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Local Narratives on the Adoption of Mango Integrated Crop Management Technologies in Samal Island, Philippines

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Abstract. The adoption of agricultural technologies is imperative in improving the performance of the local agriculture sector in the Philippines. Numerous technology-based development projects have been implemented across the country. The Mango ICM project was one of these interventions. It was carried out in the Island Garden of Samal, Davao del Norte (IGaCoS) with the objective of supporting the local mango industry through the promotion of environmentally sustainable technologies. Years since project completion, challenges have been raised in relation to technology adoption. To understand the adoption dynamics in IGaCoS, this study dissects the complex nature of the Mango ICM technologies and the perception and reception of the local producers towards them. This study is grounded on the narratives gathered through a series of in-depth interviews with key informants and local mango producers. Results show that although the potential benefits of the extended technologies were recognized, the existing local labor and market arrangements created barriers to technology adoption. The nature of technology, market arrangement, and financial constraints were the identified reasons for the non-adoption of the local mango producers.

Keywords: adoption, agricultural innovations, mango industry

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1. Introduction

The vulnerability of the agriculture sector presents issues and challenges to agribusiness operators. An important mechanism to respond to this vulnerability is through agricultural innovations. It has been recognized that technological innovations are crucial in a country's development aspirations [19]. In particular, the adoption of agricultural technologies and practices could enable agribusiness operators to improve both their level of production and income. The need for improving the production technologies and practices being utilized by agribusiness operators is especially critical for communities that are highly dependent on the agriculture sector

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[1]. This has been the case in the Philippines, where more than 9 million people are economically dependent on agriculture [22].

Throughout the years, numerous development-oriented projects have been implemented in different regions in the Philippines to facilitate agricultural technology adoption. One of these projects was the Mango Integrated Crop Management (ICM) Project. The Mango ICM Project was jointly implemented by an international organization and local academic organizations in partnership with local government units. The project was designed to support the local mango industry in the Southern Philippines. Its objectives were not limited to promoting economic and social welfare among mango producers; the project also aimed to contribute to environmental protection. Aside from Mango ICM Project, numerous technology-based projects were also implemented to support the further development of the mango industry in the region. During its implementation, the Island Garden City of Samal (IGaCoS) in Davao del Norte became among the projects' pilot sites. This allowed local mango producers to participate and benefit from the various research and extension activities.

Years after their implementation, questions on the effectiveness of the Mango ICM technologies were raised, thus calling for an evaluation. Specifically, the questions were grounded on whether the intended benefits were realized and have been translated to socio-economic welfare of the local stakeholders. This paper tackles such questions in its examination of the nature of the technology-based projects along with their rationale for its design. It highlights the perceived benefits of the local mango producers in adopting these technologies. Finally, it dissects the complex nature of the local adoption dynamics while looking into the potential challenges encountered by the local mango producers in terms of adopting the different Mango ICM technologies.

2. Materials and Methods

2.1. Data Collection

A qualitative approach was applied in examining the adoption dynamics in IGaCoS in relation to the Mango ICM technologies. A qualitative approach was used in the study to explore ideas and dissect the complexities of the local mango industry by capturing the nuances and perspectives of the research participants. Primary data were gathered through interviews with key informants and mango producers in IGaCoS. The study site is predominantly an agricultural area with mango as among its important agricultural products [2]. The key informants include project implementors, and representatives from relevant government agencies including the Cooperative Development Authority (CDA) Regional Office and Provincial Agriculture Office (PAO) of the Davao del Norte. Likewise, representatives from different offices of the Local Government Unit of the Island Garden City of Samal (IGaCoS) including the Municipal Agriculture Office (MAO).

Each office or organization was represented by one to three key informants while five key informants were selected from the list of the project implementation teams.

The key informants included experts from the fields of cooperative studies and mango production, project implementors, and representatives from relevant government agencies including the Cooperative Development Authority (CDA) Regional Office and Provincial Agriculture Office (PAO) of the Davao del Norte. Likewise, representatives from different offices of the Local Government Unit of the Island Garden City of Samal (IGaCoS) including the Municipal Agriculture Office (MAO) were interviewed. On the other hand, mango producers were selected based on their potential to adopt different mango ICM technologies. The selection was guided by representatives from the MAO and the officers of the Samal Island Mango Marketing Cooperative (SIMMCO). Table 1 shows the brief profile of the 24 mango producers selected as research participants of the study.

Table 1. Profile of the Mango Producer-Research Participants in the Island Garden City of Samal

Pseudonym	Sex	Management Role	Participation in Season Long Training
Dave	Male	Farm owner (Contracted)	Participant
Eli	Male	Farm owner-contractor	Participant
Maki	Male	Farm owner-contractor	Participant
Nong	Male	Farm owner (contracted)	Participant
Rom	Male	Farm owner (contracted)	Participant
Marba	Male	Farm caretaker	Participant
Londo	Male	Farm owner-contractor	Participant
Mace	Female	Farm owner-contractor	Participant
Rolo	Male	Contractor	Non-participant
ExO	Male	Contractor	Non-participant
Arvy	Male	Farm owner	Participant
Al	Male	Farm caretaker	Non-participant
Eddie	Male	Farm owner	Participant
Nonoy	Male	Farm owner-contractor	Participant
Ric	Male	Farm owner	Participant
Ando	Male	Farm owner	Participant
Junjun	Male	Farm owner	Participant
Boni	Male	Farm owner	Non-participant
Nela	Female	Contractor	Non-participant
Jerik	Male	Contractor	Non-participant
Yul	Male	Farm owner	Non-participant
Oneng	Male	Farm owner (contracted)	Participant
Neil	Male	Farm owner (contracted)	Participant
Leno	Male	Farm owner	Participant

2.2. Interview Process and Key Questions

Each interview was approximately one-hour in length. This allowed an in-depth discussion with the two sets of research participants while also considering their respective availability. The interviews with the key informants were conducted in their offices while the mango producers

were interviewed in their mango farms. The location of the interviews was intended to provide a natural and comfortable environment for the research participants. In addition, the research participants were allowed to answer mainly in their local language (i.e., *Cebuano/ Bisaya*) or in *Tagalog*.

The interview was qualitative in nature and guided by a set of key questions. Key questions for the key informants primarily focused on the rationale behind the implementation of the relevant Mango ICM projects. On the other hand, the mango producers were asked their reasons or motivations for adopting the different Mango ICM technologies. For both sets of respondents, challenges related to the adoption of the Mango ICM technologies were also part of the interview.

2.3. Coding Process and Data Analysis

The processing and analysis of the qualitative data was done through thematic analysis. This method was used in "systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set" [5, p. 57]. The use of thematic analysis in this study is to have a better understanding of the perspectives and beliefs of the research participants on the use of mango ICM technologies. This analytical method is characterized by a coding process. This study utilized two coding modalities – software-assisted and manual coding. The identification of the initial codes was guided by Quirkos Version 2.3, a qualitative analytical software.

In using the software, the process started with the preparation of all the interview transcripts. This preparation mainly involved the translation of the transcripts from *Bisaya/Cebuan*o (i.e., the local language in the study site) to *Tagalog* (i.e., the primary language of the researchers). All transcripts were reviewed to identify narratives that could offer insights in answering the research questions. The selected narratives were then clustered to form the initial codes, which were referred to as "quirks" in the software. These initial codes or quirks are shown in Figure 1.

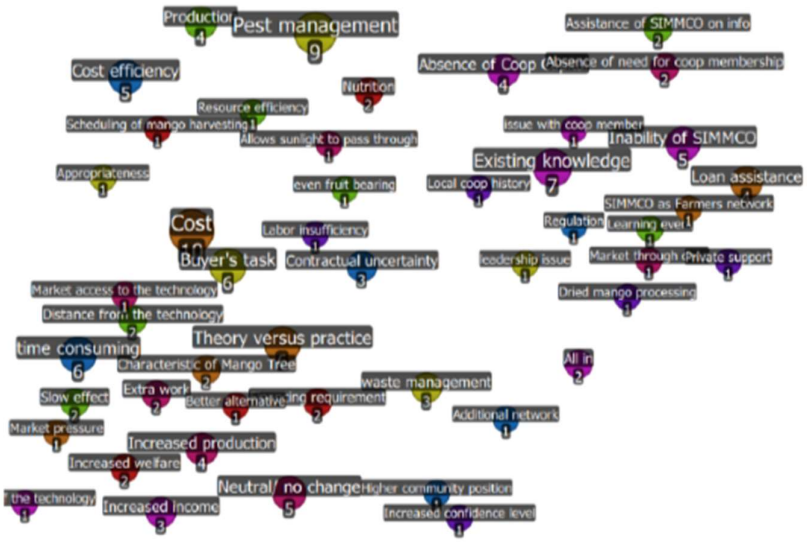

Figure 1. Quirk Canvas Showing the Initial Codes from the Transcripts

Once all the transcripts were reviewed and processed, manual coding was done in identifying the final themes. The identification of these themes involved clustering of the initial codes based on their associated meanings. These themes were categorized into (1) the rationale of the project implementation, (2) adoption motivations of the local mango producers, and (3) challenges in relation to the adoption of Mango ICM technologies.

3. Results and Discussion

3.1. Mango ICM Technologies

Mango ICM technologies were extended to farmer-beneficiaries primarily through the project funded by an international agricultural research organization. The project aimed to improve fruit quality using various practices, and ultimately enhance the livelihood of the mango producers [13]. It was implemented by partner local government units and universities. The different technologies developed and extended through this project were targeted by the project implementation team to support the local mango producers in various stages of production, harvesting, and post-harvesting. The development of improved technologies and practices can be regarded as a principal component of this research and development project. A research participant placed the technologies under three categories: cultural management, pest management, and harvesting. Their introduction to the local mango producers was expected to offer them opportunities for improving their production. Among the introduced ICM technologies were the 1) harvesting tools (Figure 2) and 2) hot water treatment.

Figure 2. Introduced Harvesting Tools as Part of the Mango ICM

Likewise, different approaches to pruning and fertilizer application were introduced through the Mango ICM Project. Pruning and fertilizer application were typical practices in the production of various agricultural products such as rice, corn, and jasmine (*see* [21], [26] [29]). Within the context of mango production in the study area, both pruning (i.e., full pruning) and fertilizer application were not generally practiced by the research participants. Through the Mango ICM Project, the importance of these practices was re-emphasized to the local mango producers.

The Mango ICM Project also introduced a plant growth regulator (PGR) and the use of a pest monitoring and control method to the local mango producers. Specifically, the pest control and monitoring method consisted of using an insect trap, which is shown in Figure 3. Although a

simple mechanism, this pest control and monitoring method allowed local mango producers to identify insects present in their farms within a specific time. This resulted in identifying a more targeted or more pest-specific solution.

Figure 3. Insect Trap to Identify Potential Pests in a Mango Farm

Aside from the technologies introduced through the Mango ICM project, research participants also identified other technologies that were intended to improve mango production within IGaCoS. This included the development of a sprayer nozzle by a university with funding from the national government (Figure 4). That project was intended to develop equipment to assist local mango producers in reducing their postharvest losses, increasing their income, and also supporting the need for environmental protection [17]. Aside from that, research participants also mentioned the introduction of re-usable bagging materials, which was intended to reduce costs in the long run from using traditional single use paper bags.

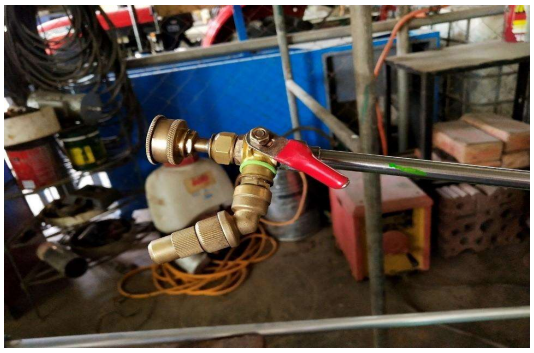

Figure 4. Sprayer Nozzle Developed Through Government Funding

3.2. Rationale of Mango ICM Project Implementation

Development projects are implemented to cater to local community needs by responding to identified local challenges such as livelihood concerns. In the case of the Mango ICM Project, the motivation behind its implementation is summarized into three main themes, which are

production, environment, and people (Table 2). These themes further reiterate that the purpose of the project goes beyond the improvement of mango production as a form of livelihood. It offers solutions to growing environmental concerns while also creating opportunities for a more cohesive community among local mango producers. A summary of these themes and their meanings is provided in Table 2.

Table 2. Summary of Themes Covering the Rationale of the Mango ICM Project Implementation

Theme	Meanings
Production	Rationale related to the improvement in the level of mango production
Environment	Rationale related to the protection of the environment. These include the reduction of chemical use to lessen the negative environmental impacts of mango production
People	Rationale that highlights the potential benefits of the Mango ICM technologies at the individual and community levels.

3.2.1. Production

For decades, increasing the level of agricultural production has always been part of the development agenda and rationale for the implementation of agricultural development projects [*see* 9]. One of the several challenges affecting the local mango industry in the Philippines is low production [20]. This prompted many government agencies and other development organizations to implement agricultural programs to respond to this growing concern. Research participants mentioned that improvement in mango production is among the main motivations behind the Mango ICM Project implementation. Its package of technologies is aimed at managing pests and diseases along with concerns about plant nutrition.

This package of technologies was expected to assist the beneficiaries in increasing their level of production and the improvement of the quality of their produce. As reported by the project implementors, one of the farmer-collaborators had an increase in their harvest from 56 kgs to 90 kgs per tree after three seasons of adopting the different technologies and practices introduced by the project [18]. This translates to at least a 60 percent increase in yield [18]. These initial findings present opportunities for the continued growth of the local mango industry.

3.2.2. Environment

As earlier mentioned, among the objectives of the agriculture sector is to increase production and the income of the producers. However, another study explains that although agricultural intensification results in an increase in agricultural production, it also negatively affects the environment [6]. The agriculture sector produces pollutants such as pesticides and excess nutrients [7, 25]. Such is the case of the local mango industry, where pesticides are extensively applied to ensure a high level of production. The heavy use of pesticides in the local mango industry could be attributed to the local climate in the region. The garden city belongs to Type IV Climate, which means that rain can be experienced all year round [10]. As explained by some

research participants, re-application of pesticides was needed after the occurrence of rain to ensure that their trees would be protected against pests.

Scholars reiterate that agricultural innovations should be able to reduce the negative environmental effects of the agriculture sector [27]. Research participants explained that the Mango ICM Project offered solutions to these environmental concerns through the reduction of the use of chemicals, which are the primary source of pollutants from the local mango industry. A research participant further explained that:

We need to reduce the use of fungicides because they are toxicants. It is the reason why we are trying to reduce the number of fungicide sprays. If there was an alternative, farmers would not be totally dependent on fungicide. Since the farmers use the same fungicide for the whole production cycle, it is not good [for them] since the pathogens could possibly develop fungicide resistance. In addition, we want to reduce the toxicants we add to the environment. Of course, we also think about food safety because to some extent, there are still residues left [on the produce]. ("Doc 3, academe, implementor").

As argued by research participants, mango production was considered a chemical intensive industry. Through the implementation of the Mango ICM project, research participants believed that it would aid in abating this environmental pollution because of the intensive mango production in the garden city. Hence, these environmental concerns were among the motivations of the project implementors when designing the package of technologies and practices extended through the project.

3.2.3. People

The implementation of the Mango ICM Project was also designed based on its potential social benefits, which could be incurred at the individual or community level. Associated also with agricultural production, health problems were identified as a possible adverse effect of intensive chemical use (*See* [16]). Another study further elaborated that exposure to pesticides could potentially lead to various illnesses including cancer and other respiratory diseases [12]. In the case of the Garden City, the potential health risks were raised, especially given the chemical-intensive nature of the local mango industry.

In addition to the heavy use of chemicals, actual exposure of the farm workers could also raise some issues. Figure 5 illustrates a case where a farm worker is exposed to chemicals without adequate protection. In terms of health risks, research participants mentioned that many local agricultural workers had the perception that pesticide exposure could affect the reproductive capacity of male workers (i.e., the spraymen). As earlier reiterated, the Mango ICM project puts forward the reduction of chemicals, thus lessening its potential adverse health effects among local farm workers. It was an important mechanism to ensure that the local mango industry would not

only cater to the needs of the market but also to the protection of one of its important stakeholders – its labor force.

Figure 5. Chemical Spraying in a Mango Farm in IGaCoS)

Aside from its role in the avoidance of health concerns among the local mango stakeholders, research participants also believed that the Mango ICM Project could also espouse positive community relations and a stronger social network. A research participant mentioned that the project strived to have a farming community where farmers help each other. The design of the extension approach was motivated by the intention of the project team to have a farming community that is built through cooperation. This means that the local mango producers would be able to share ideas within this community and offer support to each other in responding to common problems.

Aside from establishing a strong network among the local mango producers, the Mango ICM project likewise created opportunities for connecting mango producers with various institutional actors. These include the different state universities and government offices. A stronger relationship between the local mango producers and the other stakeholder groups offers several benefits. Beyond the different tangible benefits such as resource sharing, stronger relationships between the local stakeholders could increase mutual respect and trust with each other [28].

3.3. Adoption Motivations of Local Mango Producers

The study identified two main motivations of the local mango producers for the adoption of different Mango ICM technologies. Both motivations are grounded in how they could potentially increase the production and income of the local mango producers. As primarily an economic activity, these results reflect the rationality behind the decisions of local mango producers to their production activities. In Table 3, a summary of the themes that explains the motivations of the mango producers is presented.

Table 3. Summary of Themes Covering the Motivations of the Local Mango Producers in Adopting Mango ICM Technologies

Theme	Meanings
Financial returns	These are motivations of the local mango producers related to the financial benefits of adopting Mango ICM technologies. These include an increase in income and a reduction in costs.
Biological benefits	These are motivations of the local mango producers related to changes or improvements in agricultural practices that lead to health, production, and environmental benefits

3.3.1. Financial Returns

Agricultural producers have a higher propensity to adopt innovative technologies when there are potential financial returns [11]. Motivations related to potential financial returns can be considered logical given the economic nature of mango production. In many cases, higher net benefits were considered as an important determinant for technology adoption [13 14]. Such as the case of mango producers in IGaCos. Financial returns were considered important motivations in the adoption of mango ICM technologies. Some of the narratives of the research participants for adoption that are reflective of this motivation are as follows.

> It is to reduce the use of chemicals, the insects will not be able to hide, the sunlight can penetrate, and reduce [the consumption of] water. ("Leno, farm owner").

> We can save water. There are [sprayer] nozzles that are too strong. If we are only using mist, then we can save water. ("Ando, farm owner").

As explained by the research participants, the financial returns from adopting the Mango ICM technologies could be a result of the reduction of input use such as in the case of water and chemicals. To cite an example, when using the developed sprayer nozzle, there could be a reduction in the chemical use of almost 50 percent (I.e., from 3,263 L/ha to 1,444 L/ha) [17]. These narratives were reiterated in the study of [15], which states that associated costs are considered as a determinant in technology adoption decisions among agricultural producers. This means that mango producers are motivated to adopt technologies and practices, which could offer financial benefits through the improvement in production, quality of the produce, and reduction of costs.

3.3.2. Biological Benefits

The nature of the mango ICM technologies was also identified by research participants as an important motivation for technology adoption. Although these motivations could potentially result in monetary benefits, this study categorizes them as non-monetary. This theme includes adoption reasons such as avoidance of health hazards from chemical use, prevention of possible environmental damages, and overall improvement in various agricultural practices (e.g., pest management and crop nutrition). These motivations matched the rationale of the project

implementors in promoting the different Mango ICM technologies. To cite an example, a research participant shared as follows:

> … [the plant] does not get enough sunlight which is why the production decreases…the difference in production [of mango trees] with and without pruning is really significant. Production is higher when pruning is done. ("Ando, farm owner").

This narrative shows that research participants practiced pruning mainly to increase their level of production, which is attributed to better sunlight exposure of pruned mango trees. This claim among research participants was supported by the research findings of [3], which found out that sunlight exposure can positively affect the quality of both flowers and fruits. Research participants also shared that pruning presents opportunities for better pest management since it eliminates areas for pests to stay. Furthermore, the biological benefits of cultar application were also shared as an example by research participants. In a discussion with a research participant, the significance of cultar application was based on how it could assist local mango producers in controlling their harvest schedule.

3.4. Challenges in the Adoption of Mango ICM Technologies

The study revealed some challenges and issues in the adoption of mango ICM technologies among mango producers in IGaCoS. Different reasons were provided by research participants, which were collated and organized in this study under different themes. These themes generally reflect a concern about the mismatch between the needs of the local mango producers with the technologies introduced through the project. This technological mismatch is arguably a common concern among projects that are mainly implemented through a top-down approach. In the case of the Mango ICM Project, although local participation was an important component during the introduction of technology, potential participation gaps could be present in designing the introduced technologies. A summary of the themes concerning the different adoption challenges is provided in Table 4.

Table 4. Summary of Themes Covering the Challenges in the Adoption of Mango ICM Technologies

Theme	Meanings
Nature of technology	Adoption challenges that highlight the intrinsic characteristics of the different Mango ICM technologies
Market arrangements	Adoption challenges related to the dynamics and expectations between different market actors such as farm owners, buyers, and contractors
Financial constraints	Adoption challenges related to the additional cost of adopting the Mango ICM technologies

3.4.1. Nature of Technology

The characteristics and nature of technologies are recognized in the study as crucial decision criteria among local mango producers in IGaCoS. Particularly, this theme mainly highlights how

the nature of the different Mango ICM technologies results in additional work or extra layers in the mango production process. The additional labor requirement or extra step in the production process, as explained by the research participants, was not only detrimental to them as an outright additional cost but could also delay their overall process.

For instance, in the use of hot water treatment, while it is considered as an effective postharvest technology in using against mango diseases [*see* 4], a research participant noted the technology was labor intensive. Since mangoes are harvested in large volumes, using hot water treatment would require a significant amount of time and labor. Some of the narratives of the research participants for adoption that are reflective of this motivation are as follows:

> It is very tedious. If you harvest 50 tons, it is already 50,000 kilos, then pass it through hot water treatment, it is simply too many. ("Oneng, non-member, farm owner-contracted").

The concern about the nature of technology was also a concern in the case of reusable fruit bags. Some research participants shared that using reusable fruit bags was inefficient since it resulted in a slower process compared to the use of conventional fruit bags. The slower process is a result of the need to carefully remove the mangoes from the reusable bags. A research participant further elaborated that:

> First, the bag does not absorb latex from the mango. The reusable seems slippery [when used]. It is unlike the newspaper that absorbs the latex when [the mangoes] are harvested. Another thing is that when you use the introduced bagging material, you cannot use only one hand. Usually, when we do bagging, one hand is used to hold onto the tree branch while the other does the bagging. Hence, we cannot use it since it will take time and will increase our labor costs. ("Nong, officer, farm owner-contracted").

These results were corroborated by the study of [8]. Potential non-adoption of agricultural technologies occurs when additional laborers are needed [8]. It is predominantly the case when "labor markets do not function effectively" [8, p. 214]. Concern on additional labor requirements of adopting new technologies arises when there is a prevailing challenge on the availability of laborers within the locality. The local mango industry in the Garden City experienced these challenges on the labor market [*see* 2]. This challenge was rooted in the presence of other competing industries and the decreasing participation of the younger generation in the agriculture sector [2].

In addition to the concern about additional work, research participants likewise mentioned that the nature of technology was unfit to the local needs. It was shared by the research participant that:

> …but on the grounds, there are practices taught by [the international agricultural research organization] that the contractors cannot adopt. They can say that we are wrong. But since we are on the farm, we know what needs to be done and those that cannot be done. For instance, mist spray. I think that no contractor will use it. Although they have instructions in the training that it is better, we can't really apply it. ("Nong, officer, farm owner-contracted").

Another reason for non-adoption among mango producers was the local climate. Research participants explained that rainfall results in chemical washout. Local mango producers therefore opt to re-apply chemicals after each rainfall to ensure protection of their produce against pest infestations. Therefore, it was difficult for local mango producers to reduce chemical application as recommended under the Mango ICM project. Non-adoption of ICM technologies also included concerns on time resources. The increase in both harvest and turnover time is an important consideration for the choice in technology. Research participants explained that time is crucial given how fast mangoes mature, especially after harvesting.

3.4.2. Market Arrangement

The narratives of the research participants also affirmed how local market arrangements affect the adoption of Mango ICM technologies. In the Garden City, this involved the existing arrangements between the farm owners and the contractors in terms of benefit and cost-sharing in mango production. A research participant explained that informal verbal contracts were the prevailing binding agreement between the farm owners and the contractors. Contractual arrangements oftentimes influence the adoption of agricultural technologies. It has the potential to positively influence the decisions of farmers to adopt technologies [*see* 24]. However, the local experience in the local mango industry in IGaCoS reflects otherwise.

The nature of these contracts resulted in uncertainty and instability of the existing agreements between the two parties. As explained by a research participant, possible changes in these agreements might occur within a short period of time. As an example, pruning was oftentimes mentioned by research participants as an important practice in the mango production process. However, the type of pruning introduced through the program was expected to render the trees unproductive for a prolonged number of months. Research participants shared that those contractors, which include most of the mango producers in IGaCoS, could not take risks associated with this prolonged unproductivity since the contractual arrangement could end during this period. This risk was a critical reason among mango producers for non-adoption of the Mango ICM technologies.

The concern about the existing market arrangement could be considered as a significant concern given that most of the farms in the garden city were under this type of contractual arrangement. A key informant mentioned that more than 90 percent of the mango farms in the Garden City were

contracted. This was due to the high cost and risk of mango production, which was a major burden for the local farm owners. If the local contractors continue to have an aversion towards the use of the different Mango ICM technologies, it could result in a lower rate of adoption in the garden city.

3.4.3. Financial Constraints

As an economic activity, financial considerations play a huge role in the decision-making process in mango production [*see* 13,14]. This establishes the significance of potential financial benefits and costs of adopting different technologies such as those introduced through the Mango ICM project. In simplest terms, mango producers would logically adopt technologies that could increase their benefits while on the other hand would not adopt technologies that could have higher costs than their intended benefits. In the case of Mango ICM technologies, research participants shared that they incur more costs than benefits, especially in the short run. This was due to the concern of additional labor in adopting the introduced agricultural practices by the project along with the possible prolonged unproductivity of the mango trees in the case of pruning. The existing contractual arrangements in IGaCoS arguably made it less advantageous to adopt Mango ICM technologies even with its potential for long-term economic returns.

4. Conclusion

The Mango ICM project could be considered as an important innovation driver to induce sustainability in the local mango industry in IGaCoS. The rationale behind its implementation was grounded on its intended outcomes and impacts, which were categorized within the themes of people, environment, and production. However, the narratives of the local mango producers indicate challenges in the adoption of mango ICM technologies. The mismatch of the mango ICM technologies with the local needs opens a deeper discussion on the complexity of implementing a technology-based development project. This mismatch illustrates that the inherent characteristics of the extended technologies did not correspond to the prevailing labor and market institutions at the local level.

Designs of development projects should consider the complex nature of the agricultural technologies deemed to promote the development of the local commodity sectors. This would enable development practitioners to determine the appropriate package of technological interventions that can effectively respond to the needs and situation of the target farmers. Policy support mechanisms could also be put in place to support technology adoption if policymakers have an understanding of the nature of the technology along with the local dynamics of the stakeholders [13]. Demand-based technological intervention is hence qualified in this paper as being as much a matter of expressed and validated necessity as that of the farmer's context of practice.

Findings in this study point to the utility of a co-design approach in developing various interventions for the agricultural stakeholders. The approach provides an opportunity for the project proponents to integrate the needs, challenges, and aspirations of the agricultural stakeholders in the design of the different interventions. Additionally, co-design promotes the cooperation of stakeholders during implementation by capitalizing on the buy-in effect of the participatory process (see [24]). Finally, this qualitative research offers insights that can inform the conduct of quantitative impact evaluation studies on the project. Subsequent research, both completed and on-going, can likewise draw from the observations presented in this study.

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