016	5656.028	3987.298	0.158

Proportion of irrigated area in <i>Kharif</i> season	0.700	0.690	0.310	36266.670***	8179.700	0.000
Distance to nearest plot from home	-0.372	0.525	0.479	406.492	3230.927	0.900
Distance to market	-0.159***	0.042	0.000	-1135.950***	199.115	0.000
Access to extension	-0.480	0.583	0.411	7136.818**	2813.410	0.012
Credit	1.005	0.648	0.121	2079.469	2949.980	0.482
State (Jharkhand=1, Odisha=0)	0.177	0.588	0.764			
_cons	3.336	2.132	0.118	21802.370**	9539.470	0.023

Significant at 5% level of significance; * Significant at 1% level of significance

Table 4.4.2: Determinants of adoption of pond-based farming system and intensity of pond-based farming in Odisha

Dependent variable	Adoption of pond-based farming system			Intensity of pond-based farming		
	Coef.	Std.	p	Coef.	Std.	p
Explanatory variable						
Age	-0.095*	0.055	0.083	75.991	1252.956	0.952
Education	0.023	0.089	0.791	-37.708	1786.376	0.983
Farming Experience (Year)	0.079	0.061	0.192	-88.053	1410.384	0.950
Dependency Ratio	1.025	0.719	0.154	14509.070	15471.24	0.350
Own area (ha)	0.737**	0.318	0.020	17880.73**	5810.410	0.003

				*		
Distance to nearest plot from home	- 4.014***	0.878	0.000	- 52485.60** *	16762.86 0	0.002
Distance to market	-0.005	0.050	0.921	974.39	990.255	0.327
Extension contact	0.361	0.635	0.570	16442.60	13208.65 0	0.216
Credit	0.763	0.648	0.239	12875.42	13637.88 0	0.347
_cons	2.078	1.962	0.289	-1499.010	44400.51 0	0.973

Significant at 5% level of significance; * Significant at 1% level of significance

Table 4.4.2 shows the determinants of adoption of pond-based farming system in the state of Odisha. Pond-based farming consists of poultry, duckery and horticultural crops. It is observed from the table that owned land area and distance to farm had a positive and significant effect on the probability of adoption of pond-based farming system while age of the household head had a significant negative effect. The table also shows the determinants of income generated per unit area of such farming system. In this case, owned area and distance to farm had a positive significant effect. This implies that the net income generated per unit area from pond based farming system increased with increase in owned land area and distance to farm.

Table 4.4.3: Crop diversification pattern according to landholding

Land Holding Category	Herfindahl Index value		
	Jharkhand	Odisha	Total
	Mean (sd)	Mean (sd)	Mean (sd)
Small (< 2 Ha)	0.40 (0.24)	0.51 (0.14)	0.45 (0.21)
Medium (2-4 Ha)	0.37 (0.13)	0.44 (0.11)	0.42 (0.12)
Large (> 4 Ha)	0.31 (0.05)	0.45 (0.10)	0.39 (0.11)
Total	0.39(0.20)	0.47 (0.13)	0.43 (0.17)

Table 4.4.3 presents the status of crop diversification in different landholding category. Here, level of crop diversification is measured by using Herfindahl Index. A small index value indicates a competitive high level of crop diversification. The above table indicates that the farmers' group with relatively large landholding (>4 ha) have the lowest Herfindahl Index value, meaning that it has the highest level of crop diversification. The trend is almost same in both Jharkhand and Odisha.

Table 4.4.4: Determinants for crop diversification

	Jharkhand n=105			Odisha n =117			Pooled N=222		
	Coef.	Std.	p	Coef.	Std.	p	Coef.	Std.	p
Diversification									
Age	0.0006	0.002	0.780	-0.0005	0.001	0.662	-0.0002	0.001	0.872
Education	0.0004	0.007	0.951	-0.0010	0.004	0.774	-0.002	0.003	0.529
Primary occupation	0.0391	0.025	0.113	0.0178	0.013	0.159	0.0125	0.012	0.304
Own area	-0.0162	0.017	0.353	-0.0238**	0.011	0.026	-0.032***	0.011	0.005
Proportion of area under irrigation in <i>Kharif</i>	-0.0397	0.060	0.511	0.0208	0.034	0.536	0.0739**	0.032	0.021
Proportion of area under irrigation in <i>rabi</i>	-0.0660	0.122	0.589	-0.2428***	0.069	0.001	-0.344***	0.064	0.000
Distance to market	0.0130***	0.003	0.000	0.0050***	0.002	0.003	-0.0006	0.002	0.727
Access to extension	0.0311	0.046	0.496	0.0177	0.024	0.459	0.0223	0.021	0.297
Access to credit	-0.0882	0.044	0.048	-0.0462	0.025	0.063	-0.0095	0.023	0.681
Participation in training	0.0688	0.057	0.231	0.0146	0.027	0.590	-0.0161	0.023	0.490
Willingness to take risk	-0.0232***	0.008	0.007	-0.0127**	0.005	0.015	0.0014	0.006	0.811
State (Jharkhand =1, otherwise 0)				-0.1477	0.024	0.000			
Constant	0.4543	0.184	0.015	0.6927	0.101	0.000	0.5616	0.100	0.000

Table 4.4.4 presents the output of the Tobit regression model which is used to identify the determinants of crop diversification. The table reveals that in Jharkhand, distance to market ($p < 0.001$) has positively significant effect and willingness to take risk ($p = 0.007$) has negatively significant effect on Herfindahl Index value, *i.e.* distance to market and willingness to take risk influence crop diversification negatively and positively, respectively. The analysis of data from Odisha revealed that own area ($p = 0.026$), proportion of area under irrigation in *rabi* season ($p = 0.001$), distance to market ($p = 0.003$) and willingness to take risk (0.015) have statistically significant relationship on the level of crop diversification. The analysis of pooled data from Jharkhand and Odisha reveals that own area ($p = 0.005$), proportion of area under irrigation in *Kharif* ($p = 0.021$), proportion of area under irrigation in *Rabi* ($p < 0.001$) have statistically significant effect on level of crop diversification.

Table 4.4.5: Income diversification pattern according to landholding category

Land Holding Category	Herfindahl Index value			
	Jharkhand		Odisha	
	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Small (< 2 Ha)	0.325	0.243	0.409	0.248
Medium (2-4 Ha)	0.326	0.175	0.323	0.148
Large (> 4 Ha)	0.411	0.157	0.303	0.090

Table 4.4.5 presents the status of income diversification in different landholding categories. The level of crop diversification was measured by using Herfindahl Index. A low index value indicates a comparatively high level of income diversification. Analysis of level of income diversification according to landholding, indicates that in Jharkhand farmers group with relatively large landholding (>4 ha) have highest Herfindahl Index value, means lowest level of crop diversification followed by medium (2-4 ha) and low (<2 ha) landholding group. The trend is opposite in Odisha where that farmers' group with high landholding (>4 ha) have lowest Herfindahl Index value, means that the highest level of crop diversification was followed by farmers group with medium (2-4 ha) and low (<2 ha) landholding.

Table 4.4.6: Determinants for income diversification

Diversification	Jharkhand n=105			Odisha n =117			Pooled N=222		
	Std.	Err	p	Std.	Err	p	Std.	Err	p
Age	0.003	0.003	0.265	-0.002	0.002	0.143	-0.001	0.001	0.313
Education	0.019**	0.008	0.024	-0.005	0.005	0.341	0.003	0.004	0.445
Primary occupation	0.022	0.028	0.442	0.022	0.018	0.237	0.014	0.016	0.370
Land holding	0.007	0.020	0.738	-0.004	0.017	0.805	0.008	0.013	0.538
Proportion of area under irrigation in <i>Kharif</i>	0.068	0.069	0.332	0.083	0.048	0.088	0.068	0.041	0.102
Proportion of area under irrigation in <i>rabi</i>	-0.203	0.140	0.151	-0.510** *	0.097	0.000	-0.396***	0.085	0.000
Distance to market	0.004	0.003	0.217	0.003	0.003	0.331	0.002	0.002	0.251
Access to extension services	0.064	0.053	0.226	0.015	0.032	0.644	0.019	0.029	0.529
Access to credit	-0.089	0.051	0.082	-0.041	0.035	0.247	-0.058	0.031	0.058
Participation in training	-0.008	0.066	0.902	0.024	0.035	0.492	-0.006	0.033	0.866
Willingness to take risk	-0.031***	0.010	0.002	-0.032** *	0.009	0.001	-0.033***	0.006	0.000
State (Jharkhand =1, otherwise 0)							-0.107	0.030	0.000
_cons	0.422	0.212	0.049	1.006	0.152	0.000	0.903	0.125	0.000

A Tobit regression model was used to identify the factors that influence the level of income diversification, the result of which is presented in Table 4.4.6. It reveals that in Jharkhand, education ($p=0.024$) and willingness to take risk ($p=0.002$) have significant influence on the level of income diversification. In Odisha, proportion of area under irrigation in *Rabi* ($p<0.001$) and willingness to take risk ($p=0.001$) have significant influence on income diversification. The analysis of pooled data from Jharkhand and Odisha also reveals that proportion of area under irrigation in *Rabi* ($p<0.001$) and willingness to take risk ($p<0.001$) have significant effect on the level of income diversification.

Table 4.4.7: Descriptive statistics for the attitude towards adding of farm components

Belief based attitude:	Belief strength (bs) (1 to 5)			Outcome evaluation (oe) (-2 to +2)			bs×oe (-10 to +10)	
	Mode	<i>x</i>	<i>sd</i>	Mode	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Improve soil health	3	2.92	0.90	2.00	1.66	0.50	4.84	2.17
Minimize input cost with resource flow between components	3	3.02	0.94	1.00	1.44	0.55	4.36	2.21
Reduces the use of chemicals and fertilizers	2	2.16	1.02	-1.00	0.23	1.14	0.44	2.75
Increase farm productivity	4	3.98	0.77	2.00	1.86	0.35	7.42	2.04
Increase and Stable farm income round the year	4	4.06	0.88	2.00	1.83	0.37	7.44	2.24
Generate employment round the year	3	3.08	0.87	2.00	1.68	0.47	5.28	2.28
Better adapt and cope with climatic aberration	3	2.62	1.04	2.00	1.72	0.45	4.52	2.22
Minimize farm production risk	2	2.80	0.84	2.00	1.71	0.45	4.73	1.83
Improve food security for household through diversified food produce	3	3.09	1.05	2.00	1.69	0.64	5.16	2.73
Cope with livelihood insecurity	3	2.72	0.89	2.00	1.88	0.33	5.13	1.89

The farmers opined that adoption of more number of farming components would increase farm productivity, stabilize their income, generate employment, improve food security and adaptation to climatic aberration (Table 4.4.7). Majority of farmers' believed that adoption of more farm component would not reduce the use of chemical and fertilizer and there was less agreement on the item.

Table 4.4.8: Descriptive statistics of subjective norm towards adding of farm components

Belief based SN:	Normative beliefs (NB) (-2 to +2)						Motivation to comply (MC) (1 to 5)			nb(d) x mc		nb(i) x mc	
	Diversification			Integration						Diversification		Integration	
	Mode	<i>x</i>	<i>sd</i>	Mode	<i>x</i>	<i>sd</i>	Mode	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Family	2.00	1.70	0.53	2.00	1.37	0.71	5.00	4.15	1.06	7.04	2.80	5.63	3.33
Friends	2.00	1.79	0.41	2.00	1.69	0.48	3.00	2.54	0.85	4.51	1.79	4.31	1.93
Farmers with more components	2.00	1.90	0.30	2.00	1.90	0.30	4.00	3.68	0.94	7.01	2.14	6.94	2.07

Crop based farmers	2.00	1.91	0.29	2.00	1.91	0.29	1.00	1.19	0.39	2.26	0.82	2.27	0.85
Village heads/ Gram panchayat	2.00	1.31	0.89	2.00	1.37	0.77	2.00	2.70	1.19	3.76	3.24	3.76	2.82
Farm advisors / extension agents'	2.00	1.15	0.97	2.00	1.06	1.00	5.00	4.49	0.56	5.15	4.45	4.81	4.60

Normative belief shows that all the information source and family members promote to adopt more components for farm diversification and also shared to integrate their farm components to the maximum extent. The respondent gave more weightage to their family member, farm advisor and farmers with many farm components in making decision.

Table 4.4.9: Descriptive statistics of perceived behavioural control towards adding of farm components

Belief based PBC:	Control belief (cb) (1 to 5)			Power of control (pc) (-2 to +2)			cb x pc -10 to +10	
	Mode	<i>x</i>	<i>sd</i>	Mode	<i>x</i>	<i>sd</i>	<i>x</i>	<i>sd</i>
Demand for greater commitment to management of farm	5.00	4.26	0.80	1.00	0.45	1.26	1.65	5.49
High establishment cost	4.00	4.25	0.71	-2.00	-1.76	0.43	-7.45	2.18
Unanticipated and Intensive labour demand	5.00	3.74	1.18	-1.00	-0.17	1.11	-0.60	4.31
Requirement of technical knowhow of different farm components	4.00	3.85	0.73	1.00	0.53	1.04	1.93	4.07
Demands for different farm inputs	4.00	4.07	0.92	-1.00	-0.77	1.16	-3.17	5.02
Availing credit/ subsidy for farming	5.00	4.39	0.76	-2.00	-1.22	0.87	-5.35	3.96
Marketing of diversified farm produce	4.00	3.83	0.96	1.00	-0.16	1.22	-0.64	4.93
Having a suitable farm land/site for adoption of different farm components and to maximize integrations.	5.00	4.09	0.80	-2.00	-0.77	1.67	-3.11	7.03

Most of the respondents agreed that the adoption of more farm components would require greater commitment to management of farm, intensive inputs demands and high establishment cost. The farmers also perceived that with more components the needs for technical know of diversified components would be more and the

demand for labour would be more. The need for suitable farmland to add more components was given due importance by the respondents. Whereas most of the farmers faced the constraint of financial need to add more components, availing credit and subsidy for farming remained major challenges to add more components. Demand for more farm inputs and labour demand were also major challenges. Greater commitments to requirement for farming and marketing of diversified produced were not considered by majority in adoption of more farm components.

Table 4.4.10: Spearman rank coefficient (rs) for the correlation between attitude, subjective norms, perceived behavioural control and intentions and socio-economic variable

	Age	Education	Proportion of area irrigation in kharif season	Proportion of area irrigation in rabi season	Distance to market	Land holding	Attitude	Subjective norm- for choice of farm components for farm diversification	Subjective norm- for choice of farm components for integration through maximum farm resources	Perceived behavioural control	Intension to diversify of farm components	Intension to integration of farm components
Age	1											
Education	-0.1835	1										
Proportion of area irrigation in kharif season	0.1077	0.2289*	1									
Proportion of area irrigation in rabi season	-0.074	0.1129	0.3538*	1								
Distance to market	0.1567	-0.1276	-0.0257	-0.1015	1							
Land holding	0.2234*	0.4390*	0.1919*	-0.0376	0.0124	1						
Attitude	-0.103	0.0641	0.1265	-0.03	-0.0055	0.0015	1					
Subjective norm- for choice of farm components that does not emphasize on resource flow	0.0533	0.1536	0.1605	0.0543	-0.0919	0.2943*	0.0637	1				
Subjective norm- for choice of farm components that maximized resources flow	0.0437	0.1164	0.1485	0.1019	-0.0465	0.1123	0.106	0.2859*	1			
Perceived behavioural	0.0703	0.0142	-0.0245	-0.1127	-0.0307	0.1055	-0.1742	0.0226	-0.1993*	1		

control												
Intention to diversify of farm components	0.0535	0.1061	0.1178	-0.0259	-0.063	0.1832	0.1816	0.1699	0.1518	0.2282*	1	
Intention to integration of farm components	0.0581	0.2817*	0.1164	-0.1127	-0.0412	0.3790*	0.2597*	0.1886	0.0716	0.1208	0.6259*	1

*Significant correlations at $p < 0.05$

Table 4.4.10 reveals that intention to add components that does not emphasize on resource flow is positively correlate to perceived behavioural control. Whereas intention to choose component that maximized resource flow between the components is positively correlate to education, land holding, attitude toward adding of more farming component. Whereas the intentions and subjective norms does have any significant relation.

Table 4.4.11: Variable relationship of TBP framework for intention to farm diversification

Variable Relationship	Factor Loading	Standardised Factor Loading	T-Value	P-Value
Outcome Belief → Attitude	1.42	0.70	10.94	<0.05
Outcome Belief → Subjective Norm	-0.01	-0.01	-0.14*	<0.05
Outcome Evaluation → Attitude	2.10	0.39	5.96	<0.05
Subjective Belief → Attitude	-2.16	-0.37	-4.12	<0.05
Subjective Belief → Subjective Norm	3.46	0.70	15.39	<0.05
Motivation to comply → Subjective Norm	1.68	0.51	11.22	<0.05
Control of Belief → Perceived Behavioural Control	-0.34	-0.10	-1.57*	<0.05
Power of Control → Perceived Behavioural Control	4	0.73	11.14	<0.05
Attitude → Intention to add components to diversify	0.02	0.19	1.93*	<0.05
Perceived Behavioural Control → Intention to add component to diversify	0.02	0.27	2.88	<0.05
Subjective Norm → Attitude	0.56	0.48	5.31	<0.05
Subjective Norm → Intention to add component to diversify	0.13	0.13	1.30*	<0.05

The result of Table 4.4.11 revealed that intension to add components that does not emphasis on bio-resources flow is significantly influenced by attitude towards

adding of more components and subjective norm. The result also revealed that Outcome Belief → Subjective Norm and Control of Belief → Perceived Behavioural Control were found significant. Table 4.4.12 showed that model successfully meet the criteria of a good model with Standardized RMR and Goodness-of-Fit index are at the acceptance level.

Table 4.4.12: Goodness of Fit Index of Model for intention to farm diversification

Name of category	Name of index	Value obtained	Level of acceptance
Absolute fit	Chi-square	54.34 (0.00002- P-Value)	P value >0.05
	Root Mean Square Error of Approximation (RMSEA)	0.141	<0.1
	Standardized Root Mean Square Residual (RMR)	0.046	<0.05
	GFI	0.91	>0.90

Table 4.4.13: Variable relationship of TBP framework for intention to integration of farm component

Variable relationship	Factor loading	Standardized factor loading	T-value	P-value
Outcome Belief → Attitude	1.46	0.90	26.56	<0.05
Outcome Evaluation → Attitude	2.57	0.59	17.57	<0.05
Subjective Belief → Subjective Norm	3.63	0.81	29.11	<0.05
Motivation to Comply → Subjective Norm	1.57	0.51	18.44	<0.05
Control of Belief → Perceived Behavioural Control	-0.32	-0.10	-1.48*	<0.05
Power of Control → Perceived Behavioural Control	3.98	0.74	11.24	<0.05
Attitude → Intention to integrate component	0.05	0.28	2.98	<0.05
Perceived Behavioural Control → Intention to add components to integrate component	0.02	0.19	1.92*	<0.05
Subjective Norm → Intention to add components to integrate component	0.01	0.08	0.82*	<0.05

Table 4.4.13 showed that Perceived Behavioural Control influenced the farmers' intention to add components to integrate component. Subjective Norm also significantly influenced the farmers' intention to add components to integrate component was found to have significance influence on the intention to add components that maximised resource flow between the components. Control of Belief → Perceived Behavioural Control was also found significant. Table 4.4.14 also suggest that Chi-square, Goodness-of-Fit index, RMSEA and Standardized RMR are at the level of acceptance.

Table 4.4.14: Goodness of fit measures of the model for TBP framework for intention to integration of farm component

Name of category	Name of index	Value obtained	Level of acceptance
Absolute fit	Chi-square	13.12(p-value=0.90437)	P value >0.05
	Root Mean Square Error of Approximation (RMSEA)	0.000	<0.1
	Standardized Root Mean Square Residual (RMR)	0.024	<0.05
	GFI	0.98	>0.90

4.4.1 Constraints in adoption of integrated farming system

The data presented in Table 4.4.15 depicted that in cereal-pulse farming there were many constraints which were more prevalent in the cereal-pulse based farming system. It was found that high dependence on monsoon was most prevalent constraint in cereal-pulse farming system as perceived by the respondents, and it was ranked first (Garret Mean score =69.73). It was due the fact that for cereal-pulse farming is water consuming and heavily input-based system. Similarly lack of irrigation (Garret Mean score =68.73) was also found as second most constraint perceived by respondents which affected cereal-pulse farming. High pest attack (Garret Mean score=67.80) was third most important constraint in cereal-pulse farming. This may be due to lack of modern varieties in cereal-pulse farming which was another constraints (Garret Mean score=61.33) and some other reasons also. In spite of this low price during harvesting (Garret Mean score=58.85) and lack of marketing

facilities (Garret Mean score=58.85) were constraints which had less effect on cereal-pulse farming system.

Table 4.4.15: Constraints faced in cereal component in different farming system model

Sl. No.	Particular	Garret Mean score	Rank
1.	High dependence on monsoon	69.73	I
2.	Lack of irrigation facility	68.43	II
3.	High pest attack	67.80	III
4.	Lack of modern varieties	61.33	IV
5.	Low price during harvesting	58.85	V
6.	Lack of marketing facilities	57.33	VI

Table 4.4.16: Constraints faced by vegetable based farmers

Sl. No.	Particular	Garret Mean score	Rank
1.	Poor market infrastructure	70.45	I
2.	Lack of irrigation facility	69.95	II
3.	Non availability of quality seed	68.65	III
4.	High wage of labour	67.73	IV
5.	Lack of storage facility	63.65	V
6.	High interference of middleman	55.50	VI

From the table 4.4.16 it is evident that in case of vegetable farmers poor market infrastructure was the major constraints followed by lack of irrigation facility, nonavailability of quality seed. High wage of labour, lack of storage facility were ranked as fourth and fifth in vegetable farming. High interference of middleman in vegetable procurement and selling was perceived as least important constraints which affect vegetable farming.

Table 4.4.17: Constraints faced by livestock based farmer

Sl. No.	Particular	Garret Mean score	Rank
1.	Lack of availability of green fodder	73.33	I
2.	Disease problems	69.55	II
3.	Low productivity of animals	66.85	III
4.	Inadequate extension service	64.75	IV
5.	Low availability and high cost of feed concentrates	59.35	V
6.	Lack of regulated market and cooperatives	58.50	VI

Different constraints faced by livestock based farmers were studied. Table 4.4.17 revealed that livestock farmers mostly faced problem of non-availability of green fodder was ranked first followed by occurrence of disease. Low productivity of animals, inadequate extension services were ranked third and fourth. Low availability and high cost of feed concentrates was perceived as important constraint which affected livestock productivity in farming system and it was rank fifth among different constraints. Lack of regulated market and cooperatives was ranked sixth.

Table 4.4.18: Constraints faced by fish based farmers

Sl. No.	Particular	Garret Mean score	Rank
1.	Lack of market facilities	70.55	I
2.	High establishment cost	68.66	II
3.	Unavailability of quality fingerlings	65.46	III
4.	Lack of storage facilities	63.85	IV
5.	Limited knowledge about improved farming technology	59.33	V
6.	Unavailability of quality feed	56.50	VI
7.	Social problems like thieves and poisoning	55.95	VII

It is evident from the table 4.4.18 that in fish farming, the respondents faced several problems. Lack of market facilities was the major constraint as perceived by respondents followed by high establishment cost Unavailability of quality fingerlings

was also found to be another constraint which affected the fish farming was rank third. Lack of storage facilities limited knowledge about improved farming technology and unavailability of quality feed were ranked fourth, fifth and sixth respectively. Social problem like thief and poisoning was ranked seventh.

4.5: Impact of Integrated Farming Systems

It is drawn from the table Table 4.5.1 that there are 6 major combinations of IFS model. (Crop +Livestock) combination had been adopted by 9.5 per cent of the sampled farmers and gave a net income Rs. 61777.91 with B: C ratio of 2.53. The system generate an average man days of 181 per annum. The major combination was Crop +Livestock Vegetable which was adopted by about 27 per cent. The combination gave an annual income of Rs. 16623 as net profit with 1.46 B: C ratio. The second major combination is Crop +livestock Vegetable +goat, which gave a net benefit of Rs. 60111 with B: C ratio of 2.2. Moreover it generates about 195 man days per annum. Another combination Crop + livestock +vegetable +fish +horticulture +poultry adopted by about 6 per cent of sampled farmers, which give an average with net income of Rs. 94731.99 with B: C ratio 2.5 and generate man days of 247 per annum.

Table 4.5.1: Impact of different IFS Model on income and employment generation in Jharkhand

Farming system	Frequency (%)	Component average unit*	Cost/ha (Rs)	Return/ha (Rs)	Net return/ha (Rs)	B:C ratio	Average Man-days
Crop +livestock	10 (9.52)	SAU=7.38	44129.40	1059073.15	61777.91	2.53	181
Crop +vegetable	13 (12.38)	-	30324	62163	30939	2.00	111.49
Crop +livestock + goat	5 (4.76)	SAU:7.2 Goat: 7	58289	147707	89409	2.52	214
Crop +livestock+ Vegetable	29 (27.62)	SAU:4.62	44759.29	61382.54	16623.26	1.46	195

Crop +livestock Vegetable +goat	16(15.23)	Goat :6 SAU:7.85	52520	112631	60111	2.21	189
Crop + vegetable +pig +poultry	4 (3.81)	Pig :8 Poultry:17	45285.00	129463.07	84178.08	2.91	125
Crop + livestock +vegetable +fish +horticulture +poultry	6 (5.71)	SAU:13.16 Duck:14.5 Banana:56 Mango:15 Pond area :0.32	65512.17	160244.16	94731.99	2.50	247

*Crop and vegetable income from one ha from both *kharif* and *rabi* season

SAU: Standard Animal Units

Table 4.5.2: Impact of different IFS Model on income and employment generation in Odisha

Farming system	Frequency (%)	Component average unit*	Cost/ha	Return/ha	Net return/ha	B:C ratio	Average Man-days
Crop + vegetable	24 (20.51)	-	40470.92	78639.5	38168.58	1.97	106
Crop + Vegetable + Horticulture + Plantation crops	4 (3.42)	Papaya plant:9 Banana plant:18 coconut plant:20 Areca nut: 26	31976.64	87115.64	55139	2.77	81
Crop + Livestock + Vegetable + Horticulture + Plantation crops	4 (3.42)	Banana:30 Papaya:10 Coconut:15 Arecanut:24 SAU:2.8	43833.5	138170	94336.26	3.02	146
Crop + Livestock + Vegetable + Mushroom	2 (1.71)	SAU:1.9 No. of mushroom Beds:46	52483.03	126146.4	73663.32	2.4	99

Crop +livestock +Vegetable	14 (11.97)	SAU:3.6	38660.39	101678.4	63018.03	2.63	92
Crop+ Livestock+ Vegetable+ Fish+ Horticulture	10 (8.5)	SAU:3.5 Fish pond area :0.26 ha Banana plant:29 Papaya plant: 16	53268.06	161095.7	107827.6	3.02	131
Crop + Livestock +Vegetable +Fish +Horticulture +Plantation crop +Poultry /duckery	7 (5.98)	Fish pond area : 0.29 ha Banana plant:21 Mango:11 Papaya:16 Coconut: 17 Arecanut: 14 SAU:3 Poultry:12 Duckery:18	45957.96	155982.1 1	110025	3.39	177

*Crop and vegetable income from one ha from both *kharif* and *rabi* season

The study reveals seven major combinations of IFS model in Odisha (4.5.2). The Crop + Vegetable combination was adopted by 20 per cent of the sampled household in Odisha, which provided average an average net income Rs. 38168.58 with 1.97 B:C ratio. Another major combination was Crop + Livestock + Vegetable, adopted by 12 per cent with average net income of Rs. 63018 with B: C ratio 2.63. Third major combination was Crop + Livestock + Vegetable + Fish + Horticulture; adopted by 8.5 per cent farmers generate an average net income of Rs. 107827.6 with B: C ratio 3.02. The system also generated employment of about 131 man days per annum. There is another major combination (Crop + Livestock +Vegetable +Fish +Horticulture + Poultry) adopted by about 6 per cent sample household farmers earning net benefit of Rs. 110025 with B:C ratio 3.39. The system generate about 177 man days.

4.5: Extension strategies for promotion of integrated farming system

A SWOT analysis of Integrated Farming System in Jharkhand and Odisha was conducted to assess the situation in terms of strengths, weaknesses, opportunities and threats (SWOT). The items for SWOT analysis were derived from interactions with

stakeholder, field observation, in-depth farm household surveys and literature review. SWOT analysis guides how the promotion of IFS could be further improved by identifying the critical factors impacting the extension strategies.

All of the issues included represent potential areas of action through the policy-makers, research organizations and extension agents to improve the promotion of IFS.

Strengths of adoption of integrated farming system

- ❖ Provides ecologically and environmentally sound sustainable intensification option
- ❖ Facilitates Efficient and complementary utilization of scarce land and water resources
- ❖ Improves soil fertility
- ❖ Minimizes input cost with resource flow between components
- ❖ Reduces the use of chemicals and fertilizers
- ❖ Increases farm productivity
- ❖ Ensures stable and increased farm income round the year
- ❖ Generates employment round the year especially in lean period.
- ❖ Helps better adaptation and coping with climatic aberration
- ❖ Minimizes farm production risk through diversification of farm
- ❖ Improves food security for household through diversified food produce
- ❖ Ensures a pro-poor focus, and benefits small-scale farmers and other value chain actors
- ❖ Provides different farming system models for different agroecosystem
- ❖ *Crop-livestock based farming system:*
 - Increases soil fertility through resource flow and less dependent on external inputs specially chemical fertilizers
 - Ensures income diversification
 - Improves food and nutritional security
 - Leads to reduction in cost of farming
- ❖ *Crop- livestock-fish based farming system:*
 - Importance to crop-livestock-fishery based farming system for rural livelihoods especially in coastal areas.
 - Reduction in cost of farming
 - Availability of a platform for discussion between different institutions

- Engagement of several agencies involved in crop and fishery management and officially concerned with developing crop and fishery technologies, specifically rice-fish technologies among farmers
- Nutritional security through rice and fish together as a source of carbohydrate and animal protein

❖ **Weakness (W)**

- ❖ No defined strategy is available for the dissemination of the integrated farming system. There is duplication of activities of the various agencies in technology dissemination and support system.
- ❖ Lack of system thinking and coordination in research and extension in model development process. Development of IFS models by research organization with “one model fit for all” ignores the social and bio-physiological characteristics.
- ❖ *Farmers’ level*
 - Lack of backward and forward linkage actors and their inputs
 - Need for suitable bio-physical conditions
 - Initial cost of preparation/ investment is high for poor farmers
 - Needs continuous supervision
 - Needs more labour
 - Needs more technical knowledge
 - Lack of irrigation facilities
 - Limited availability of component technologies
 - Lack of timely availability of quality inputs
 - Lack of post-harvest knowledge
 - Weak and inadequate infrastructure eg. Road, irrigation etc.
 - Lack of marketing facilities.

❖ **Opportunities (O)**

- ❖ Sustainable agricultural development is the important developmental agenda
- ❖ Promotion of IFS is on the national development agenda
- ❖ Increased farm sustainability through resources flow between components
- ❖ Increased backward and forward linkages of the farmers through public-private partnerships

- ❖ Scope to increase the productivity of the farm through adoptions of high yielding varieties, breeds and management practices.
- ❖ Different farming system models for different socio-economic and bio-physical characteristics of the areas
- ❖ Increased areas to irrigated and rainfed rice field
- ❖ Optimal use of scarce land and water resources optimally
- ❖ Increased dietary and crop diversity
- ❖ Increased agricultural labour employment
- ❖ More employment opportunities
- ❖ Increased dietary and crop diversity
- ❖ Potential to introduce innovative IFS systems, such as improvements in genetic potential and management practices

❖ **Threats**

- ❖ Risk and uncertainty from climatic variability, flood, drought, poaching, poisoning, etc.
- ❖ Land fragmentation due to high population growth
- ❖ Unfavourable land tenure systems and absence of successful land reforms
- ❖ Conservative societal structure due to low education, especially for women
- ❖ Inadequate access to timely credit, high interest rate and unfavourable repayment schedules
- ❖ Poor extension service and lack of information among farmers
- ❖ Low education and farmers unconcerned with the long-term environmental benefits
- ❖ Unfavourable property rights of land, especially for the tenant farmers
- ❖ Lack of timely availability of farm inputs
- ❖ Increasing trend towards landlessness
- ❖ Small farm size reduces land man ratio which ultimately increases the production cost
- ❖ Increased use of fertilizer, pesticides, insecticides, herbicides and irrigation facility ownership
- ❖ Significantly labour-intensive production systems
- ❖ Inadequate extension service and lack of information among farmers

Different Perspectives based extension strategies for promotion of integrated farming system for sustainable livelihood

Perspective 1: Model Development

1. Convergence in Stakeholders with active community participation for sustainable development of location-specific IFS model development
2. System thinking and coordination in research and extension in model development process
3. Differentiated Model rather than “One best model fit for all” considering farmer’s socio-economic and bio-physical characteristics

Perspective 2: Research & Extension

1. Capacity Building in IFS Research & Development by ICAR Research Institutes, SAUs and KVKs
2. Strengthening IFS research through strong partnerships with other stakeholders such as private agency
3. Promotion of Cluster-based farmer participatory farming systems research in tribal areas by integration of development departments
4. Up-scaling of IFS models involving KVKs as partners

Perspective 3: Macro level (Supply Side: Policy based)

1. Extension agency should promote Public–Private Partnership in effective implementation of IFS model
2. Extension agency should sensitize the IFS model adoption for creating employment opportunities through all time engagement of family labour throughout year while curbing underemployment problems in rural community
3. Extension agents should sensitize farming community regarding various government policy and schemes providing adequate subsidy and incentives for adoption of IFS model by different section of farmers
4. Capacity development and specialised extension programmes for women farmers involved in IFS model should be prioritised in ICAR Research institutes, SAUs, KVK, line departments and private agency.
5. Multiple agencies having stake in Agriculture and Rural development should come forward for preparing plan of action with “IFS” as common agenda for development leading towards food and nutritional security in the rural community

6. Promotion of IFS model as Climate Smart Agriculture by the stakeholders in order to diversify the source of income to combat climate variability and risk
7. Adequate infrastructure (road, irrigation, storage, technical requirements etc.) and marketing facilities are to be provided by Govt. agencies

Perspective 4: Micro level (Demand Side: Farmers based)

1. Traditionally important crop and livestock based farming system should be promoted by the line departments for sustainable livelihood security.
2. There should be mobilisation of locally available resources to make IFS self-reliant rather than depending on external inputs especially chemical fertilizers.
3. There should be technically feasible, economically viable, socially acceptable and environmentally sustainable IFS model development which suits the farmer's socio-economic and bio-physical characteristics.
4. IFS model should be developed through farmers' active participation with extension agency for sustainable livelihood model which can be adapted by local farmers.
5. Integrated farming system has a pro-poor focus, and can benefit small-scale farmers and other value chain actors.
6. The extension agents should create different alternatives of IFS model with reduced cost of cultivation and maximum benefits to small and marginal farmers
7. Several component technologies as combination should be provided according to local farming situation and farmers demand
8. Provision of quality inputs and information which should be supply timely, adequate and affordable to the farmers should be of paramount importance for concerned line departments.
9. Awareness campaigns for farmers about IFS and its eco-friendly sustainable livelihood generation among the rural poor should be organized
10. Line department should strengthen backward and forward linkages with IFS farmers for adequate and timely supply of inputs and outputs

DISCUSSION

In India, majority of farmers are small and marginal, often cultivating less than 1 ha or 1-2 ha of land. Approximately, 57.8 per cent of rural households are engaged in agriculture in India, out of which, over 69 per cent possess or works on marginal landholdings and 17.1 per cent on small. Near about 72 per cent of the rural households work as cultivators or agricultural labourers (Census, 2011). The slow agricultural growth has pushed the rural populations towards the non-farm sector which increased the employment in the non-farm sector by about 12 per cent between 1999-2000 and 2011-2012. As per the Situation Assessment Survey of Farmers, 2003, conducted by NSSO, four out of ten farmers disliked farming and preferred another occupation if they had a choice. Further, out of these, 27 per cent were of the view that farming was not a profitable enterprise and eight per cent felt that it was risky.

In India, small and marginal farmers face various hurdles in terms of securing financial, technological and institutional support. Some of these issues include limited access to formal credit and insurance, lack of capacity-building programmes to train them about up-to-date farm equipment and practices, inadequate irrigation water supply, little or no scope for crop diversification and lack of marketing facilities. Most of these challenges are faced by both small and large farmers, although the degree of access to various agricultural inputs often varies and large farmers find some sort of advantage. Even though studies have shown that IFS is feasible with respect to socio-economic imperatives, the actual adoption rate is limited and unevenly spread among farmers. So, there arises a need to examine the integrated farming systems with respect to the feasibility of integrated farming practices, techno-economic efficiencies, as well as their socio-economic and farm level impacts. As the systematic adoption of IFS is very low, there is also a need to analyze the factors for adoption and non-adoption and the extension strategies for promoting the IFS.

Documentation and identification of best practices in different integrated farming system models

Different farming system models with different farming components were observed during the study. Diversification of components was more in farms with pond based farming system. In Odisha, farmers with fish component also had horticulture, dairy, plantation crops and duckery components. Utilization of space of pond bunds area with horticulture (fruits and vegetables) and plantation crops are common in pond-based farming system. Most common horticultural crops were banana, papaya, mango and *Acacia* for agroforestry whereas bottle gourd, pumpkin, brinjal *etc.* were the common vegetables grown in the pond dike. Dash *et al.* (2015) categorized integrated farming system broadly into by-product/waste utilization and space utilization. In by-product/waste utilization, the by-product or waste of one component or enterprise is used as input of another component. With this, an enterprise is expected to maximize production and minimize the cost of cultivation as well as environmental pollution. However, in space utilization, the emphasis is more on optimum utilization of the available land/space rather than by-product /waste utilization and there exists no direct/very less relationship between the enterprises *e.g.* fruits and vegetable crops. Adoption of good varieties of fruits and vegetable improved the productivity of the farm. Moreover, an integrated farming system usually has components which are synergetic and complementary to each other. Some of the components are jointly managed with the same kind of input as in the case of poultry-duckery and goat-dairy. Besides fisheries, cultivation of prawn and fingerling production enhanced the income many folds. *Khakhi Cambell* was usually penned beside the pond along with poultry bird. Dual purpose poultry birds, *Vanaraja* and *Gramapriya*, were usually reared in a semi-intensive way and gave about 140 to 180 eggs per annum. The challenges for water scarcity are often tackled by harvesting water from pond which also helps *Rabi* season crops, especially vegetables.

Extension and financial support play an important role in the development of integrated farming system in the farmers' field. High investment cost in construction of pond and in purchase of good quality breeds of animal remains the major reason for non-

adoption of the intensified integrated farming system especially pond-based farming system. Adoption of farm components is determined by farm characteristics, market facilities and socio-economic and regional characteristics. Per unit area productivity of pond-based farming system are more compared to conventional farming. It is worth to note that farmers with intensive pond-based farming system often have conventional farming with fertilizers and chemical inputs for their main crop *i.e.*, rice. It was observed during the study that most of the successful farmers were willing to take risk and were cosmopolite in nature. They always search for modern varieties, breeds and other components to improve the productivity of their farm. They chose components which would lower the cost of cultivation.

Techno-economics of the integrated farming system

The study identified different farming systems in each state. The average net cropped area of the respondents of Jharkhand was less than that in Odisha. Average gross cropped area was 2.56 ha in Jharkhand while 3.08 ha in Odisha. Some farmers of Jharkhand have fallow land even in *Kharif* mainly due to the topography of the field and lack of irrigation facilities. Average fallow land in *Rabi* season was more in Odisha than Jharkhand, which may be due to larger agricultural area in Odisha and relatively smaller irrigated area in *Rabi* season. The crop is an important component of every farming system, and land resources are often not utilized fully in both the state mainly due to lack of irrigation. The average cropping intensity of the respondent was more than the national average, but the scope to improve it still exists. Lavanya (2010), in her study on assessment of farming systems efficiency among paddy farmers, observed that 21.70, 18.30, and 60 per cent of farmers had low, medium and high level of cropping intensity, respectively.

In Jharkhand, majority of the household (27.62 %) practiced crop + dairy + vegetable farming system followed by crop + dairy + vegetable + goat system (15.24 %), while in Odisha, majority of the household (20.51 %) had crop + vegetable system followed by crop + dairy + vegetable. In most of the households, fish rearing was a component in Odisha whereas crop-livestock farming system constitutes the major farming system in Jharkhand. The low-lying areas of coastal region favour the fishery component in the study area, whereas the dry land agro-ecosystem of the respondents of

Jharkhand led to livestock dominated farming system. Dairy animal and goat were the components in Jharkhand besides piggery and poultry in tribal areas of the state. A similar result was found by Mohanty *et al.* (2010) who identified that IFS model contained field crops (rice, groundnut, maize, pigeon, pea and ragi), vermicomposting and poultry (*Vanaraja* breed), horticultural crops (yam, banana, tapioca and vegetables), in Gajapati district of Orissa. Chitra (2010) in her study found that almost an equal per cent (43.4 % and 40%) of the respondents belonged to small and marginal size of land holding category, whereas, 16.60 per cent were having large size of land holdings in farming system of paddy +sugar cane +dairy. Similar study was done by Tripathi and Rathi (2011) who found that among various predominant farming system models in Uttarakhand, crop + dairy, crop + dairy + goats + horticulture, crop + horticulture +goats, crop +dairy + vegetables, horticulture + dairy + vegetables, vegetables + dairy and crop + dairy + companion animals were the major components in IFS.

Average area under different crops and vegetables varied across the state, district and season. Majority of respondents allocate their land resources, labour and capital mainly to rice in *Kharif* in both the states and wheat in *Rabi* season in Jharkhand. In Odisha, average land size in *Kharif* season for rice was 1.98 ha, followed by vegetables (0.25 ha) and maize (0.16 ha). For *Rabi* season, in Jharkhand average land size under wheat was 0.79 ha followed by chickpea (0.31 ha), vegetables (0.28 ha), mustard/toria (0.27 ha) and linseed crops (0.13 ha). In case of Odisha, in *Rabi* season, average land size for vegetables was 0.52 ha, mustard/ toria (0.32 ha), urad (0.30 ha) and moong (0.29 ha).

The average productivity of field crops was lower in Jharkhand as compared to Odisha. The system productivity can be improved by promoting locally suitable high yielding varieties of the different crops. Timely availability and improving the accessibility to quality inputs, especially seed, can enhance the income of the farmers. The labour productivity in field crop components was less in Jharkhand. The average labour man-days involved in rice production/ha were 83.05 man-days in Jharkhand while it was 77.02 man-days in Odisha. Farmers of both the states were using fertilizer in cultivating major crops, rice and wheat, though in less amount. In Jharkhand, the average fertilizer cost of rice was Rs. 1785.52 / ha compared to Rs 2846.43/ ha in Odisha. This result was supported by Singh *et al.* (2006). The study found that the price per unit of

production in all the crops differs across the state and farmers. Hence, good marketing facilities and infrastructure can enhance the income of the IFS farmers. A similar result was also found in livestock produced.

The average rice production was 39.13 q/ha in Jharkhand compared to 43.55 q/ha in Odisha. Average cost per hectare for rice production was more in Odisha as compared to Jharkhand. The average gross income from rice production/ha was Rs. 41762.41 in Jharkhand and in Odisha, it was Rs 56640.40 while average net income/ha from rice production was Rs.19049.02 in Jharkhand and Rs. 29150.96 in Odisha. Wheat cultivation in Jharkhand consumes an average fertilizer of Rs. 1698.68/ha and produced 30.86 q/ha which is near equal to the national average of wheat production. In Jharkhand, the average gross income from wheat production was Rs. 28219.95 /ha and net income was Rs. 18181.83/ha.

Vegetable was an important farm component in both states. Majority of farmers produced vegetable for consumption and to generate extra income. Allocation of area and capital was usually low in *Kharif* than *Rabi*. Irrigation was a major challenge for allocation of area especially in the *Rabi* season. Farmers tend to intensify vegetable crop in the *Rabi* season compared to *Kharif* season in both the states. Intensive vegetable farmers with large vegetable land near the market reported using fertilizer to improve productivity, whereas majority of the farmers in both the state do not apply fertilizer in vegetable. Farmers tend to grow wide ranges of seasonal vegetables with differential allocation of land to different vegetable crops. The farmers of both the states also grew maize, mustard and pulses besides their main crop for home consumption. Niger, linseed and groundnut were also grown in Jharkhand for consumption. Pigeon pea (*Arhar*) was found to be grown by some farmers as *Kharif* pulse in Jharkhand whereas in Odisha no *Kharif* pulse growing farmers was observed during the survey. Majority of the respondent of Odisha grew *urad* and *moong* as their main crop of *Rabi* season. Paira cultivation was usually practiced in the state to utilize the moisture for cultivation of this pulse. Even though these pulses were considered as main *Rabi* season crop in Odisha, very less inputs in the form of quality seed, fertilizers and plant protection measure were used. The productivity of the pulse was very low compared to other states. In Jharkhand, 5.54 q/ha

was the average pulse production while in Odisha, it was 7.00 q/ha. Majority of the farmers in both the state grew pulses for family consumption only.

In case of livestock animals, it was observed that average number of cows was 7.64 and 4.76 in Jharkhand and Odisha, respectively. The number of local cows was higher than the exotic cows in both states. Sheep and piggery were not reported in the study locale of Odisha. In Jharkhand, the average number of backyard poultry was 15.5 nos. while in Odisha it was 16.44. Duckery unit was on an average of 13 and 16.22 nos. in Jharkhand and Odisha, respectively. The average yield of milk of local and exotic cows was 2.35 l/day and 5.44L/day, respectively in Jharkhand, while in Odisha, it was 2.46 l/day for local cows and 7.73 l/day for exotic. Yield of milk of 7.56 l/day for buffalo was reported in Jharkhand.

Livestock was a major component in integrated farming system in both the states. The adoption of exotic cow by the farmers could improve the productivity of the farm. The average labour utilized in dairy farming was 87.24 man-days and 63.38 man-days in Jharkhand and Odisha, respectively. Most of the farmers of Jharkhand reared their animal with pasturing system whereas in Odisha it was mostly in semi-stall. Pasturing system which demands more labors was common among the large local cow owners. Different pasture systems also affected the cost of feed and production of cow dung. Most of the dairy component owners also had goat components which helped in earning extra income without much extra efforts in feeding and labour. The average cow dung produced was 34.64 ton and 31.15 ton per dairy household in Jharkhand and Odisha, respectively. Ramrao *et al.* (2005) carried out a study on crop-livestock IFS for augmenting socio-economic status of smallholder tribal of Chhattisgarh in central India and reported that 2 bullocks + 1 cows + 1 buffaloes + 10 goats + 10 poultry + 10 ducks along with crop cultivation was the best with a net income of Rs. 33076 per year against arable farming (crop farming) alone (7843 per year). Singh *et al.* (2006) in their study found that the rice-based IFS comprising of crop components, dairy, poultry and fishery was the most appropriate and efficient farming system model giving the highest system productivity and ensured the multiple uses of water. Piggery was found as an important component among the tribals of Jharkhand and was reared in a semi-intensive way. Poultry and duckery were mostly adopted by farmers who either had ponds or farms. Most of the

farmers of Odisha reared *Vanaraja* breeds whereas in Jharkhand, most reared local breeds.

Fish cultivation contributed a sizable proportion of income among the farmers of Odisha. Most of the farmers had inherited their ponds from the ancestor. Excavation cost was the major reason for non-adoption of fish pond farming system, besides not having a suitable land for adoption of pond-based farming system. Prawn and fingerling production, besides fish farming, enhanced the fish pond productivity. Farmers with fish pond usually had dairy components and most of the farmers used their waste in fish pond at regular interval. Among the major horticultural plants, average number of banana plants per households in Jharkhand was 52.5 followed by 23.33 for mango and 18.67 for papaya. Likewise, in Odisha, average number of banana plants per household was 37.2 followed by 12.55 for mango and 12.72 for papaya. More number of households adopted horticulture and plantation crops in Odisha as compared to Jharkhand. Horticulture and plantation crops like coconut and areca nut were commonly grown in the pond dike. Most common agro-forestry tree was *Acacia auriculiformis* and was usually grown in the pond bund in Odisha.

Mushroom production in Odisha is a good income generating enterprise. The demand for paddy mushroom was high and was sold at a rate of Rs. 140-180 per kg. Paddy is the major crop in Odisha and availability of straw can be effectively utilized in mushroom production. The perishable nature of mushroom also affects the price of the mushroom. Processing of mushroom could enhance the income of the farmers.

In both the states, majority of farm households was concentrated in the range of 90-100 per cent Technical Efficiency (TE) (42.86 % in Jharkhand and 32.76 % in Odisha). The minimum value of TE was 47.80 per cent in Jharkhand and 44.20 per cent in Odisha.

Overall, the average TE was higher in case of Jharkhand (83.31 %) as compared to Odisha (81.34 %). In case of Jharkhand, the efficiency was highest in large farms (85.10 %) followed by small (83.78 %) and large categories (85.10 %). However, in Odisha, it was highest in medium followed by small and large categories with value of 83.43 per cent, 80.35 per cent and 80.35 per cent, respectively.

Adoption of integrated farming system

Farmers with more owned land and irrigation facilities were more likely to adopt vegetable as a farming component and also the nearer the farmers were to the market, the more was the likelihood of adopting vegetable farming. The intensity of vegetable cultivation was also influenced by age, education, irrigated area and extension contact. The determinants of adoption of pond-based farming system in the state of Odisha were analyzed. It showed that owned land area had a positive effect whereas distance to farm had a significant and negative effect. These implied that farmers with more owned land and those having farm nearer to their home tend to adopt pond-based farming system. Srivastava *et al.* (2004) in their study reported that for realization of multiple uses of water, particularly vegetables, duckery and aquaculture on pond embankment, the water body has to be near the homestead for better management and security.

The analysis of the determinants of crop diversification in Jharkhand showed that distance to market and willingness to take risk influenced crop diversification negatively and positively, respectively. In Odisha, factors like own area, the proportion of area under irrigation in *Rabi* season, distance to market and willingness to take risk had statistically significant relationship on the level of crop diversification. Further analysis of pooled data from Jharkhand and Odisha revealed that owned area, the proportion of area under irrigation in *Kharif* season, the proportion of area under irrigation in *Rabi* had statistically significant effect on level of crop diversification. Similar results were obtained by, Desai (1981), Reddy (1983) and Malathesh (2004). Analysis was done to identify the factors that influenced the level of income diversification which revealed that in Jharkhand, age and participation in training had significant influence on the level of income diversification. In Odisha, proportion of area under irrigation in *Kharif* and training were important for promotion of income diversification. Marketing facilities should be strengthened and improvements in conditions of roads can improve the farmer's income diversification activities. Malathesh (2004) and Ugwumba (2010) found a similar result.

Result from the theory of planned behavior showed that farmer perceived adding more component in adoption of more number of farming components would increase farm productivity, stabilize their income, generate employment, enhance food security and help better adaptation to climatic aberration. Majority of farmers believed that

adoption of more farm component will not reduce the use of chemicals and fertilizers. Most of the respondent weighed the suggestions of their family and progressive farmers before taking decision of adding more components in their farm. Most farmers had the belief that adoption of more components would demand greater commitment to management of farm, intensive inputs and high establishment costs. Farmers also perceived that with more components, the need for technical know-how of diversified components will be more and the demand for labour would be more. The need for suitable farmland to add more components was given due importance by the respondents. Financial and extension support will help in adoption of more components. Demands for more farm inputs and labor were also major challenges which could emphasize the need for unique IFS models considering household characteristics. Marketing of diversified produce was not a hurdle in all kinds of produce. Marketing problem was product specific. While adding components one should also consider the market availability especially by the intensive farmers.

Impact of integrated farming system

In Jharkhand, crop + livestock +vegetable +fish +horticulture +poultry gave the highest average net income of Rs. 94731/ annum and employment with B: C ratio 2.5 followed by crop + livestock combination with net income Rs. 61777.91/ annum and B: C ratio of 2.53, while crop + vegetable combination gave average net income of Rs 30939/ annum with B: C ratio 2. Crop + livestock generated about 181 man days, whereas, crop + livestock +vegetable +fish +horticulture +poultry generated about 247 man-days per annum as the semi-intensive and pasturing nature of dairy farmers demand more employment among the farmers,

Whereas, in Odisha, crop+livestock+vegetable+fish+horticulture gave average net benefit of Rs.107827.6 with B: C ratio 3.02 and generated about 131 man-days per annum, a net benefit of Rs. 110025 with B:C ratio of 3.39 and 177 man days were generated from the combination of crop + livestock + vegetable +fish +horticulture + plantation crop. Crop + livestock + vegetable + horticulture + plantation crops combination was found to give an average net benefit of Rs 107827.6 per annum with B: C ratio 3.02 and generated 146 man-days.

Adoption of integrated farming system enhanced the annual income from farming. It also helped in stabilizing the farmer's income round the year. The adoption of IFS approaches also fulfilled the household needs and enriched the diet of human being and animals both, for nutritional security. Further, it also provided employment opportunity for the households.

Adoption of livestock based farming system like dairy-poultry or/and dairy-goat or dairy-goat/piggery could enhance the livelihood security of the resource-poor farmers. Promotion of this farming system model needs special attention among the vulnerable small and marginal farmers for sustaining their livelihood. Adoption of pond-based farming system has not only helped in providing income and employment, it has also helped to diversify to other components and use of water resources to add more components. Pond-based farming system was often found with other components like horticulture, plantation crop such as coconut, areca nut besides vegetables in pond dike and duckery components.

Irrespective of different components, the integrated farming system enhanced the income and employment. Farmers with more farming components had more income than the ones with less components and practiced conventional farming. These findings were in line with the earlier studies of Radhamani *et al.* (2003) who described IFS as a type of farming system which helped in minimizing risk and increasing production and profits, while improving the utilization of organic wastes and crop residues. The production of fish, milk, food-grains, vegetables, fruits *etc.* helped in improving livelihood and nutritional security. The dietary diversity of the household also increased thereby improving the standard of living and providing better nourishment to the family members. The recycling of cow-dung manure, paddy straw, weed biomass and kitchen wastes *etc.* was achieved in a gainful and sustainable way.

At the farm level, having farm components which enhanced bio-resources flow helped rely less on external chemical inputs. In Jharkhand, 5.15 ton straw was obtained from one hectare rice field while in case of Odisha, this was slightly lower, *i.e.*, 5.08 ton /ha.

Strategies

Assessment of resource availability in the farm environment and identification of bio-physical, socio-economic, institutional and technological constraints should be considered before designing any location-specific farming system model. Different farm components suited to local agro-climatic conditions and demands of different products in the nearby market need to be incorporated. Recommendation of the IFS model should be on the basis of economic feasibility and compatibility of the farming system. There is need of creating an economic, social and political environment that will encourage the adoption, adaptation and dissemination of new technologies and farming systems. Participatory on-farm research should be conducted to refine and validate different farming system models for different beneficiary classes. Linkages between scientists and institutions have to be strengthened to speed up cooperation. There is a great potential for increasing the productivity of limited land by integrating different technologies into the existing farming system, which were successfully applied in other regions and at national and international research centers. Demonstration and popularization of integrated farming systems have to be taken in a system approach rather than specific component 'Package of practices'. The awareness about the scope and benefit of resource recycling should be promoted among the farmers.

There is huge gap in productivity of crop and livestock components and are far below the national average. The adoption of superior varieties and breed will improve the productivity of the farm. Providing credit and initial investment will help in adoption and development of sustainable integrated farming system. Different farm inputs must be made available at a fair marketing system. Development of sustainable integrated farming system should look beyond production, as marketing is also an important aspect for farm sustainability.

A single window system should be developed for popularization and delivery of inputs for promoting integrated farming system for creation of awareness and delivery of services about various schemes. Different developmental organizations promote integrated farming system with different schemes and subsidy programme. However, there is need of cooperation and convergence. Linkage of extension organization with various other rural development organizations in delivering the need for farmers will go a long way in promotion of IFS models.

SUMMARY AND CONCLUSION

In recent years, food security, livelihood security, natural resources conservation and environment protection have emerged as major issues worldwide generally and more specifically in developing countries like India. The small and marginal farmers are facing problems like unavailability of income round the year, depleting water resources, climate variability, dependency on single crop/farm activity as a source of income, lack of contingency income sources in case of failure of major economic activities and lack of integrated practices for efficient use of natural resources and byproducts of farm production system. The potential benefits of Integrated Farming System (IFS) in enhancing livelihood security have gained attention and many initiatives are afoot.

IFS is a resource management strategy to achieve economic and sustained production to meet the diverse requirements of farm household while preserving the resource base and providing income round the year by combining different farm enterprises in a single land piece in a complementary way. It gives greater emphasis on the sound management of farm resources to enhance the farm productivity, to reduce environmental degradation, to maintain sustainability and to improve the quality of life for farmers. The main difference between the IFS and commercial farming or conventional farming system is not absolute; rather it is a matter of degree of integration of resources in the farm system (Tipraqsa, 2006). The systems cope with the changes at farm level in a manner that balances food production, profitability, safety, animal welfare, social responsibility and environmental care (Little and Muir, 2003).

Although studies have shown that IFS is feasible with respect to socio-economic imperatives, actual adoption rates of integrated farming are limited and unevenly spread among farmers. So, there is a need to examine the integrated farming systems with respect to the feasibility of integrated farming practices, techno-economic efficiencies, as well as their socio-economic and farm level impacts. As the systematic adoption of IFS is very low, there is also a need to analyze the factors for adoption and non-adoption and the extension strategies for promoting IFS. To address various researchable issues, the present study was conceived with the following specific objectives:

Objectives:

1. To document and identify the best practices of different integrated farming system models.
2. To conduct comparative techno-economic assessment of integrated farming system models.
3. To analyze the determinants for adoption and constraints in adoption of integrated farming systems.
4. To assess the socio-economic and farm level impact of integrated farming systems.
5. To analyze the extension strategies for promotion of integrated farming system for sustainable livelihood

Research Methodology

The study was conducted in Jharkhand and Odisha states which were selected purposively to represent the dry land and coastal agro-ecosystems. While three districts of Jharkhand *viz.* Gumla, Sahebganj, and Dumka were randomly selected to represent the dry land agriculture; four districts of Odisha *viz.* Cuttack, Jagatsingpur, Khorda and Puri were selected randomly to represent coastal and semi-coastal regions of the state. From each district, one block was chosen randomly. From Jharkhand, 105 farm households were selected, 35 from each district; while 117 farmers were selected from Odisha with sample of 29, 29, 29 and 30 farmers selected from Cuttack, Jagatsingpur, Khorda and Puri, respectively. The data for the present investigation were collected from both primary and secondary sources to accomplish the set objectives of the research study. In order to make the research methodology robust, error minimization in data collection and analysis is essential. Therefore, several methodologies namely survey (structured and unstructured scheduled based interviews), focus group discussion, observation and case study were chosen for data collection. Tobit and Logistic regressions; Theory of Planned Behavior; and Data Envelopment Analysis (DEA) for efficiency analysis were used in the study. Descriptive statistics were also used to analyze the data.

Findings

- ❖ Majority (53 %) of farmers of Jharkhand were in middle age group followed by age group below 44 years. Similarly, in Odisha, 45.30% belonged to middle age group followed by younger age group (40.17 %).
- ❖ In Jharkhand, most of the farmers (42 %) had attended middle school followed by primary education (32.38 %). About 12 per cent of farmers were illiterate and none of the respondents were graduate and above. Further, it was observed that 7.62 per cent had attended Secondary School. Whereas in Odisha, 37.61 per cent farmers had attended middle level followed by primary school (24.79 %). About 12 per cent and 3 per cent farmers had attended higher secondary and graduate education, respectively.
- ❖ About 41 per cent of respondents from Jharkhand were having less than 1 ha of land , while 26.67 per cent and 24.76 per cent belonged to medium and small land holding, respectively. Only 7.6 per cent constituted the large farmers. Meanwhile, in Odisha, 46.15 per cent farmers belonged to medium category of landholding followed by small and marginal farmer categories with 31.62 per cent and 12.82 per cent, respectively. Large farmers constituted about 9 per cent of the respondents of Odisha. The mean land holding of the respondents was 1.66 ha and 2.23 ha for Jharkhand and Odisha, respectively. The average number of plot per household was 2.22 and 4.10 for Jharkhand and Odisha, respectively.
- ❖ The mean proportions of area under *Kharif* irrigation of the total cultivated area were 0.33 and 0.49 for Jharkhand and Odisha, respectively, whereas for *Rabi* season it was 0.08 and 0.18.
- ❖ The average distance to market from the farmer's house was 17.28 km and 15.68 km for the respondents of Jharkhand and Odisha, respectively.
- ❖ Majority of the respondents had no access to extension services in both the state. Only 18.10 per cent and 39.32 per cent had access to extension services in Jharkhand and Odisha, respectively. Majority of the respondents in Jharkhand (80.00 %) had no access to credit facility. Similarly, in Odisha, majority of farmers (73.50%) had no credit facilities. In Jharkhand, majority of the respondents (99.05%) had not received any direct subsidies and in Odisha, only 11.97 per cent had received subsidy. In

Jharkhand (88.57%) and Odisha (70.94%) majority of farmers had not attended any training programme in agriculture. In Jharkhand (88.57%) and Odisha (80.34%) majority of farmers did not have any membership in social organisations.

- ❖ From the case studies, it was observed that successful farmers tend to move from the step of crop diversification to farm diversification, and introduced components that were synergetic and utilized space diligently. Among the many options for adding component, pond based farming system was often cited as a door to other components. Investment in the form of pond usually paved the ways for other components like poultry, duck, vegetable and horticultural crop. Farmers tend to add components that add benefits to the conventional farming *e.g.* prawn and fingerling cultivation in fish pond. *Khakhi Cambell* was usually penned beside the pond along with poultry bird. Dual purpose poultry birds, *Vanaraja* and *Gramapriya*, were usually reared in a semi-intensive way and gave about 140 to 180 eggs per annum. The challenges for water scarcity were often solved by harvesting water from pond which also helped *rabi* season crops, especially vegetables. Most of the farmers adopted improved varieties and breeds in their farm. Location of farm and distance to market played an important role in determining the success of the farm. Education, contact with extension agencies and accessibility to credit were found to determine the adoption of improved technologies and farming components. Most of the farmers had taken support from government agencies. Exposure to appropriate training on improving technical and managerial skill would help in sustaining the IFS. Most of the successful farmers emphasized on marketing of their produce. Through various combination of income, farmers could earn up to Rs. 671000 with (Crop + Vegetables + Dairy + Poultry + Fishery + Horticultural + Flower) and up to Rs 214500 with (Crop + Vegetable + Dairy + Goat +Poultry-Duckery + Fish +Horticulture) from 1.20 ha of land. Most of the farmers had a specialized component which contributed a major share of income. High investment cost in construction of pond and in purchase of good quality breeds of animal remain the major hurdle for adoption of integrated farming system especially pond based farming system.

- ❖ Majority of the sample household (27.62%) practiced “Crop + Dairy +Vegetable” farming system followed by “Crop + Dairy + Vegetable + Goat” system with 15.24 per cent in Jharkhand. The major components in Jharkhand were crop, dairy, vegetable, goatery and piggery. Majority of the farmers had 4 numbers of different components, with maximum up to 7 components. Most of the piggery farmers adopted poultry and duckery also, whereas farmers with fish components also had Horticulture and Poultry /Duckery component. In Odisha, majority of the household (20.51 %) had Crop + Vegetable system followed by Crop + Dairy + Vegetable. Fishery was one of the major components of integrated farming system in Odisha. In Odisha also, farmers with fish component had horticulture plant, dairy, plantation crops and duckery components. Mushroom farmers were also observed in the state of Odisha. Farmers adopting up to eight components were observed during the survey in Odisha.
- ❖ In most of the households in Odisha, fish rearing was a component whereas crop-livestock farming system constituted the major farming system in Jharkhand. The low lying areas of coastal region favoured the fishery component in the study area, whereas the dry land agro-ecosystem of the respondents of Jharkhand led to livestock dominated farming system. Dairy animal and goat were the components in Jharkhand besides piggery and poultry in tribal areas of the state.
- ❖ The average net cropped area of the respondents of Jharkhand was 1.63 ha compared to 2.11 ha in Odisha. Average gross cropped area was 2.56 ha in Jharkhand while it was 3.08 ha in Odisha. In Jharkhand, the average fallow land in *Kharif* season was 0.33 ha (20.24 % of net crop area) while no fallow land was found in Odisha in the *Kharif* season. About 49.69 per cent and 54.03 per cent of net crop area were fallow lands in *Rabi* season respectively, in Jharkhand and Odisha. The average cropping intensity of the respondent of Jharkhand (157.33%) was higher than Odisha (145.67%). Cropping intensity across the different landholding categories in Odisha was relatively similar whereas in Jharkhand it was 161.54 per cent, 152.29 per cent and 158.88 per cent for large, medium and small farmer group, respectively.

- ❖ Average area under different crops and vegetables varied across the state, district and season. Majority of respondents allocated their land resources, labour and capital mainly to rice in *Kharif* in both the states and wheat in *Rabi* season in Jharkhand.
- ❖ In *Kharif* season average acreage under rice crop was 1.25 ha followed by 0.32 ha for vegetables, 0.27 ha for maize, 0.24 ha for pulses, 0.25 ha for Niger and 0.17 ha in groundnut in Jharkhand. Similarly in Odisha average acreage in *Kharif* season for rice was 1.98 ha, followed by 0.25 ha for vegetables and 0.16 ha for maize crops.
- ❖ In *Rabi* season, average acreage under wheat was 0.79 ha followed by 0.31 ha for chickpea, 0.28 ha under vegetables followed by 0.27 ha for mustard/toria and 0.13 ha under linseed crops in Jharkhand. In case of Odisha, average allotted area for vegetables was 0.52 ha, 0.32 ha for mustard/ toria crops, 0.30 ha for *urad* and 0.29 ha for *moong*.
- ❖ The average productivity of field crops was lower in Jharkhand compared to Odisha. The average labour man-days involved in rice production/ha were 83.05 man-days in Jharkhand while it was 77.02 man-days in Odisha. Farmers of both the states were using fertilizer in cultivating major crops, rice and wheat, though in less amount. In Jharkhand, the average fertilizer cost of rice was Rs. 1785.52 / ha compared to Rs 2846.43/ ha in Odisha. The average rice production was 39.13 quintal/ha In Jharkhand compared to 43.55 quintal/ha in Odisha. The average net income/ha from rice cultivation was Rs.19049.02 in Jharkhand and Rs. 29150.96 in Odisha. 5.15 ton and 5.08 ton of straw were obtained In Jharkhand and Odisha respectively.
- ❖ In Jharkhand, average acreage under *Kharif* vegetables was 0.32 ha compared to 0.25 ha in Odisha. In Jharkhand, the average labour involved in *Kharif* vegetable production was 45.67 man-days/ha while it was 51.08 man-days/ha in Odisha. The average net income/ha from *kharif* vegetable of Rs. 27604.16 and Rs. 41469.00 respectively for Jharkhand and Odisha.
- ❖ Pigeon pea was grown as *Kharif* pulse production in Jharkhand. The average production of *Kharif* pulse was 7.05 q/ha with a net income was Rs.13474.44/ha.
- ❖ In Jharkhand, the average size of land under wheat cultivation is 0.72 ha. The average labour man-days involved in wheat production was 73.62/ha. Average yield of wheat was 30.86 q/ha which is near equal to national average of wheat yield. In

Jharkhand average gross income/ha from wheat production was (pigeon pea) was Rs. 28219.95 and net income/ha was Rs. 18181.83. Production of wheat straw was 3.90 ton/ha.

- ❖ The average land holding size for *Rabi* pulse production was 0.32 ha while in Odisha it was 0.48 ha. In Jharkhand, average labour man-days involved in *Rabi* pulse crop production was 28.66 man-days /ha while it was 34.51 man-days/ha in Odisha. In Jharkhand, 5.54 quintal/ha was average pulse production while in Odisha it was 7.00 q/ha which was higher than in Jharkhand. The average net income from *Rabi* pulse production was Rs. 6251.07/ha in Jharkhand and Rs. 3835.86 /ha in Odisha.
- ❖ 0.27 ha was allocated for mustard /toria in Jharkhand while in Odisha it was 0.32 ha. In Jharkhand, average labour man-days involved in toria crop production was 27.69 man-days/ha while it was 28.80 man-days/ha in Odisha. The average net income/ha from toria production was Rs. 7992.56 in Jharkhand and Rs. 7269.45 in Odisha.
- ❖ In Jharkhand, average area under *Rabi* vegetable production was 0.28 ha while in Odisha it was 0.24 ha. The average labour man-days involved in vegetable crop production was 86.21 man-days/ha in Jharkhand while it was 60.18 man-days/ha in Odisha. In Jharkhand, the average labour cost per ha for vegetables was Rs. 17242.60 while in Odisha it was Rs. 12035.42. The average net income from vegetable production was Rs. 26759.25/ha in Jharkhand and Rs. 50428.45/ha in Odisha which was much higher in comparison to Jharkhand.
- ❖ In case of livestock animals, it was observed that average number of cow was 7.64 and 4.76 in Jharkhand and Odisha, respectively. The number of local cows was higher than the exotic cows in both states. Sheep and piggery were not reported in the study locale of Odisha. Goat is a major component in Jharkhand with 28.57 per cent household having goat as a major component. In Jharkhand, the average number of backyard poultry was 15.5 nos. while in Odisha it was 16.44. Duckery unit was on an average of 13 and 16.22 nos. in Jharkhand and Odisha, respectively. The average yields of milk of local and exotic cows were 2.35 L/day and 5.44L/day, respectively in Jharkhand, while in Odisha, it was 2.46 L/day for local cows and 7.73 L/day for exotic. Yield of milk of 7.56 L/day for Buffalo was reported in Jharkhand. The

average labour utilized in dairy farming was 87.24 man-days and 63.38 man-days in Jharkhand and Odisha, respectively.

- ❖ Most of the farmers of Jharkhand reared their animal with pasturing system whereas in Odisha mostly in semi-pasturing. Pasturing system which demands more labours are common among the farmers with large number of local cows. Different pasture system also affects the cost of feed cost and production of cow dung. Most of the dairy component owners also have goat components which help in earning extra income without much extra efforts in feeding and labour. The total net income was also more in Jharkhand (Rs. 28596.49/ annum) than in Odisha (Rs. 30204.08 / annum). The average cow dung produced was 34.64 ton and 31.15 ton per dairy household per annum from average dairy unit of cow was 7.64 and 4.76 in Jharkhand and Odisha, respectively.
- ❖ Piggery was found to be an important component among the tribals of Jharkhand and was reared in a semi-intensive way. The estimated cost of labour averaged at ₹ 3360 while the total cost was about ₹ 9747 per annum. The average net income generated were ₹ 64273 and ₹ 54527 per annum, respectively from the average piggery unit of 8.8. Poultry and duckery were mostly adopted by farmers who either have ponds or farms. Most of the farmers of Odisha reared *Vanaraja* breeds whereas, in Jharkhand, most reared local breeds.
- ❖ Fish farming contributed a sizable proportion of income among the farmers of Odisha. Most of the farmers have inherited their ponds from the ancestor. The average labour man-days was 25.4 and 35.88 man-days in Jharkhand and Odisha, respectively. The net income generated in Odisha was approximately ₹ 23520.98 compared to ₹10240 in Jharkhand. Fingerling and prawn were found to be produced only in Odisha generating an income of ₹ 75000 and ₹ 11333.33 per annum. Excavation cost was the major reason for non adoption of fish pond farming system, besides not having suitable land for adoption of pond-based farming system. Prawn and fingerling production, besides fish farming, enhance the fish pond productivity. Farmers with fish pond usually have dairy components and most of the farmers used their waste in fish pond in regular interval. Among the major horticultural plants, average number of banana plants per households in Jharkhand was 52.5 followed by

23.33 for mango and 18.67 for papaya. Likewise, in Odisha, average number of banana plants per household was 37.2 followed by 12.55 for mango and 12.72 for papaya.

- ❖ Mushroom cultivation was practiced by farmers in Odisha. Farmers owned 55.33 number of bed for mushroom production. The average number of production cycle was 7 with 20-26 days per production cycle. The average labour engaged was about 58 man-days. While the cost incurred in labour was ₹11622, input and other cost was Rs.15222.22. The total cost of cultivation of mushroom was approximately ₹ 26844. The per annum average net income generated was about ₹ 41778 from the average number of bed and production cycle of about 55 and 7 production cycles.
- ❖ In both the states, majority of farm households were concentrated in the range of 90-100 per cent Technical Efficiency (TE) (42.86 % in Jharkhand and 32.76 % in Odisha). The minimum value of TE was 47.80 per cent in Jharkhand and 44.20 per cent in Odisha. Overall, the average TE was higher in case of Jharkhand (83.31 %) compared to Odisha (81.34 %). In case of Jharkhand, the efficiency was highest in large farms (85.10 %) followed by small (83.78 %) and large categories (85.10 %). However, in Odisha, it was highest in medium followed by small and large categories with value of 83.43 per cent, 80.35 per cent and 80.35 per cent, respectively.
- ❖ Farmers with more owned land and irrigation facilities were more likely to adopt vegetable as a farming component whereas the nearer the farmers are to the market, the more the likelihood of adopting vegetable farming. The intensity of vegetable cultivation was also influenced by age, education, irrigated area and extension contact. The determinants of adoption of pond-based farming system in the state of Odisha were analyzed. It showed that owned land area had a positive relationship whereas distance to farm had a significant and negative effect. These implied that farmers with more owned land and those having farm nearer to their home tend to adopt pond based farming system.
- ❖ The analysis of the determinants of crop diversification in Jharkhand showed that distance to market and willingness to take risk influence crop diversification negatively and positively, respectively. In Odisha, factors like own area, the

proportion of area under irrigation in *Rabi* season, distance to market and willingness to take risk had statistically significant relationship on the level of crop diversification. Further analysis of pooled data from Jharkhand and Odisha revealed that owned area, the proportion of area under irrigation in *Kharif* season, the proportion of area under irrigation in *Rabi* had statistically significant effect on level of crop diversification.

- ❖ Result from the Theory of Planned Behavior showed that farmer perceived adding more number of farming components would increase farm productivity, stabilize their income, generate employment, enhance food security and help better adaptation to climatic aberration. Majority of farmers believed that adoption of more farm component would not reduce the use of chemicals and fertilizers. Most of the respondent weighs the suggestions of their family and progressive farmers before taking decision of adding more components to their farm. Most farmers had the belief that adoption of more components will demand greater commitment to management of farm, intensive inputs and high establishment costs. Farmers also perceived that with more components, the needs for technical know-how of diversified components would be more and the demand for labour would be more. The need for suitable farmland to add more components were given due importance by the respondents. Financial and extension support would help in adoption of more components. Demand for more farm inputs and labour were also major challenges which could emphasize the need for unique IFS models considering household characteristics. Marketing of diversified produce was not a hurdle in all produce. Marketing problem was product specific. Adding components should also consider the market availability especially for intensive farmers.
- ❖ In Jharkhand, (crop + livestock +vegetable +fish +horticulture +poultry) combination gave the highest average net income of Rs.94731/ annum and employment with B: C ratio 2.5 followed by crop + livestock combination with net income Rs. 61777.91/ annum and B: C ratio of 2.53 and crop + vegetable combination gave Rs 30939/ annum with B: C ratio 2.0. Crop + livestock generated about 181 man days, whereas, crop + livestock +vegetable +fish +horticulture +poultry generated about 247 man-

days per annum as the semi-intensive and pasturing nature of dairy farmers demanded more employment among the farmers.

- ❖ In Odisha, (crop+ livestock+ vegetable+ fish+ horticulture) combination gave average net benefit of Rs.107827.6 with B: C ratio 3.02 and generated about 131 man-days per annum. Net benefit of Rs. 110025 with B:C ratio of 3.39 and 177 man days were generated from the combination (crop + livestock +vegetable +fish +horticulture + plantation crop). (Crop+livestock+vegetable+horticulture+plantation crops) combination was found to give an average net benefit of Rs 107827.6 per annum with B: C ratio 3.02 and generate 146 man-days
- ❖ Assessment of resource availability in the farm environment and identification of bio-physical, socio-economic, institutional and technological constraints should be considered before designing any location-specific farming system model. Different farm components suited to local agro-climatic condition and demands of different products in the nearby market needs to be incorporated. Recommendation of the IFS model should be on the basis of economic feasibility and compatibility of the farming system.
- ❖ Participatory on-farm research should be conducted to refine and validate different farming system models for different beneficiary class. Linkages between scientists and institutions have to be established to speed up cooperation. There is great potential for increasing the productivity of limited land by integrating different technologies into the existing farming system, which are successfully applied in other regions and at national and international research centres. Demonstration and popularization of integrated farming system have to be taken in a system approach rather than specific component 'Package of practices'.
- ❖ There is a huge gap in productivity of crop and livestock components and are far below the national average. The adoption of superior varieties and breed will improve the productivity of the farm. Providing credit and initial investment will help in adoption and development of sustainable integrated farming system. Different farm inputs must be made available at a fair marketing system. Development of sustainable IFS should look beyond production, as marketing is also an important aspect of farm sustainability.

- ❖ A single window system should be developed for popularization and delivery of inputs for promoting IFS for creation of awareness and delivery of services about various schemes. Different developmental organizations promote IFS with different schemes and subsidy programme. Linkage of extension organizations with various other rural development organizations in delivering the need for farmers will go a long way.

Effectiveness of Integrated Farming System Models for Sustainable Livelihood

ABSTRACT

Though studies have established that appropriate Integrated Farming System (IFS) model could improve livelihood and nutritional security even with small size of holdings, its systematic adoption has been very low. It suggests for an analytical socio-economic study of IFS models. Therefore, a research study entitled “Effectiveness of Integrated Farming System Models for Sustainable Livelihood” was conducted in Jharkhand and Odisha with the objectives of identifying the best practices of different IFS models, undertaking their techno-economic assessment, analyzing the determinants for their adoption and constraints, assessing their socio-economic and farm level impact, and analyzing the extension strategies for their promotion for sustainable livelihood. The sample size of the study was 222, which comprised 105 farmers randomly selected from three districts (Gumla, Sahebganj and Dumka) of Jharkhand and 117 farmers randomly selected from 4 districts (Puri, Khordha, Jagatsinghpur and Cuttack) of Odisha. Theory of planned behavior, Data Envelopment Analysis for efficiency analysis, benefit-cost ratio (B:C), regressions (Logit and Tobit) and descriptive statistics were used for data analysis and inferencing.

The major IFS models adopted in Jharkhand were Crop+Livestock+Vegetable (adopted by 27.62 per cent farmers; having average net income of Rs. 16623 and B:C of 1.46), Crop+ Vegetable (adopted by about 13 per cent farmers with average net income of Rs. 30939 and B:C of 2) and Crop+ Livestock (adopted by about 10 per cent farmers with average net income of Rs. 61777 and B:C of 2.53). The major IFS models adopted in Odisha were Crop+ Vegetable (adopted by 20.5 per cent farmers with average net income of Rs. 38168.58 and B:C of 1.97), Crop + Livestock+ Vegetable (adopted by about 12 per cent farmers with average net income Rs. 63018 and B:C of 2.63) and Crop+ Livestock+ Vegetable +Fish+ Horticulture (adopted by 8.55 per cent farmers with average net income Rs. 107827.6 and B:C of 3.02).

A majority of farmers (65.71 %) in Jharkhand adopted local cattle breed wherein Odisha majority of farmers (46.15 %) adopted exotic breed. Goat was another popular

component in Jharkhand. Fish rearing and plantation crop was a common component in Odisha.

In both the states, majority of farm households were concentrated in the range of 90-100 per cent Technical Efficiency (42.86 % in Jharkhand and 32.76 % in Odisha).

Logistic regression showed that owned land and proportion of irrigated area in *Rabi* season positively and significantly influenced the probability of adoption of vegetable farming as a component of the farming system in Odisha and Jharkhand. The age and education of farmers, proportion of irrigated area under *Kharif* crops and extension contact had a positive effect on the intensity of vegetable cultivation. The size of owned land area and distance to farm had a significant effect on the adoption of pond-based farming system and income generated per unit area.

Tobit regression revealed that in Jharkhand and Odisha, own area ($p=0.005$), proportion of area under irrigation in *Kharif* ($p=0.021$), and proportion of area under irrigation in *Rabi* ($p<0.001$) had statistically significant effect on level of crop diversification. It further revealed that in Jharkhand, farmer's education ($p=0.024$) and willingness to take risk ($p=0.002$) had significant influence on the level of income diversification, while in Odisha, proportion of area under irrigation in *Rabi* ($p<0.001$) and willingness to take risk ($p=0.001$) had significant influence on income diversification.

The major constraints in cereal-pulse based farming were high dependence on monsoon, lack of irrigation facility and pest attack. The major constraints in vegetable-based farming were poor market infrastructure, lack of irrigation facility and non-availability of quality seed. Lack of availability of green fodder, disease and low productivity were the major constraints in livestock-based farming. Major constraints in fish based farming were lack of market facilities, high establishment cost and unavailability of quality fingerlings.

The study suggests to lay emphasis upon convergence of stakeholders with active community participation; augmentation system thinking, promotion of differentiated models of IFS considering farmer's socio-economic bio-physical characteristics rather than "One best model fit for all"; and capacity building in IFS Research & Development for sustainable and location-specific IFS model development.

Keywords: Integrated Farming System, Sustainable Livelihood, Jharkhand, Odisha

सतत आजीविका के लिए एकीकृत खेती प्रणाली मॉडल की प्रभावशीलता

सारांश

यद्यपि अध्ययनों ने स्थापित किया है कि उचित एकीकृत कृषि प्रणाली (आई० एफ० एस०) मॉडल लघु स्तरीय जोत क्षेत्र के स्थिति में भी आजीविका और पोषण सुरक्षा में सुधार कर सकता है, इसका व्यवस्थित अधिग्रहण बहुत धीमा है। यह स्थिति आई एफ एस मॉडल का एक विश्लेषणात्मक सामाजिक-आर्थिक अध्ययन के लिए सुझाव देता है। अतः "सतत आजीविका के लिए एकीकृत खेती प्रणाली मॉडल की प्रभावशीलता" नामक एक शोध अध्ययन झारखंड और ओडिशा में किया गया, जिसके विभिन्न उद्देश्य थे - आई एफ एस मॉडलों के सर्वोत्तम विधाओं को पहचानना, उनका तकनीकी व आर्थिक आंकलन करना, उनके अधिग्रहण के निर्धारकों और अवरोधों का विश्लेषण करना, उनके सामाजिक-आर्थिक और फार्म स्तर के प्रभाव का आकलन करना, तथा सतत आजीविका के लिए इनके उन्नति हेतु प्रसार रणनीति का विश्लेषण करना। अध्ययन का नमूना आकार 222 था, जिसमें झारखंड के तीन जिलों (गुमला, साहेबगंज और दुमका) से 105 किसानों को यादृच्छिक रूप से और ओडिशा के 4 जिलों (पुरी, खोरधा, जगतसिंहपुर और कटक) से 117 किसानों को यादृच्छिक रूप से चुने गए कृषक शामिल थे। थ्योरी ऑफ़ प्लान्ड बिहेवियर, डाटा इनवेलोपमेंट विश्लेषण, लाभ-लागत अनुपात, रिगेशन (लोजीट व टोबिट) तथा डिस्क्रिप्टिव सांख्यिकी का प्रयोग आकड़ों के विश्लेषण व निष्कर्ष हेतु किया गया।

झारखंड में अपनाया गया प्रमुख आई एफ एस मॉडल था "फसल + पशुधन + सब्जी", जिसे 27.62 प्रतिशत किसानों द्वारा अपनाया गया और औसत शुद्ध लाभ रूपया 16623 और बी: सी अनुपात 1.46 पाया गया। "फसल + सब्जी" मॉडल लगभग 13 प्रतिशत किसानों द्वारा अपनाया गया जिससे औसत शुद्ध आय रूपया 30939 तथा बी: सी अनुपात 2 पाया गया। "फसल + पशुधन" लगभग 10 प्रतिशत किसानों द्वारा अपनाया गया जिससे रूपया 61777 रुपये की औसत शुद्ध आय और बी: सी अनुपात 2.53 पाया गया। ओडिशा में अपनाया गया प्रमुख आई एफ एस मॉडल था "फसल + सब्जी", जिसे 20.5 प्रतिशत किसानों द्वारा अपनाया गया तथा औसत शुद्ध आय रूपये 38,568.58 और 1.97 बी: सी अनुपात 1.97 प्राप्त किया गया। "फसल + पशुधन + सब्जी" लगभग 12 प्रतिशत किसानों द्वारा अपनाया गया और औसत शुद्ध आय रूपया 63018 तथा बी: सी अनुपात 2.63 प्राप्त किया गया। "फसल + पशुधन + सब्जी + मछली + बागवानी", 8.55 प्रतिशत किसानों द्वारा अपनाया गया जिससे औसत शुद्ध आय रूपये 107827.6 और बी:सी अनुपात 3.02 प्राप्त किया गया।

झारखंड में अधिकांश किसानों (65.71%) ने स्थानीय मवेशी नस्ल को अपनाया है, ओडिशा के अधिकांश किसानों (46.15%) ने विदेशी नस्ल अपनाया है। झारखंड में बकरी एक और लोकप्रिय घटक था। ओडिशा में मछली पालन और रोपण फसल एक आम घटक था। दोनों राज्यों में, अधिकांश कृषक परिवार 90-100 प्रतिशत तकनीकी दक्षता (झारखंड में 42.86% और ओडिशा में 32.76%) की सीमा में केंद्रित थे।

लॉजिस्टिक समाश्रयण ने दर्शाया कि जोत क्षेत्र व रबी मौसम में सिंचाई वाले क्षेत्र का अनुपात का सब्जी की खेती के अधिग्रहण के संभाव्यता पर सकारात्मक तथा सार्थक प्रभाव पाया गया। कृषकों के उम्र व शिक्षा स्तर, खरीफ फसलों के अंतर्गत सिंचित क्षेत्र तथा प्रसार से

संपर्क का सब्जी की खेती के गहनता पर सकारात्मक प्रभाव था। स्वामित्व वाले जोत क्षेत्र का परिमाण और फार्म तक की दुरी का तालाब-आधारित कृषि प्रणाली के अधिग्रहण तथा प्रति इकाई क्षेत्र से अर्जित लाभ पर सार्थक प्रभाव था।

टोबिट समाश्रयण ने प्रत्यक्ष किया कि झारखण्ड और ओडिशा में स्वामित्व जोत क्षेत्र ($p=0.005$), खरीफ में सिंचित क्षेत्र का अनुपात ($p=0.021$) तथा रबी में सिंचित क्षेत्र का अनुपात ($p=0.001$) का फसल विविधीकरण पर सांख्यिकीय रूप से सार्थक प्रभाव था। आगे यह भी प्रत्यक्ष किया कि झारखण्ड में कृषकों का शिक्षा स्तर ($p=0.024$) तथा जोखिम उठाने की इच्छा ($p=0.002$) का आमदनी विविधीकरण के स्तर पर सार्थक प्रभाव था। ओडिशा में रबी में सिंचित जोत क्षेत्र का अनुपात ($p<0.001$) तथा जोखिम उठाने की इच्छा ($p=0.001$) का आमदनी विविधीकरण पर सार्थक प्रभाव था।

अनाज- दाल आधारित खेती में प्रमुख बाधा थे - मानसून पर अत्यधिक निर्भरता, सिंचाई सुविधा का अभाव और कीट संक्रमण। सब्जी आधारित खेती में प्रमुख बाधाएं खराब बाजार व आधारभूत संरचना, सिंचाई सुविधा की कमी और गुणवत्ता वाले बीज की अनुपलब्धता थीं। हरे चारा की उपलब्धता की कमी, बीमारी और कम उत्पादकता, पशुधन आधारित खेती की प्रमुख बाधाएं थीं। मछली आधारित खेती में प्रमुख बाधाओं में बाजार सुविधाओं की कमी, उच्च प्रतिष्ठान लागत और गुणवत्ता वाले मछली के बच्चे की अनुपलब्धता की कमी थी।

सक्रिय सामुदायिक सहभागिता सहित पणधारियों का अभिसरण, प्रणाली स्तर कि सोच का आवर्धन, कृषकों के सामाजिक व आर्थिक तथा जैवभौतिक विशिष्टताओं को ध्यान में रखते हुए भेदित आई एफ एस मॉडलों को बढ़ावा देना ना कि "सबके लिए उपयुक्त एक सर्वोत्तम मॉडलों" को बढ़ावा देना, तथा सतत एवं क्षेत्रीय विशेष आई एफ एस मॉडल के विकास हेतु आई एफ एस के शोध व क्षमता विकास का वर्धन इस अध्ययन के सुझाव रहे।

BIBLIOGRAPHY

- Agbonlabor, M. U., Aromolaran, A. B., and Aiboni, V. I. (2003). Sustainable soil management practices in small farms of Southern Nigeria: A poultry-food crop integrated farming approach. *Journal of Sustainable Agriculture*, 22(4), 51-62.
- Agricultural Census (2011). Agriculture Census Division. Department of Agriculture & Cooperation. Ministry of Agriculture. New Delhi.
- Ahlawat, I. P. S., Omprakash., and Saini, G. S. (2002). Scientific crop production in India. Aman Publishing House, Meerut. p. 576.
- Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behavior and Human Decision Processes*, 50, 179-211.
- Ajzen, I., and Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.
- Altieri, M. A., Funes-Monzote, F. R., Petersen, P. (2012). Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron Sustain Development*, 32, 1–13.
- Amjath–Babu, T.S., and Kaechele, H. (2015). Agricultural system transitions in selected Indian states: What do the related indicators say about the underlying biodiversity changes and economic trade–offs? *Ecological Indicators*, 57, 171–181.
- Andersen, E. (2009). Regional Typologies of Farming Systems Contexts, seamless Integrated Project, Eu 6th Framework Programme.
- Aquaculture, A. I. T. (1994). Partners in development: the promotion of sustainable aquaculture. *AIT Aquaculture*.
- Ashby, J. A. (2001). Integrating research on food and the environment: An exit strategy from the rational fool syndrome in agricultural science. *Ecol. Soc.* 5(2), 20.
- Ashby, J. A. (2002). Integrating research on food and the environment: an exit strategy from the rational fool syndrome in agricultural science. *Conservation Ecology*, 5(2).
- Ashby, J. A. (1986). Methodology for participation of small farmers in the design of on-farm trials. *Agricultural Administration*, 22(1), 1–19.

- Asian Institute of Technology (AIT), Pathumthani, Thailand. *Faculty of Economics*. (2000). Sustainable agriculture: Case study in northeast Thailand. Research report. Kasetsart University (KU), Thailand.
- Bahinipati, C. S., and Venkatachalam, L. (2013). Determinants of farm-level adaptation practices to climate extremes: A case study from Odisha, India. Working Paper No. 219. December 2013. Gujarat Institute of Development Research. Gota, Ahmedabad.
- Bahire, V. V., Kadam, R. P., and Sidam, V. N. (2010). Sustainable Integrated Farming is the need of the Indian farmer. In *22nd national seminar on "Role of Extension in Integrated Farming Systems for sustainable rural livelihood, 9th-10th Dec, Maharastra* (Vol. 65).
- Banerjee, A., and Kuri, P. K. (2015). Agricultural Growth and Regional Disparity in India: A Convergence Analysis. *Sri Lankan Journal of Agricultural Economics*, 16(1), 61–77.
- Banerjee, B. N., Sarker, S. C., and Maity, A. K. (1990). Impact of resource optimisation on cropping pattern and income on 'crop-dairy mixed farm'. *Indian Journal of Dairy Science*, 43(3), 295-301.
- Banker, R.D., Charnes, A., and Cooper, W.W. (1984), Some Models Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science*, 30(9), 1078-1092.
- Bationo, A., Nandwa, S.M., Kimetu, J.M., Kinyangi, J.M., Bado, B.V., Lompo, F., Kimani, S., Kihanda, F., and Koala, S. (2004). Sustainable interaction of crop–livestock systems through manure management in Eastern and Western Africa: Lessons learned and emerging research opportunities in Williams (eds.), *Sustainable crop–livestock production for improved livelihoods and natural resource management in West Africa*. International Livestock Research Institute, Nairobi. pp. 173–198.
- Behera, U. K., and Mahapatra, I. C. (1999). Income and employment generation for small and marginal farmers through integrated farming systems. *Indian Journal of Agronomy*, 44(3), 431-439.
- Behera, U. K., Jha, K. P., and Mahapatra, I. C. (2004). Integrated management of available resources of the small and marginal farmers for generation of income and employment in eastern India. *Crop Research (Hisar)*, 27(1), 83-89.

- Behera, U. K., Sharma, A. R., and Mahapatra, I. C. (2007). Crop diversification for efficient resource management in India: problems, prospects and policy. *Journal of sustainable agriculture*, 30(3), 97-127.
- Behera, U. K., Yates, C. M., Kebreab, E., and France, J. (2008). Farming systems methodology for efficient resource management at the farm level: a review from an Indian perspective. *The Journal of Agricultural Science*, 146(5), 493-505.
- Behera, U.K. (2013). A text book on farming systems. Udaipur, India, Agrotech Publishing House. pp. 273.
- Behera, U.K., and Sharma, A.R. (2007). Modern concept of agriculture farming systems. Advanced publishing IARI, New Delhi pp.1-36.
- Behera, U.K., Kaechele, H., and France, J. (2014). Integrated animal and cropping systems in single and multi-objective frameworks for enhancing the livelihood security of farmers and agricultural sustainability in Northern India. *Animal Production Science*, 55(10), 1338-1346.
- Benzécri, J.P. (1992). Correspondence analysis handbook. Marcel Dekker, NY, 665 pp.
- Bergevoet, R. H. M., Ondersteijn, C. J. M., Saatkamp, H. W., van Woerkum, C. M. J., and Huirne, R. B. M. (2004). Entrepreneurial behaviour of Dutch dairy farmers under a milk quota system: Goals objectives and attitudes. *Agricultural Systems*, 80, 1–21.
- Bhattacharyya, R., Ghosh, B. N., Mishra, P. K, Mandal, B., Rao, C. S., Sarkar, D., Das, K., Anil, K.S., Lalitha, M., Hati, K. M., and Franzluebbbers, A. J. (2015). Soil degradation in India: Challenges and potential solutions. *Sustainability*, 7(4), 3528-3570
- Binswanger, H. P., and Rosenzweig, M. R. (1986). Behavioural and material determinants of production relations in agriculture. *The Journal of Development Studies*, 22(3), 503-539.
- Bisht, D. (2011). Integrated fish farming for food, nutritional security and economic efficiency in mid hills of Indian Central Himalaya. *Research Journal of Fisheries and Hydrobiology*, 6(1), 1-6.

- Biswas, B.C. (2009). Challenges in Indian Agriculture. *Fertiliser Marketing News*, 40(7), 1-7.
- Biswas, C., & Singh, R. (2003). Integrated farming system: an intensity approach. *Intensive Agriculture*, 41(7-8), 22-23.
- Byerlee, D., Harrington, L., and Winkelman, D. L. (1982). Farming system research: Issues in Research Strategy and Technology Design. *American Journal of Agricultural Economics*, 64, 897–904.
- Carmona, A., Nahuelhual, L., Echeverría, C., and Báez, A. (2010). Linking farming systems to landscape change: an empirical and spatially explicit study in southern Chile. *Agriculture, Ecosystems & Environment*, 139(1-2), 40-50.
- Castel, J. M., Madry, W., Gozdowski, D., Roszkowska-Madra, B., Dąbrowski, M., Lupa, W., and Mena, Y. (2010). Family dairy farms in the Podlasie province, Poland: farm typology according to farming system. *Spanish Journal of Agricultural Research*, 8(4), 946-961.
- Castel, J. M., Mena, Y., Delgado-Pertíñez, M., Camúñez, J., Basulto, J., Caravaca, F., and Alcalde, M. J. (2003). Characterization of semi-extensive goat production systems in southern Spain. *Small Ruminant Research*, 47(2), 133-143.
- Census of India (2011). Directorate of Census Operation, New Delhi.
- Chand, R. (2017). Doubling Farmers' Income: Rationale, Strategy, Prospects and Action Plan, NITI Policy Paper 01/2017 National Institution for Transforming India, Government of India, New Delhi.
- Chand, R., Prasanna, P. L., and Singh, A. (2011). Farm size and productivity: understanding the strengths of smallholders and improving their livelihoods. *Economic and Political Weekly*, 46(26), 5-11.
- Chandrani Saha, (2008). A study on sustainability of farming system and livelihood security among rural house hold in Tripura. *M.Sc. (Agri.) Thesis (Unpub.)*, University of Agriculture Science, Bangalore.
- Channabasavanna, A.S., Biradar, D.P., Prabhudev K.N., and Mahabhaleswar, H. (2009). Development of profitable integrated farming system model for small and medium farmers of Tungabhadra project area of Karnataka. *Karnataka Journal of Agricultural Science*, 22(1), 25–27.

- Charnes, A., Cooper, W.W., and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2(6), 429-444.
- Chavas, J. P., and Kim, K. (2010). Economies of diversification: A generalization and decomposition of economies of scope. *International Journal of Production Economics*, 126(2), 229-235.
- Chavas, J. P., Chambers, R. G., and Pope, R. D. (2010). Production economics and farm management: a century of contributions. *American Journal of Agricultural Economics*, 92(2), 356-375.
- Cheshire, L., Meurk, C., and Woods, M. (2013). Decoupling farm, farming and place: Recombinant attachments of globally engaged family farmers. *Journal of Rural Studies*, 30, 64-74.
- Chiputwa, B., and Qaim, M. (2016). Sustainability standards, gender, and nutrition among smallholder farmers in Uganda. *Journal of Development Studies*, 52, 1241–1257.
- Chitra, B.M. (2010). A study on knowledge and adoption of improved practices in selected farming systems of Mandya district. *M.Sc. (Agri.) Thesis (Unpub.)*, University of Agriculture Science, Bangalore.
- Choosakul, S. (1999). Challenging crisis with sustainable farming. Sustainable resource management project northeast region, Mahasarakham, Thailand.
- Coelli T., Rahman S., and Thirtle C. (2002). Technical, Allocative, Cost and Scale Efficiency in Bangladesh Rice Cultivation: A Non-Parametric Approach. *Journal of Agricultural Economics*, 53(3), 607-626.
- Coelli, T. (1996). A guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program, CEPA Working Paper 96(08), Centre for Efficiency and Productivity Analysis, Department of Econometrics, University of New England, Australia.
- Cournut, S., and Dedieu, B. (2004). A discrete events simulation of flock dynamics: a management application to three lambings in two years. *Animal Research*, 53(5), 383-403.

- Craswell, E. T. (1998). Sustainable crop and soil management on sloping lands. In International Symposium of Asian Agriculture in the 21st Century. Taipei, Food and Fertilizer Technology Centre.
- Csavas, I. (1992). Regional review on livestock-fish production systems in Asia. In: Mukherjee, T.K., Moi, P.S., Panandam, J.M., and Yang, Y.S. (Eds.), Proceedings of the FAO/IPT Workshop on integrated livestock-fish production systems, 16-20 December 1991, Institute of Advance Studies, University of Malaya, Kuala Lumpur, Malaysia.
- Das, B. (2017). Green Revolution and its impact on Indian agriculture. *Imperial Journal of Interdisciplinary Research*, 3(9), 535-537.
- de Haen, H., Klasen, S., Qaim, M. (2011). What do we really know? Metrics for food insecurity and undernutrition. *Food Policy*, 36, 760–769.
- De Wit, C.T. (1992). Resource use efficiency in agriculture. *Agricultural Systems*, 40, 125–151.
- Debreu, G. (1951). The Coefficient of Resource Utilisation, *Econometrica*, 19, 273-292.
- Desai, G.B. (1981). A critical analysis of the contribution of education and extension guidance of economic performance of cotton farmers of Karnataka state. *M.Sc (Agri.) Thesis (Unpub.)*, University of Agriculture Science, Dharwad.
- Dev, S. M. (2008). Challenges for revival of Indian agriculture. *Agricultural Economics Research Review*, 22(1).
- Devasenapathy, P., Mytswamy, V., Christopher Louduraj, A., and Rabindran, R. (1995). Integrated farming systems for sustained productivity. *Madras Agricultural Journal*, 82, 306-307
- Devendra, C. (1997). Mixed farming and intensification of animal production systems in Asia. *Outlook on Agriculture*, 26(4), 255–265.
- Devendra, C. (1998). Improvement of small ruminant production systems in rainfed agro–ecological zones of Asia. *Annals of Arid Zone*, 37(3), 215–232.
- Devendra, C. (2000). Animal production and rainfed agriculture in Asia: Potential opportunities for productivity enhancement. *Outlook on Agriculture*, 29(3), 161–175.

- Dhaka, B. L., Jat, R. A., and Poonia, M. K. (2009). Integrated farming system approach for natural resource management. *Indian Journal of Fertilisers*, 5(11), 31-37.
- Dibissia, N. and Peters, K.J. (1999). Livestock species composition and herd size in relation to household farm resources in mixed farming systems in the Ethiopian highlands. *Outlook on Agriculture*, 28(1), 51–54.
- Dixon, J. A., Gibbon, D. P., Gulliver, A., and Hall, M. (2001). Farming systems and poverty: improving farmers' livelihoods in a changing world. Food & Agriculture Organization.
- Doss, C. R. (2006). Analyzing technology adoption using micro studies: limitations, challenges, and opportunities for improvement. *Agricultural Economics*, 34 (3), 207–219.
- Dubey, J.K. (2010). Studies on crop diversification based on rice for sustainable production in Rewa region of Madhya Pradesh. M.Sc. Thesis, J.N. Krishi Vishwa Vidyalaya, Jabalpur, M.P, India.
- Eagly, A., Chaiken, S. (1993). The psychology of attitudes. Forth Worth TX: Harcourt Brace Jovanovich.
- Ecker, O., and Qaim, M. (2011). Analyzing nutritional impacts of policies: an empirical study for Malawi. *World Development*, 39 (3), 412–428
- Edwards, P. (1997). Sustainable food production through aquaculture. Aquaculture Asia. Volume 2. School of Environment, Resources and Development.
- Edwards, P. (1998). A systems approach for the promotion of integrated aquaculture. *Aquaculture Economics & Management*, 2(1), 1-12.
- E-gyankosh. (2018). <http://egyankosh.ac.in/bitstream/123456789/38013/1/Unit-10.pdf>
- Ellis, F. (2000). Oxford University Press; Oxford, UK. Rural livelihoods and diversity in developing countries.
- FAO (2001). Mixed crop-livestock farming: a review of traditional technologies based on literature and field experience. *Animal Production and Health Papers 152*.

- Faroda, A. S., Yadav, R. S., and Pal, R. N. (1978). Comparative economics of specialized dairy farming, mixed farming and arable farming. *Haryana Agricultural University Journal of Research*, 8, 234-39.
- Farrell, M.J. (1957). The measurement of production efficiency”, *Journal of Royal Statistical Society, Series A (General)*, 120(3), 253-290.
- Feder, G., Just, R. E., and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, 33(2), 255-298.
- Fishbein, M. (2000). The role of theory in HIV prevention. *AIDS Care*, 12, 273–278.
- Fishbein, M. and Ajzen, I. (1975). Belief, attitude, intention, and behaviour. New York: Wiley.
- Fishbein, M., and Yzer, M.C. (2003). Using theory to design effective health behaviour interventions. *Communication Theory*, 13, 164–183.
- Gibon, A., Sibbald, A. R., Flamant, J. C., Lhoste, P., Revilla, R., Rubino, R., and Sørensen, J. T. (1999). Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming. *Livestock Production Science*, 61(2-3), 121-137.
- Gill, M. S., Samra, J. S., and Singh, G. (2005). Integrated farming system for realizing high productivity under shallow water table conditions. *Research Bulletin of Punjab Agriculture University*.
- Gill, M. S., Singh, J. P. and Gangwar, K. S. (2009). Integrated farming system and agriculture sustainability. *Indian Journal of Agronomy*, 54(2), 128-139.
- Gliessman, S. R.; Garcia, R. and Amador, M. (1981). The ecological basis for the application of traditional agricultural technology in the management of tropical agro-ecosystem, *Agro-Ecosystems*. 7, 173- 185.
- Goode, W. J., & Hatt, P. K. (1952). *Methods in Social Research*. New York: McGraw-Hill Book Company.
- Gopinath, K.A., Dixit, S., Srinivasarao, Ch., Raju, B.M.K., Chary, R.G., Osman, M., Ramana, D.B.V., Nataraja, K.C., Devi, G.K., Venkatesh, G., Grover, M., Maheswari, M., and Venkateswarlu, B. (2012). Improving the existing rainfed farming systems of small and marginal farmers in Anantapur district, Andhra

- Pradesh. *Indian Journal of Dryland Agricultural Research and Development*, 27(2), 43–47.
- Gorton, M., Douarin, E., Davidova, S. and Latruffe, L. (2008). Attitudes to agricultural policy and farming futures in the context of the 2003 CAP reform: A comparison of farmers in selected established and new Member States. *Journal of Rural Studies*, 24, 322–336.
- Government of India, (2007). 18th Indian Livestock Census 2007. Department of Animal Husbandry and Dairying, Ministry of Agriculture.
- Govindan, R., Chinnaswami, K. N., Chandrasekaran, B., Budhar, M. N., and Prince, J. (1990). Poultry-cum-fish culture in rice farming in Cauvery delta region of Tamil Nadu. *Indian Journal of Agronomy*, 35(1/2), 23-29.
- Greene, W. (2003). *Econometric Analysis*. New Jersey: Prentice Hall.
- Gupta, V, Rai, P.K., and Risam, K.S. (2012) Integrated Crop-Livestock Farming Systems: A Strategy for Resource Conservation and Environmental Sustainability. *Indian Research Journal of Extension Education*, 2, 49-54.
- Guto, S.N., Pypers, P., Vanlauwe, B., de Ridder, N., Giller, K.E. (2010). Socio-ecological niches for minimum tillage and crop-residue retention in continuous maize cropping systems in smallholder farms of Central Kenya. *Agron J*, 104,188–198
- Hagger, M. S., Chatzisarantis, N. L., & Biddle, S. J. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of sport and exercise psychology*, 24(1), 3-32.
- Hair, J. F., Anderson, R. E., Tathaam, R. L., Black, W.C. (1998). *Multivariate Data Analysis*. Macmillan Publishing Company, New York , 5th ed, Prentice Hall Int, 799 pp.
- Hansen, J. W. (1996). Is agricultural sustainability a useful concept? *Agricultural Systems*, 50, 117–143.

- Hanson, J., Dismukes, R., Chambers, W., Greene, C., and Kremen, A. (2004). Risk and risk management in organic agriculture: Views of organic farmers. *Renewable agriculture and food systems*, 19(4), 218-227.
- Hansson, H., and Lagerkvist, C. (2012). Measuring farmers preferences for risk: A domain-specific risk preference scale. *Journal of Risk Research*. 15, 737-753.
- Hansson, H., Ferguson, R., and Olofsson, C. (2012). Psychological constructs underlying farmers' decisions to diversify or specialise their businesses – an application of Theory of Planned Behaviour. *Journal of Agricultural Economics*, 63(2), 465–482.
- Haque, T. (2006). Resource use efficiency in Indian Agriculture. *Indian Journal of Agricultural Economics*, 6(1) 65-76.
- Haque, T. (2010). Constraints and Potentials of Diversified Agricultural Development in Eastern India. Project Report. Project Sponsored by Planning Commission (Government of India).
- Hartigan, J. A., and Wong, M. A. (1979). Algorithm AS 136: A k-means clustering algorithm. *Applied Statistics*, 28(1), 100-108.
- Hayakawa, H., Sasaki, M., and Kimura, K. (1996). Integrated systems of animal production in the Asian region. Proceedings of a symposium held in conjunction with 8th AAAP Animal Science Congress, Chiba, Japan, October 13-18, 1996. AAAP.
- Haylor, G. (2003). Aquatic resources management for sustainable livelihoods of poor people: proceedings of the DFID-ARM e-mail conference.
- Hosamani, M. M. (1999). Research-extension linkage in IFS development. Lecture Notes of Summer Short Course on Farming Systems for Sustainable Production, 266-269.
- ICAR-CIWA Vision 2050 Document, (2015) <http://icar-ciwa.org.in/pdf/visiondocuments/CIWA-Vision%202050.pdf>.
- IRRI (International Rice Research Institute), (1998). Sustaining food security beyond the year 2000: a global partnership for rice research; Medium-term Plan 1999–2001. International Rice Research Institute (IRRI), Los Banos, pp. 1–136.

- Jain, N. K., Singh, H., Dashora, L.N., and Mundra, S.N. (2015). Diversification and intensification of maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system for sustainable productivity and profitability. *Indian Journal of Agronomy*, 60(1), 38–44.
- Jat, R.A., Dungrani, R.A., Arvadia, M.K., and Sahrawat, K.L. (2012). Diversification of rice (*Oryza sativa* L.) based cropping systems for higher productivity, resource–use efficiency and economic returns in south Gujarat, India. *Archives of Agronomy and Soil Science*. 58(6), 561–572.
- Jayanthi, C., Rangasamy, A., and Chinnusamy, C. (1997). Integrated nutrient management in rice-based cropping systems linked with lowland integrated farming system, *Fertilizer News*, 42 (3), 25-30.
- Jayanthi, C., Rangasamy, A., and Chinnusamy, C. (2000). Water budgeting for components in lowland integrated farming systems. *Madras Agricultural Journal*, 87(7/9), 411-414.
- Jitsanguan, T. (2001). Sustainable agricultural systems for small-scale farmers in Thailand: implications for the environment. Food and Fertilizer Technology Center.
- Jones, S.C., Magee, C., and Andrews, K. (2015). ‘I think other parents might Using a projective technique to explore parental supply of alcohol. *Drug and Alcohol Review*, 34 (5), 531-539.
- K. Singh, J.S. Bohra, Y. Singh., and J.P. Singh. (2006). Development of farming system models for the northeastern plain zone of Uttar Pradesh. *Indian Farming*, 56(7), 2006, 5-11.
- Kabunga, N.S., Dubois, T., and Qaim, M. (2014). Impact of tissue culture banana technology on farm household income and food security in Kenya. *Food Policy*, 45, 25-34.
- Khon Kaen University (KKU). (2001). New theory: Water and land management for agriculture. Study report on agriculture following the Kings concept. Khon Kaen, Thailand.
- Khush, G. S. (2001). Green revolution: the way forward. *Nature Reviews Genetics*, 2(10), 815.

- Knowler, D., and Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food policy*, 32(1), 25-48.
- Köbrich, C., Rehman, T., and Khan, M. (2003). Typification of farming systems for constructing representative farm models: two illustrations of the application of multi-variate analyses in Chile and Pakistan. *Agricultural systems*, 76(1), 141-157.
- Koopmans, T. C. (1951) An Analysis of Production as an Efficient Combination of Activities, In T.C. Koopmans (Ed.), Activity Analysis of Production and Allocation, Cowles Commission for Research in Economics, monograph no. 13. New York: Wiley.
- Korikanthimath, V.S., and Manjunath, B.L. (2009). Integrated farming systems for sustainability in agriculture production. *Indian Journal of Agronomy*, 54(2), 140–148.
- Kumar, A., Reddy, N.V., and Rao, S.K. (2005). Profitable and energy– efficient rice– based cropping systems in Northern Telangana of Andhra Pradesh. *Indian Journal of Agronomy*, 50(1), 6–9.
- Kumar, A., Tripathi, H. P., Yadav, R. A., and Yadav, D. S. (2008). Diversification of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system for sustainable production in eastern Uttar Pradesh. *Indian Journal of Agronomy*, 53(1), 18-21.
- Kumar, S., Dey, A., Kumar, U., Chandra, N., and Bhatt, B. P. (2012). Integrated farming system for improving agricultural productivity. Status of agricultural development in eastern India. Eds: B.P. Bhatt, A.K. Sikka, Joydeep Mukherjee, Adlul Islam. 205- 230.
- Lagerkvist, C. J. (2005). Assessing farmers' risk attitudes based on economic, social, personal, and environmental sources of risk: Evidence from Sweden', 2005. Paper presented at the American Association of Agricultural Economist Meeting, Providence, RI.
- Lavanya, S. (2010), Assessment of farming systems efficiency in Theni district of Tamil Nadu. *M.Sc. (Agri.) Thesis (Unpub.)*, Univ. Agri. Sci., Bangalore.

- Leemans, R., and Van den Born, G. J. (1994). Determining the potential distribution of vegetation, crops and agricultural productivity. *Water, Air, and Soil Pollution*, 76(1-2), 133-161.
- Legesse, G., Abebe, G., Siegmund-Schultze, M. and Valle Zarate, A. (2008). Small ruminant production in two mixed-farming systems of southern Ethiopia: Status and prospects for improvement. *Experimental Agriculture*, 44, 399-412
- Lesschen, J. P., Verburg, P. H., and Staal, S. J. (2005). Statistical methods for analysing the spatial dimension of changes in land use and farming systems. International Livestock Research Institute. ISBN: 92-9146-178-4
- Lesschen, J.P., Verburg, P.H., Staal, S.J. (2005). Statistical methods for analyzing the spatial dimension of changes in land use and farming systems. Lucc Report Series No. 7.
- Lightfoot, C. (1997). Promoting low external inputs agriculture (LEIA) from LEIA to intensive integrated farming systems. In: Dolberg F. and Petersen P.H. (Eds.) Maximizing the influence of the user: alternatives to the training and visit system. Proceedings of a Workshop April 7-11, 1997, Tune Land boskole, Denmark.
- Lightfoot, C., and Minnick, D. R. (1991). Farmer-first qualitative methods: Farmers diagrams for improving methods of experimental design in integrated farming systems. *Journal for Farming Systems Research and Extension*, 2, 11-34.
- Limpinuntana, V., Trelo-ges, V., Vityakon, P., and Patanothai, A. (2001). Sustainability analysis of existing land-use systems in northeast Thailand. *Southeast Asia*, 20, 22.
- Little, D. C., and Edwards, P. (2003). Integrated livestock-fish systems. FAO, Rome, Italy.
- Little, D. C., and Muir, J. (2003). Integrated Agri-aquaculture Systems-The Asian Experience. In: Gooley, G.J. and Gavine, F.M., (Eds.) Integrated Agri-Aquaculture Systems. A Resource Handbook for Australian Industry Development. A Report for the Rural Industries Research and Development Corporation. RIRDC Project no.MFR-2A, pp. 24-36. Victoria, Australia, RIRDC.

- Livestock census (17th), (2002). Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi.
- Lloyd, S. (1982). Least Squares Quantization in PCM. In: IEEE Trans. Information Theory.
- Loomis, R. S., Williams, W. A., and Hall A. E. (1971). Agricultural productivity. *Annual Review of Plant Physiology*, 22:431-468
- Lynne, G. (1995) Modifying the Neo-Classical approach to technology adoption with behavioural science models, *Journal of Agricultural and Applied Economics*, 27, 67-80.
- Mahapatra, I. C. (1994). Farming system research – a key to sustainable agriculture. *Fertilizer News*, 39, 13–25.
- Makinde, E.A., Saka, J.O. and Makinde, J.O. (2007). Economic evaluation of soil fertility management options on cassava-based cropping systems in the rain forest ecological zone of South Western Nigeria. *African Journal of Agricultural Research*, 2(1), 7–13.
- Malathesh, G.B. (2004). An Analysis of selected farming system in eastern dry zone of Karnataka, *M.Sc. (Agri.) Thesis (Unpub.)*, Univ. Agri. Sci., Bangalore.
- Mangala, B. (2008). Impact of integrated farming system on socio-economic status of BAIF beneficiary Farmers *M.Sc. (Agri.) Thesis (Unpub.)*, Univ. Agri. Sci., Dharwad.
- Mantel, S. P., & Kardes, F. R. (1999). The role of direction of comparison, attribute-based processing, and attitude-based processing in consumer preference. *Journal of Consumer Research*, 25(4), 335-352.
- Mccann, E., Sullivan, S., Erickson, D., & De Young, R. (1997). Environmental awareness, economic orientation, and farming practices: a comparison of organic and conventional farmers. *Environmental management*, 21(5), 747-758.
- Meuwissen, M., Huirne, R., and Hardaker, J.B. (2001). Risk and risk management: an empirical analysis of Dutch livestock farmers. *Livestock Production Science*. 69, 43–53.

- Ministry of Labour and Employment (2016). Report on Fifth Annual Employment-Unemployment Survey (2015-16), Volume I, Labour Bureau, Government of India.
- Mishra, A., and Mohanty, R. K. (2004). Productivity enhancement through rice–fish farming using a two-stage rainwater conservation technique. *Agricultural Water Management*, 67(2), 119-131.
- Mishra, D., and Sahu, N. C. (2014). Response of farmers to climate change in Odisha: An empirical investigation. *International Journal of Environmental Sciences*, 4(5), 786- 800.
- Mishra, M. M., Nanda, S. S., Mohanty, M., Pradhan, K. C., and Mishra, S. S. (2007). Crop diversification under rice based cropping system in western Orissa. In *Extended summaries 3rd National Symposium on Integrated Farming Systems, October* (pp. 26-28).
- Mitra, K., Bharadwaj, R., Kaur, S. and Khan, M. A. (2012). State Level Vulnerability Assessment and Adaptation Strategies: A Case Study of Orissa. INDO-UK Collaborative Programme on the Impacts of Climate Change on India. INSPIRE Network for Environment (InsPIRE). New Delhi- India.
- MoA&FW, Annual Report (2017-18). Department of Agriculture, Cooperation & Farmers Welfare. Ministry of Agriculture & Farmers Welfare. Government of India. Krishi Bhawan, New Delhi-110 001.
- Mohanty, D., Patnaik, S. C., Jeevan Das, P., Parida, N. K., and Nedunchezhiyan, M. (2010). Integrated farming system for sustainable livelihood: A success story of a tribal farmer. *Orissa Rev*, 41-43.
- Muir, J. F. (1981). 5.7 Integrated fish farming in developing countries. *BSAP Occasional Publication*, 4, 311-316.
- Muir, J. F. (1986). Integrated carp farming in Western Europe. In *Aquaculture of Cyprinids* (pp. 391-399). INRA Paris.
- Murugan, G. and Kathiresan, R.M. (2005). Income and economic efficiency under low land integrated farming systems. *Research-on-Crops*, 6(2), 234-236.

- Musshoff, O., and Hirschauer, N. (2008). Adoption of organic farming in Germany and Austria: an integrative dynamic investment perspective. *Agricultural Economics*, 39(1), 135-145.
- National Dairy Development Board, (2016). NDDDB Annual Report 2015-2016, Anand, Gujarat (India).
- Norman, D. W. and Gilbert, E. (1982). A general overview of farming systems research. In: Readings in Farming systems research and development. (Shaner, W. W., Philipp, P. F. & Schmehl, W. R. (Eds)), Westview Press, Boulder, Colorado, pp. 17-30.
- Norman, D. W. (1978). Farming system research to improve to livelihood of small farmers. *American Journal of Agricultural Economics*, 60, 813–818.
- Okigbo, B. N. (1995). Major farming systems of the lowland savanna of sub-Saharan Africa and the potential for improvement. In Proceedings of an IITA/FAO Workshop, Cotonou, Republic of Benin, IITA, Ibadan, Nigeria September. 19(23), 49-68.
- Olayide, S.O., and E.O. Heady, (1982). Introduction to Agricultural Production Economics, p. 319. Ibadan University Press.
- Oraon, V. (2012). Changing patterns of tribal livelihoods: A case study in Sundargarh District, Odisha. M.A. Thesis. Department of Humanities and Social Sciences. National Institute of Technology. Rourkela, India.
- Orskov, E.R. (2000). New challenges for livestock research and production in Asia. *Outlook on Agriculture*, 28(3), 179–185.
- Osty, P. L. (1978). L'exploitation agricole vue comme un système. Diffusion de l'innovation et contribution au développement. *Bulletin technique d'information*, 326, 43-49.
- Paltasingh, K. R., and Goyari, P. (2015). Climatic risks and household vulnerability assessment: a case of paddy growers in Odisha. *Agricultural Economics Research Review*, 28, 199-210.
- Panda, A. (2017). Vulnerability to climate variability and drought among small and marginal farmers: a case study in Odisha, India. *Climate and Development*, 9(7), 605-617.

- Pandey, A. K. (2016). Project Report on Livelihood Promoting Activities of Women Farmers in Palamu District of Jharkhand. Submitted In Partial Fulfilment of the Requirements for the Degree of Master of Business Administration in Agribusiness. Centre for Agribusiness Management Faculty of Agriculture Birsa Agricultural University, Ranchi (Jharkhand).
- Panin, A. and Moukhi, M. (2000). Relative economic efficiency of cattle and small ruminant enterprises of small-holder farmers in Botswana. *World Agricultural Economics and Rural Sociology Abstracts*, 42(4), 325.
- Pant, J., Demaine, H., and Edwards, P. (2005). Bio-resource flow in integrated agriculture-aquaculture systems in a tropical monsoonal climate: a case study in Northeast Thailand. *Agricultural systems*, 83(2), 203-219.
- Pardos, L., Maza, M.T., Fantova, E., and Sepulveda, W. (2008). The diversity of sheep production systems in Aragon (Spain): characterisation and typification of meat sheep farms. *Spanish Journal of Agricultural Research*, 6, 497-507.
- Parreño-de Guzman, L. E., Zamora, O. B., and Bernardo, D. F. H. (2015). Diversified and Integrated Farming Systems (DIFS): Philippine Experiences for Improved Livelihood and Nutrition. *Journal of Developments in Sustainable Agriculture*, 10(1), 19-33.
- Patnaik, U., Das, P. K., and Bahinipati, C. S. (2013). Analysing vulnerability to climate variability and extremes in the coastal districts of Odisha, India. *Review of Development & Change*, 18(2), 173-189.
- Patrick, G.F., and Musser, W.N. (1997). Sources of and responses to risk: factor analyses of large-scale US cornbelt farmers. In: Huirne, R.B.M., J.B. Hardaker, and A.A. Dijkhuizen (eds). *Risk Management Strategies in Agriculture; State of the Art and Future Perspectives*. Mansholt Studies No. 7, Wageningen Agricultural University, Wageningen, The Netherlands, pp. 45-53.
- Phengvichith, V. (1998). The integration of livestock in shifting cultivation systems in the upland of the Lao PDR. *Food and Fertilizer Technology Center, Extension Bulletin* 464, 1-10.

- Poulton, C., Dorward, A., Kydd, J. (2005). The future of small farms: New directions for services, institution, and intermediation. In: The future of small farms: Proceedings of a research Workshop, Wye, UK, June 26–29, 2005. International Food Policy Institute, Washington, D C.
- Prein, M. (2002). Integration of aquaculture into crop–animal systems in Asia. *Agricultural systems*, 71(1-2), 127-146.
- Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society B*, 363, 447-465
- Puillet, L., Martin, O., Tichit, M., and Sauvant, D. (2008). Simple representation of physiological regulations in a model of lactating female: application to the dairy goat. *Animal*, 2(2), 235-246.
- Radhamani, S., Balasubramanian, A., and Ramamootthy, V. K. (2015). Sustainable integrated· farming'systems for drylands-agiculture. *Agricultural Reviews*, 24(3), 204-210.
- Radhamani, S., Balasubramanian, A., Ramamoorthy, K. and Geethalakshmi, V. (2003). Sustainable integrated farming systems for dry lands: A Review. *Agricultural Reviews*, 24(3), 204-210.
- Rahman, S. (2015). Green Revolution in India: Environmental Degradation and Impact on Livestock. *Asian Journal of Water, Environment and Pollution*, 12(1), 75–80.
- Ramrao, W. Y., Tiwari, S. P. and Singh, P. (2005). Crop-livestock integrated farming system for augmenting socio-economic status of small holder tribal of Chhattisgarh in Central India. *Livestock Research for Rural development*, 17(8), 90.
- Ramrao, W. Y., Tiwari, S. P., & Singh, P. (2005). Crop-livestock integrated farming system for augmenting socio-economic status of smallholder tribal farmers of Chhattisgarh in Central India. *Livestock research for rural development*, 17(8), 90.
- Rana, S.S., and Chopra, P. (2013). Integrated Farming System. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishva vidyalaya, Palampur, 90 pages.

- Rangasamy, A. (1996). Rice-poultry-fish-mushroom integrated farming systems for lowlands of Tamil Nadu. *Indian Journal of Agronomy*, 41(3), 344-348.
- Rao, J. M. (1989). Agricultural supply response: A survey. *Agricultural economics*, 3(1), 1-22.
- Raut, S., Rathod, M.K., and Deshmukh, K. (2013). Integrated farming system model for the farmers of Wardha district in Vidarbha. *Indian Journal of Applied Research*, 3(9), 1-3.
- Rautaray, S. K., Das, P. C., and Sinhababu, D. P. (2005). Increasing farm income through rice (*Oryza sativa* L.) - fish based integrated farming system in rainfed lowlands of Assam. *Indian Journal of Agricultural Sciences*, 75 (2), 79-82.
- Reddy, G.K. (1983). A study of management orientation farming efficiency and consultancy of rainfed ground nut growers in Kolar district of Karnataka state. *M.Sc. (Agri.) Thesis (Unpub.)*, Univ. Agri. Sci., Bangalore.
- Riveiro, J. A., Marey, M. F., Marco, J. L., and Alvarez, C. J. (2008). Procedure for the classification and characterization of farms for agricultural production planning: Application in the Northwest of Spain. *Computers and electronics in agriculture*, 61(2), 169-178.
- Rodríguez, L., Salazar, P., and Arango, M. F. (1995). Lombriz roja californiana y azolla-anabaena como sustituto de la proteína convencional en dietas para pollos de engorde. *Livest Res Rural Develop*, 7(3), 145-149.
- Rogers, E. M. (2003). *Diffusion of Innovations* 5th ed. A Division of Macmillan Publishing Co Inc.
- Samal, P., Barah, B. C., and Pandey, S. (2006). An analysis of rural livelihood systems in rainfed rice-based farming systems of coastal Orissa. *Agricultural Economics Research Review*, 19(2), 281-292.
- Samui, R. C., Kundu, A.L., Majumder, D. Mani., and Sahu, P.K. (2004). Diversification of rice (*Oryza sativa*)–based cropping system in new alluvial zone of West Bengal. *Indian Journal of Agronomy*, 49(2), 71–73.

- Sasikala, V., Tiwari, R., and Saravanan, M. (2015). A Review on Integrated Farming Systems. *Journal of International Academic Research for Multidisciplinary*, 319- 328.
- Sauvant, D., and Phocas, F. (1992). A mechanistic model to simulate the long term regulation of the dairy cow nutrition. *Journal of Dairy Science*, 75, 168.
- Seiford, L.M. and Thrall, R.M. (1990). Recent developments in DEA: The Mathematical Programming Approach to Frontier Analysis. *Journal of Econometrics*, 46, 7-38.
- Sekhar, D., Rao, T. K., and Rao, V. N. (2014). Studies on integrated farming systems for tribal areas of Eastern Ghats in Andhra Pradesh. *Indian Journal of Applied Research*, 4(10).
- Senthilvel, T., Latha, K.R. and Gopaldasamy, N. (1998). Farming system approach for sustainable yield and income under rainfed *vertisols*. *Madras Agricultural Journal*, 55(1), 65–67.
- Serra, T., Zilberman, D., and Gil, J. M. (2008). Differential uncertainties and risk attitudes between conventional and organic producers: the case of Spanish arable crop farmers. *Agricultural Economics*, 39(2), 219-229.
- Shah, M.S., Verma, N. and Vishwkarma, S.K. (2015). Diversification of rice (*Oryza sativa*)–based cropping systems for higher production efficiency, water productivity and economic viability in Madhya Pradesh. *Indian Journal of Agronomy*, 60(1), 25–30.
- Shaner, W. W., Philipp, P. F., and Schmehl, W. R. (1982). Farming systems research and development: guidelines for developing countries. Consortium for International Development.
- Sharda, V.N., and Juyal, G. P. (2007). Rainwater harvesting, ground water recharge and efficient use in high rainfall areas. Souvenir. pp 59–70. Ensuring water and environment for prosperity and posterity. 10th Inter- Regional conference on Water and environment, 17–20 October, 2007
- Sharma, A.K., Thakur, N.P., Sanjay, K. and Dileep, K. (2007b). Profitable and energy efficient rice–based cropping system under subtropical irrigated conditions of Jammu. In: Extended summaries 3rd National Symposium on Integrated

- Farming Systems, October 26–28, 2007 organized by Farming System and Development Association (Project Directorate for Cropping System Research, Modipuram, Meerut) at Agricultural Research Station, Durgapura, Jaipur.
- Sharma, H. R. (2007a). Crop diversification in Himachal Pradesh: extent, impact, determinants and challenges. *Indian Journal of Labour Economics*, 50(4), 689-702.
- Sharma, K. D. (2011). Rain-fed agriculture could meet the challenges of food security in India. *Current Science*, 100(11), 1615-1616.
- Sharma, V., Reddy, B., and Sahu, N. (2014). Sustainable rural livelihoods approach for climate change adaptation in Western Odisha, Eastern India. *Development in Practice*, 24(4), 591-604.
- Sharma, Y. K., Bangarva, G. S., and Sharma, S. K. (2008). Farming system-based constraints faced by farmers. *Indian Research Journal of Extension Education*, 8(1), 57-59.
- Shekinah, D. E., Jayanth C, Sankaran N. (2005). Physical indicators of sustainability a farming systems approach for the small farmer in the rain-fed vertisols of western zone of Tamil Nadu. *Journal of sustainable agriculture*, 25(3), 43-65.
- Shiferaw, B., Kassie, M., Jaleta, M., Chilot Yirga, C. (2014). Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy*, 44, 272–284
- Simmons, R.W., Noble, A.D., and Lefroy, R.D.B. (2001). International workshop on nutrient balance for sustainable agricultural production and natural resources management in Southeast Asia, 20-22 February 2001, Thailand.
- Singh, J. P., Gangwar, B., Pandey, D. K., and Kochewad, S. A. (2011). Integrated Farming system model for small farm holders of western plain zone of Uttar Pradesh. Project Directorate for Farming Systems Research, Indian Council of Agricultural Research.
- Singh, K, Bohra, J.S., Singh, Y. and Singh, J.P. 2006. Development of farming system models for the north-eastern plain zone of Uttar Pradesh. *Indian Farming*, 56(2): 5-11.

- Singh, K. M., Meena, M. S., Singh, R. K. P., Kumar, A., and Kumar, A. (2012). Rural Poverty in Jharkhand, India: An Empirical Study based on Panel Data. ICAR-RCER, Patna, NCAP, New Delhi.
- Singh, M.K., Rai, B., Singh, P., Singh, P.K. and Singh, N.P. (2008). Goat production status in different agro-climatic regions of India: An overview. *Indian Journal of Small Ruminants*, 14(1), 48–70.
- Singh, R., Riar, T. S., and Gill, J. S. (2017). Integrated farming systems and socio-economic characteristics of Punjab Agricultural University awardee farmers. *Asian Journal of Agricultural Extension, Economics and Sociology*, 16(3), 1-5.
- Singh, S. (2000). Crisis in Punjab Agriculture. *Economic and Political Weekly*, 35 (23), 1889-1892.
- Singh, S., and Pati, B. K. (2015). Empirical proof on benefits of integrated farming system in smallholder farms in Odisha. *Current Agriculture Research Journal*, 3(1), 69-74.
- Singh, S., and Pati, B. K. (2015). Empirical proof on benefits of integrated farming system in smallholder farms in Odisha. *Current Agriculture Research Journal*, 3(1), 69-74.
- Sirohi, S., Bardhan, D. and Chand, P. (2015). Cost and Returns in Milk Production: Developing Standardized Methodology and Estimated for Various Production Systems. Project Report Submitted to Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India.
- Soni, R. P., Katoch, M., and Ladohia, R. (2014). Integrated Farming Systems-A Review. *Journal of Agriculture and Veterinary Science*, 7(10), 36-42.
- Srivastava, R. C., Singhandhupe, R. B., and Mohanty, R. K. (2004). Integrated farming approach for runoff recycling systems in humid plateau areas of eastern India. *Agricultural Water Management*, 64(3), 197-212.
- Suman, S. (2018). <http://www.economicdiscussion.net/agriculture/problems-agriculture/indian-agriculture-problems-7-major-problems-of-indian-riculture/12859>

- Tarwariya, M.K. and Maurya, B.M. (2013). Crop diversification and intensification of rice based cropping system under irrigated condition of Madhya Pradesh. *International Journal of Agricultural Sciences*, 9(1), 213–215.
- Thamizoli, P.R., Rengalakshmi, K., Senthilkumar. And Selvaraju, T. (2006). Agronomic Rehabilitation and Livelihood Restoration of Tsunami Affected Lands in Nagapattinam District of Tamil Nadu. *M.S. Swaminathan Research Foundation Chennai*, pp. 31.
- Thamrongwarangkul, A. (2001). For out Thailand. Annual report on sustainable community development for good livelihoods and environmental project. *Khon Kaen University*.
- Tipraqsa, P. (2006). Opportunities and constraints of integrated farming system in Northeast Thailand. A case study of the Huai Nong Ian catchment, Khon Kaen Province. Ecology Development Series No. 35. University of Bonn. Cuvillier Verlag, Göttingen, Germany.
- Tipraqsa, P., Craswell, E. T., Noble, A. D., and Schmidt-Vogt, D. (2007). Resource integration for multiple benefits: multi functionality of integrated farming systems in Northeast Thailand. *Agricultural Systems*, 94(3), 694-703.
- Tipraqsa, P., Craswell, E. T., Noble, A. D., and Schmidt-Vogt, D. (2007). Resource integration for multiple benefits: multifunctionality of integrated farming systems in Northeast Thailand. *Agricultural Systems*, 94(3), 694-703.
- Tripathi, S.C. and Rathi, R.C. (2011). Livestock farming system module for hills. In: Souvenir. National symposium on technological interventions for sustainable agriculture, 3rd - 5th May, GBPUAT, hill campus, Ranichuri, pp. 103 -104
- Ugwumba, C. O. A., Okoh, R.N., Ike, P.C., Nnabuife, E.L.C. and Orji, E.C., (2010) Integrated farming system and its effect on farm cash income in awka south agricultural zone of Anambra State, Nigeria. *American-Eurasian J. Agric. & Environ. Sci*, 8 (1): 01-06.
- van de Steeg J, Verburg P, Baltenweck I, Staal S. (2010). Characterization of the spatial distribution of farming systems in the Kenyan Highlands. *Applied Geography*, 30,239-253.

- Van de Steeg, J. A., Verburg, P. H., Baltenweck, I., and Staal, S. J. (2010). Characterization of the spatial distribution of farming systems in the Kenyan Highlands. *Applied Geography*, 30(2), 239-253.
- Vatta, K., Budhiraja, P., and Dixit, S. (2017). Vulnerability of Tribal Rural Households in India: Measuring the Current Status, Risks of Climate Shocks and Impact of Potential Interventions for Improving Rural Livelihoods. *Indian Journal of Agricultural Economics*, 72(3), 341- 361.
- Weber, J., and Gillespie, J. (1998). Differences in Ethical Beliefs, Intentions, and Behaviors: The Role of Beliefs and Intentions in Ethical Research Revisited. *Business and Society*, 37: 447-467.
- World Bank (2012). India: Issues and Priorities for Agriculture <http://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities>
- Yadav, R. L., and Prasad, K. (1998). Farming systems research in India: needs and strategies. In: Singh, P., Prasad, R., Ahlawat, I.P.S. (Eds.), Proceedings of First International Agronomy Congress: Agronomy, Environment and Food Security for 21st Century. Indian Society of Agronomy, New Delhi, pp. 333-341.

Annexure I
Interview Schedule
Division of Agricultural Extension
ICAR- Indian Agricultural Research Institute
New Delhi - 110012

Schedule no. :

Date:

1. Name:.....Village:.....Block:.....District:.....
2. Age:.....Caste:.....Religion:.....
3. Family information:

S.n.	Age	Sex (M/F)	Edn	Occupation		Food habit (veg. / non veg.)	Agricultural activities perform	
				Pri.	Sec.		Activities	hrs/day

4. Approximate gross annual income:
 (a) On-farm income: Rs (b) Off-farm income: Rs
5. Which income group are you belong? BPL/APL/ any other
6. Primary farming objective : Subsistence / Commercial
7. Landholding (ha):ha
 - a) Owned by farmer :ha
 - b) Leased/mortgaged in :ha
 - c) Leased/mortgaged out :ha
 - d) Irrigated landha
 - e) Area under irrigation in *kharif* season :.....
 - f) Area under irrigation in *rabi* season :.....
8. Land fragmentation:
 Number of separate plots of land:
 Average area of each plot :
9. Farm topography (please ✓): Low Lying / Sloppy/ Plain / Water Logging
10. Soil type (please ✓) : Sandy / Clay/ Loam / Sandy loam / Any other
11. Source of irrigation (please ✓): Pond/Tube well/bore well / Canal/ any other(
 give detail)
12. Farm equipment possession(please ✓): Tractor/ Pumping engine/Power
 tiller/Rice thresher/ sprayer/ any other

13. Distance: (a) Farm to house:Km (Avg.)
 (b) House to nearest plotKm
 (c) House to nearest market: Km
14. Do you have access to any extension contact? Yes / No, if yes ,
 Agency of extension personnel:
 Topics:
 Nature of contact:
 Frequency...../year (month)
 Satisfaction level (please ✓): highly satisfied/Satisfied/ cannot say/ not Satisfied/never satisfied
15. Are you a members of (please ✓): Agricultural society(s) / Associations/
 Cooperatives/ Farmers organization / SHGs
 (Give details about the nature of participation):
16. Do you get subsidies for farming in any form? Yes/No, if yes, give details.
 In what form how much
17. Do you have access to marketing facilities like : storage/ transportation/
 marketing space / any other /none
18. Do you have access to credit : Yes / No, If yes,
 i. Credit source (please ✓): Bank/ Local moneylender/ Microfinance
 ii. Total amount of credit taken in last year: Rs
19. Years of (a) farming experience:..... (b) IFS practices:
20. Sources of information for IFS farming (please ✓): mass media/ opinion leader/
 village head/ extension agent / any others
21. Have you been prescribed/suggested/personal access (aware) to any IFS model-
 for an adoption of a particular IFS model? Yes/ No, if yes by whom?

 i. Have you adopted the same model?' Yes/No,
 ii. Does it fit well to your farm plan? Yes/No,
 If not, what were the major constraints in adopting the model?
22. Does any of your family member attended training/ demonstration/ study tour etc.
 on agriculture/IFS? Yes / No,
 If yes, give details
 (a) Who attended
 (b) Topic/theme of the training(s)/ demonstration:
 (c) Total number of such programme attended by your family members:

(d) Organized by :

23. Risk attitude (Risk aversion):

(a) Farmer's willingness to take risk: [Continuum: 1 (do not agree) to 5 (fully agree)].

S.n	Statement	1	2	3	4	5
1.	I am willing to take more risk than other farmers with respect to production					
2.	I am willing to take more risk than other farmers with respect to marketing					
3.	I am willing to take more risk than other farmers with respect to finance and investment					
4.	I am willing to take more risk than other farmers with respect to farming in general					

24. IFS components:

S.n.	IFS components	Area /unit)	Years of adoption	Pri./sec./ ter. Component	Target Income	Reason for choosing	
						Subsistence/ Commercial	(Remarks)
1.							
2.							
3.							
4.							
5.							

25. Please list the reasons for adopting IFS and score them in order of the importance on a scale from 1 (not important) to 5 (extremely important)

- i. (12....3....4....5)
- ii. (12....3....4....5)
- iii. (12....3....4....5)
- iv. (12....3....4....5)

26. Reasons for non adoption of components- - components those are common in the locality/ region?

s.no.	Component not adopted	Reasons for not adoption

27. Have you changed any components of your farming in terms of addition and deletion of component(s) in the last two/ three years? Yes/ No

Give reasons for the act,

- i.

- ii.
- iii.
- iv.
- v.

28. Do you have a plan for improving the productivity of the farm in the near future? Yes /No, if yes give details about your plan and give the preference for farming component?

29. **Seasonal calendar:** (Please tell about the activities also):

s.n.	Activities / Events	J	F	M	A	M	J	J	A	S	O	N	D
1)	Agriculture crop												
2)	I.												
3)	II.												
4)	III.												
5)	IV.												
6)	Vegetable Cultivation												
7)	I.												
8)	II.												
9)	III.												
10)	IV.												
11)	Livestock												
12)	Fish culture												
13)	Poultry rearing												
14)	Duckery												
15)	Piggery												
16)	Post harvest enterprises												
17)	Off –farm activities												
18)	Labour problem												
19)	Credit crunch												
20)	Food crisis												
21)	Marketing problem												
22)	Flood/ excess rainfall												
23)	Draught/ Water stress												
24)	Cyclone												
25)	Any other,												

H: harvesting, W: weeding, S: sowing, M: milking, N: nursery preparation

30. **Crop/vegetables component:**

Particulars	Crops / vegetables					
Season(rabi/zaid /kharif)						
Primary reason for cultivation(subsistence /						

commercial)						
Area (ha)						
Years of farming experience						
Varieties						
Source of seed (owned/ purchase/ received)						
Major diseases						
Application rate :						
1. Nitrogen (kg/ha)						
2. Phosphorous (kg/ha)						
3. Potassium (kg/ha)						
4. Manure (kg/ha)						
Pesticide /fungicides/herbicides/insecticides (unit/ha)						

36. Cost of cultivation of Crop/vegetables component:

Cost (Rs)	Rabi	Zaid	Kharif	Total
Crops / vegetables				
Nursery raising				
Land preparation				
Value of machine labour (hired + owned)				
Cost of fertilizers				
Cost of plant protection chemicals (Pesticides/herbicides/ insecticides etc.)				
Cost of manures (owned + purchased)				
Cost of seed (farm produced + purchased)				
Irrigation charges@.....				
Value of hired human labour @.....				
Imputed value of family labour				
Rent paid for leased-in land(if any)				
Misc. cost				
Total cost				

37. Economic benefit fromcrop/vegetables component :

Particulars	Season							
	Rabi			Kharif			Zaid	
Crop/vegetables	wheat			Rice				
Yield (q)								
Productivity (q/ha)								
Total production (q)								
Gross Value of Production (Rs)								
Sold (kg)								

Consumed (kg)										
Given away (kg)										
For Seed (kg)										
Income if sold (Rs) @.....										
Quantity of by-product (kg)										
Monetary value of by-products(Rs)										

39. Do you grow forest tree/ horticultural plant on the farm? Yes/ No, If yes give detail about

Particular tree	Number	Year of plantation	Initial investment (Rs/-)	Style of planting (as fence/ with layout /any other)	Management cost	Total production (unit)	Income earn Rs./year (if sold)

40. Livestock and fishery component:

Particular	Livestock #	Poultry/ Duckery	Piggery	Goat /Sheep	Fishery
Unit /Herd size					
Adult					
Young					
Offspring					
Herd flow					
Monetary value (Rs)					
Number of draught animals [#]					
Number of lactating animals [#]					
Years of farming experience					
No. of production cycle /year					
Number and name of breed					
Local/exotic breed					
Area allocated (ha)					
Target Income (Rs)					
Feeding system/type					

Sources of feeds					
Amount of feed per week (per annum)					
i. Purchase feeds					
ii. On farm produced feeds					

41. Cost of Livestock components:

Cost	Livestock	Poultry/Duckery	Piggery	Goat/Sheep
Cost of buying / value of animal				
Feed (owned + purchased)				
Value of hired human labour @.....				
Imputed value of family labour				
Veterinary cost (services + chemical)				
Housing facilities				
Machinery cost				
Misc cost				
Total costs				

42. Fisheries component:

i. Nature of aquaculture (please ✓): Rice field based / Pond based

If pond based, give detail:

Pond size: (Sq .m) Number of ponds:

Type of ponds:

What are the other uses of the pond?

ii. If rice field based aquaculture, describe the benefits, threats and management practices in details

ii. Source of fingerling: Sources of information for fish farming:

iii. Source of purchased feed: Quantity purchased feedkg

43. Cost of fish farming:

s.n.	Cost (Rs.)	PC *1	PC 2	Total
1.	Fish fingerlings cost			
2.	Feeds (owned +purchased)			
3.	Pond preparation and maintenance			
4.	Liming cost (if done)			
5.	Hired Labour cost			
6.	Imputed value of family Labour			

7.	Net rental value			
8.	Transportation			
9.	Land & Available Structures			
10.	Misc cost			
11.	Total costs			

* PC=production cycle

44. Economic benefit from Livestock and fishery component:

Particular	Livestock	Poultry/ Duckery	Piggery	Goat/ Sheep	Fishery
Amount earn from draught power (Rs)					
Milk production per cow (kg)					
Total milk production (kg)					
Volume of meat/ animal produced (Kg) for sale					
Total production of egg (number)					
Volume (kg) + Value of by-products (Rs)					
i.					
ii.					
iii.					
Amount earned from selling (Rs)					
1. Selling of animal + (no. of unit) @					
2. Milk@.....					
3. As meat @.....					
4. egg@.....					
5. Selling of by-products@.....					
Total Gross value of production (Rs)					
Total income (Rs)					
Value of Stocking(Rs) (if any)					
Amount generated per production cycle(Rs)					

45. Post -harvest and value addition practices:

Do you process any product at home or access to any processing unit in your village?

Yes/ No,

If yes, give details

Product	Processed @ Home/other	Additional Income earn	Remarks

46. What are the marketing strategies followed by you for increasing the income of farm produced?

47. Cash flow for integrated farming system:

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Inflow												
Outflow												
Net flow												

47. Farm Income and Exposure to shock in last 4/ 5 years:

Year	On-farm Income (Rs)	Exposed to shock		Severity of the shock (High /Medium/ Low)	Degree of impact to components (High /Medium/ Low)			
		Yes / No	Flood / drought/ cyclone / Diseases and pests/input prices/ Personnel risk/ any other		Crop	Livestock	Fishe ry	-
2011								
2012								
2013								
2014								
2015								

48. Input dynamics and Preference for on-farm produced by- product (input) utilization:

Input	Purchase/ on farm produced	Source compt.	Recipient compt. (s)	Quantity (kg)	Cost (Rs)	Appl. Kg / ha/ yr	Used as
1. No. of major bio-resource flows:							
2. Total purchased input / total input :							

50. Do you use/ practice any ITK on your farm? Yes/ No, if yes, please list down the ITKs and give details in terms of local name, source, relevancy and relative advantage of it
51. Do you innovate in terms of allocation of resources for effective utilization of space and time on your farm? Yes/ No, if yes, please list down and give details in terms of local name, source, relevancy and relative advantage of it
52. Major constraints in livestock farming : (Rank in order of their severity)

Rank	Constraint
I.	
II.	
III.	
IV.	
V.	

Constraints in adoption of integrated farming system

S.No.	Constraints	Ranking
1: Constraints Faced in cereal-pulse		
a)	High dependence on monsoon	
b)	Lack of irrigation facility	
c)	High pest attack	
d)	Lack of modern varieties	
e)	Low price during harvesting	
f)	Lack of marketing facilities	
2: Constraints Faced by Vegetable Based Farmer		
a)	Poor market infrastructure	
b)	Lack of irrigation facility	
c)	Nonavailability of quality seed (specially hybrid variety)	
d)	High wage of labour	
e)	Lack of storage facility	
f)	High interfere of middleman	
3: Constraints Faced by Livestock Based Farmer		
a)	Lack of availability of green fodder	
b)	Disease problems	
c)	Low productivity of animals	
d)	Inadequate extension service	
e)	Low availability and high cost of feed concentrates	
f)	Lack of regulated market and cooperatives	

4: Constraints Faced by Fish Based Farmers		
a)	Lack of market facilities	
b)	High establishment cost	
c)	Unavailability of quality fingerlings	
d)	Lack of storage facilities	
e)	Restricted knowledge about improved farming technology	
f)	Unavailability of quality feed	
g)	Social problem like thieves and poisoning	

53. Outcome beliefs (b)

If you add more component to your farm you will : (please rate the degree of agreement using the continuum strongly disagree(SD), disagree(D), undecided(U), Agree(A) and strongly agree(SA)

s.n.	Items	SD	D	U	A	SA
1.	Improve soil health					
2.	Minimize input cost with resource flow between components					
3.	Reduces the use of chemicals and fertilizers					
4.	Increase farm productivity					
5.	Increase and Stable farm income round the year					
6.	Generate employment round the year					
7.	Better adapt and cope with climatic aberration					
8.	Minimize farm production risk					
9.	Improve food security for household through diversified food produce					
10.	Cope with livelihood insecurity					

54. Evaluation of the outcome:

How important is the issue (outcome) to you? Using the continuum: Completely not important to me (CNI), Not important to me (NI), No opinion/ indifference (NO), Important to me (I), Very important to me (VI)

Sl.no	Outcome beliefs	CNI	NI	NO	I	VI
1.	Improve soil health					
2.	Minimize input cost with resource flow between components					
3.	Reduces the use of chemicals and fertilizers					
4.	Increase farm productivity					
5.	Increase and Stable farm income round the year					
6.	Generate employment round the year					
7.	Better adapt and cope with climatic aberration					
8.	Minimize farm production risk					
9.	Improve food security for household through diversified food produce					
10.	Cope with livelihood insecurity					

55. Subjective Norm:

Please tick (✓) on what your referent group has expressed their opinion on the following items:

Referent group	Adopt component with much consideration of resources flow (-2 -1 0+1 +2)	Adopt farm component that maximized resources flow (-2 -1 0+1 +2)
Family		
Friends		
Farmers with more components		
Crop based farmers		
Village heads/ <i>Gram panchayat</i>		
Farm advisors / extension agents'		

56. Motivation to comply:

Please tick (✓) how important are your referent groups on decision making:

Referent group	Completely not important to me (CNI), Not important to me (NI), No opinion/ indifference (NO), Important to me (I), Very important to me (VI)
Family	
Friends	
Farmers with more components	
Crop based farmers	
Village heads/ <i>Gram panchayat</i>	
Farm advisors / extension agents'	

57. Please rate the degree of agreement using the continuum strongly disagree (SD), disagree (D), undecided (U), Agree (A) and strongly agree (SA)

s.n.	Belief statements	SD	D	U	A	SA
1.	I expect adoption of different farming components will induce a great commitment to farm management					
2.	I expect adoption of different farming components will induce High establishment cost					
3.	I expect adoption of different farming components will induce Unanticipated and Intensive labour demand					
4.	I expect adoption of different farming components will Require of technical knowhow of different farm components					

5.	I expect adoption of different farming components will Require different farm inputs					
6.	I expect adoption of different farming components need credit/ subsidy for farming					
7.	I expect adoption of different farming components will need Marketing of diversified farm produce					
8.	I expect adoption of different farming components will need a suitable farm land/site for adoption of different farm components and to maximize integrations.					

58. Please rate the degree of agreement using the continuum

Sl. No	Statement	Very Easy (2) to Very Difficult (-2)”.
1.	The demand for greater commitment to farm management as a result of adopting different farming components is	
2.	The demand for High establishment cost adopting different farming components is	
3.	The demand for Unanticipated and Intensive labour demand while adopting different farming components is	
4.	The need for technical knowhow of different farm components while adopting different farming components is	
5.	The Demands for different farm inputs	
6.	The need for Availing credit/ subsidy for farming is	
7.	Marketing of diversified farm produce is	
8.	I have a suitable farm land/site for adoption of different farm components and to maximize integrations.	

59. **Socio- economic impact:**

1: How do farmers manage issues of chemical used when practices rice-field based aquaculture farming?

Is there any change in chemical uses patterned in the community?

3: What are the prominent diseases reoccurring in family/ region?

Major disease	Frequency among family member	Major Causes

(How do you relate such diseases with your environment like the ponds?)

3: Does any member of your family work outside your villages? (migration problem)

Individual	Age	Month	Where	Number of man days	Nature of work	Drivers of migration

ANNEXURE II

Standard Animal Units for Different Regions in India

Region	Breed	Adult male	Adult female	Young stock M <1	Young stock F <1	Young stock M ≥ 1	Young stock F ≥ 1	Heifer
North	CB	1.23	1.27	0.41	0.41	0.61	0.52	0.78
	LC	1.08	1.00	0.39	0.39	0.54	0.46	0.73
	BU	1.25	1.35	0.43	0.41	0.65	0.51	0.79
South	CB	1.12	1.62	0.24	0.3	0.63	0.52	0.86
	LC	0.97	1.00	0.22	0.27	0.54	0.47	0.82
	BU	1.04	1.22	0.24	0.28	0.6	0.51	0.77
West	CB	0.87	1.18	0.39	0.37	0.55	0.42	0.51
	LC	0.72	1.00	0.36	0.35	0.40	0.38	0.40
	BU	0.82	1.22	0.4	0.38	0.46	0.42	0.48
East	CB	1.07	1.20	0.25	0.24	0.51	0.38	0.71
	LC	0.92	1.00	0.27	0.24	0.41	0.37	0.64
	BU	1.02	0.86	0.25	0.23	0.42	0.38	0.63
Hills	CB	1.48	1.71	0.41	0.72	0.71	1.08	1.24
	LC	1.11	1.00	0.29	0.63	0.55	0.82	0.98
	BU	1.43	1.70	0.35	0.63	0.73	0.94	1.09

Note: CB- Crossbred cattle; LC- Local cow; BU- Buffalo; M- Male; F-Female

Adult male and female ≥3 years for LC and BU and ≥ 2.5yrs for CB

The state level classification of regions is as follows:

- North (Northern Plains) - Punjab, Haryana, U.P., M.P.
- South- A.P., Tamil Nadu, Kerala, Karnataka
- West- Maharashtra, Gujarat, Rajasthan
- East (including North East)*- Bihar, Jharkhand, West Bengal, Odisha, Chattisgarh and all 7 NE states
- Hills- J&K, Himachal and Uttrakhand

*As Jharkhand and Odisha comes under the East states, the conversion coefficients of the Eastern region which includes North east regions has been used in this study.