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One Country
One Priority Product

The Jackfruit Value Chain in Bangladesh

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- List of Acronyms

BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CSO	Civil Society Organization
CV	Curriculum Vitae
DAM	Department of Agricultural Marketing, Bangladesh
DAE	Department of Agriculture Extension, Bangladesh
FGD	Focus Group Discussion
FAO	Food and Agriculture Organization of the United Nations
HIHI	Hand-in-Hand Initiative
KII	Key Informant Interview
MT	Metric Ton
NGO	Non-Government Organization
OCOP	One Country, One Priority Product
SAP	Special Agricultural Products
ToR	Terms of Reference
USAID	United States Agency for International Development

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- Executive Summary

Agriculture is crucial for providing the growing demand for food, feed, fiber, and fuel. Bangladesh's economy relies on agriculture and employs a large section of the people while boosting GDP. As an agricultural product, jackfruit is widely grown in Bangladesh, with an annual production of about 1.05 million metric tons. This study incorporates the four primary components of the Sustainable Food Value Chain (SFVC) methodology: functional analysis, sustainability assessment, upgrade strategy formulation, and implementation planning (actions and investments). This methodology has been used to analyze the jackfruit value chain in Bangladesh. It assesses the essential components and processes along the value chain, providing insights into the aspects that influence the jackfruit industry's efficiency, sustainability, and profitability. With a focus on both global and regional views, the study is a significant resource for stakeholders wishing to make informed decisions and strategic interventions in the jackfruit industry, such as growers, processors, distributors, and policymakers. This report is conducted to know the present status of jackfruit production practices along with the possibilities and obstacles in Bangladesh.

Bangladesh's jackfruit value chain (VC) is distinguished by many small-scale growers, traders, processors, and retailers who encounter diverse obstacles, such as inadequate productivity, quality, and profitability. The chain represents Bangladeshi jackfruit produced from household farms (small-medium farmers) and commercial farms (medium and large farmers), which mainly supply the domestic market, as exports represent an insignificant percentage of the overall sales. The core functions in the value chain include production, aggregation, wholesaling, processing, and distribution (retailing/wholesaling). Jackfruit is grown all over the country, but the intensive production area is location-specific. Some areas in Mymensingh, Sylhet, Rangamati and Jessore are the hotpot of jackfruit. During peak season, jackfruits are transported from these areas to different parts of the country, and the extended supply chain makes them costlier to consumers. Most of the value chain actors mentioned that the market competition is oligopoly, and a small portion of them mentioned perfect competition. Improving post-harvest storage facilities like cold storage for the over-supplied jackfruits during peak season and developing nutrient-sensitive and market-driven jackfruit processing technologies are marked as potential market opportunities. There is a need to develop low-cost transportation and packaging systems for the bulk movement of jackfruits. In order to export jackfruit, producers must be trained on the standards necessary to produce safe and quality fruit that meets buyer requirements. Specifically, intensive training of farmers on the adoption of Good Agricultural Practices (GAP) in the jackfruit production systems needs to be prioritized. Training on the standard processing and transportation procedures of fresh and processed jackfruits is also needed to increase the buyer's confidence. However, extension services were rarely offered by DAE through its officials because both farmers and authorities were focusing more on other crops. Bank financing services are seldom available to producers. They instead appropriated the credit from NGOs. In addition to NGOs, many banks provided loan services to other VC entities. Providing agricultural credit, particularly to poor farmers (small, marginal, and landless farmers), from formal credit sources can facilitate the timely and sufficient supply of farming inputs to promote food production, including

jackfruit, and improve the livelihoods of poor farmers. VC actors are associated with weak horizontal linkages. No formal associations are observed among the producers and hence, no collective action such as joint inputs purchasing, value addition, or marketing is visible. JVC actors in the path of vertical linkages are found to be diverse with diversified influences on pricing. Local wholesalers have more power/leverage in their specific activity than other actors. In contrast, distant wholesalers have more effect on local wholesalers due to their large size and more capital.

Assessing the sustainability of the jackfruit value chain involves evaluating various domains like economic analysis, social analysis, and environmental analysis. Sustainability scores for each domain are calculated by adding up sub-domains (1 for green, 0.5 for yellow, and 0 for red) and dividing this by the number of sub-domains in the domain for which the average sustainability score is to be calculated. The overall sustainability performance of the jackfruit value chain in Bangladesh is moderate, with an overall sustainability score of 59. Social sustainability is the area where the VC shows the weakest performance, having the lowest score of 48 percent, followed by economic sustainability at 61 percent and environmental sustainability at 69 percent. The resilience aspect is the second most vital area of the VC, obtaining a score of 75 percent. There are 15 highly concerning hotspots in terms of value chain sustainability performance. Overall, the JVC remains profitable with an upward trend in net profit, return on investment, and return on sales. However, there's a decline in net income. Producers and pre-contractors have low revenue and net income despite showing higher ROS due to lower production costs and investments. The job status along the value chain is poor, especially in terms of wage and salaried jobs and full-time employment. The level of value addition at the processor level is only 10%, indicating a need for increased processing and value-added activities within the chain. Addressing these challenges may require interventions to improve job stability, enhance value addition, and educate consumers about the nutritional and cultural value of jackfruit products to align with changing food trends.

The social sustainability performance of the VC is a low-performing domain with a high concern for inclusiveness, gender equity, and institutional strength. Poor inclusiveness was shown in the wages and employment distribution and value-added distribution. This is because of the low participation of women in VC activities due to their nature (heavy duty), cultural barriers, and lack of processing opportunities. Their underrepresentation also affected gender equality in the JVC sub-domain of women's economic involvement and gendered division of labour. Regarding social and cultural capital, horizontal linkages were found to be highly concerning due to weak capacity-building efforts for building linkages between producers and downstream processors. In contrast, vertical linkages were found to be more concerning due to weak capacity-building efforts for building linkages between producers and upstream industrial partners. The sustainability performance of VC is less concerning. The plant health domain had high concerns in two subdomains: the application of bio-security measures and appropriate plant growing practices. About half of a jackfruit is inedible and discarded as waste that has a significant impact on the environment. Hence, organic solid waste generation under the pollution and toxicity subdomain was found to be highly concerning. This also impacts the food waste subdomain, leaving it as a medium concerning. However, there is a huge post-harvest loss in terms of qualitative

and quantitative along the value chain (about 37%) that has a significant impact on its sustainability. The resilience of VC to shocks is moderate, with one domain (red) being highly concerning, two domains (yellow) being concerning, and three domains (green) being non-concerning. Poor diversity--particularly limited access to the international market and uneven participation of market actors--made this domain concerning. VC actors lack structured accusations and have fewer bargaining opportunities, which makes collaboration and governance highly concerning. The level of experimentation and innovation in JVC to deal with shocks is absent and makes the learning adoption domain concerning.

Finally, this value chain research acts as a strategic guide for industry actors, governments, and other stakeholders, providing practical insights and recommendations for realizing the full potential of the jackfruit value chain in a fast-changing global market. This report is packed with a theory of change narrative that outlines a strategic plan to upgrade the Bangladesh JVC. By merging hotspots and expanding organized jackfruit production, green processing, and distribution, we can attract private sectors to invest and take the JVC to new heights. Some of the key strategic options arise from the SWOT analysis, based on utilizing strengths and resolving weaknesses to capitalize on opportunities and mitigate against threats. To optimize the utilization of jackfruit in Bangladesh, it is imperative to prioritize improving cultivation methods, promoting a wide range of value-added products, collaborate with stakeholders, and expanding worldwide market reach, particularly within the plant-based meat substitute industry. The shared and agreed vision for the jackfruit value chain (JVC) in Bangladesh is developed by engaging relevant stakeholders and thus is considered realistic and achievable through successful implementation of the upgrading strategy and aligned with national development plans. The upgrading strategy lists out some independent activities that will address the relevant constraints responsible for reduced functionality using a system-based approach and sustains the VC functionality by merging the concerning hotspots. This implementation may expand organized jackfruit production, green processing, and distribution, and that will add value to the JVC and attract private sectors to invest. The theory of change proposed several catalytic actions as the outputs aiming to influence the structure, production, infrastructure, marketing, and enabling environment of the JVC that will lead to outcomes both at enable environment and actor levels where the VC actors and service providers are expected to change their behaviours and adopt new operations. These new outcomes lead to impacts described as related to the sustainability of economic, social, and environmental domains, which in turn support the realization of the proposed vision. This theory of change is linked to national needs and policies stated in various national Plans (e.g., Hand-in-Hand Initiative), Frameworks, and Acts proposed in OCOB, FAO, and SDG's. Considering the developed national strategy (along with vision statements, where the five major elements of the strategy are explained in more detail), the upgraded business models upgraded enabling environment, and upgraded governance need to be addressed as vital activities. This model indicates the improving strategies such as more scaling up, including advanced technologies, processes, standards, collaborators, markets, etc., to make a more profitable and sustainable business. The log-frame is constructed to determine the long-term horizon (10 years) of jackfruit based on the expected rate of change in the Value chain. Hence, there is a requirement for investments in the

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sustainable value chain of jackfruit to amplify its economic, social, and environmental advantages. It can involve both the government and the private sector, with potential collaborations through public-private partnerships (PPPs) or other approaches. The FAO's HHI Investment plan can be advantageous for the jackfruit value chain in Bangladesh. A comprehensive, integrated approach to the jackfruit value chain in Bangladesh should analyze the entire chain from production to consumption and address significant obstacles and opportunities at each stage. This approach will help tackle significant challenges and capitalize on potential opportunities, which will eventually develop our jackfruit value chain.

1 Introduction

1.1 Background and Objectives

This report is developed under the Food and Agriculture Organization of the United Nations (FAO) project “Innovative approaches for better plant production” (FMM/GLO/177/MUL) to implement the One Country One Priority Product (OCOP) Initiative.

The FAO developed OCOP to optimize positive components of the agrifood system, minimize negative impact, and maximize integrated agricultural profits under current and existing challenges. The OCOP will help countries leverage their unique potential and identify the Special Agricultural Products (SAPs) adapted to their specific agroecological production systems and linked to national or cultural heritage, ensuring improved access to stable local, national, regional, and global markets and acting as a key entry point for reaching their defined priorities.

The key principles of OCOP are collaborative designing and country-led implementation of activities, demand-driven and comparative advantage-oriented approach, focusing on production with consideration of all elements of the food value chain, and engagement with multi-disciplines and multi-stakeholders. The OCOP supports the thematic areas covering the whole value chain of selected SAPs, i.e., sustainable production, storage, processing, and marketing (FAO, 2022).

FAO launched OCOP in September 2021. Subsequently, the regional launch of the OCOP initiative for Asia and the Pacific was conducted in May 2022. In November 2022, FAO launched the OCOP country projects by identifying the first-round demonstration countries to lead the implementation of the OCOP initiative at the country level and in farmers’ fields. As of September 2023, 83 Members across all five FAO Regions have committed to promoting the sustainable development of 53 SAPs. The first-round demonstration countries include Malawi, representing Africa in promoting banana; Bangladesh, representing Asia and the Pacific in promoting jackfruit; Uzbekistan, representing Europe and Central Asia in promoting sweet cherry; Trinidad and Tobago, representing Latin America and the Caribbean in promoting cocoa; and Egypt, representing Near East and North Africa promoting date palm.

The FAO regional launch event and workshop on implementing OCOP country projects in Asia and the Pacific were successfully organized in Dhaka, Bangladesh, in July 2023. The OCOP Regional Organization Group in Asia and the Pacific and the National Task Force in Bangladesh have been established to coordinate the implementation of the OCOP country project and the sustainable value chain development of the selected SAP at regional and national levels, respectively.

The sustainable value chain of each SAP can play an essential role in ensuring food security and nutrition, more effective use of underutilized resources, and supporting farmers’ livelihoods and economic growth while protecting the environment and biodiversity for present and future generations. Jackfruit (*Artocarpus heterophyllus* Lam.) is the national fruit of Bangladesh and one of the country's most important and

widely grown fruits. The Government of Bangladesh has selected jackfruit as a priority product for OCOP. The nation interprets the expansion of the Jackfruit value chain as an opportunity not solely to strengthen the availability of nutritious foods but also to provide employment opportunities and generate revenue from exported goods. The jackfruit value chain is divided into several segments: inputs, production, packing and storage, processing, distribution, and marketing, which increases work scale and saves time by utilizing complex machinery. The development of the jackfruit value chain in Bangladesh is of great importance, not only to improve nutrition and food security but also as an industry with high potential to drive job creation and bring in export revenue. The country proposal points out that Bangladesh is the world's second-largest jackfruit producer next to India, with a yearly production of 1097001 MT (BBS, 2022); the value chain faces several challenges at the level of input supply and support services, which has limited growth.

As a result, this value chain assessment report was created in response to the possibilities and obstacles pointed out in the Bangladesh country proposal.

1.2 Methodology

In the context of the OCOP Initiative, the FAO OCOP Secretariat has joined forces with the FAO ESF division Sustainable Food Value Chain (SFVC) team. The SFVC methodology has four main components: functional analysis, sustainability assessment, upgrading strategy development, and implementation planning (actions and investments). The approach is highly participatory, involving value chain stakeholders from the public and private sectors from the outset to ensure national ownership.

The *functional analysis* looks at the current structure of the VC, the dynamics that explain how and why this structure is changing, and the capacities and incentives that drive the behaviours of VC actors. It starts with the identification of end-market opportunities, as the economic performance of the VC is ultimately determined by its ability to capture value in an end-market. Based on the in-depth analysis of a wide range of primary and secondary data, the functional analysis presents a detailed VC map. It systematically analyses the nature of the various VC elements across four layers, namely: (1) actors in the core VC, (2) input and service providers, (3) the societal environment, and (4) the natural environment). This analysis includes the constraints and opportunities associated with the various VC elements and their linkages. The analysis is explicitly based on understanding the behaviour of the VC actors and the governance mechanisms that create incentives or disincentives for the observed behaviour. Through this in-depth and systemic approach, the functional analysis helps to identify the binding constraints in the VC and their root causes, as well as the leverage points for maximum impact that will critically inform the development of an upgrading strategy that will bring about the desired economic, social and environmental impacts.

The *sustainability assessment* then uses a range of quantitative and qualitative indicators to measure the performance of the value chain in terms of its economic, social, and environmental dimensions. This assessment includes six economic

sustainability domains (i.e., profitability, employment, value-added, effects on the national economy, international competitiveness, and value for end-consumers); six social sustainability domains (i.e., inclusiveness, gender equality, food and nutrition security, decent employment social and cultural capital, and institutional strength); and seven environmental sustainability domains (i.e., climate impact, water footprint, soil quality, biodiversity and ecosystems, plant health, toxicity and pollution, and food loss and waste). The sustainability assessment identifies sustainability hotspots, which help to determine which opportunities should be pursued for upgrading alongside government priorities and private sector ambitions. The assessment also includes the value chain's resilience to shocks.

The **upgrading strategy development**, the next step in the approach, starts with developing a shared vision based on the findings from the functional analysis and sustainability assessment. With facilitation by the project, VC stakeholders themselves develop this shared vision, along with an associated set of targets for where to take the VC over a given time-period. This vision and these targets are then used to devise an upgrading strategy. This upgrading strategy addresses the binding constraints, sustainability hotspots, and their root causes. It builds on the strengths and opportunities in the VC, as identified in the functional analysis and sustainability assessment. Various upgrading options are proposed in three categories: upgraded business models (elements), upgraded governance (linkages), and upgraded enabling environment (organizations, infrastructure, institutions, socio-cultural elements). These upgrading options are either derived from global best practices adapted to the situation at hand or represent unique solutions prepared by experts in the particular upgrading area. The validity of these solutions typically needs to be assessed during the early stages of the action plan implementation. A holistic approach to sustainability is included throughout this vision and strategy development process in order not to overlook any potential adverse impacts of the proposed upgrading interventions and to assure maximum resilience to shocks.

1.3 Brief history and overview of the value chain

Bangladesh's jackfruit value chain (VC) is distinguished by many small-scale growers, traders, processors, and retailers who encounter diverse obstacles, such as inadequate productivity, quality, and profitability. The origins of jackfruit cultivation in Bangladesh may be traced back to the 1500s when the fruit was brought to the country by Indian and Southeast Asian traders and travellers. Subsequently, jackfruit has been extensively cultivated across the nation, particularly in the southern and central areas. Since the 1500s, when Bangladesh began cultivating Jackfruit, the Jackfruit value chain in Bangladesh has undergone several significant stages.

Before the 19th century (the 1500s-1900s): In the 1500s, traders and travellers introduced jackfruit to Bangladesh. During the 1800s, the cultivation of Jackfruit spread across the entire country, and in the 1900s, public institutions began to undertake research and development efforts for Jackfruit.

Early to Mid-20th Century (1920s-1950s): Jackfruit was brought to Bangladesh during the British colonial era, primarily for its edible fruit. Initially, it was cultivated for domestic use in household gardens and little orchards. Jackfruit was a conventional agricultural product that was utilised in a diverse range of gastronomic preparations.

During the mid to late 20th century (1960s-1990s), Jackfruit cultivation experienced significant growth. An increasing number of farmers initiated the cultivation of jackfruit trees, leading to the expansion of orchards across the entire country. Jackfruit gained popularity in local markets and was extensively consumed in various forms. The increasing demand for jackfruit as a healthy and adaptable fruit led to a rising interest in its commercial cultivation during the second half of the twentieth century.

In the late 20th century, namely during the 1980s and 1990s, Bangladesh contemplated exporting jackfruit and jackfruit-derived products to global markets. Multiple endeavours have been undertaken to establish jackfruit as a commodity for export. The increasing demand for jackfruit as a healthy and adaptable fruit led to a rise in the commercial cultivation of this fruit throughout the second part of the twentieth century. Progress in promoting jackfruit as an export commodity was hindered by various barriers. The factors contributing to the problem are inadequate post-harvest processing and packaging facilities, limited research on enhancing the value of jackfruit, and insufficient marketing initiatives.

Present Status (Up to the Present): In 2000, the private sector took the initiative to promote the processing and commercialisation of jackfruit. Currently, the government of Bangladesh has shifted its attention towards the enhancement of the jackfruit industry. Efforts have been undertaken to facilitate the advancement of jackfruit processing. The government offers training programmes to young entrepreneurs, with a particular focus on women, to enhance their skills in creating processed products derived from jackfruit. Jackfruit is extensively cultivated across Bangladesh, primarily in rural regions. Jackfruit is a fundamental component of native cuisines, utilised in a diverse range of recipes in both its ripe and unripe states. A significant number of rural households depend on jackfruit as their primary source of income. In recent years, jackfruit and its derivatives have become increasingly popular in the local market, sometimes utilised as a substitute for meat in vegetarian and vegan cuisine. A project was initiated by FAO in 2022 to assist in the development of the jackfruit value chain.

TABLE 1. OVERVIEW OF THE BANGLADESH JACKFRUIT VALUE CHAIN

Aspect	Description
Species	<i>Artocarpus heterophyllus</i> (Jackfruit)
Size	Small to large (1 kg to an average of 55 kg), irregularly shaped fruit
Farms	Grown in orchards and home gardens
Characteristics	Green unripe fruit, sweet and aromatic ripe fruit, highly versatile, used in a variety of dishes
Demand Size	High in both domestic and international markets
Demand Deficit	Moderate demand deficit in international markets due to export challenges
Consumption	A staple in local diets, used in a variety of culinary dishes, increasingly popular as a meat substitute in vegetarian and vegan dishes
Production Region	They are widely cultivated across various regions of Bangladesh, with a higher concentration in rural areas.

2 Functional analysis

The functional analysis describes the value chain of the Bangladeshi national fruit named jackfruit by identifying the sequence of activities and actors that bring the jackfruit from the garden/orchard to the table. This analysis addresses the relevant elements of the jackfruit value chain, such as actors, input and service providers, enabling environment, natural environment and their behaviour, and their interactions. The numbers, volume, and values of some of the elements were also addressed in the section. Producers and traders were the significant actors in the jackfruit value chain in Bangladesh. However, some processors and exporters were also included in the value chain of jackfruit, but on a small scale.

Jackfruit is rich in nutrients, while crude protein (7.9%), natural fibre (14.1%), calcium (0.8%), and phosphorus (0.1%). Except for these nutrients, ripe and raw jackfruit wastes are also utilised as potential substrates for energy production and nitrogen-free extracts (NFE 65%) (Saragi et al., 2023). Moreover, jackfruit has 70 to 80 % waste and by-products (peel, central core, and perianth as waste and account for 55-60%, while seeds as a by-product and accounts by-products account for 12-14% of total jackfruit) and much more compared to any other tropical fruits. However, according to the Department of Agricultural Extension (DAE), the amount of postharvest loss in the country is about 25-45% every year and is equivalent to about BDT 50 million (1 USD=110.06 BDT). This is because of the inappropriate or, sometimes, say, the limited processing technology of jackfruit as well as the lack of storage facilities (Chowdhury, 2020). The poor market structure is also causing the wastage of jackfruits. On the other hand, 75% of the jackfruit products in India get wasted due to inadequate marketing, negligence, and a lack of processing facilities, and it is estimated that almost 20,000 million Indian rupees (Sundarraj and Ranganathan, 2018).

2.1 VC mapping

The Bangladeshi jackfruit value chain map in Figure 1 demonstrates the main actors, activities, and product flows in major jackfruit-producing areas in Bangladesh, which may also represent the national jackfruit value chain of jackfruit. The chain represents Bangladeshi jackfruit produced from household farms (small-medium farmers) and commercial farms (medium and large farmers), which mainly supply the domestic market, as exports represent an insignificant percentage of the overall sales. The core functions in the value chain include production, aggregation, wholesaling, processing, and distribution (retailing/wholesaling). However, jackfruit has been served in different processed products like Jackfruit curry, kebab, juice, pickle, burger, chapati, ice cream, and even baking flour made from drying and grinding the seeds or fruit are just a few examples of jackfruit's remarkable versatility in the kitchen. Therefore, now jackfruit is being exported as both fruit and vegetable, even as processed food like burger, but at a small scale in Bangladesh.

Production

Jackfruit (*Artocarpus heterophyllus*) is one of the most important and widely grown fruits in the country. Bangladesh is the world's second-largest jackfruit producer, behind India, and accounts for about 21% of the total fruit production of the country

(Islam et. al., 2022). In Bangladesh, about 1049890 Metric Tons (MT) of jackfruit were produced in 28000 ha of land during 2021-2022, whereas 1097001 MT was produced in 2020-2021. The production has decreased to 47111 MT (BBS, 2023). However, production in the homestead arena (852360 MT) is relatively more than the production in the garden (197530 MT). But the post-harvest loss of the fruits is about 24-44% because of a lack of knowledge on harvest maturity, packaging, and handling during loading and unloading the fruits (Hasan, 2021; Chowdhury, 2020). The number of farmers involved in jackfruit production was 227296 at household level farms, while 5487 farmers were engaged at commercial farms.

Based on the nature of jackfruit farms, there are mainly two categories of farmers: household farmers and commercial farmers. However, most of the farmers who produce jackfruit at household farms are small-scale, whereas medium and large-scale jackfruit are also produced at commercial farms. These two categories' farmers represent 81.2% of jackfruit production, while only 18.8% of jackfruits are produced from commercial gardens (medium and large scale) (BBS, 2023).

In the study area, household farmers have a minimum 5 number of jackfruits along with 0.004 ha of land for jackfruit production, while the maximum number of jackfruits is 40 with 0.809 ha of land for the same. However, the average number of jackfruits was about 19, while the average land for the jackfruit production area was 0.121 ha at the household farm. Surprisingly, there is no specific information about the number of farmers who are involved in small, medium, and large-scale production under both household and commercial farms along with acreage of land except total production along with acreage at the divisions as well as the national level (BBS,2023). However, according to the Department of Agricultural Extension (DAE), farmers having up to 1 ha belonged to a small category (DAE, 2018). Thus, all the surveyed farmers at household levels were recognised as small-category farmers. But, considering the expert opinions, farmers having up to 10 jackfruit trees and /or producing jackfruit are recognized as small-scale producing farmers, while farmers having 11-20 and more than 20 jackfruit trees are denoted as medium and large-scale producing farmers, respectively. Therefore, study findings indicate that small, medium, and large category scale farmers are also growing jackfruits under the household levels farms.

Aggregation Jackfruits produced from household as well as commercial gardens have been collected by the different aggregators locally called Bepari/Faria (a very insignificant amount that is 4% of the total production at the household level), Aratdar and pre-contractor. In Bangladesh, Bepari/Faria (N=3787) collects the jackfruits (V=22843 MT from the farmers, and Aratdar (N=300) keeps the jackfruits (V=214959MT that represent 17% of the total production) brought by the farmers for a short time (a few days) and Aratdar get commission thus they called as a commission agent. They took risks at their premise but did not take any responsibility after marketing/transporting. Besides, pre-contractors (N=3136) communicated in advance and bought the whole jackfruits (V=121679MT, which represents 11.6 % of the total production) in the farms or gardens.

Wholesaling

A significant wholesale jackfruit distribution system moves from central jackfruit-producing districts named Mymensingh, Tangail, Gazipur Narsingdi, and Khagrachori

to the northeast and northwest, even in the southern part of the country. Wholesalers purchase about 80% of jackfruits and transport them to markets. Later on, these were also purchased mainly by market retailers and partly by processors, but supermarkets purchased a very negligible number of jackfruits. There are two categories of wholesalers in Bangladesh: local wholesalers (N=935; V= 171324 MT that represent 16.3% of the total production) and distant wholesalers (N=925; V=214959 MT that represent 20.5% of the total production). Reversely, producers also acted as retailers while wholesalers also purchased jackfruits from them.

Processing

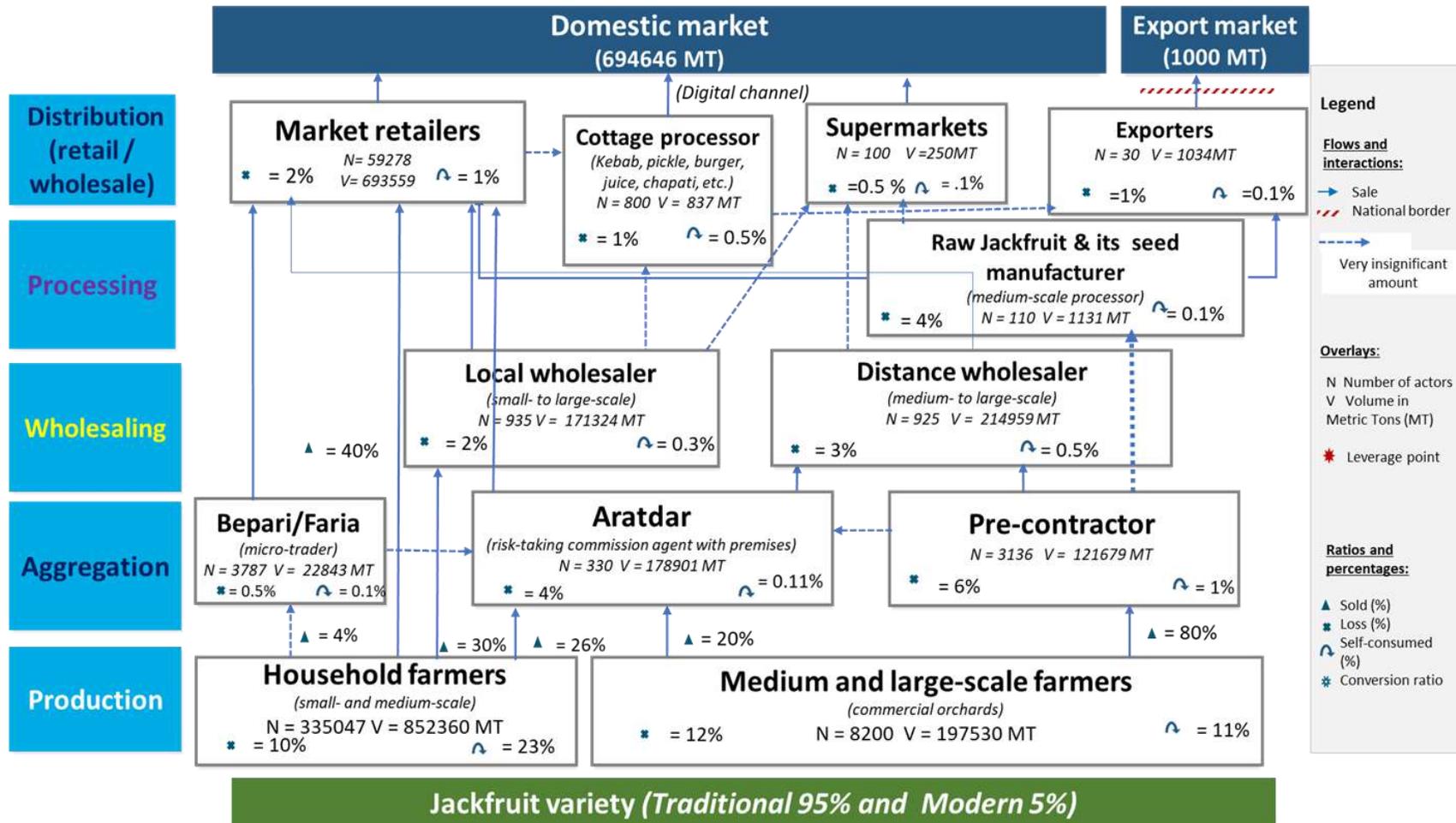
No significant processing jackfruit industries or entrepreneurs exist in the country. Still, some small-scale entrepreneurs have been working to process the jackfruits, which represents an insignificant contribution to value addition. The entrepreneurs, particularly cottage processors (N= 910, V=1968 MT that represent 0.1% of the total production), have been processing several processed food items like kebabs, jackfruit burgers, pickles, chapati, juice, chips, etc., and jackfruit seeds in Bangladesh and supplying the domestic market using digital tools as well as international markets through exporting system.

There is no specific data or information on how much raw jackfruits have been utilised for processed foods and seeds for exporting. But considering our study observations through key informant interviews and literature reviewed, there are about 1000 MT of jackfruit exported in 2019-20. But time says it could be possible to utilize the jackfruits more for processed foods in the coming days. Interestingly, about 0.4 million jackfruit burgers have been exported to Iceland this year.

Distribution

There are a few distributors named market retailers, supermarkets, exporters, and digital platforms who are responsible for distributing the jackfruits to the consumers. While market retailers are the significant part who sell out the major jackfruits to the consumers (V=693559 MT), a minor portion (V= 250 MT) of the jackfruits is sold to consumers by the supermarket, which is very insignificant. Very few portions (V=1000 MT) of the jackfruits have been exported abroad. Moreover, about 837 MT of jackfruit were used by the processors and delivered using digital channels to the consumers.

FIGURE 1. VALUE CHAIN MAP OF JACKFRUIT IN BANGLADESH



Calculation: Number of Producers:

Amount of total production produced by farmers divided by (average number of jackfruits produced per farmer multiple by average weight of per jackfruit). The similar method we followed while calculating the number of traders.

2.2 End-market analysis

2.2.1 Global jackfruit market (market size and growth rate)

Jackfruit is a seasonal fruit and is farmed in an equatorial to subtropical climate. Jackfruit is economically grown in over 60 countries around the globe, and Asian countries are the top global suppliers. India is the largest jackfruit producer, recording a production of close to 2 million MT (1.86 MT). In Southeast Asia, Bangladesh, where jackfruit is a national fruit, ranks second in jackfruit production with a figure of about 1.25 million MT, which accounts for 25% of the total fruit production. Other producers of jackfruit include Thailand, Indonesia, Malaysia, and Nepal. A variety of fruits are grown in Bangladesh, where jackfruit is considered the second most crucial fruit after mangoes. Reliable information on the global trade of fresh jackfruit is hardly available. Literature reveals that India is the largest exporter of jackfruit in the world, followed by Vietnam and South Africa at the 3rd spot. India exports most of its jackfruit to the UAE, UK and USA. Malaysia recently gained market access to China for fresh-cut jackfruit, and Singapore is the largest exporter of Malaysian jackfruit at present.

Trade flow (Export & Import): Data from secondary sources revealed that Bangladesh exports more than 35 different types of fruits to 15 other countries. The share of jackfruit exports to the total fruit exports is relatively low. In the financial year 2019-20, the export of jackfruit was about 1,000 tons, and most of its buyers are expatriate Bangladeshis. As per the Hortex Foundation data, fruit export was an increasing trend up to 2013, but it started to decline then due to different safety and regulatory issues. However, according to Department of Agricultural Extension data, jackfruit exports have increased slightly compared to earlier, and there is ample scope for further growth. Presently, the jackfruit is shipped entirely in its raw form, and the major destinations are Qatar, Oman, Bahrain, Saudi Arabia, UAE countries in the EU, the UK, and the US. Processed jackfruit is also on the export list. In 2019, Bangladesh began exporting processed jackfruit products to European Union countries. Boiled and processed jackfruits are popular as an alternative to red meat in the US, Canada, and the EU. As per key respondents, a good amount of processed jackfruit seeds (about 1-2 tons per month during production season) are shipped to different countries. About the import of fresh and processed jackfruit, no market data on it is available. Jackfruit chips, powder, dried bulbs, etc., originated from Thailand, Vietnam, and China and are occasionally found in the supermarket.

2.2.2 Domestic Market

According to DAE, Bangladesh grew nearly 1049890 MT of jackfruit in the fiscal year 2021-22, and most of the fruit was consumed locally. Jackfruit is only available for consumption for a short period and is not a significant part of our daily diet. The central portion of the produced jackfruit is consumed in ripened form; however, green jackfruit is also popular as a vegetable. Jackfruit seeds are popular with almost all the consumers. Value-added products from green and ripened jackfruit like boiled green jackfruit bulb, vacuum fried chips, jackfruit burgers, jackfruit leather, steamed jackfruit seeds, and jackfruit pulp-incorporated products like ice cream are gaining popularity and have economic prospects for getting high returns. The inedible portion

of a jackfruit, which is almost about 50% of its weight, is a popular animal feed. It is also a seasonal gift item for relatives and used in rituals during the harvesting season.

As per respondents' feedback, half of the produced jackfruits are sold, and the remaining half are used for their consumption, and a significant part is lost and wasted. Jackfruit varies in size (weight) and quality. The weight of jackfruit varies from 4 to 21 kg, with an average weight of 10 kg, as per our respondents' feedback. Average-size jackfruit has a higher demand from consumers. Consumers usually prefer ripened jackfruit, but they also prefer unripened mature jackfruit when they buy several jackfruits at a time. Consumers also buy immature jackfruits to use as vegetables. Jackfruit seeds are sold at retail shops and consumed as vegetables in roasted form. Seed powder is used in preparing different value-added products. Normally, the peak time of jackfruit harvest is summer, but early harvesting is practised to get a higher price.

Jackfruit is grown all over the country, but the intensive production area is location-specific. Some areas in Mymensingh, Sylhet, Rangamati and Jessore are the hotpot of jackfruit. During peak season, jackfruits are transported from these areas to different parts of the country, and the long supply chain makes them costlier to consumers. Jackfruit is a highly nutritious and tasty fruit. It contains a wide range of micronutrients and carotenoids. People of any age prefer it, but some consumers dislike it due to its intense flavour. Most of the respondents reported having a negative demand for jackfruit in the market currently. The common reasons behind it, as reported by the respondents, are health and nutrition issues about sweet fruits, lack of product innovation and marketing, food culture like more dependency on first foods by the young generation, the influence of social media regarding fruit safety, etc. Other reasons for changing the demand for jackfruit over the last five years are temperature and humidity rise, availability of many alternative exotic fruits, ease of sale, deforestation, and so on.

The price of jackfruit varies depending on its size, availability, production, and marketing systems. One piece of jackfruit is sold in the local market in a range of 31 to 155 taka having an average price of Tk. 59 as per respondents' responses. The market system has a significant influence on the selling price of jackfruit at the retailing points. Consumers could buy a jackfruit at a low price when they buy it from producers directly at the time of retailing jackfruits at local bazar. With changing the hands of jackfruit market actors, the price is getting higher. When jackfruits were transported to distant markets, their prices went up even higher. Transportation costs and road extortion influence this price hike unexpectedly. Fuel prices due to global crises contribute to increasing the transportation costs of jackfruits.

More than half of the respondents reported having faced different market competitions while selling raw jackfruits in the domestic market. Those who faced competition informed that it was good for their business. Most of them told that the market competition is oligopoly, and a small portion of them mentioned perfect competition. The benefits of competition are increased efficiency, customer satisfaction, reasonable price, customer satisfaction, market expansion, collaboration and partnerships, etc. In the case of processed jackfruits, market competition is absent since commercially marketed jackfruit products are hardly seen. However, dried

imported jackfruits are occasionally seen in the supermarket. Hence, processors should consider these foreign products at the time of their product development.

2.2.3 Market opportunities

Opportunities in the domestic market

Jackfruit is a seasonal fruit, and its supply in the market is abundant during harvesting season, having a duration of about 1 to 2 months. The matured jackfruit takes 3 to 7 days to ripe, and once ripened, their shelf life is even shorter. Potential opportunities are revealed when addressing these challenges. Improving post-harvest storage facilities like cold storage for the over-supplied jackfruits during peak season and developing nutrient-sensitive and market-driven jackfruit processing technologies are potential market opportunities. It is noted that cold storage technology could help extend the storage life of jackfruit for 10 to 15 days. Hence, the productivity and profitability of cold storage for jackfruits need extensive studies. In this case, the development of jackfruit varieties that would be available year-round could create new opportunities to reduce seasonal dependency as well as jackfruit availability for the new storage structures. Consumers of ripe jackfruits are widespread in the country, but production is localized. Hence, there is an opportunity for improving post-harvest handling, particularly low-cost transportation and packaging systems for bulk movement of jackfruits. Unripe jackfruit is used as a vegetable and is also a favorite to almost all levels of consumers. In this case, quick freezing technology is an option to make it available in the market year-round, particularly during the lean season when the supply of seasonal vegetables in the market is low. However, this may adversely affect the supply of ripe jackfruit in the market during harvesting seasons. The use of a part of the increased output resulting from decreasing the post-harvest losses, reducing the disease burden, and introducing year-round production in quick freezing processing opportunity will balance the market demand for any form of jackfruit. Steps of transforming jackfruit in green or ripe form into value-added products will even create a demand for additional production for seasonal as well as year-round jackfruits. Since there is a huge impact of jackfruit demand with its availability, care needs to be taken to manage the intensive jackfruit production areas. They should be prioritized in case of establishing processing units. There is a high demand for jackfruit seeds in the domestic market. However, its collection, processing, and preservation techniques are poorly addressed. There is an opportunity to create entrepreneurs for jackfruit seed collection and processing. Half of a jackfruit is thrown away as waste that pollutes the environment. However, this waste is highly nutritious and can be used to extract high-value ingredients and compounds like pectin, carotene, and fiber, which are useful for the food, pharmaceutical, and cosmetic industries. Transformation of jackfruit waste into animal feed and biofertilizer has potential market opportunity and has scope to integrate in its value chain. Currently, micro- and home-scale fruit processing is expanding, and a segment of women entrepreneurs are engaged there. Hence, training on the e-marketing of their processed products has come to the scene as a market opportunity.

Opportunities in the export market

There is a potential demand for unripe, ripe, and jackfruit seeds abroad. Consumers of these products are Bangladeshi expatriates. The number of Bangladeshi expatriates in different countries is growing, and this opens opportunities to increase the export of raw and processed jackfruits abroad. Most of the exporters reported that strict buyer requirements are the key barriers to accessing foreign markets. Hence, producers need training on the standards necessary to produce safe and quality jackfruit that will meet the buyer's requirements. Specifically, intensive training of farmers on the adoption of Good Agricultural Practices (GAP) in the jackfruit production systems needs to be prioritized. Training on the standard processing and transportation procedures of fresh and processed jackfruits is also needed to increase the buyer's confidence.

Opportunities for processed products

Both unripe and ripened jackfruits are popular with consumers, but they are only available for a very short period due to a lack of proper post-harvest management, including storage. Processing covers a very negligible part of its VC, and there is ample opportunity to add value to jackfruit at its different stages. Research Institutes and Universities have developed quite a good number of technologies for processing jackfruits like Vacuum Fried Jackfruit Chips, Freeze Dried Jackfruit, Vegetable Meat (Fresh-Cut), Ready-To-Cook (RTC) Dried Jackfruit, Ready-To-Eat (RTE) Ripe Jackfruit Bulb (Fresh-Cut), Jackfruit Pickle, Jackfruit Chutney, Jackfruit Jam, Jackfruit Leather, Jackfruit Candy, Jackfruit Juice, Osmo-Dehydrated Jackfruit, Roasted Jackfruit Seed, Jackfruit Papads, Preserved Green Jackfruit (RTC), Preserved Ripe Jackfruit Bulb (RTE), Jackfruit Curry, Mashed Green Jackfruit, Jackfruit Cutlet, Jackfruit Singara, Jackfruit Somucha, Jackfruit Vegetable Roll, Jackfruit Sandwich, Jackfruit Burger, Jackfruit Cake, Jackfruit Chocolate, Jackfruit Yoghurt, Jackfruit Cheese, Jackfruit Ice Cream, Ready-To-Serve (RTS) Ripe Jackfruit Powder, Ready-To-Use (RTU) Green Jackfruit Powder, Jackfruit Seed Powder, roaster jackfruit seeds, etc.. There is rapid growth of frozen vegetables in the local as well as international markets. People in the EU, Canada, USA, and Australia are looking for alternatives to red meat, and boiled and processed jackfruits could be an excellent substitute for red meat. Hence, exporting possibilities of fresh-cut frozen jackfruit bulbs, jackfruit seeds, and jackfruit meat is huge. Market opportunities concerning this issue are the production of uniform jackfruit varieties suitable for processing, investment in research for developing export-oriented jackfruit products, and training on standards and certification essential to meet the buyer's requirements.

2.3 Analysing the elements of the value chain

This sub-section includes detailed information about the different actors involved in the jackfruit value chain. In addition, support services may help to accelerate the whole value chain activities. Finally, enabling environments that may relate to jackfruit value are also explained in the sub-section.

2.3.1 Actors in the core value chain

The jackfruit value chain in Bangladesh includes several market actors such as producers (farmers), traders, processors, exporters, distributors etc. However, details of the actors are mentioned below:

Producers

Jackfruit cultivation in Bangladesh takes place mainly in rural area; however, urban area and rural zones of the outskirts of urban areas also cultivates jackfruits. However, a significant amount of land, 28000 ha, has been used for jackfruit cultivation, while more than 1 million jackfruits are produced both at household farms and commercial farms (BBS 2023). All categories of farmers (producers) have been involved in the production system. It does not require significant investment except land with minimum labour. Once planted saplings then jackfruit trees are grown enough and it produces jackfruits year after year with minimum intercultural operations. After the third or fourth year, the jackfruit trees will begin developing edible fruit. It will take another 4 to 5 months (potentially up to 8 months) for the young fruit to ripen. Pick the fruit once they have a yellow tinge and possesses a sweet-smelling odour. Bangladesh Agricultural Research Institute (BARI) has so far developed three varieties of fruit named BARI Kathal-1, BARI Kathal--2, BARI Kathal, and BARI Kathal-6 that provide yields within 12 months. However, these varieties are not yet well disseminated throughout the country. On the other hand, traditionally, farmers in Bangladesh have been cultivating jackfruit using three varieties: i) Khaja-hard pericarb, ii) Gala- the pulp is very juicy and soft and, iii) Dorosa, an intermediate one, the pulp of which is fairly firm and juicy. Jackfruit is seasonal, but one of the mentioned varieties is named BARI Kathal-2, providing year-round jackfruits and thus becoming popular among farmers. At the same time, the Jack tree bears the most significant fruits of all trees. The dimensions of jackfruit are 55 kg weight (120 pounds), 90 cm in length (35 inches), and 50 cm in diameter (20 inches). A mature tree is capable of producing 200 fruits per year, whereas old jack trees can bear up to 500 fruits in a year. Jackfruit in the trees produce within three to four years, even 1.5 years after planting, and may live up to 100 years old with productivity declining as they age. While it can produce fruit for 30–60 years. During the survey of the study, we also observed that a good number of mature, even old jackfruit trees have medium to large size fruits like 50 kg, while farmers also said that it could be 70 kg, but it is a very rare case. Most of the jackfruit trees, especially at household-level farms in the country, have grown since a long time ago, and thus, farmers have been enjoying the jackfruits and their benefits for a long time without investment. But they devoted their labor, spending time on management such as pruning, fertilizing, irrigating, and pest controls with less cost.

Nowadays, interested farmers can plant jackfruit saplings at homestead areas on small and medium scales, but few of the farmers plant jackfruit trees in orchards for commercial purposes. No intensive management is taking care of the jackfruit trees over the mature time at the farms, particularly in the homestead farms, except caring for them at the early stage. Some of the farmers in Bangladesh have just planted saplings in the backyard of their houses, and no intensive care has been taken. This is very common, particularly for small and medium-scale farmers at household-level farms. In most cases, women farmers are more responsible for taking care of the jackfruit trees, as they said to us during the survey and also we observed. However, commercial farmers in Bangladesh are conscientious about jackfruit cultivation as they undergo training and follow scientific procedures even though they have been receiving advisory services from extension officers and scientists.

Farmers involved in jackfruit cultivation have low education, mostly primary to secondary. Still, some of those are illiterate, particularly those occupying small farms (women are primarily engaged), like 5 to 10 jackfruit trees. However, commercial orchard producers (men are mainly responsible) have secondary to higher education that serves the technical requirements of the jackfruit's cultivation. These requirements include the selection of the land and suitable varieties, collection of saplings, proper fertilization, irrigation, pest management, proper intercultural operations, proper harvesting time, etc., that lead to quality jackfruit production. However, most of the farmers receive non-formal education or training that is provided by the Department of Agricultural Extension (DAE), and sometimes NGOs are also offered. But it is a sporadic case or, most of the time, absent that the mentioned activities are provided to the farmers only for jackfruit cultivation; instead, these have been providing for fruits and vegetable cultivation in general. However, farmers living in the major jackfruit areas like Mymensingh, Tangail, Gazipur, Narsingdi, Khagrachori districts, etc, may receive some special training and advisory services as said Upazila (sub-district) Agriculture Officer.

Besides, none of the farmers rely on jackfruit cultivation for their livelihoods rather, they are involved in agricultural integration. They integrate the jackfruit with other crops like vegetables, fruits, livestock, and even fish culture. The reason for the high involvement of agricultural integration is that most farmers were not focused on commercial jackfruit business activity. Moreover, this jackfruit cultivation and business occupies only three months (seasonal).

Farmers' classification, as we mentioned earlier, however, according to the DAE (2018), farmers are classified based on their acreage, into the different types, and are presented in Table 2.

TABLE 2. CATEGORIES OF FARMERS

Categories of farmers	Occupying land (ha)
Landless and marginal farmers	up to 0.02 ha
Small farmers	0.021-0.99 ha
Medium farmers	1-2.99 ha
Large farmers	3 and above ha

Generally, In Bangladesh, most of the jackfruits are produced under the supervision of small and medium farmers at household levels farms. While medium and large farmers produce the jackfruits under commercial farms.

Farmer types

However, based on the nature of jackfruit production, farmers are classified as household farmers and commercial farmers.

Household farmers

Household farmers have up to 20 jackfruit trees in the case of exceptional situations; it may extend to more than 20 that are capable of producing fruits. Household farmers often plant the jackfruits sampling (5 to 10) behind their homestead or in front of their homestead, generally called around the homestead. However, they have free space at the homestead and are planting several jackfruit trees (up to 20) accordingly.

Household farmers often transition into small and medium-scale producers and have their production facilities. These farmers produce most of the jackfruits in Bangladesh, which is about 82 percent of the total production, as discussed earlier in the report.

Commercial farmers

They are treated as medium and larger farmers having more than 20 jackfruit trees and occupying more than 1 ha of land while mostly occupying jackfruit gardens. These farmers produce only 18 percent of the total jackfruits in Bangladesh, as also mentioned earlier in the report. They have huge land and capital in terms of money, and thus, they have planted a considerable number of jackfruit trees/saplings. They employed labours full-time and also part-time to look after the gardens. Some of the supermarkets in the country contract with commercial farmers to ensure their product is at a large scale via other intermediaries.

One of the significant problems of jackfruit production faced by the producers is an insect named fruit borer that causes serious injury to the jackfruit. It is a very common insect in Bangladesh and India, which reduces both the quality and quantity of fruit. Once this insect infests the trees and causes serious injury, then the farmers locally call it `Cancer` of the jackfruit trees. The insect goes inside the fruit and eats the flesh, resulting in a burst of the fruit. Thus, water goes into the fruit and causes rotten fruit. The fruit borer causes about 30–40% damage in jackfruit from flower bud formation up to fruit ripening, indicating more economic losses. This insect occurs sporadically or epidemically every year in Bangladesh. Burning the infested fruits after picking from the jackfruit tree is one of the control measures, while cypermethrin 10 EC per liter water and spray $\frac{2}{3}$ times at 10 days intervals. Squirrels are animal that attack and eat jackfruit, causing low production. Farmers also suffer from a good number of varieties. However, there are a few good numbers of varieties developed by BARI, as mentioned above, yet do not reach out at the farmers' level. Another big challenge of jackfruit production is the scarcity of labour, especially the time of harvesting as well as marketing.

Traders: In addition to jackfruits consumed as well as distributed to relatives by the producers, the jackfruits produced at the farm's level need to be distributed to the consumers via different market traders/intermediaries. These are recognized, such as locally called Faria, Bepari, Aratdar, pre-contractors, wholesalers, and retailers. All traders are aggregating jackfruits from the producers except retailers.

Faria is the first value chain actor whose numbers are huge in the market, basically for other fruits and vegetables, even in the rice market. But in the case of jackfruit marketing, they are not significant numbers. However, they took jackfruits from the farmers at the farm gate, collected jackfruit from the local bazaar (market), and sold it to Beparies (another actor in the jackfruit value chain). Sometimes, they also kept it at Aratdar. Generally, Farias have a small amount of capital to run their business. They worked as a middleman to transfer the ownership of the business. Most of the time, Farias completed their buying and selling at a Haat (The market takes place one or two days once a week).

Bepari is the next actor after Faria. Beparies are the ultimate traders to transfer jackfruits from Faria and or producers to wholesalers. They collect jackfruits from Farias and large farmers in the local markets and sell them to wholesalers. Beparies

also sold their product to retailers in different local markets. Sometimes, to meet the demand for jackfruit in the local area, Beparies collected jackfruits from other district markets. However, this type of actor, particularly in jackfruit trading, was observed to be insignificant.

Aratdar

In the jackfruit marketing system, jackfruits from the farmers were bought by the Aratdars or, sometimes, say, commission agents and supplied to mainly distant wholesalers. The Aratdar mainly acts as an aggregator of jackfruits for a short period, having free space near the market. However, they also buy some jackfruits from the farmers who were coming to the market with few jackfruits as retailers' even from the Faria and Bepari, pre-contractors, but a very insignificant number of jackfruits. But mainly, they have been functioning as commission agents. Most of the time, they did not buy jackfruits but were given space for them and took a certain percentage of money instead. At the same time, Aratdar invested in crate-free space, with shade, so that jackfruits remained well protected from externalities.

Pre-contractors

But on the other hand, those who were acting as pre-contractors were making connections between farm gates and mostly distant wholesalers. At the same time, pre-contractors bought jackfruits from jackfruit gardens/commercial farmers in advance and negotiated with distant wholesalers. Later on, informed the distant wholesalers while maturing/ripening the jackfruits and selling the jackfruits to the distant wholesalers' commercial farm gate.

Wholesalers

Wholesalers buy jackfruits from traders like Faria and Bepari and even from the farmers through commission agents and sell them to retailers. Wholesalers are also categorised as local wholesalers (small to medium scale) and distant wholesalers (medium to large scale).

Wholesalers frequently communicate with commission agents like Aratdar and even pre-contractors of production zones from which they procure jackfruit. They have several young and energetic workers who send the vehicles to the production zones to purchase the jackfruit. The workers often collect the jackfruits with the assistance of Aratdar or farmers. Farmers usually do not harvest until the wholesaler's vehicles are present at their farms. These wholesalers are the key intermediaries who sell the major jackfruits to the market retailers. However, a very insignificant number of jackfruits sell out to supermarkets, processors, and exporters.

Sometimes, large-scale wholesalers prefer to buy from a single orchard, while they typically advance some of the money as small-scale farmers have resource limitations. Thus, with this commitment, the farmers must sell to the wholesaler at the prices they negotiated earlier. Large-scale wholesalers are the most profitable actors in the value chain because of the large numbers (for example, 10,000 jackfruits) of jackfruits, particularly the distant wholesalers from the commission agents or pre-contractors or even from the farms. Then, they sold out to the supermarkets, processors, market retailers, etc.

Small-scale wholesalers purchase the jackfruits from farmers as well as from other wholesalers to sell out the retailers at the local markets, and these are prevalent issues in Bangladesh. They generally operate within specific geographical zones, transporting less than 1000-2000 jackfruits.

Retailers

This type of trader is one of the common market actors in Bangladesh, both in rural and urban markets, and we can call it roadside retailers. Almost all jackfruits are sold to consumers via market retailers in Bangladesh, and this is also reflected in the value chain map. The market infrastructure that retailers typically sell is weak, with concerns for hygiene and food safety standards, and thus requires significant updating and development. Therefore, retailers of the local markets humbly requested the study teams during the fieldwork to develop their infrastructures and at least construct a few sheds near the market. The retailers in the local market that was close to significant jackfruit growing areas just looked vulnerable. They were on the road having open spaces where the general public was passing through the road. Sometimes, they are charged by the local police and or authority. Most of the retailer in the study areas explained their feelings that they don't have a good marketplace place, and thus, the fruits brought to the markets deteriorated in quality. They have even been fighting against the rain, heating, etc. Unsold jackfruits require more money to get back home, and thus, they sell them to the local wholesalers or Aratdars at the cheapest rate.

Processors

Processors are necessary to make diversified food items using raw fruits. Day by day, people's food habits are changing, and thus, it's an excellent opportunity to utilize domestic fruits to make more processed food. One of the good examples is mango; through this fruit, different food items (juice, bar, etc.) are produced in the country. However, in Bangladesh, no significant number of processors were established, and no jackfruit-based food industries were found. However, some of the entrepreneurs have been processing some products from jackfruits in Bangladesh. We met them and discussed accordingly during the workshops held at Gazipur and Dhaka and even talked while taking their interview as KII. They said that they have been processing products like Jackfruit curry, burgers, kebab, chapati, pickles, and even baking flour by drying and grinding the seeds. The processed food items sell out to the domestic market and even sell out using digital platforms. However, the processed items named jackfruit burgers (0.4 million) were exported this year to the international market, particularly in Iceland. They also express their demand to make more processed food on a larger scale, which requires governmental support.

Thus, processors need to be capable of understanding production technology, marketing systems, and processing techniques. Considering the field observations, expert consultations, and literature searching, not only processors but also other actors should train enough to improve their skills, increase their knowledge, and change their attitude toward Jackfruit and its' value chain activities. Therefore, respective authorities like DAE, Department of Marketing (DAM), and Ministry of Commerce (MoC) should take initiatives like need-based training for the stakeholders. MoC should organise several training sessions for processors that may be accelerated

to motivate them in making various food items of jackfruit such as chips, burgers, vegetable meat, fresh-cut, dried products, ready-to-cook, jam, and pickles. Moreover, MOC should also provide several services, including credits and business licenses for exporters. Besides, jackfruit-based processed food industries need to be established, and then these processed foods meet the domestic as well as international markets, resulting in foreign currency.

Exporters

Although Bangladesh is recognized as the second largest jackfruit producer country, no significant number of exporters are found in the country. However, a very insignificant number of jackfruits are exported to the international market, and most of its buyers are expatriate Bangladeshis. According to Department of Agricultural Extension data, jackfruit exports have increased slightly compared to earlier, and there is ample scope for further growth. In the financial year 2019-2020, the export of jackfruit was about 1,000 tons. One of the districts in Bangladesh, named Habiganj, produces large and good quality jackfruits that are being exported to various countries, including Qatar, Oman, Bahrain, Saudi Arabia, UAE, countries in the European Union, the UK, and the US. More seeds of jackfruits are also exported to international markets¹.

Jackfruit is processed, and thus, processed foods are also on the export list. In 2019, Bangladesh exported processed jackfruit products to European Union countries (EUCs). The experts in the area are predicting that it will diversify the country's range of exports. Several companies under the Bangladesh Agro-based Product Producers and Merchants Association (BAPPMA) provided osmotically dehydrated food made from jackfruit, as well as jackfruit seed powder, to several food chains in (EUCs). As mentioned above, about 0.4 million jackfruit burgers have already been exported to Iceland this year. This information might be a reasonable basis for interested traders to export the burger as well as other food items processed from Jackfruit.

Moreover, research initiatives are being focused on making new processed jackfruit food products. Thus, this attempt will indeed lead to opening a wide range of new export door. One of the projects called the “a2i project” under the Prime Minister's Office has taken the initiative to involve the private sector in the production of jackfruit chips, a meat substitute that will add significant value to the national fruit. Moreover, Bangladesh Agricultural Research Institute (BARI) has also taken a project named Postharvest Management and Marketing of Jackfruits project of Krishi Gobeshona Foundation (KGF) to promote processed food items in the country.

2.3.2 Support service providers in the extended value chain

The jackfruits production requires the following supports:

Physical inputs (Agricultural inputs)

Good and quality production depends on various agricultural inputs such as quality seed, sapling and/or variety, fertilizer, pesticide, irrigation, etc. Of which, unfortunately, we don't have a good variety available except recently developed modern BAU Kathal-1, BARI Kathal-1, BARI Kathal-2, BARI Kathal-3, and BARI Kathal-6. Traditionally, producers have been cultivating jackfruit using three varieties: i) Khajahard pericarb, ii) Gala- the pulp is very juicy and soft, and iii) Dorosa, an intermediate

one, the pulp of which is fairly firm and juicy. These traditional varieties provide only three months of jackfruits a year, but the modern varieties developed by BAR and BAU can provide year-round jackfruits. While BARI kathal-1 provides jackfruit during May–June, BARI Kathal-2 provides January-April and BARI Kathal -3 jackfruits during September- June of the year.

The jackfruit can be cultivated through propagation, and this propagation can be done by seed, grafting, and cuttings. In some areas, seed propagation is still used. Jackfruit from seed may be more precious than many other fruits, and trees may begin production in the 3rd to 4th year. Procedures can be propagated by themselves at their nursery or can be bought from the commercial nursery that is available in the country. However, the Bangladesh Agricultural Research Institute (BARI) has taken initiatives to disseminate their devolved varieties through demonstrations, workshops, training, and distribution of their saplings to the farmers. The Department of Agricultural Extension is also working on the issue as it has a horticultural centre in all districts under the wing of horticulture, where producers can get service as per their needs.

High-quality sapling is the limiting factor of good jackfruit production. High-quality saplings indicate and/or enhance the high growth and less pest-affected plant, resulting in high and good quality fruit production. High-quality saplings also require pest management, which also affects the market price. However, production and supply of good quality saplings to the producers are not available due to poor or limited disseminating efforts.

In the case of sapling production and distribution, no proper organization exists like the Bangladesh Agricultural Development Corporation (BADC), which is working for rice seed production and distribution to the producers. However, BADC is producing a very insignificant number of saplings. However, the Horticulture Centre under the DAE works for fruits and vegetables, but dealings with jackfruits and its propagation units like saplings are tiny scale. Moreover, low-quality saplings have been produced at local and even commercial nurseries. Because nursery owners have a low capacity for sapling production. Therefore, there is a gap in producing good quality saplings. Besides, saplings received from BARI, horticulture centres under the DAE, and approved nurseries by the mentioned organizations were good enough, but the proportions were very low according to the demand.

Fertilizer is one of the essential inputs that need to be applied for jackfruit production. About 10-15 days before transplanting the saplings, prepare a 1 × 1 × 1 meter hole for a sapling and use dung/compost 25-35 kg, TSP 400-500gram. Requires 175 grams of MOP well filled with soil and fill the hole in April every year before the rainy season and also apply at the end of the monsoon per year. Jackfruit is sensitive to both drought and water logging conditions. The plants should be irrigated regularly in dry periods, and there should be improved drainage during rains. However, ring-type irrigation is generally adopted for irrigating jackfruit trees, ensuring the economy of water. The frequency of irrigation will depend on the soil moisture condition of the jackfruit farm.

Jackfruit is affected by various types of diseases that cause significant damage during the production stage. Consequently, a significant economic loss was incurred by the producers. A survey report prepared by Rahman and Afroz, 2016 indicated that 66%

of jackfruit trees were infested with fungal disease, which severely affected trees, resulting in losses (15 to 32%) in terms of quality as well as quantity of jackfruit. Meanwhile, the Jackfruit borer *Diaphaniacaesalis* (Lepidoptera: Pyralidae) is considered one of the major pests of Jackfruit, which severely affects jackfruit. Besides, Rhizopus rot is a prevalent fungal disease of jackfruit. The disease is prevalent in the countries of the tropics. Infection in flowers and fruits is more likely to occur in high-rainfall areas in warm, humid, and wet weather conditions. Infection at the flowering stage causes total loss. Interestingly, no pesticides/insecticides application was used in the jackfruit trees like other field crops. However, Bordeaux paste is a common fungicide for the management of jackfruit borer pests and rhizopus rot, leaf spot, dieback, and gummosis diseases. In addition, pruning and training are effective management techniques to control insect pests and diseases. However, the development of resistant varieties and upscaling of integrated pest management (IPM) and integrated nutrient management (INM) approaches could be good options for increasing productivity. On the other hand, bio-rational, botanical, and microbial management methods for controlling insect pests and diseases of jackfruit need to be developed in the future (Khan et al., 2021). Limited producers' knowledge of the control measures and poor advisory services for the jackfruit's insect-pest management are the major constraints to producing more fruits.

Financial supports

Providing agricultural credit, particularly to poor farmers (small, marginal, and landless farmers), from formal credit sources can facilitate the timely and sufficient supply of farming inputs to promote food production, including jackfruit, and improve the livelihoods of poor farmers.

The Bangladesh Bank has said that banks will determine the maximum limit for lending to farmers as per the agricultural and rural credit policy. However, for the cultivation of crops and vegetables, small, marginal, and tenant farmers can be given a maximum loan of BDT 200,000 (USD 2000.00) without collateral.

One of the leading public banks in Bangladesh is named Bangladesh Krishi (Agriculture) Bank (BKB), which offers credit facilities both for the production and marketing of different agricultural equipment and farm machinery, including irrigation equipment. This credit plays an inevitable role in agricultural productivity since it has increased the quantity and quality of inputs used in the production process. However, Private and foreign banks, which have limited branch network coverage in rural areas, may distribute agricultural and rural credit through a partnership with Micro-credit Finance Institute (MFIs).

All private and foreign banks must disburse at least 2% of their total loan and advance as agricultural loans to achieve their yearly target. Moreover, Non-government Organizations (NGOs) have also been providing loans for agrarian production, including fruits. Unlike banks, the NGOs often show up at the farmers' doorsteps, making the entire process much easier and faster. The NGOs also call on the farmers to collect instalments, removing another hassle.

Like farmers, other actors in the value chain may not prefer to get loans from the NGOs; instead, they have been taking loans from the government and private banks.

However, people who are interested in becoming entrepreneurs, even in the jackfruit business, may get loans from the government bank at low interest.

Non-Financial services

Certifications

DAE is responsible for the certification of the required pesticides and insecticides even in fertilizations, while these inputs have also been used in jackfruit production. Moreover, Bangladesh Standard and Testing Institutes (BSTI) is also responsible for providing certification for the processed food products from jackfruits, whether the processed food items are safe for the human body, even other parameters like food ingredients and proportions, proper weight, expiration date, production date, etc. The Plant Quarantine division under the DAE also checks and gives certificates about any agriculture materials while passing the ports. Besides, DAM is also responsible for providing certification for a few fruits, particularly for the processed jackfruit food.

Extension and training services

An advisory service is essential, particularly for the production of jackfruit. Public and private, even NGOs are providing those services in Bangladesh. DAE is one of the most significant extension service providers in Bangladesh and offers advisory services as well as training to the producers.

DAE is designing its programmes for the service considering the different categories of farmers. Sub-Assistant Agriculture Officer who is responsible for working at grassroots levels like village level while they directly advise the jackfruit farmers. Advice related to the collection of good quality saplings, land preparation, fertilization, irrigation management, intercultural operations, disease and pest management, harvesting time, etc. Another public organisation like the DAM is also responsible for keeping a good market environment for the producers as well as traders. They arranged training programmes for the different kinds of traders like wholesalers, retailers, Bapari, Faria, etc. DAM has also made recommendations to the financial authorities for the traders to get loans. Sometimes, research organisations like BARI are also responsible for giving service by generating new varieties and new practices, even providing training on production, processing, etc.

Transport

Transportation is one of the vital support services systems, particularly for distant wholesalers. However, other actors may also use a variety of transports such as private vehicles, public transport, motorcycles, bicycles, wheelbarrows, vans, auto rickshaws, and motorised three-wheelers, as well as carrying the commodity on foot/head load. Sometimes, distant wholesalers face severe problems while transporting their jackfruits from one division to another due to accidents and other unexpected occurrences like hijacking. The auto-rickshaw and van are more common local transportation to carry jackfruit from the homestead to the local market, particularly by the producers who are also acting as retailers.

2.3.3 The (societal) enabling environment

In this section, the analysis covers four core parts of the enabling environment: (1) institutional elements (policies, laws, and regulations), (2) organizations and cooperation, (3) infrastructure elements, and (4) socio-cultural elements.

Institutional elements-

Different ministries of Bangladesh have formulated separate policies. These are the Environment Policy 1992, National Agricultural Policy 1999, National Agricultural Extension Policy 2012, Safe Food Policy 2013, Sustainable Development Goal (SDG 2016- 30), and National Pesticide Policy 2017. The first Agriculture Policy was formulated in the country as National Agriculture Policy 1999. The policy was then amended as National Agriculture Policy 2013. Recently, the National Agriculture Policy 2018 has been drafted and approved by the Ministry of Agriculture to undertake and guide proper development activities in the crops sub-sector. For jackfruit, not a single policy has been formulated in Bangladesh so far.

Organizations and cooperation

Different national organisations like the Department of Agricultural Extension (DAE), Bangladesh Agricultural Research Council (BARC), Bangladesh Agriculture Research Institute (BARI), and Agricultural Universities are working in cooperation with donor Agencies –World Bank, FAO, ADB, etc. Bangladesh Agricultural University (BAU) and BARI have been working on the development of high-yielding and year-round jackfruit varieties. Both organizations also formulated improved cultural management techniques, irrigation systems, and intercultural operations for the production of quality jackfruit.

Infrastructure elements

Jackfruit is growing in the rural areas of the country. Road communication is poor, and there are limited transport facilities. In the marketplace, there is no such infrastructure for jackfruit storage and marketing. Significant challenges for the jackfruit value chain are poor road conditions, faulty transport systems, and a lack of storage facilities.

Socio-cultural elements

In the jackfruit value chain, mostly male workers are visible in production, harvesting, loading & unloading, transportation, and marketing. Women have the strength and ability to do most of the work, but they cannot participate due to social and cultural limitations. In some parts of the country (hilly areas), where women take part in the production and marketing of jackfruit to some extent. However, jackfruit processing has been started in the country on a limited scale, where primarily women are working as entrepreneurs.

2.3.4 The Natural Environment

Any event, particularly for the agriculture sector, needs a good/favourable environment, especially a natural environment; otherwise hampers jackfruit production even during transportation for marketing. Fertile soil, temperature, rainfall, humidity, etc., are the primary concerns while jackfruit growing. Jackfruit tree requires *fertile and well-drained sandy loam soil with a pH value of 6.0 to 7.5*. The

jackfruit tree is well suited to tropical lowlands where humid and warm climate is prevalent. It requires an average rainfall of 100 to 240 centimetres for healthy growth and fruit production, while temperature requires between 75°F and 90°F (25-32°C) for the same. The temperature and rainfall highly influence the fruit size and shape. In Bangladesh, the most critical issue for jackfruit cultivation is slightly acidic soil, and thus, jackfruit has been cultivated and grown well in soil having slightly acidic conditions with excellent drainage facilities. Therefore, a favourable environment for jackfruit is not available in the whole country. But, Dhaka, Gazipur, Mymensingh, Narsingdi, Tangail, Hill tract districts, etc., in the country had the required soil, and thus, they are recognized as major jackfruit-producing regions. Besides, Jackfruit trees are easy to grow, require a minimal amount of water to survive at high temperatures, and don't need much more pesticides or chemicals to survive pests and diseases. This makes jackfruit a drought-resistant crop, ideal in the fight for soil and water conservation. Another critical issue is the lifespan of the jackfruit tree. Jackfruit trees can live up to 100 years and can also produce fruit for 30–60 years. Long life span depends on several factors mentioned above, like soil, temperature, water (mainly environmental factors), and intercultural operations, including good disease and pest management. Moreover, indiscriminate application of chemicals, particularly pesticides and insecticides, may cause severe environmental deterioration and health hazards (Pathak et al., 2022).

2.4 Governance analysis (linkages)

Vertical linkages

JVC actors in the path of vertical linkages are found to be diverse, with diverse influences on pricing. In the case of setting prices of jackfruits between pre-contractors and producers, both are independent, having limited middlemen influence, and pricing is selected based on their interest. Local wholesalers have more power/leverage in their specific activity than other actors and can control pricing to some extent. Sole jackfruit retailers are hardly visible in the market, and they retail jackfruit only for production periods with other seasonal fruits. The growers carried out a large part of retailing at the local market, and on-spot bargaining is the primary way of setting a price. Wholesalers from a distance have a more significant influence on the local wholesalers due to their larger size and having more capital. Local wholesalers/aggregators aggregate the jackfruits on the roadside Aratdar and load them to the distance whole sellers' truck having a capacity of 1000 fruits. Local wholesalers collected jackfruits from producers through a mediator either by their carrier or producers' arrangement. When producers buy their jackfruits to Arat by their carrier, whole sellers dominate in controlling fruit prices. There is good coordination among the local wholesalers in the case of setting jackfruit prices, but retailers and producers are fragmented and have no access to price bargaining. Harvesting time also has a significant influence on the price of jackfruit. Farmers gained more price benefits from early harvested jackfruit.

Horizontal linkage

VC actors are associated with weak horizontal linkages. No formal associations are observed among the producers and hence, no collective action such as joint inputs purchasing, value addition, or marketing is visible. Local wholesalers maintain solid

links and get benefits in case of price forecasts. Most of the exporters have links with wholesalers, and hence, producers who are connected with them have changed to get a reasonable price. Due to the absence of a strong association, no formal mechanisms for getting technical and financial support like training, local-level advocacy, and inputs in exchange for membership fees are not observed.

External linkages

All value chain actors were reported to have a good relationship with input suppliers, private and government service providers, and intermediaries. No formal association was observed among the producers, but they have good connectivity with the extension workers since they provide counselling, training, and inputs for free. VC actors, particularly producers, have poor access to government financial agencies due to official hassles, but they have good connectivity with the NGOs and dadons. However, aggregators and distance wholesalers are politically influential, and hence, they have good access to government financial agencies as well as extension workers.

3 Sustainability assessment

3.1 Economic analysis

The economic analysis comprises six domains, namely 1. Profitability (financial analysis), 2. Employment, 3. Value added, 4. Effects on the national economy, 5. International competitiveness, and 6. Value for end-consumers. It focuses on the actor-level and value chain-level contributions in measuring economic growth. The economic analysis is based on primary data collected through economic interviews with VC actors of each actor type. The data is then formatted into operating accounts of VC actors to assess profitability, employment, and value-added. For each VC actor type, the operating accounts of all VC actors under that type are then averaged to obtain the operating accounts of a single, typical VC actor of each type. These standard operating accounts provide economic indicators for each segment of the VC. The data obtained from economic actor interviews has also been cross-referenced through more comprehensive but less detailed focus group discussions, key informant interviews, and surveys.

3.1.1 Profitability

An overview of the VC actors' profitability is provided in Figure 2 below. Figure 2 presents the average annual revenue, net income, and return on sales (ROS, or net income over revenue) for a typical individual VC actor jackfruit value chain in Bangladesh. It was observed that the average net income for the producers, pre-harvest contractor, local wholesaler, Aratdar, distant wholesaler, and retailer are respectively BDT 10801, BDT 85903, BDT 208169, BDT 414415, BDT 267921, and BDT 140699 (Figure 2). Figure 2 shows that Aratdar has the highest seasonal turnover, followed by distant wholesalers, local wholesalers, and retailers. The principal expenditures of the Aratdars consist of jackfruit procurement from the other performers and remunerating their labour force. On the other hand, the majority of the funds spent by distant wholesalers are on jackfruit purchases and transportation. Both Aratdars and distant wholesalers of Bangladesh oversee a substantial volume of jackfruits daily via their jackfruit-related undertakings. Therefore, the profit margin is independently increasing. Though they earned higher revenues, their total cost is also high. This is why the RoI and RoA of Aratdar and distant wholesaler are relatively low in comparison to other participants in the value chain.

Figure 2. PROFITABILITY ASSESSMENT IN A JACKFRUIT VC

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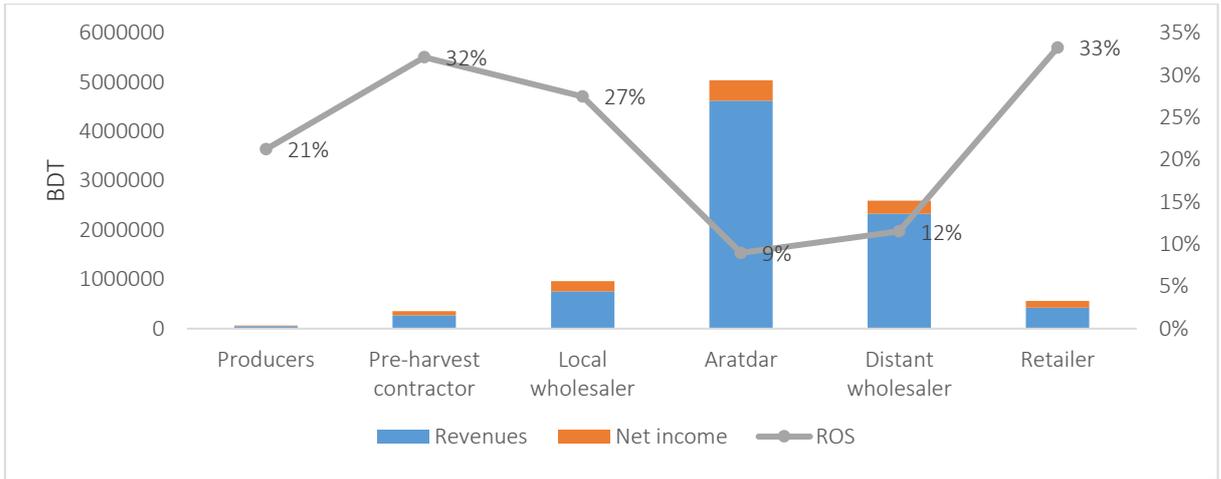
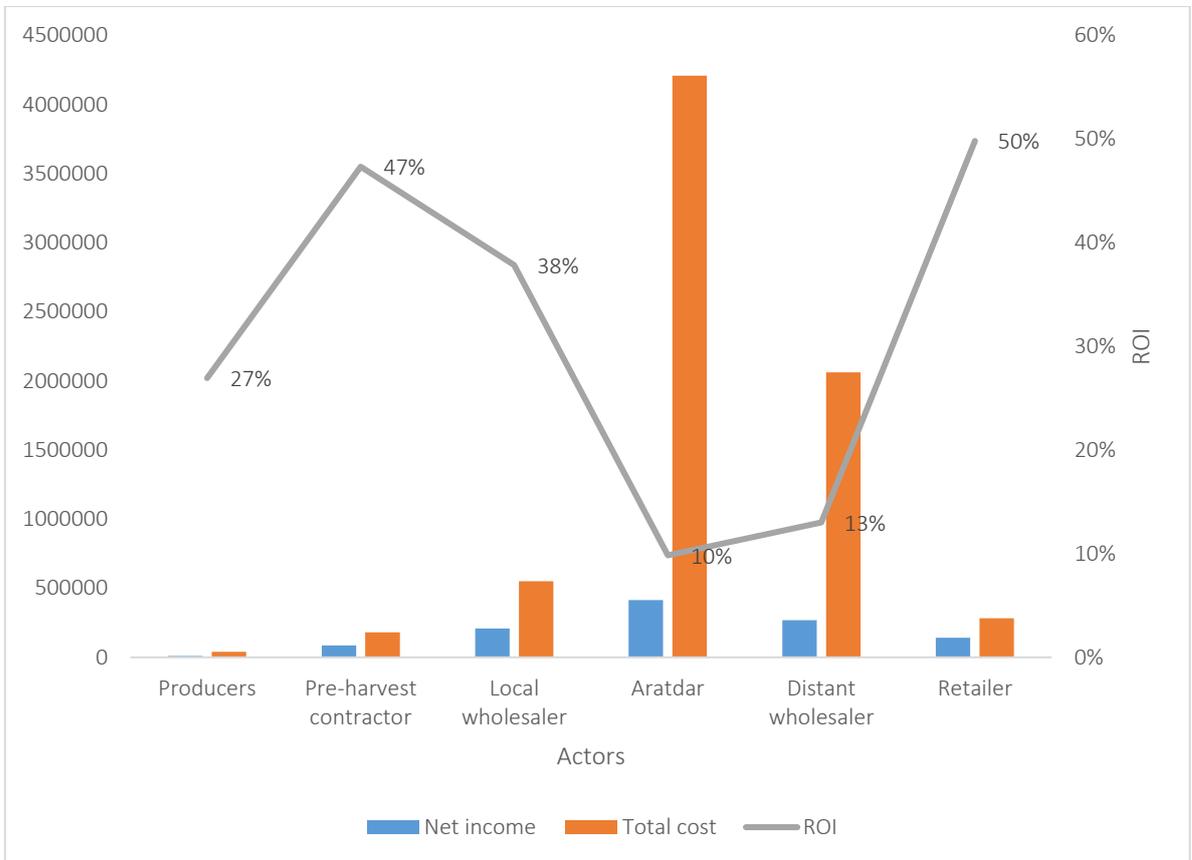


Figure 3 shows that return on investment was the highest for retailers (50%), followed by pre-harvest contractors, local wholesalers, producers and distant wholesalers, and Aratdars, respectively.

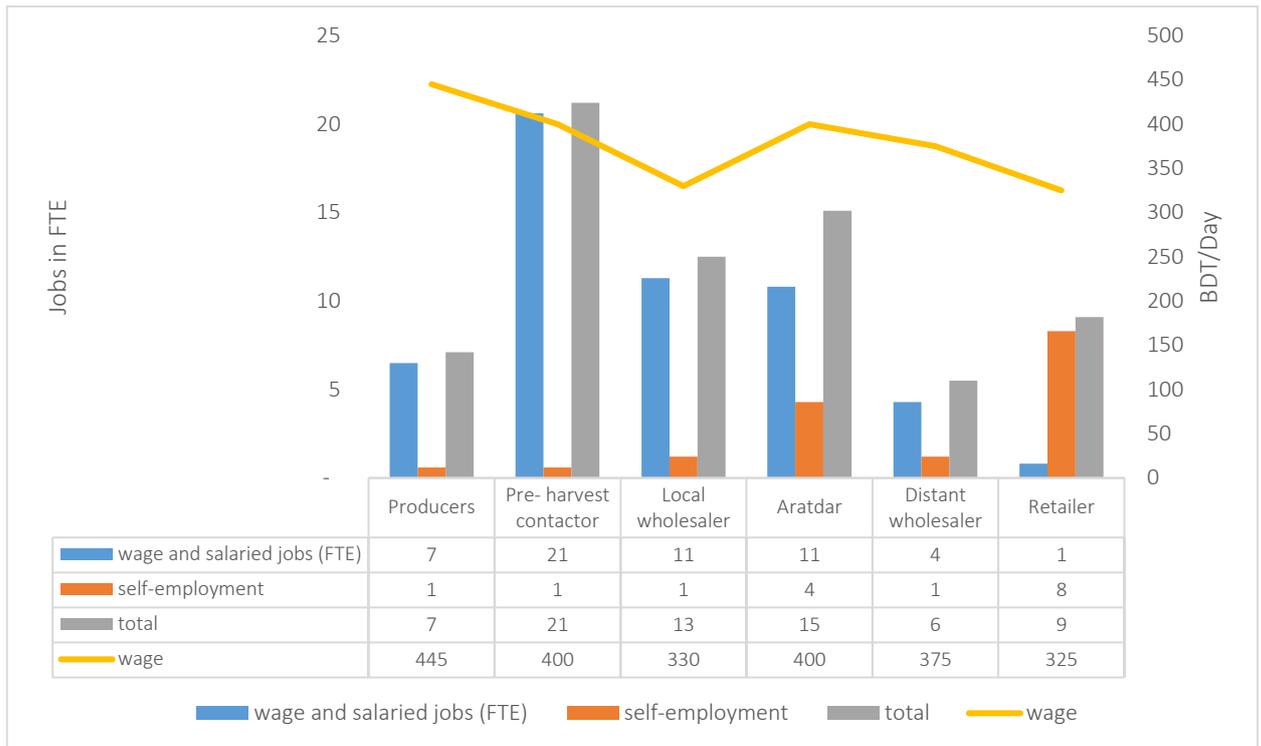
Figure 3. RETURN OVER INVESTMENT IN A JACKFRUIT VC



3.1.2 Employment

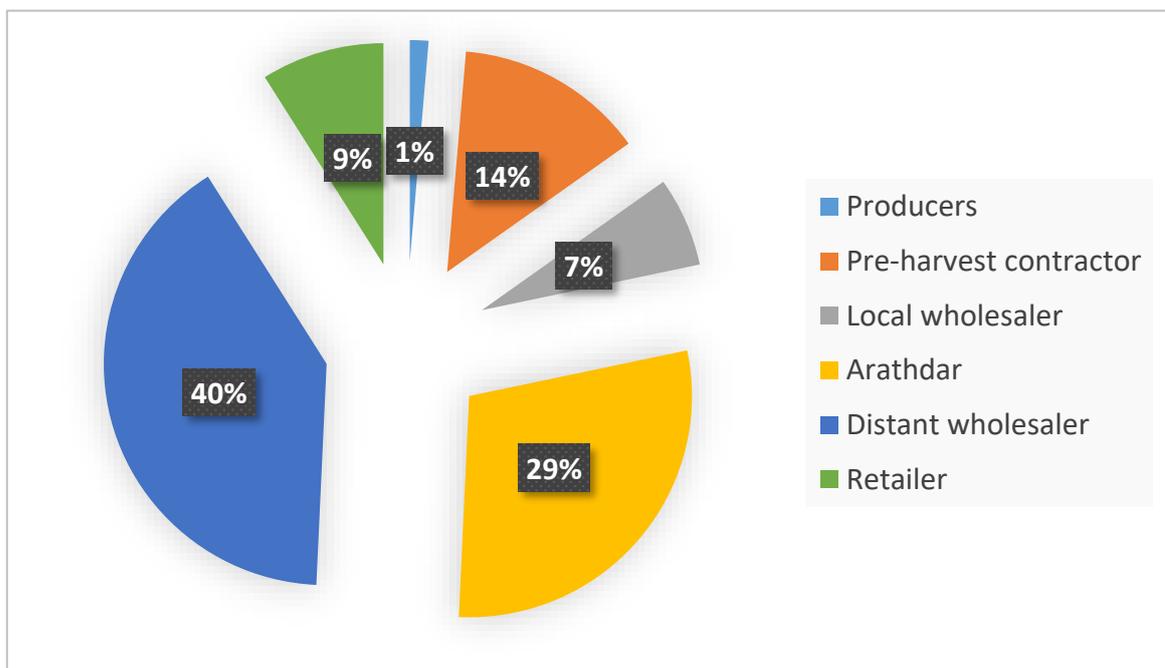
Figure 4 presents the number of man-days, including family labor, used across all functions in the VC. The pre-harvest contractor employed more workers, followed by Aratdar, local wholesalers, retailers, producers, and distant wholesalers. The wage rates of different actors are given in Figure 4.

Figure 4. EMPLOYMENT LEVEL BY FUNCTIONAL LEVEL AND TYPE



The analysis also revealed that the jackfruit value chain generates a total of 5 jobs at the producer level, 8 jobs at the pre-harvest contractor level, approximately 3 jobs at the local wholesaler level, 25 jobs at the Aratdar level, 9 jobs at the distant wholesaler level, and 2 jobs at the retailer level.

Figure 5. Percent share of wages paid by an actor



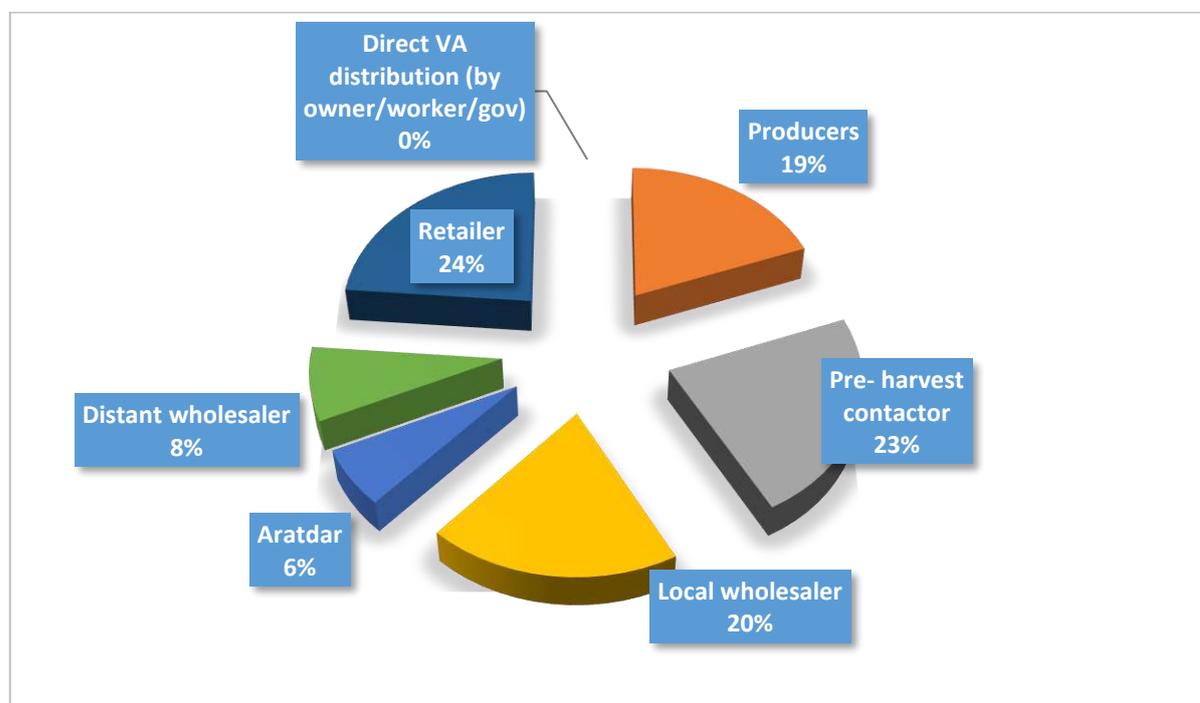
The aggregate sum of remuneration disbursed by the various participants within the jackfruit value chain amounts to Tk. 895100. Figure 5 illustrates that the Aratdar

provides 29% of wages, while the distant wholesaler provides the maximum share at 40%. Pre-harvest contractors, retailers, local wholesalers, and producers provide corresponding pay of 13%, 9%, 7%, and 1%.

3.1.3 Value added

The (financial) value added is assessed at two levels: (i) the **direct value added**, which includes net profits (after taxes) for VC actors, net wages for their workers, and government revenue in the form of taxes and fees, and (ii) the **indirect value-added**, which is embedded in the domestic goods and services that the VC actors purchase from outside of the core VC. The creation of direct value added, the distribution of this value-added, and the total value of outputs (i.e., total revenues) are therefore calculated from the operating accounts of the core VC actors and are summarised in Figure 6 below. Figure 6 shows that the value added is the highest for retailers (24%), followed by pre-harvest contractors (23%), local wholesalers (20%), producers (19%), distant wholesalers (8%) and Aratdar (6%) respectively. The aggregate value added by each participant in the value chain is as follows: Tk. 10801 for producers, Tk. 85903 for per-harvest contractors, Tk. 208168 for local wholesalers, Tk. 414415 for Aratdar, Tk. 267921 for distant wholesalers, and Tk. 140698 for retailers.

Figure 6. SHARE OF DIRECT VALUE ADDED CAPTURED BY DIFFERENT ACTORS



3.1.4 Effects on the national economy

According to the Bangladesh Bureau of Statistics, about 1.5 million metric tons of jackfruit are produced in Bangladesh every year. About 33% of this total production was wasted in the last few years. Most people in Bangladesh think that jackfruit can only be eaten when it is ripe. There is a lack of interest in consuming unripe jackfruit. So, a large part of the jackfruit produced in Bangladesh is wasted every year. However, in recent years, various types of delicious foods have been prepared from jackfruit in

Bangladesh, which include jackfruit jam, pickles, chutney, chips, cutlets, ice cream, curd, ready-to-cook jackfruit, fresh cut (vegetable meat), jackfruit powder, and various other packaged products. Bangladesh Agricultural Research Institute has developed these products for the first time in Bangladesh. Customers can find these products in several supermarkets and retail markets nationwide. In addition, an international organization named the Christian Commission for Development in Bangladesh (CCDB) has been producing some products from jackfruits. Presently, a range of food items, such as unripe jackfruit vegetable rolls, cutlets, and shingara, are being prepared in the market. Meanwhile, ripe jackfruit juice is being used to make ice cream, cakes, and fruit roll-ups. In addition, these products made using jackfruit are already creating employment in the country. On the other hand, there is also a demand for these products in the international market. A minimal amount of jackfruit, about 1000 tons grown in the country, is exported abroad, and most of its buyers are expatriate Bangladeshi.

If we calculate all the contributions of jackfruit considering the factors mentioned above and value addition, it would likely contribute to the country's GDP by 0.1%.

3.1.5 International competitiveness

The international competitiveness of the value chain indicates how competitive domestic production is compared to imports at the wholesale price. Even when there are few imports of value chain products, international competitiveness can be calculated based on the import parity price – or the hypothetical price at which an imported good would be available in the market if it were imported. Value chains with more competitive domestic products are considered to be more protected from competitive international products. However, we do not import jackfruit, that's why it is not competitive in the international arena. It could become competitive if global demand is created through the development of various value-added processed products. Currently, the price of jackfruit in the international market can vary depending on the size, season, and region of the fruit. On average, a jackfruit can cost anywhere from Tk. 220 to Tk. 880 (about \$2 to \$8). The typical wholesale price in Bangladesh is between Tk. 60 to Tk. 80 (about \$0.5 to \$0.7). When exported to foreign markets, the same product can fetch as much as Tk. 220 (about \$2), but the standards of quality, color, size, and exemption from cracks and pest or insect assault must be strictly adhered to. So, we can consider the value chain as secured & sustainable.

3.1.6 Value for domestic end-consumers

As mentioned earlier, younger jackfruit can be eaten as vegetables full of protein, vitamins, and minerals and is considered to be a meat substitute. In addition, unripe jackfruit vegetable rolls, cutlets, and shingara are being prepared in the market, which has huge demand, especially for younger consumers. Similarly, ripe jackfruit jam, pickles, chutney, chips, cutlets, ice cream, yogurt, etc., are being prepared, which nutritionally reaches the consumers. These products have high demand domestically and internationally. Furthermore, fresh, ripe jackfruits are also nutritious, delicious, and preferred by many consumers, especially during financial crises. Rice consumption can be substantially reduced during jackfruit season as ripe jackfruit contains carbohydrates, potassium, calcium, magnesium, vitamins, organic acids, iron, etc. There are other health benefits of jackfruit. As the soil of Bangladesh is congenial

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to jackfruit production, it grows in abundance across the country, particularly in the highland areas. That’s why most of the people are accustomed to consuming it.

3.1.7 Economic Analysis Overview

Based on the analytical assessment of economic performance addressing all six domains, profitability, employment, value-added, effects on the economy, international competitiveness, and value for consumers, an overview has been presented in Table 3 and Figure 6.

TABLE 3. ECONOMIC SUSTAINABILITY PERFORMANCE SCORES FOR THE VC

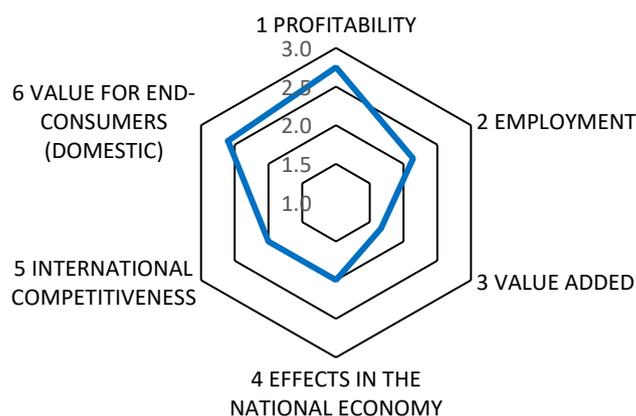
1 PROFITABILITY		
Net income	3	Not concerning
The trend in net income	2	Concerning
Return on sales	3	Not concerning
Return on investment	3	Not concerning
2 EMPLOYMENTS		
Number of jobs in FTE	2	Concerning
Number of FT jobs	1	Highly concerning
Number of wage labour jobs	3	Not concerning
Number of family/self-employed jobs	3	Not concerning
The average wage for hired workers	2	Concerning
Average wage proxy family labour	2	Concerning
Total value of net wages	2	Concerning
3 VALUE ADDED		
Direct value added at the VC level	3	Not concerning
Total value added	2	Concerning
4 EFFECTS IN THE NATIONAL ECONOMY		
Contribution to GDP	3	Not concerning
Contribution to the trade balance	2	Concerning
Rate of integration	3	Not concerning
Public finances impact	2	Concerning
Contribution to investment	1	Highly concerning
5 INTERNATIONAL COMPETITIVENESS		
Nominal protection coefficient	2	Concerning
6 VALUE FOR END-CONSUMERS (DOMESTIC)		
Consumer surplus	2	Concerning
Food safety violations	3	Not concerning
Consumer evaluation	3	Not concerning
Consumer preference	2	Concerning
Price relative to substitutes	3	Not concerning

FTE = full-time equivalent

FT = full time

GDP = gross domestic product

Figure 7. ECONOMIC SUSTAINABILITY PERFORMANCE DIAGRAM OF THE VC



3.2 Social analysis

The social sustainability analysis covers six domains: inclusiveness, gender equality, food and nutrition security, decent employment, social and cultural capital, and institutional strength. These are discussed next, with summary overviews of the social profile of the value chain analysis of jackfruit provided at the end of the section.

3.2.1 Inclusiveness

Wage and employment distribution

Out of the 71.10 million people engaged in various sectors in the 1st quarter of 2023, about 31.94 million are engaged in the agriculture sector (BBS, 2023). According to the Bangladesh Bureau of Statistics, about 1.5 million metric tons of jackfruit are produced in Bangladesh every year. A significant portion of people are engaged in this jackfruit value chain. Among producers, 65% are engaged in commercial farming, and 35% are involved in homestead farming. At the traders' level, 20% is allocated to pre-harvest contractors, 22% to local wholesalers, 4% to Aratdars, 14% to distant wholesalers, and 40% to retailers. The survey information indicates that the average wage rate at the producers' level is Tk.445. The average wage rate at various levels of traders ranges from Tk.330 to Tk.400. The wage rate at different levels of traders ranges from Tk.330 to Tk.440. Furthermore, it was determined that there is a difference in wage rates between male and female workers. Producers spent about 1.5% of their profit as wages to different workers. In the case of traders, they spent about 10% to 15% of their profit on wages.

Value-added distribution

Value addition varies at different stages of jackfruit marketing. The percentage of value addition gained by the producers of jackfruit cultivation is 19% and requires less investment. At the pre-contractor level, about 23% value is added. Local wholesalers added a value of approximately 20%. Aratdar, distant wholesalers and retailers added value of roughly 6%, 8%, and 24%, respectively.

Poverty and vulnerability

The national poverty rate dropped to 18.7%, with rural areas at 20.5% and urban areas at 14.7% (HIES, 2022). The final HIES 2022 report showed that the wealthiest 10% of Bangladeshis earn 41% of the nation's total income, while the poorest 10% earn 1.31%. According to the value chain study of the jackfruit project, 35% of producers live above the national poverty threshold, while 65% live below it, regardless of gender or education. About 93% of merchants live above the national poverty level, while 7% live below it. In the value chain, processors, Aratdar, and aggregators earned the most.

Discrimination

With many men and women in value chain enterprises and no disabled people, gender discrimination seemed unlikely. Over 60% of traders and 55% of producers were senior adults. A few respondents knew about national legislation against job discrimination, but most use informal methods to deter discrimination. The worker poll found that nearly all employees did not feel biased at work despite the lack of norms.

3.2.2 Gender equality

Women's economic involvement

The underrepresentation of women in the jackfruit value chain is unfortunate. A mere 15% of the female population is involved in production activities, mostly in hilly areas, while 10% are labourers. They only participate in the cleaning and packaging of jackfruit and cannot join in jackfruit harvesting or carrying. But most of the time, they cannot join due to social limitations. A significant number of women maintain the processing stage. Entrepreneurial women are the primary processors of various jackfruit value-added products. Consumers can purchase modified fruit products such as jackfruit burgers, cutlets, sandwiches with raw jackfruit, jackfruit rolls, *Shingara*, *Samutcha*, jackfruit curd, juice, custard, cakes, and ice cream from their tiny offline and online food shop that serves as a caterer.

Gender division of labour

Women's participation in jackfruit value chain activities is minimal. Males carry out the majority of the activities in the jackfruit value chain. Women have no engagement in any formal activities related to the jackfruit value chain. Our survey report revealed that female workers do only 15% of value chain-related work within a week, and for males, it's 85%. Women's representation in the Jackfruit value chain is relatively recent, primarily in business as processors. In contrast, men have been heading jackfruit value chain firms since their inception. Men are predominantly hired as labourers in gardens and markets, while women are primarily engaged in processing duties related to cleaning and packaging. Members of the Jackfruit processing organization have highlighted the active involvement of women in the processing of jackfruit for export purposes.

Gendered access to productive resources

The interviews revealed that both men and women have an unequal ability to participate in value chain activities with dissimilarities in land and other productive resources— only 9% of women had secure land tenure. Access to credit appeared to be over 63% among both men and women, including access to other financial services.

About 20% of women related to the jackfruit value chain have access to extension services. A minimal portion of women have access to training on business management from public and private service providers. However, the men and women surveyed requested further support for improving business performance. Market information is not sufficiently disseminated to producers and other value chain actors through farmer organizations compared to other agricultural products.

Women's decision-making and leadership

Our survey report revealed that women were hardly involved in any value chain associations or trade unions. But in the hill areas, women were the primary decision-makers. Approximately 9% of the female processors were affiliated with a cooperative rather than individual producers. Several benefits were provided for belonging to such organizations, such as access to funding and loans, access to information, and coordination for marketing products. Approximately 75% of the female processors surveyed can make their decisions in jackfruit value chain analysis. Despite women's engagement in the value chain, only a few indicated leadership positions in their organization.

3.2.3 Food and Nutrition Security

Availability of food

Bangladesh produces 1.5 million metric tons of jackfruit annually, according to the Bangladesh Bureau of Statistics. Researchers found that 45% of this production—0.5 million tons of jackfruit—was squandered in recent years. Considering these issues, researchers are trying to make jackfruit food products that can be preserved for months. They seek to cut waste and boost the country's economy. However, these products are popular abroad. Exports now include processed jackfruit. Experts say Bangladesh began exporting processed jackfruit to EU nations in 2019, broadening its export portfolio. As a jackfruit producing country, Bangladesh produces enough in excess to meet local demand, so even if it were to be exported, there would be an ample supply. However, as of right now, it is an export good and will be served on platters in restaurants in Iceland. According to representatives of the Palli Karma-Sahayak Foundation (PKSF), Iceland Superstore, a chain superstore, has placed an order for 0.4 million pieces of jackfruit burgers from Bangladesh this year.

Accessibility of food

Bangladesh sells tiny, medium, and enormous jackfruits to satisfy different income groups. The value chain analysis survey found that 100% of producers shared their fruits with all home members and 85% with relatives. However, regional consumption habits vary. Jackfruit prices have risen in the past five years, according to respondents. In the last five years, 23% of dealers thought supply had dropped.

Utilization of food (nutrition, safety)

Compared to 2016, 2022 saw greater vegetable and fruit consumption (HIES, 2022). A villager now eats 90.9 grams of fruits daily, up from 32.2 grams in 2016. City dwellers eat 105.3 grams of fruit daily, up from 45.2 grams in 2016 (HIES, 2022). Jackfruit's fibre content changes with ripeness. Seeds have 5.8–6.3% protein, which is outstanding. One cup of raw sliced jackfruit has 157 calories, 2 gm fat, 38 gm carbs, 3 gm protein,

and 40 mg calcium. Ripe flakes contain 287-323mg of potassium per 100g, according to the NIH. It provides vital amino acids, including lysine, leucine, methionine, cystine, histidine, and tryptophan, for body growth. However, jackfruit value chain food safety is maintained by hygiene and quality control. At the farm level, hazardous pesticide residues on jackfruit can be avoided by using safe, controlled pesticide application techniques. Conversely, at the trader level, proper transportation and storage procedures help to avoid contamination and spoiling. Thus, there haven't been any reports of illnesses caused by jackfruit consumption up until this point. Compared to certain other fruits and vegetables, jackfruit is less likely to become contaminated when handled and kept correctly. The jackfruit's outer layer acts as a barrier for preventing damages.

Stability of food (trends)

The price of Jackfruit seems affected by seasonality as the product is not available throughout the year, according to the study interviews. In the market right now, a variety of food items, such as unripe jackfruit vegetable rolls, cutlets, and shingara, are being prepared. Meanwhile, ripe jackfruit juice is used in the manufacture of ice cream, cakes, and fruit roll-ups. During peak periods, prices are relatively low, whereas beginning and end-of-season prices are relatively high.

3.2.4 Decent employment

Respect for labour rights

Most of the workforce works in the informal sector without labour rights, so economic growth has not increased employment. The minimum monthly wage is based on 8-hour workdays and 48-hour weeks. Overtime pay is 1.5 times or two times the daily wage. The minimum salary in Bangladesh is BDT1,500.00 per month in 2023. The minimum wage in Bangladesh is 38 Taka (0.36 USD) per hour. Almost all interviewed workers live over minimum salary without overtime. During loading-unloading and harvesting, producers may engage seasonal workers without contracts.

Child and forced labour

The value chain analysis study found that about half of VC actors had children ranging in age from 10 to 20 years, helping them only during their spare time in their activities, including harvesting, delivery, packaging, maintenance, and online marketing. There was no forced child labour. The majority of the labour force was beyond the age of 25.

Job safety and security

As the jackfruit value chain is primarily land-based, the incidences of workplace injuries at the production level are lower. In transporting that involves loading- and unloading, there is a heightened risk of harm to employees. The majority of workers interviewed reported that safety standards are available in their workplace.

Attractiveness

Jackfruit farming is attracting new entrants – from very small-scale subsistence homestead farmers to medium-scale producers. The value chain analysis workers survey found that there are no written terms of the contracts. More than 75% of value chain actors interviewed have embraced technological innovation, mainly using the

internet and digital equipment to support business operations, as part of modernising their businesses. However, the value chain still relies on very traditional methods.

3.2.5 Social and Cultural Capital

Collective action

Horizontal linkages are pretty weak at the production, processing, and retail levels in the value chain. According to the interviews, about 21% of value chain actors belonged to a cooperative or association. Almost all actors agreed that membership in such platforms has advantages, particularly in terms of access to information, finance, networking, and support during shocks. Workers, on the other hand, had limited coordination because most of them were employed under informal/verbal contracts and thus were unable to initiate any collective bargaining to improve their working conditions.

Coordination of transactions

Despite the high rate of informality in the value chain, there appears to be a relatively high level of trust among value chain actors. The majority of value chain actors interviewed indicated that they do not have any contracts with buyers or suppliers but use spot transactions and sometimes verbal or informal contracts. They all mentioned having secure access to markets even without formal supply contracts and having good relationships with input suppliers.

Social cohesion

There is not sufficient membership organization where they could influence policy-making by submitting their position through their cooperatives or associations, individual participation, or public consultations. Only 21% of respondents are engaged with the association, while collaboration and trust are not high. So, the value chain's success will require that public policy and engagement be strengthened as the value chain grows.

Cultural traditions

As Jackfruit played an essential role in the cultural life of many Bangladeshi people, nearly 95% of respondents indicated that the value chain was supportive of traditional practices. Jackfruit is used during ceremonies or illnesses. Furthermore, the value chain has had an advantageous effect on overall growth in employment among people of various income levels.

3.2.6 Institutional strength

Policy and regulations

Jackfruits have no formal policy or laws, so assessing value chain performance may be complex. Business registration formalities and output volumes are unclear. Most value chain actors are unaware of the laws. No important guideline exists to ensure value chain players work in food safety and environmental sustainability.

Access to finance

Financial services are widely available to value chain participants. Most responders use financial services. Many value chain participants have bank and other formal

credit. However, few were borrowing from those sources. About 4% of value chain operators take bank loans, and 14% take additional credit. Low-interest rates, bank access for everybody, straightforward banking procedures, agricultural loans, etc., are needed to increase value chain participants' formal lending. Some value chain actors use banks to support their businesses, mainly using personal resources, family, or friends. Although formal financial products are available, hefty interest rates and collateral requirements are significant impediments to institutional funding. Lastly, no performers have purchased business insurance. There is no insurance for a business like this.

Access to natural resources

Bangladeshi Jackfruit growing requires land. All producers grow jackfruit on their property. Other value chain operators said they don't need land because they operate in open spaces or roadside areas. Only Aratdar tenancy land for jackfruit season, mostly `Khash.` About 95% of value chain participants report positive interactions. Over 70% of value chain participants have secured land.

Access to information

Only 23% of producers have access to extension services in the case of jackfruit cultivation. Value chain actors collect market information from different informal sources, but there is no formal source to provide market information.

3.2.7 Social Analysis Overview

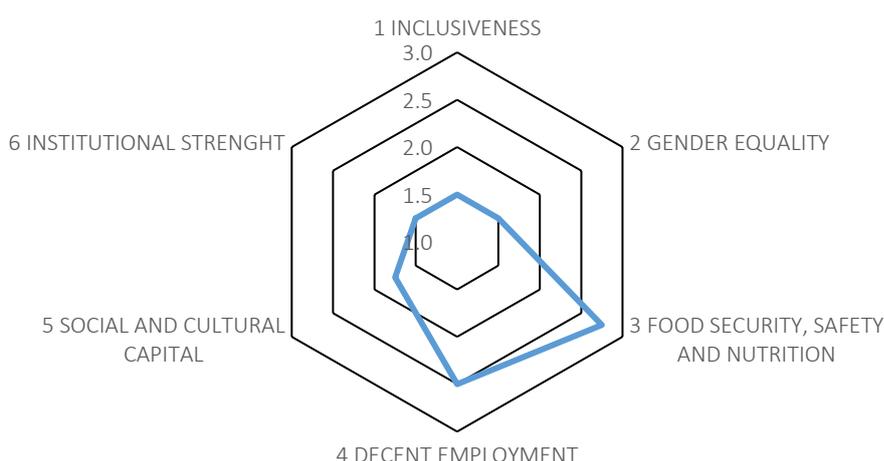
This section integrates many dimensions of social sustainability to create an overall social profile. It includes an overview table and a spider diagram.

TABLE 4. OVERVIEW OF SOCIAL ANALYSIS

1 INCLUSIVENESS		
1.1 Wages and Employment Distribution	1	Concerning
1.2 Value-added distribution	1	Concerning
1.3 Poverty and Vulnerability	2	Moderate concerning
1.4 Discrimination	2	Moderate concerning
2 GENDER EQUALITY		
2.1 Women's Economic Involvement	1	Concerning
2.2 Gendered division of labor	1	Concerning
2.3 Gendered access to productive resources	2	Moderate concerning
2.4 Women's decision-making and leadership	2	Moderate concerning
3 FOOD SECURITY, SAFETY AND NUTRITION		
3.1 Availability of food	3	Minor concerning
3.2 Accessibility of food	3	Minor concerning
3.3 Utilization of food (nutrition, safety)	3	Minor concerning
3.4 stability of food (trends)	2	Moderate concerning
4 DECENT EMPLOYMENTS		
4.1 Respect for labour rights	3	Minor concerning
4.2 Child and forced labour	3	Minor concerning
4.3 Job safety and security	2	Moderate concerning
4.4 Attractiveness	2	Moderate concerning

5 SOCIAL AND CULTURAL CAPITAL		
5.1 Collective action (horizontal linkages)	1	Concerning
5.2 Coordination of transaction (vertical linkages)	1	Concerning
5.3 Social cohesion	2	Moderate concerning
5.4 Cultural traditions	3	Minor concerning
6 INSTITUTIONAL STRENGTH		
6.1 Policy, regulations and standards	1	Concerning
6.2 Access to finance	3	Minor concerning
6.3 Access to natural resources	1	Concerning
6.4 Access to information	1	Concerning

Figure 7. SOCIAL SUSTAINABILITY PERFORMANCE DIAGRAM OF THE VC



3.3 Environmental analysis

Eight environmental domains are stated in this section such as climate impact, water footprint, soil quality, biodiversity and ecosystem, plant health, animal health and welfare, toxicity and pollution, and food loss and waste. Each domain is composed of various subdomains. For each subdomain, several indicators have been identified, which are measured and discussed to assess the environmental impact of Jackfruit VC.

3.3.1 Climate Impact

Electricity, solar energy, natural gas, and fossil fuel are the key energy sources used for jackfruit VC. In jackfruit VC, energy is used during production, transportation, marketplace, processing, and marketing. Along the jackfruit VC, the energy mainly comes from national grid electricity, solar energy, and fuel (diesel and petrol).

Use of electricity

In the jackfruit VC activity, the producer uses electricity to recharge the spray machine/motor vehicle. The input supplier uses electricity in the shop. Jackfruit wholesalers, Aratdar, and retailers also use electricity to illuminate the workplace. Jackfruit processors use electricity for various purposes of the jackfruit value chain, such as electric ovens, electric fans, blenders, refrigerators, dryers, grinders, slicers, cutters, shapers, and cookers. In this analysis, electricity use is estimated to be 0.039

kWh per kilogram of jackfruit. These findings reflect that the impact of electricity consumption in the jackfruit value chain is not concerning.

Fuel consumption

Along the jackfruit value chain, the primary fuel used is diesel and petrol. This is mainly used during the transportation of jackfruit from the production place to the market and distance marketing. Some VC actors use natural gas to carry jackfruit when they use gas-driven vehicles. Fuel consumption is estimated to be 1.184 MJ per kilogram of jackfruit, reflecting that the impact of fuel consumption in the jackfruit value chain on the climate is not concerning.

Renewable, clean energy use

Along the jackfruit value chain, the use of renewable energy, like solar panels, is low, but respondents are interested in using this alternate energy source. Many of the actors in the jackfruit value chain are using solar panels for their household activities and other purposes. Therefore, it is not a concerning issue in a sustainable environment.

Carbon footprint

The most important energy source in the jackfruit value chain is fuel (diesel and petrol). The carbon footprint in the jackfruit value chain is 0.00592 kg CO₂ per kilogram of jackfruit, reflecting that the impact of the carbon footprint in the jackfruit value chain does not concern greenhouse gas emission.

3.3.2 Water footprint

The primary water use in jackfruit VC is irrigation during production, and smaller volumes are used at the processing level. On average, the producer uses 0.04 m³ of water per plant for irrigation to produce one kilogram of jackfruit.

Water and ice consumption

The water and ice consumption in the Jackfruit value chain are negligible. A minimal number of jackfruit growers (particularly in homestead cultivation) are using water for irrigation purposes. As per the respondent feedback, the average water consumption by the JF value chain actors is below 1 m³ per kilogram of jackfruit, so this is not an issue of concern in the jackfruit value chain.

Water treatments and water pollution

The main sources of water pollution in jackfruit VC are chemical pesticides and chemical fertilizer runoff from the field/orchard into water bodies during the rainy season. There are no wastewater treatment facilities along the Jackfruit VC. This pollution has no negative impact on the environment; therefore, this is not an issue of concern in the jackfruit value chain.

3.3.3 Soil quality

Soil erosion

The general risk of soil erosion in the jackfruit value chain is relatively low. Instead, it is beneficial to control soil erosion in some places. Therefore, there is no negative

impact of the jackfruit value chain on soil erosion. Thus, it is not a concerning issue with a sustainable environment.

Soil fertility

In the jackfruit value chain, soil fertility is improved by the decomposing of jackfruit leaves and other debris into the soil. In addition, farmers are using organic manures to the plant, thus improving soil physical health by increasing microorganism activity. So, the risk of soil fertility reduction is shallow. It is a non-concerning issue in a sustainable environment.

3.3.4 Biodiversity and Ecosystems

Impact on associate species

In the jackfruit value chain, particularly at the production level, some respondents said that they gradually transformed jackfruit orchards into citrus or mango plantations. These activities might have some negligible impact on associated species.

Status of vulnerable ecosystems

Jackfruit is grown in a terrace ecosystem where other crops are grown in an agroforestry system. Under a jackfruit-based agroforestry system, aroids, zinger, turmeric, etc., can be grown. Therefore, in the Jackfruit value chain, there is no scope to create any vulnerable environment for the ecosystem. So, this is not an issue of concern for environmental sustainability.

Status of ETP species

Jackfruit is mainly cultivated in the backyard or homestead, on the roadside, and in the orchard to some extent. Farmers use self-produced seedlings/saplings or sometimes collect from plant nurseries. There is no hybrid or genetically modified jackfruit in Bangladesh. So, the status of endangered, threatened, and protected (ETP) plant species is not interrupted due to the jackfruit value chain. So, the effect on ETP species as a result of jackfruit value chain activities is not considered an issue for a sustainable environment.

Responsible use of genetic resources

Genetically modified jackfruit varieties, as well as hybrids, are not used by growers/farmers at the production level. So, there is no scope to escape genetic resources from the ecosystem.

3.3.5 Plant Health

Application of biosecurity

In the jackfruit value chain, insecticides and fungicides are being used at the producer level to control insects and disease infestation. According to the responses of the jackfruit growers, they apply chemical pesticides to the plants without taking any protection measures. There are no biosecurity measures in the jackfruit value chain.

Appropriate plant-growing practices

In the production level of the jackfruit value chain, plants and fruits are affected by various insects, diseases, and other pests (squirrels, monkeys). Farmers are reluctant to take any protective measures for jackfruit. According to the reply from the

respondents, about 33% of producers apply insecticides and fungicides for jackfruit production. There are no appropriate plant health measures in the jackfruit value chain.

3.3.6 Toxicity/pollution

Responsible use of fertilizers

In the jackfruit value chain, a good number of jackfruit growers use chemical fertilizers for jackfruit cultivation in consultation with the Upazila Agriculture Officer (UAO) or Sub Assistant Agriculture Officer (SAAO). So, the growers have a scope to use recommended doses of fertilizers for jackfruit. Usually, farmers are not using fertilizers based on soil nutrient analysis value. A significant number of respondents said that they never use any fertilizers for jackfruit production. So, for a sustainable environment, using fertilizers in the jackfruit value chain is not an issue of concern.

Responsible use of drugs and chemicals

Very few farmers have used chemical pesticides for the production of jackfruit, while other value chain actors never use any drugs and chemicals. Therefore, for a sustainable environment, the jackfruit value chain is not an issue of concern.

Air pollution

Since there is minimal use of fertilizers and pesticides in the jackfruit value chain, there are no ways to cause air pollution. So, this is not a concerning issue in the sustainable environment.

Inorganic solid waste pollution

The primary inorganic solid wastes in the jackfruit value chain are plastic bottles and containers used by the input suppliers and processors. Although the amount of these kinds of waste materials is negligible, most of the inorganic waste materials are thrown away. So, it is a concerning issue in the jackfruit value chain.

Organic solid waste pollution

The major organic wastes in the jackfruit value chain are jackfruit peel and the central axis. Disposal of those unused parts of fruit causes an unpleasant odor in the environment. However, a significant portion of the jackfruit peel is used as animal feed. Since it is biodegradable, organic waste is not a concern for a sustainable environment.

3.3.7 Food loss and waste

Food loss

Food loss in the jackfruit value chain is comparatively high. Food loss occurs in almost all value chain stages, such as production, harvesting, transportation, storage, wholesale marketing, and processing. In production up to the pre-harvest stage, jackfruit is infested by various insects, diseases, and other pests such as squirrels and monkeys; poor cultural management causes a significant amount of food loss. On the other hand, some farmers do not harvest fruit due to low prices. Thus, the fruit becomes ripe on the tree and ultimately rotten. Improper harvesting methods and immature & and over-mature fruit harvest also cause food loss. A significant number

of harvested jackfruits in remote areas are also lost due to a lack of proper transport facilities. The overall food loss in the whole jackfruit value chain is 27.45%, which is a highly concerning issue in a sustainable environment.

Improved production practices such as intercultural management, control of weeds, control of insects and diseases, application of balance manures & fertilizers, pruning the plants after each harvesting period, and application of irrigation during dry season could help to reduce food loss. Establishing storage facilities and boosting postharvest processing activities, as well as expanding the export marketing scope of processed products of jackfruit, will help to reduce food loss.

Food waste

Food waste in the jackfruit value chain is also very high at the retailer and consumer levels. At the retailer level, about 6.0% of fruits are wasted due to delayed selling and rotten due to rain, while at the consumer level, about 4.5% of fruits go to waste. So, the total food waste is estimated to be 10.5%. Therefore, food waste in the jackfruit value chain is a concerning issue.

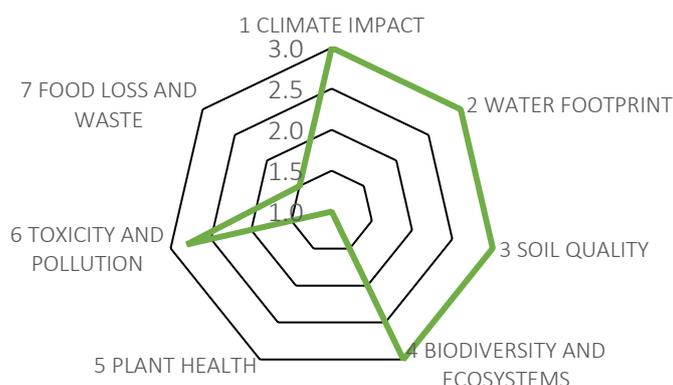
3.3.8 Environmental Analysis Overview

TABLE 5. ENVIRONMENTAL SUSTAINABILITY PERFORMANCE SCORES FOR THE VC

1. Climatic Impact		
1.1 Electricity use	3.0	Not concerning
1.2 Fuel consumption	3.0	Not concerning
1.3 Carbon footprint	3.0	Not concerning
1.4 Renewable energy use	3.0	Not concerning
Average	3.0	Not concerning
2. Water Footprint		
2.1 Water consumption	3.0	Not concerning
2.2 Water pollution and wastewater treatment	3.0	Not concerning
Average	3.0	Not concerning
3. Soil Quality		
3.1 Soil erosion	3.0	Not concerning
3.2 Soil quality	3.0	Not concerning
Average	3.0	Not concerning
4. Biodiversity and Ecosystems		
4.1 Impact on associated species	3.0	Not concerning
4.2 Status of Vulnerable Ecosystems	3.0	Not concerning
4.3 Status of ETP species	3.0	Not concerning
4.4 Responsible use of genetic resources	3.0	Not concerning
Average	3.0	Not concerning
5. Plant Health		
5.1 Application of biosecurity measures	1.0	Highly Concerning
5.2 Appropriate plant growing practices	1.0	Highly Concerning
Average	1.0	Highly Concerning
6. Toxicity and pollution		
6.1 Responsible use of fertilizers	3.0	Not Concerning
6.2 Responsible use of drugs and chemicals	3.0	Not concerning

6.3 Air pollution	3.0	Not concerning
6.4 Inorganic solid waste pollution	2.0	Concerning
6.5 Organic solid waste pollution	3.0	Not concerning
Average	2.8	Not concerning
7. Food loss and waste		
7.1 Food loss	1.0	Highly concerning
7.2 Food waste	2.0	Concerning
Average	1.5	Concerning

Figure 8 ENVIRONMENTAL SUSTAINABILITY PERFORMANCE DIAGRAM OF THE VC



3.4 Resilience analysis

Shocks usually affect the performance of economic, social, and environmental sustainability of a VC, where resilience relates to how to cope with them. There are three significant shocks affecting the jackfruit value chain (JVC), as revealed by JVC analysis. They were found to be the most relevant considering their likelihood of occurrence as well as the (potential) severity of their impact:

3.4.1 Relevant shocks and stressors

The relevant shocks and stressors in the JVC identified during interviews with the key actors are categorized under the environment, economic, and social classes. The relevancy of the shocks and stressors perceived by the VC actors and stakeholders are assessed based on their significance to the threat, the likelihood of occurrence (or re-occurrence), and the (potential) severity of the shock or the stressor.

Environmental shocks and stressors

Natural calamities, drought and flood, low rainfall, and soil and water pollution due to industrial waste are the existing shocks under the environmental issue.

Economic shocks and stressors

seasonal variation of price & demand, price control, urbanization and infrastructure development, high inflation due to global issues, etc.

Social shocks and stressors

Market control, political conflict, etc.

Health shocks - exposed to during the COVID Pandemic

3.4.2 Sustainability Impact Pathways

Impact pathways of the potential shocks in the VC identified in Step 1 are described in the following section.

Environmental shocks

The potential impacts that occurred due to environmental shocks identified in Step 1 are a decline in jackfruit production, poor quality, and high post-harvest loss. Climate change shifts the rain amount and pattern as well as the temperature profile that influences the availability of water during fruiting stages and its production. The cross-pollination nature of jackfruit and environmental parameters like sunshine influence rapid quality attributes modification like size, shape, colour, and taste. Emerging pests and diseases due to climate change also decrease jackfruit quality. The most affected actors due to these shocks are the jackfruit producers. These factors influence many producers in Madhupur to shift their land to produce other high-value crops like Malta. There is rapid industrialisation in some JVC areas. Huge wastes generated by them pollute JVC areas, which in turn affects the production and quality of the products.

Economic shocks

Economic shocks impact the overall production and transportation costs that ultimately affect the producers' incomes/returns and consumers' purchase ability. The economic crisis due to the Ukraine-Russia war made livelihood very costly, and the prices of daily commodities went beyond the general people already. This resulted in increased transportation costs for jackfruit due to increased fuel prices. Market syndicates controlled by market actors like contractors and wholesalers impact producers in getting fair prices. Road extortion in the JVC influences jackfruit prices, ultimately affecting consumers.

Social shocks

Social shocks impact VC activities as well as frustrate many VC actors. The most affected VC actors due to social shocks are market actors like contractors, distance buyers, Aratdar, and sellers directly and producers indirectly. Sometimes, political violences, like strikes, blockades, etc, causes obstacles in supplying jackfruit in remote places from production sources. It results in low market price and post-harvest loss of jackfruit if it specifically happens in harvesting season.

Health shocks

JVC activities were disrupted due to the COVID-19 Pandemic, as reported by about 60% of the respondents. In Bangladesh, strict restriction on movement was started at a time when jackfruit season had just begun, and its list was not in the category of exemption due to its low contribution to the daily essentials. This disrupts the supply chain route of jackfruit seriously. Distance buyers stopped buying jackfruit due to movement restrictions, which resulted in substantial post-harvest loss. Producers and suppliers reported economic loss but were able to tackle the situation with incomes

from other sources like borrowing, deposits, etc. Consumers at production locations increased the purchase and intake of low-priced jackfruit.

3.4.3 Resilience Domains Assessment

Resilience to such shocks is assessed based on six domains. There are three structural domains - redundancy, diversity, and connectivity and three behavioural domains - collaboration and governance, learning and adaptation, and participation and inclusion. The presence and nature of certain structural elements that may contribute to resilient value chains are evaluated under a structural domain. The ways of interaction of actors and other stakeholders' behavioural patterns contributed to resilient value chains are discussed under behavioural domains. Six domains are then classified and explained in detail in the following sections right after Table 6.

TABLE 6. RESILIENCE DOMAIN WITH CLASSIFIED HOTSPOT

Resilience domains		
Structural resilience domains		
Redundancy	Diversity	Connectivity
Behavioural resilience domains		
Collaboration and governance	Learning and adaptation	Participation and inclusion
Hotspot classification		
Not concerning	Concerning	Highly concerning

Redundancy

Redundancy, i.e., having excess capacity within the JVC, was assessed about infrastructure, finances, incomes, savings, stocks, numbers of actors performing the same function, etc. VC analysis shows that the level of redundancy across most functions in the JVC is **non-concerning**. The significant actors within the JVC at the production and market level are producers, retailers, and wholesalers. They engage in JVC activities temporarily, and most of them have multiple income sources. Infrastructure for jackfruit storage is unfeasible due to its size and seasonality. Buffer stock for jackfruit is also not feasible and relevant since its role in our diet is insignificant, and large-scale processing facilities do not exist. Instead, producers in many areas shifted the jackfruit land for the cultivation of other high-value crops due to its economic value, emerging potential alternative of jackfruit stems in making furniture.

Diversity

The level of diversity, i.e., the presence of multiple components and substitutes in terms of end markers and channels, value addition options, variety of actors in the core as well as extended VC, etc, with different risk profiles within the value chain is less and hence concerning. The end market of the jackfruit is domestic, and there is a limited international market for fresh jackfruit and jackfruit seeds. VC analysis shows that many market actors, like suppliers, wholesalers, distance sellers, etc, act independently as producers as well as retailers and control the entire market. Processing covers a very negligible part of its VC, and the number of processors mainly involved in jackfruit processing is rare. Micro- and home-scale jackfruit processing is

extending, and a segment of women entrepreneurs are engaged there. There is limited export of fresh jackfruit and processed jackfruit seeds. Diversity exists in the production systems in terms of location, but traditional technologies are still practised everywhere. Input suppliers (saplings, pesticides and insecticides, fertilizer), market actors (distant wholesalers, Aratdar, retailers), and extension workers are the core actors, but they are less accessible to JVC. JVC is rich in terms of biodiversity.

Connectivity

Identified actors within the jackfruit value chain are relatively connected and, hence, less concerning. Jackfruit production is location-specific, but consumers are spread over the whole country, and thus, robust connectivity is established for the sake of reaching the products to consumers. Distant whole sellers have direct contact with producers and purchase the tree's fruit in advance through an informal agreement. In most cases, intermediaries play a significant role in establishing connectivity between producers and Aratdar. Producers directly communicate with Aratdar to sell their products. Producers retail their products to consumers in the local markets. Mobile communication plays a vital role in keeping connected among the JV actors. A few home processors use WhatsApp and Facebook for networking and online marketing of their products. All value chain actors reported having a good relationship with input suppliers, private and government service providers, and intermediaries. No formal association was observed among the producers, but they have good connectivity with the extension workers since they provide counselling, training, and inputs for free. VC actors, particularly producers, have poor access to government financial agencies due to official hassles, but they have good connectivity with the NGOs and dadons.

Collaboration and Governance

Collaboration and VC governance about achieving everyday purposes is found to be very poor and hence highly concerning. There is no structured association or clusters within any type of JV actors who could bargain with their demand. In some locations, producer associations are visible, but they operate for multiple commodities and share price-related information among the association members to a limited extent. However, their collaboration level with the ministry is poor and ineffective. Qualitative studies showed that most of the VC actors belonged to associations or cooperatives that worked for multiple purposes. In this case, some actors, like intermediaries and wholesalers, are more organized and take advantage of price bargains. Many producers claimed that they got low prices for their products due to market syndicates controlled by market actors like contractors and wholesalers. Hence, the level of trust and transparency among the commodity platforms is questionable. At the same time, contractors and wholesalers claimed that the transportation cost of the jackfruit went up due to the increased price of fuels and road extortion.

Learning and Adoption

The level of learning and adaptation about the level of flexibility and innovation in the VC is low and hence concerning. The level of experimentation and innovation in JVC to deal with shocks is hardly observed. The attention to developing new techniques, equipment, and practices in the JV chain has low priority. The business model that exists in JVC is traditional and actors have hardly any motivation to adapt to shift in a new environment. Most of the actors are used to facing multiple shocks for multiple

produces, and there are no organized preparedness plans to face shocks specifically for JF. Many actors rely on mobile networking to gather information and warnings to monitor daily market prices, local and distance demand and supply, etc. The quick response capacity at the jackfruit producers’ level is high. They usually keep a few trees un-harvested and supply them in time of crisis at the market.

Participation and inclusion

Despite having a low level of participation and inclusion in the VC due to its work nature and engagement duration (seasonality), actors consider it non-concerning. Low producers are the most vulnerable section in JVC; they were found poorly connected and, hence, disorganized in shock response and recovery mechanism. Young people are unwilling to participate in JVC activities since there is hardly any scope for stable work scope. Women's participation is only at the production level, particularly in the handling of the fruits. There is less chance of sharing risks equally in the case of market actors. Contractors and wholesalers dominated the market, depriving producers of fair prices at the farm gate. Selling jackfruit to distant buyers helps them earn money at a time with less risk. However, distance buyers have to risk fruit damage by storm and stealing from the garden. Many labourers engaged in loading and unloading fruits to trucks have the chance of getting injured. They managed this shock by wearing gloves during this work. Despite being involved in heavy-duty work, they are low-paid and insured. They have hardly any means to tackle their adverse conditions like illness and injury.

3.5 Sustainability heat map

The overall visualization of the sustainability hotspot in the form of a heat map generated by the VC team through a rapid qualitative assessment is presented in Figure 9.

Figure 9 SUSTAINABILITY HEAT MAP OF THE VC

Economic Sustainability	Social Sustainability	Environmental sustainability
Net profits	Wages and employment distribution	Electricity use
The trend in net income	Value added distribution	Fuel consumption
Return on sales	Poverty and vulnerability	Carbon footprint
Return on investment	Discrimination	Renewable, clean energy use
Number of jobs in FTE	Women's economic involvement	Water consumption
Number of full-time jobs	Gendered division of labour	Water pollution & wastewater
Number of wage labour jobs	Gendered access to productive resources	Soil erosion
Number of family jobs	Women's decision-making & leadership	Soil quality
The average wage for hired workers	Availability of food	Impact on associated species

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Average wage proxy for family labour	Accessibility of feed	Status of vulnerable ecosystems
Total value of net wages	Utilisation of feed (nutrition, safety)	Status of ETP species
Direct value added at the VC level	Stability of food (trends)	Use of genetic resources
Indirect value added at the VC level	Respect for labour rights	Biosecurity measures
Total value added	Child and forced labour	Plant growing practices
Contribution to GDP	Job safety and security	Responsible use of fertilisers
Contribution to trade balance	Job attractiveness	Use of chemicals
Rate of integration	Collective action	Air pollution
Public finance impact	Coordination of transactions	Inorganic waste pollution
Contribution to investment	Social cohesion	Organic waste pollution
Nominal protection coefficient	Cultural traditions	Food loss
Consumer surplus	Policy, regulations & standards	Food waste
Food safety violations	Access to finance	
Consumer evaluation	Access to natural resources	
Consumer preference	Access to information	
Price relative to substitutes		
Resilience		
Redundancy	Diversity	Connectivity
Collaboration and governance	Learning and adaptation	Participation and inclusion
Key		
Not concerning	Concerning	Highly concerning

Sustainability scores for each domain, namely economic, social, environmental, and resilience, are calculated by adding up sub-domains (1 for green, 0.5 for yellow, and 0 for red) and dividing this by the number of sub-domains in the domain for which the average sustainability score to be calculated. The sustainability performance results in the form of sustainability scores are shown in Table 7.

TABLE 7. SUSTAINABILITY PERFORMANCE RESULTS IN THE FORM OF SUSTAINABILITY SCORES

SL	Domain	Results obtained
1.	Economic sustainability score (%)	61
2.	Social sustainability score (%)	48
3.	Environmental sustainability Score (%)	69
4.	Resilience score (%)	75
5.	Overall sustainability score (%)	59
6.	The number of highly concerning hotspots (Nos.)	15

Overall sustainability

The above Table shows that the overall sustainability performance of the jackfruit value chain in Bangladesh is moderate, with an overall sustainability score of 59. Social sustainability is the area where the VC shows the weakest performance, having the lowest score of 48 percent, followed by economic sustainability (61%) and environmental sustainability (69%). The resilience aspect is the second most vital area

of the VC, obtaining a score of 75%. There are 15 highly concerning hotspots in terms of value chain sustainability performance.

Economic sustainability

The JVC shows economically viable. Though there is a downward trend in net income, JVC is still profitable, as revealed by the upward trend in net profit, return on investment, and return on sales (ROS). Producers and pre-contractors have low revenue and net income, but ROS for them showed higher due to less production cost and investment. Job status along VC is poor, but there is a good distribution among families and hired labours. Still, wage and salaried jobs and full-time jobs status are highly concerning since activities along the JVC are seasonal till today and low paid in nature. Value addition indirect form is concerning and shows only 10% at the processor level. The rate of integration and contribution to investment are the two sub-domains under economic sustainability that are found to be highly concerning areas since JVC is a highly disorganized and low-priority horticulture crop to policy planners. Regarding value for end consumers, consumer preferences and consumer surplus are found concerning since people are highly concerned about sugary foods, and new generations are pretty inclined to first foods.

Social sustainability

The social sustainability performance of the VC is a low-performing domain with a high concern in inclusiveness, gender equity, and institutional strength, followed by a medium concern in social and cultural capital. Poor inclusiveness was shown in the wages and employment distribution and value-added distribution. This is because of the low participation of women in VC activities due to the nature of activities (heavy duty), cultural barriers, and lack of processing opportunities. They also affected gender equality in the JVC, particularly in the sub-domain of women's economic involvement and gendered division of labour. Regarding social and cultural capital, horizontal and vertical linkages are found highly concerning.

Environmental sustainability

The performance of VC regarding environmental sustainability is less concerning. The plant health domain was found to be highly unsustainable since its two sub-domains, like the application of bio-security measures and appropriate plant growing practices, have shown high concerns. About half of a jackfruit is inedible and discarded as waste that has a significant impact on the environment, and hence, organic solid waste generation under the pollution and toxicity sub-domain was found highly concerning. This also impacts the food waste sub-domain, leaving it as a medium concerning. However, there is a huge post-harvest loss in terms of qualitative and quantitative along the VC (about 37%) that has a significant impact on its sustainability.

Resilience

VC has shown good performance in terms of resilience. Out of six domains, one of them was found highly concerning (red), two of them found concerning (yellow), and the other three were non-concerning (green). Poor level of diversity, particularly limited access to the international market and uneven participation of the market actors, made this domain concerning. VC actors lack structured accusations and have fewer bargaining opportunities, which makes collaboration and governance highly

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concerning. The level of experimentation and innovation in JVC to deal with shocks is absent and makes the learning adoption domain concerning.

4 Upgrading strategy

4.1 SWOT analysis and strategic options

In Bangladesh, where jackfruit is widely available and has a rich cultural past, a SWOT analysis can help stakeholders, farmers, and businesses make well-informed decisions on cultivation, processing, marketing, and export plans. It can direct initiatives to strengthen the fruit's advantages, fix its disadvantages, grab opportunities, and neutralize possible threats, all of which will eventually support the nation's expansion and sustainability of the jackfruit industry. The SWOT analysis is drawn based on the economic, social, and environmental sustainability studies as well as the functional analysis, which includes the value chain map and study of possibilities and constraints in the chain.

FIGURE 10 SWOT ANALYSIS FOR THE VC

Strengths	Weakness
During the season, jackfruit is quite accessible and reasonably priced.	Post-harvest losses from jackfruit are significant, with around 37% of the product lost annually as a result of inadequate processing facilities, interest, and knowledge.
Favorable climate for jackfruit growth in Bangladesh ensures a surplus of supply.	Shallow penetration of extension services and absence of jackfruit value chain actors' associations.
Jackfruit accounts for about one-fifth of Bangladesh's fruit production.	Jackfruit is difficult to carry and store, especially when it is ripe and has a short shelf life.
Jackfruit is a valuable source of vitamins, minerals, and dietary fibre due to its richness in key nutrients, which aligns with the growing trend of health-conscious consumers.	Inadequate technology and infrastructure for safe transportation and storage influence the jackfruit value chain's overall efficiency.
Jackfruit has the potential to be exported, creating new job opportunities and giving the populace a reliable supply of food.	Due to its reputation as a backyard fruit and lack of customer preference, jackfruit has a poor market value and demand.
Over 30 products can be made from jackfruit, including jam, pickles, chutney, chips, cutlets, ice cream, curd, ready-to-cook jackfruit, fresh cut (vegetable meat), powder, and burgers.	Jackfruit has problems with quality and safety since bugs, illnesses, and chemicals can contaminate it.
Jackfruit can contribute to climate resilience, as it is a drought-tolerant crop that can grow in marginal lands and requires minimal inputs.	Jackfruit goods lack grading, quality control, and traceability.

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The cultural relevance of jackfruit in Bangladesh is evident, as its integration into local culinary practices enhances its consumption, thereby nurturing a profound feeling of identity and heritage.	The manufacturing of value-added products is hampered by inadequate processing facilities, which reduces the possibility of export and increases profitability.
Jackfruit reduces the risk of heart disease and stroke, relieves gastric ulcers, removes cancer-causing toxins from the big bowel, and protects the gastrointestinal mucous obstacle.	Inadequate investments in research and development lead to a lack of innovation in jackfruit-based products, restricting the sector's competitiveness in the global market.
Jackfruit waste is a valuable source of food for domestic animals.	Bangladesh has very few jackfruit orchards, and the majority of the fruit is grown in the homestead area.
	The terrible stench of ripe jackfruit draws flies and other insects.
	The occurrence of improvement in the jackfruit variety is infrequent.
Opportunities	Threats
The exportation of processed jackfruit has the potential to generate a substantial amount of revenue on the international market.	Jackfruit encounters competition from fruits with greater market value and demand, including litchi, banana, mango, and pineapple.
Processed jackfruit has the potential to create new business models and empower women and emerging entrepreneurs.	Changing climate and weather patterns, including storms, floods, droughts, and cyclones, present obstacles for jackfruit that can impact its growth and yield.
The growing consumer interest in and understanding of natural, organic, and healthful foods can be advantageous for jackfruit because it is an excellent source of phytochemicals, dietary fiber, and antioxidants.	Lack of policy support, infrastructure, and incentives (e.g., subsidies, financing, insurance, extension services) can hinder the development and profitability of Jackfruit.
Jackfruit can take advantage of the expanding domestic and international markets for plant-based foods because it can be utilized as a vegetarian and meat substitute.	Lack of knowledge, skills, and technology, such as improved varieties, farming practices, post-harvest management, and processing equipment, limits jackfruit quality and productivity.
Governments, research institutes, commercial companies, NGOs, and farmer associations can work together to promote jackfruit	Social and cultural elements that can affect jackfruit's acceptance and consumption, such as prejudice, ignorance, and tradition, threaten the fruit.

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production, processing, and marketing.	
Jackfruit can explore value addition, branding, and innovation by creating delicious, diversified goods with longer shelf lives and better value.	The marketability of Bangladeshi jackfruit goods may be impacted by import countries' stringent laws, which could impede export potential due to inconsistent quality requirements.
Jackfruit has the potential to profit from its status as Bangladesh's national fruit and one of the unique agricultural products in the area.	Economic downturns or worldwide variations may affect consumer purchasing power and demand for non-essential food goods like processed jackfruit.
The jackfruit value chain may benefit from government agriculture and agribusiness promotion, including infrastructure and research funding.	
Integrating jackfruit products into the tourism industry can create a unique selling point for Bangladesh, attracting visitors interested in experiencing local flavors.	

The following are the key strategic options that arise from the SWOT analysis, based on utilizing strengths and resolving weaknesses to capitalize on opportunities and mitigate against threats:

- Improving jackfruit cultivation's quality and yield through better cultivars, pest control techniques, irrigation methods, and fertilization techniques and support actors to take advantage of strong market demand.
- Developing and promoting value-added products from jackfruit, such as chips, pickles, jam, ice cream, burgers, etc. These products can extend the shelf life of jackfruit, reduce post-harvest losses, increase consumer demand, and create new market opportunities.
- Increasing the footprint of jackfruit and its derivatives on the international market, particularly in nations where plant-based meat substitutes are in high demand. Due to its meaty consistency, jackfruit can be used in place of poultry, pork, or beef in various dishes. Efforts are being made to encourage the local and international markets to adopt jackfruit patties, a recent addition to Bangladesh's export portfolio.
- Jackfruit is a climate-resilient crop that can grow in various soil and weather conditions, but it also encounters obstacles such as diseases, insects, and drought. Farmers can receive training and assistance from the Department of Agricultural Extension to increase their jackfruit yields and quality.
- Raising awareness and appreciation of jackfruit as a nutritious and versatile fruit by conducting campaigns, festivals, workshops, and media programs.

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- The establishment of vertical integration entails the integration of multiple stages within the value chain, encompassing activities such as farming, processing, and distribution. Implementing effective quality control measures and efficient cost management strategies can lead to improved outcomes in terms of product or service quality and financial performance.
- Implement quality control and safety measures to guarantee product quality consistency. Obtaining certifications for sustainable or organic agricultural practices can attract environmentally conscious consumers and enhance the brand image of jackfruits.
- Allocate resources towards research and development endeavors to enhance jackfruit varieties, processing methods, and cultivation techniques. This may result in increased productivity, disease resistance, and product innovation.
- Foster collaborative alliances between governmental entities and regional producers to guarantee a consistent and excellent provision of jackfruit. Educating individuals on sustainable agricultural practices has the potential to augment overall productivity.
- Improve the efficacy and punctuality of product deliveries to retailers and consumers by fortifying the distribution network. One possible strategy is establishing exclusive venues or forming partnerships with established distribution channels.
- Increase your audience reach by adopting e-commerce platforms. Communicate directly with customers and solicit their input by establishing an online presence via websites and social media.
- Engage in partnerships with governmental entities and non-governmental organizations (NGOs) to access initiatives, subsidies, and support programs specifically designed to advance sustainable agriculture and rural development.
- Embrace environmentally conscious and sustainable practices across the entire supply chain. This may involve energy efficiency, ethical procurement, and waste reduction, thereby appealing to environmentally conscious consumers.

To optimize the utilization of jackfruit in Bangladesh, it is imperative to prioritize improving cultivation methods, promoting a wide range of value-added products, and expanding worldwide market reach, particularly within the plant-based meat substitute industry. To capitalize on market demand, it is essential to collaborate with stakeholders, allocate resources towards research and development, enhance distribution networks, and prioritize sustainability. Additionally, cultivating partnerships can ensure consistent provision of goods and services, while using e-commerce platforms can facilitate broader outreach and engagement with customers.

4.2 Vision, Upgrading Strategy, and Theory of Change

Vision statement

The **shared and agreed vision** for the jackfruit value chain (JVC) in Bangladesh is developed by engaging relevant stakeholders during the validation and activity planning workshops and, thus, considered as realistic and achievable through successful implementation of the upgrading strategy and aligned with national development plans is:

“Improved practices and technologies along the value chain will result in increased value add throughout with a special focus on market-driven products, generating equitable increases in income and employment with the minimum environment and health impacts, and while reinforcing domestic and export-focused and resilient value chain within the next 10 years”.

Specific and measurable targets for the vision statement:

Economic:

1. The production of the JVC products increased by 50% by 2033 from 1.04million MT in 2023 to 1.56 million MT in 2033 due to the adoption of new technology and practices.
2. The export of jackfruit products increased by 10% with less than 1% incidence of buyers’ non-compliance
3. The number of jobs in the JVC increased by 10% to 5,000, with a growth rate of nearly 1% in terms of added value and efficiencies, including job creation and hiring.

Social:

1. The disparity in the share of added value at different marketing stages brought down to a target level of not less than 20%.
2. Women's engagement and their value-added share in the JVC increased by 25% from a current value of 15%.

Environmental:

1. At least 20% of producers use IPM techniques to reduce the incidence of disease by 15%.
2. Reduce post-harvest loss and waste by increasing post-production management and valorization of waste.

Theory of change narrative:

The description of the upgrading strategy for the Bangladesh JVC is a narrative of the main strategic actions that drive the achievement of the shared vision. The strategy lists out some independent activities that will address the relevant constraints responsible for reduced functionality using a system-based approach and sustains the VC functionality by merging the concerning hotspots. This is implemented by expanding organized jackfruit production, green processing, and distribution, and that will add value to the JVC and attract private sectors to invest.

Five major elements or outcomes are proposed in the upgrading strategy to reach the vision. They are described under the individual sub-heading:

- 1. Organized JVC actors use upgraded information for technology, market information, and investment possibilities:** The first proposed outcome is related to the structural level where effective and self-sustained commodity association is established with initial external funds. JVC is highly disorganized and possesses weak horizontal linkages at the production, processing, and retail levels. Effective commodity associations would be advantageous, particularly in terms of access to information, finance, networking, and support during shocks. Producers will be more connected to the upstream actors and as well as support providers that will help them in getting better prices and easy marketing of their products. They will also have direct access to support providers that will help them improve capacity in terms of training, new technology, and quality support. This community could act as a direct entrepreneur when they are supported with processing aids.
- 2. Organized JVC actors adopt improved on-farm & postharvest technologies & practices:** The common constraints in the functionality at production and post-production management are unavailability of uniform and year-round variety, increased infestation of jackfruit with insects, pests, and diseases and substantial post-harvest losses. Farmers produce their jackfruit saplings based on their needs. It is necessary to make available the saplings for improved jackfruit varieties. To do so, producers will be supported with improved jackfruit varieties by connecting them to the nursery owners, and sapling suppliers will be connected to the jackfruit breeders. As a control mechanism for the increased pest and disease infestation specifically fruit borer in JVC, the support provider will be assisted to provide training as a fee-based service; rather than directly provided for free by the project. For minimizing the huge post-harvest losses, the adoption of processing technology is the most viable option. This can be facilitated by engaging existing processors in the VC, offering different facilities from policy levels. Commodity associations can be demonstrated with a new profit-enhancing technology by a change leader and linked to a distributor who will scale up the adoption through replication.
- 3. JVC actors used modern storage and processing infrastructures:** It is noted that effective commodity associations are formed and linked to improved information in Outcome 1 and improved on-farm and post-harvest practices are ensured in Outcome 2. It is expected that these initiatives will result in increased jackfruit production due to the minimization of postharvest loss and increasing productivity. However, existing consumption patterns and marketing systems are not enough to manage these additional jackfruits. Hence, the strategy proposed in this concern is to construct storage and processing centers by the communities and the private sector in a PPP arrangement for use by VC actors. Value-added products from these processing plants should be innovative and demanded by consumers in domestic and export markets. In the case of the domestic market, consumers consumed jackfruit directly in its ripened form and vegetables in its unripened form. In this case, quick freezing technology needs to be introduced by the processors for unripe jackfruit as well as jackfruit seeds. Half of a jackfruit is thrown away as waste that pollutes the environment. However, this waste is

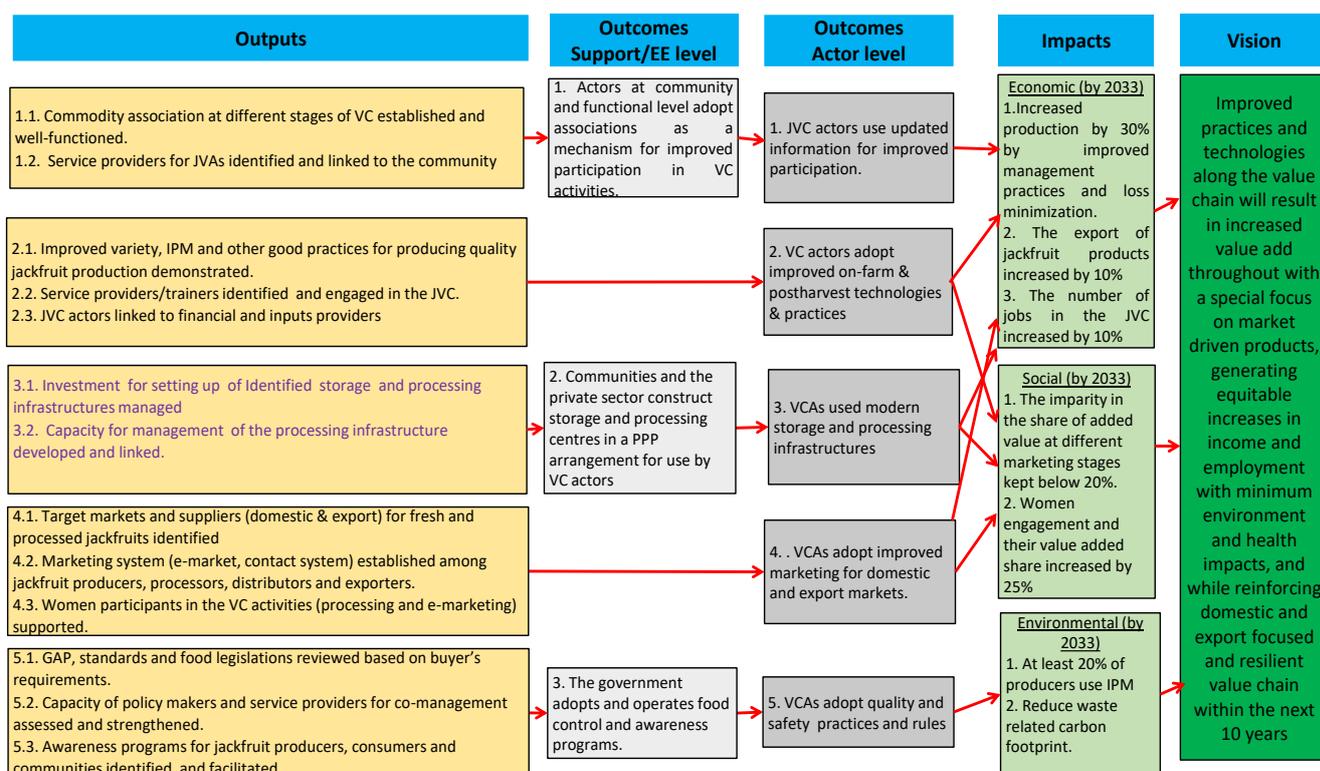
highly nutritious and can be used to extract high-value ingredients and compounds like pectin, carotene, and fiber, which are useful for the food, pharmaceutical, and cosmetic industries. Jackfruit waste and its by-products have the potential to be used as animal feed.

4. **VCAs adopt improved marketing for domestic and export markets:** The new storage and processing centers, as outlined in outcome 3, will result in diversified value-added products from jackfruits. However, the sustainability of these centers will depend on the profit obtained. One of the important catalysts to make centers profitable is the effective marketing strategy. Hence, a strategy is proposed to identify target markets and suppliers (domestic & export) for fresh and processed jackfruits, followed by establishing market linkages among jackfruit producers, processors, and distributors, and exporters. Women participants in the VC activities, particularly for home and micro-processing, need to strengthen their capacity for e-marketing.
5. **VCAs adopt quality and safety practices and rules:** To access the international market, producers have to manufacture products as per buyer's requirements. The basic food control systems have to be ensured along the JVC. Primarily, policymakers should review the GAP standards and other food legislation and amend them as per buyers' requirements. In this case, the capacity of policymakers and service providers for co-management needs to be assessed and strengthened. Awareness programs for jackfruit producers, consumers, and communities also need to be identified and facilitated.

Theory of change graphic: The graphic shown below magnified the theory of change that outlines the outputs, enabling environment/support level outcomes, actor level outcomes, and impacts leading to the achievement of the vision.

FIGURE 11 THEORY OF CHANGE FOR THE VC

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The ToC presented in Figure 3b proposed several catalytic actions as the outputs aiming to influence the structure, production, infrastructure, marketing, and enabling environment of the JVC that will lead to outcomes both at enable environment and actor levels where the VC actors and service providers are expected to change their behaviours and adopt new operations. Outputs proposed at the enabling environment level are the intermediate-level outcomes that address the behavioural changes of the enabling environment and service providers involved in the jackfruit value chain. At the same time, actors will adopt the new inputs at the actor-level outcomes. These new outcomes lead to impacts described as related to the sustainability of economic, social, and environmental domains, which in turn support the realization of the proposed vision.

Link to OCOP, FAO, and SDG framework: The ToC is linked to national needs and policies stated in various national Plans (e.g., Hand-in-Hand Initiative), Frameworks, and Acts proposed in OCOB, FAO, and SDG. The proposed strategy is in alignment with the guidance and regulations established by these documents. These documents address environment protection and waste management, engagement of private sectors in agro-processing, food standards and best practices through certification programs, production of special agricultural products and creation of employment in agriculture, encourage access to finance, and promote environmentally sustainable agro-based enterprises development. The focus of the **FAO Strategic Framework for 2022–2031** includes strengthening national capabilities in sustainable value chain developments, including crop improvement and management, post-harvest management, storage, transport, processing, and marketing, which is clearly linked to the strategy. The OCOP framework proposes four thematic areas, namely green production, green storage, green processing, and green marketing, and is in alignment with the proposed strategy.

The strategy will primarily contribute to achieving the following SDGs:

SDG 5: decent work and economic growth, especially for youth and women

SDGs 8: Decent work and economic growth, and its goal to “promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.”

SDG12: sustainable consumption and production

SDGs 13 and 15: reduce food and biodiversity loss, reverse land degradation, mitigate the effects of climate change

4.3 Upgrading activities

Considering the developed national strategy (along with vision statements in section 4.2, where the **FIVE** major elements of the strategy are explained in more detail), the upgraded business models upgraded enabling environment, and upgraded governance need to be addressed as vital activities are stated below:

4.3.1 Upgraded business models

The model indicates the improving strategies such as more scaling up, including advanced technologies, processes, standards, collaborators, markets, etc., to make a more profitable and sustainable business. This model is presented below through a narrative description:

The Business models may also describe new systems for an operation that encompass the activities of multiple actors (producers, collectors, traders, processors, exporters, consumers, etc.) from within a function or across functions at JVC. The model addressed the improved operational system that may influence the JVC actors (Outcome 2). A business model will be upgraded once the existing production operation system has been improved. In this case, the followings are the ways that jackfruit producers are improving their operations to upgrade a good business model:

Disease and insect attacks are the causes of significant losses in jackfruit production, as indicated in the literature. The average loss of jackfruits is 36.5% of total losses, while 14.2% are caused by disease, 15.1% by insects, and 6.2% by weeds. These losses may be reduced by improving operational activities like Integrated Pest Management (IPM), improved cultural practices, adoption of improved saplings, etc. As discussed in the core VC section, a part of the low income of jackfruit producers is the significant losses from pests and diseases. Farmers have low knowledge about methods of combatting pests and do not correctly follow protocols about the usage of pesticides or other deterrents. Moreover, poor advisory services received from extension organizations like the Department of Agricultural Extension (DAE) and Ministry of Agriculture (MoA), or poor participation in training on the measurements of pest management, etc., are also responsible for poor management of pests and diseases. There is even less information about the proper management of pests and diseases. Integrated Farm Management Components (IFMC), previously called Integrated Pest Management (IPM), through the farmers` field school model, farmers will be able to learn proper pest management techniques to reduce the incidence of pests and plant diseases. Besides, planting pest-repellent trees around their fields and using hard

pruning of the relatively old jackfruits may reduce the cost required for disease and insect management. In this case, the potential return from the jackfruits is expected to double the labor cost required for its management. Using the modern varieties developed by research organizations like Bangladesh Agricultural Research Institutes (BARI), which have the potential to have three production cycles per year. These cycles increase jackfruit production, which might influence the livelihood of the producers. In this case, of course, producers should adopt the saplings of the modern jackfruit varieties as indicated in the report earlier, which enable the farmers to produce year-round jackfruit. Thus, producers need to be competent in operating more advanced practices as well as adopting new and modern varieties to promote upgraded business models. The activities mentioned above, including FFS, and motivation for the adoption of improved saplings' produced from modern varieties of jackfruits by the farmers, will be facilitated by both the government and non-government extension organizations, particularly the Department of Agricultural Extension (DAE).

The strategy promotes the construction of cold storage infrastructure, having solar panels at the local level as a PPP arrangement between the government and private sector, which many producers could use by paying a service fee (Outcome 3). The business model of the proposed ownership and management arrangements is described as follows:

The government, particularly the Department of Food, under the Ministry of Food, will own the cold storage but have a management contract with a private company like Advanced Chemicals Industries (ACI). The company will charge producers a service fee to store fruits like jackfruit, making the infrastructure economically viable and sustainable. The new business model is expected to be profitable, with low costs and a wide market of producers using the service. It would also enable producers to increase their incomes by reducing post-harvest losses using cold storage. Therefore, producers even traders those will use the cold storage resulted reduce post-harvest losses and could able to increase their sale (around 30%). Besides, establishing sheds at the local markets, particularly for retailers, may accelerate the jackfruit business and make business more profitable as well as sustainable.

One of the limitations of the JVC actors is access to credits that need to upgrade their business like more production using farm inputs, more transactions for the market in shortage period, more processing the jackfruits to produce processed food, etc. Thus, a formation of actors' associations, particularly commodity (in this case jackfruit) based farmers' associations, as an upgrading activity that may help them to increase their bargaining power with the sector (Outcome 1). Once this system is created, then access to BANK or other credit-providing institutions like Micro-Finance Institutions (MFIs) by the JVC actors, particularly farmers, could be easier (Outcome 2). The low interest on the possible loans for the JVC actors should also confirmed with minimum collaterals. This interest loan should be lower than the potential gain from the produced products (raw jackfruit, processed food like chips, burgers, juice, etc.). One of the upgrading activities is to develop entrepreneurship for jackfruit processing, particularly for women, and thus, providing credits with low interest for them should be taken into consideration in the policy measures. The promotion of Good Agricultural Practices (GAP) to produce safe jackfruit, producers need to improve their capacity through providing training, credits, supplying inputs, etc. Besides, increasing

export of the jackfruit, the processed jackfruit foods should produce through establishing industries along with strong linkage with international market. Thus, the standard of the exportable products should be ensured by the concerned authorities like the Ministry of Industry and GoB through Bangladesh Standard and Testing Institution (BSTI) before making international transactions. These standards should meet the buyers' requirements to make a sustainable business agreement (Outcome 5).

4.3.2 Upgraded enabling environment

The generations of relevant policy & regulations, developed required organizations, constructed infrastructures, etc, are the upgrading activities that may promote enabling the JVC environment. However, one of the important initiatives, named policy negotiation related to upgrades in the enabling environment and stated below:

One of the requirements of the jackfruit exporting markets is the lack of established standards for fresh and processed products, which makes it difficult for VC actors in a country like Bangladesh. To increase the export through the creation of international markets, processors need to be capable of purchasing higher quality raw jackfruits (free of antibiotics or pesticide residues) to produce exportable products. Moreover, to produce processed products like burgers, chips, juice, etc., processors need to be knowledgeable about the standards of export markets regarding product and package quality/specifications through intensive training. In this regard, the Ministry of Agriculture, Ministry of Commerce, and Ministry of Industries, GoB will be supported to elaborate a set of standards for production, processing and marketing (domestic and international) through relevant policy generations. The policy should include the adoption of GAP and application of bio-pesticides while producing the jackfruits, particularly for exporting, maintaining the sets of standards given by the importers while processing and packaging the processed foods, etc. Potential processors, as well as exporters, should also visit the country where similar transactions have been successfully conducted.

The creation of rural employment supported by respective ministries like agriculture, food, commerce, and industry and engaged the rural local people in the upgrading JVC activities such as intensive jackfruit cultivation rather extensive (because of limited land) for more production, developing entrepreneurship for jackfruit processing and exporting. The engagement of rural women should be included as a policy option in the upgrading activities, especially in entrepreneurship development. At the same time, they will receive different supports (from GOs and NGOs) like credits with low interest, space for processing the jackfruits, receiving training, etc. Besides, private sectors should get the opportunity to establish an industry for producing processed foods (burgers, juice, chips, etc.) where women can get a chance to work (policy option) either full-time or part-time.

One of the options for ensuring year-round jackfruit production is the adoption of modern varieties developed from the research institute named BARI. As of today, no sufficient supply of the saplings of modern varieties is yet to be ensured. Thus, disseminating the saplings of the modern varieties to the producers through extension activities could be conducted by the Department of Agricultural Extension. Besides, the private sector may also play a great role in establishing nurseries and producing

more saplings that may be available for producers. Thus, private sectors may be leading the issue and creating employment where rural people especially women can also work. Besides, an independent government organization is needed for producing and supplying saplings/seedlings of fruits, including jackfruit, in addition to private companies.

4.3.3 Upgraded governance

The following interventions are the strategic issues that may influence the upgraded governance:

Contract farming may be a good option for securing the market of jackfruit producers. Exporters and processors may have a demand to get quality jackfruit for producing their expected product. Besides, the formation of a commodity-based farmers association may be another good option for selling out their product to local or distant wholesalers through their bargaining power with good market price. At the same time, single farmers have been facing problems (low market price) while market transaction happened between wholesalers and farmer himself.

Social media or other digital platform may create an opportunity to place notices about the quantity and specifications of the raw jackfruit, processed food produced from the jackfruit and information for sale and at what price like other products (garments, mobile and computer accessories etc.) in Bangladesh. These media may be operated by the private sector under the supervision of government organizations like the Ministry of Agriculture, Ministry of Commerce, Ministry of Industry, and Ministry of Food. This platform may also work as bridge between producers and processor/exporters/traders while processors place their request to purchase. This system may help to overcome the problems created while market transaction happened between producers and multiples traders (Faria, Bepari, pre-contractors and wholesalers) with low price.

4.4 Anticipated sustainability impact

The strategic options, as well as the vision mentioned above, are realistic to achieve through the implementation of the national value chain strategy. Improved production practices and technologies will help to increase the amount of quality jackfruit production. Use of appropriate plant growing practices like integrated pest management, following good agricultural practices (GAP), application of irrigation, and pruning plants after harvesting of fruit will also increase the gross yield of jackfruit. The amount of jackfruit production would be 1.21 million MT after five years and 1.4 million MT after 10 years.

In addition, the production of market-demanding processed products through improved processing technologies will create the opportunity to generate equitable income and employment. So, the number of job facilities in JVC will be increased by 20% after 10 years. Increasing the export of Jackfruit processed products to the international market along with the development of infrastructural facilities, particularly storage facilities, will reduce the postharvest loss and waste of jackfruit, and the expected loss reduction will be 10 % from 37.95% after 10 years.

An upgraded business model, including advanced technologies, processes, standards, partners, markets, etc., will ensure a more profitable and sustainable business in the

Jackfruit value chain. Upgraded enabling environment, particularly established standards for fresh and processed products, will enhance export marketing. In addition to these, implementing quality control and safety measures to guarantee the processed product quality consistency and obtaining food safety certification will increase the export market. Currently, the amount of export products is < 1%; it is likely to increase to 10% after the years.

Upgraded governance will also be helpful to the promotion of the jackfruit value chain. Formation of farmers group or producer cooperatives and wholesaler will purchase products from cooperative and all payments will be made through banking transfer.

Log-frame/sustainability performance target:

The sustainability performance target, including economic key performance indicators (KPI), social KPI, and environmental KPI, are given below. The log-frame is constructed to determine the long-term horizon (10 years) based on the expected rate of change in the Value chain.

TABLE 9 Key economic, social, and environmental performance indicators (Logframe)

Item	Baseline (2023)	2028 (5-years)	2033 (10-years)
Economic indicators			
Amount of JVC production	1.05 million MT	1.21 million MT	1.4 million MT
Export amount of JF products	< 1%	5%	10%
No. of Job facilities in JVC	< 10%	15%	20%
Social indicators			
Reduction of imparity in the share of added value	40%	30%	<20%
Women engagement	15%	20%	25%
Environmental indicators			
Appropriate plant growing practices	< 1%	10%	20%
Reduction of food loss and waste	37.95%	25%	10%

4.5 Investments in Sustainable Value Chain of Jackfruit

Jackfruit, a tropical fruit indigenous to South and Southeast Asia, is extensively farmed in Bangladesh. It is viewed as a promising crop for ensuring food security, generating revenue, and adapting to climate change. Nevertheless, the jackfruit value chain in Bangladesh has various obstacles, including inadequate productivity, significant post-harvest losses, little value enhancement, and insufficient market connections. Hence, there is a requirement for investments in the sustainable value chain of jackfruit to amplify its economic, social, and environmental advantages. It can involve both the government and the private sector, with potential collaborations through public-private partnerships (PPPs) or other approaches. The government can play a role in facilitating partnerships with the private sector, leveraging their expertise, efficiencies, and investment capital while aiming to reduce costs. Public-private

collaborations can benefit both parties by harnessing the private sector's knowledge and resources while also addressing societal and environmental challenges. Such partnerships can help enhance the value chain of jackfruit, ensuring sustainable production, processing, and distribution. The potential investment opportunities based on the OCOP thematic areas are:

Sustainable Production:

- Allocating resources towards the development of enhanced jackfruit varieties and seeds that exhibit adaptability to diverse agro-ecological zones, resilience against pests and diseases, and desirable qualities.
- Implementing crop management practices that improve nutrient management, water use efficiency, and soil health.
- Promoting the use of biological control and cultural methods while decreasing reliance on chemical pesticides through the implementation of integrated pest prevention and management strategies.

Sustainable Storage:

- Distributing resources towards the acquisition of post-harvest handling and treatment technology aimed at reducing physical harm, microbiological pollution, and enzymatic browning of jackfruit.
- Allocating resources towards the acquisition of sorting and packing methods that guarantee accurate categorization, labelling, and ability to track the origin and movement of jackfruit.
- Allocating resources towards the development of cold chain infrastructure and logistics to facilitate the efficient and secure movement of jackfruit from the farm to the market.

Sustainable Processing:

- Investing in on-site processing facilities to enhance the value of jackfruit through the conversion into a range of products, including dried chips, pulp, jam, juice, wine, and flour.
- Allocating resources towards low-carbon and high-efficiency processing methods that effectively reduce waste production.
- Investing in the processing of jackfruit by-products, such as the peel, seeds, and core, to produce animal feed, fertilizer, biogas, and bioplastics.

Sustainable Marketing:

- Allocating resources towards market research and analysis to ascertain the demand, preferences, and trends of jackfruit customers in both domestic and foreign markets.
- Investing resources towards marketing techniques that specifically target distinct consumer segments, including those that prioritizes health, environmental consciousness, and ethical considerations.

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- Allocate resources towards improving market linkages in order to promote long-term market growth, demand stimulation, stakeholder empowerment, and price stabilization.
- Allocating resources towards enhancing service delivery and prioritizing customer pleasure to guarantee the superior quality, safety, and convenience of jackfruit goods.

Environmental Sustainability:

- Investing in methods to use jackfruit waste material, like composting or biodegradable packaging, will help save the environment and reduce the amount of waste.

Community Engagement and Social Impact:

- The cultivation and processing of jackfruit can be a means of empowering local communities, particularly women and marginalized groups. This can have a good impact on community engagement and social impact through Community Development Programmes.

The areas of investment mentioned are in accordance with the FAO Hand-in-Hand Initiative (HHI) Investment plan (FAO, 2023), a prominent programme by FAO that aids in the execution of country-led and country-owned initiatives to expedite the transformation of agri-food systems. The ultimate objective is to eliminate poverty, eradicate hunger and malnutrition, and diminish inequalities. The HHI Investment plan combines sophisticated geospatial modelling and analytics, along with a strong partnership-building strategy, to expedite the market-driven transformation of agrifood systems.

The synergies between the OCOP thematic areas and the HHI Investment plan are:

- Both initiatives strive to optimize the economic, social, and environmental advantages of the agri-food industry, with a particular focus on improving conditions for impoverished and susceptible communities.
- Both initiatives prioritize enhancing the efficiency, excellence, and financial success of key products, such as jackfruit, which possess significant opportunities for increased value and market penetration.
- Both approaches employ a comprehensive and unified strategy that takes into account the full process of the agri-food system, from production to consumption and tackles the main difficulties and opportunities at each step.
- Both utilize cutting-edge technologies, data, and collaborations to enable the identification, planning, execution, and tracking of impactful and enduring interventions.

4.6 Investment Plan

4.6.1 Major Investment Areas

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The following broad Areas need to be considered while planning recommends investments for further development of JVC in Bangladesh:

- Capacity development of JVC actors (infrastructure, training, credits, etc.)
- Varietal development
- Adoption of GAP
- Agro-processing and innovations in products
- Strengthening the support services system
- Public-Private Partnership
- Technological interventions and their implementations
- Market development and commercialization of products and services
- Gender inclusion
- Environmental stewardship
- Institutions inclusion for legislative issues
- Reducing post-harvest loss (cold storage and post-harvest management)
- Climate-resilient, climate-smart agriculture
- Dissemination of the developed interventions among the interested groups/actors

Additionally, the Government of Bangladesh has set in place a long-term plan focusing on four strategic areas through HIH investment, including agro-processing, marketing, and commercialization; climate-resilient, climate-smart agriculture; cold storage and post-harvest management, and supply chain management; and irrigation and water management. HIH Investments in Bangladesh tackle seven critical value chains of agricultural products, including jackfruit. The investment opportunity 1 on developing multipurpose cold storage facilities aims at incremental 30% capacity for jackfruit, about USD 214 extra-income per farmer per year, and emission reduction by about 0.17M tonnes of CO₂ equivalent. The investment opportunity 2 on develop agro-processing facilities aims at developing 10% of jackfruit production into chips, 10 facilities of 10000MT each, reach of 63 000 producers, Income increased USD 256 per farmer per year, and emission reduction by about 0.03M tonnes of CO₂ (FAO, 2023).

4.7 Project Budget

Outcome 1: JVC actors use the updated information for improved participation					
Outputs	Activities	Funding source	Total Cost (USD)	Type of cost (USD)	Timing by
1.1. Commodity association at different stages of VC established and well-functioned	1.1.1 Identify the potential commodity and associated actors	OCOB	10000	Studies	Q1, 2024
	1.1.2 Formation of potential commodity association, including GoB formalities	OCOB	5000	Facilitation	Q1, 2024
	1.1.3 Preparation of operation and fund generating policies and investment plan	OCOB	5000	Facilitation	Q2, 2024
1.2. Service providers for JVAs	1.2.1 Association will be linked with financial organizations and	OCOB/Donor	5000	Facilitation	Q3, 2024

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identified and linked to the community	government and non-government service providers				
	1.2.1 Train them on fund sourcing formalities	GOB/ OCOB	10000	Technical assistance	Q3, 2024
2. VC actors adopt improved on-farm & postharvest technologies & practices					
2.1 Improved variety, IPM, and other good practices for producing quality jackfruit production demonstrated	2.1.1 Development of improved varieties that resist disease and insects	GOB/OCOB	800000	Technical	2025-2027
	2.1.2 Conduction of trails for developed varieties at different locations of the country	GOB/OCOB	200000	Facilitation	2027
2.2 Service providers/trainers identified and engaged in the JVC.	2.2.1 Identification of service providers and engaged them in production as well as post-harvest activities	Donor	10000	Studies	Q 1 & Q 2, 2025
	2.2.2. Capacity development of service providers on developed technologies of post-harvest handling	Donor	25000	Technical	Q3 & Q4, 2025
2.3 . JVC actors linked to financial and input providers	2.3.1 Identification of JVC actors and establishing a linkage between JVC actors and service providers like inputs and finance providers	OCOB	10000	Studies	1Q & 2Q, 2026
	2.3.2. Provision of monitoring to keep linkage between JVC actors and service providers	Donor	25000	Facilitation	Q3 & Q4, 2026
Outcome 3. VCAs used modern storage and processing infrastructures					
3.1 Investment for setting up of Identified storage and processing infrastructures managed	3.1.1. Identification of donors for investment to develop facility of storage and processing centers	OCOB	10000	Studies	1Q & 2Q, 2027
	3.1.2 Feasibility study on the infrastructural development like construction of cold storages	PPP	50000	Technical	1Q & 2Q, 2027
	3.1.3 Development of a few Models of cold storage and processing centres at the major producing area	PPP	200000	Facilitation	3Q &4Q, 2027 and 2028
3.2 Capacity for management of the processing infrastructure developed and linked.	3.2.1. Recruiting skilled manpower with proper facilities to promoted the developed infrastructures	Association	10000	Facilitation	1Q &2Q, 2029
	3.2.2. Organization of training for the manpower to improve their technical skilled	Donor	20000	Technical	3Q, 2029
4. VCAs adopt improved marketing for domestic and export markets					

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4.1 Target markets and suppliers (domestic & export) for fresh and processed jackfruits identified	4.1.1. Identification of markets both in domestic and international for fresh and processed jackfruits	GoB (PPP)/Donor	10000	Studies	4Q 2029 & 1 Q, 2030
	4.1.2. Established linkage between producers and markets actors	OCOB/Donor	10000	Facilitation	2Q, 2030
4.2. Marketing system (e-market, contact system) established among jackfruit producers, processors, distributors and exporters.	4.2.1 Development of apps for online market facilities	GoB/Donor	10000	Technical	3Q & 4Q 2030
	4.2.2. Organize motivational training for all actors	Donor/ GoB	25000	Technical	1Q 2031
4.3. Women participants in the VC activities (processing and e-marketing) supported.	4.3.1. Formation of women entrepreneurs group for JVC	OCOB/GoB	10000	Facilitation	2Q & 3Q 2031
	4.3.2. Organizing training for Women to improve their skilled to promote the JVC activities	Donor	25000	Technical	4 Q 2031
5. VCA's adopt quality and safety practices and rules					
5.1 GAP, standards and food legislations reviewed based on buyer's requirements.	5.1.1. Formation of authority or cell at the BSTI to generate standards safety and rules/policy for jackfruits processed foods for domestic as well as export market.	GoB	100000	Facilitation	1Q & 2Q 2032
	5.1.2. Established a national committee to formulates laws and legislations for food standards	GoB	10000	Facilitation	3Q 2032
	5.1.3. Identification of good agricultural Practices and motivate producers to adopt the GAP to produce quality jackfruits	GoB/Donor	20000	Studies and technical	4Q 2032
5.2. Capacity of policymakers and service providers for co-management assessed and strengthened	5.2.1. Formation of authority or cell with high-profile policymakers and service providers to monitor the overall management of processed foods at domestic as well as export markets.	GoB/OCOB	10000	Facilitation	1Q 2033
	5.2.2. Organizing foreign visits to developed countries to observe their value chain activities	OCOB/Donor	50000	facilitation	1Q 2033
	5.2.3. Organizing regular workshops, seminar, and meeting among policymakers and service providers regarding jackfruit value activities	OCOB	25000	Facilitation	2Q 2033

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5.3. Awareness programs for jackfruit producers, consumers and communities identified and facilitated.	5.3.1. Publicity of jackfruits and their potentiality through organizing rallies, postering, distributing leaflets etc., among the community	Association/ Donor	10000	Facilitation	3Q 2033
	5.3.2. Organizing regular programs at electronic media like TV to popularize the jackfruit	Association	10000	Facilitation	4Q 2033
Total			3485000		

4.8 Conclusion

The post-harvest loss, as well as the poor market both domestically and internationally, are the major challenges to promoting the jackfruit value chain (JVC) development in Bangladesh. Besides the lack of adoption of improved jackfruit varieties at the farmers' level, diseases, and pest attacks are also problems for jackfruit production. Quality jackfruit production is also another challenge for JVC. Moreover, no recognized processing center even no available jackfruit entrepreneurs developed those are producing processed foods from jackfruit in Bangladesh. The poor capacity of all actors is also indicating poor JVC in Bangladesh.

The promotion of jackfruit production, as well as its marketing, are needed because of its huge economic value. Besides, the conduction of research to release/develop disease and insect's resistant jackfruit varieties is inevitable, while diffusion of those developed varieties is also a major concern. Inclusion of women entrepreneurship especially in jackfruit processing while different interventions like credits, training, new market creations etc. need to be ensured. Moreover, international collaboration needs to be promoted to create markets for exporting the jackfruit as processed foods, in addition to fresh jackfruits. Necessary infrastructural development particularly cold storage that may be promoted to reduce post-harvest loss. Promoting use of environment friendly practices like GAP, IPM practices in producing jackfruit at farmers' level might be accelerated to the safe jackfruit production. Both government and private sectors will be a governance body to facilitate the services needed for the jackfruit value chain actors to run the activities which make jackfruit sustainable in Bangladesh.

5 Conclusion

The jackfruit value chain in Bangladesh is an intricate and ever-changing system that encompasses diverse stakeholders, activities, and processes, spanning from cultivation to consumption. The jackfruit has the capacity to enhance the economic, social, and environmental progress of the nation. The fruit can ensure food stability, generate income, and promote the conservation of natural resources. Nevertheless, the jackfruit value chain has certain obstacles that restrict its effectiveness and long-term viability.

Key challenges: Some of the major challenges that affect the jackfruit value chain are:

Inadequate productivity and subpar quality:

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- Relying on conventional variety results in decreased productivity and subpar quality.
- Insufficient availability of high-quality seeds, inputs, and extension services impedes productivity.
- The susceptibility to pests and diseases also has an impact on the quality and quantity of the yield.

Elevated levels of post-harvest losses:

- The perishability of jackfruit leads to a limited duration of freshness and necessitates cautious handling.
- Insufficient post-harvest infrastructure results in significant losses, ranging from 30% to 40%.
- Inadequate sorting, grading, storage, and transportation facilities are responsible for losses.

Restricted enhancement of worth and broadening of variety:

- Primarily consumed in its natural state as a fruit, with limited enhancements or processing.
- The current processing facilities are characterized by their modest scale, informal nature, and lack of efficiency.
- There is significant untapped potential for the production of valuable goods such as grain, wine, leather, and bioplastics.

Lack of strong market connections and competitiveness:

- The market is characterized by fragmentation and lack of organization, with a large number of intermediaries and high costs associated with transactions.
- Producers possess a restricted ability to negotiate, encounter price volatility, and lack access to market intelligence.
- The main challenges include the lack of customer knowledge and interest in jackfruit products, as well as worries regarding their quality and safety.
- The export potential is limited due to the lack of standardization, certification, and branding.

Key Opportunities and Solutions: Some of the possible opportunities and solutions that can address the challenges and enhance the sustainability of the jackfruit value chain are:

1. Nutritional Value:

Promoting jackfruit consumption and incorporating it into community nutrition activities is crucial as it can enhance nutrition and food security.

2. Export Potential:

Establish strategic alliances for the jackfruit value chain in order to explore export markets and upgrade packaging, quality control, and infrastructure in accordance with international standards.

3. Employment Generation:

Jackfruit production and processing can provide employment opportunities, but farmers and businesses need advanced agriculture and value-added training.

4. Biodiversity Conservation:

jackfruit cultivation may help in the protection of biodiversity by increasing biodiversity and conserving natural ecosystems, using agroecological techniques and sustainable agricultural methods.

Way forward:

- The way forward for the jackfruit value chain in Bangladesh is to take a comprehensive and integrated approach that analyses the entire value chain, from production to consumption and addresses the significant obstacles and opportunities at each stage. This approach should effectively tackle the significant challenges and capitalize on the potential opportunities at each stage.
- The successful implementation of effective and sustainable interventions entails the cooperation and synchronization of multiple stakeholders, including producers, processors, traders, consumers, government entities, non-governmental organizations, research institutions, and donors.
- The FAO's HIFI Investment plan can be advantageous for the jackfruit value chain in Bangladesh. It can facilitate the identification, planning, implementation, and monitoring of interventions that are most suitable for enhancing the economic, social, and environmental advantages of the jackfruit sector.

To tap into the immense potential of its jackfruit sector, Bangladesh can overcome these obstacles by inventive ideas and cooperative endeavors along the entire value chain. This would lead to economic growth, higher farmer earnings, and improve.

6 Recommendation

1. As jackfruit is a highly perishable fruit its post-harvest loss is about 37.9%, that we figured out from our field survey. To lessen this high amount of post-harvest loss, we need to promote the construction and use of well-ventilated storage facilities to slow down ripening and reduce spoilage. The introduction of low-cost storage solutions such as modified atmospheric storage (MAS) or evaporative cooling to extend the shelf life is another way to reduce post-harvest loss.

2. In Bangladesh, the jackfruit production rate is on the positive side but has a lower demand in the urban market due to its larger size. Conducting a consumer survey and understanding consumer behaviour can help us determine jackfruit demand in general and which kind of jackfruit is in higher demand in the market in particular. The study strongly recommends to conduct another study in this regard. Then, the Researchers can then work to establish that variety of jackfruit by taking into account the preferred size of the product.

3. We might additionally take into account the untapped vegetative aspect of jackfruit. It can be sold like baby corn, or before it reaches maturity, we can sell it so that it can be consumed as a vegetable.

4. We need more jackfruit and jackfruit that are available all year long because we intend to process our jackfruits to create a variety of products. If that is the case, we must train our farmers to apply Integrated Pest Management (IPM) and Good Agricultural Practices (GAP) and transplanting year-long varieties to increase their rate of production and meet the goals we have set for the next ten years.

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