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Agroecological Mango Business Models in Kenya

A Report of the Assessment of the Mango Business Models in Makueni Agroecological Living Landscapes (ALLs), Kenya

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November 2024

Acronyms and abbreviations

AE-I	Agroecology Initiative
AEPs	Agroecological Principles
ALL	Agroecological Living Landscape
ASDSP	Agricultural Sector Development Support Programme
B-ACT	Business - Agroecology Criteria Tool
BMC	Business Model Canvas
CBO	Community Based Organization
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
DNRC	Dryland Natural Resource Centre
GAP	Good Agricultural Practices
HACCP	Hazard analysis and Critical Control Point
HCD	Horticultural Crops Directorate
HLPE	High Level Panel of Experts
IITA	International Institute for Tropical Agriculture
ISO	International Organization of Standardization
KALRO	Kenya Agricultural Livestock Research Organization
KEBS	Kenya Bureau of Standards
KEPHIS	Kenya Plant Health Inspectorate Service
KES	Kenya Shillings
KFA	Kenya Food Authority
KIRDI	Kenya Industrial Research and Development Institute
MESPT	Micro Enterprises Support Programme Trust
MFI	Micro-finance institution
M-PESA	Mobile Money
NARIGP	National Agricultural and Rural Inclusive Growth Project
NCCFP	National Climate Change Framework Policy
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
RTD	Resistance Temperature Detector
RTI	Research Triangle Institute
RVCA	Rapid Value Chain Analysis
SDG	Sustainable Development Goals
SMS	Short Messaging System
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TOT	Trainer of Trainers
USAID	United States Agency for International Development
VC	Value Chain

Executive summary

Makueni is the leading County in Kenya in production of Mangoes. This is due to the County's favourable environmental conditions and dedicated actors within the value chain. Since 2010, Kenya has progressively been producing about 650,000 metric tonnes of mango annually, with more than 20% coming from Makueni County. The thriving mango industry in Makueni County not only generates income for the value chain actors but also addresses food security, creates employment, and promotes sustainable agricultural practices. However, this commodity is affected by challenges involving market access, post-harvest losses and quality issues. Nevertheless, opportunities exist for the actors to optimize their gains from mango production, especially through leveraging on the most feasible business models that would properly and holistically link them to markets in the entire value chain. A rapid assessment of the mango value chain by the CGIAR Initiative on Agroecology showed that there exist three business models in Makueni ALL: (i) a public processor business model where farmer groups sell their produce to a public processing company through cooperatives, (ii) a private processor business model where farmer groups sell mangoes to the private sector processors, and (iii) the conventional business model where individual farmers sell to the wholesale market through brokers. The public and private processors business models were selected for further diagnosis and analysis given their potential for a wider economic, social, and environmental impact on the local community. A comprehensive assessment of their customer segments, value propositions, channels and customer relations, income streams, key resources, key activities, as well as key partners and cost structures was conducted using the Business Model Canvas (BMC). In addition, the Business Agroecological Criteria Tool (B-ACT) was used to assess the level of integration of agroecological principles in the two business models. A Cost Benefit Analysis (CBA) of selected agroecological interventions within the two business models was also conducted.

The BMC analysis helped actors in the selected business models to identify gaps that could be addressed to strengthen their business relationships. The B-ACT results show that the private processors performed better in terms of integration of the AEPs in their operational strategies (52.4%) compared to the public processor (32.8%). The private processors' activities aligned better with principles that contribute to improved resource efficiency (76.2%) and strengthen resilience (55.6%). However, there is need to integrate more activities that contribute to secured social equity in their operations, which scored relatively low (25.6%). Farmers linked to the private processors also scored significantly high for most of the AEPs. Overall, these farmers scored 100% on resource use efficiency, 88.3% on resilience, and 52.2% on social equity. The public processor scored relatively low across most of the AEPs. It achieved a score of 49% on improved resource efficiency, 42% on securing social equity, and 7% on strengthening resilience. This means that the public processor needs to integrate more activities that strengthen resilience in its operations. Farmer groups supplying the public processor scored relatively high on principles that improve resource efficiency (85.7%). However, they performed relatively low on principles that contribute to securing social equity (20%).

The CBA analysis of both business models show positive returns on investment with repayment periods ranging between two to four years for both farm and non-farm enterprises. On-farm

interventions would take a shorter time (about two years) to breakeven than the business enterprises which would require three to four years. The outcomes and recommendations highlight strategies to enhance value creation, market access, and profitability within the mango value chain in Makueni County, and potential areas of intervention for agroecological transition.

1. Overview of the mango value chain

Mango is among the most important fruits in Kenya, second only to banana in terms of gross value and volume (HCD, 2020). It is largely produced in the Eastern and Coastal regions in Kenya and is dominated by small-scale farmers who constitute about 80% of the production, with the remaining 20% distributed among medium and large-scale producers, farmer groups and institutions. The two regions have prolonged drought periods which favour mango growth. Kenya produces an average of 650,000 MT of mango per year since 2010 generating an average of USD 84.4M per year in gross production value. In 2020, the top five producing counties were Makueni (19.7%), Lamu (19.0%), Kilifi (12.2%), Kwale (8.4%), and Meru (8.1%) (HCD, 2020).

The highest mango production in Kenya is reported in Makueni County. The County is estimated to have a total of 4,311,375 mango trees grown by about 28,696 farmers producing approximately over 303,000 MT per season. Most producers are concentrated in 18 out of 30 wards of the County. Crop diversification is common in Makueni County to help smooth varying production cycles and variable incomes. It is estimated that 61 - 80% of the population in Makueni are directly or indirectly involved in the mango value chain with about 30% involved in direct production of mangoes (MOALF, 2016).

Mango value chain in Makueni County consists of direct and indirect actors, and external influences. The direct actors include producers (smallholders, farmer groups, medium and large-scale orchards, and institutions); formal and informal aggregators; fresh mango wholesalers, exporters, and retailers; small, medium, and large-scale processors; fresh and processed mango products distributors and retailers; and fresh and processed mango products consumers. The indirect actors include input supplies (mainly mango seedling producers and agro dealers), extension service providers, transporters, export clearing agencies, Makueni County Investment Authority who does local and international promotions, and financial institutions especially banks, Micro Finance Institutions (MFIs), Kenya Farmers Association (KFA) and local farmer organizations involved in savings and credit issuance. The external influences on the value chain include climate change and variability; research and development; and National and County government policies on production, crop protection, value addition, trade, safety, and consumption. Despite the importance of mangoes to the County, 90% of mangoes are still sold in the informal markets. The main mango processor in the County, a public processing company, operates below the installed capacity of 5MT per hour, and processes only around 3,000 MT of mangoes per season, leaving about 300,000 MT of mangoes produced in the County to go to other market actors including private processors.

An analysis of mango value chain in Makueni County revealed three business models[1] with the potential of ensuring that low-income rural communities in Makueni County equitably capitalize on business opportunities in the value chain. The three business models identified through a Rapid Value Chain Analysis (RVCA) of the Mango value chain in the County included: (i) a public

[1] A business model is the combination of product/markets, internal business operations and organization, technology employed, supply and marketing links that an enterprise uses to run its business, and to succeed and grow.

processor model where producers who are formally registered in associations/cooperatives supply their mangoes to the public processing plant, (ii) a private processor model where producers in groups supply to private processing companies that produce mango puree, dried mangoes, and juices for local and international markets, and (iii) a conventional model where individual mango farmers supply the wholesale market through the informal market linkages with brokers. The later model is informal, mostly unstructured and had a myriad of challenges. This study sought to:

- Assess the challenges and opportunities (e.g., in terms of competitiveness and financial feasibility) of integrating agroecological principles (AEPs) in existing business models.
- Diagnose the current agroecological performance of existing business models with upgrading potential.
- Develop a business model upgrading strategy for the mango value chain
- Co-creating an upgraded agroecological mango business models with relevant stakeholders
- Conducting a cost benefit assessment of the agroecological transition

2. Business model diagnosis and upgrading approaches

Diagnosis of the existing mango business models was done using the three approaches: Strengths, Weaknesses, Opportunities, and Threats analysis (SWOT), Business Model Canvas (BMC) and the Business Agroecology Criteria Tool (B-ACT). This activity was done through workshops with key stakeholders in the Mango value chain. A total of 33 stakeholders participated in the workshop (16 female, 20 male). After each activity, a plenary session was held to allow stakeholders to share their views on the results and chat a way forward.

Figure 1 shows the four steps used in co-designing the improved agroecological business models:

Step 1: conducting the SWOT analysis
Step 2: Understanding the business using the BCM
Step 3: Assessing the level of integration of the 13 agroecological principles in the business model using B-ACT, and
Step 4: Using results of (i) to (iii) to co-design an improved business model.

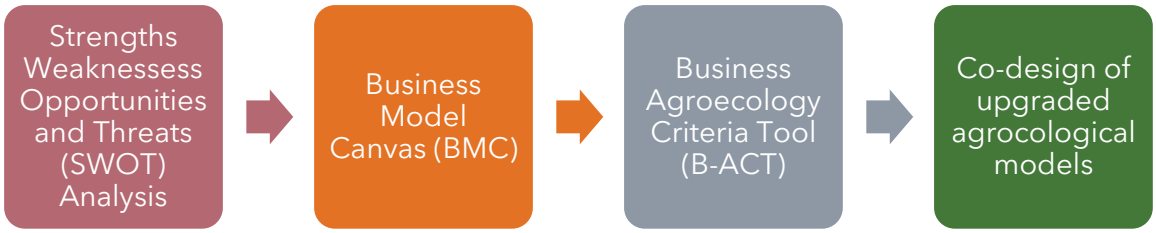

Figure 1: Steps in co-designing upgraded agroecological business model

A detailed description of the four methodologies and steps used in the business model diagnosis and upgrading is presented below.

2.1. Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis

This is the first step used in the business model diagnosis and upgrading. SWOT analysis is important in understanding strengths and opportunities of a business and pinpointing the challenges and barriers that hinder upgrading of the business model to achieve its maximum potential and efficiency (Taherdoost & Madanchian, 2021). It is a valuable tool for uncovering areas for improvement and potential growth.

In the current analysis, strength, weakness, threats and opportunities were discussed by the stakeholders in the different mango business models, including both the demand and supply side actors. The stakeholders were grouped into three groups as per the two-

business models of the mango value chain in Makueni: the public and the private processor models. Through this discussion, they identified and outlined the threats, weaknesses, strengths, and opportunities inherent in their respective business models. Afterwards, these results were presented to all participants in the workshop by a representative from the group.

2.2. The business model canvas (BMC)

Analysis of the mango business models using BMC[2] was the second step taken in the mango value chain diagnosis. BMC is a tool that allows the user to focus on one link of the value chain and helps in unveiling the actors' distinct business models. Applying BMC allows zooming in on a specific link in the chain, using a 360-degree perspective and have a clear understanding of business functionality (Lundy et al, 2014).

The tool is important in many ways: (i). it allows the user to construct canvases at any link in the value chain (e.g. between a producer and a buyer) which helps to analyse trading relationship between the two actors (ii). It also helps in facilitating dialogue between the two actors, (iii). Helps the actors to establish formal trading relationships; (iv). highlights bottlenecks and financial imbalances in the commercial relationship; (v). helps in identifying areas of innovation or improvement in the trading arrangement; (vi). Helps to evaluate how distinct business relationships between the two actors' function; and (vii). Helps to develop a shared language for description and assessment of the existing business model and create a baseline for the development of innovations in the business model.

BMC consists of the following blocks (Lundy et al., 2014):

(i) **Customer segment:** Customers are at the core of the business model because without them no business can survive. It is important to understand the needs of customers or customer segments to determine how to best satisfy their needs.

(ii) **The value proposition:** The value proposition is the reason customers choose your product or service over another. To identify the value proposition for each customer or customer segment, one must consider the problem or need that their product or service satisfies. In most cases, the value proposition has a tangible component which includes all characteristics that can be perceived

[2] The LINK Methodology is a participatory guide created by the International Center for Tropical Agriculture (CIAT) and partners in 2007 to foster inclusive commercial relationships between rural producers, especially smallholders, and modern markets.

with the five senses, such as the size of the product, nutritional composition, colour, taste, and smell. Intangible characteristics cannot be directly perceived and include properties such as health or characteristics to do with the origins of the product or the processing of the product, such as organic agriculture or fair commerce. Actors must clearly define their value proposition to their customers to make their business stand out.

(iii) **Channels**: Channels refer to how the product or service reaches and interfaces with its customers. In the case of agricultural products, the sales channel is often the same as supply chain logistics, which transfers the product from the producer to the end consumer. Transport is a common consideration in this block.

(iv) **Customer relations:** A business model must also describe the type of relationship it wants to establish with each customer segment to deliver the product or value proposition. Relationships can range from personal to automated. Key considerations in this block include communication channels, consistency of communication, cost of maintaining communication, and the potential for distinct customer relationships or customer service.

(v) **Revenue streams:** Revenue stream is made up of elements such as a value proposition that reaches a customer (segment) through a certain channel supported by a distinct type of relationship. In this block we define the actor's revenue sources including income from sale of products and by-products.

(vi) **Key resources:** This describes those physical, intellectual, financial, or human resources that are essential to create and sustain the value proposition, deliver it to the market, establish customer relationships and generate income. Resources such as land, production equipment, transport equipment, stores etc are identified and described under this block.

(vii) **Key Activities:** These are activities crucial for the business to function successfully. Like key resources, they are required to create and sustain a value proposition, reach markets, maintain customer relationships, and generate income. The activities include those associated with production, activities associated with value addition, activities associated with quality control/assurance etc.

(viii) **Key partners:** Only very few business models can operate without a support network of key partners. Partners can be divided into two groups: (a) Direct

partners with whom the company operates its core business model (e.g., producers, transporters, input suppliers, etc.); (b) Indirect partners who support or facilitate the development of the business model (e.g., financial institutions, research centres, universities, NGOs, public sector agencies, local governments, etc.).

(ix) **Cost structure:** The business model's cost structure describes the costs incurred for the creation and delivery of a value proposition, maintaining customer relationships, and generating income. Those costs are easy to determine once the key resources and key activities are identified.

A schematic presentation of BMC with the critical questions that focus the analysis and diagnosis of the business models is shown in **Figure 2**.

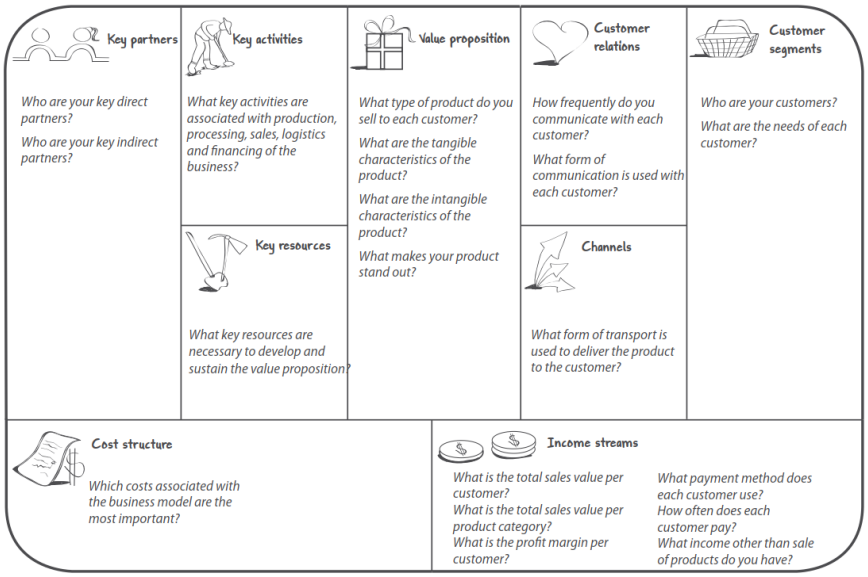

Figure 2: An illustration of a business model canvas and its blocks.
Source: Lundy et al. (2014)

This step comes after the SWOT analysis and it involves understanding the business structure across various models, encompassing both the demand and supply sides. During the workshop, the BMC was used as the primary tool for dissecting, analyzing, and diagnosing the existing business models in the mango value chain. A comprehensive introduction to the BMC was given to help participants gain a deeper understanding of its purpose and functionality, emphasizing the double-facing concept. Participants were divided into six distinct groups to facilitate hands-on learning and foster collaborative problem-solving and co-creation of knowledge, each representing a different segment of the mango supply chain and business model. These groups included farmers selling directly to the private processor, farmers selling to the public processor through the

cooperative, farmers selling through brokers to the wholesale market, the public processor itself, the private processor, and the cooperative cooperatives. This segmentation allowed participants to assess their business operations in greater detail, leading to valuable insights and constructive discussions during the workshop. **Figure 3** shows actors analyzing their business models using the BMC tool.

Figure 3: Left – public processor staff, and right- a farmer group supplying the public processor, developing their business model canvases

Photo credit: Kevin Onyango (Alliance Bioversity-CIAT)

2.3. The business agroecology criteria tool (B-ACT)

B-ACT is a tool used to assess and identify promising agroecological enterprises that contribute to sustainable food systems. The extent to which an enterprise 'inspires' is reflected in its alignment with the 13 AEPs (HLPE, 2019) while the aspect 'promising' is reflected in its business model, value-generating activities, and scalability. Under the Agroecology Initiative (AE-I), the tool is used to assess the selected business enterprises to inform on their level of agroecological adoption and potential for improvement. B-ACT evaluation includes several aspects such as the alignment of the enterprise with the agroecological principles; the potential of the enterprise to address additional AEPs; the targeted stakeholder groups (e.g., farmers, processors, consumers, government); the transformative potential of the enterprise; the scores of the assessment based on the AEPs; and the traffic light showing the degree of how agroecological an enterprise is. The evaluation using the B-ACT included the following components:

i. Agroecology Score: This was used to measure the alignment of the enterprise with the 13 AEPs.

ii. Sustainable Development Goals Alignment: This is usually used to highlight the SDGs the enterprise works towards and to what extent.

iii. Suggestions for agroecological improvement: Suggestions on how to improve the lowest scoring AEPs.

iv. Screening questions: These were used to identify practices and activities which are in direct conflict with the AEPs.

v. Impact questions: These were used for gauging the enterprises' impact on carbon, water, biodiversity, soil health, economic and social indicators.

vi. Systemic potential score: This measures the potential of an enterprise to make a systemic impact.

In the agroecological business model diagnosis, B-ACT was used in the third step (after SWOT and BMC) to understand the agroecological principles covered in each business model. This entailed a detailed analysis of activities done by the actors in the business model related to the 13 agroecological principles using guiding questions, pinpointing existing gaps, and identifying areas with a potential for interventions to transition towards an agroecological improved business model. This activity was also done in groups. The WP3 team spearheaded the discussions, using the B-ACT tool to gather comprehensive information on the activities. Post-discussion, the results from the B-ACT tool were presented to each of the six groups, highlighting areas of potential growth and opportunities for improvement. This strategic approach aimed to showcase actionable areas for improvement and outline potential pathways towards an agroecological improved business model.

2.4. Co-designing of the upgraded agroecological business model

This fourth step involves using analysis results of SWOT, BMC, and B-ACT (under steps 1-3 above), to codesign and develop upgraded agroecological business models, strategically addressing challenges identified in previous steps. Stakeholders from each of the three business models were put in three groups as per the respective business models. Their primary focus was to collectively design an improved business model, pinpointing essential activities, assigning responsibilities, setting timelines, and specifying the requisite support from other partners or stakeholders. In this session, the actors in each business model actively collaborated to outline the necessary steps for implementation, identifying individuals responsible for each task and establishing clear timelines for execution. Furthermore, they listed the type of support necessary from external partners or stakeholders that is needed for a successful transition toward the co-designed, agroecologically Improved business model

3. Mango business models in Makueni ALL

In Makueni ALL, three distinct business models were identified in the mango value chain: (i) the public processor business model where mango farmer groups trade a public processor through a cooperative, (ii) the private business model where mango farmer groups trade with private mango processor, (iii) the conventional business model where producers sell individually at farmgate to brokers or wholesalers or retailers or consumers. The first two business models are considered formal, while the third one operates informally. Some AEPs have been incorporated into these business models, both at farm level and beyond, although to a limited extent. Additionally, there are challenges within the existing business models, along with opportunities for improvement and the potential for agroecological transition.

3.1. Public processor business model

3.1.1 Business model overview

The model involves trading between farmer groups and a public processor through cooperatives **(Figure 4).** Farmers supply 50% of their mango production to cooperatives, and the rest is supplied to private sector. Currently the processing plant is owned by the government but there is an ongoing discussion to either privatize it or sell or lease some shares to stakeholders like the farmers. The public processor often contracts the cooperatives who in turn work directly with different farmer groups. The cooperative buys unripe mangoes which are kept by the processor in the shed for ripening. The mangoes are then processed to puree which has a shelf life of around two years. The plant is however diversifying into other products like mango juice.

Figure 4: Public processor business model

The tendering or procurement process is done every three years, and the County sets the prices for the mangoes which are approximately KES 18 - 21 per kilogram. The Cooperative receive KES 18 or KES 21 per kilogram from the public processor and pays KES 15 or KES 18 per kilogram to the farmers, KES 1 per kilogram goes to administration and KES 2 per kilogram is used for logistics. The County government allocates a given budget to the public processing plant every season to support operation of the plant. The plant's revenues in turn goes to the County government. The public processor also carries out workshops for the suppliers to train on quality and specifications of the mangoes supplied. The refresher workshop on the same is done on a seasonal/yearly basis to ensure supply of quality mangoes and reduced post harvesting losses.

The public processor only purchases the *apple* variety of mangoes from farmers. However, they supply both *apple* and *ngowe* varieties to other processors including the private processors and other counties and countries. The Cooperative provides means of transport to pick the mangoes from the farmer groups. However, on some occasions, the farmers are given money to hire trucks for the delivery of mangoes to the processing plant. They also provide extension services to farmers, although, the ratio of farmers to extension officers is too high such that not all farmers are reached. In addition, the cooperative owns a few coolers which are placed in the farmers' fields. The coolers can hold about 10 tons of mangoes for a maximum of five days.

3.1.2 Strengths, weaknesses, opportunities and threats of the public processor business model

Figure 5 shows the SWOT analysis results of the public processor business model, developed by the cooperative representatives, staff from the public processor and farmers supplying to the company through the cooperative.

Some of the strengths of this model include the availability of adequate farmers involved in mango production, ready market for farmers' produce, easy access to inputs by farmers through the cooperative, and availability of skilled labour and personnel. However, the model is limited in terms of transport facilities (the cooperative has only one truck), inadequate funding, poor marketing channels, and inadequate storage facilities.

The model is largely dependent on one market - the public processing company - which has limited processing capacity. Nevertheless, there exists multiple opportunities to enhance the performance of the model. For instance, farmers in this model have adequate unutilized land that can be allocated to mango production which would increase the supply of the produce to the market. However, the model faces different threats including uncertain weather conditions, emerging diseases and pests, poor road network among others.

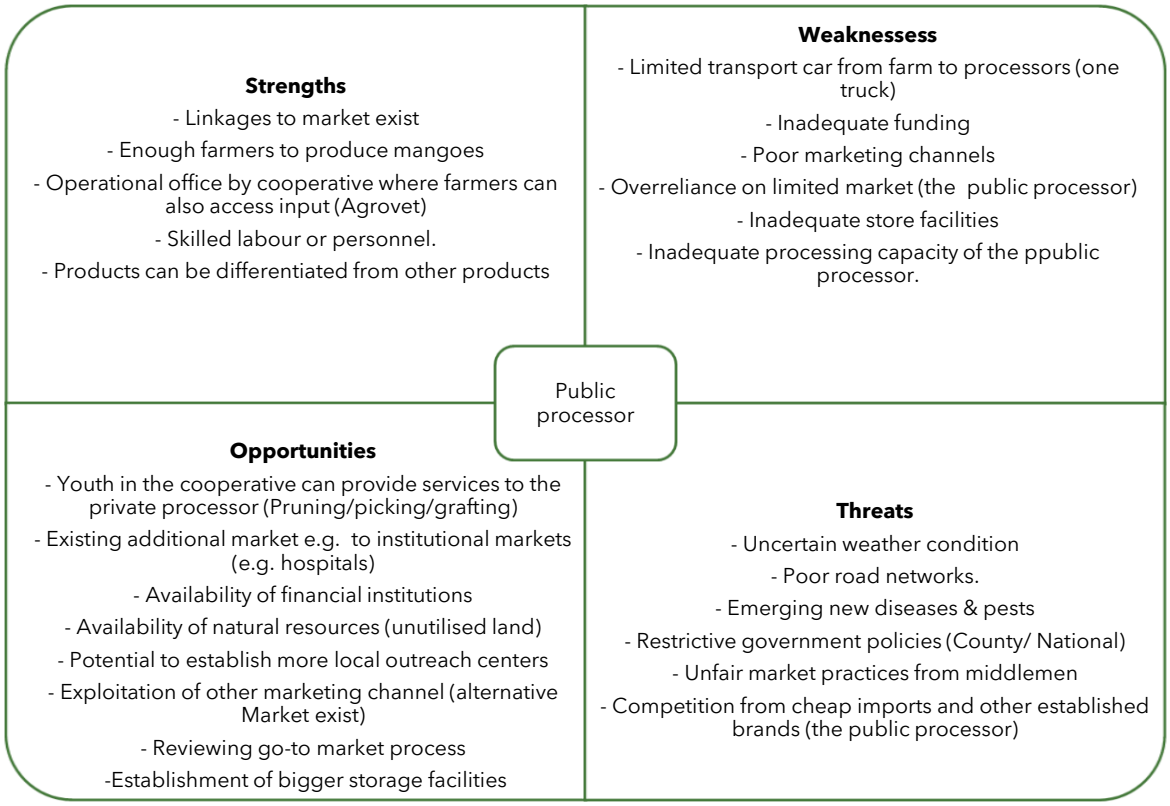

Figure 5: SWOT analysis for the public processor business model

3.1.3. Challenges facing the public processor business model

In addition to conducting a SWOT analysis, the actors discussed challenges they experience in this business model. **Table 1** shows the challenges within the public processor business model that hinder its smooth operation. Farmers group members mentioned that seasonality highly affects their production capabilities. More often, mangoes are available only one season in a year. Oversupply of mangoes when in season lowers the market prices, making it difficult for them to break even. Farmers also indicated that mango selection by cooperatives when purchasing reduces their incomes. The cooperative only buys big and medium-size mangoes, leaving the small ones with the farmers.

Cooperatives on the other hand have a limited number of extension workers and therefore are not able to reach all farmers. Even so, the cooperative does not have adequate cooling equipment for all farmers. Moreover, the processor lacks proper transportation trucks leading to high losses. Other challenges mentioned by the cooperative include limited decision making

with regards to prices, and delayed payment by the processor which leads to delayed payment to farmers.

The public processor has limited processing capacity and therefore is not able to take all the produce from farmers. Moreover, the company does not have good equipment to facilitate ripening, which makes the mangoes take long to ripen. These challenges are summarized in **Table 1.**

Table 1: Challenges facing the different actors in the public business model

Actor	Challenges experienced
Farmer groups	- The processor does not work directly with farmers but with an organized and registered cooperative/association. - There is no direct engagement between the processor and the farmer as the public procurement requires engagement with the cooperative/association. - The cooperative only purchases medium and big size mangoes, leaving the small mangoes to the farmer. - Seasonality in production leading to mango deficit during off season and flooded markets during peak season - Delayed payments from the processor to cooperative which leads to delayed payments from the cooperative to farmers - Low prices for the mangoes which makes it hard for the farmers to breakeven. - Pests and diseases in mango during production
Cooperative	- Limited number of extension workers thus not able to reach all the farmers. - Few Coolers. The Cooperative has coolers that the farmers use, however, they are few and not able to serve the farmers in all the sub counties. - Delayed payment from the processor to cooperative thus delaying payments by cooperative to farmers. - Poor transportation facilities leading to postharvest and economic losses. The mangoes are transported in the lorries with no special equipment thus high post harvesting losses. - Lack of control or engagement in pricing as the government is the one that set mango prices.
Public processor	- Low capacity of the processing plant. It takes only three days to fill the processing plant and another three days for the mangoes to ripe for processing. The processing plant is not able to absorb mangoes from all the farmers. The capacity for the extraction section is five tons per hour. - Natural ripening of the mango fruit. It takes longer to ripen the mangoes yet there is a technology that can take a shorter period to reduce the waiting time. This was not considered during construction. - Seasonality of the mango fruit in the County as it is available and in plenty for around four months only in a year.

3.1.4. Business model canvas results

Four business canvases were developed in the public processor model using the double-facing concept. The canvases include farmers facing cooperative, the cooperative facing farmers, cooperative facing public processor, and the processor facing the cooperative.

a) Farmer groups facing the cooperative

Table 2 shows the business canvas developed by the farmer groups facing the cooperative. The farmer groups supply good quality mangoes (apple variety) that are spotless and medium-to-large in size to the cooperative as required. The cooperative also requires the farmers to supply mature mangoes at the right time to reduce post-harvest losses. Farmers must also keep records of their produce as well as the amount supplied for accountability. Apple mangoes are supplied to the cooperative using different means of transport like hired trucks, pick-ups, or carts. The information is passed down to the actors using phone calls, messages (SMS), WhatsApp, face-to-ace communication, emails and *baraza* meetings.

Table 2: Business canvas done by farmers selling to the cooperative

Blocks	Description
Customer segment	- The customer here is the cooperative. - Customer needs from the farmers: The cooperative requires good quality mangoes, that are mature, spotless (no rust), and either medium or large in size; Minimum of 10 tonnes supplied at a time; Timely delivery of mangoes; and members should keep records
Value proposition	- Farmers supply the right variety of mangoes (apple mangoes) of good quality that meet global gap standards. o Quality attributes: Spotless, medium to large in size
Channels	- Delivery through hired trucks, pickups, and carts
Customer relations	- Frequent communication will be through: Phone calls, WhatsApp, Emails, Face-to-face meetings, and *Barraza's* (village meetings)
Income streams	- Current farmer groups' income streams include sale of mangoes, poultry, and livestock and livestock products. - Proposed mango prices: 1kg of mango for KES 15. - Payment methods: Instant cash (through mobile money- M-PESA), cheques - Payment period: Done immediately after supplying, or sometimes there's a two-week delay in case there is no money.
Key resources	- Farm/land - Established mango trees - Some farmer groups have coolers - Knowledge and experience in mango production
Key activities	- Production activities such as manure application, pest control, channelling water to the land during rains, timely harvesting. - Cooling using available charcoal coolers (Mangoes can be kept in the cooler for up to 5 days) - Post harvest management
Key partners	- Direct partners: the processing company and the cooperative - Indirect partners: financial institutions such as Equity Bank, transporter service providers, inputs suppliers, Syngenta, KALRO, KEPHIS, HCD and County government
Cost structure	- Cost of seed and other inputs like fertilizers and herbicides - Costs associated with labour, transport, and storage. - Service providers during pruning, sprays, cooler cost

Apart from the two main actors, the processing company and the cooperative, and the farmer groups also work with other partners like Kenya Agricultural Livestock Research Organization (KALRO), Kenya Plant Health Inspectorate Service (KEPHIS), Horticultural Crops Directorate

(HCD), County government, input suppliers' financial institutions, transporters, and other service providers to ensure timely supply of quality mangoes to the main partners. County government provides extension to farmers, while KALRO focuses on the research. Farmers also carry out different activities in mango production and post-production using the two main resources they have; the farm and the cooler to ensure quality and quantity required is achieved. Production activities include application of manure to the mango trees, pest control and channelling of water to the mango trees during rainy season to help through the dry season. Post-production activities involve timely planting and putting the mangoes in the charcoal cooler for a maximum of five days as they await the transportation to the cooperative.

Figure 6: Private and public processor business model stakeholder meeting in Makueni
Photo credit: Rosina Wanyama (Alliance Bioversity-CIAT)

All the activities in the value chain are associated with financial costs. Farmer groups incur different types of costs from production to delivery of produce to the cooperative. These include cost of inputs like fertilizer and herbicides, labour, costs of storage and transportation. The revenue, on the other hand, depends on the quantity of mangoes that each farmer supplies. The farmers currently receive KES. 15 per kilogram of apple mango supplied through cash payment,

mobile money (M-PESA) or cheque payment which is paid either immediately after delivery or after two weeks.

b) Cooperative facing farmer groups.

Table 3 shows the business canvas that was developed by the cooperative facing farmers. The cooperative provides market to individual farmers, farmer groups, and CBOs. However, the cooperative provides training on different aspects of the value chain, subsidized input, market, transport, linkages with other partners as well as capacity building on governance. Apart from the ready market, farmers also benefit from timely and regular training on different aspects of mango production and postharvest handling, subsidized input, access to finance and fair prices. All these activities need communication which is done on a weekly or on need basis using phone calls, short messages, and social media.

Table 3: Business canvas developed by the cooperative facing the farmer groups

Block	Description
Customer segment	- Customer(s): Individual farmers; Farmer groups; CBOs - Customer needs include training on mango production, input use, and quality standards, subsidized inputs, market for mangoes, transport services, linkage with other partners such as extension service providers, input dealers, capacity building on governance and group dynamics
Value proposition	The cooperative offers: - Fair buying prices - Ready market - Training on mango production practices. - Subsidized inputs and credit facilities. - Timely and regular trainings on input use, mango quality standards.
Channels	- Organic fertilizer distribution to farmers using: Motor bikes, bicycles, and lorries. - Training will be delivered through group meetings.
Customer relations	- Frequent communication through: Face-to-face trainings with individual farmers, group meetings, direct calls, SMS, and social media (Facebook, twitter). - Weekly communication or on need basis
Income streams	- Current income streams of the cooperative include hiring out of trucks and machinery, monthly subscription by members, cyber services, sale of farm inputs, grants. - Payment is done through: Cash through mobile money (M-PESA) and banks, and instant cash payment
Key resources	- Finance pool, machinery- lorries, collection centres, - Farm inputs, packaging materials - Strong linkage with mango processors
Key activities	- Training of mango producers, harvesting, transportation and marketing - Service provision on management practices - Management of collection centres - Price negotiation with the processors - Credit facility management
Key partners	- County government, individual farmers, farmer groups, Equity Bank, NGOs (MESPT, RTI).
Cost structure	- Costs related training, marketing, transport, and agro inputs.

The cooperative carries out different activities to offer the value proposition that is beneficial to different farmers. This includes training of the farmers on different topics in the mango value chain (VC), harvesting of the mangoes from the farmers' fields, service provision on management practices, marketing, and transportation of the mangoes. The transportation is sometimes done using trucks secured by the cooperative, motorcycles, bicycles or carrying on backs. Other partners involved to ensure smooth operation of the linkage include the National government through the Agricultural Sector Development Support Programme (ASDSP) and County government, individual farmers and farmer groups, financial institution like Equity Bank and the National Climate Change Framework Policy (NCCFP). Different NGOs e.g., Micro Enterprise Support Program Trust (MESPT), RTI International, and NARIGPVERT are also involved to provide support in different nodes of the model to ensure the cooperative provide good service and address some of the need of their supplies as well as smooth running of the business.

The cooperative has key resources that help them in day-to-day activities and to ensure deliverables to the farmers which include the finance, collection centers, farm inputs, packaging materials and machinery like lorries for transporting mangoes. The cooperative incurs training costs when training the farmers, marketing cost, agro-input costs, and marketing costs. This is however recovered through the different income streams, with payments made through instant cash, M-PESA or banks.

c) Cooperative facing the public processor.

Table 4 shows the business arrangement between the cooperative and the public processor as developed by cooperative. cooperative gets apple and *ngowe* mango varieties from different farmers and supplies it to different markets within and outside the country. The main market in this business model is processor who purchase only unripe apple mangoes, but they also supply other varieties like *ngowe* to private processor, open air markets like *Marikiti* in Nairobi, and other markets in the neighbouring countries like Uganda and Tanzania. The cooperative offers their customers high quality mangoes, capacity to aggregate required volumes, sweet and nutritious fruits, right maturity index, consistent supply as well as capacity to transport the mangoes to the respective customers through own trucks, hired trucks and service provider transports.

Communication is done through phone calls, emails, and social media monthly. However, sometimes communication is done to different actors on need basis. Different resources like de-sapping racks, office and staff, finance for purchasing mangoes, machinery like trucks, collection centres, harvesting and packaging products are owned by the cooperative to ensure smooth running of the business and delivery to the processor and other customers. Other activities include transportation, aggregation, harvesting, grading, and sorting to ensure value propositions to their customers. Apart from the main partner processor, the cooperative also works with other partners to support the business model in various aspects like finance, training,

market among etc.; these partners include the County government, private processor, Equity bank and NARIGP.

Table 4: Business canvas developed by cooperative facing public processor

Block	Description
Customer segment	- Customer(s): Local / regional markets, the public and private processors, Open air markets e.g., *Marikiti* in Nairobi, and other markets in Uganda and Tanzania. - Customer (the processor) needs: Good quality mangoes (Medium and big size mangoes; mangoes without skin injury and spots, apple and ngowe varieties); Consistent mango supply through the season; Big volumes (greater than 10 tons); Capacity to transport the mangoes. - The local/open/regional market needs/expect: Eye appealing mangoes; Shiny and bright; Big sized mangoes; Mangoes free from scales or rust
Value proposition	- Supply of high-quality mangoes - Supply of desired mango varieties (apple and ngowe varieties) - Aggregation of required mango volumes - Supply of mangoes at the right maturity index - Consistent supply during production seasons - Delivery of mangoes to the processor in a timely manner
Channels	- Mangoes will be delivered to the processor using: Own trucks, hired trucks, or service provider transport
Customer relations	- There will be frequent communication with the processor through: Direct phone calls; Emails or social media. - Monthly communication ideal
Income streams	- Current income streams of the cooperative include hiring out of trucks and machinery; monthly subscription by members; cyber services; sale of farm inputs, and grants. - Payment is done through: Instant cash via mobile money (M-PESA) and banks, or bi-monthly payments
Key resources	- De-sapping racks - Office and staff - Finance for mango purchases - Machinery trucks and weighing machines. - Collection centres - Harvesting and packaging labour.
Key activities	- Harvesting of mangoes - Grading and sorting of mangoes - Aggregation of mangoes from producers - Transport of mangoes to the processor - Payment of farmers and farmer associations - Training of farmers on good crop management practices - Financing of needy farmers through credit facility - Quality assurance of the mangoes - De-sapping of mangoes
Key partners	- County government; the processor; private processors; Equity Bank; NARIGP
Cost structure	- Costs associated with transport, harvesting, marketing, market survey, and purchasing capital.

All the activities in the cooperative are associated with different costs for transportation, marketing, surveys in the mango value chain, as well as cost of purchasing capital. These costs are covered by some of the revenue that the cooperative get from different sources and services offered such as hiring of trucks and machineries, revenue from monthly subscription by members, cyber services offered, sale of agro-inputs and mango fruits, as well as grants.

Figure 7: Business model discussion in Makueni

Photo credit: Aurillia Ndiwa (IITA)

d) The public processor facing the cooperative

Table 5 shows a detailed business canvas from the processor facing the cooperative. The processor provides market for fruit cooperative societies including the cooperative and private companies dealing with fruits in Makueni county to ensure smooth running of the business model and delivery of quality produce, the cooperative and the private companies expect timely payment and services offered as agreed, increased, and continued order demand and loyalty from the company. The processor on the other hand needs assurance of consistent supply for their production/ processing, timely information related to quality of the mango supplied, food and safety as well as specification and requirement associated with the same.

The processor provides a market with stable prices for mangoes to the cooperative and ensure reduced postharvest losses through purchase of unripe apple mangoes, which is one of the challenges that affects small scale farmers. the plant has also created job opportunities both at the firm level through picking and loading of the mangoes as well as the factory level. they communicate to their suppliers through phone calls, meetings, emails on need basis and through meetings which is held twice per year.

Table 5: Business canvas developed by the processor facing the cooperative

Block	Description
Customer segment	- Customer(s): Fruit cooperatives societies in the county, and private companies dealing with fruits in the county. - Customer needs: Assured and consistent market for mangoes, Timely information related on quality, quantity. - Expectations: Timely payments for the goods and service offered, increased and continued order demand, loyalty from the company, and timely handling of complaints.
Value proposition	- Reduction of post-harvest losses of mangoes in Makueni county - Stabilization of mango prices during peak season - Providing alternative market for mango fruit in the county - Production of quality puree with extended shelf life of 24 months - Increase job opportunity at both the firm level (picking and loading mangoes) and factory level (puree production, off-loading)
Channels	- Trucks (road worthy trucks which are closed containers)
Customer relations	- Communication through: Phone calls, meetings (twice a year or on need basis), Emails, and WhatsApp groups - Frequency of meetings: Twice a year or on need basis.
Income streams	- Current income streams for the processor include sale of puree. - Other upcoming income streams; Ready to drink juice (mangoes), and bottled drinking water
Key resources	- Funds to procure mangoes. - Competitive work force/ employees - Processing machinery and equipment - Factory building and structures. - Vehicles e.g., trucks, tractors, forklift etc - Water, electricity, compressed air, chiller, and effluent treatment plant
Key activities	- Mango purchasing, ripening, processing, storage, dispatch and transportation, Cooperative training on quality requirements on the fruits, product, and system certification (S MARK, HACCP, and ISO 14001)
Key partners	- County government, suppliers, banks, consumers - Research institution i.e., KALRO, KIRDI, regulatory bodies i.e., KEBS, KEPHIS - European union, USAID - Public health department, National Environmental and Management Authority (NEMA)
Cost structure	- Costs associated with purchase of mangoes and packaging. - Salaries and wages - Maintenance and repair, electricity cost, waste disposal - Personal protective equipment - Chemicals and detergents

Different resources are required by the processor to deliver their value proposition to the cooperative. this includes competitive work force/employee, enough funds to procure raw material for the processing plant, processing machineries and equipment, factory building and structures, water, and utilities. Other activities include ripening of the mangoes, processing, storage, dispatch and transportation, cooperative trainings on the quality requirement of the mango fruit and different product and system certification like S MARK, Hazard Analysis and Critical Control Points (HACCP) and ISO 14001. Apart from the activities and resources, the processor works with different partners both at the County and national level to ensure efficient operation of the plant and services offered. This includes the county government, suppliers,

financial institutions, consumers, research institutions i.e., KALRO, KIRDI, Regulatory bodies i.e., KEBS, European union, USAID and NEMA.

The processing plant incurs both fixed and variable costs to carry out different activities and in operation of the plant. This involves costs of purchasing mangoes, packaging the puree, electricity cost, salaries and wages, cost of machinery repair and maintenance, and purchasing of chemicals and detergents. These costs are however covered by the revenue that the plant gets from the sale of puree which goes directly to the county government and a part of it is allocated to the plant every year. The plant is planning to diversify its source of income to include sell of mango juices and bottled water.

3.1.5 Gaps and action points

Different gaps were identified by the actors in the business model between the farmers/ cooperative and the processor that need to be addressed to improve the business model. **Table 6** shows gaps and proposed action points.

Table 6: Gaps and action points in the public processor business model

Gaps	Action points
Mango traceability: Mangoes are rejected based on a few bad mangoes from one / few farmers as they are mixed up without traceability of the farmer who supplied them	To trace the mangoes from the cooperative and to the farmer. In case of the issue with mango only one person will be affected and not the entire group or cooperative
Post harvest handling/losses: Thorough inspection and sorting of the mangoes is done at the plant. Physical damages or punctures on the fruit even few mm, once subjected to ripening the plant loose like 8%. This is contributed by poor handling and transportation of mangoes in lorries with no special equipment.	Proper handling of the mangoes from the farm level, transportation of mangoes using required materials like crates, good harvesting, and use of recommended storage material.
Transparency in pricing and price determination: The county government set the prices without involving the farmers. The current price was determined in 2021 in collaboration with the ministry of Agriculture. (Cost of producing a kilo of mango was KES 9.80 and they trace it back to the farmers with other cost. Price to be reviewed in the year.	Inclusion of farmers and respective partners in price setting negotiations. Price review on a yearly basis to capture inflations rates.
Transportation: Transportation cost to the cooperative is quite expensive especially to the farmers who are far.	Government to come up with transportation system and farmers to come up with an initiative of purchasing their own truck/pick up by leaving like 1 or KES 2 /kg of the total mangoes supplied.
Record keeping: Farmers are not keeping records on the cost of production, yet the the cooperative set the prices based on the cost of production from the gross margin provided by the ministry of agriculture's office.	All farmers to keep records (production-sale) and adopt agroecological principles to cut input/production cost.
Coordinated trainings: There are less extension officers. Well-structured trainings. The farmers meet or being trained by different actors that they even conflict thus confusing the farmers (example different agro dealers who are promoting different pest control products). County	Harmonizing training from private processor and cooperative together with other stakeholders. This can be done through well-structured training to avoid confusing the farmers. Farmers to also be firm

government use one extension officer per ward which is hard to reach all the farmers	in their decisions on what to take up and not get confused easily. Digitalization of trainings or information. The county government is trying to take up this approach to address the issue of few extension workers.
Additional collection centres: The cooperative has only 8 collection centres. One collection centre in the 8 wards which is still not enough given the mango production in the Wards. 22 wards do not have collection centres.	Building of more collection centres. Cooperative is targeting to build one collection centres for each ward
Capacity of the cooperative: Low capacity to take up all the mangoes from the farmers. (The plant does not have the capacity to absorb all the mangoes). They also have a challenge with the ripening shed as it cannot accommodate a lot of mangoes.	Ripening shed issues has been identified and taken up by the government and are in the process of recommending if they will get another ripening shed or upgrade the one, they have. Purchase of another one is around KES 28 million

3.2. Private processor business model

3.2.1 Business model overview

This model involves two main actors: a private processing company and farmer groups **(Figure 9).** The private processor purchases medium and large apple mango variety from different farmer groups in Makueni County at KES 19/kg and deducts 5% of the total to cover for damages. The private processor contracts organized farmer groups on a yearly basis. Currently, they are working with seven farmer groups - three groups in Mbooni and four groups in Kaiti sub-county.

Figure 8: Private processor business model

The private processor provides different services to farmers like trainings on global gap, good agricultural practices, pesticide use, and recommended standards of the mangoes supplied. The

private processor produces two major value-added products, dried mangoes, and mango pulp. Dried mangoes constitute 90% of the value-added product and mango pulp 10%. They supply the pulp to the local market both in the rural and urban area and dried mangoes together with other fruits to the international market (export).

3.2.2 Strengths, weaknesses, opportunities, and threats of the private processor business model

Figure 9 shows the strengths, weaknesses, opportunities, and threats of the private processor business model. Some of the key strengths of the model include the fact that farmers are organised in functional registered groups which makes it easy for them to access services like extension and better prices for their produce. In addition, the processing company is located close to the farmers which is convenient collection/delivery of farm of produce. The contractual arrangements between farmers and the company provides ready and reliable market for farmers' produce. Nevertheless, the weaknesses within the processing company limits its ability to operate at full potential. For instance, the company has few technical assistants in the field which makes it difficult to reach all farmer groups. In addition, the company is currently using manual processing thus limiting the ability to optimize its processing capacity.

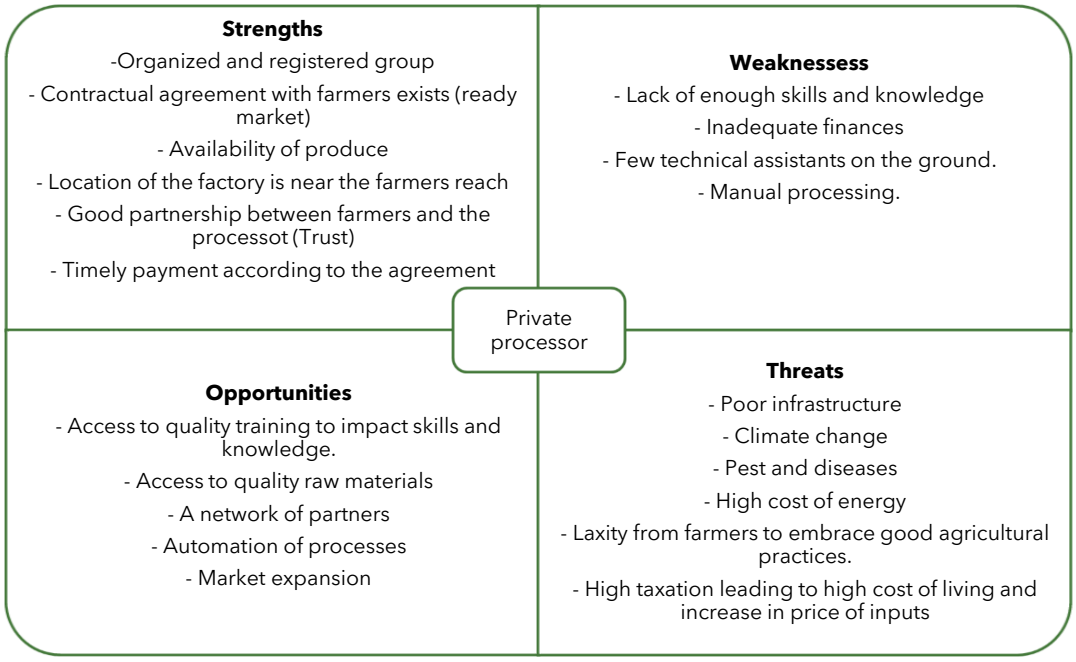

Figure 9: SWOT analysis for the private processor business model

Opportunities to enhance the company's production capacity include the availability of high-quality raw materials, opportunity to automate the processing activities, market expansion, and access to quality training to impact skills and knowledge. Potential threats to the model include climate change and variability, pests and diseases, poor infrastructure, high taxation, and laxity by farmers to embrace good agricultural practices.

3.3.3 Challenges facing the private processor business model.

The two main actors in the business model (farmer groups and the processor) face different challenges that hinder smooth running of the business arrangement on different aspects including production, financial as well as post-production.. Challenges facing farmer groups include low prices, delayed payment by the processor, low processing capacity thus leaving a lot of mangoes with the farmers, few mango pickers which increases postharvest losses, and financial constraints. The private processor lacks collection centres for the mangoes. The company also mentioned that farmers sometimes sell to brokers instead of waiting for the pickers. This may however be attributed to the fact that the pickers are few and therefore not able to reach all farmers in time. A summary of the challenges is presented in **Table 7.**

Table 7: Challenges facing the private processor business model

Actor	Challenges
Farmer/farmer groups	- Financial constraints - Challenges in spraying overgrown mangoes. - Low prices - Delays in payment - Low capacity by the private processor to absorb all mangoes thus increased post harvesting losses. - Few mango pickers by the private processor that take time to reach all the farmers. These increases post harvesting losses as mangoes continue to ripe and even rot in cases of long delays and farmers are sometimes forced to sell to the traders.
The private processor	- Lack of collection centres - Low capacity to absorb all the mangoes from the farmers. Around 80 tonnes per season. - Contract breach by the farmers. Farmers sometimes sell to brokers instead of waiting for the private processor to pick the mangoes. - Seasonality in production

2.4.3 Business model canvas results

Two business canvases were developed between the farmers and the private sector. The first business canvas was developed by farmer group facing the private processor and the second business canvas was developed by the processor facing the farmers as discussed below:

a) Farmer group facing the private processor.

Table 8 shows the business model canvas developed by farmer group facing the processor. The farmer groups supply high quality organically produced mangoes to the processor; these are mangoes that are large or medium in size, mature and free from diseases. The mangoes are delivered by farmers using ox carts, pick-ups or the processor picks the fruits from the farmers'

farms. To understand the time of delivery, time of pick up and any other information the farmers communicate to the processor through phone call or regular visits which is done on a weekly basis.

Table 8: Business canvas developed by farmer groups facing the private processor

Blocks	Description
Customer segment	- Customer(s): The private processor - Customer needs/expectations: Ripe, big to medium size mangoes, mangoes free from diseases and pests, mangoes free from scratches, cracks, or skin damage, organically produced mangoes
Value proposition	- Mangoes free from disease and inorganic pesticide, good size and mature - Adequate and quality mangoes.
Channels	- Mangoes will be delivered to collection centres through: Ox carts, pick-up, hired lorries. - The private processor picks from farmers using tucks
Customer relations	- Regular weekly farm visits - Communication through phone calls
Income streams	- Income streams for farmers: Sale of fresh graded mangoes and other crops - Preferred mode of payment; Mobile money - Payment to take two weeks from delivery
Key resources	- Farm inputs e.g., manure - Manpower/labour - Land - Farm equipment's (wheelbarrows, pumps, pruning saw, secateurs)
Key activities	- Production activities - Transportation to collection centres - Financing e.g., FSA, table banking, mobile loans
Key partners	- The private processor, County agriculture officers, Micro finance - NGOs e.g., MESPT, agro- input suppliers - Research organizations
Cost structure	- Costs related to input, transport, and financing.

The farmers use different resources and carry out different activities to ensure supply of quality mangoes to processor. This includes farm inputs, trainings from the processor, manpower, farm, and farm equipment such as wheelbarrows, pumps, pruning saw and secateurs. The activities conducted include pruning, spraying, transportation to the collection centre as well as financing related activities through table banking and mobile loans. In addition to the processor, the farmers also work with the County government officers, especially from the ministry of agriculture, who help with extension services and agro-input suppliers/ agrovet supply input, microfinance institutions that provide financial services like loans, and NGOs/research organizations who majorly deal with research, innovations, and trainings across the value chain. The costs incurred by farmers in this business model include input costs, transportation, and financing costs. These costs are partly covered by the revenue they get from selling mangoes to processor which they receive through phone (M-PESA) and is paid on a biweekly basis.

Figure 10: Alliance staff supporting farmers supplying private processor to develop a business model canvas. Photo credit: Kevin Onyango (Alliance Bioversity-CIAT)

b) Private processing company facing the farmer groups.

Table 9 shows the business canvas developed by the private processor facing the farmer groups. The processor purchases mangoes from farmer groups and farmer cooperatives at KES 19/KG, which is considered a good price. Through this linkage, farmers receive support inform of subsidized input and trainings on harvesting, good agricultural practices (GAP) and organic production of mangoes. The private processor also links farmers to donors like MESPT, ensure timely purchase of produce from farmers and provide support in harvesting and transportation.

Table 9: Business canvas developed by private processor facing farmer groups.

Block	Description
Customer segment	- Customer(s): Farmer groups and farmer cooperatives - Expectations: Timely payments for the mangoes supplied, inputs e.g., fruit fly traps, trainings
Value proposition	- Competitive prices - Support through input supply - Training of harvesters - Training on GAP certification and organic farming - Timely purchase of mangoes from farmers - Linkage to donors e.g., MESPT - Technical support in mango harvesting. - Transportation service
Channels	- Trucks for transportation - Crates for packaging - Workshop for trainings - Website
Customer relations	- Frequent communication through phone calls, messages, physical meetings, and website messages - Weekly communication

Income streams	-	Current income streams for the processor include donor and investor funds, and investors, processing of pineapple, coconut, banana, papaya, passion, French beans, avocados, and dried chili. - Mode of payments: Cash payment using mobile money (M-PESA), or banks - Farmers paid within two months after supply
Key resources	-	Technical assistants to help in the trainings, trucks, - Harvesters (people who do mango picking) - Funds - Machines for drying. - Packhouse
Key activities	-	Gap training - Training in organic mango production - Extension service - Field inspection - Farm level certification - Input supply e.g.., fruit fly traps for IPM
Key partners	-	Farmer Groups, MESPT, USAID, WYLDE - County government - Alliance of Bioversity and CIAT - Banks
Cost structure	-	Costs associated with transport, inputs, and training cost on staff and TOTs

They also organize workshops where farmers receive trainings and provide a lot of information on different topics across the value chain on their websites where farmers can access at any given time. They communicate to the farmers through phone calls, physical meetings, text messages and through their website on a weekly basis.

To ensure service delivery to the farmers, processor provides training on GAP and organic production, extension services, field inspections, certification, and provision of input supply like fruit fly traps to the farmers. This is done with the help of resources that they have such as trucks, harvesters, funds, machineries for drying fruits and the pack house. They also partner with different stakeholders across the VC to ensure smooth running of the business model. This includes the County government, financial institutions, NGOs such as MESPT, CIAT, USAID and WALYDE.

The business arrangement is associated with both costs and revenue. The processor incurs transportation costs, input costs and training costs on staff and ToTs to ensure good service delivery. They also receive revenue to help with the expenses from three main channels; donor funding, investors and selling of the processed products which includes pulp and dried fruits from processing of mangoes, pineapple, coconut, banana, papaya, passion French beans avocados and dried chili.

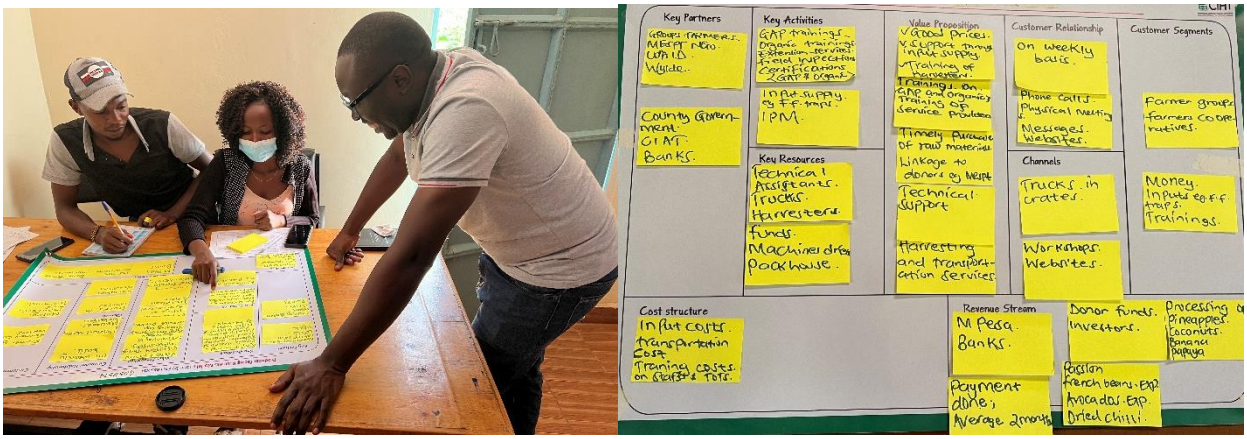

Figure 11: Alliance staff assisting private processor representatives to develop a business model canvas.

Photo credit: Aurillia Ndiwa (IITA)

3.4.4 Gaps and action points

Table 10 shows the gaps, action points, and areas of support by the AE-I to help in smooth running of the business model. Addressing the gaps in the business model will help in providing solutions to some of the challenges that the business model or the actors are facing, hence improving the efficiency of the model.

Table 10: Gaps and action point in the private processor business model

Gaps	Action points	Area of support by the AE Initiative
Payment period: The private processor is currently paying the farmers after a period of two weeks to two months. This seems challenging to some farmers who may fail to timely meet their financial plans	Farmers to be paid better e.g.., some percentage of the total value of mangoes supplied and the remaining at an agreed later date. This is still under discussion.	
Low capacity: The current contract states that the company takes only one ton per farmer per season, but this is still low compared to the volume of mangoes that are left in the farmers' fields	There is need to increase the quantity of mangoes that the processor buys from the farmers	Expansion of the packhouse and ripening shed to increase the processing capacity
Few fruit pickers: Very few mango fruit pickers come from the processor, which increases the time taken to complete harvesting from one farmer.	The processor needs to increase the number of fruit pickers and/ or the collection centres to be able to reach all the farmers on time. There is need to train the farmers on how to harvest the fruits by themselves so that they avoid waiting pickers form the processor.	
Pricing: The processor is currently in the process of letting the farmers do picking and transportation to the collection centres	The processor needs to ensure that they cater or cover the transport and picking	

on their own. This is a change in policy that is still under discussion.	cost during pricing and ensure inclusivity of farmers in discussing the changes	
Record keeping: Farmers do not keep records on the cost of production to help with price negotiation.	All farmers need to keep records (from production to sale). Farmers also need to adopt agroecological principles to reduce the cost of inputs and hence production costs	
Training needs: Limited knowledge on good post-harvest handling including storage and transportation.	The trainings should focus on: - Mango harvesting innovations to reduce post harvesting losses. - Transportation requirement - Training and use of agroecological principles including organic products cost of production	Training of farmers on organic production, good agricultural practices, leadership, and market linkages.
Collection centres: Limited collection centres make it hard for the private processor to pick mangoes from each farmer.	The processor is working to get support to build collection centres. Currently, MESPT is planning to build one for Kaiti and Mbooni	Explore possibility of partnering with development partners to build simple collection centres.

The farmer groups/cooperatives requested support on: (i) Training on leadership, (ii) Market linkages - they need more buyers apart from the private and public processor, (iii) Collection centres - there is need to collaborate with all actors in the value chain to put up more collection centres designed cooling facilities. These would be simple collection centres made from locally available materials, involving timber, and charcoal among other materials. Every actor was suggested to hold stake in the facility establishment, with some responsible for bringing timber/poles, charcoal, roofing materials, provision of labour, among others. The facilities will be established in areas where many farmers within the locality can easily access them. Th private processor requested support on; (i) Expansion of the packhouse and ripening shed to increase the processing capacity, (ii) Training of farmers on organic mango production and GAP standards, and (iii) Exploring possibility of partnering with development partners to build collection centres. The public processor requested support with regards to certification of the processed products for export market, and environmental management certification.

4. Results from the B-ACT assessment

The B-ACT tool was used to assess the general alignment of the businesses (enterprises) identified in the three business models with the three pillars of sustainable food systems. B-ACT contains screening questions to rapidly determine whether an enterprise's business model, operations or strategy are potentially in conflict with agroecology. Each node of the two business models were assessed.

Under the **private processor model**, the results show that the **private processor** demonstrates a commendable agroecological performance, exhibiting a high overall score **(Table 11, Figure 12).** Its operational strategies align with key agroecological principles (AEPs), which can be categorized into three domains: improved resource efficiency (76.2%), strengthened resilience (55.6%), and secured social equity (25.6%). Specifically, the private processor employs 11 out of the 13 AEPs, albeit with varying degrees of emphasis. These include animal health (100%), input reduction (86%), recycling (67%), co-creation and knowledge sharing (67%), synergy (64%), biodiversity (44%), economic diversification (36%), soil health (34%), connectivity (33%), fairness (33%), and social values and diets (20%). However, certain agroecological principles remain conspicuously absent from the private processor's operational framework. These include participation and land and natural resource governance. Nonetheless, there exist opportunities for enhancement within enterprise. Notably, the principles of social values and diets (40%), connectivity (33%), economic diversification (18%), recycling (17%), and input reduction (14%) can be further integrated and optimized to elevate the enterprise's overall agroecological performance **(Figure 13).**

Table 11: Alignment of the mango business enterprises with agroecological principles (%)

Agroecological principle	Private processor engaging farmer groups	Farmers groups engaging private processor	Public processor engaging Cooperative	Farmers engaging Cooperative
Overall agroecology score	**52.5**	**52.4**	**32.8**	**54.3**
Improve resource efficiency	**76.2**	**100.0**	**48.8**	**85.7**
Recycling	67	100	83	100
Input reduction	86	100	14	71
Strengthen resilience	**55.6**	**88.3**	**7.3**	**57.2**
Soil health	34	100	-	67
Animal health	100	100	-	100
Biodiversity	44	78	-	56
Synergy	63	82	-	36
Economic diversification	36	82	36	27
Secure social equity	**25.6**	**52.2**	**42.2**	**20.0**
Co-creation of knowledge	67	100	33	33
Social values and diets	20	80	20	20
Fairness	33	67	33	33
Connectivity	33	33	100	33
Land and natural resource governance	-	-	-	-
Participation	-	33	67	-

In alignment with:

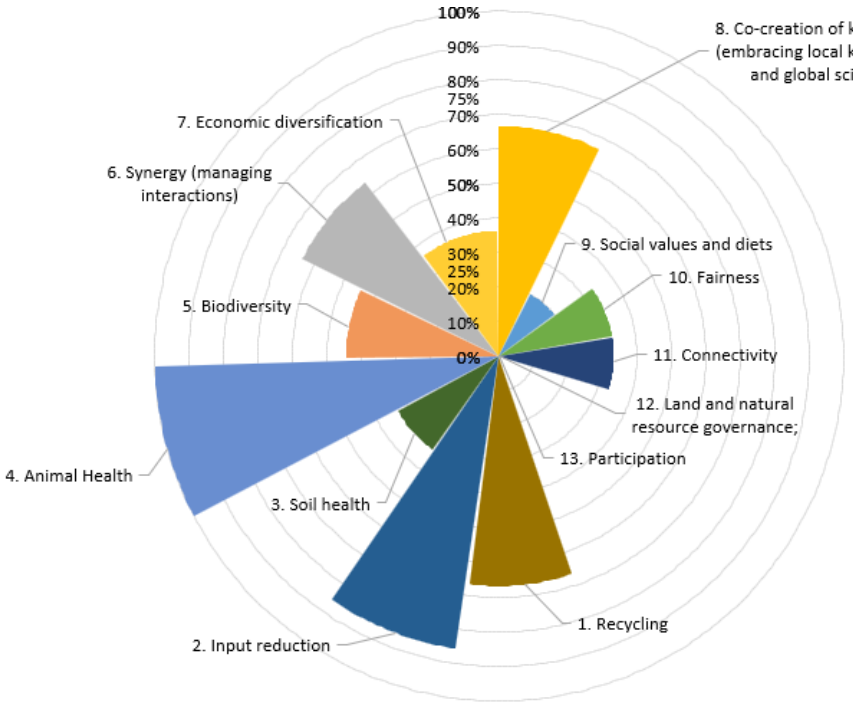

Figure 12: B-ACT results of the private processor engaging farmers groups showing alignment and areas of potential for strengthening agroecology principles

Potential for:

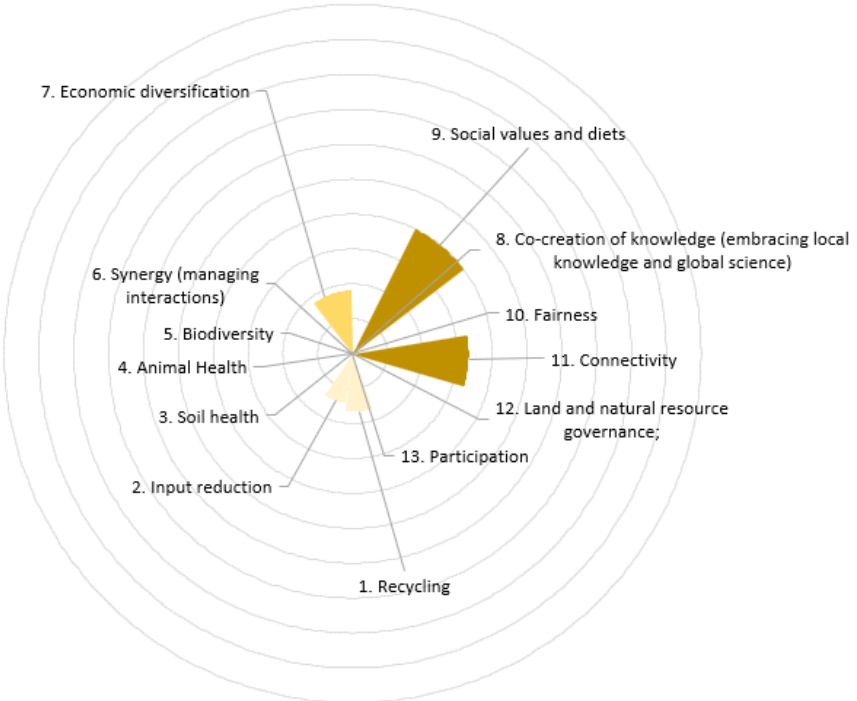

Figure 13: B-ACT results of the private processor engaging farmer groups showing areas of potential for strengthening agroecology principles

The results in Table 11 also show that production activities undertaken within the mango enterprise by the **farmer groups engaged with the private processor** exhibit a high degree of alignment with AEPs. These activities closely relate to 12 out of the 13 AEPs, including recycling, input reduction, soil health, animal health, biodiversity, synergy, economic diversification, co-creation of knowledge, social values and diets, fairness, and participation. On the overall, these farmers scored 100% on resource use efficiency, 88.3% on resilience, and 52.2% on social equity. On the other hand, none of the farm activities aligned with land and resource governance **(Table 11 & Figure 14).** There is however a significant potential for integration of more AEPs by these farmers. Specifically, certain practices related to connectivity, synergy, and fairness possess the potential to inspire a transition towards more sustainable food systems **(Figure 15).** Realizing this potential may necessitate capacity-building efforts such as training and sensitization for the farmer groups to adopt these associated practices effectively.

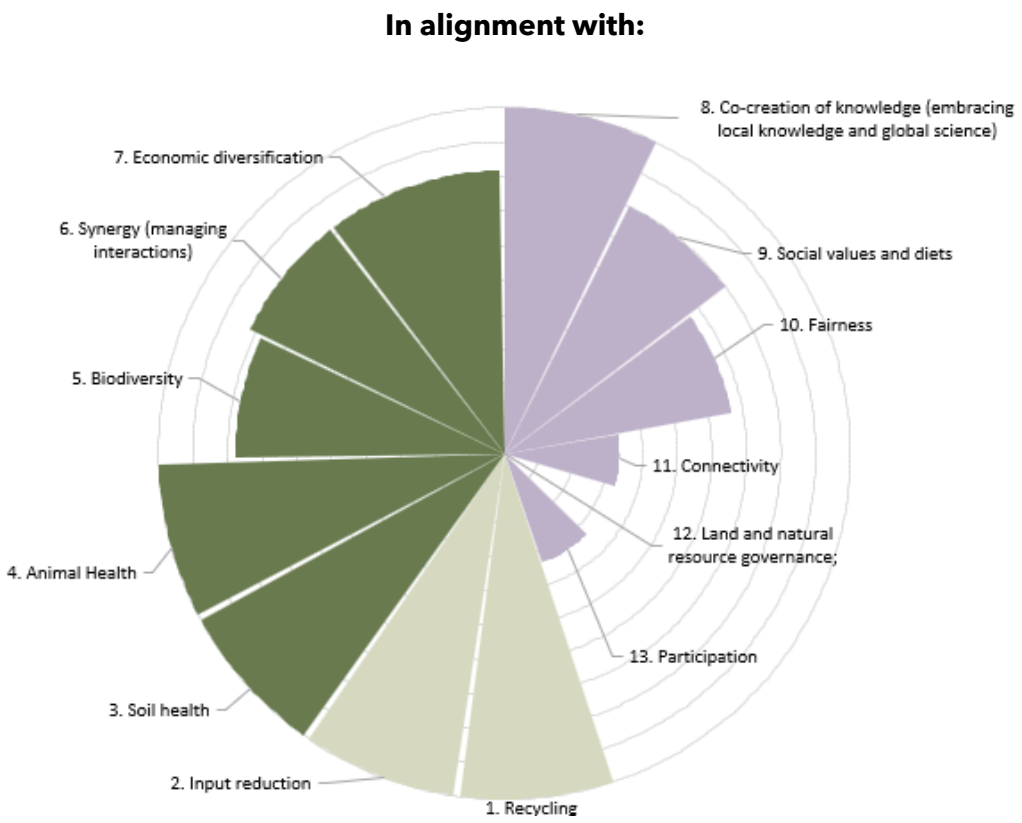

Figure 14: B-ACT results of the farmer groups engaging the private processor showing alignment with agroecology principles

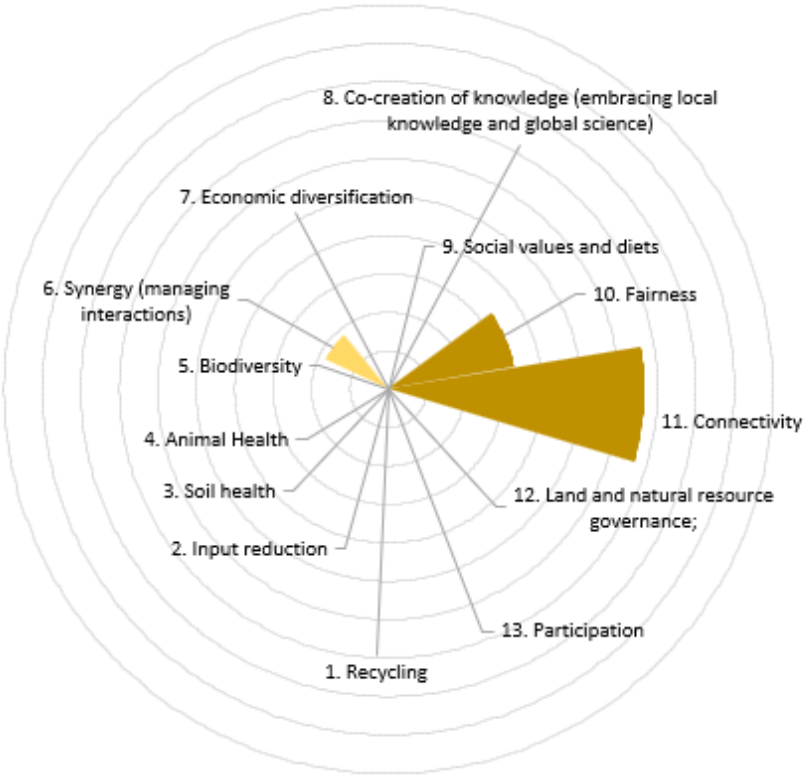

Figure 15*: B-ACT results of the farmers groups engaging the private processor showing areas of potential for strengthening agroecology principles*

Under the **public processor model,** results show that the **public processor** has, to a significant extent, incorporated three AEPs into its operations. These include recycling (83%), participation (65%), and connectivity (100%) **(Table 11 & Figure 16).** However, the integration of other AEPs within the public processor framework is less pronounced, with economic diversification (37%), fairness (35%), co-creation of knowledge (32%), social values and diets (19%), and input reduction (15%) being integrated to a lesser degree **(Figures 16 and 17).** Notably, several other AEPs have yet to find their place in enterprise's operations. On the overall, the results show that the public processor achieved a score of 49% on improved resource efficiency, and 42% on securing social equity, and only 7% on strengthening resilience. These scores imply that while the public processor is presently incorporating a few AEPs in with respect to two domains, but its yet to fully integrate principles associated with strengthening resilience.

In alignment with:

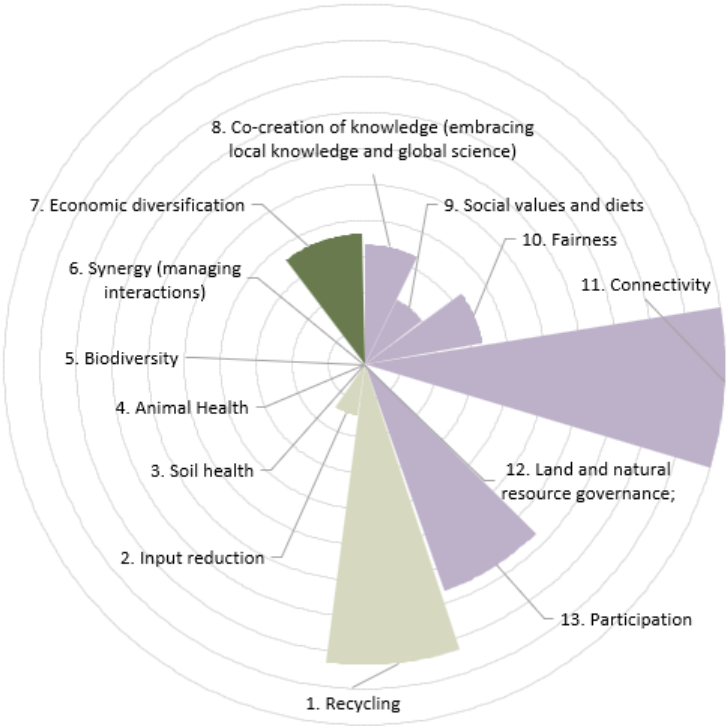

Figure 16: B-ACT results of the public processor engaging farmers through the cooperative showing alignment with agroecology principles

Potential for:

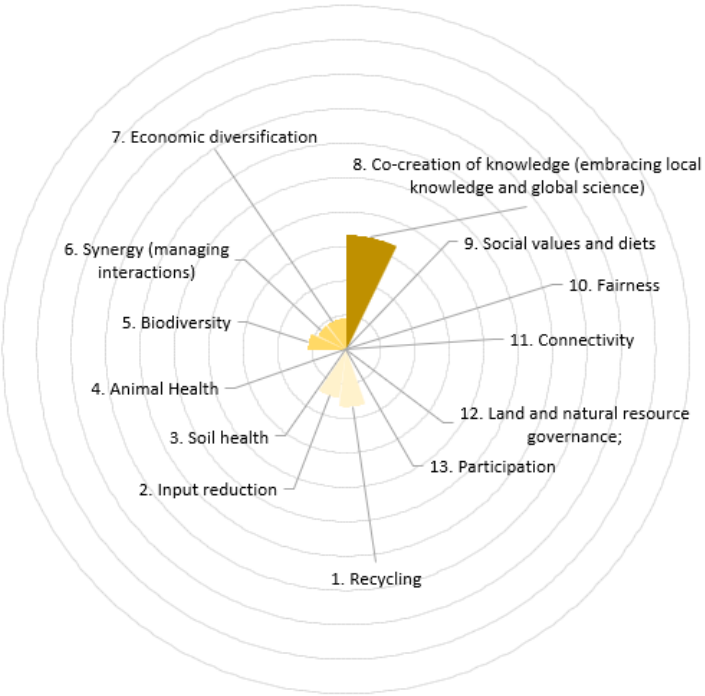

Figure 17: B-ACT results of the public processor engaging farmers through the cooperative showing areas of potential for strengthening agroecology principles

Farmer groups supplying the public processor through the cooperative achieved a score of 85.7% on improving resource efficiency, 57.2% on strengthening resilience and 20% on securing social equity **(Table 11).** Furthermore, the results highlighted a strong connection to incremental change, as evidenced by their alignment with principles encompassing recycling, input reduction, soil health, animal health, biodiversity, synergy, and economic diversification **(Figures 18 and 19).** Farm-level activities demonstrated robust alignment with recycling and animal health. There was moderate alignment with input reduction, soil health, and biodiversity, while the least alignment was recorded on synergy and economic diversification.

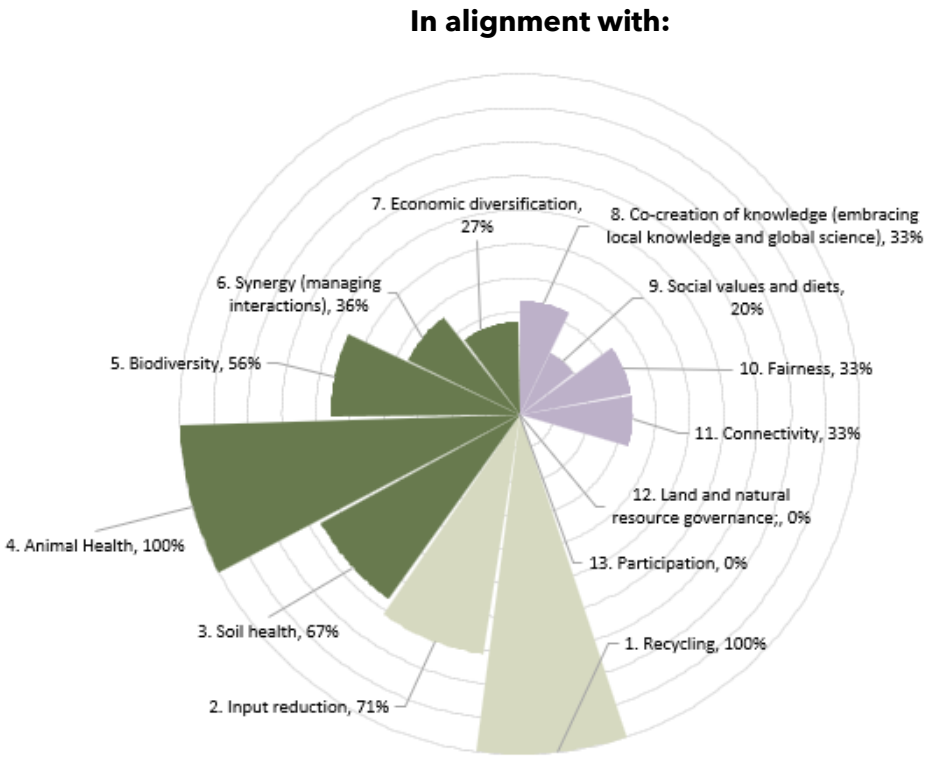

Figure 18: B-ACT results of farmers engaging the public processor through the cooperative showing alignment with agroecology principles

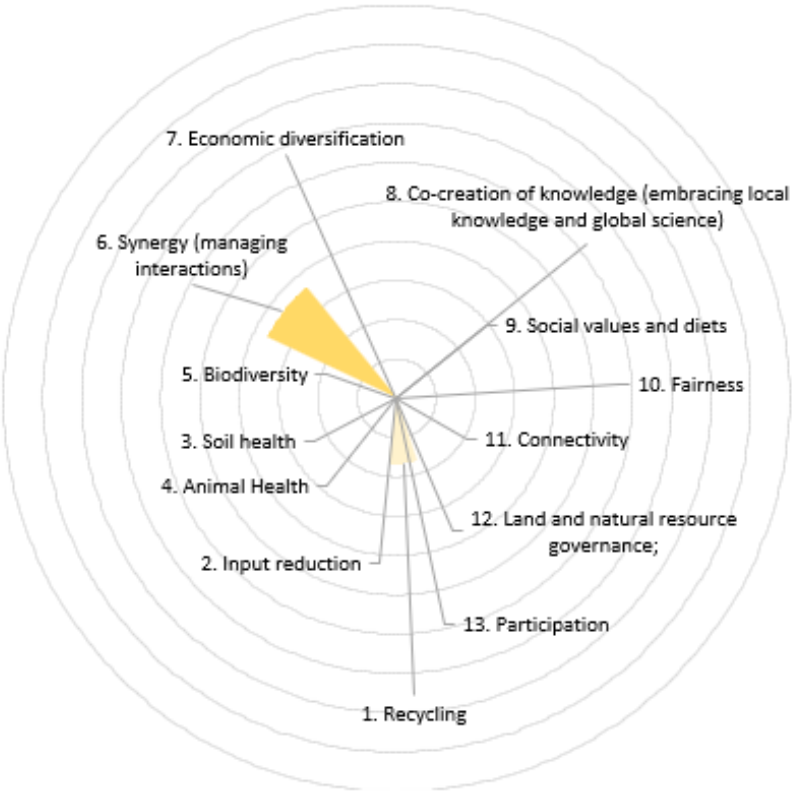

Figure 19: B-ACT results of farmers engaging the public processor through the cooperative showing areas of potential for strengthening agroecology principles

Tables A1-A3 (see the appendices), show the alignment of AEPs in the two business models. The activities are summarized under each specific AEPs. The results are arranged based on practices that improve resource efficiency (Table A1), strengthen resilience (Table A2), and improve social equity/responsibility (Table A3).

5. Upgraded agroecological business models

The design of upgraded agroecological models was done in a stepwise process. First, all stakeholders in the two mango business models (private and public) were invited for a two-day workshop. The primary objective of this meeting was to collectively design improved business models based on the gaps and action points identified in the public **(Tables 6)** and private **(Table 10**) business models. In addition, the B-ACT results in each model were used to identify AEPs that could be improved/strengthened through implementation of the proposed action points. For each action point/objective, the actors identified key activities that need to be done, indicators to track progress, status of the indicators at the start of the upgrading process, expected target, person(s)/institutions responsible for the activities and the supporting actors, time frame to achieve the overall target, estimated costs, financing plan, and the relevant AEPs to be improved or strengthened once the activities are implemented (see Table A4 in the appendices). Two follow-up meetings were done in the subsequent months to assess the progress in implementation of the action points, challenges experienced, and potential solutions. The results in Table A4 (in the appendices) show a detailed plan of activities and status of implementation of the activities as of June 2024, and the revised targets for the subsequent 6 months.

In the private processor model, some of the activities that were proposed include training of farmers on integrated pest management (IPM), record keeping, financial management, climate smart agriculture, adoption of resilient crop varieties, and proper harvesting. In addition, the private processor was required to streamline its internal financial system to enhance payment of farmers within a shorter period and expand the company to increase the volume of produce from farmers. By June 2024, the company was taking 50 tons of mangoes every week, but this needed to improve to 80 tons per week by December 2024. In the public processor model, the proposed activities include certification of farmers to promote standardization of products, training on agroecology and record keeping, identification and utilization of alternative markets, increased access to financing, and management of postharvest loss. A significant progress had been made especially on capacity building where about 8000 farmers had been training in agroecology and record keeping. Adoption of the proposed activities in both models is expected to strengthen the business relationship between actors and increase the adoption of various agroecological practices, which would eventually lead to gradual agroecological transition.

Implementation of the activities was however faced with several challenges. For instance, participants in the private model mentioned that the process was constrained by climatic/weather related challenges – especially excess rains and drought, poor infrastructure in the ALL, and poor participation of farmers in group activities. On the other hand, challenges in the private model include financial constraints, ignorance/illiteracy among farmers land disputes, poor road network and strict market standards.

6. Cost benefit analysis of agroecological transition

To understand the profitability of agroecological transition, the AE-I team conducted a cost benefit analysis (CBA) of selected interventions proposed for upgrading the two business models. A CBA shows whether an agroecological intervention is profitable by comparing the total costs versus the benefits. Data for analyses was obtained from an in-depth survey conducted with the public and private processing companies, and five farmers from each of the two business models. Four indicators of CBA were computed:

i) Net Present Value (NPV) – this is a sum of all the future cash flows of an enterprise to determine the present value and shows if the intervention's predicted financial return will be more than the current investment. A positive value of NPV shows that the investment is profitable,

ii) Internal Rate of Return (IRR) – this is the discount rate at which the NPV is equal to zero or the discount rate at which the total present value of inflows equals the total present value of outflows. An IRR greater than the assumed discount rate (cost of capital on investment) shows that the investment is profitable,

iii) Discounted payback period (DPP) - this shows the length of time needed for the interventions to breakeven taking time value of money into account. A shorter payback period is preferred as it reduces any potential risk associated with the agroecological investment and is more profitable, and

iv) Benefit Cost Ratio (BCR) – this shows the cost effectiveness of an intervention. A profitable intervention has a CBA greater than one, implying that the benefits outweigh the costs.

Table 12 shows the bundled agroecological interventions that were considered in the CBA. The interventions were selected by AE-I research team together with the improved business models representatives following a set of action points proposed for the upgrading of the models.

Table 12: Agroecological interventions assessed in the mango business model

Actor	Interventions
Public processor	i) Product diversification (specifically organic products) ii) Diversification of marketing channels iii) Postharvest handling practices (use of proper transportation materials like crates, support in training on postharvest handling and storage)
Private processor	i) Physical expansion of the production facility ii) Product diversification iii) Market diversification iv) Organic input production using the black soldier fly (BSF) v) Capacity building on postharvest handling practices
Farmers (those supplying both public and private processors)	i) Intercropping of mango trees with other crop like maize and beans ii) Use of organic inputs in the production of the mango and intercrops iii) Postharvest handling practices (including training on proper postharvest handling and storage, use of locally improvised cooling collection centers

(e.g., charcoal coolers or simple shades), and more efficient procurement and delivery processes.)

Farmers in both models were evaluated for a similar set of interventions including intercropping, use of organic inputs, and improved postharvest handling including the use charcoal coolers, simple shades, and a more efficient procurement and delivery system. The public processing company was assessed for a combination of interventions including diversification of processed products and marketing channels and improved postharvest handling techniques. The interventions at the private processing company includes the physical expansion of the processing company, diversification of the processed produce and marketing channels, production of organic inputs using black soldier fly (BSF) and improved postharvest handling.

Table 13 shows the results of the CBA for agroecological transition. At farm level, the NPV was USD 362 and USD 369 for the public and private models respectively. This value was significantly lower for businesses in the public model having an NPV of USD 11,948 compared to USD 55,802 for the private model. The positive values of NPV shows that the agroecological investment in both models is profitable but higher in the private model. The IRR in both models is greater than the assumed rate of 13.6% (over 100% at farm level and over 15% at business level) indicating that the investment is profitable. At firm level, the proposed agroecological upgrading interventions will take about two years to breakeven in both models, while businesses would require 3-4 years to achieve their return on investment. The BCR values are greater than one at both farm and business level showing that the investments are cost effective.

Table 13: CBA indicators of the upgraded agroecological mango business models

Indicator	Public processor model		Private processor model	
	Farmers	Business	Farmers	Business
NPV (USD)	362	11,948	369	55,802
IRR (%)	103	37	226	16
Payback period (years)	2	3	2	4
BCR	1.69	8.76	1.23	1.79

Notes: CBA, cost benefit analysis; NPV, Net Present Value; IRR, Internal Rate of Return, BCR, Benefit cost ratio.

In addition to the economic benefits assessed through the CBA, agroecological transition is associated with social and environmental benefits. While these were not quantified in this study, respondents were asked about their perception on the social and health benefits associated with different agroecological interventions. The results point to multiple perceived benefits from both private and public models. For instance, the use of organic inputs was associated with better human health resulting from consumption of foods that are free from harmful chemical residues. In addition, the use of organic inputs was associated with improved soil health and improved biodiversity. From a social perspective, the trading relationship between farmers, input service providers, and off-takers creates a sense of trust and mutual support. Contractual agreements also promote a good business relationship between farmers and traders which promotes

adherence to contracts. Further studies are needed to quantify the social, health and environmental benefits of agroecological transition.

7. Conclusion

Under the CGIAR Initiative on *Transformational Agroecology across Food, Land, and Water Systems*, the WP 3 team in Kenya conducted a rapid assessment of the mango value chain Makueni ALL. The primary objective of this research was to gain insights into the actors involved and their roles, assess the level of adoption of agroecological principles, identify potential business models, and pinpoint key constraints and opportunities for agroecological transitions. From the results, three business models were identified in mango value chain in Makueni county ALL These include: (i) the public processor model where farmer groups sell their produce to the County public processor through cooperatives, (ii) the private processor model where farmer groups sell to the private sector processors, and (iii) the conventional model where individual farmers sell to the wholesale market through brokers. Based on these results, a follow-up workshop was help with key stakeholder engaged in the three business models. The purpose of the workshop was to diagnose the performance of existing business models with upgrading potential, by applying SWOT, BMC and B-ACT and assess the challenges and opportunities (e.g., in terms of competitiveness and financial feasibility) of integrating AEPs.

The SWOT analysis and BMC tool were used to diagnose the performance of the enterprises and B-ACT was used to assess the level of integration of AEPs. SWOT analysis of the public business model show that the model has several strengths including availability of adequate mango producers, ready market, and accessible farm inputs through the cooperatives. However, the model is limited in terms of existence of only one buyer (public processor) which does not have adequate processing capacity hence not able to absorb all mango produced. In addition, there is only one truck used to transport mangos form farmers to the processing plant, and the whole model suffers from inadequate financing. Several opportunities are reported for this model. Farmers have adequate unutilized land that can be allocated to mango production which would increase the supply of the produce to the market and on the other hand the processing plant has adequate space for expansion, based on funds availability, which would help increase its processing capacity.

SWOT analysis of the private business model reports more strengths and opportunities than the weaknesses and threats. The fact that farmers are organized in functional registered groups which makes it easy for them to access services like extension and better prices for their produce is a key strength for this model. There are also several private processors who buy mangos, therefore increasing market opportunities for the producers. Farmers also have contractual agreements with the private company buyers which increases commitment to sell and buy. The fact that these private processors do not have adequate technical assistants in the field to work with mango producers is a big weakness and it brings a risk of farmers producing poor quality mangoes. The private company has an opportunity to automate its processing activities (currently operated manually), which will increase processing capacity and speed. Climate change and variability, pests and diseases, poor infrastructure, high taxation, and laxity by farmers to embrace good agricultural practices are threat that affect both models.

The BMC results showed the strengths of these actors with respect to their business operations as well as potential areas for upgrading. The B-ACT results showed that within the mango value chain actors were already employing a significant number of AEPs in their operations. For instance, most businesses scored highly on practices related to resource use efficiency i.e., recycling and input reduction. However, practices related to social equity/responsibility have not been well integrated in most business enterprises. All these results were key inputs in designing the upgraded business models.

Based on the assessment results, actors in the selected business businesses and the AE-I research team co-developed an agroecology upgrading plan. A set of action points were suggested to enhance agroecological transition and actors in the two business models started implementation of the proposed interventions. A cost benefit analysis (CBA) of the upgraded business models compared to the business as usual (previously existing business model) show that the investment in upgrading the two business models to becoming more agroecological is profitable with both farmers and business enterprises taking 3-4 years to breakeven. This therefore shows that a pathway to agroecological transition can be undertaken by the different food system actors, and this will be profitable to the food system actors (including businesses), and at the same time it will benefit the planet, land and people.

8. Recommendations and next steps

Different recommendations can be drawn from these results. First, the mango business models in Makueni have the potential for agroecological transition, as shown in the B-ACT tool results. Moreover, investment in these interventions is evidently profitable. There is a need to promote increased use and adoption of agroecological principles in business models to support the agrifood system transformation. This can be achieved through the creation of awareness and promotion of agroecological activities among different actors in the mango business model. There is also a potential for more market and other niche markets of agroecological products within and outside the country that may attract premium prices. This can be complemented by good record keeping as it enables traceability of inputs and activities in the farm and eases certification (e.g. in the case of organic farming) when needed.

Second, due to the seasonality of mango production and market fluctuations, it is crucial for processors/exporters to explore and invest in diversifying mango products. This can include the production of value-added products such as more puree and dried mangoes as well as mango jams, mango juices and mango-based snacks, which can be sold year-round. There is also a need to explore ways to extend the availability of mango processing and products throughout the year both by the private and public processor. This could involve processing and preserving mangoes during peak seasons for later distribution by taking up more volumes during peak season, which can be done by adopting advanced mango ripening technologies, for instance, by the public processor, that can reduce the waiting time, improve efficiency, and reduce the dependency on natural ripening cycles, invest in additional cooler infrastructure to accommodate mango storage for a more extended period as well as consider expanding the processing plant's capacity to handle a more significant volume of mangoes. This will help accommodate mangoes from most farmers and ensure mango products from the processing plants/exporters all year round.

Third, there is a need for stakeholders' collaboration in the mango business model/sector. This would entail engaging all stakeholders, including farmers, cooperatives, private processors, research organizations, financial institutions, and government authorities, in open discussions to find collaborative solutions to some of the challenges; regular meetings and forums can facilitate better cooperation and decision-making. This can help solve issues around training and access to extension through harmonization of training by different stakeholders. It would also reduce contradictory or confusing information received by farmers as well as promote information sharing and scalability among farmers. Relevant stakeholders can also be brought on board to support construction of mango infrastructure such as collection centres.

Fourth, low pricing and delay in payment are challenges in both private and public processor business models. The private processor needs to explore more flexible payment options and engage in transparent pricing discussions with farmer groups coupled with longer-term contracts to provide stability, trust commitment and assurance to both parties. On the other hand, while the government sets mango prices in the public processor model, negotiations could involve farmers and other key stakeholders to ensure that prices are fair and reflective of market conditions as well as to consider factors such as production costs and inflation.

Finally, these recommendations should be implemented in consultation with both actors in the two agroecological business models. These are the private processor and the farmer groups in the private processor model and the public processor, cooperative, and farmer groups in the public processor model, with a focus on collaborative problem-solving and mutual benefit. Frequent monitoring and evaluation of the business model's performance is also needed to identify further opportunities and areas for improvement. Implementing these recommendations, the actions point as well as agroecological activities by the actors in the different business models would lead to an improved agroecological model that is effective and sustainable, ultimately benefiting the producers, the businesses, and overall beneficial to the environment, people and land. In the mid-to-long term period, we would expect to see the business model actors in the conventional system shifting towards improved agroecological business models both in the private and public sides.

9. Acknowledgement

The authors would like to thank everyone who contributed to the development of this report. We acknowledge the partnership between researchers from the Agroecology Initiative and the Initiative's host centre, Dryland Natural Resource Centre (DNRC), whose collaborative efforts resulted in the successful completion of project activities on Agroecological business models around mango value chain in Makueni County. We appreciate the support of the County Government of Makueni, Makueni Fruit Processing Plant, Goshen Farm exporters ltd, Equity bank, Kenya Agricultural and Livestock Research Organization (KALRO), Juhudi Kilimo social enterprise, Makueni Fruit Processors Cooperative, Kwiminia Cooperative, and all mango farmers, traders and input dealers who attended the different workshops. We acknowledge the technical contributions from other Agroecology Initiative staff at the national and level during the study design.

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Appendices

Table A 1: Agroecological practices implemented in the mango business model actors that **improve resource efficiency**

AE Principle	Practices	Private processor engaging farmers groups	Farmers groups engaging private processor	Public processor engaging cooperative	Farmers engaging Cooperative
Recycling	*Practices Implemented* i. use of alternative inputs like biogas for cooking, ii. use of some biomass for energy and recycling of biomass residues. iii. use wastes from processing (i.e., mango peels and seeds) in running the biogas that further produces products used in the farms. iv. recycling of biomass and organic matter, involving drying of coconut husks and using them for cooking. v. Tree planting to promote carbon cycling vi. use compost manure as an alternative soil input that substitutes the use of synthetic fertilizers vii. plant legumes that fix nitrogen in the soil thus minimizing synthetic inputs viii. plant trees (including deep rooting plants) that increase soil carbon stock and contribute to stabilization of soil structure ix. composting to recycle organic matter x. use water from washing utensils to water their farms, especially in kitchen gardens. *Practices with potential* *p1. potential to recycle water used in the fruit processing plant in the farms and toilets.* *p2. using wastewater from fruit washing in the processing machinery cooling systems* *p3. Potential to use biomass residues to generate energy*	*Practices implemented* i, ii, iii, iv *Practices with potential* *p1*	ii, vi, vii, viii, ix, x	ii, v, iii *p2,*	vi, vii, viii, ix *p3,*
Input reduction	i. training their farmers on water conservation approaches, ii. use of tanks and digging water basins to capture and store rainwater. iii. train farmers on new technologies, e.g. use of Bio fertilizers such as *Rion* fertilizers that is a water absorber mixed with paronamics (a fertilizer that makes nutrients more available to nutrients)-currently under some demonstration plots. iv. Ssupports their farmers to use fruit fry traps (they give to farmers on credit at subsidized prices-because buy directly from manufacturers at wholesale) v. Training farmers on organic farming, advocate use of organic inputs and train them on natural methods of management including inducing mango flowering vi. Train farmers on selection of best quality seeds; on appropriate spacing, among others, in order to reduce seed use vii. trains the farmers and harvesters to ensure they harvest mangos the right way and harvest the correct sizes for processing (by ensuring that mangoes are harvested when they are almost ripe -not when ripe) to minimize losses viii. advocate mango transportation using crates to reduce mango damages. ix. The private processor also encourages farmers to use improved mango varieties and support farmers to diversify mango varieties.	i, ii, iii, iv, v, vi, vii, viii, ix, x	x, xii, xiii, xiv, xv, xvi, xvii, xviii, xix	v, xi,	xii, xiii, xiv, xv, xvi

x.	Encourage farmers to use improved varieties such as Kent which are resistant to pests and diseases to reduce losses.
xi.	Training of cooperatives and producer groups on the alternative production practices
xii.	Planting crop varieties that can utilize little water in their growth cycle e.g., millet, sorghum, etc.
xiii.	Reducing wastage via timely harvesting, proper dying of produce post-harvest (i.e., relating to grains and cereals), and use of hermetic bags for storage of produce
xiv.	Planting other crops that do not necessarily require fertilizer inputs, e.g., millets, to reduce the use of external inputs
xv.	Good agriculture practices like crop rotation to reduce pests and pesticide use
xvi.	Use of biopesticides (mostly self-made) and applying integrated pest management practices
xvii.	Doing bottle irrigation for the young seedlings
xviii.	Making some trenches around the areas covered by mango canopies, put manure in the trenches and then allow water to flow in.
xix.	Use of compost manure to reduce inorganic fertilizer usage

Table A 2: Agroecological practices implemented in the mango value chain that **strengthen resilience**

AE Principle		Practices	Private processor engaging farmers groups	Farmers groups engaging private processor	Public processor engaging cooperative	Farmers engaging Cooperative
Soil health	i.	Training to farmers on use of mulching and approaches to reduce soil erosion and increase soil organic matter	i	ii, iii, iv	-	ii, iii, iv
	ii.	Conserving soil moisture, fertility and reducing soil erosion by mulching planting cover crops, layering terraces, using compost/farmyard manure and sometimes retaining residues (especially from leaf falls) in the farms				
	iii.	Conserve soil and minimize degradation by practicing zero grazing (tethering livestock)				
	iv.	Planting different types of animal fodder and silage.				
Animal health	i.	Ensuring proper pest and disease control to all livestock (including poultry)	-	i, ii,	-	i, ii
	ii.	Providing adequate and proper feeding and watering to the livestock				
Biodiversity	i.	Training of farmers on the importance of planting trees and integrating mango trees with legumes e.g., green grams, beans and pigeon peas	i, ii	iii, iv, v, vi, vii, viii, ix	iii,	iii, iv, v, vi, vii, viii
	ii.	Encourages farmers to embrace crop rotation and intercropping cereals and legumes alongside doing mixed farming				
	iii.	Promotes agroforestry among actors				
	iv.	Promoting diversified farming systems, alley cropping, fodder crops, etc				
	v.	Planting local seed varieties like sorghum, cowpeas and millet, among others				
	vi.	practice intercropping and rotation of cereals with legumes				
	vii.	Maintaining native/indigenous plant species alongside rearing local livestock and poultry breeds				
	viii.	reducing use of chemicals to protect soil and soil life				
	ix.	Using of hedges along mango orchards to act as a multi-habitat approach to host more biodiversity (both plants, animals, birds, insects, etc).				
Synergy	i.	Encouraging farmers to use organic farming management practices	i, ii, iii, iv, v, vi, vii	viii, ix, x, xi,	i, v,	viii, ix, x,
	ii.	Training of farmers on use of natural methods of inducing flowering (e.g., burning certain plant to produce smoke that induce flowering)				
	iii.	Training of farmers on use of ash to expel ants form mango trees; painting bottom part of mango trees to expel ants, among others.				
	iv.	Training of to plant Garlic and coriander (dhania) and use as pest repellents within the mango plantations.				
	v.	encourage farmers to use mango fruit fly traps, which have pheromones that attract fruit flies into the traps.				
	vi.	support organic mango production as well as encourage farmers to plant perennial crops.				
	vii.	capacity build their farmers by supporting trainings on tree planting, mulching, cover crops, terracing and use of natural approaches for inducing flowering				
	viii.	Biological pest management through integrated pest management, planting of cover crops to suppress weeds, use of biopesticides, hand-picking, use of fly traps, wasps to eradicate fruit flies/pests, push-pull technologies, alternative crop hosts like thorn melon, squash, watermelon, etc, among others.				
	ix.	practicing low input farming techniques, involving use of manure				
	x.	landscape planning and activities involving construction of terraces, contour ploughing, mulching, cover-cropping, planting trees to act as windbreaks, among others.				

	xi.	sometimes use of herbal medication for their livestock to foster good health and continue realization of the associated benefits				
Economic diversification	i. ii. iii. iv. v.	Training farmers on other income generating activities (agribusiness), as well as the importance of local foods for improving their diets. Processing of oranges and tomatoes Agroforestry to improve income generation and environment. Engaging in, and selling of, multiple agricultural commodities, involving fruits and vegetables, poultry and their products, livestock and their products, seeds, trees for timber, among others Some diversify from mango farming to become traders and transporters of the produce	i	iii, iv, v	ii, iii	iii, iv

Table A 3: Agroecological practices implemented in the mango value chain that improve **social equity/responsibility**

AE Principle		Practices	Private processor engaging farmers groups	Farmers groups engaging private processor	Public processor engaging cooperative	Farmers engaging Cooperative
Co-creation and sharing of knowledge	i. ii. iii. iv. v. vi. vii. viii.	Conducting demonstration plots. Promoting farmer-to -farmer learning on farm practices, Training on finance literacy and sharing experiences through what they use and what has worked for them. Conduct in house extension and agronomic services combined with the county extension officers. Facilitate meetings on mango production, handling, and marketing where farmers share their experiences freely. Collaboration with other organizations such as research institutions, NGOs and individuals working in the mango value. conducting field days with other relevant stakeholders Farm tours and exposure visits	i, ii, iii, iv	iv, vii, viii	v, vi	iv, vii, viii
Social values and diets	i. ii. iii. iv. v. vi. vii. viii. ix.	Provision of commercialization opportunities for mangoes and other fruits in the area Working only with farmer groups where they build farmers capacity by doing a lot of training to the farmer groups, service providers from the groups. Advise groups to include women in the mango producer groups. Attending social events organized by the various mango farmer groups and cooperatives. Advocates for producers to consume part of their produce, i,e, not all mangoes produced should be marketed Having the right to grow what they want. planting a variety of nutritious crops e.g., cereals, fruits, indigenous vegetables, wild fruits, etc Keeping a variety of locally adapted livestock to provide different food with different nutritional values hence balanced diets. Observing cultural days; social gatherings and events like dowry payments; where some cultural foods are cooked and shared *p1. potential to work on nutritional and healthy diets especially when they collaborate with other organizations.*	i, ii, iii p1,	vi, vii, viii	iv, v	vi, vii, viii
Fairness	i. ii. iii. iv. v. vi. vii.	group trainings, collection and marketing of the commodities Intervening in pricing. Fair hiring/recruitment process to ensure gender equity Ensuring good working conditions for all employees Have liberty to form groups; from which, they can benefit through trainings and other capacity development needs Farmers reserve the right and liberty to sell to any buyers that they deem appropriate	i, ii, iii	vi, vii	iv, v	vi, vii
Connectivity	i. ii.	Offering subsidy to their farmers for water tanks and fruit fly traps which they buy in wholesale from suppliers at subsidized prices training in good handling and food safety	i p1	-	ii, iii, iv	-

	iii. iv.	Offering educational programs for mango value chain actors including nurseries, input dealers, farmers and traders on the marketing and quality standards acceptable in the market Connects thousands of farmers to the market through cooperatives. *p1. potential to expand to more financing options.*				
Land and natural resource governance	i.	Promotes policies that aim at conserving land, water, and natural resources in collaboration with the county government	-		i	-
Participation	i. ii. iii. iv.	Participating in and promoting participation of mango stakeholders in public policy development fora processor was at the forefront of the initiative to make mango a priority crop in the county. Getting involved in the County planning meetings; Taking part in public events right from the village, sub-ward and ward levels	-	iii, iv	i, ii	iii, iv

Table A 4: Co-design of upgraded agroecological business models

Gaps/ Objectives	Goals	Activities to achieve objectives	Indicators	Status	Targets	Responsible actors	Supporting actors	Timeframe	Estimated costs etc. (KES)	Financing plan	Indicate the relevant AE principles to be addressed/improved	Progress on Indicators by November 2024	Challenges	Solutions
Private processor business model														
Pest and disease	Improve productivity Improve quality of fruits	Training Access to IPM	No. of farmer groups trained. No of farmers adopting	None	40 groups	Private processor	Organic fields, DNRC, County government, Farmers	Dec-24	200,000	Private processor, Organic fields	Land and natural resource governance, connectivity, soil health, input reduction, co-creation of knowledge, fairness, fairness		Climatic/weather challenges - excess rains/droughts Finances Poor participation in group activities Poor infrastructure Harvesting skills gap	More training in harvesting/picking Better planning and scheduling of training Good mobilization
Record Keeping	To manage loss and costs	Training	No of trainings done(groups) No of farmers implementing	40 groups	40 groups	Private processor	County government; MESPT	Dec-24		Private processor, MESPT	Participation, connectivity, fairness, co-creation of knowledge	November- 0 and by June 40 groups trained		
Capital	Finance for procurement of inputs	Training Linkage to financial institutions	Linkage to at least 2 number of institutions	None	2	Private processor	Agroecology team: MESPT	Dec-24	200,000	Private processor	All the 13 principles	Introduced to 2 financial institutions (Equity and Juhudi)		
Climate change	Improve adaptation to climate change	Training (CSA)	No of farmer groups trained.	None	40 groups	Private processor	County government, Organic fields,	Dec-24		Private processor, Organic fields	Soil health, biodiversity, economic diversification, synergy, fairness, co-creation of knowledge, connectivity			
		Access to resilient crop varieties	No. of improved varieties adopted	None	100,000 seedlings (3 varieties)	Private processor	Farmers	Dec-24	2Million					
Delayed payment	Reduce turnaround time for farmers payment	Streamlining internal financial system	Turnaround time	14 days	7 days	Private processor	Farmers	Dec-24		Private processor	Fairness, Connectivity, participation	From 2 months waiting for payment to 14 days		

High cost of logistics	Reduce costs of logistics	Training of pickers/harvesters and farmers Zoning of farmers during collections	No of pickers trained and farmer groups Number of zones	30	70	Private processor	MESPT, Farmers	Dec-24		Private processor	Fairness, participation, economic diversification, co-creation of knowledge	none		
Low capacity	Increase capacity	Expansion	Quantity of produce taken No of farmer groups	50 tons/week	80 tons/week	Private processor	Farmers, County	Dec-24		Private processor, Financing, institutions, Grants	Participation, connectivity	Used to produce 14tonnes per week and now they produce 50 tons per week		
Public processor business model														
Product standardization	High quality produce Increased income Environmental conservation Improved health	Certification of farmers	Number of farmers certified	400	500	Farmers	CABI, VERT, MESPT, BAMBA & BUTTON, Organic Fields, County Government	6 months	300,000	Grant	Participation, co-creation of knowledge, biodiversity, input reduction, soil health, economic diversification	300	Financial constraints, Farmer ignorance, Illiteracy among farmers, Over-reliance on incentives, Land disputes, Poor road network, Strict market standards,	Establishment of alternative revenue streams, Regular follow up after training, Use of local language, Champion farmers to be role models to other farmers
Improvement of food safety measures	Increase in agroecologically produced products	Training on agroecology	Number of farmers trained	8,000	10,000	Public processor, Farmers	CABI, Organic Fields, CGA, MESPT, CGIAR	6 months	500,000	Grant, Cooperative	Participation, co-creation of knowledge, connectivity, input reduction, soil health, economic diversification	5000		
			Number of farmers practicing agroecology	6,000	8,000			6 months				5000		
Postharvest loss and Improvement of living standards	Improved household income Unlock price premiums	Market access	Quantity of mangoes sold	450 tons	500 tons	Cooperative, Public processor, VERT - LTD	NARIGP, CABI	6 months	8M	Cooperative, Grant	Participation, connectivity, economic diversification, co-creation of knowledge,	430		

Surplus produce	Improved household income	Access to alternative markets	Quantity of mangoes sold to alternative markets	200 tons	300 tons	Cooperative; Farmers Service providers	County Government, Private processor	Dec-25	3.5M	Grant, Private processor, County government	social values and diets	100		
Post-harvest loss	Constant supply of produce to the markets	Value addition	Quantity of value-added products	50kgs	200 tons	Cooperative Public processor VERT - LTD	Cooperative	Dec-25	2.5M	Grant, Cooperative	Economic diversification, connectivity, synergy, land and natural resource governance, soil health, recycling, participation	-		
Delayed payment Surplus produce	Increased volume of produce purchased by the cooperative	Increased financing to the cooperative	Amount of finance accessed	KES 9M	KES 14M	Cooperative	Cooperative	Dec-25	5M	Grant, Buyers contracted by the cooperative	Connectivity, economic diversification, participation, fairness	8M		
Monitor progress Price setting	Enhance accountability and traceability	Training on record keeping	Number of farmers trained	8,000	100,000	Cooperative	Cooperative	6 months	500,000	Well-wishers, Grants, CABI, CGIAR, Organic Fields, MESPT	Connectivity, economic diversification, participation, fairness, co-creation of knowledge, social values and diets	5000		

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Cover Photo: Mango farm in Makueni County, Photo credit: Kevin Onyango (Alliance Bioversity-CIAT)

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