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REVIEW ARTICLE

Integrated farming and value chains: A resource and market perspective - A review

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Abstract

An integrated farming system (IFS) is a holistic approach to sustainable agriculture that optimizes resource utilization while ensuring economic viability. The value chain in IFS encompasses several key stages, including input supply, production, processing and marketing, each playing a crucial role in enhancing efficiency and profitability. Effective resource utilization within IFS ensures optimal use of land, water, labour and inputs, minimizing waste and maximizing productivity. The economic benefits of value addition are significant, as they enhance product quality, extend shelf life and create diversified income streams for farmers. Managing the value chain strategically is essential for improving supply chain efficiency, reducing losses and ensuring better price realization for producers. In the livestock component of IFS, a well-structured value chain supports feed management, disease control, quality assurance and market access, leading to higher productivity and profitability. Similarly, in aquaculture and fisheries, value chain integration strengthens sustainable harvesting, efficient processing and reliable distribution, improving both output and economic returns. Agro-tourism integration within IFS provides additional value by promoting farm-based experiences, attracting tourists and generating supplementary income while fostering rural development. Risk management strategies within the value-added chain, such as diversification, insurance mechanisms and technological innovations, play a critical role in mitigating uncertainties related to climate change, market fluctuations and supply chain disruptions. The study takes a forward-looking approach by highlighting how IFS can evolve through stronger value chain integration. Emphasis is placed on enhancing resource-use efficiency, promoting on-farm value addition and aligning production with market demands. Overall, the study outlines how IFS can serve as a future-ready model for sustainable and profitable agriculture.

Keywords: agroforestry; agro-tourism; aquaculture; IFS; livestock; resource utilization; value chain

Introduction

The integrated farming system (IFS) is emerging as a sustainable strategy for farmers, which is increasingly adopted to enhance their standard of living. As the global population continues to grow, the risks to food security are also escalating. In recent decades, human activities and intensive farming practices have significantly impacted natural agroecosystems (1). These practices have led to declining soil fertility, water scarcity and reduced biodiversity, affecting long-term agricultural sustainability. Small and marginal farmers are particularly vulnerable to these challenges. To overcome this, a shift from conventional to improved, integrated practices is essential. IFS, with its holistic approach combining crops, livestock, fisheries and other components, offers a sustainable solution by enhancing resource use efficiency, ecological balance and income diversification. To mitigate these challenges, farmers need to shift from conventional practices to more improved approaches. Thus, the IFS, which takes a holistic view of the farm from various perspectives, can serve as an effective means of improving the circumstances for small and marginal farmers (2).

Agricultural systems must be multifunctional to ensure food security, drive economic growth, support social needs and maintain ecological sustainability (3). The "Farming System" is defined as a complex inter-related matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled in part by farming families and influenced to varying degrees by political, economic, institutional and social forces that operate at many levels (4). Modern agriculture is operational in 2 main dimensions, viz., time and space. Income through cropping alone is insufficient for a massive percentage (70-80 %) of the marginal farmers in India. In India, land scarcity has eliminated the potential for expanding food production horizontally. From 1971 to 2011, the number of small holdings has consistently increased at a rate exceeding 2 % per year, while the area under cultivation has risen by only 0.1 %. Consequently, the average size of farms has declined (5). Survival in the changing environment is possible only by the competitive enterprises and many producers and manufacturers found not only engaged in producing innovative products but also involved in the conversion of the "manufacturing service industry" to "fulfill the consumers' diverse needs" (6).

The "Value Chain" is a sequence of value-adding processes that flow across many levels and form products and services that are suitable to satisfy the consumer's needs (7). The formation of a value chain can be accomplished through a process known as the value chain, which involves a series of interconnected and dependent stages where specific inputs are transformed into final outputs (8). The value chain provides opportunities to minimize costs and mitigate risks throughout the supply chain (9). Traditional crop-based farming is no longer sufficient to sustain the livelihoods of small and marginal farmers, especially with shrinking landholdings and rising input costs. Unsustainable agricultural practices have led to resource degradation, low productivity and increased vulnerability. There is an urgent need for a diversified, integrated and market-oriented farming approach to ensure sustainability and income security. Therefore, integrating value addition into farming systems enhances resource efficiency, economic productivity and environmental sustainability. Accordingly, this review examines "value addition in IFS".

Purpose of the study

The purpose of this study is to review the role and potential of value addition within IFS as a means to enhance resource use efficiency, improve farm profitability and ensure long-term sustainability for small and marginal farmers. It aims to assess how integration of various components and value chain approaches can contribute to food security, livelihood improvement and environmental resilience.

Objectives of the study

1. To review the structure and functioning of IFS with emphasis on component integration.
2. To examine the role of value addition across different components of IFS, such as crops, livestock, fisheries and agro-tourism.
3. To explore the significance of market linkages and value chain development in enhancing profitability and reducing post-harvest losses.

Stages of IFS

The integrated farming system involves 4 main stages: input, production, processing and marketing.

Input supply

In developing countries, small-scale farmers put in significant effort to feed their families and earn a livelihood from limited land, raising a few livestock and cultivating crops. The farming system approach has been widely acknowledged and promoted as a tool to ensure the balanced use of inputs and their combined effects, helping to create a sustainable production system (10). It is a regulated system that incorporates natural resources into farming practices to minimize reliance on external inputs and maintain sustainable farm income (11). IFS rely on a thorough understanding of the interactions among 4 key input components: fertilizers, pesticides, cultivation practices and crop rotations. These interactions play a crucial role in determining crop yields and farm profitability (12). Animal manure serves as a valuable fertilizer, contributing more to the soil than just basic nutrients like nitrogen (N), phosphorus (P) and potassium (K). In crop cultivation systems, manure remains a crucial link between crop and livestock production, especially in developing countries (13).

Production

Marginal farmers with small plots of land focus primarily on growing crops, particularly cereals, which carry significant risks of flooding and drought. Due to unreliable monsoons and the limited size of their holdings, they often struggle to earn enough income to support their families. An IFS includes various resource-saving practices designed to achieve satisfactory profits and maintain high, sustainable production levels, all while reducing the adverse impacts of intensive farming and protecting the environment (14). In an IFS, farm waste is more efficiently repurposed for productive applications (15). To improve production within the IFS, several agronomic principles can be applied, including mixed farming systems, crop rotation with balanced cropping patterns, effective management of uncultivated land, non-inversion tillage, selecting suitable cultivars, balanced fertilization techniques and integrated pest management (IPM) (16).

Processing

The expansion of the agro-processing industry promotes agricultural growth by establishing new output markets and boosting farmers' incomes, allowing for investment in land and inputs to improve productivity (17). Processing is essential for adding value to products. In corn production, losses occur at different stages: 1.69 % during harvesting, 0.28 % during shelling and 2.99 % during drying. These losses often result from traditional methods or improper machine use. To mitigate these issues, introducing corn sheller machines and implementing effective postharvest practices are necessary (18). The milk produced by the livestock component of IFS is processed into butter, giving it a significant advantage over fresh milk due to its increased temporal flexibility for household use and sale (19). Biochar, which is processed from agricultural waste, is attracting increasing attention in the energy sector because of its sustainability and affordability (20). The by-products are not utilized to their full potential, leading to diminished or lost value. Addressing the management and reprocessing of these large volumes of by-products presents a significant sustainability challenge for the industries (21).

Marketing

Market participation is essential for enhancing farmers' subjective and objective well-being, with research revealing favourable implications on income, poverty reduction and dietary

diversification. and the selection of marketing channels greatly impacts income (22). Initiatives like farmers' markets and community-supported agriculture (CSA) programs address several key challenges. CSAs allow communities to support farms directly, sharing in both the risks and rewards of farming. These efforts stimulate local economies by creating a direct connection between consumers and producers, enhancing access to nutritious food (23).

Resource utilization of IFS

The IFS has shown significant advantages over conventional farming by enhancing resource use efficiency, promoting effective recycling of farm waste, generating year-round employment and increasing overall farm productivity (Fig. 1). Various studies have highlighted the benefits of integrating components like livestock, aquaculture, poultry and organic manure management within IFS models. Table 1 summarizes key outcomes from these studies, demonstrating the system's potential to improve sustainability, profitability and livelihood security for small and marginal farmers.

Economic benefits of value addition

Stubble burning negatively impacts agricultural productivity, which reduces the sector's contribution to the country's gross domestic product (GDP) by degrading soil health, increasing costs and disrupting the agricultural value chain (24). IFS aims to boost farm employment and income by combining various farm enterprises and reusing crop residues and byproducts on the farm. Value addition is a key aspect of the IFS (25). The value-added products not only reduce the post-harvest losses but also enhance the additional income (26). There are generally 4 methods available to add value to raw commodities produced by farmers. These include (i) forming producer-owned businesses; (ii) utilizing production or marketing contracts; (iii) investing in a portfolio of food companies and (iv) selling through open markets via traditional distribution and processing channels (27). Consumers' desire to purchase at more varied establishments and their growing interest in value-added, unique products continue to be the foundations for the next wave of agricultural and regional community economic development (28). Many high-value agricultural products tend to have a high ratio of transaction costs to their final value, due to the extensive processing involved in these items (29).

In India, over 50 % of children still suffer from malnutrition long after the country became self-sufficient in the production of cereals and grains (30). Value-added food products made from maize would not only increase farmers' profits but also create jobs for women and young people while offering customers more dietary diversity in their food options (31). In this regard, various market-based approaches, such as value chains, are gaining popularity. These strategies not only help farmers access profitable markets but also serve as tools to address food insecurity and poverty (32). IFS's components include: (i) Agriculture, which includes fish farming, duck breeding, dairy, forestry and horticulture. (ii) The production of mushrooms, sericulture, azolla farming, kitchen gardening, fodder and nurseries. (iii) Seed production, poultry, apiary, pigeon, goat and vermiculture. (iv) Raising sheep: value addition, pig farming and rabbitry (33).

Agriculture combined with livestock farming yields higher profits than agriculture alone. In addition to raising goats for agricultural purposes, growers who raise 20 to 30 goats a year will earn at least 40 to 50000 rupees in extra revenue. Farmers may gain greatly from agroforestry and goat farming in tandem. The IFS model was tested on a 1.0 ha farm in Gujarat from 2010 to 2019. It included four cropping systems, fruits and vegetables, livestock and vermicomposting, with farm waste recycled to reduce external inputs. The groundnut-wheat-multicut fodder millet system recorded the highest grain equivalent yield (8696 kg ha^{-1}) and employment (476 man-days $year^{-1}$), followed by the overall IFS model (7977 kg ha^{-1}) (34). The IFS model (rice-onion cropping system, pisciculture, poultry and mushroom farming) outperformed the conventional rice-green gram system, yielding 28081 kg ha^{-1} rice equivalent yield (REY), net returns of ₹142201 ha^{-1} and a B:C ratio of 1.82, compared to 4188 kg ha^{-1} REY, net returns of ₹9522 ha^{-1} and a B:C ratio of 1.25 in the conventional system. The IFS also produced diverse outputs such as rice, onions, fish, poultry and mushrooms, alongside recyclable by-products, leading to higher sustainability with a sustainable yield index (SYI) of 0.82 and a sustainable value index (SVI) of 0.44 (35).

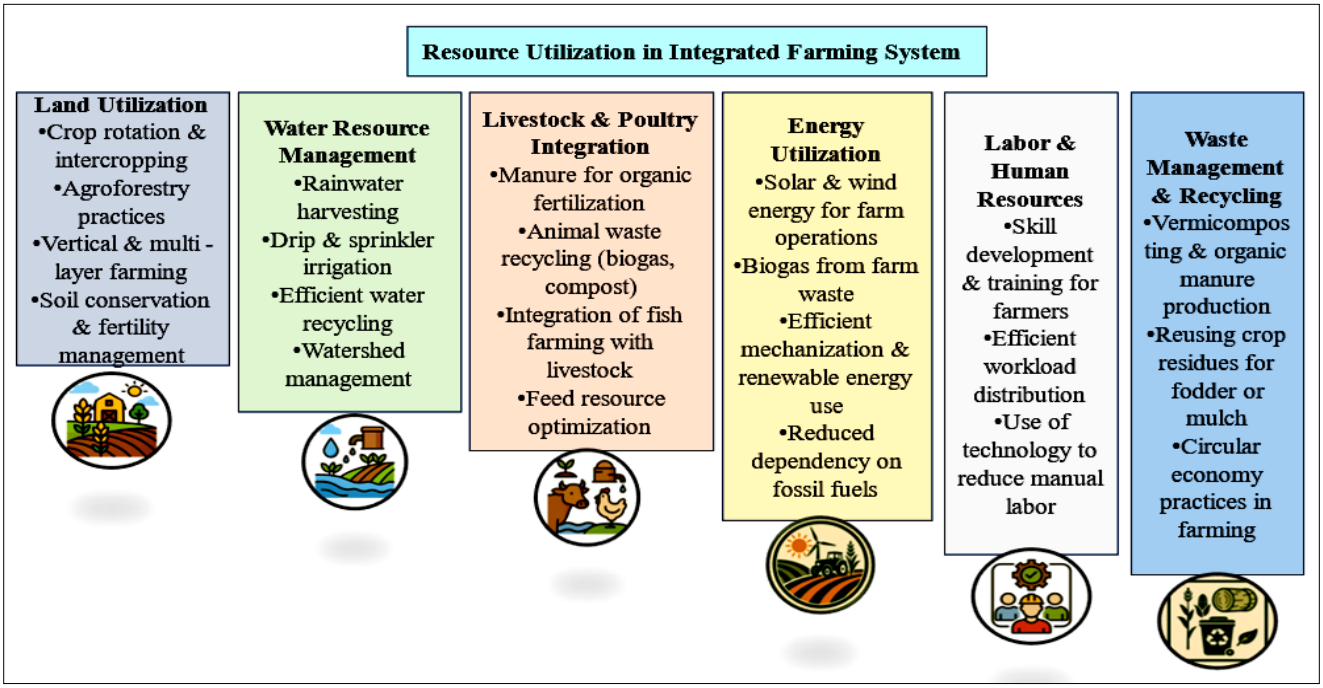

Fig. 1. Resource utilization in IFS.

Table 1. Impact of integrated farming system (IFS) on resource utilization

S. No.	Component	Outcome	References
1.	Crop-livestock integration	Enhances economic returns and utilizes crop residues, animal waste and draft power efficiently	(95)
2.	Human labour utilization	Effectively uses men's and women's labor throughout the year, especially during leisure time	(96)
3.	Waste recycling and cost reduction	90–95 % of nutrient needs are fulfilled through recycling, reducing cultivation cost and increasing marginal benefits	(97)
4.	Organic manure usage	Application of vermicompost, pond silt, FYM and other recycled manures improves crop productivity and reduces chemical fertilizer use	(98)
5.	Water use efficiency	IFS consumed 14249 m^3 of water, significantly lower than 22925 m^3 used in conventional systems	(99)
6.	Aquaculture infrastructure	Use of locally available materials like bamboo mats and fiber nets for fish enclosures improves income in wetland-based IFS	(100)
7.	Aquaculture productivity	Fish-based systems produced 200 kg protein ha^{-1}, surpassing traditional land -based protein systems	(100)
8.	Livestock-aquaculture integration	Cattle produce sufficient dung and urine to fertilize ponds, yielding 9000 kg milk and 3000-4000 kg fish ha^{-1} $year^{-1}$	(101)
9.	Poultry integration	Poultry manure enriches fish ponds; 100 fowls + pigeons yield 1500 eggs, meat sales and income of ₹8000-10000 annually	(102)
10.	Model IFS (multi-component)	Model (1.04 ha crops, dairy, fishery, poultry, horticulture, mushrooms, etc.) produced 124.96 t $year^{-1}$ and recycled 19950 kg farm waste	(103)
11.	Goat-based dryland IFS	20 goats produced 45 lambs $year^{-1}$ and manure providing 200 kg N, 106 kg P, 91 kg K, enhancing soil fertility	(104)
12.	Cattle and buffalo manure contribution	Daily dung yield contributes 3.6-4.3 t $year^{-1}$; stall-fed manure contains up to 15 kg N, 6.5 kg P, 8.6 kg K annually-boosting soil nutrients	(105)

Mushrooms are used to create a variety of value-added products, including mushroom pickle, mushroom beef paste, mushroom sauce, mushroom ketchup, mushroom preserves, mushroom candy, mushroom jam and assorted mushroom sauce (36). Value-added products not only help reduce post-harvest losses but also increase the income of mushroom growers, while providing consumers with a nutraceutical, low-fat, protein-rich food option (37). Farmers contribute approximately 13 % value kg^{-1} of meat, but after processing, the value increases by 30 % (38). Compared to ₹533221 from the rice-wheat system, the highest return (₹79064 ha^{-1}) was obtained from fisheries + piggery + poultry, registering a 48.6 % gain. Additionally, this created roughly 500 extra man-days of employment per hectare annually (39). Fish is a popular but perishable food; great care is taken in its processing, preservation, packing, storage and transportation. The term "value addition initiatives" in fish farming refers to the application of production techniques, innovation and handling procedures meant to enhance the farmer's operations and output in order to increase the product's consumer base and the percentage of revenue that goes to the fish farmer. The value addition results in a twofold increase in the net return achieved (40).

Importance of managing the value chain

Agriculture value chain finance had a significant impact on profitability. The value chain evolved from the supply chain but emphasizes the value created at each stage, which is essential for fulfilling consumer demands. The main factors driving the value chain include product differentiation, quality enhancement and boosting overall system efficiency (41). The administration of the value chain is essential for facilitating the participation of value chain stakeholders in assisting agricultural producers in the adoption of sustainable methodologies, enhancing their financial well-being and contributing to the realization of Sustainable Development Goal 2 (SDG 2), which seeks to eradicate hunger, attain food security and foster sustainable agricultural practices by the year 2030 (42). The primary themes examined in value chain analysis include recognizing the factors that drive transformations within the value chain, identifying limitations in current value chains, conducting a strengths, weaknesses, opportunities and threats (SWOT) analysis of value chains, assessing post-harvest losses across, evaluating the level of farmer engagement, understanding the effects of value chain development on production and consumption, analyzing value distribution and exploring gender involvement (43).

The importance of managing the value chain (Fig. 2) lies in understanding and optimizing key factors such as the investment considerations (e.g., capital outlays and loan conditions), technology adoption (e.g., cost and availability of mechanization), product characteristics (e.g., perishability, labour intensiveness), market requirements (e.g., global standards and sector-specific demands), all of which influence the efficiency, competitiveness and profitability (44). These changes have significant impacts on food consumers, farmers and intermediaries (such as wholesalers, processors, third-party logistics providers and retailers), along with their employees who handle and transport products throughout the supply chain. The value chain strategy symbolizes a movement in agricultural development from a traditional, technology-dominated, production -oriented approach to one that is demand and market-oriented. It is a systematic technique. The value chain development approach focuses on enhancing interactions, knowledge sharing, trade, financing and partnerships among different stakeholders in a product's value chain, including suppliers, producers, processors, traders and logistics providers (45). The goal of value chains is to increase competitiveness, lower production costs, superior quality, a diverse range of inputs and continuous learning, all of which contribute to innovation. The value chain concept is now commonly applied in development initiatives as a key strategy for integrating small-scale farmers into high-value export markets, whether individually or in groups.

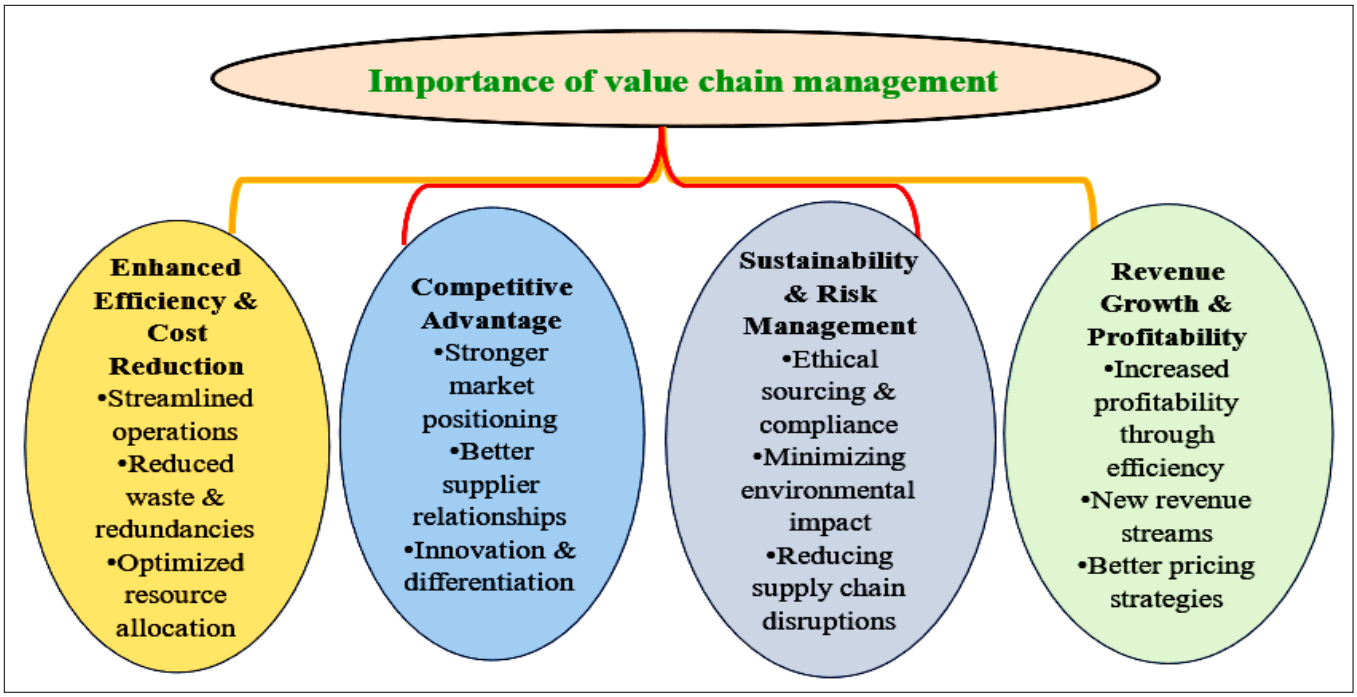

Fig. 2. Importance of managing the value chain.

Role of value chain in agroforestry components of IFS

Agroforestry is a key element of the IFS model, characterized by the strategic integration of trees and crops (46). The Consortium of Industrial Agroforestry (CIAF) was established in 2015 to link all value chain players and address challenges in the agroforestry production-to-consumption system sustainably (47). Farming is progressively becoming a skilled profession, with agricultural markets shifting to the digital realm, consumer preferences becoming more global, entrepreneurial roles requiring technical and managerial expertise and value chains becoming more complex (48). On-site processing, Direct marketing and voluntary price signalling could enhance the perceived value of products and bring farmers in mixed farming and agroforestry systems (MiFAS) closer to the end consumers, reducing the value transferred to intermediary actors in the value chain and allowing farmers to capture a greater share of the added value (49). Manufacturers aim to convert this extra brand value into a market advantage. This market value, along with the supply risk management benefits of an agroforestry approach, encourages companies to bear the cost and complexity of certification, while prompting farmers to get certified and traders to supply certified materials (50).

Intermediaries play key roles in transportation, selling and processing and as the volume of products increases, the cost of marketing functions decreases. They can also absorb risks, handle large volumes and reduce market search and transaction costs. However, this does not imply that all intermediaries are efficient or essential, nor that farmers should avoid performing their own marketing functions (51). For agroforestry crops, the vertical networks identified 6 distinct channels, with the primary and longest channel involving phoria, bepary, paiker/arathdar and retailer (52). Gum arabic is one of the major commercial non-timber forest products (NTFPs) and agroforestry enhances the gum arabic value chain by improving yield and quality through sustainable land management, while value-adding steps like grading, better storage and micro-finance support help prevent distress selling and ensure higher-quality produce for export markets (53). At the local level, engaging in value-adding activities can enhance labour returns, even without focusing on large-scale or external markets, as exemplified by marula beer, where traders earn higher hourly incomes than those supplying fruit and kernels to other markets (54). Wood products that add more value are made through mechanical transformation and used in construction, including structural and appearance timber. Cross-laminated timber (CLT) and thermally modified timber (TMT) should be considered as alternatives for value addition, similar to a remanufacturing plant producing mouldings, panels and furniture parts (55). Moringa agroforestry provides economic advantages to smallholders and local communities, while contributing to the creation of resilient landscapes (56).

The export of moringa leaves is a growing industry in regions such as Tamil Nadu, Andhra Pradesh, Karnataka and Odisha, where producers and manufacturers have developed a diverse range of 18 value-added moringa products. These products include moringa leaf powder, tablets, capsules, oil, tea (in 4 flavors), energy bites, organic energy bars, instant soup, honey, dry flowers, plant growth promoters, chips and more. However, as both a producer and manufacturer of these high-margin products, the business faces increased production and distribution costs due to the premium prices required by dealers and the additional expenses of establishing and maintaining organic plantations (57).

Role of value chain in the livestock component of IFS

Livestock products, being widely distributed and highly perishable, require efficient marketing and processing systems across their entire value chain from production to consumption to maximize their value (58). The average gross income from livestock enterprises (cow, buffalo, goat and poultry) was ₹36499.52, with an input-output ratio of 1:2.07. When crops and livestock were integrated, the highest net income of ₹284005.18 came from the crop + vegetable + dairy combination (59). The total output of the integrated crop-livestock system exceeds the sum of its individual components, as the output from one land unit serves as input for another part of the system. This integration enhances the overall efficiency of the farm and boosts the productivity of both crop and livestock production. Properly managed, an integrated crop and livestock system can provide significant income and a diverse food source, helping to

sustain farmers' livelihoods (60). The livestock value chain can be simple, involving rural producers, intermediaries and processors/ packagers. Understanding the goals of this value chain is crucial for guiding investments, market access, sales assurance and quality.

Enhanced market access for smallholders is recognized as a key component of the national policy on food and nutrition security, with the integrated maize-soy-poultry value chain being a priority sector (61). The livestock sector is crucial for food supply and security, with livestock products (meat, milk and eggs) accounting for 15 % of global per capita calorie intake and 31 % of protein supply, though this varies by region (62). In value chain management (VCM), strategic decision-making that effectively integrates resources to boost competitiveness is emerging as a key approach, helping organizations adapt to the dynamic business environment (63). Value addition in milk is essential for boosting sector profitability, but it is only feasible if the organized sector expands its reach. The organized sector's involvement is key to driving growth through value addition and tapping into the consumer market. Postharvest technologies for products like pickled eggs, salted chicken eggs, albumin rings, egg rolls, egg crepes and egg powder are also available. In general, the marketing of poultry products relies heavily on an organized marketing network, the development of processing infrastructure and ensuring quality and safety standards throughout the food chain, from production to consumption (64).

The use of modern freezing, packaging and transportation technologies has enabled large poultry companies to efficiently deliver high-quality, predominantly value-added premium products (65). The value of goat meat can be enhanced through improved production practices or meat processing. Reducing the number of market channels or distribution costs and marketing animals in uniform or consistent groups typically boosts the value of live animals (66). To address these challenges, it is essential to modernize facilities, upgrade cold storage and supply chains and improve packaging and processing methods. Adding value through diversified dairy, wool and meat products can enhance profitability and market appeal. Innovations in sheep and goat milk products, wool processing and pashmina production present significant growth opportunities.

Role of value chain in aquaculture and fisheries components of IFS

Farmers who implement fish-crop-livestock IFS, particularly those combining fish, piggery and poultry, experience the highest levels of food, nutrition and livelihood security. Adopting this IFS leads to an overall improvement of 26.83 % in the respondents' standard of living (67). The rice-fish system, the integrated pig-duck-fish-vegetable system and integrated systems involving animals are key farming practices. The first 2 are traditional systems commonly used in Southeast Asia, particularly in regions with high rainfall (68). Formulated feed tends to be costly and is therefore suited primarily for the production of high-value products aimed at wealthier consumers (69). A key type of aquaculture-integrated agriculture (AIA) system is the pond-based AIA, where fish are raised as a primary crop for production and income. This system is environmentally sustainable, providing a method for water reuse and nutrient recycling. In fish-vegetable AIA systems, the water use efficiency was found to be 8.46 kg m^{-3} (70). The highest REY was achieved in model 6 (pond + rice + vegetables + pig integration) with 4.04 magnesium (Mg), followed by model 8 (pond + vegetable + pig + fruit integration) at 4.02 Mg. The lowest REY was observed under the farmers' practice (rice + vegetables) with 0.53 Mg (71). Modern farming systems focus on productivity-boosting technologies, often relying on chemical compounds that degrade soil quality.

Aquaponics offers a sustainable approach by raising fish and vegetables together in a symbiotic relationship for sustainable food production. Examples of commercially available intelligent solutions for aquaculture and fish processing include Marel's FleXicut, FleXisort and RoboBatcher, which automate fish processing systems (72). Government policy frameworks that focus on rural infrastructure, including transport, irrigation, storage facilities, processing and farmer incentives, promote agricultural diversification. Marketing and processing are essential prerequisites for promoting IFS under specific agro-ecological conditions. When a reliable market for alternative produce from IFS is established, farmers are more likely to be motivated to diversify their farming systems (73). Efforts are underway to enhance the efficiency of aquaculture as a food production system by maximizing the edible yield through genetic improvements and advanced processing technologies (74). Fish by-products can pose considerable environmental and food-technical challenges due to their high microbial content and endogenous enzymes, making them prone to rapid degradation if not properly processed or stored under suitable conditions (75). Since fish production, landing and processing sites are geographically dispersed, the most effective management strategy for converting fish residues into higher-value products is local processing immediately after production (76). Adopting a value chain perspective in the small-scale fisheries sector can identify strategies that improve the sustainability and competitiveness of the entire value chain and the economic agents within it (77). The main market participants in the pangas and tilapia value chain include farmers, aratdars, wholesalers, processors and retailers. Of all the actors, processors contributed the most value, followed by farmers.

Role of agro-tourism integration into IFS for value addition

Agro-tourism is a growing trend in our country, allowing tourists to escape city life, experience local customs, stay in rural homes and participate in local sports. Agro-tourism is a complex system that offers a valuable opportunity for modern society to support both farmers' livelihoods and the national GDP (78). Agro-tourism boosts local economic activities, which in turn enhances the appeal of the area, increases demand for local products and creates direct marketing opportunities (79). Rural tourism and agrotourism are promising businesses that can stabilize the economic and social development of rural areas, playing a key role in regional growth (80). Farming, pensions and other income sources were considered inadequate to ensure a decent standard of living for families, with tourism seen as a viable way to improve their livelihood (81).

Community-based agro-tourism, as an integrated farming model, promotes sustainable agriculture and tourism. Each salak plantation package covers about 3 hectares of productive trees, with a permanent path for fruit picking from December to March. Visitors are charged an entrance fee of ₹10000-15000, depending on group size (82). Agro-tourism is an agribusiness activity where local farmers or residents offer tours of their farms, allowing visitors to observe the cultivation, harvesting and processing of locally grown crops like coconuts, pineapples, sugar cane, corn, or other agricultural products that are not typically found in urban areas or visitors' home countries.

Agro-tourism is a contemporary evolution of the IFS, where

agricultural activities are combined with tourism, creating a unique opportunity for visitors to experience farming practices while also enjoying the cultural and natural aspects of rural areas (Fig. 3) (83). The agritourism value chain provides residents with greater opportunities to offer additional services, such as tours, recreational activities, tastings and gastronomic experiences, leading to higher income compared to those not participating in these networks (84). Promoting rural community involvement in the agro-tourism sector has driven modernization and diversification, contributing to the stability of products and services (85). Coffee agro-tourism can enhance economic benefits for coffee farmers and local businesses in surrounding areas. The "relationship coffee" model helps develop value chains that stimulate economic activity and create opportunities to improve the welfare of rural communities (86). Introducing agrotourism on farms would diversify farmers' income sources, thereby increasing their overall earnings.

Risk management strategies in value added chain

The value-added chain refers to the process in which technology is integrated with materials and labour inputs and then the processed inputs are assembled, marketed and distributed (87). The issues and difficulties related to value addition include traditional production methods, high costs, poor factory layout and facilities, insufficient machinery, lack of capital, inadequate education and entrepreneurial mindset, outdated technology, absence of market research, lack of competitive analysis and ineffective marketing strategies (88). Many public and private sectors in our country are concentrating on low-cost drying technology, hurdle technology, minimal processing and steeping preservation to enhance processing facilities and boost farmers' income (89). Agricultural production refinement equipment, including cleaners, graders and dryers, is used for both on-farm and industrial operations (90). The creation of equipment like leaf cup and dona making machines, multipurpose mills, mini flour mills, grain pearlers, maize dehuskers, shellers, groundnut decorticators, fruit graders, juice extractors, high-efficiency mechanical oil expellers and improved storage solutions for cereals, pulses, oilseeds, onions and potatoes.

Agricultural mechanization is a strategy for boosting agricultural and food production by raising cropping intensities, reducing the physical strain of labour-intensive farming and processing tasks and helping to eliminate poverty (91). Effective extension services and training are crucial in strengthening capacity throughout the value chain by promoting proper postharvest practices. The agro-processing sector should be viewed as a key element of agricultural and export policies, necessitating the introduction of a new initiative, like "Grow, Process and Export from India", similar to the "Make in India" campaign (92). Small growers are unable to utilize storage for their harvested vegetables. Therefore, it would be beneficial if cold storage facilities were established by government agencies or the private sector near production areas to store the produce, which could then be used by processing industries (93). The concept of farmer producer organizations (FPOs) has shown great potential by organizing small and marginal farmers and facilitating collective agricultural activities. The collaborative strength of FPOs plays a key role in enhancing the agricultural value chain (94) (Fig. 4).

Conclusion

The value chain is a cornerstone of the IFS, enabling farmers to maximize the value derived from their activities. By efficiently managing each step such as input supply, production, processing and marketing. Farmers can enhance the quality and profitability of their products. Integrating various components like livestock, aquaculture, agroforestry and agro-tourism within the value chain not only creates diversified income streams but also strengthens the system's resilience. Properly managing the value chain in IFS is key to improving resource utilization, reducing waste and adding value at each stage. Ultimately, a well-structured value chain in IFS leads to greater economic benefits and sustainability for farmers. However, this review is limited by the lack of quantitative analysis and field-

Fig. 3. Integration of agro-tourism as a component in IFS.

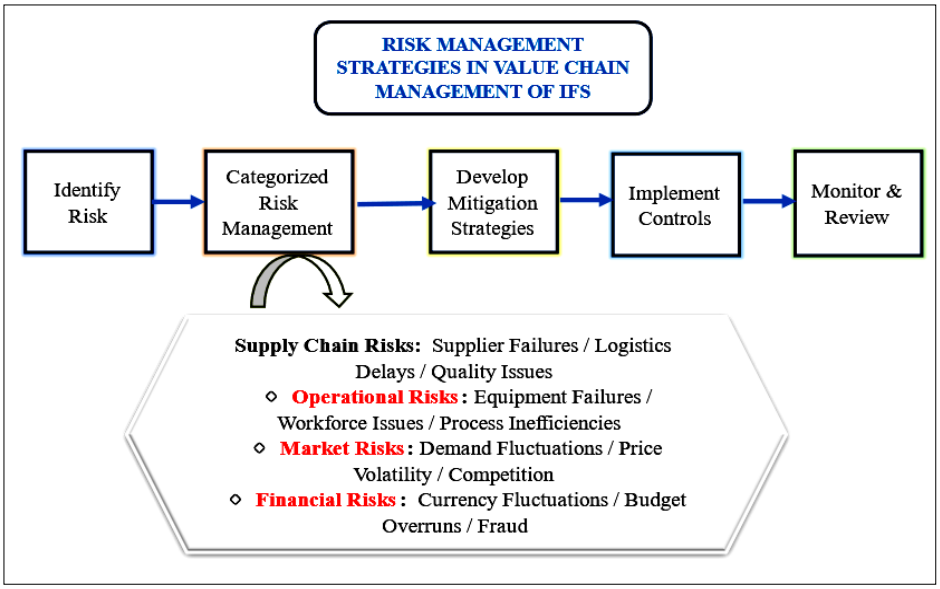

Fig. 4. Risk management strategies in the value chain management of IFS.

level validation, as it primarily relies on secondary sources. Regional variations, policy constraints and socio-economic factors affecting the adoption of value-added IFS models are not thoroughly analyzed. Future studies should focus on empirical data collection, performance benchmarking and impact assessment of integrated value chains in real-world farming contexts. Looking ahead, the integration of digital technologies such as precision farming tools, blockchain for traceability, artificial intelligence for decision support and information and communications technology (ICT)-based market access platforms holds promise for enhancing the effectiveness of IFS value chains.

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Authors' contributions

SKN, RG and PMS conceived the idea for this manuscript. RG conducted the literature review and drafted the initial manuscript. SRV, NR, KS, SPS, NS and TP provided critical feedback and revisions to the manuscript. SKN, RG and PMS prepared the final version of the manuscript. All authors read and approved the final manuscript.

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