Assessment of Risks and Risk Management for Agriculture Supply Chain

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1 Introduction

Agriculture has transformed from ancient traditional agriculture of the 1950s, mainly labor workforce-dependent, to modern smart agriculture. The studies reveal that the agricultural production processes have resulted in high agricultural production due to modern technology's contributions. The rise in agricultural productivity has led to the growth of factories and industries (Liu et al. 2020). The need for factories and the processing industry has helped generate revenue from fruits and vegetables and increased employment for the youth (Christiaensen et al. 2021). The growing agriculture productivity and initiatives have raised serious concerns for the agriculture supply chain (ASC), topical in the international markets. The agriculture supply chain from the field to factories and the processing industries has helped generate revenue from fruits and vegetables and increased employment for the youth (Christiaensen et al. 2020). To build an export-oriented production environment, marketing agencies plan awareness and promotional activities. In the meantime, stakeholders are keen to assess the risks and their management strategies through the institutional, climate, lead-time, and financial perspectives (Imbiri et al. 2021). The risks in ASC cannot be compared with the risks in other supply chains. An ASC is different from other supply chains as it is driven by various risks like institutional, financial, climate, and market risks. The ASC deals with agriculture commodities, which has

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a short shelf life. Despite short shelf life, agricultural commodities cannot maintain the quality specifications with climate change. There have been studies on ASC risks that majorly focus on climate change. Very few reports analyze the risk factors for ASC in detail by linking them to practice. Thus, there is a scope to investigate the shelf-life of agricultural commodities and work on the knowledge gap to minimize the ASC risks. The necessary awareness and promotion activities must be planned through marketing agencies to build an export-oriented production environment. The ASC also needs to look at the infrastructure facilities for primary processing, packaging, storage, etc. for example, agricultural commodities like strawberries have a short shelf life. Maintaining the quality of such products becomes a concern for the stakeholders. Perishable commodities like bananas, mango, strawberries, tomatoes, citrus, and guava have many risks. These commodities cannot be stored for a long and have a very short shelf life. The produce needs special care during the production to protect it from insects, pests, and disease. The distributors claim poor quality specifications with time (Salah et al. 2019). Agricultural commodities such as food grains require proper storage facilities to protect from moisture and spoilage from pests and insects.

The ASC for expensive agriculture commodities such as saffron needs special care as the commodities are driven by poor traceability resulting in poor quality (Salah et al. 2019). The stakeholders, especially developing countries, do not have a firm hold on the ASC. This results in losses and disruptions in the ASC. Inadequate knowledge of the advantages of digital agriculture, lack of system integration, ease of use of the application, language barriers, low access to farm sites, lack of technical motivation, lack of information, and lack of infrastructure are the challenges that farmers have been facing in the ASC (Mittal 2001). More risks need to be documented for the efficient management of ASC. Therefore, it is essential to document all ASC risks and their management concerning the farmers and literature. It is also essential to derive the risk management strategies from the assessed risks in the ASC.

Against this background, this chapter explores the following research questions: *What are the risks in the agriculture supply chain, and What are the risk management strategies for the same?* The chapter will result in risk management strategies that could help the readers to understand the scope for improving the existing ASC. The chapter with detailed documentation of different types of risks will help the stakeholders of ASC to manage the supply chain carefully. The deliberation is based on the literature and field interview analysis of different risk types and their management strategies highlighted in the secondary database and qualitative data from the progressive farmers. The chapter also documents the result of interviews conducted with the progressive farmers. Questions asked to the progressive farmers during the discussion were

- What are the risks in the agriculture supply chain?
- How did you manage the risks for the Agriculture supply chain?
- What were the challenges and their remedial measures?

- Do you receive any support from any scheme or government body concerning the agriculture supply chain?

ASC creates new development paradigms that warrant more interaction with institutional and environmental factors (Sørensen et al. 2010). ASC is compelled to save water, smart agriculture, high-quality specifications, productive growth, pollution-free agriculture, and economies of value. The production stage has to be integrated with ASC to meet stakeholders' expectations. It helps to improve crops production—per drop, per acre, per rupee. For this, digital tools and techniques have a significant role in managing any ASC. To be precise, state-of-the-art technologies such as machine learning, urban farming, hydroponics, aeroponics, aquaponics, blockchain, etc., are significant for creating a global market (Salah et al. 2019). Digitalization offers relevant solutions to agricultural production management. It has established a ground-breaking platform for sustainable agriculture, making ASC more competitive (Kumari and Patil 2019). ASC risks are now being managed with artificial intelligence tools (Kumari et al. 2018). This chapter will act as a catalyst to bridge the gap between theory and practice. The researchers will be benefitted from understanding the ASC in a better way.

The rest of the chapter is structured as follows: Sect. 2 provides an overview of risks in ASC. Section 3 discusses the risk assessment frameworks. Section 4 records the feedback from stakeholders' interviews. Section 5 offers a plausible risk management strategy for agricultural inputs. Section 6 reveals the changing paradigms. Section 7 deliberates on the role of supply chain financing, and finally, Sect. 8 concludes the chapter.

2 Risks in Agriculture Supply Chain

An ASC is a complex web of functions. Each function comprises risks such as lack of exposure to the farmers, promotion activities for building an export-oriented production environment, lack of infrastructure facilities for primary processing, packaging, storage, inadequate market linkages, weak market intelligence, and lack of training. The ASC in the chapter mainly focuses on agriculture commodities, dairy supply chain, floriculture, and fisheries. Each sector is dominated by risk factors, which can be visualized in Fig. 1.

The treemap roots down the risks in different sectors. Firstly, the floriculture sector has marketing, infrastructure, and cold chain risks (Mittal 2007). The flowers, if not stored at an optimum temperature, may add to waste (Roy 2015). It has been observed that a fall in demand for floral products, along with a lack of infrastructure for their storage, results in their damage (Hulme et al. 2018). To manage the ASC risks in floriculture, there is a need for the delegation of services for an integrated model of floriculture (Messner et al. 2021). The dairy sector is dominated by risks like cold chain and technology applications (Mor et al. 2018).

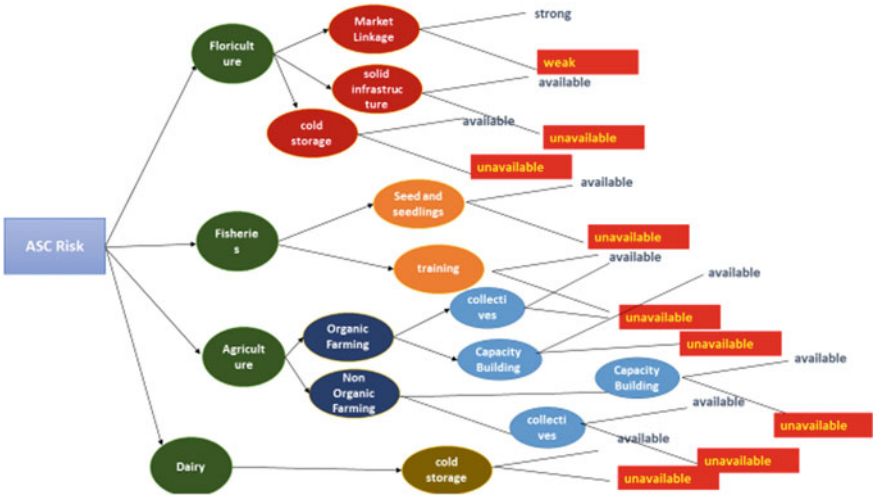

Fig. 1 Decision tree for primary issues for agriculture supply chain

The technology adoption for cold chains in the dairy sector helps increase income. The increase in milk procurement and processing capacity can create jobs for many unemployed and casual laborers. The animal husbandry department has fixed many subsidies for generating income and employment from poultry and farm. This sector, too, has a huge potential for income generation. Secondly, fisheries seeds and seedlings are often missing, which adds to the risk in this profession (Beck et al. 2011). There is a need for the conversion of stakeholders, the role of the bank, and training for income generation from fisheries. Thirdly, the agricultural sector has an untapped potential for exporting products that can be harnessed through 'natural farming.' There is a need for risk management in the agriculture sector through capacity building and collective action approach. There is a need to improve the shelf life of agricultural commodities and work on the knowledge gap. The investments in the cold chain have been triggered by market reform, investment subsidies, public service provision, and governance (Minten et al. 2014). Cold storage is associated with improved efficiency in supply chains and low waste (Kumari and Jeble 2020). Small farmers have the disadvantage of a lack of technical knowledge. Deficiency of technical skills and awareness about cold chain facilities are needed. Thus, Fig. 1 suggests the collective action approach, technology, and capacity building for agriculture risk management.

3 Risk Assessment of Agriculture Supply Chain Through Interviews with Progressive Farmers

This section explores the risks in ASCs through interviews with progressive farmers across the world. The 15 progressive farmers were approached through telephonic conversation for an interview on a purposive sampling approach, and the discussions were designed for 20–30 min addressing the questions on risks for ASCs. The insights from the key farmers are below.

Farmer 1—ASC depends upon the quality of agriculture production. Agriculture production is often challenged by inadequate rainfall and drought conditions. Transforming drought-hit farmland into a green belt is a prime challenge (Singh and Kumdhar 2016). The timely and effective water conservation approach coupled with soil, seed, and fertilizer management witnesses horticulture and pulses' quality bumper production, which brings a pleasant surprise to fellow farmers. Suitable applications of technology and knowledge in the farm field have not only made him a progressive farmer but took him to be an integral part of the governing body of a *World Bank-sponsored Agriculture Technology project*. He shifted into Agriculture diversification and marketing coordination. Technology application and knowledge are the keys to managing the risks. Most farmers face risks due to a lack of technology and unawareness. The prime element for ASC is the quality of agricultural produce. To meet the quality specifications, the farmers need to shift towards technology.

Farmer 2—Left the job and started the agriculture profession, even though people dissuaded him with the perception of no income from agriculture. He started working in Mango production. The land for the same was in the worst condition and passed on to them deliberately to discourage his agriculture venture. He worked consistently for 1 year and, with the support of scientists from the local leading agriculture university, adopted scientific techniques in pruning, cutting, and fertilizer applications. In a year, they increased the income from the mango field from twenty-five 350 USD to 1500 USD (roughly) within a year. This was an encouragement and an eye-opener for the farmers. Then his team started the production of Litchi with the help of drip irrigation and micro-sprinkler. They controlled the microclimate for litchi. They were in touch with processors, and for 8 days, the whole night, they harvested the litchi. This helped them increase their income from 1200 to 3500 USD (roughly). In 15 acres of land, the litchi today is sold at 40,000 USD annually. Agriculture has a huge potential with technology for increasing income. The team took the help of government subsidies to set up the complete automatic technology. They have good broadband and subscribed farm ERP system to digitize agriculture. He has been awarded many rewards for smart agriculture and online marketing. The turnover of his farm is roughly 100,000 USD, which will increase to 300,000 USD in the coming 5 years. While this is growing, they face marketing risks as the farmers should have good quality specifications for ASC. The farmers can increase productivity, but somewhere there is a need to look into the quality aspect of the agricultural produce. It is essential to focus on consumer-driven agriculture commodities. Consumer-driven products help in managing the market risks.

Farmer 3—One of the farmers was troubled by the barren lands. She ran a self-help group, and with its help, she built watersheds, tanks, check dams, and rainwater harvesting systems. All this helped her make the farm green and improve the water problems in the villages. Her initiatives towards making the villages green removed the water barriers for the crops. The farmers face the individual risk of having low landholdings and economies of scale. Therefore, it is essential for collective action by the farmers. The farmer also concluded that quality specification is the primary element in ASC. A collective or cluster-based approach needs to monitor and manage the quality. Farmers have shifted towards a collective approach for managing the risks of economies of scale.

Farmer 4—Attempted to store agricultural commodities such as wheat, coriander, mustard, and maize to avoid wastage. Therefore, there were restrictions, and they did not find access to the market for the ready crops. The farmers will face storage risks, but they need to learn to manage them. ASC risk is accompanied by the lack of infrastructure and inventory management issues, resulting in poor ASC performance. Risks like infrastructure and storage drive the ASC. Most of the agriculture commodities get wasted due to improper inventory management.

Farmer 5—The farmers grew maize, paddy, wheat, oats, and pulses. The major challenge was the procurement of agricultural inputs like seed, fertilizer, and tractors. This case tells us that agriculture has the potential to become viable. The need of the hour is to guide the farmers for effective pre-harvest and post-harvest management along with the proper market linkages. The farmers risk being untrained and having poor technical skills, leading to poor performance. The farmer pointed out a need for capacity building of the farmers and stakeholders. This can be done by providing proper training on producing and handling the agricultural produce.

The majority of the farmers agreed that inadequate rainfall, pests, insects, and disease affect the product's quality (Fig. 2). The poor infrastructure, lack of technology, storage structures, and unawareness are other risk factors in the ASC.

Fig. 2 Risks assessment based on the Farmers' Interview

4 Risk Assessment in Supply Chain of Agriculture Inputs Through Interviews

The farmers face risks in the supply chain of agriculture inputs. The risks involved with the agriculture inputs are explained below. The response from the farmers is clustered in Fig. 3.

Seed

Farmer 6—Good quality seed is a critical input to high productivity and farmers' welfare (Khanal and Maharjan 2015). The seed supply chain suffers from a weak regulatory mechanism, weak intellectual property rights (IPR) policy, and low investments in biotechnology. The risk management for the seed supply chain can be done through investment in R&D. The *Protection of Plant Varieties and Farmers' Rights Act* (PPVFRA), 2001 needs to be revisited to facilitate a robust IPR regime. Improving the financial position of the seed company, operation cost, logistics, and diverse agro-climatic conditions need to be carefully monitored for the supply chain.

Insecticide

Farmer 7—Losses caused by the pests have threatened the agricultural cropping system (Heong et al. 2015). The supply chain of insecticides depends on the information and the product, and the information supply chain needs to flow from the government agencies to farmers through training, media campaigns, extension activities, field study, and trials. Surveys report that most of the insecticides sprayed by the farmers are unnecessary and disrupt the supply chain of the agriculture inputs.

Fig. 3 Risks in agriculture supply chain for agri inputs

Fertilizers

Farmer 8—The fertilizer sector faces risk in the supply chain in the form of reformulation with minor hazardous components, storage, disposal, labeling, training, engineering controls, protective equipment, emission controls, incident monitoring, controls in raw material purchasing, and product sourcing, controls in storage, and distribution, auditing of operators, contractors, suppliers, responsible advertising, and after-sales support. Lack of knowledge about the usage of neem-coated urea (NCU), the challenge in calculating the recommended dose of fertilization (RDF) from different fertilizer brands, lack of knowledge about the method of fertilizer application, and lack of awareness about fertilizer use in crop farming are the major risks here. For these reasons, awareness amongst farmers regarding integrated nutrients management with NCU is required to be created. It can be done by more and more field demonstrations regarding the usage of NCU in the cultivation of crops and its use in other than crop production purposes, i.e., silage making, mixed with weedicide, and fisheries feed preparation to be conducted by a farmers field (Chouhan et al. 2018).

Drones

Farmer 9—The application of bar codes, radio frequency identification, and QR codes efficiently apply technology in agriculture and drone usage. The flight time and range vary in drones from 20 to 60 min, and drones are dependent upon the weather, knowledge, skills, and better connectivity (Tubis et al. 2021). However, the technology implementation requires awareness creation with user-training sessions, and the lack of exposure is the most significant risk in using the technology applications.

Farm Machinery

Farmer 10—The demand for farm machinery has increased over time. However, the risk in farm machinery is the accessibility and credibility of farm machines (Hinnou et al. 2022). Significant logistics issues such as order processing, inventory planning, distribution structure, and transportation issues contribute to the risks in the supply chain of tractors (Raghuram 2004).

Agrochemicals

Farmer 11—Smallholder farmers are not provided proper training and capacity building to use agrochemicals, leading to unsafe use of agrochemicals (Mengistie et al. 2016). Climate change and biodiversity norms have put restrictions on the agrochemical supply chain. Organic Compost Manure faces the challenge of a lack of infrastructure, legislation, and framework (Jiang et al. 2022).

5 Risk Management Strategies in Agriculture Supply Chain

ASCs are difficult to organize and stabilize in countries with many small and marginal farm holdings, and the production and aggregation parts must be efficient to achieve higher returns. The greatest job at hand is to encourage the small and marginal farmers and build confidence in them to move away from subsistence-level farming to market-oriented and remunerative agriculture through the adoption of newer technologies, post-harvest processing, and value additional agri-products at the community level. Considering several sub-activities in the ASCs, management of such sub-activities, financing at each level, and monitoring the supply chain activities through networking with stakeholders become problematic if one relies on financial assistance from Commercial banks. The community-level financial organizations in the form of collectives can meaningfully transform low-value primary agri-produce to higher values through demand-based contract farming, aggregating, processing, packaging, branding, transporting, warehousing, marketing/retailing, etc.

Collectives have the potential to transform agriculture into a profitable business venture through a well-coordinated collective action. The following are the possible intervention by which the ASC risks can be managed, as shown in Fig. 4.

- *Fruits and Vegetables Supply Chain*: Collectives are best suited for effective marketing of fruits and vegetables. Small and marginal farmer members can save themselves from being exploited by local traders during the flush season of production. In the absence of immediate local demand and facilities for transportation and storage, the collective effort can explore marketing potential in the nearby urban markets and fetch remunerative prices for their products (Poulton et al. 2010). Community-led fruit preservation or processing units can also process perishable

Fig. 4 Word cloud on risk management for agriculture supply chain

commodities, enhance shelf life, and realize more price than raw agri-produce. This will improve the confidence level of the growers and create additional jobs, particularly for the local small, marginal, and landless families.

- *Dairy Supply Chain*: Dairy is one of the most potent tools for ensuring sustainable livelihood income for millions of small farmers in rural India. Collectives promote dairy husbandry through efficient delivery of breeding and health care services at farmers' doorsteps. Collectives have the capabilities to ensure systematic effort to develop and operationalize the supply chain in the dairy and dairy processing sector. A little handholding by the government or an expert agency can ensure transparency, coordination, and networking of various dairy supply chain stakeholders to sustain the related business ventures.
- *Contract Farming*: Contract farming enables small and marginal farmers to participate in new high-value and diversified product markets and helps in improving quality standards to ensure remunerative prices for the products so produced by contract growers (Singh 2002). Since agri-markets are largely buyer-driven and vertically integrated, contract farming through community-based farmers would offer the best possible income stream to the farmers by reducing labor-related transaction costs, costs on technology and innovation, research and development, and their application in the field. In comparison to individual farmers, cooperative producer organizations can reap the benefits of lower input costs, stability, and longevity of contract farming arrangements and deliver a fair and sustainable distribution of profits amongst the member farmers. Co-operative producer organizations have the desired potential for balancing the complicated dynamics between firms and farmers through collective bargaining, creation, and maintenance of long-term relationships with input vendors and logistic support providers, and timely mitigating of risks and uncertainties faced by the farmers.
- *AgriInputs Supply Chain*: The Agri input market, both at the level of the user-farmer and the producer-investor, can be managed through the following measures: (i) farm-level extension and promotion programs, (ii) financial assistance to investors in setting up units, (iii) subsidies on sales, and (iv) direct production in the public sector and cooperative organizations and in universities and research institutions (Mazid and Khan 2015; Pal et al. 2015).
- *Co-operation and Agri-marketing*: Agri-marketing ensures a vital link between the farmers and consumers. Co-operative agriculture marketing has immense potential in resolving the complex and complicated problems faced by the present agri-marketing system. The strengthening and revival of the existing co-operative marketing system in the agriculture sector would eliminate not only excessive dependence of agents and intermediaries in the organized wholesale markets and unorganized rural periodical markets (Village Agricultural Markets) but also ensure appropriate price discovery by resolving issues of effective information dissemination, use of digitized means of marketing, management of transportation costs by joint transportation of commodities and establishment of a network of warehouses for storage of perishable and semi-perishable agri-commodities.

Setting up co-operative sale societies and co-operative warehousing units may be the best solutions to help the agriculturists realize the rightful profits on their output at the community level.

Small and marginal farmers' availability and access to markets are vital in designing the market infrastructure. At present, co-operative marketing consists of commission shops in various marketplaces. These shops neither undertake collection or aggregation of agri-produce from the farmers at the farms nor do they provide joint and cost-effective transportation and other logistic support for ensuring better price discovery. Further, the cooperative marketing system lacks adequate mechanisms to undertake and provide timely and adequate processing and preservation facilities for perishable/semi-perishable agriculture products. The need of the hour is to upgrade and strengthen the establishment of organized facility centers for aggregation and transportation of agri-commodities, assaying, pre-conditioning, grading, to standardize packaging and storage of the products. Thus, a solid and vibrant collective marketing infrastructure has significant potential in making ASC efficient by effective and timely dissemination of market intelligence and actual demand statistics of the commodity to be traded and the ruling prices of such items amongst the member farmers of the societies. Thus the need of the hour is to:

- Establish community-level hubs strategically placed in rural and urban growth centers.
- Ensure finance to such processing and value-addition units by assuring access to banking infrastructure or adequate and efficient public–private partnerships.
- Facilitate collectives and startups and encourage venture capitalists to invest in innovative agri-processing startups through appropriate policy interventions.
- Setting up adequate accredited food quality testing labs at convenient and strategic locations.
- Make available infrastructure for skill development and capacity building for farmer members to process and preserve perishable and semi-perishable agri-products.
- Impart training and essential orientation tips to members of collective marketing societies on grading, assaying, sorting, and standardization of agri-commodities.

The growth of the agriculture sector remains an important area of discussion for policymakers. In the present situation, the agriculture sector's significant constraints are controlling small and marginal farmers' financial and market conditions. The collective action of farmers can result in agriculture value addition and marketing (Levay 1983). Small farmers' critical concerns are inadequate extension services, low-level technology adoption, lack of capital, poor business skills, low income due to poor infrastructure, and low marketing efficiency. Many forms of aggregation in farmer interest groups, self-help groups, cooperatives, and *Farmer Producer Organizations* (FPOs) emerge as the most effective tools to manage the overall supply chain professionally. In addition to the challenges like ineffective leadership, small and

marginal holdings of farmers, poor market linkages, inability to attract talent, absence of time-tested thinking and planning, ignorance of principles of basic accounting, and not knowing how to make a business plan for the organization, the farmers also lack understanding of the rules and regulations of a Company and the statutory requirement. There is also a need to collectively promote FPOs to handle multiple commodities for value addition and marketing. The ability of leaders' energy at the age of space-time can be a driver for sustainable agriculture growth.

6 Changing Dimensions for Risk Management in Agriculture Supply Chain

The agriculture supply chain needs to be integrated with technology and other dimensions, as shown in Fig. 5.

- Leadership—Professional leader who is willing to work for the farmers. Professionals and youths need to be attracted to collectives.
- Philosophy—The value for money and the value of many are essential for encouraging the farmers toward the supply chain. The incoming professionals are required for the supply chain despite the lucrative offers.
- Consistency—A sustained approach is required in communication and human resources planning; there is a need for a dedicated and efficient supply chain.
- Technology adoption at all levels—The low input and low output model needs to be changed to better information.
- Creation of dedicated supply chain—The supply chain demands a dedicated team in the supply chain who are consistent in their approach.
- Innovation—Regular education of the farmers is required for adaptation to innovation in collectives.
- Branding and Marketing is the essential element for a better supply chain.

Fig. 5 Changing dimensions for risk management in agriculture supply chain

7 Agriculture Supply Chain Financing for Risk Management

In general, the farmers and stakeholders in emerging countries are not financially sound, and therefore tangible investments are one of the demanding needs for ASC. The financing requires substantial investments to adopt technology, infrastructure, or process. A significant effort exists for capacity building at various levels, i.e., farmers, managers, governing councils, and bankers. Limited access to better inputs, including credit and technologies, a low market surplus of food crops, and inadequate warehousing facilities, including cold storage, cold chain, or perishable, have made it very difficult for the ASC to sustain. ASC financing is required for capacity building, integrated management, IT-enabled technology services, infrastructure credit, biotechnology, processing, and aggregate financial models. Sustaining ASC financing in solid business and profitable lines is a challenging task because the sector is dominated by small landholders (Ceballos et al. 2020). In some cases, farmers are at a disadvantage due to scale limitations (Behzadi et al. 2018). To overcome the drawback, the rural population composed of cooperatives, regional banks, commercial banks, non-banking financial institutions, and lending agencies has supported agriculture through credit flow. ASC actors need finance for production, procurement, processing, storage, and distribution. The credit flow at each stage is essential for sustaining the ASC.

Financial institutions provide loans to the farmers based on their repayment and risk-bearing capacity. Small farmers have a meager compensation and risk-bearing ability, making it difficult for financial institutions to get credit flow. Financial agencies can indirectly engage the supply chain stakeholders to provide credit to the farmers. The economic approaches help in the value proposition, creation and delivery, customer relationships, capturing value, intentions, partnership, and collaboration. The financial institutions can follow the different economic approaches (Fig. 6).

- Indirect Supplier Financing: The financial agencies are aware that the farmers are not in a position to bear high risk. Therefore, they may support the ASC players, viz., agro-processors and market agencies who are more creditworthy and less prone to risk. The ASC players may take the risk of lending to the farmers to sustain ASC financing.
- Interdependence Financing: This approach has interdependent links. The financial agency is ready to provide credit to the farmers if they have the following link in the supply chain. The business success of one link is dependent upon the other connection.
- Cascade Financing: The financial agency targets the linkage of the supply chain. The agency may not finance the farmers in isolation but provides finance to the primary producers, processors, distributors, or end buyers.
- Joint Liability Group Financing: This approach has individual and group financing. Underfunding individuals, each member of the joint liability group

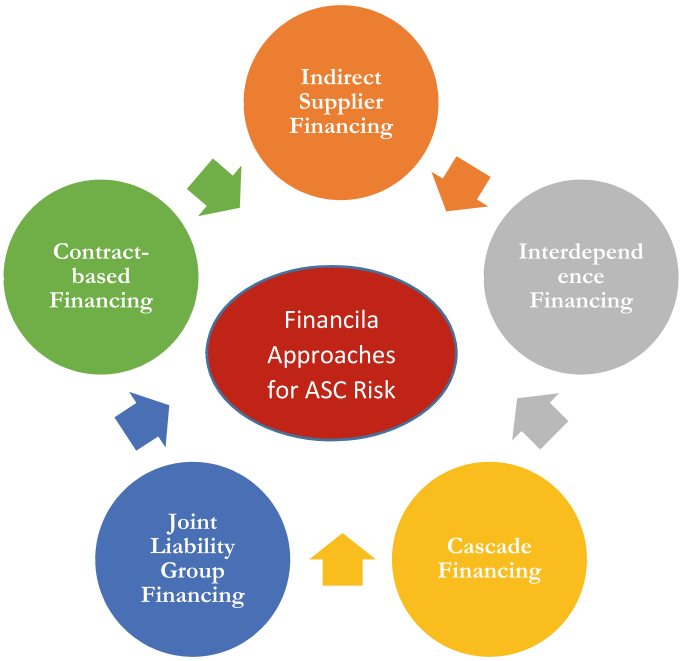

Fig. 6 Linking financial approaches for agri supply chain risk management

may be provided Kisan Credit Card (KCC). Under the group financing approach, the Joint liability Group acts as one borrowing unit.

- Contract-Based Financing: In this financial approach, the financial agency is willing to reduce the risk of the defaulters. The farmers who enter into a contract with some reliable buyers are financed, wherein the agreement ensures that the farmers' income may be used as loan repayments.

8 Implications

8.1 Theoretical Implications

Our study offers vast literature on ASC risk and risk management. The extensive literature review and qualitative approach add to the pool of knowledge on the ASC risks assessment and management. Overall, we adopted an interview-based approach for understanding the ASC risks and the strategies essential for managing the risks in ASC. Our findings also add to understanding the importance of risk management strategies. The study maps the practical challenges and risks in the ASC with the literature review.

8.2 Practical Implications

The findings have implications for policymakers, collectives, clusters, cooperatives, practitioners, and farmers. The schemes and policy initiatives promote uniform standards to integrate the stakeholders. It is time for the Government and Industry Association to work together to address the gaps in minimizing the ASC risks. Collective Action and network building will help strengthen the ASC in developing countries. The practitioners can understand the linkage of different managing tools for reducing the ASC risks. The policymakers need to understand the risk assessment to link the schemes with the ASC risk prioritization model. The study has more practical exposure than theoretical as the ASC needs to be managed by carefully working on the study results. The study has posed future research directions that can help the ASC practitioners.

9 Conclusions and Future Research Scopes

The study can help develop a road map for the youths to increase their income from the agriculture supply chain. Many very well-educated young persons with diverse fields have come into the agriculture supply chain, and ASC is coming up with a more innovative and upward-looking perspective. There is a need to derive solutions for developing connections between farmers and markets (Kumar et al. 2020a, b). The study is limited to an extensive literature survey and interviews conducted with the farmers. The result concludes that eco-innovation technology needs to be implemented in the supply chain to reduce risks (Hasler et al. 2016).

The domestic ASC is graduating towards global ASC demand. To make the agri sector a superpower, there is a need to bring suitable innovation for ASC financing. The three fundamental aspects of the agriculture supply chain are open market and transparency, agri-ecosystem, and farmers' perspective. The market should be more accessible to farmers, traders, entrepreneurs, and industry. Transparency policy should be welcomed because transparency will bring in more growth in ASC. Openness is the key factor in the development of the ASC. The 3S that require the constant attention of policymakers and the government are Suitability, Sustainability, and Scalability. Suitability provides exclusive benefits to farmers, stakeholders, entrepreneurs, and the industry. Sustainability focuses on the long-term vision of the agriculture sector. Scalability is the scale of numbers operating in the market, i.e., to make the system completely accessible. Agriculture is moving towards technology, where new technological trends have been adopted, like E-Commerce. ASC risk management strategies can help sustain the ASC.

The study is limited to secondary data and qualitative research. The findings are based on the interviews conducted with the farmers, and the results need to be validated by conducting a quantitative study. The study has come up with the critical antecedents for ASC risk management. The key result of the study is presented in

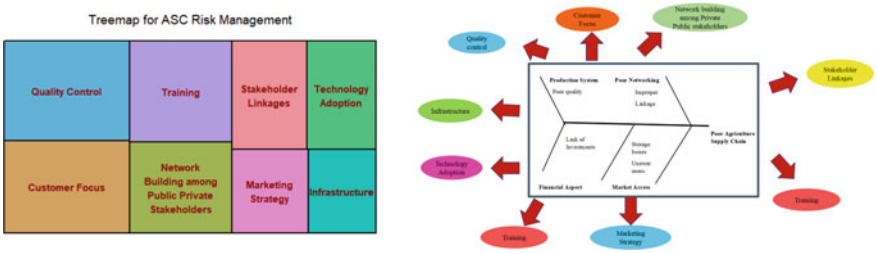

Fig. 7 Treemap and fish bone diagram for agriculture supply chain risk management

Fig. 7. The Fish Bone diagram explains the primary risks in ASC. The risks focus on improper linkages among the stakeholders, poor quality, poor network, lack of sources for investments, storage issues, and unawareness. Academicians and practitioners need to prioritize the risks. The risk prioritization has been further explained through treemap. The treemap has been constructed based on the farmers' responses regarding the risk managing strategies. The results show that quality specification and customer focus produce are highly preferred antecedents by the stakeholders.

The treemap and Fish Bone Diagram pose the below future research questions. These future research questions can help academicians and practitioners to reduce the complexity of ASC.

- How can the stakeholders maintain the quality of the agriculture commodities?
- What are the customer-focused products in current times?
- What kind of training is required for the farmers for ASC risk management?
- What are the drivers for network building among public–private partnerships?
- What are the marketing strategies for ASC?
- What are the drivers for technology adoption in ASC?
- How can the stakeholders be driven for technology adoption?

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