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Understanding the complexity of the Indonesian fresh mango industry in delivering quality to markets: A systems thinking approach

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ABSTRACT

In response to anticipated export demand growth and the expansion of the modern domestic market, the Indonesian mango industry faces both opportunities and challenges in elevating the production of high-quality mangoes. This industry's complexity, characterised by various actors with wide-ranging interests, poses a key challenge. We implemented a systems thinking approach in this study to comprehend this complex Indonesian mango value chain and identify deep-rooted issues that could obstruct high-quality mango production. Our research employed participatory group model building with primary actors and stakeholders, which disclosed that conventional agricultural management practices, inadequate postharvest handling, and a lack of coordinated quality standards are key drivers of low-quality mango production. By utilising system archetypes—interpretive tools capturing complex food system behaviour—we demonstrate that adopting clear market orientation through mutual contractual arrangements and fostering collaboration among key actors can significantly influence high-quality mango production. This study provides a nuanced understanding of the underlying factors affecting system behaviour over time, a component often overlooked in traditional value chain analysis. As a result, policy formulation can better address the root causes of Indonesia's low production of high-quality mangoes.

1. Introduction

There has been an increase in mango consumption due to the consumers' rising awareness of health (Evans et al., 2017). The growth of modern retail channels in developing countries has also resulted in the growth of the demand for high-quality mangoes (Badar et al., 2015; Wahida et al., 2013; Yaseen et al., 2016). However, a key challenge for most mango producing countries around the globe is meeting the expected quality from the end consumers (Evans et al., 2017; Kiloes et al., 2022). As a result, there has been growing concern about quality, especially for consumers who live in urban areas (Qanti et al., 2017; Wahida et al., 2013).

Indonesia, recognised as the fourth-largest mango producer worldwide, grapples with the pressing issue of satisfying consumer expectations for quality (Evans et al., 2017). A wave of socio-economic transformation within the country has spurred a significant expansion in modern retail markets, positively influencing domestic mango demand (Arifin, 2013; Natawidjaja et al., 2014; Reardon et al., 2007; Reardon et al., 2015). This evolving consumer landscape has manifested an increased desire for bigger size, better aroma and taste, and more visually appealing mangoes with reduced chemical residue (Deliana, 2011; Kiloes et al., 2021). Such preferences are evidenced by a rise in sales within modern retail markets, boasting an annual growth of approximately 10–20% (Qanti et al., 2017). However, despite reaching a production peak of over 2 million tons in 2020 (Indonesian Statistic, 2022; Puspitasari et al., 2021), the Indonesian mango industry faced difficulties in meeting the escalating demand for high-quality mangoes in the domestic market (Natawidjaja et al., 2014). This challenge also extends to the global arena, limiting Indonesia's involvement in the burgeoning global mango export market, with less than 1% of its mangoes reaching foreign markets (Arifin, 2013; Puspitasari et al., 2021; Sulistyowati & Natawidjaja, 2016).

In response to current opportunities and challenges, the Indonesian government has listed mango as a national agricultural development

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fruit commodity priority (Arifin, 2013; Nur Aziz & Boga Andri, 2016; Natawidjaja et al., 2014; Qanti et al., 2017). The Indonesian Ministry of Agriculture has also targeted a three-fold increase in mango exports by 2023 (Directorate General of Horticulture, 2019). These policies are targeted to improve the overall performance of the Indonesian mango industry to cater to the growing domestic and export markets effectively.

Previous research has proposed interventions to facilitate change in the Indonesian mango industry to achieve this goal. One such study has analysed the linkages between actors toward the commercialisation of mango farming and found that actors who provide production inputs and on-farm technologies contribute to connecting farmers to more modern markets (Qanti et al., 2017). Another study found that farmers' participation in modern retail market channels could be achieved by increasing the production of quality mango through improved irrigation, farm equipment and infrastructure (Natawidjaja et al., 2014). However, relatively little research has focused on identifying the constraints within the industry in producing high-quality mangoes to meet current consumer needs. Therefore, further study is required to identify the factors contributing to this limitation and develop strategies to improve the Indonesian mango industry's performance in delivering expected quality to the markets.

Value chain analysis is a commonly used approach for improving the performance of the food system as a whole (Lowitt et al., 2015). This approach can improve the overall performance of the Indonesian mango industry by analysing the different components and activities in a value chain system (Kaplinsky & Morris, 2001). However, a conventional value chain analysis provides a generally static output. It also has limitations in analysing the causal relationships between components in the system (Muflikh et al., 2021a). These limitations could lead to a failure to comprehensively understand the feedback mechanism within the value chain system. This issue is primarily compounded when a study is designed to focus on a specific subsystem within the value chain (Alizadeh et al., 2020; Banson et al., 2016; Stead, 2019; Tey et al., 2019).

Integrating a systems thinking approach with value chain analysis in food systems can address these existing limitations in conventional value chain analyses (Muflikh et al., 2021a). A systems approach allows the modelling of real-world problems based on the fundamental idea of a system and can contribute to the understanding, design, and analysis of components in an entire system (Banson et al., 2016; Rajagopal, 2012). Systems thinking facilitates the understanding of interactions between various factors in a system, such as biophysical, socio-economic, and institutional elements (Ali et al., 2021). Understanding these interactions between elements is important as they can influence behavioural change within a system (Banson et al., 2016; Sterman, 2000). This makes the use of a systems thinking approach more appropriate for improving the mango value chain in Indonesia due to its complex and multidimensional nature (Fizzanty et al., 2008).

The primary objective of this study is to elucidate the dynamic intricacies within the Indonesian mango industry. This complexity arises from the multifaceted interactions among parameters, actors, and activities, all of which significantly influence the delivery of high-quality mangoes to the market. The systems thinking methodology, utilised in this research, offers a comprehensive viewpoint on the effects of mango quality fluctuations, instigated by shifts in both exogenous and endogenous elements of the mango industry system. Such an approach surpasses the insights gained solely from conventional value chain analysis (Muflikh et al., 2021a; Tey et al., 2019). Comprehending the Indonesian mango industry's system enables the identification of essential feedback mechanisms to enhance industry performance, an aspect that remains unexplored in previous studies (Karyani et al., 2016; Natawidjaja et al., 2014; Suhaeni et al., 2015). This lack of exploration has generated a gap in the holistic understanding of the system. Furthermore, the use of participatory methods in this research ensures the representation of all stakeholders in the industry, consequently bolstering the analysis's robustness.

2. Research methods

In this study, we addressed the complications encountered by the Indonesian mango industry in delivering mangoes that adhere to the high-quality standards demanded by the market. It focuses on identifying the drivers of high-quality mango production in Indonesia by adopting a systems thinking approach. This approach consists of five sequence steps: problem articulation, formulation of dynamic hypothesis, formulation of the simulation model, model testing, and policy design and evaluation (Maani & Cavana, 2007; Sterman, 2000). However, it is crucial to note that this current research is dedicated exclusively to the qualitative aspects of the systems thinking approach. We have specifically focused on the first two stages of the systems thinking approach: problem articulation and dynamic hypothesis formulation. In the problem articulation stage, we seek to understand and define the problem holistically, considering all relevant factors and their interconnections (Ali et al., 2021; Mai and Smith, 2015; Muflikh et al., 2021a). Next, in the formulation of a dynamic hypothesis, we construct a conceptual map that identifies cause-and-effect relationships and potential feedback loops within the system (Paterson & Holden, 2019). The following stages, which we did not explore in this study, would traditionally involve formulating a simulation model to represent system behaviour, testing this model to ensure it accurately reflects reality, and designing and evaluating potential policy interventions based on insights gained from the model.

2.1. Problem articulation

In implementing systems thinking in value chain analysis, problem articulation serves as the initial step, paving the way for a deeper understanding of the system's structure (Muflikh et al., 2021a). This phase incorporates historical data analysis, stakeholder consultation, and various participatory methodologies that pinpoint and elaborate on the significance of problems, including the rationale behind their recognition as issues (Ali et al., 2021; Mai and Smith, 2015; Muflikh et al., 2021a). Within the context of the Indonesian mango industry, our study detected problems related to producing high-quality mangoes that align with market demands. We gathered data via secondary sources and participatory techniques such as focus group discussion (FGD), semi-structured interviews, and stakeholder workshops. Secondary data, encompassing aspects like mango production and export figures, were obtained from the Directorate General of Horticulture and the Indonesian Ministry of Agriculture. The participatory methodologies were conducted across two phases. Table 1 outlines the specifics of the stakeholders involved, locations selected, and methods employed to extract information regarding the issues impacting the Indonesian mango industry system.

In the initial stage, we hosted one FGD that included 12 representative policymakers from both national and regional government institutions. This process was then supplemented with individual semi-structured interviews involving each participant from the FGD. During these sessions, we posed a set of predetermined questions (as presented in Table 2), aimed at unearthing the key challenges faced by the Indonesian mango industry. These discussions primarily took place in Jakarta, the capital city of Indonesia. Additionally, the knowledge gleaned from these engagements served to guide us in identifying the primary locations associated with the Indonesian mango industry and the key actors to approach during the second stage of data collection.

In the second stage, at the regional level, we implemented participatory methods that included semi-structured interviews and group model building (GMB) workshops with value chain actors and relevant stakeholders. Here, value chain actors refer to individuals directly engaged in the industry's operations, whereas stakeholders refer to individuals indirectly involved but providing substantial support to the industry. The purpose of this stage was to identify challenges throughout the value chain and to recognise any additional value chain actors and

Table 1
Stakeholder groups that participated in data collection and the data collection methods.

Participants	Category	Geographical origin	Number of participants	Data collection method
Participants at the policymakers level (stage 1)				
Directorate of Fruits and Floriculture, DGH, MoA	Support providers	National	2	FGD and semi-structured interview
Directorate of Horticulture Postharvest and Marketing, DGH, MoA	Support providers	National	1	
Indonesian Center for Horticulture Research and Development, IAARD, MoA	Support providers	National	3	
Indonesian Center for Agricultural Postharvest, IAARD, MoA	Support providers	National	1	
Agriculture Quarantine Agency, MoA	Support providers	National	1	
Department of Agriculture, Cirebon Regency	Support providers	West Java	2	
Department of Agriculture, Pasuruan Regency	Support providers	East Java	2	
Participants at the regional level (stage 2)				
Farmers	Primary actors	West Java	30	Semi-structured interview
		East Java	70	
		West Java	10	GMB workshop
		East Java	5	
Pre-harvest contractor	Primary actors	West Java	9	Semi-structured interview
		East Java	9	
		West Java	4	GMB workshop
		East Java	3	
Collectors	Primary actors	West Java	6	Semi-structured interview
		East Java	8	
		West Java	2	GMB workshop
		East Java	2	
Regional traders	Primary actors	West Java	5	Semi-structured interview
		East Java	5	
		West Java	2	GMB workshop
		East Java	1	
Input suppliers	Primary actors	West Java	5	Semi-structured interview
		East Java	5	
Wholesalers	Primary actors	Surabaya	5	Semi-structured interview
		Jakarta	2	Semi-structured interview
Traditional retailers	Primary actors	Surabaya	5	Semi-structured interview
		Jakarta	15	Semi-structured interview
Modern retailers	Primary actors	Surabaya	1	Semi-structured interview
		Jakarta	3	Semi-structured interview
Exporters	Primary actors	National	20	Semi-structured interview
Extension officers	Support providers	West Java	2	Semi-structured interview
		East Java	2	
		West Java	2	GMB workshop
		East Java	1	
Researchers	Support providers	National	2	Semi-structured interview
			2	GMB workshop

DGH = Directorate General of Horticulture.
IAARD = Indonesian Agency for Agriculture Research and Development.
MoA = Ministry of Agriculture of the Republic of Indonesia.

Table 2
Set questions asked during stakeholders' semi-structured interviews and workshops.

1. What are the problems in producing good quality mangoes?
2. Why is it a problem?
3. Where do the problems come from?
4. How do you deal with the problems that have existed so far?

pertinent stakeholders not previously identified in the FGD with policymakers. We chose two of Indonesia's major cities, Jakarta and Surabaya, for these activities, as these locations house the primary downstream value chain actors, such as wholesalers and retailers, in both modern and traditional markets. We identified the provinces of West Java and East Java as key mango production centres. These regions are home to the upstream primary value chain actors, including farmers, pre-harvest contractors, collectors, and regional traders. In West Java, the specific locations for our study included Indramayu, Majalengka, and Cirebon Regency, while in East Java, we focused on Pasuruan, Probolinggo, and Gresik Regency.

Given the substantial number of research participants and restricted time, we enlisted and trained four research assistants to facilitate the semi-structured interview process. To adequately equip them for the task, we conducted a comprehensive two-day training program. This session was designed to enlighten the research assistants on the research goals and objectives, acquaint them with the research tools, and provide an opportunity to pilot test the research instrument. Similar to the first phase, the objective of this stage was to pinpoint challenges within the Indonesian mango industry. We adhered to the same set of guiding questions detailed in Table 2 to steer this explorative process. All semi-structured interviews were carried out in Bahasa Indonesia, the national language, and each interview typically spanned between 20 and 30 min per stakeholder. After the interviews, we translated the responses transcribed in Bahasa Indonesia into English. As the research participants were also proficient in Bahasa Indonesia, no translation was required from any local dialects. Problem themes were identified from the semi-structured interview transcripts that were transcribed from the audio recording of the interviews. These themes provide a clear depiction of the biophysical, socio-economic, and institutional challenges encountered at various stages including on-farm, postharvest, and distribution and marketing (Ali et al., 2021). The outcome of the problem articulation guides the following step, which is to develop a dynamic hypothesis of the system structures that generate system behaviour over time (Muflikh et al., 2021a).

2.2. Dynamic hypothesis formulation

In addition to clarifying the problems found in the semi-structured interviews, the GMB workshops were also aimed at formulating a dynamic hypothesis by modelling the dynamic system structure of the Indonesian mango industry and linking it to its behaviour. The dynamic hypothesis presents the qualitative model of how and why the Indonesian mango industry performs in delivering quality mango to the markets. This study describes the dynamic hypothesis using a causal loop diagram (CLD). This allows the simple visualisation of reinforcing and balancing feedback loops within the system that control the system's behaviour (Mai & Smith, 2015; Mui et al., 2019; Paterson & Holden, 2019; Rich et al., 2018; Trisnasari et al., 2020).

The Indonesian mango industry comprises a multifaceted value chain, encompassing numerous actors and stakeholders (Fizzanty et al., 2008). Recognising this complexity, we employed a participatory approach, utilising GMB workshops to gather data and to integrate the views of these actors and stakeholders into the development of the CLD (Mui et al., 2019; Mumba et al., 2017; Rich et al., 2018). This process is crucial because a participatory approach in model development enhances the data's quality and relevance. It enables a more precise parameter identification and validation process, as it is identified directly by the actors, thereby enhancing the analysis's robustness and precision (Rich et al., 2018). Moreover, GMB workshops serve to foster awareness among participants about the inner workings of the system. They empower actors and stakeholders to partake in decision-making, offer insights into additional issues, and inspire transformative actions within the community (Benninger et al., 2021; Mumba et al., 2017).

The GMB workshop implemented in our study followed a structured progression. It began with the introduction of the researcher and participants, followed by an explanation of systems thinking. We then mapped the mango industry value chain, identified and clarified problems, examined their causes and consequences, and explored feedback mechanisms. The workshop concluded with a comprehensive discussion (Mui et al., 2019; Mumba et al., 2017; Rich et al., 2018).

The formulation of dynamic hypotheses through CLD is a method designed to delineate the complex system structure and illustrate the feedback loops that regulate both material and information flow within the value chain system (Muflikh et al., 2021b). A CLD comprises variables interconnected by causal links, outlining the causality chains present in the system. These links are assigned polarities, either positive (+) or negative (-), to indicate whether the variables are directly or inversely related. Feedback loops can either be reinforcing (R), signifying growth or decline within the system, or balancing (B), acting as self-correcting mechanisms countering changes to maintain stability (Paterson & Holden, 2019; Sterman, 2000). This structure assists in understanding the intricate interplay of factors within the value chain system.

The GMB workshop facilitated the creation of a preliminary CLD, which was open to review and input from stakeholders (Mai & Smith, 2015). Subsequent refinement of this preliminary model incorporated information derived from FGD and semi-structured interviews with various actors and stakeholders within the Indonesian mango industry value chain. To formulate the final CLD, discussions were held with a panel of experts in the field, including researchers and academics from the Indonesian Centre for Horticulture Research and Development, the Indonesian Tropical Fruit Research Institute, The Indonesian Centre for Agricultural Postharvest Research and Development, and Brawijaya University. These simplified CLD serve to articulate the complex dynamics within the system (Martinez-Moyano & Richcardson, 2013). Following their creation, these diagrams were presented back to the value chain actors and stakeholders for validation, ensuring their accuracy and relevance. The construction of the CLD was conducted using the Stella® Architect software version 2.0.

The final step in the dynamic hypothesis formulation is to identify system archetypes, loops that model the interaction of all the factors that cause a problem in the real world (Alizadeh et al., 2020; Muflikh et al., 2021a). System archetypes represent standard structural patterns that encapsulate the typical dynamic processes exhibited by a system (Braun, 2002; Maani & Cavana, 2007; Sterman, 2000). They offer narrative interpretation of food system complexity and aid in identifying potential solutions for transformative improvement of the system's performance (Benninger et al., 2021; Setianto et al., 2014b). We further deliberated on the identified system archetypes in subsequent GMB workshops. These discussions aimed to pinpoint areas where strategic interventions could be initiated to boost the performance of the Indonesian mango industry system. It's important to note that these potential interventions were derived from the identified system archetypes and leverage points. They were then deliberated among the various stakeholders, fostering a collaborative environment. This approach encourages collaborative problem-solving, enabling value chain actors and stakeholder groups to collaborate with modelling teams in formulating interventions to tackle specific problems within complex systems (Hovmand et al., 2012).

3. Results

3.1. A brief description of the Indonesian mango industry

Before delving into the intricacies of the qualitative systems thinking approach, which explores the industry's problems and systemic structure, it is crucial to gain an initial comprehension of the current state of the Indonesian mango industry. To this end, we have undertaken a thorough mapping of the industry to provide a more updated perspective than the information previously available (Suhaeni et al., 2015). The results gleaned from the FGD, semi-structured interviews, GMB worskhops, and field observations corroborate the assertion that the Indonesian mango industry embodies a complex system. This system exhibits a governance structure that, when compared to the standards of an ideally modern value chain system, can be considered less organised. It consists of wide-ranging activities such as production, local trading, wholesaling, retail and consumption, and export conducted by the primary and supporting actors. The primary actors include farmers, preharvest contractors, collectors, regional traders, wholesalers, modern retailers, traditional retailers, exporters and consumers. These actors sometimes perform more than one role. For example, many collectors and regional traders in production centres are also farmers who manage their own trees or rent trees belonging to other farmers. These practices are common in the Indonesian mango industry and can be found in many production centres. In addition to the primary actors, the relevant stakeholders identified in this study are the government, input suppliers, freight forwarding, financial institution, research institutions, and extension services. Fig. 1 illustrates the complexity of the Indonesian mango industry system.

There are 15 marketing channels in the Indonesian mango industry. The most extended marketing channel involves almost all the primary actors of the Indonesian mango industry. The short marketing channel involving only farmers and consumers has only recently emerged due to the escalating use of social media platforms and online transactions in agriculture. In this system, three types of transactions are found: the spot market, transactional, and. contractual transactions are still limited and generally occur in more modern marketing channels, such as those involving modern retail and export markets.

3.2. The quality issue in the Indonesian mango industry

The critical issue profoundly visible in the Indonesian mango industry is the low quality of mango produced. This was also an issue identified by Indonesian domestic consumers and mango exporters. In the context of the Indonesian mango market, the concept of quality encompasses a combination of physical and chemical attributes. High-quality mangoes typically exhibit superior physical characteristics such as larger size, better taste and aroma, and an appealing appearance.

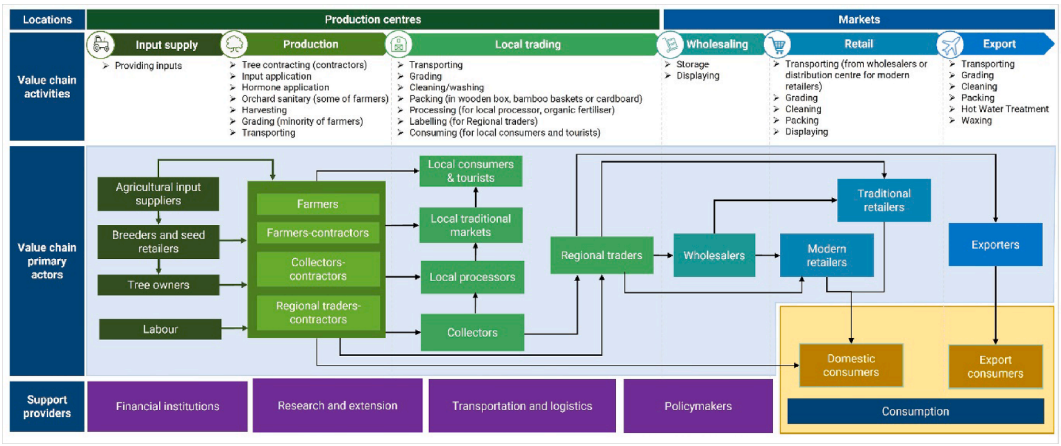

Fig. 1. The Indonesian mango industry value chain map.
Source: Primary data collection (2021)

Simultaneously, they contain fewer chemical residues, indicating healthier, more sustainable cultivation practices. Low-quality mangoes, in contrast, may lack some of these desired physical traits and often have higher chemical residue levels.

Presently, consumers express dissatisfaction with the mangoes available in the domestic market. This is an understandable trend, given that the Indonesian market is undergoing a transformative phase, and consumers are increasingly seeking higher-quality products. Beyond the physical attributes of mangoes, consumers place considerable emphasis on safety information, such as data on chemical residues. This factor is often perceived as paramount, despite the current lack of incorporation of this information into retailers' pricing considerations. Feedback from Indonesian mango exporters echoed these sentiments. They attributed the low export volume, which currently stands at less than 1% of Indonesian mango production or approximately 2,000 tons out of a production volume of roughly 2 million tons in 2020 (Indonesian Statistic, 2022), to a shortage of export-quality mangoes supplied by local producers. A key insight from an interview with an Indonesian mango exporter was a challenge faced during an inspection by a Japanese importer. The inspection revealed the Indonesian mangoes were unsuitable for export due to excessive pesticide residues. This is a significant problem in efforts to increase Indonesia's mango exports.

Since detailed data on the production of good quality mangoes is not available, we used information obtained from the Indonesian mango industry actors and stakeholders, and export data to estimate the production of good quality mangoes over time. Semi-structured interviews with mango farmers, extension officers, and researchers indicate that only a small proportion of high-quality mango is produced. The high-quality mangoes only account for 10 to 20% of the total mangoes produced at the on-farm level. Moreover, Indonesian mango export data also demonstrate that from 2012 to 2019, Indonesia's mango exports constituted no more than 1% of the total national mango production (Fig. 2). Semi-structured interviews with mango exporters reveal that one of the causes of this small number of export is a lack of supply of quality mangoes.

The low supply of high-quality mango is a highly visible symptom. This is what most policymakers react to because it needs immediate attention. Unfortunately, the symptom-based policy does not target the underlying problems. As a result, the same problem often reoccurs (Sun et al., 2014). A deeper understanding of events and their underlying problems is needed in an effort to develop fundamental solutions. It can provide a robust foundation for understanding problematic behaviours in the value chain (Muflikh et al., 2021a).

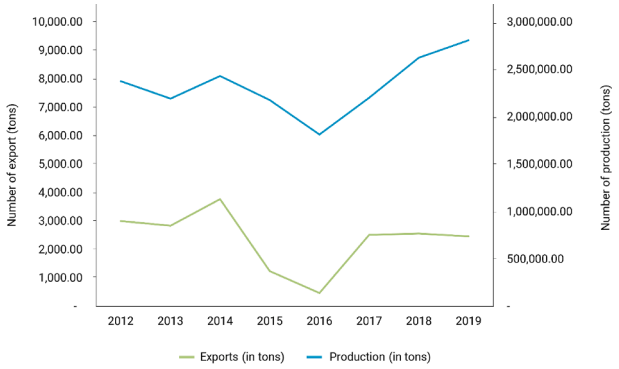

Fig. 2. Indonesian mango production and export trends.
Source: (Indonesian Statistic, 2022)

3.3. *Problems in producing high-quality mangoes*

The problems identified by the Indonesian mango industry actors and stakeholders concerning producing high-quality mangoes are presented in Table 3. The factors and associated problems are categorised into three activity levels: on-farm, postharvest, and marketing and distribution. The problems identified for each level are presented below, and they are further categorised based on biophysical, socio-economic, and institutional conditions (Ali et al., 2021).

3.3.1. *On-farm problems*

At the on-farm level, some tree owners leave their mango trees to grow naturally without any treatment. These tree owners generally collect fruit only during the fruiting season. In contrast, other farmers apply inputs like organic or chemical fertilisers to enrich soil nutrients and utilise pesticides to control pests and diseases. There is no accurate official information on the comparison of the number of productive mango trees that are unmanaged and managed. However, from the interviews and the GMB process, we estimate that around 50–60% of productive mango trees are managed, especially by farmers with more resources. These farmers manage the trees they own or rent unmanaged trees belonging to other farmers.

On-farm practices, as well as in the postharvest and marketing and distribution subsystems, were identified as two types: conventional and advanced. Conventional agricultural management practices refer to those which fail to comply with recommended cultivation guidelines. Many farmers tend to underuse fertiliser while overusing pesticides and plant growth regulators (PGR—paclobutrazol is commonly used),

Table 3
Problems identified by Indonesian mango industry actors and stakeholders in delivering quality.

Level	Biophysical		Socio-economic		Institutions and policies	
	Factors	Problems	Factors	Problems	Factors	Problems
On-farm	• Input availability • Application of mango production technology • The chemical residue (pesticide) • Weather condition	• Lack of quality input at an affordable price • Lack of application of advanced agricultural management practices (pruning, fruit thinning, micronutrients) • Poor tree architecture • Excessive use of pesticide • Lack of irrigation • Pest and disease attack due to rapid changes of weather	• Mango price • Farmers' revenue • Farming cost • Farmers' concerns about the quality • Access to finance • Lack of awareness and understanding of quality	• No price and market certainty • The price will continue to fall during the peak harvesting season • Lack of capital and access to finance • Tree tenants only care about the quantity of production and override the quality • Fear of failure	• Government support • Extension services	• Government support is still concerned with increasing production rather than improving quality • Lack of extension services • Lack of quality standards adopted
Postharvest	• Losses • Application of good postharvest practices • The chemical residue (carbide)	• Bulk harvesting • Excessive use of carbide for ripening • Improper waste management causes pest and disease attack	• Grading activity • Postharvest cost	• Lack of advanced postharvest practices	• Quality standard	• Lack of quality standards adopted
Marketing and distribution	• Losses • Advanced logistic and transportation	• High losses at the retail level • Lack of application of advanced logistics and transportation	• Quality standards	• Quality bias	• Marketing institutional • Quality control	• Lack of marketing institutional • Lack of quality control

Source: Primary data collection (2021)

contrary to recommendations. On the other hand, advanced agricultural management practices align with the cultivation practices recommended by local Departments of Agriculture and research institutions. These include balanced fertiliser application according to the age of trees and soil conditions, regulated pesticide application based on pest and disease activity and climate conditions, and dosed PGR application in accordance with tree age. These advanced practices also incorporate recommended supplementary activities such as pruning, fruit thinning, and irrigation. Of the total mango trees managed, approximately 95–98% are managed with conventional agricultural management practices, and the rest are managed with advanced agricultural management practices. In this study, we did not observe any advanced organic production practices that exclusively utilised organic inputs. In our interviews with mango researchers, they indicated that organic mango management technologies, such as plant-based pesticides, had been introduced to farmers. However, these practices were not widely adopted, as farmers found the preparation to be both time-consuming and complex. As a result, the only organic practice currently identified involves allowing mango trees to grow in their natural state.

The impact of these different management practices on mango quality and overall productivity varies. From the GMB workshops and semi-structured interviews, we found that a single 10–15-year-old (after planting) conventionally managed mango tree could yield 100–110 kg, 20% more than unmanaged trees of the same age. The use of PGR in conventional practices can amplify overall mango production due to its influence on the flowering process, especially during off-season periods (Desta & Amare, 2021; Zainuri et al., 2019). Yet, this practice typically yields only 10 to 20% high-quality mangoes and is often deemed unsustainable. Many stakeholders noted that the excessive application of PGR might temporarily boost production, but only for a span of 3–5 years. After this period, a nutritional deficit occurs as the tree is continuously stimulated to produce fruit and consequently draws nutrients from its own reserves to support the induced flowering. Under these conditions, the tree compensates by pulling nutrients from its own reserves to sustain the induced flowering, leading to a gradual decrease in production. Eventually, these practices risk damaging the tree beyond recovery. As corroborated by previous research, while PGR can indeed enhance productivity by triggering early flowering, their excessive application can have the unintended consequence of slowly leading the tree to its demise (Qanti et al., 2017). This is further aggravated by the over-application of pesticides, driven by farmers' fear of potential crop failure due to pests and diseases. This practice could result in chemical residues on the fruit, jeopardising both the quality of mangoes and the health of consumers.

Advanced agricultural management practices, due to more appropriate input application and cultivation techniques, produce a higher proportion of mangoes meeting quality standards—bigger size, better taste and aroma, improved appearance, and minimal chemical residue—accounting for at least 80% of total output. This practice is more sustainable, given the balanced nutrients and treatments promoting tree health. However, advanced managed trees yield less fruit compared to those managed conventionally. According to the GMB workshops and semi-structured interviews, a single 10–15-year-old (after planting) advanced managed mango tree will only yield approximately 70–80 kg per tree. A brief difference between conventional and advanced practice is presented in Table 4.

Most value chain actors and stakeholders shared a consistent view on the causes of the low production of high-quality mango by attributing it to the lack of adoption of advanced agricultural management practices. Some of the reasons suggested to be behind this lack of adoption include the lack of price and market certainty for quality mangoes, inaccessible input costs despite their availability in the market, high cost of irrigation, limited access to capital, finance and extension services. Problems related to agroecological conditions such as unfavourable climate, pests and diseases also contribute to the low production of high-quality mango. Rapid and significant weather changes can affect the population of pests and diseases, so if not taken seriously it will have an impact on the quality and production of mangoes.

In addition, the widely adopted tree renting practices also lead to a lack of advanced agricultural management practices. In the GMB workshops and interviews, stakeholders mentioned that actors who adopt the renting practice would spend their resources to produce more mango to pay back their capital, rather than produce high-quality mangoes. Tree tenants and certain mango farmers often lack the incentive to invest in the trees they manage, leading to a significant challenge in producing high-quality mangoes. Despite having sufficient

Table 4
The differences between conventional and advanced practices in the Indonesian mango industry.

Level	Conventional	Advanced
On-farm	• The use of pesticides: Not according to recommendations. Often excessive regardless of the level of pest and disease attack. • The use of fertilisers: Often given less than needed • The use of PGR: Often given in excess of the recommended dosage amount • Pruning and fruit thining: rarely conducted • Irrigation: rarely conducted, only rely on rain • Yield: 100 kg for 10–15-year-old trees, only maximum 20% mangoes with bigger size, better taste and aroma, better appearance, and less chemical residue	• The use of pesticides: according to the recommendations stated on the pesticide packaging and official recommendations from the agricultural service officers, and used according to the level of pest and disease attack • The use of fertilisers: Organic and chemical fertilizers in a balanced amount according to the needs and age of the tree • The use of PGR: the recommended dose is 10-15 cc per litre of water • Pruning and fruit thining: conducted regularly • Irrigation: conducted regularly • Yield: 70–80 kg for 10–15-year-old trees, up to 80% mangoes with bigger size, better taste and aroma, better appearance, and less chemical residue
Postharvest	• Simple postharvest practices, just wipe the mango manually and wash it using a detergent. • Single picking for a tree, despite the fruit having different maturity levels • Poor postharvest practices: Excessive use of calcium carbide for artificial ripening and poor waste management	• Advanced postharvest practices, using more advanced technology, such as a mango washing machine and a proper dose of fungicide. • Picking based on the level of ripeness of the fruit • Good postharvest practices: natural ripening and burying mango waste or utilise it for organic fertilisers
Marketing and distribution	• Packing in bulk using wooden crates or bamboo baskets with an estimated capacity of 50 and 30 kg, respectively. • Often packaging exceeds its capacity. • There is no fix quality grade	• Packing using plastic crates with an estimated capacity of 40 kg or cardboard with an estimated capacity of 10–20 kg. • A more coordinated governance system, fix quality grade

Soucre: Primary data collection (2021)

business capital, these actors are reluctant to invest appropriately in the care of the trees, whether rented or owned. This reluctance has two main underpinnings: firstly, a sense of detachment from the trees, especially in the case of tree tenants, which diminishes their sense of responsibility for proper maintenance. Secondly, they harbor the perception that implementing essential treatments, like pruning and fruit thinning, would merely escalate costs and diminish overall yield. This focus on volume, often to the detriment of quality, is a practice not only observed among tree tenants but also among mango farmers who manage their own trees, indicating a lack of investment in crucial areas such as soil and tree management.

According to the information gathered during the problem articulation stage of our study, particularly from researchers from the Ministry of Agriculture and several interviewed farmers, it became evident that the role of extension officers is not always executed as intended. Often, these officers focus primarily on assisting farmer groups in securing government aid, neglecting their fundamental function of disseminating technology and knowledge among farmers. Moreover, extension officers and researchers also revealed that government programs, up to this point, only focused on increasing production rather than improving quality.

The lack of price and market certainty for high-quality mango causes farmers and traders at the upstream level to lose motivation to produce quality mangoes, leading to rarely adopted advanced agricultural management practices, such as pruning and fruit thinning. In the dynamics of mango farming, the relationship between expected and actual revenue becomes crucial. Surprisingly, many mango farmers seem to gloss over this aspect, focusing instead on maximising income through managing a larger number of trees with less effort. Despite realising higher-than-expected income through this approach, they show reluctance towards adopting advanced agricultural practices. A pervasive belief among farmers is that transitioning to advanced methods may diminish mango yields, even though such practices could yield substantial benefits, including enhanced fruit quality, higher market prices due to lower pesticide residues, and larger fruit sizes. Concerns revolve around the potential dip in reve[1]nue due to the associated costs of advanced agricultural practices, such as pruning and fruit thinning. Furthermore, the market value of high-quality mangoes produced through advanced agricultural practices is met with uncertainty. Farmers prefer to produce more mangoes because the large quantities of fruit will pay off their production costs and meet their income targets even if prices fall.

Mango prices in Indonesia typically decline during the peak harvest season between September and December, as mango production increases. Farmers are well aware of this continuous trend. During this period, farmers experience an average mango price decline down to IDR 9,000/kg.[1] Some farmers have even encountered very low mango prices, ranging from IDR 2,500 to 4,500/kg. This unpredictable decline in prices affects both low-quality and high-quality mangoes. Even high-quality mangoes are deemed worthless and are considered low-quality during this period. This situation leads farmers to perceive that there is little incentive to produce high-quality mangoes, given the fluctuating prices. Conversely, during the off-season harvest period, typically around July to September, mango prices increase, reaching as high as IDR 45,000/kg. However, even during this time, the rising prices fail to motivate farmers to prioritise the production of high-quality mangoes. This is primarily because, during the off-season, low-quality mangoes can still be sold at high prices simply due to a lack of overall production.

The identified problems also highlight the absence of mango quality standards. In addition to contributing to the uncertainty of the quality that needs to be produced, it would lead to varying prices set by value chain actors. Because of this, most mango farmers, who manage their trees and rent trees belonging to other farmers, will continue to focus on increasing production to increase income without emphasising quality. Furthermore, the upstream value chain actors also feel that applying advanced agricultural management practices requires them to spend more resources on activities such as pruning and fruit thinning.

3.3.2. *Postharvest problems*

Although advanced postharvest management technologies and guidelines are readily available, their adoption within the Indonesian mango industry remains disappointingly low. This limited application is a significant factor contributing to the shortage of high-quality mangoes in the market. Parallels can be drawn to the on-farm level, where advanced practices are underutilised, predominantly due to inadequate market incentives. The actors involved often perceive a diminished return on their investment, which in turn discourages them from both adopting advanced postharvest management technologies and committing to the production of high-quality mangoes. Most postharvest activities are conducted by collectors or regional traders, who have more resources to harvest mangoes. Due to price and market uncertainty,

[1] On the 4th of January 2021, 1 USD = 13,869.92 IDR (Source: https://www.rba.gov.au/statistics/historical-data.html#exchange-rates).

many traders harvest all mangoes on the tree during a single picking despite the fruit having different maturity levels. Traders conduct this practice to achieve efficiency in harvesting. Because of this practice, mangoes that have not reached the optimal ripeness stage need to be ripened in a postharvest hub or during transportation to markets. Calcium carbide is a commonly used chemical to ripen mangoes. However, the application of calcium carbide is still widely conducted without regard to the optimal dosage. The use of this chemical in excessive doses can have an adverse effect on health conditions such as headaches, cerebral edema, seizures and prolonged hypoxia (Asif, 2012; Shaeda et al., 2018).

Even factors that may be overlooked, such as waste management, can significantly influence the system's ability to produce high-quality mangoes. For instance, many traders tend to discard unsellable, off-grade mangoes onto any available land without appropriate waste treatment. This discarded mango waste can serve as a breeding ground for pests, especially fruit flies, as the fruit may have been infested with eggs before harvesting. Stakeholders involved have emphasised the necessity of implementing efficient waste management practices, such as converting waste into organic fertiliser following specific treatments.

3.3.3. Marketing and distribution problems

Several problems were identified at the marketing and distribution level, contributing to Indonesia's low supply of high-quality mangoes. The lack of advanced logistics and transportation causes high losses of mangoes when delivered from the production centres to markets. This is especially experienced at the wholesaler and retailer levels. Predominantly, mangoes are packaged in bulk using wooden crates or bamboo baskets, each with approximate capacities of 50 kg and 30 kg, respectively. However, there is a prevailing practice of exceeding the container's capacity, which results in the mangoes being tightly compressed against each other. This scenario raises the risk of damage and subsequent losses during marketing and distribution activities. Most retailers interviewed acknowledged that these practices can lead to losses amounting to as much as 30% of their traded mangoes. This issue is not exclusive to Indonesia but is common in mango industries of developing countries, where postharvest and handling losses can reach up to 40% (Gunathilake & K. Tiwari, 2018). In addition, the use of refrigerated vehicles to preserve the quality of mangoes from the production center to the market are still uncommon.

In addition, the lack of a consolidated governance system, which is instrumental in setting and upholding mango quality standards, results in inconsistent quality control among downstream value chain actors. As a result, most of the information regarding quality standards does not reach farmers and marginal intermediaries, as the most upstream value chain actors. A significant issue that also emerges from this is the lack of a unified quality standard in the industry. The absence of robust involvement from professional marketing institutions has led to inconsistencies in the application of quality benchmarks. Each stakeholder, consequently, applies their own standards, which may fluctuate based on factors such as market demand and seasonal variations. For example, low production in the off-season may lead to selling low-quality mangoes as high-quality. On the other hand, due to the abundance of production during the peak harvesting season, high-quality mangoes are sometimes placed as low-quality grades. These unfavourable conditions reinforce the reason value chain actors do not apply advanced management practices at the on-farm or postharvest levels.

3.4. The dynamic complexity of the Indonesian mango industry

The CLD was developed to understand the value chain system structure of the Indonesian mango industry (Fig. 3). The CLD is divided into three subsystems in the detailed discussions: on-farm, postharvest, and marketing and distribution.

In total, there are 67 feedback loops consisting of 36 reinforcing and 31 balancing loops. The list of feedback loops identified in the CLD is presented in Table 5. The following subsection will analyse the feedback loops that lead to the low production of high-quality mango.

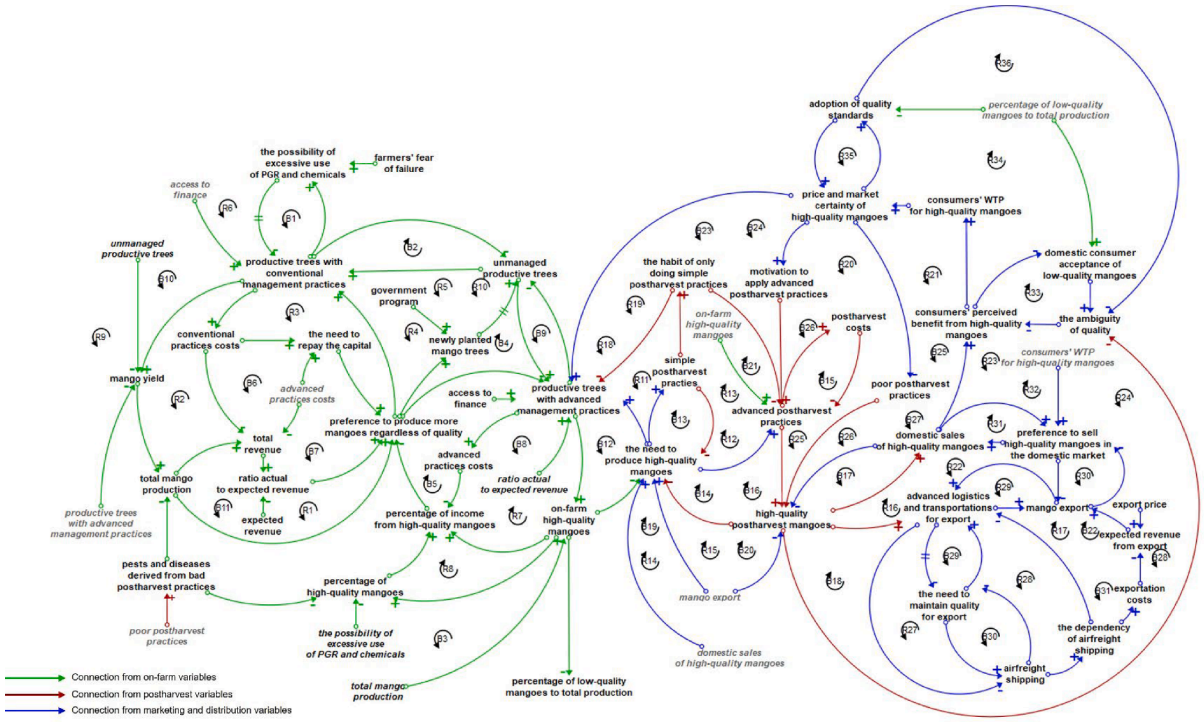

Fig. 3. The dynamics of the Indonesian mango industry. Cutting lines is a delayed process, meaning that changes in one source variable take time to affect the destination variable. Variables printed in cursive show copies of other variables that already exist.
Source: Primary data collection (2021)

Table 5
A description of the feedback loops which generate the dynamic complexity of the Indonesian mango industry in delivering quality.

Feedback loops	Label	Variables involved	Themes
Reinforcing	R1	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, mango yield, total mango production	Motivation to produce more mangoes regardless of quality
	R2	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, mango yield, total mango production, total revenue, ratio actual to expected revenue	
	R3	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, conventional practices costs, the need to repay the capital	
	R4	preference to produce more mangoes regardless of quality, newly planted mango trees, unmanaged productive trees	
	R5	preference to produce more mangoes regardless of quality, newly planted mango trees, unmanaged productive trees, productive trees with conventional management practices, mango yield, total mango production	
	R6	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, the possibility of excessive use of PGR and chemicals, percentage of high-quality mangoes, percentage of income from high-quality mangoes	
	R7	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, on-farm high-quality mangoes, percentage of income from high-quality mangoes	Motivation to produce high-quality mangoes
	R8	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, on-farm high-quality mangoes, percentage of high-quality mangoes, percentage of income from high-quality mangoes	
	R9	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, mango yield, total mango production	
	R10	preference to produce more mangoes regardless of quality, newly planted mango trees, unmanaged productive trees, productive trees with conventional management practices, mango yield, total mango production, on-farm high-quality mangoes, percentage of high-quality mangoes, percentage of income from high-quality mangoes	
	R11	the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, productive trees with advanced management practices, on-farm quality mangoes	Motivation to only apply simple postharvest practices
	R12	the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices, postharvest quality mangoes	
	R13	the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes	Effect of the need for high-quality mangoes on advanced practices
	R14	domestic sales of quality mangoes, the need to produce high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes	
	R15	mango export, the need to produce high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes, advanced logistics and transportation for export	
	R16	domestic sales of quality mangoes, the need to produce high-quality mangoes, advanced postharvest practices, postharvest quality mangoes	
	R17	mango export, the need to produce high-quality mangoes, advanced postharvest practices, postharvest quality mangoes, advanced logistics and transportation for export	
	R18	domestic sales of quality mangoes, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes	Effect of domestic demand on high-quality mangoes in increasing advanced practices
	R19	domestic sales of quality mangoes, consumers perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices, postharvest quality mangoes	
	R20	domestic sales of quality mangoes, consumers' perceived benefit from quality mangoes, consumers' Willingness to Pay (WTP) for quality mangoes, price and market certainty of quality mangoes, motivation to apply advanced postharvest practices, advanced postharvest practices, postharvest quality mangoes	
	R21	domestic sales of quality mangoes, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, poor postharvest practices, postharvest quality mangoes	
	R22	domestic sales of quality mangoes, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, advanced postharvest practices, postharvest quality mangoes, advanced logistics and transportations for export, mango export, traders benefit from mango export, preference to sell high-quality mangoes in the domestic market, traders benefit from domestic selling of quality mangoes	

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Table 5 (*continued*)

Feedback loops	Label	Variables involved	Themes
	R23	postharvest quality mangoes, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices	
	R24	postharvest quality mangoes, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices	
	R25	postharvest quality mangoes, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, motivation to apply advanced postharvest practices, advanced postharvest practices	
	R26	postharvest quality mangoes, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of quality mangoes, poor postharvest practices	
	R27	advanced logistics and transportation for export, air freight shipping, dependence on air freight shipping	Effect of the lack of implementation of advanced transportation and logistics on the dependency on air freight for export
	R28	advanced logistics and transportation for export, the need to maintain quality for export, air freight shipping, dependence on air freight shipping	
	R29	advanced logistics and transportation for export, mango export	Effect of the lack of implementation of advanced transportation and logistics to export
	R30	mango export, preference to sell high-quality mangoes in the domestic market	Effect of preference to sell mangoes in domestic markets to export
	R31	preference to sell high-quality mangoes in the domestic market, domestic sales of quality mangoes	
	R32	domestic sales of quality mangoes, consumers' perceived benefit from quality mangoes, consumers' WTP for high-quality mangoes, preference to sell high-quality mangoes in the domestic market	Effect of consumers' perceived benefit to WTP
	R33	Consumers' perceived benefit from quality mangoes, domestic consumer acceptance of low-quality mangoes, the ambiguity of quality	Effect of consumers' perceived benefit to consumers' acceptance of low-quality mangoes
	R34	percentage of low-quality mangoes to total production, domestic consumer acceptance of low-quality mangoes, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumers WTP for high-quality mangoes, price and market certainty of quality mangoes, productive trees with advanced management practices, on-farm quality mangoes	
	R35	price and market certainty of quality mangoes, adoption of quality standards	Effect of price and market certainty to the adoption of quality standards
	R36	price and market certainty of quality mangoes, adoption of quality standards, the ambiguity of quality, consumers' perceived benefit from quality mangoes, consumer WTP for quality mangoes,	
Balancing	B1	productive trees with conventional management practices, the possibility of excessive use of PGR and chemicals	The negative effect of excessive use of chemicals
	B2	unmanaged productive trees, productive trees with conventional management practices	Shifting of unmanaged trees to conventional
	B3	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, mango yield, total mango production, on-farm high-quality mangoes, percentage of high-quality mangoes, percentage of income from high-quality mangoes	Limitations due to preference to produce more mangoes
	B4	preference to produce more mangoes regardless of quality, newly planted mango trees, unmanaged productive trees, productive trees with advanced management practices, on-farm high-quality mangoes, percentage of income from high-quality mangoes	Limitations due to preference to produce more mangoes
	B5	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, advanced practices costs, the need to repay the capital	Limitations due to production costs
	B6	preference to produce more mangoes regardless of quality, productive trees with conventional management practices, conventional practices costs, total revenue, ratio actual to expected revenue	
	B7	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, advanced practices costs, total revenue, ratio actual to expected revenue	
	B8	productive trees with advanced management practices, advanced practices costs, total revenue, ratio actual to expected revenue	
	B9	productive trees with advanced management practices, unmanaged productive trees	Shifting of unmanaged trees to advanced
	B10	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, unmanaged productive trees, mango yield, total mango production, total revenue, ratio actual to expected revenue	The decrease in yield due to advanced practices
	B11	preference to produce more mangoes regardless of quality, productive trees with advanced management practices, unmanaged productive trees, mango yield, total mango production	

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Table 5 (*continued*)

Feedback loops	Label	Variables involved	Themes
	B12	the need to produce high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes	Reduced efforts when goals have been achieved
	B13	the need to produce high-quality mangoes, simple postharvest practices	Reduced efforts when goals have been achieved
	B14	the need to produce high-quality mangoes, advanced postharvest practices, postharvest quality mangoes	Limit of advanced postharvest due to costs
	B15	advanced postharvest practices, postharvest costs	
	B16	the need to produce high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes	Reduced effort when goals have been achieved
	B17	postharvest quality mangoes, domestic sales of quality mangoes	Decrease in stock due to increased sales
	B18	postharvest quality mangoes, advanced logistics and transportations for export, mango export	Decrease in stock due to increased export
	B19	domestic sales of quality mangoes, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes	The decline in efforts to produce quality mangoes due to simple postharvest practices
	B20	mango export, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, postharvest quality mangoes, advanced logistics and transportation for export	The decline in efforts to produce quality mangoes due to simple postharvest practices
	B21	domestic sales of quality mangoes, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices, high-quality postharvest mangoes	Reduced effort when goals have been achieved
	B22	mango export, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices, high-quality postharvest mangoes, advanced logistics and transportation for export	
	B23	domestic sales of high-quality mangoes, consumers' perceived benefit from high-quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, advanced postharvest practices, high-quality postharvest mangoes	
	B24	domestic sales of high-quality mangoes, consumers' perceived benefit from high-quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, simple postharvest practices, the habit of only doing simple postharvest practices, advanced postharvest practices, high-quality postharvest mangoes, advanced logistics and transportations for export, mango export, traders benefit from mango export, preference to sell high-quality mangoes in the domestic market, traders benefit from domestic selling of quality mangoes	Small mango export due to domestic sales of high-quality mangoes
	B25	domestic sales of high-quality mangoes, consumers' perceived benefit from high-quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, advanced postharvest practices, high-quality postharvest mangoes, advanced logistics and transportation for export, mango export, traders benefit from mango export, preference to sell high-quality mangoes in the domestic market, traders benefit from domestic selling of quality mangoes	Small mango export due to domestic sales of high-quality mangoes
	B26	domestic sales of high-quality mangoes, consumers' perceived benefit from high-quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of high-quality mangoes, traders' motivation for advanced postharvest practices, advanced postharvest practices, high-quality postharvest mangoes, advanced logistics and transportations for export, mango export, traders benefit from mango export, preference to sell high-quality mangoes in the domestic market, traders benefit from domestic selling of quality mangoes	
	B27	domestic sales of high-quality mangoes, consumers' perceived benefit from high-quality mangoes, consumers' WTP for high-quality mangoes, price and market certainty of high-quality mangoes, poor postharvest practices, high-quality postharvest mangoes, advanced logistics and transportation for export, mango export, traders benefit from mango export, preference to sell high-quality mangoes in the domestic market, traders benefit from domestic selling of quality mangoes	
	B28	postharvest high-quality mangoes, the ambiguity of quality, consumers' perceived benefit from high-quality mangoes, consumers WTP for high-quality mangoes, price and market certainty of high-quality mangoes, productive trees with advanced management practices, on-farm quality mangoes, the need to produce high-quality mangoes, advanced postharvest practices	Decreasing the ambiguity of quality
	B29	advanced logistics and transportations for export, the need to maintain quality for export	The effort to maintain quality for export
	B30	the need to maintain quality for export, air freight shipping	
	B31	the need to maintain quality for export, airfreight shipping, the dependency of airfreight shipping, exportation costs, expected revenue from export, mango export, advanced logistics and transportation for export	

Source: Primary data collection (2021)

3.4.1. On-farm dynamics

The need to produce high-quality mangoes requires more advanced agricultural management practices (B12). However, findings from this study show that conventional agricultural management practices are primarily applied to increase mango production per tree. The increase in mango production reinforces the motivation of farmers to produce more mangoes through conventional agriculture management practices (R1). This increase in motivation can occur due to an increase in total revenue (R2) and the need to repay the capital spent (R3). In addition, the preference to produce more mangoes regardless of quality encourages farmers to increase the number of newly planted mango trees. These newly planted trees, independently by farmers or through government programs, when they are able to produce, will be managed by farmers either with conventional or advanced practices (B2, B9). It will increase the productive mango tree population and increase mango production under conventional agricultural management practices (R4, R5). However, if productive trees are left unmanaged, it can potentially reduce mango tree yield, which will result in a decrease in total production (B10, B11).

Despite the high production, conventional management practices can only provide a low number of high-quality mangoes (20%) from the total mangoes produced. Excessive pesticide and PGR usage significantly contributes to this low yield (R6). Long-term application of these substances can harm the trees and deplete the productive tree population (B1). The tree structure in conventional farming practices necessitates extensive pesticide use as they are sprayed over all parts of the unpruned tree. This, in turn, results in higher pesticide residues on the mangoes, compromising the quality and raising production costs. As such costs can strain farmers' income, they may prioritise producing a higher volume of mangoes to recoup their capital investment (B3).

Applying advanced agricultural management practices is the key to increasing quality mango production at the on-farm level (R7). This practice can contribute to total revenue and negatively influence farmers' preferences to produce many low-quality mangoes (R8, R9, R10). This practice, especially pruning, also makes pesticide application more efficient, which leads to improved mango quality due to minimal residue (Abate & Dechassa, 2021). As with conventional agricultural management practices, advanced agricultural management practices also increase production costs (B7, B8), potentially reducing the farmers' motivation to produce high-quality mangoes. Farmers will again need to produce large quantities of mangoes, although of low quality, to recover the costs incurred (B4, B5). The on-farm dynamics in the Indonesian mango industry are presented in Fig. 4.

3.4.2. Postharvest dynamics

Feedback loops that explain the dynamics at the postharvest level are also influenced by variables from the on-farm and the marketing and distribution levels. The need to produce high-quality mangoes have the potential to increase the number of productive trees grown with advanced agricultural management practices, which further increases the application of advanced postharvest management practices (R14, R15, B14). It leads to the availability of high-quality mangoes from the postharvest level, which can increase domestic sales of high-quality mangoes (B17, R16) and achieve economies of scale for mango export delivery (B18, R17). The quantity and consistency of high-quality mango production at the on-farm level directly impact the adoption of advanced postharvest management practices. A shortage of high-quality mangoes can disincentivise the application of advanced postharvest techniques, as the expected output quality cannot be guaranteed (B16). High-quality mangoes from the postharvest level are only currently obtained from simple postharvest processes such as sorting and grading (B13). This is the most widely used practice compared to advanced management practices at the on-farm and postharvest levels (R11, R12). Many value chain actors stated that they are already satisfied with the

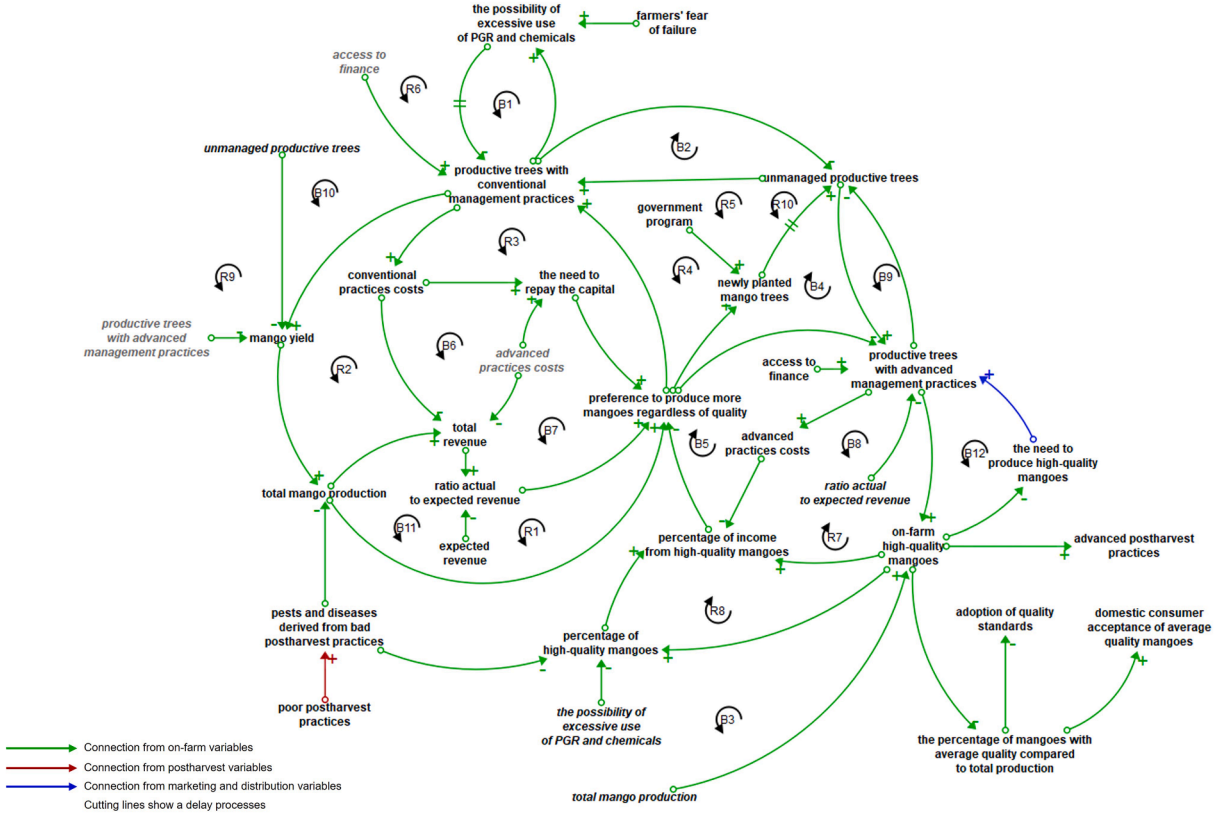

Fig. 4. On-farm dynamics of the Indonesian mango value chain. Cutting lines is a delayed process, meaning that changes in one source variable take time to affect the destination variable. Variables printed in cursive show copies of other variables that already exist.
Source: Primary data collection (2021)

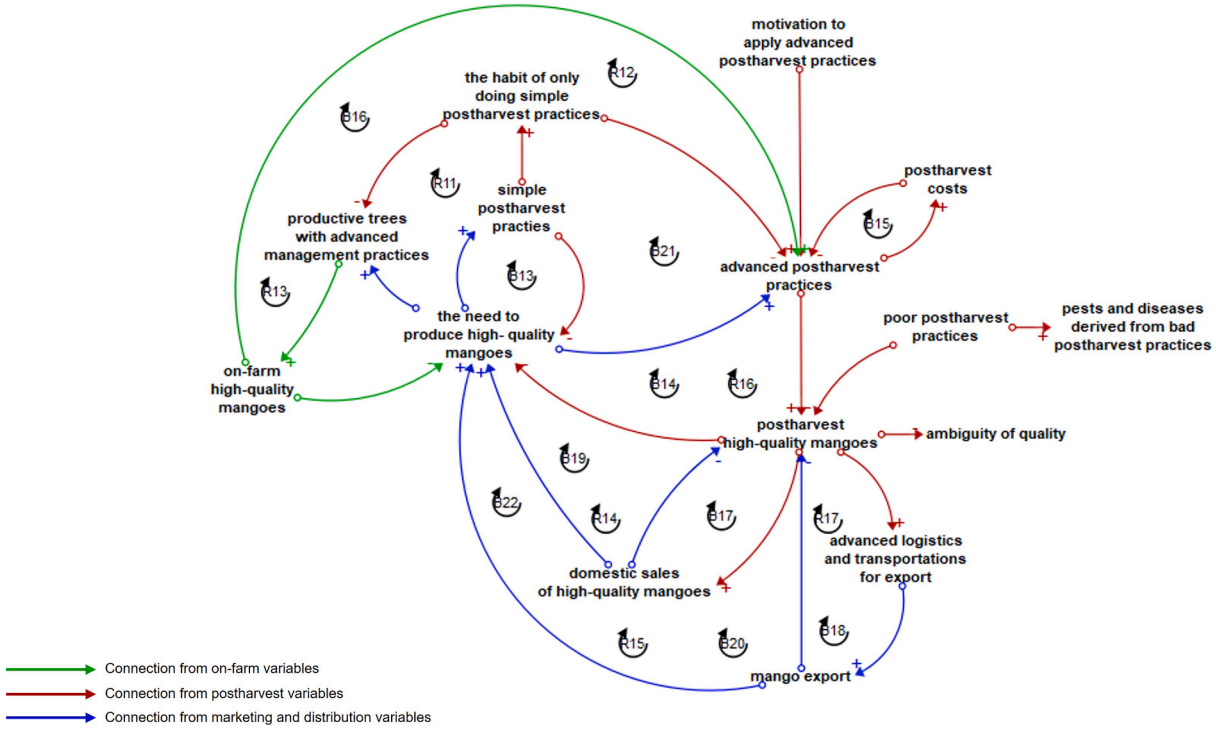

Fig. 5. Postharvest dynamics of the Indonesian mango value chain.
Source: Primary data collection (2021)

current postharvest practices and do not need to apply advanced postharvest practices. They are also mentioned that advanced postharvest practices only will increase the cost incurred (B15). Consequently, it contributes to the lack of advanced postharvest management practices (B19, B20, B21, B22) and reinforces the simple postharvest practices to continue to be conducted (R13). The postharvest dynamics in the Indonesian mango industry are presented in Fig. 5.

3.4.3. *Marketing and distribution dynamics*

The supply–demand dynamics in the domestic mango market reveal an underlying issue: the absence of well-established quality standards and a pervasive acceptance of lower-quality mangoes, largely due to the scarcity of high-quality ones. Implementing quality standards could ensure consistent mango quality, reducing market ambiguity and increasing consumer perceptions of high-quality mango value (R33). This could, in turn, raise consumers' willingness to pay for high-quality mangoes, creating more stable pricing and market conditions for these products (R36). Such stability would stimulate the adoption of quality standards (R35), encouraging the implementation of advanced practices in the on-farm and postharvest stages. Consequently, this would boost high-quality mango production and availability in the domestic market (R18, R19, R20, R21, R22, R23, R24, R25, R26, R32, R34). Establishing quality standards, along with securing price and market certainty, could elevate the number of high-quality mangoes in the market. This would enhance consumers' perceived benefits of high-quality mangoes and their willingness to pay, as the mangoes they encounter would indeed meet high-quality standards. Ultimately, this would fulfil the growing need for high-quality mango production to cater to the evolving domestic market (B23, B24, B28).

In addition to the domestic market, export is recognised as one of the modern market channels in the Indonesian mango industry. This marketing channel requires a supply of high-quality mangoes. Price and market certainty for high-quality mangoes can also contribute to increasing the availability of mangoes for export. The availability of high-quality mangoes can increase the efficiency of using advanced logistics and transportation for export (R28, R29), thereby overcoming the issue of the need to maintain quality for export which all this time had been conducted using airfreight shipping (R27, B29, B30). However, the export market needs to compete with the domestic market to obtain a supply of high-quality mangoes (B25, B26, B27). It should be noted that some Indonesian mango exporters are also suppliers to the domestic market. They will be more motivated to sell high-quality mangoes in the domestic market if there are no benefits and conveniences offered by exporting mangoes (R30, R31, B31). This could threaten efforts to increase Indonesia's mango exports, the program of the Indonesian Ministry of Agriculture to increase Indonesia's competitiveness in the world mango trade. The Indonesian mango industry marketing and distribution dynamics are presented in Fig. 6.

3.5. *System archetypes and recommendations to improve Indonesian mango industry performance*

To satisfy the demand for high-quality mangoes, necessary enhancements must be implemented, spanning from the on-farm processes to postharvest handling. Currently, the Indonesian mango industry actors only conduct simple postharvest practices, such as grading, to meet the demand for quality mangoes. Based on interviews with local traders in the production centres, the high-quality mangoes produced with these practices currently make up no more than 20% of total mango production. In this section, we use system archetypes to identify fundamental actions that can be taken to increase the ratio of high-quality mangoes. As mentioned by Braun (2002), ten system archetypes are widely recognized as indicative of behavioural patterns within a system. From the developed CLD in our study, we identified and extracted three such system archetypes - *success to the successful*, *limits to growth*, and *shifting the burden*.

3.5.1. *Success to successful*

The *success to successful* archetype reflects a condition when two activities compete for limited resources (Setianto et al., 2014b). Activities with greater success will consistently receive more support, while poor performers receive less support (Senge, 2006). Fig. 7 shows 10

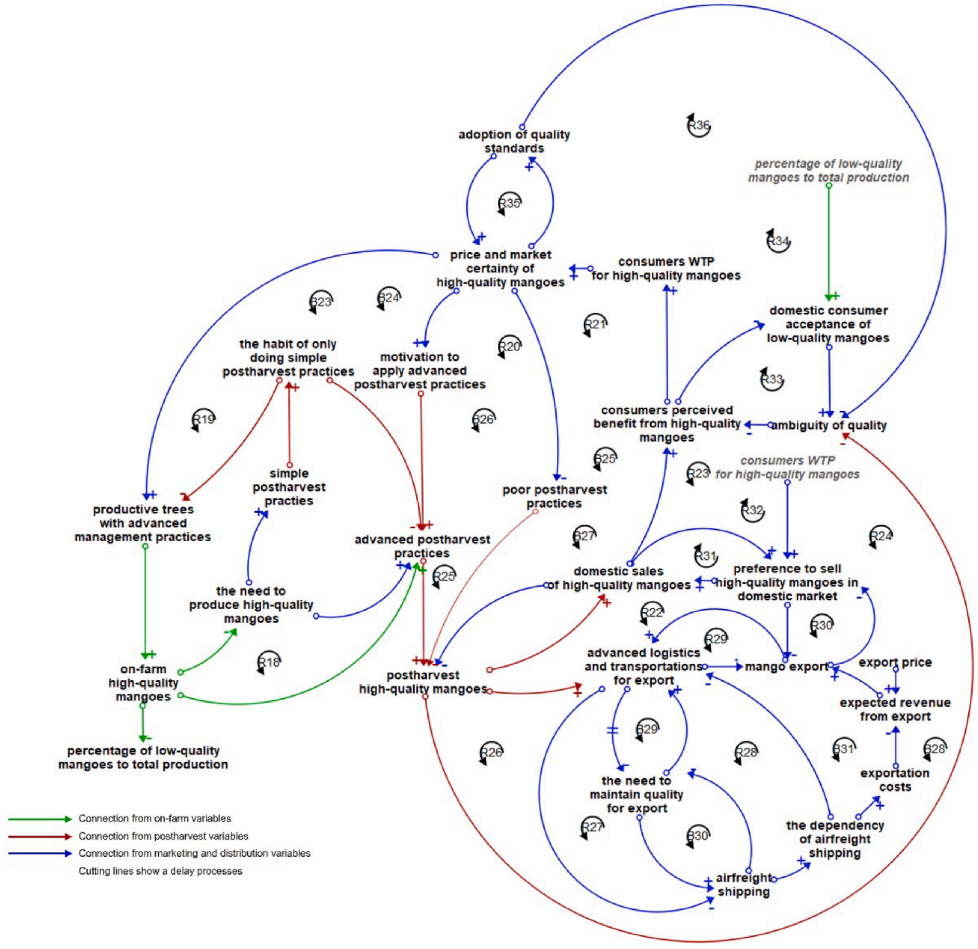

Fig. 6. Marketing and distribution dynamics of Indonesian mango value chain. Cutting lines is a delayed process, meaning that changes in one source variable take time to affect the destination variable. Variables printed in cursive show copies of other variables that already exist.
Source: Primary data collection (2021)

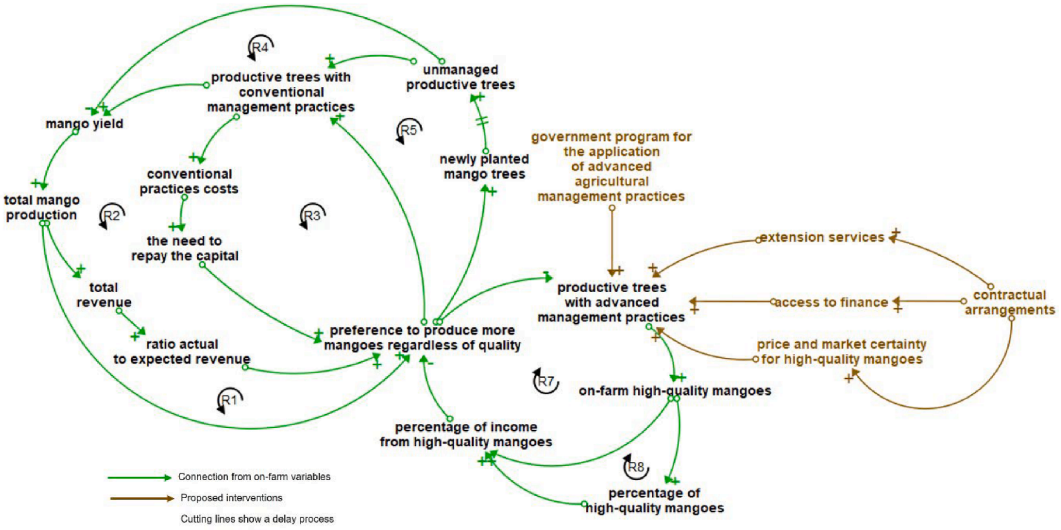

Fig. 7. Preference to produce more mangoes compared with producing on-farm quality mangoes, success to successful archetypes. Cutting lines is a delayed process, meaning that changes in one source variable take time to affect the destination variable.
Source: Primary data collection (2021)

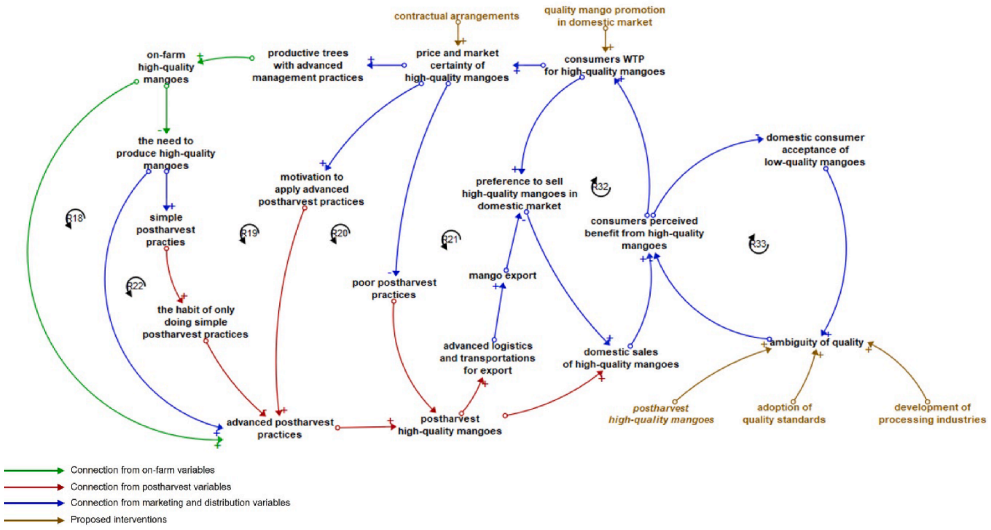

Fig. 8. Consumer perceived benefit from quality mangoes, success to successful archetype.
Source: Primary data collection (2021)

success to successful archetypes identified in the Indonesian mango industry. They reflect farmers' preference to produce more mangoes regardless of the quality instead of high-quality mangoes. The consequence of this preference leads to behaviour where over time, farmers allocate more resources to produce more mangoes by applying conventional agricultural management practices (R1, R2, R3) and planting new trees (R4, R5) rather than by applying advanced agricultural management practices (R7, R8).

The recommended strategy for the *success to successful* archetype is to balance the outcomes of the two choices (Senge, 2006). We have identified productive trees with advanced management practices in loops R7 and R8 as the leverage points that can help balance loops R1-R5. This suggests that there should be an increase in the number of productive trees with advanced management practices. Several proposed government-initiated programs can facilitate the adoption of advanced agricultural management practices. For example, mango researchers and extension officers suggest the provision of agricultural machinery such as water pumps for irrigation and chainsaws for pruning. These actors and most of the farmers involved in the GMB workshops also mentioned that the government needs to provide financial assistance for labour costs. However, based on the discussion with the authorities, this is not a viable solution as the government's financing allocation scheme does not allow for this form of assistance. Another proposed intervention is to create a coordinated governance structure through contract farming for high-quality mangoes. This intervention was mostly proposed by farmers in the workshops. This arrangement creates a secure market for high-quality mangoes and minimises the potential for improper production practices with pre-agreed quality and quantity (Man & Nawi, 2010). In addition, the contractual arrangement can also increase access to external financial sources and help the government optimise the role of extension services (Liverpool-Tasie et al., 2020; Susilowati et al., 2020). The *success to successful* archetypes representing the preference to produce increased numbers of mangoes rather than on-farm quality mangoes, including the recommended intervention, are presented in Fig. 7.

On the consumer side, their perceived benefits of quality mangoes can influence advanced practices in on-farm and postharvest, which lead to increased domestic sales of high-quality mango (R18-22, R32). However, the lack of control and established quality standards in the value chain allows for the occurrence of fraud, where low-quality mangoes are deceitfully sold as high-quality mangoes. This cheating behaviour undermines consumer trust and hinders the recognition of the true benefits of high-quality mangoes. Consequently, consumers inevitably have to accept that the low-quality mangoes on the market are the only option they have (R33). Fig. 8 shows six 'success to successful' archetypes that reflect these issues.

Interventions can be applied at some of the leverage points identified. Increasing 'price and market certainty for high-quality mangoes' and 'WTP consumers for high-quality mangoes' are crucial leverage points in loops R18-22 and R32. Moreover, addressing the 'ambiguity of quality' in loop R33 is important. The establishment of a formal marketing institution can facilitate contractual arrangements between value chain actors, ensuring the delivery of the right product quality at the right price (Michler & Wu, 2020). It would also lead to an increase in the adoption of advanced agricultural management practices and a decrease in poor postharvest practices due to the rising certainty of the specified quality (Khanal et al., 2020). Crucial to increasing consumers' perceived benefit from high-quality mango is to reduce the amount of low-quality mangoes sold as high-quality. Promoting high-quality mangoes in the domestic market can increase consumers' WTP for high-quality mangoes. In addition, To ensure safer consumption patterns, it is crucial to elevate consumer awareness about choosing high-quality fruits. While shedding light on health risks linked to low-quality, chemically contaminated fruits, educational campaigns should also highlight consumers' influence in steering demand towards safer, higher-quality fruits. This increased demand could encourage adopting improved agricultural and postharvest practices, potentially increasing the production of high-quality mangoes. Collaborative efforts among stakeholders, such as government agencies, non-profits, and media, are vital. This recommendation underscores the need for consumer education for a safer, more sustainable Indonesian mango industry.

Mango researchers suggest that the development of the mango processing industry can also be a market alternative for low-quality mangoes so that the numbers sold as low-quality are reduced. Equally important, adopting a uniform quality standard would make it easy to differentiate and classify high and low-quality mangoes in the markets.

3.5.2. *Limits to growth*

Limits to growth archetypes describe the process in which a period of accelerated growth is followed by a period of deceleration (Senge, 2006). We identify two *limits to growth* archetypes related to limited resources for implementing advanced agricultural management practices (Fig. 9). The CLD shows that on-farm high-quality mango production can increase the percentage of income from high-quality mangoes and reduce the preference for producing more mangoes without quality. This will further increase the number of productive

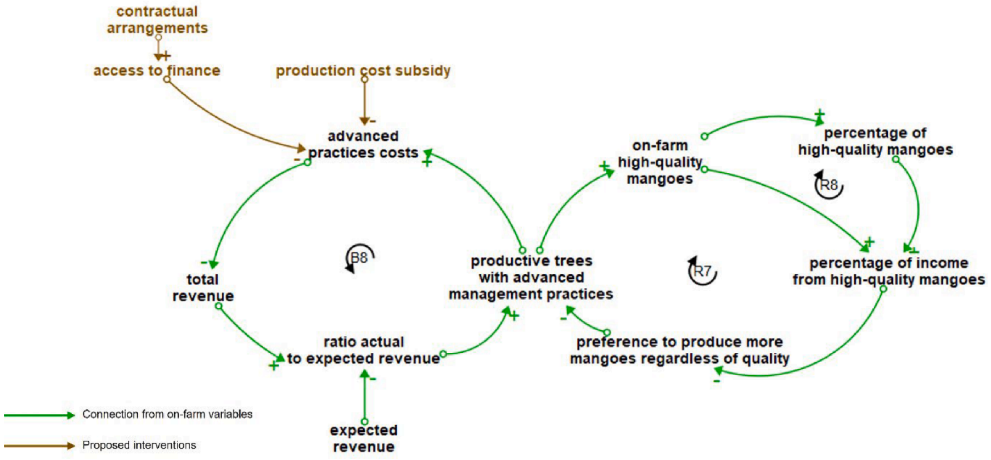

Fig. 9. Limit for advanced agricultural management practices, limits to growth archetype.
Source: Primary data collection (2021)

trees with advanced management practices (R7, R8). However, this practice is limited by the costs of advanced agricultural management practices, which will reduce the total revenue. This will then negatively impact the ratio of actual to expected revenue, thus motivating farmers to produce more mangoes regardless of quality (B8). In loop B8, 'advanced practices costs' is a leverage point that can minimise the performance limitation of increasing the number of productive trees with advanced management practices. The farmers and traders proposed interventions such as production cost subsidies and improved access to finance to implement this.

We also found three *limits to growth* system archetypes related to the limit in the conventional agricultural management practices. As previously explained, the preference to produce higher numbers of mangoes tends to adopt conventional agricultural management practices, and increased production motivates the farmers to continue adopting the conventional agricultural management practices (R1, R2, R3). However, this process has a balancing loop, in which applying conventional agricultural management practices increase the possibility of excessive use of PGR and chemicals. Farmers' fear of failure gives rise to this condition, causing them to apply PGR and chemicals excessively to ensure high production and freedom from pests and diseases. In the long term, this practice can kill trees and reduce their numbers, especially those currently managed conventionally (B1). The 'possibility of excessive use of PGR and chemicals' is the leverage point in loop B1 that needs to be intervened with to prevent the continuous decline of productive tree populations. In order to do this, mango researchers suggest the improvement of the performance of extension services to educate farmers on the proper use of PGR and chemicals is a recommended intervention. Fig. 10 reflects these three *limits to growth* archetypes.

3.5.3. *Shifting the burden*

The *shifting the burden* archetype represents a situation where the typical easy short-term solutions are preferred over fundamental solutions. The easy solution offers temporary benefits, which then cause side effects that make things worse (Senge, 2006; Setianto et al., 2014b). Our dynamic hypothesis identifies *shifting the burden* archetypes related to the effect of only doing simple postharvest practices (Fig. 11).

To obtain quality mangoes, various actors involved in the value chain, including farmers and regional traders, often rely on simple postharvest practices such as grading (B13). Grading allows for the separation of high-quality mangoes from the overall crop. However, it is important to recognise that grading alone has its limits in increasing the actual percentage of quality mangoes. To address this, it is crucial to implement fundamental actions that can effectively enhance the production of high-quality mangoes. This can be achieved through the adoption of advanced agricultural management practices for mango trees (B12) and the utilisation of more advanced postharvest practices and facilities (B14). Unfortunately, relying solely on grading has become a common practice among value chain actors, as they perceive it to be the most straightforward and effective method to obtain high-quality fruit. However, this approach indirectly affects the minimum number of high-quality mangoes produced, both at the on-farm (R11) and

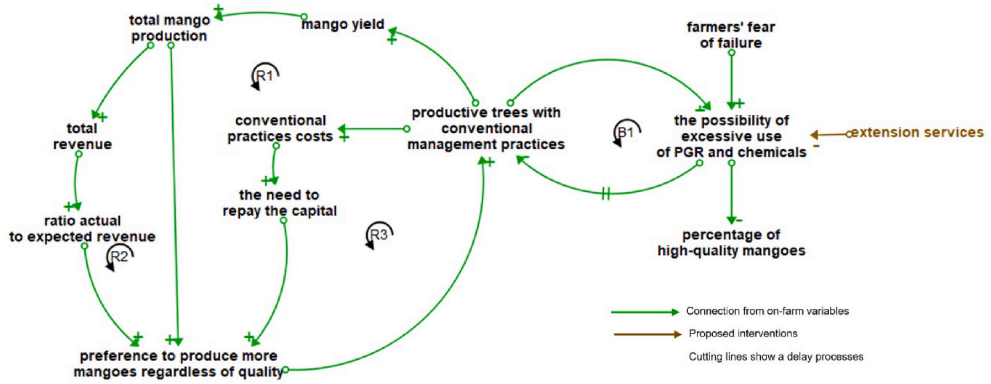

Fig. 10. Productive trees with conventional agricultural management practices, limits to growth archetype. Cutting lines is a delayed process, meaning that changes in one source variable take time to affect the destination variable. Variables printed in cursive show copies of other variables that already exist.
Source: Primary data collection (2021)

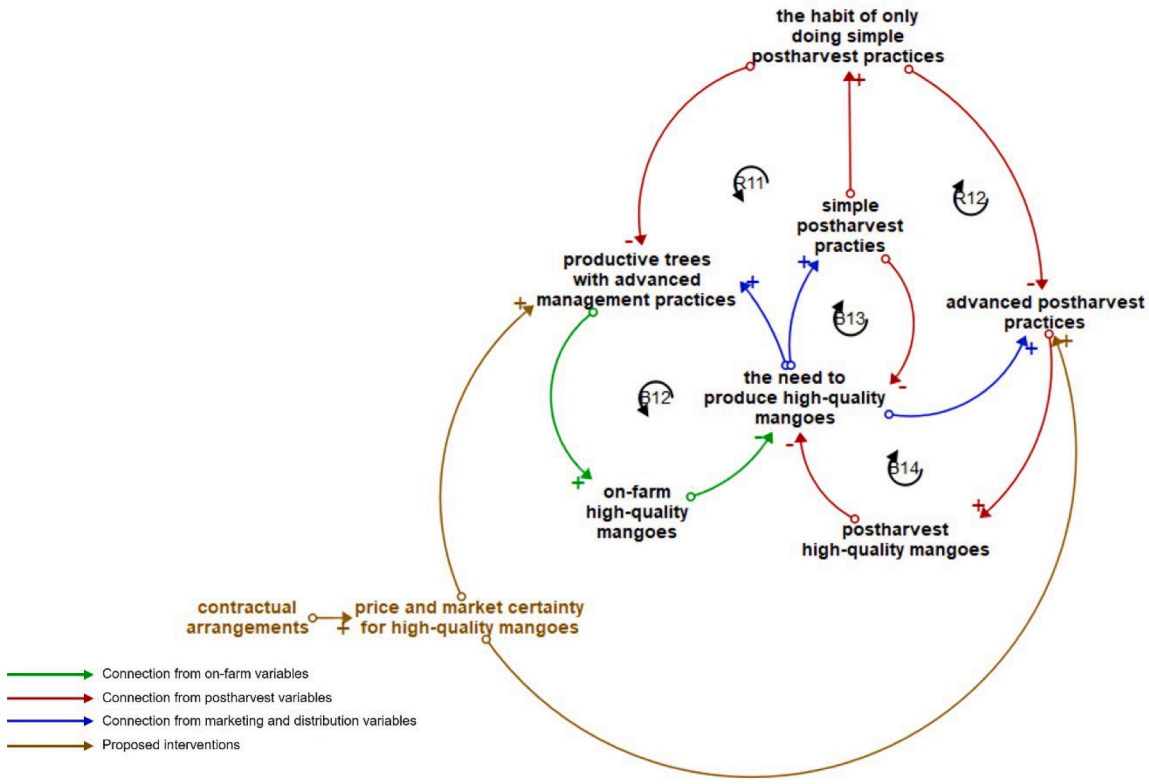

Fig. 11. The need to fulfil mango quality demand from on-farm and postharvest, shifting the burden archetypes.
Source: Primary data collection (2021)

postharvest levels (R12). In this archetype, the key leverage points include increasing the number of 'productive trees with advanced management practices' and increasing the application of 'advanced postharvest practices'. The recommended interventions suggested by mango researchers are facilitating farmers and traders to adopt advanced postharvest practices such as proper handling, cold logistic systems and packaging, and advanced agricultural management practices. To encourage the adoption of advanced practices, farmers should receive a reasonable premium price for high-quality mangoes. This can be facilitated through a coordinated governance structure, such as contractual arrangements.

4. Discussion

The results have shown challenges and opportunities for the Indonesian mango industry, either in on-farm, postharvest, and marketing and distribution levels, to increase the delivery of high-quality mangoes to domestic and export markets. The lack of price and market certainty is one of the causes of the wide adoption of conventional agricultural management practices at the on-farm level and the lack of adoption of advanced postharvest management practices at the postharvest level. In addition, the lack of resources (capital and inputs) and access to extension services also contribute to this problem.

Consumers are willing to pay for the quality of mango at a premium price if the actual quality meets their preference. The findings have provided lessons for the Indonesian mango industry as a whole system for the need to adopt a market orientation approach by focusing on consumers' needs in terms of quality mangoes. Achieving this aim requires collaborative actions among primary actors and key stakeholders. This highlights the importance of the GMB process in identifying challenges and proposed interventions based on the actors' perspectives within the systems (Mui et al., 2019; Mumba et al., 2017). The GMB process is indeed vital, as effective policy shifts demand more than just robust models and extensive databases (Rich et al., 2018). It fosters collaborative engagement, helping to align differing perspectives and encouraging shared understanding among stakeholders. This inclusivity not only enhances the model's quality and acceptance but also promotes sustained implementation of proposed policies. Furthermore, GMB supports collective learning and capacity-building, essential for long-term system improvement and resilience (Mumba et al., 2017). This can reduce policy resistance should the proposed interventions be implemented. Finally, recommendations to improve the overall system performance of the Indonesian mango industry system are obtained through the analysis of the identified systems archetypes. It is a process that has not been widely adopted in studies integrating systems thinking approaches into value chain analysis (Muflikh et al., 2021a). The identification of system archetypes enables the ability to effectively explain the dynamic process that forms the system's behaviour (Maani & Cavana, 2007; Sterman, 2000).

This study extends the results of previous studies, which have mapped the Indonesian mango industry (Karyani et al., 2016; Natawidjaja et al., 2014). It allows for a more thorough understanding of how the variables within the system interact and form the system's dynamic behaviour, which cannot be explored and explained in-depth when only using a conventional value chain analysis (Dizyee et al., 2019; Muflikh et al., 2021a). It also contributes to the richness of the literature on integrating the systems thinking approach into the agricultural value chain analysis. The systems thinking approach has allowed for a more systematic analysis of the problems, unveiling relationships and interdependencies among different subsystems that may not be apparent in conventional value chain analysis. By linking problems, key drivers or causes, and appropriate solutions, this approach provides a holistic understanding of the complex dynamics within the mango value chain (Benninger et al., 2021). It is operationalised by associating the system behaviour to the correct dynamic systems structure presented in the CLD (Setianto et al., 2014b). The CLD development enriches the mapping of the value chain of the Indonesian mango industry by visualising the causal relationships and feedback loops that control the system's

behaviour (Muflikh et al., 2021a). This process can further explain non-linear processes in the Indonesian mango industry and illustrates multiple feedback loops for existing variables (Jagustović et al., 2019).

Minimising the perceived and existing quality gap should begin at the pre-harvest stage (Kyriacou & Rouphael, 2018). However, we may not understand the characteristics of the food system solely from a single perspective (Gamboa et al., 2016). Many challenges of the Indonesian mango industry, either on the on-farm, postharvest, or marketing and distribution subsystem, need to be addressed. Focusing only on a certain subsystem in improving the performance of the food system can lead to biased and incomplete outputs (Clay & Feeney, 2019; Setianto et al., 2014a). For example, producing high-quality mangoes is not only simply by providing advanced postharvest technology. The results of this study show that no matter how advanced the postharvest system is built, in the absence of an adequate supply of high-quality mangoes from on-farm, the Indonesian mango industry is still unable to improve its performance. In addition, many actors, with their respective interests, value systems, codes of conduct, and other practices across the value chain, can also influence the performance of the Indonesian mango industry (Arifin, 2013; Natawidjaja et al., 2014).

Systems thinking used in this study has improved the understanding of the dynamic complexity of the Indonesian mango industry by focusing the analysis on the whole system and its dynamic interactions. This study provides practical implications for policymakers and other decision-makers to facilitate the value chain actors in delivering high-quality mangoes. Given the intricate nature of the Indonesian mango industry, which involves multiple stakeholders with differing interests, it is imperative for the government to assume the role of a facilitator in driving the progress of this sector. For instance, the Ministry of Agriculture in Indonesia can support farmers in adopting advanced agricultural management practices by facilitating easy access to essential resources such as planting materials, fertilisers, and pesticides. Additionally, the government can take the initiative to promote the utilisation of advanced postharvest facilities, including implementing postharvest machinery. This can serve as a catalyst for value chain actors to adopt and utilise these facilities effectively. Furthermore, the government can play a supervisory role to ensure the continuous and sustainable utilisation of these postharvest facilities in the mango industry (Hardiyanto et al., 2020). Besides easy access to various production resources, facilities and infrastructures, the government could provide affordable production inputs, especially for smallholder farmers, the industry's primary and most significant actors.

The limited access to affordable production resources, facilities and infrastructures makes advanced production practices rarely adopted, even by smallholder farmers who have received government aid. On the other hand, farmers with adequate capital and who do not rely on government assistance often prefer to produce larger numbers of mangoes regardless of the quality due to the lack of price incentives for high-quality ones. These conditions could threaten the sustainability of the mango quality improvement program because it does not change the fundamental factors that could increase farmers' motivation to produce high-quality mangoes.

A study by Natawidjaja et al. (2014) suggested that price incentives could increase farmer participation in modern retail channels, which are directed to implement advanced agricultural management practices to produce mangoes that meet high-quality standards. Our research revealed an intriguing trend: an increase in income does not necessarily lead to a greater uptake of advanced agricultural management practices among farmers. Hence, we propose that strategies to incentivize farmers should extend beyond price considerations. We recommend enhancing the governance structure through a formalised contractual agreement designed to stabilise price fluctuations and mitigate other market risks. This approach would provide a safety net for farmers, encouraging the long-term adoption of advanced agricultural management practices. As part of this recommendation, we suggest the development of a professional and structured contract farming system. Several studies have analysed the advantages of contract farming as a tool to improve the performance of several fruit industries in Indonesia, such as bananas (Widyadana et al., 2014), watermelon (White & Wijaya, 2022), and mangosteen (Astuti et al., 2014; Patrick, 2004). The contractual arrangement provides advantages for smallholders, such as increasing income, market access, credit, and technology application, and developing a more comfortable business culture (Astuti et al., 2014; Susilowati et al., 2020). Banana smallholder farmers in East Java that were introduced to contractual arrangements were found to be motivated to produce bananas with the required quality and are no longer willing to switch to growing other commodities (Widyadana et al., 2014). The contractual arrangements also can overcome the absence of price and market certainty problems that makes the price of high-quality mangoes follow the existing market price, which does not care about quality standards. With price and market certainty for high-quality mangoes, advanced management practices across the value chain may be more widely adopted. This is because even though the quantity of product obtained is less, the appreciation price for high-quality mangoes can increase the revenue of value chain actors (farmers and traders) compared to only producing a lot of low-quality mangoes from conventional management practices. It is also important to note that contract farming must be managed professionally and not just act as an ordinary trader. In our discussions with the stakeholders, we identified that relevant government agencies could perform the supervision activities to ensure this system runs appropriately.

5. Conclusion

This study adopts the systems thinking approach to analyse how the Indonesian mango industry delivers mango quality to its markets. We model the industry based on three levels of activities: on-farm, postharvest, and marketing and distribution. Through semi-structured interviews, GMB workshops, and expert discussions, we identified underlying problems of the low number of high-quality mangoes produced by the Indonesian mango industry. The CLD built from the participatory process provides a simple visual representation of the complex Indonesian mango industry system, with 67 feedback loops consisting of 36 reinforcing and 31 balancing loops. Three systems archetypes were identified: *success to successful, limits to growth*, and *shifting the burden*. Building upon the identified system archetypes, the GMB process facilitated the formulation of several policy recommendations aimed at enhancing the Indonesian mango industry's performance in delivering high-quality mangoes to the market. These suggestions encompass the development of government policy that stimulates the shift from currently dominant conventional agricultural management practices to more sophisticated recommended practices for mango cultivation. Further recommendations include amplifying the role of extension services, advocating for high-quality mangoes in the domestic market, bolstering advanced postharvest management capacity, cultivating the mango processing industry, and refining the governance structure through contractual arrangements. These initiatives can potentially lead to market and price stability for quality mangoes, improved access to finance, and more widespread adoption of quality standards. This study adopted the first two steps of systems thinking. Despite its advantage as an alternative to formulating policy recommendations to improve the performance of the Indonesian mango industry, the identified feedback loop and the system archetypes constitute a hypothesis that still needs to be tested through the final three steps of systems thinking. Through these three quantitative steps in systems thinking, we will be able to further this study by simulating a shift in the dominance of the loop over time and the effect of delay on the system behaviour. The future development of a system dynamics model to quantitatively improve the Indonesian mango industry performance is necessary to advance this study.

CRediT authorship contribution statement

Adhitya Marendra Kiloes: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Yanti Nuraeni Muflikh:** Methodology, Formal analysis, Writing – review & editing. **Daryl Joyce:** Supervision, Writing – review & editing. **Ammar Abdul Aziz:** Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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