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Secondary Agriculture towards Increasing Production and Sustainability

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

There is a pressing need for global agriculture to shift its focus to secondary agriculture in order to produce jobs as the world's population increases. The method of generating agricultural produce is biological in nature, making it a primary agriculture operation; but, when the raw produce is refined, it receives additional benefit, making it a secondary agriculture activity. Any farm related activity that uses the land or labor beyond the *Kharif* and *Rabi* seasons would qualify for a 'Secondary Agriculture' activity. India's scope for diversified agriculture is vast because of extensive arable land, multiple agro-climatic zones and a rich cafeteria of soils. However, India's reputation as a global agricultural powerhouse is ironically at odds with its farmers' low average wages. The road to higher agricultural Gross Value Added and farmers' income rests in efficient management of the post-production segment, comprising agri-logistics, processing and marketing. Agriculture generates raw materials that meet basic human requirements, and is considered as a primary economic activity. Of course, there are certain alternative agriculture activities like beekeeping, mushroom cultivation, backyard poultry, etc., which fall under the ambit of secondary agriculture. Secondary agriculture

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helps in using all parts of an agricultural produce, processing to enhance shelf-life, increasing total factor productivity, and generating additional jobs and income for farmers. It, thus, encompasses both food and non-food processing, and represents agro-processing. Income generation activities such as paddy straw fodder blocks, duck farming, honeybee keeping, mushroom cultivation, backyard poultry, among others, that do not compete with the time that is required for various inter-cultivation activities of primary agriculture production, qualify to be defined as a secondary agriculture. These Small-scale activities utilizes rural manpower, skills and locally available inputs efficiently. These enterprises can interact in space and/or time to achieve benefits through a synergistic resource transfer among enterprises, working closely such that waste from one part becomes a supply for another component of the system known as Integrated Farming System (IFS). Not only this but waste management is also one the important issue tackled with the help of secondary agriculture like leftover cane can be processed to produce by products of sugarcane. Thus, secondary agriculture realizes better productivity, profitability and sustainable production systems that would help to solve the fuel, feed and energy crisis, create more employment avenues, ensure regular income and encourage agriculture-oriented industry.

Keywords: Enterprises; income; productivity; secondary agriculture.

1. INTRODUCTION

Coming decades are going to be very crucial for global agriculture. By 2050, the global population is expected to be 9.1 billion inhabitants, up from the present population of 7 billion. More food must be produced to feed an increasingly rising global population that will require a more nutritious diet, contribute to the overall growth and alleviation of poverty in many developing countries, face intensified competition for alternate uses of scarce land and water supplies, respond to climate change, and contribute to preserving biodiversity and restoring fragile ecosystems. Improving agricultural productivity, while conserving and enhancing natural resources, is an essential requirement for farmers to increase global food supplies on a sustainable basis. The role of smallholder farmers and their families in increasing agricultural productivity growth sustainably will be very crucial. Estimates suggest that by 2050, in order to feed the increasing population alone, agricultural output will need to increase globally by 70% over the same period, and more precisely by almost 100% in developed countries, excluding increased demand for crops as feedstock by the biofuel sector [1].

Agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050. Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors. Analyses in 2016 found that 65 percent of poor working adults made a living through agriculture. Agriculture is also crucial to economic growth: in 2018, it accounted for 4 percent of global gross domestic product (GDP) and in some developing countries, it can account for more than 25% of GDP (The World Bank, 2020). Development in agriculture refers to many related activities that can promote the total value of goods and services produced, improve human welfare, quality of life, and social well-being. Such a development can ultimately reduce poverty and save lives by promoting better farming conditions, so that agricultural operations can be done more efficiently. Agricultural development can help subsistence farmers to have enough to eat, be able to send their children to school, and earn enough money for saving [2].

But agriculture-driven growth, poverty reduction, and food security are at risk: Climate change could cut crop yields, especially in the world's most food-insecure regions. Agriculture, forestry and land use change are responsible for about 25 percent of greenhouse gas emissions. Mitigation in the agriculture sector is part of the solution to climate change.

The current food system also threatens the health of people and the planet: agriculture accounts for 70 percent of water use and generates unsustainable levels of pollution and waste. 1/3 of food produced globally is either lost or wasted. Addressing food loss and waste is critical to improving food and nutrition security, as well as helping to meet climate goals and reduce stress on the environment. Risks associated with poor diets are also the leading cause of death worldwide. Millions of people are either not eating enough or eating the wrong

types of food, resulting in a double burden of malnutrition that can lead to illnesses and health crises. A 2020 report found that nearly 690 million people—or 8.9 percent of the global population—are hungry, up by nearly 60 million in five years. Food insecurity can worsen diet quality and increase the risk of various forms of malnutrition, potentially leading to undernutrition as well as people being overweight and obese. The cost of healthy diets is unaffordable for more than 3 billion people in the world [3].

2. AGRICULTURAL SUSTAINABILITY

Although the term sustainability in agriculture was previously considered in the 16th century, the term did not appear on the public debates until the late 1980s. Sustainable agriculture means an integrated system of plant and animal production practices that will, over the long-term satisfy food, feed, and fiber needs; but also enhance environmental and human health [4]. Sustainable agriculture makes the most efficient use of non-renewable and on-farm resources and also integrates, where appropriate, natural biological cycles and controls, sustains the economic viability of farm operations, and enhances the quality of life for farmers and the society as a whole [5]. Sustainable agriculture works mainly with the rural population to address political and socio-economic problems that are an obstacle for both agricultural growth and development [6]. It is a system that applies proper management of natural resources [7,8,9,10]. In other words, sustainable agriculture seeks to reduce chemical inputs, uses ecological pest and weed management, maintains soil fertility, rural and urban community's empowerment, produces constant farm income, and promotes healthy family and social values [11]. Supplying human nutritional needs should maintain both environmental quality and prevent the degradation of natural resources [12]. In sustainable agriculture, reducing pressure on land under cultivation [13], minimizing use of chemicals (fertilizers and pesticides) and natural resources, and protecting the health of present and future generations, are among the main objectives [14]. Sustainability originated as a response to the global challenge of dealing with agriculture as a whole and interconnected system. The concept of sustainability and its related notion of sustainable development are derived from a global belief that human activity for long periods cannot be sustained. As an instruction, it requires us indirectly to have a sense of feeling responsible to improve or change our lifestyle, so as to be able to deal with looming social, ecological and economic crises.

3. SECONDARY AGRICULTURE

The emphasis on secondary agriculture may be of great benefit in this respect. While the Planning Commission and scholarly circles have made several previous attempts, it was found specifically insufficient to describe the word 'Secondary Agriculture'. It includes all the operations of post-production before it hits the final buyers, and is nothing but the concept of agricultural marketing. Secondary Agriculture comprises' all practices and processes which, through the use of efficient technology, market knowledge and consumer preference, add value to primary agricultural commodities.' It should be mentioned that a method of increasing the economic benefit and market interest of an agricultural product is the expression for value addition in agriculture. Basically, it is an alternate manufacturing and marketing method.

With the declaration of the objective of doubling farmers' incomes, secondary agriculture takes precedence. The word 'secondary' has an impact on climate change adaptation and mitigation, the viability and feasibility of small farmers, food stability, nutrition, the productive use of natural resources and the optimum use of primary agricultural produce and farm profits. In other words, the promotion of secondary agriculture has consequences for achieving sustainable development goals aimed at linking primary, secondary and tertiary sectors through the use of slack/idle output factors, such as land and manpower, adding to the production of primary agriculture, capturing value in primary agricultural operations, and producing additional profits at the enterprise level.

While there is no formal definition of secondary agriculture, based on the Economic Accounts for Agriculture of the European Union, a Technical Advisory Committee on Secondary Agriculture was formed by the then Planning Commission in 2007, and the committee had set out the inclusion criteria as “assembling, ripening, cleaning, grading, sorting, drying, preserving, packing and storing.”

Any activity on the farm that is done beyond the kharif, rabi and zaid seasons is secondary agriculture, it says. Income-generation activities

that use crop residues -- paddy straw, fodder blocks and crop residue briquettes, would qualify.

All output from farming has inherent value and nothing should be considered as waste if it is put to gainful use, the committee notes. Cleaning, sorting and grading of agri-produce to make it saleable, bee keeping, mushroom cultivation, backyard poultry, dairying and sheep rearing -- in short, activities that utilise the spare time of the family also qualify as secondary agriculture.

The concept of secondary agriculture was understood when the Ashok Dalwai Committee submitted its report on “adding value to primary agriculture and building agricultural enterprises in rural India” through “farm-linked activities and secondary agriculture” in February 2018. The concept of secondary agriculture was known when, by "farm-linked activities and secondary agriculture," the Ashok Dalwai Committee submitted its report in February 2018 on " adding value to primary agriculture and building agricultural enterprises in rural India."

Three avenues have been described that effectively help to use money, human resources, technology, organizational skills, and risk management.

3.1 Value-addition to Primary Agriculture Production Systems

By strengthening livelihood change action plans that are initiated by farmer-based/community-based organizations, the first avenue can be accomplished. Linking farmers to the market will assist them in value enhancement and appropriation through aggregation and assaying/grading of agricultural products. It is important to develop this avenue with cluster farming, financial literacy, marketing skills.

3.2 Value Addition for Commercialization

Increased Preference for Value Added Products: Value addition in agriculture is a method of increasing the economic value and consumer appeal of an agricultural commodity. It is essentially an alternate method for development and marketing (Chengappa, 2013). In India, only about 8% of the overall agricultural output of the country undergoes value addition. The highest value addition is seen in milk (35%) followed by marine (26%), buffalo meat (20%), poultry (6%) and fruits and vegetables (2.2%). The level of value addition is higher in developed countries for the same products; milk (60-70%), fruits and vegetables (65%), buffalo meat, marine and poultry (65- 70%). The low value addition is due to the lack of availability of processable raw material varieties, the seasonal nature of production, the lack of sufficient post-harvest

Table 1. Avenues of secondary agriculture under first type

Inputs – Centric
Nursery for horticulture crops
Nursery for forest species
Nursery for field crops
Nursery for flowers
Vermicompost
Anaerobic digested compost
Bio-fertilizers production (Azospirillum, Azolla etc.,)
Bio-pesticides (concoctions, bio/plant extracts, etc.)
Water, Soil Testing / Analysis
Animal feed / fodder production (including urea enriched straw blocks)
Harvest / Post Harvest – Centric
Pre-conditioning produce for markets: Fruits, vegetables, flowers, spices, etc. Assaying, packaging, pre-cooling and dispatch hubs
Micro and Small Enterprises that can process the primary agriculture produce: garlic extracts / paste, turmeric powder, pickles, jams, etc.
Custom Hiring Centers
Agro-tourism
Weaving, breeding, flavors, dyes, ayush medicines, etc.

Table 2. Alternative enterprises, but linked to rural off-farm activities

Level of processing	Level of value addition	Items	Percent expenditure/ consumption on food items	
			Urban	Rural
Unprocessed	Nil	Fruits, vegetables, eggs, fluid milk	16.8	15.3
Minimum processing (dehusking, milling, drying and grinding)	Low (0- 5%)	Rice, flour, pulses, spices and dried fruits	34.8	43.9
First processing products	High (5-15%)	Dairy products, meat, fish and sugar	38.2	35.1
Second processing products (have as an input a first processed product and to which another product (a flavor, a preservative, or another ingredient) is added.)		Biscuits, bread, ghee, ice-cream, & jam	10.2	5.7

Source: Adapted from Reardon & Minten [16]

Table 3. Type B- avenues of secondary agriculture

Bee Keeping	Palmyra Palm Products	Eucalyptus
Need Products	Broomstick Production	Bamboo Products
Coir Extraction & Products	Daincha	Mahua Products
Venom Farming	Kitchen Gardening / Sack Vegetable Cultivation	Integrated Farming Philosophy
Hydroponics	Aloe Vera	Babui Grass Products
Corn Powder Production	Ram Servicing	Lac Cultivation
Rural Tourism/Agri Tourism	Bull Servicing	Sericulture, silk works

facilities, such as processing, the cold chain, transport and proper storage. The government has a vision to raise the processing speed from 8 to 20 percent by 2015, add value from 20 to 35 percent and share in global food trade from 1.5 percent to 3 percent [15].

The second type is focused on the use of alternative firms for primary agriculture, but is related to off-farm rural activities. Poultry, beekeeping, duck farming and livestock management, for example, are off-farm industries that can be marketed as part of an integrated method of farming. In the time of crop failure, integrated farming will hedge farm risk or ease out the seasonality in the stream of cash flows.

3.3 Mushroom Cultivation

Mushrooms have been grown for their nutritional value and flavour in Asia since ancient times, especially in the Far East. Mushrooms have a lower protein content than animals, but they have a higher protein content than most plants. They're low in sugar, high in fibre, and contain all essential amino acids, as well as all necessary minerals (with the exception of iron) [17]. Mushrooms contain significant quantities of vitamin D when exposed to UV radiation, which is difficult to access from a daily diet. This low-cost vegetable is not only high in nutrients like vitamin D, but it also has anti-cancer, anti-HIV-1 AIDS effects. With the rising rates of cancer in today's world, it's beyond time for people to become aware of the health benefits of mushrooms and to take advantage of their cancer-fighting properties [18]. It is a low-cost, low-resource, low-area crop that can be cultivated all over the world and at any time of year using low-cost starting materials. There is a lot of promise and appeal in growing a highly nutritious food with great flavour from inexpensive and abundant substrates [19]. Also, it is very environmentally friendly, capable of converting the lignocellulosic waste materials into food, feed and fertilizers [20].

Table 4. Some chemical compounds extracted from mushrooms

Chemical compounds	Obtained from	Properties
Peptido glycans	*Lentinus, Schizophyllum, Grifola, Sclerotinia*	Anti-tumour
Ergosterol	*Agaricus blazei*	Anti-tumour
Lipid fraction	*Grifola*	Anti-oxidant
Steroids, hydroquinones	*Ganoderma pfeifferi*	Anti-bacterial
Oxalic acid	*Lentinula edodes*	Anti-protozoal
Schizophyllan	*Schizophyllan commune*	Anti-tumour
Epicorazin	*Podaxis pistillaris*	Anti-microbial
Ganoderic acid	*Ganoderma lucidum*	Anti-viral (HIV)
Ganodric acid, lucidadiol,	*Ganoderma sps.*	Anti-viral (influenza)
Lignins	*Inonotus obliquus*	Anti-viral (HIV)
Polysaccarides	*Trametes versicolor*	Anti-viral (HIV)
Velutin	*Flammulina velutipes*	Anti-viral (HIV)
Illudins	*Omphalotus olearis*	Cytotoxic
Triterpenes	Ganoderma concinnum	Apoptosis
Polysaccarides	Phellinus linteus	Antiangiogenic
Hispolon, hispidin	Indocalamus hispidin	Anti-allergic
Ergosterol peroxide	Tricholoma populinum	Anti-allergic

3.4 Bee Keeping

Managed honey bees are the most effective commercial pollinators of crops that need animal pollination for reproduction and account for 35% of global food supply. As a result, they are critical for a profitable, long-term agricultural sector as well as food stability. Furthermore, honey bees pollinate a wide range of wild flowers, contributing to the biodiversity of many ecosystems. Honey and other hive products are, at least economically and ecologically rather, by-products of beekeeping. Due to honey bees' important position, extreme and unexplained honey bee colony losses, which have recently been confirmed to be gradually growing, have drawn a lot of interest and sparked a lot of study. This function of beekeeping is now of economic importance [21,22] in all developed agricultural systems. Contracts between beekeepers and growers have evolved to the extent that they have given rise to a market in pollination services with prices varying according to farm and the time of year. The bee colony yield from a given forage site, whether honey production or commercial pollination services, depends on the strength of the bee colony, which in turn depends on the quality of the food assimilated throughout the migration. The type of forage provided by crops covering the site cannot be ignored because it influences the honey production but also because it is an input that affects the dynamics within-year of the bee colony stock. [23].

Migratory beekeeping produces marketable outputs but also, as is generally the case in agriculture [24,25], externalities and public benefits. A non-marketed ecosystem service could therefore be produced jointly with a marketed output [26].

In India, beekeeping has traditionally been centered on the forest. As a result, nature provides the raw material for honey production. Bee hives do not need extra land or compete for resources with agriculture or animal husbandry. To look after his bee colonies, the beekeeper just has to devote a few hours per week. As a result, beekeeping is an excellent part-time occupation.

Beekeeping is a means of long-term revenue for rural and tribal farmers. Honey, protein-rich pollen, and brood provide them with essential nutrients. In folk and herbal medicine, bee products are also essential ingredients.

3.5 Backyard Poultry

Poultry meat and eggs have a lot of promise for fulfilling human nutritional animal supply requirements [28] Poultry farming has been a profitable industry in developing countries, surpassing all other poultry enterprises. It has the potential for a large and quick return. In recent years, backyard poultry production has received a lot of attention as a way to keep and improve rural livelihoods. Birds are maintained in a low-input, low-output environment in this farming and can be easily handled by women and children of

Table 5. Marketed output of exported natural honey

Country	US million $	Percent of exported natural honey
China	235.3	11.8
New Zealand	228.8	11.5
Argentina	146.7	7.4
Germany	131.5	6.6
Ukraine	113.3	5.7
India	99.6	5.0
Spain	92.1	4.6
Hungary	82.5	4.1
Brazil	67.9	3.4
Belgium	64.1	3.2

(Source: Natural Honey Exports by Country by Daniel Workman)[27]

the households. Now that there is an increasing concern about meeting the per capita protein requirement of India's rural people, poultry meat, especially eggs, has been proven to be the best and cheapest solution. While India's poultry production has increased dramatically over the years, rural poultry farming continues to lag behind and is often overlooked. This farming method requires improvement because it is the best choice for small-scale farmers to supplement their income with minimal input.

The livestock sector has been one of the fastest growing segments of Indian agriculture in recent years, and within that sector, poultry husbandry has played a key role in both providing jobs and contributing a significant portion of the national GDP. Development in the livestock sector will undoubtedly lead to poverty reduction in a developing country like India, as the majority of the rural poor depend on livestock for their everyday livelihoods. In addition, it has been found that the market for animal protein is increasingly growing in developing countries [29,30].

According to government estimates, egg production reached 69.73 billion at the start of the 12th five-year plan, with a per capita availability of about 57 eggs, and poultry meat production was expected to be 2.68 million tonnes in 2012-2013 [31].

The adoption of a scientific commercial production method is responsible for the quantum leap in these production parameters. While commercially reared improved breed birds account for the majority of poultry items, indigenous sources of poultry eggs and meat are still valued for their flavour and texture in both rural and organised developed markets. Market studies show prices per kg live weight for these birds can be 50 –100 % higher than that of industrially produced birds [32].

Despite the fact that rural backyard poultry is the most effective source of supplemental income for landless poor farmers, it has long been overlooked. This is despite the fact that their goods are much more expensive than those produced by commercial poultry. There is enough evidence to support the importance of backyard poultry husbandry in improving the food and nutrition protection of the poorest people in rural areas [33,34,35].

Backyard poultry is a powerful tool for upliftment of poor because it needs hardly any infrastructure. Rural backyard poultry may provide nutrient enrichment in the form of valuable animal protein, in addition to generating revenue and reducing poverty.

A basic description of backyard poultry production as defined by Mandal et al. [36] is a low-input or no-input enterprise, with indigenous night shelter systems, scavenging systems, little supplementary feeding, natural chick hatching, low bird productivity, local marketing, and no health care practice [37].

3.6 Advantages of backyard poultry [38]

- Provides livelihood to small-scale and marginal farmers in rural areas, as well as extra revenue to rural households.
- Aids in improving backyard soil fertility (15 chickens produce 1-1.2 kg of manure per day).
- When opposed to intensive poultry farming, products from rural poultry farming garner a higher profit.
- Ensures the egg and meat are available with little to no expense.

- When opposed to eggs and meat raised under intensive poultry production, free range birds yield lower cholesterol eggs and meat, which reduces protein malnutrition in vulnerable communities such as pregnant women, feeding mothers, and infants.

3.7 Duck Farming

Duck farming is one of India's main agricultural occupations. Ducks are not only farm animals that keep insects and pests at bay, but they also lay eggs, which provide the owner with a steady stream of income. Although there are many advantages to breeding and rearing ducks, there are still several drawbacks. Many people have turned to duck breeding and caretaking as a full-time job, despite the fact that it takes a lot of expertise and isn't for everybody. The following are some of the most important advantages and drawbacks of duck farming.

3.7.1 Low maintenance

Ducks are simple creatures. When it comes to keeping and managing them, they don't require much physical care or financial assistance. Insects, worms, snails, and seeds are only a few of the foods that ducks consume. Furthermore, there is no requirement of building an additional house or stable for them to reside in. Any small place made with raw materials is enough as a shelter for them and will suffice well enough for a few ducks. Little to no monetary investment on farm animals is a major advantage, especially when it comes to low-budget farming.

3.7.2 No special care needed

Ducks are relatively easy to care for. To put it another way, you don't have to spend the whole day caring for them and attending to their needs. They only lay eggs during the day and choose to lay them early in the morning or late at night. They're also sturdy birds that don't get sick too much. In addition to this, there is no particular business strategy of duck farming required for growing them. In terms of their diet, you can feed them nutritious foods, but they can also cope on their own if necessary. Ducks are relatively easy to care for and have a good return on investment.

3.7.3 Controlling Bugs and Insects

Ducks play an important part in reducing the number of bugs and insects on the farm. Bugs, insects, worms, snails, and even the grains you provide are all consumed by them. This helps to ensure the worms stay away from your farm and don't damage your crops or development in the long run. This is one of the most underappreciated advantages of duck farming. In reality, duck farming is one of the most sustainable methods of pest control in agriculture.

3.7.4 Stable source of employment

While ducks do not need human care, it is often preferable to have a guardian to ensure that they do not leave their territories or get themselves into trouble. If you're a busy farm owner, you should hire a caretaker to look after your ducks, harvest their eggs on a regular basis, and ensure that the benefits of duck farming are realized. This even creates a source of employment for unemployed or under qualified people, which in turn will help you too.

3.7.5 Constraints in duck farming in India

- Lack of quality feed
- Lack of financial resources
- Lack of healthy ducklings

3.7.6 Integrated rice-duck farming (IRDF)

Integrated rice-duck farming (IRDF) is an essential mode of ecological agriculture for achieving agriculture's long-term sustainability. Rice production and the rice environment benefit from integrated rice-duck farming (IRDF), in which ducks feed on insects and weeds in paddies and fertilise rice plants. Ducks in rice fields can efficiently manage weeds, rodents, and plant diseases while also improving soil properties and aeration by paddling, trampling, and foraging [39,40], but also reduce N runoff and leakage loss in rice fields [41]. In addition, IRDF has increased rice population dry matter accumulation, root activity and stem strength [42,43]. Furthermore, duck bioturbation may alter environmental factors in rice fields, potentially affecting GHG production and emission in the paddy soil.

4. CASE STUDY

A 2-year split-plot field experiment was performed by Guochun Xu and his coworkers to evaluate the effects of IRDF on methane (CH_4) and nitrous oxide (N_2O) emissions and its ecological mechanism in rice season. This

experiment was conducted with two rice farming systems (FS) of IRDF and conventional farming (CF) under four paddy-upland rotation systems (PUR): rice-fallow (RF), annual straw incorporating in rice–wheat rotation system (RWS), annual straw-based biogas residues incorporating in rice–wheat rotation system (RWB), and rice green manure (RGM). During the rice growing seasons, IRDF decreased the CH_4 emission by 8.80–16.68%, while increased the N_2O emission by 4.23–15.20%, when compared to CF. Given that CH_4 emission contributed to 85.83–96.22% of global warming potential (GWP), the strong reduction in CH_4 emission led to a significantly lower GWP of IRDF as compared to CF. The reason for this trend was because IRDF has significant effect on dissolved oxygen (DO) and soil redox potential (Eh), which were two pivotal factors for CH_4 and N_2O emissions in this study. The IRDF not only mitigates the GWP, but also increases the rice yield by 0.76–2.43% compared to CF. Moreover, compared to RWS system, RF, RWB and RGM systems significantly reduced CH4 emission by 50.17%, 44.89% and 39.51%, respectively, while increased N_2O emission by 10.58%, 14.60% and 23.90%, respectively. And RWS system had the highest GWP. These findings suggest that mitigating GWP and improving rice yield could be simultaneously achieved by the IRDF, and employing suitable PUR would benefit for relieving greenhouse effect.

5. INTEGRATED FARMING SYSTEM (IFS) AS AVENUE FOR SECONDARY AGRICULTURE

Integrated farming has been characterized in several respects and may be interpreted to include a number of agricultural systems organized along a continuum of potential organizational structures and spatial and temporal scales [44]. Any traditional meanings include the method of agricultural processing with several firms interacting in space and/or time to achieve benefits through a synergistic resource transfer among enterprises. Working closely such that waste from one part becomes a supply for another component of the system is an emphasis in these schemes, minimizing the need to purchase and apply costly and potentially polluting materials, such as gasoline, fertilizers and pesticides, eliminating leakages to the atmosphere, and increasing overall productivity or profits. Interdependence between firms within the system, synergetic movement of capital between companies and the flexibility of the system to be viable in the long term are the main factors in integrated farming systems. [46]. Integrated farming systems, called mixed crop-livestock farming or integrated crop-livestock systems, are also believed to include both crop and livestock enterprises. Integrated farming systems, however, can broadly involve systems in which only multiple components of crops communicate. This includes rotational crop systems, annual and perennial cover crop use, green manure crops or intercropping to reduce the need for purchased inputs by fixing or retaining nutrients and reducing weed, disease, and pest pressures.

Several types of drivers influence the adoption of integrated farming systems including economic, environmental, and social [46]. Economic drivers include production complementarities, risk, and management requirements. Integrated farming systems have economic benefits through economies of scope. Economies of scope occur when it is cheaper to produce two or more products simultaneously than producing them separately. Integrated crop-livestock systems reduce production costs due to complementarities in production such as use of grain screenings or crop residues for animal feed and subsequent application of livestock manure to land as fertilizer. The benefits of economies of scope tend to be more pronounced for small farms than for large farms, so there are stronger incentives for integration in small farms. Farmers are generally risk averse and favor practices that reduce risk exposure. Integrated farming systems may reduce economic risk through diversification of production across multiple enterprises, when economic returns for these enterprises are imperfectly correlated. Integrated systems, however, increase management complexity due to the need to understand and coordinate multiple enterprises. This can be an important barrier to the adoption of these systems, and exemplifies the concept of bounded rationality. Productivity and economic performance can be reduced if administrative decisions are limited by managers' ability to process and act on complex information. Thus, if integrated systems are more complex, this can decrease productivity and create incentives against integration [47]. While integrated agricultural systems have many benefits, there is a current trend f toward specialized and large-scale farms, reducing the number of farmers and increasing total assets through mergers and consolidations. This is particularly apparent in developed countries where the benefits gained

Table 6. Total CH4 and N2O emissions, GWP and rice yield during the rice growing seasons in 2014 and 2015.

		2014				2015			
PUR	FS	CH_4 ($kg \cdot ha^{-1}$)	N_2O ($kg \cdot ha^{-1}$)	GWP (kg CO_2-eq$\cdot ha^{-1}$)	Rice yield ($t \cdot ha^{-1}$)	CH_4 ($kg \cdot ha^{-1}$)	N_2O ($kg \cdot ha^{-1}$)	GWP (kg CO_2-eq$\cdot ha^{-1}$)	Rice yield ($t \cdot ha^{-1}$)
RF	CF	129.81	1.88	4133.2	9.32	144.76	1.46	4441.1	9.42
	RD	117. 77	2.05	3840.8	9.41	129.03	1.56	4025.4	9.54
RWS	CF	268.77	1.71	7978.1	9.53	300.51	1.25	8745.0	9.70
	RD	223.94	1.89	6772.2	9.76	253.12	1.44	7468.3	9.83
RWB	CF	145.83	1.93	4595.4	9.84	158.66	1.51	4841.8	9.97
	RD	133.01	2.12	4286.2	9.91	139.10	1.64	4330.4	10.05
RGM	CF	164.85	2.17	5190.4	9.72	176.41	1.60	5362. 5	9.76
	RD	140.29	2.36	4553.8	9.85	151.43	1.66	4680.8	9.92

(Guochun Xu, 2016) [45]

through economies of scope decrease with increased farm size. Large farms may benefit from specialization, which is associated with economies of scale. Economies of scale exist if the per unit cost decreases with an increased farms size by spreading incremental cost over more production units. Specialized and large-scale farms characteristically use technology intensive production systems. Intensive use of technology in agriculture may lead to a transition from within farm integration to among-farm integration, and favor large agribusinesses that reduce cost through economies of scale and through higher market power and market access. Policy makers and large agribusinesses may prefer large systems as it reduces the number of stakeholders they must deal with and reduces transaction costs [48].

6. COMPONENTS OF IFS

These include agriculture, fish breeding, horticulture, duck rearing, forestry, pigeon rearing, planting of mushrooms, sericulture, Azolla farming, dairy, kitchen planting, poultry, production of fodder, goat rearing, greenhouse, sheep rearing, production of seeds, piggery and vermiculture [49]. The different IFS are:

- crop-livestock forestry farming system,
- crop-fish-poultry farming system,
- crop-livestock poultry-fishery farming system and
- labor-intensive farming system for small area.

Integrated systems are about getting crops and livestock into an interconnected partnership with the goal that they will produce beneficial impacts on results of importance, such as profitability, total production and non-renewable resource management, together as opposed to alone. It is, however, much more than this. The “system” includes the environment, soil characteristics, landscape positions, genetics and ecology of plant and animals. This covers human resources methods, priorities and lifestyles, socioeconomic pressures, economic prospects, marketing techniques and externalities, including the supply of energy and the cost and effect of agricultural policies. Systems also reflect natural resources available and the impact on their use, wildlife issues, target and nontarget plant and animal species, micro-organisms and indeed all of the definable and indefinable factors that ultimately interact to result in an outcome that is never constant [50]. Integration of various farm enterprises in a farm ensures growth and stability in overall productivity and profitability. It also ensures recycling of residues, optimization of resources, minimization of risk and generation of employment. Crops, vegetables, fruit, flower production, dairy, poultry, fish, goat, pigs, sericulture, mushroom cultivation, agroforestry, beekeeping, silviculture, agro-based businesses and food processing are numerous enterprises that may be included in the agricultural framework. A judicious combination of firms that are complementary to cropping and suitable to the given farm situation and the choice of the farmer will bring overall prosperity. Under farming system, the farm is viewed in a holistic manner. Farmers are subjected to many socio-economic, biophysical, institutional, administrative and technological constraints. Farming system conceptually is a set of elements or components that are interrelated which interact among

themselves. At the centre of the interaction is the farmer exercising control and choice regarding the type and results of interaction [51].

6.1 Enterprises that Thrive on Crop Residues and Waste Materials of Primary Agriculture

Third avenue are such enterprises that strive on crop residues, or by-products of primary agriculture. For example, after recovering sugar from cane, cane can be used as bagasse for molasses production. Similarly, cotton stalk and seed (after ginning) can be used for de-oiled cake preparation or utilized in the secondary/tertiary sector.

6.2 Sugarcane By-Products

Sugarcane is one of the most effective solar-to-biomass-to-sugar converters. Using chemical, biochemical, and microbial technology, biomass containing fiber, lignin, pentosans, and pith can be processed into value-added products. Sugarcane cultivation provides bagasse, molasses, and press mud, all of which have a high economic importance. Aside from these key byproducts, sugarcane residues such as trash, green tops, wax, fly ash, and spent wash are produced and have less commercial value. The Indian sugar industry has been processing these by-products to manufacture bioethanol, bio-electricity, and a number of other products with added value.

Table 7. Type C – Avenues of Secondary Agriculture

Cotton Stalk Products	Fibre Boards etc., from Rice Straw	Agave / Banana Fibre Extraction & Products
Dung logs, bio-gas, leather extracts, etc.	Urea Enriched Fodder Block from Rice Straws	Cutlery plates from Wheat Husk, Arecanut Leaves, Siali Leaves, etc.

Table 8. Agro-industrial and economic value of sugar industry by-products

Sector of economy	Value added products from sugarcane & sugar industry residues
Food	Sweeteners (traditional, modern, synthetic), vitamins acids, beverages, fats and oils edible proteins (SCP and mushroom)
Health	Chemical, antibiotics, anti-cholesterol (policosanol), lingo-meds, enzymes, vaccines, juice
Agriculture fertilizers, compost, food, feed, fodder, forages, pesticides	A range of food, feed, fodder, fertilizer and forages
Industry	Solvents, plastics, bio-plastic, alcohol-based chemicals, anti-corrosive compounds, tenso-active compounds, biocides
Energy electric power, biogas, bagasse fuel, fuel alcohol	Bagasse as fuel, biogas, co-generation of power, ethanol from bagasse
Transportation	Ethanol-petrol/diesel blends (gasohol), bio-diesel
Education and culture	Text books, note books, newsprints, writing and printing paper
Housing/construction	Particle boards, hard boards, ac ducts, decorative laminate
Light industry	Textile, polish, bitumen, carbon paper and chemicals
Communication	Insulating materials
Heavy industry	Resins for casting molds
Human resource development	Employment generation in rural areas

(Source: S. Solomon, 2011)[52]

There is a lot of opportunity for bagasse-based factories to set up plants to manufacture market pulp, newsprint, writing and printing papers, particle board, MDF, cattle feed, and chemicals like furfural, since there is a lot of demand for all of these goods in the world. The molasses-based products made in India can favorably compete in the international market with the products produced in other countries, due to the fact, that the price of molasses in India is quite reasonable. There are already many industries working in India based on the by-products of the sugar industry.

7. CONCLUSION

The high dependency on agriculture among India's community, coupled with sophisticated labor-substituting technology, leaves little space for non-farm sectors to absorb surplus manpower. As a result, agriculture must have gainful jobs and sufficient incomes while still maintaining food and nutrition stability. With the change in demand for value-added goods and the region's diverse supply base, secondary agriculture has a huge amount of potential. The goal of strengthening and expanding secondary agriculture through rural industrialization in the form of a cluster strategy is to add value to primary agricultural goods to meet market demands through manufacturing. Reorienting agricultural education to include secondary agriculture in the curriculum will help to increase the manpower available. Similarly, including secondary agriculture research and extension in the mandates of the ICAR and SAUs is crucial in order to develop and transfer relevant technology and methods for primary farmers to benefit from secondary agriculture. The promotion of secondary agriculture would not happen unless it has been understood as an independent roll-out program to generate new income-generating work opportunities in order to increase farm incomes. In this sense, secondary agriculture must be given careful consideration, reference, and budget allocation, both separately and in the context of various ongoing projects. As many ministries such as agriculture, petroleum, food processing, and rural development are concerned, the committee on doubling farmers' income has proposed that the government create an institutional framework to resolve the problem of generating wealth from agricultural wastes and encourage "secondary agriculture". Secondary agriculture will benefit from enterprise-level funding, which could be achieved by creating a Secondary Agriculture & Enterprises division in each of the ministry of agriculture and farmers' welfare's three divisions, and organizing their activities through a structured forum. The increasing migration of manpower from agriculture without a corresponding infusion into manufacturing and service industries necessitates the provision of alternate income generation opportunities in rural India, possibly requiring an immediate emphasis on Secondary Agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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