Working Paper

Vulnerability of smallholder farmers and their preferences on farming practices in Buol District, Indonesia

Sacha Amaruzaman, Betha Lusiana, Beria Leimona

World Agroforestry Centre

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Abstract

The majority of residents of Buol District in Central Sulawesi Province in Indonesia depend on farming for their livelihoods. Similar to those in other poor districts in Indonesia, the smallholders in Buol are vulnerable to hazards and shocks, whether related to climate or socio-economic-political changes. Programs are carried out by the government and development agencies to improve the smallholders' resilience to those shocks and hazards.

This paper analyses vulnerability perceptions of female and male smallholders in Buol. The analysis of vulnerability includes productivity fluctuation of commodities and the shocks, exposure, response and impact smallholders experience with extreme events. Further, to see the potential of increasing smallholders' resilience through agricultural activity, the paper discusses smallholders' criteria for selecting tree and crops, and actual preferences for tree and crop species based on those criteria.

The study was conducted in three cluster sites of the Climate-smart, Tree-based, Co-investment in Adaptation and Mitigation in Asia (Smart Tree-Invest) project in Buol District, Central Sulawesi, Indonesia. The vulnerability assessment was conducted using a focus-group discussion approach while preferences for trees and crops were analysed using the Analytical Hierarchical Methodology (AHP).

The community in the upstream cluster stated that water scarcity was one of the main problems owing to unavailability of a technical irrigation system in their area, thus, they were highly dependent on rainfall. In the midstream cluster, the community perceived floods as their main problem, which began after dam construction that altered the direction of river flow. The smallholders in the coastal zone faced the threat of coastal abrasion owing to mangrove degradation. Regarding productivity fluctuation, coconut productivity was the most resilient during extreme events while cacao was perceived as the most vulnerable commodity because its productivity tended to fluctuate during years with extreme events.

The top three priority criteria for selection of trees and crops were land suitability; household income; and ease of maintenance. These were selected by all groups across all clusters. The five main commodities prioritized by farmers in all clusters were cacao, coconut, rice, clove and coffee.

For each agricultural problem identified, smallholders had already undertaken actions and were considering other potential solutions. Recognizing these major problems and the ideal responses perceived by farmers is essential for providing effective solutions to improve farmers' resilience in these clusters.

Keywords

Vulnerability, shocks and hazards, trees and crops, criteria, smallholders' preferences

Acknowledgements

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Introduction

Background

The District of Buol, established in 1999, is located in the eastern part of Central Sulawesi Province. Buol's GDP was ranked 11 out of the 12 districts in the province, with more than 20% of its population living in poverty (BPS Provinsi Sulawesi Tengah, 2014). The residents of Buol mainly depend on farming for their livelihoods: more than 60% of the population are working in the agricultural sector (BPS Kabupaten Buol, 2015). Wet rice and maize, the two main crops cultivated in Buol, have relatively low yields compared to other districts in Central Sulawesi (BPS Provinsi Sulawesi Tengah, 2014).

Examining land-use and land-cover changes shows an improvement in agroforestry or tree-based farming systems in Buol during 1996–2014, from approximately 9 to 12% of total land-cover (Wijaya et al 2015). Tree-based farming can reduce smallholders' vulnerability and act as a buffer for their livelihoods (Minang et al., 2015; van Noordwijk et al., 2011). Such farming practice has multiple functions, for example, as sources of income, food and environmental services. Considering that complex agroforestry increased moderately in Buol during 1996 to 2014, there is potential to improve smallholders' resilience through enhancement of these farming practices. However, further understanding is needed of the rationales of local communities in selecting types of crops and trees, and on the vulnerability of their livelihoods dependent on their particular agricultural practices. Such knowledge may enable the formulation of a proper program for poverty alleviation through agricultural activity.

Similar to other poor districts in Indonesia, smallholders in Buol are vulnerable to hazards and shocks. These hazards and shocks are not only related to changes in climatic patterns but also to those in socio-economics and politics. It is necessary for development actors, such as the government and development agencies, to recognize smallholders' vulnerability in order to develop a robust agricultural program that can improve smallholders' resilience to hazards and shocks.

An indication of a successful agricultural development program is the adoption rate of the new practices by smallholders. The adoption rate will likely be higher when a program is able to address the perspectives and rationales of farmers on choosing (or not choosing) specific activities. Understanding what factors influence such decision-making—such as gender, social structure and culture—is needed to make any such program effective. A 'bottom–up' approach will help decision-makers understand the targeted smallholders, and beyond, to improve a program's adoption rate.

This working paper analyses the vulnerability of female and male smallholders in Buol. The analysis of vulnerability includes productivity fluctuation of commodities; shocks, exposure, response and impacts of extreme events. Further, to see the potential for increasing smallholders' resilience through

agricultural activity, we discuss smallholders' criteria for selecting trees and crops, and actual preferences for species based on those criteria. By recognizing smallholders' vulnerability and their preferences for particular trees and crops, we can provide informed input for development of a 'bottom–up' program that can more effectively address the needs of smallholders.

Research sites

We conducted the study in the cluster sites of the Climate-smart, Tree-based, Co-investment in adaptation and mitigation in Asia (Smart Tree-Invest) project in Buol District, Central Sulawesi, Indonesia. A cluster is a landscape that consists of 2–3 villages and shares similarities of landscape attributes and socio-economic characteristics (Figure 1).

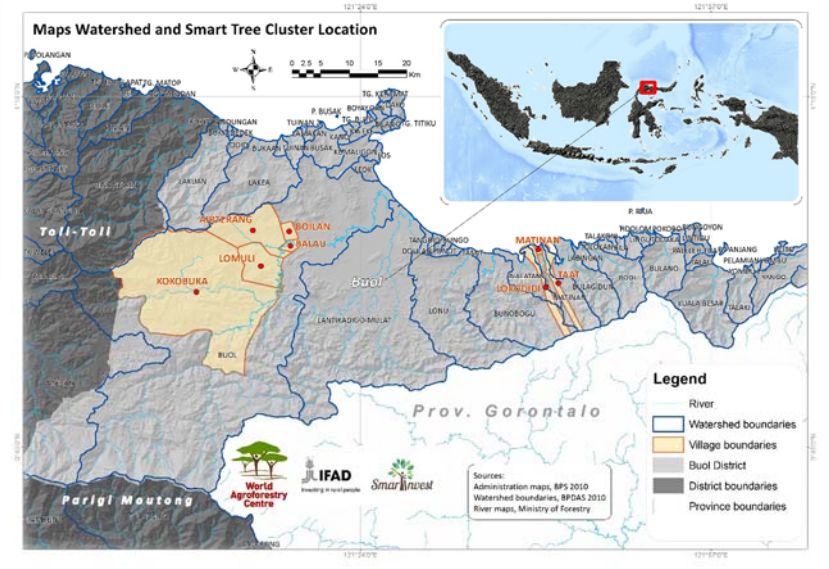

Figure 1. Location of clusters in Buol District

There are three cluster sites of Smart Tree-Invest in Buol, representing an upstream watershed, midstream watershed, and coastal area.

Table 1. Characteristics of clusters

Cluster	Upstream	Midstream	Coastal
Sub-district	Tiloan	Tiloan	Gadung
Village	Kokobuka, Lomuli	Boilan, Air Terang	Taat, Lokodidi, Matinan*
Origin of residents	Migrants from Java, Bali and Lombok	Migrants from Java, Bali and Lombok	Buol native
Commodities available in the cluster	Oil palm (large-scale plantations), cacao, rain-fed rice, coconut, pulse, patchouli	Irrigated rice, pulse, sweet corn, coconut, cacao	Cacao, coconut, clove, nutmeg, rain-fed rice
Accessibility and infrastructure	• Far from the district's main town (2–3 hours' motorcycle ride) • Bad road access • Limited electricity and communications infrastructure • No irrigation for agricultural activities	• Relatively good access and shorter distance from the district's main town (1.5–2 hours' motorcycle ride) • Better electricity and communications infrastructure • Technical irrigation for agricultural activities	• Good access, located on the main road, shorter distance from the district's main town (1 hour motorcycle ride) • Better electricity and communications infrastructure
Livelihoods' options	1. Rice and other crop-based agriculture 2. Tree-based agriculture 3. Labour in oil-palm plantation	1. Rice and other crop-based agriculture 2. Tree-based agriculture	1. Tree-based agriculture 2. Coastal fisheries 3. Community mining 4. Rice and other crop-based agriculture*

Source: Key informant interviews and observation, 2014

Two large-scale, oil-palm plantations operate in the upstream cluster of Buol Watershed, which is the main watershed in the district. Since the end of the 1990s, oil-palm plantations have gradually replaced forests in the upstream.

Methodology

Vulnerability analysis

A vulnerability analysis was carried out using the Capacity Strengthening for Vulnerability Assessment (CaSAVA) framework (Dewi et al., 2013). CaSAVA combines information from stakeholders on their landscape through participatory focus-group discussions (FGD), spatial analysis over time to evaluate land-use changes as drivers of socio-economic and socio-ecological changes, and scientific assessment of changes in ecosystem functions (Dewi et al 2013). This paper describes the vulnerability analysis of farming systems, hence, it specifically addresses the vulnerability of farmers in Buol in management of their farming systems. We carried out FGDs at each cluster site

(Table 1) with groups of farmers differentiated by gender. A total of six were carried out, in which three were women-only groups. The FGD questions focused on the agricultural systems (including tree-based systems), the shocks or catastrophes that the smallholders had encountered and descriptions of the catastrophe's magnitude and extent. Farmers' responses to the problems (successful and unsuccessful) were recorded, including their perceptions of desirable or ideal responses. Farmers' assessments of the reasons such shocks had occurred were also recorded. The FGD further asked farmers about changes in profitability and productivity owing to shocks. The results were analysed qualitatively and compared within, and across, the clusters.

Preferences for agricultural systems

Farmers' preferences for trees and crops were analysed using the Gender Tree-Preference (G-Tree) assessment tool. The objective of G-Tree is to clarify the primary functions of a farming system and then focus on which commodities (trees, crops or a particular farming system) can best fulfil those functions.

We used the Analytical Hierarchical Process (Saaty, 1980) to assess tree and crops that smallholders preferred to manage. Within the same group discussions, we asked the participants to list the top-five plants that they preferred. They could choose any plant, including those that they had already planted and/or desired to plant.

In the second step, we asked farmers to list criteria they had used when choosing the plants to cultivate. In the third step, farmers were specifically asked to rate each plant against the criteria that they had just set. Thus, the AHP approach essentially was used to estimate the weight or prioritization that farmers put for each plant based on the criteria they had listed. We analysed the data using the Microsoft Excel AHP template (http://bpmsg.com/new-ahp-excel-template-with-multiple-inputs/).

Based on the ranking of criteria and trees and crops in each cluster, the priority commodities were summarized across all groups (male and female groups in all clusters) using the scoring method. The score for a commodity was based on the rank of Eigen value resulting from the AHP analysis. The score values were 7 to the highest (Rank-1) while the lowest score depends on the number of commodities selected by the farmer groups, for example, lowest score 2 for a group that selected six commodities. Thus, the maximum possible score for a tree is 42 as there were six farmers' groups involved. However, the maximum number we found from our FGDs was 25. Thus, subjectively we used the following criteria to group the trees and crops that farmers preferred: '–' (not selected), '+' (Score range of 1–7), '++' (Score range of 8–14), '+++' (Score range of 15–21) and '++++' (Score range of 22–28). Trees and crops priority for each criteria were further analysed using the Score.

Table 2. Example of criteria comparison matrix

CRITERIA	Criterion A	Criterion B	Criterion C	Criterion D	Criterion E	….
Criterion A						
Criterion B						
Criterion C						
Criterion D						
Criterion E						
……..						

Table 3. Example of commodity comparison matrix for each criterion

CRITERION A						
Commodity	Comm. 1	Comm. 2	Comm. 3	Comm. 4	Comm. 5	….
Comm. 1						
Comm. 2						
Comm. 3						
Comm. 4						
Comm. 5						
……..						

Results

Farming systems

Table 4 shows the variety of farming systems in the upstream, midstream and coastal clusters. The upstream farmers mainly grew rain-fed annual crops with rice as the main commodity. The yields were mostly for domestic consumption, occasionally marketed when they had a good cropping year. The farmers also managed mixed systems (trees and annual crops), which were mostly devoted to market production, except for coconut. The farmers no longer relied on forests for their food or livelihoods because nearby forests had disappeared and the farmers were aware that harvesting timber from forests was forbidden.

Table 4. Existing farming systems and commodity use

Farming system	Commodity utilization					
	Upstream		Midstream		Coastal	
	Cash	Domestic consumption	Cash	Domestic consumption	Cash	Domestic consumption
Rice & seasonal crops	1. Rice 2. Corn 3. Peanuts	All commodities	1. Rice 2. Peanut 3. Soybeans 4. Eggplant 5. Vegetables	All commodities	1. Corn 2. Pepper 3. Rice	1. Rice 2. Pulses
Mixed crops	1. Cacao 2. Coconut 3. Patchouli 4. Rambutan 5. Durian	1. Coconut 2. Coffee	1. Cacao 2. Coconut 3. Patchouli 4. Rambutan 5. Teak	1. Coconut 2. Fruit trees	1. Clove 2. Cacao 3. Nutmeg 4. Coconut 5. Durian	1. Coconut 2. Fruit trees
Monocultures	N/A	N/A	N/A	N/A	Teak	N/A
Forests	N/A	N/A	Teak	Teak	1. Rattan 2. ‘Palapi’ 3. ‘Ngantu’	N/A
Sea fisheries	N/A	N/A	N/A	N/A	1. Anchovies 2. Sea cucumber 3. Tuna	N/A

Owing to the availability of irrigation, the smallholders in the midstream cluster had more choice of agricultural systems and commodities to manage throughout the year. Some village members still harvested teak from the forests although not as frequently as in the 1990s. Similar to the upstream and coastal clusters, many smallholders planted cacao and coconut although the number of cacao trees was less in recent years owing to productivity reduction and more pest and disease problems. The farmers in this cluster indicated that they wanted to grow clove but failed in several attempts and assumed that the condition of their land was not suitable for the commodity.

The people in the coastal cluster still used forests, mainly for harvesting rattans. The other products they extracted from forests were local timber species, called 'palapi' (*Heritiera (*aka *Tarrietia)* sp) and 'ngantu' or 'nyatoh' (*Palaquium* sp). The people in the coastal cluster also practised sea fishery in combination with their agricultural activities. As a result, they preferred to practise mixed crop farming systems, which require minimum maintenance compared to seasonal crops.

Productivity fluctuation during extreme events

Based on the agriculture farming system, the smallholders were asked to select the main commodities available in their cluster and share their experiences of extreme events that had an impact on the commodities' productivity.

The extreme events that frequently occurred in all clusters were drought, prolonged rainy seasons and limited fertilizer supply. The midstream farmers also named pests and diseases and limited pesticide availability as events that had an impact on their agricultural productivity.

Both male and female groups were able to identify events that affected negatively or positively their agricultural systems, however, only the male groups were able to quantify how much the events affected the productivity and profitability of their systems (tables 5, 6 and 7).

Table 5. Male group perceptions of production fluctuation for several trees and crops in the upstream cluster

Commodity	Production Fluctuation		
	Dry Season	Rainy Season	Limited Fertilizer
Rice	↓ -95.2%	↑ 90.5%	↓ -23.8%
Cacao	↑ 16.7%	↓ -75.0%	↓ -66.7%
Peanut	-	↓ -57.1%	-
Patchouli	-	-	-
Coconut	-	-	-

Note: Green arrow = increased productivity; Red arrow = decreased productivity; - = no fluctuation perceived

Table 6. Male group perception of production for several trees and crops in the midstream cluster

Commodity	Production Fluctuation				
	Dry Season	Rainy Season	Limited Fertilizer	Pest Season	Limited Pesticide
Rice	-	-	↓ -57%	↓ -100%	-
Cacao	-	↓ -50%	↓ -40%	↓ 100%	↓ -100%
Coconut	-	-	-	-	-
Peanut	↓ -67%	↓ -20%	-	↓ -100%	-
Sweet-Corn	↓ -50%	-	-	↓ -100%	-

Note: Red arrow = decreased productivity; - = no fluctuation perceived

Table 7. Male group perceptions of production fluctuation for several trees and crops in the coastal cluster

Commodity	Production Fluctuation		
	Dry Season	Rainy Season	Limited Fertilizer
Clove	↓ -50%	-	↑ 0%
Cacao	↓ -50%	↓ -50%	↓ -47%
Coconut	-	-	-
Nutmeg	-	-	-
Durian	-	-	-

Note: Green arrow = increased productivity; Red arrow = decreased productivity; - = no fluctuation perceived

Coconut was the most resilient commodity across all clusters: it was perceived to be unaffected by extreme events. Rice production of the upstream cluster was drastically reduced during dry periods owing to dependence on rainwater for irrigation. The dry season did not affect the midstream cluster as much as the upstream and coastal clusters. However, the midstream cluster frequently experienced pests and diseases that affected almost all commodities, except coconut.

The discussions revealed that cacao production required relatively high amounts of inputs, such as fertilizers and pesticides. Midstream and coastal farmers perceived that cacao productivity was very vulnerable, experiencing reductions ranging 40–100% during extreme events. Farmers in the upstream cluster had somewhat different opinions because their experience was that cacao productivity frequently increased, by approximately 16%, in the dry season.

Farming systems: shocks, exposure, response and impacts

The male and female groups in the upstream cluster stated that ‘water scarcity’ was the main issue that affected their agricultural activities. The male farmers mentioned that the cause of water scarcity was natural and female farmers added that the unpredictable weather often worsened the water supply. Both groups stated that they expected to have technical irrigation built in their villages to reduce their dependency on rainwater for irrigation.

The male group perceived that the cause of pests and diseases was natural. They considered that a better coordination among the farmers of planting periods could reduce the probability of pest and

disease attack because they could arrange the planting, management and harvesting activity to occur at the same times across all smallholding plots, hence, reducing the probability of plague conditions of pests and diseases. At the time of study, the smallholders cultivated and manage their plots to separate schedules from each other, dependent on the availability of capital and inputs (for example, seedlings and fertilizer).

Male and female groups perceived that the scarcity of fertilizer had a negative impact on their agricultural productivity. However, male farmers perceived that attack by pests and diseases had a worse impact compared to fertilizer scarcity. Both groups stated that these problems could greatly reduce harvests (figures 2 and 3). When water was scarce in the lead up to harvests, smallholders in the upstream cluster borrowed money from external sources, such as the agricultural-inputs shop owner and loan 'sharks', to pay for replanting and to fulfil their daily needs.

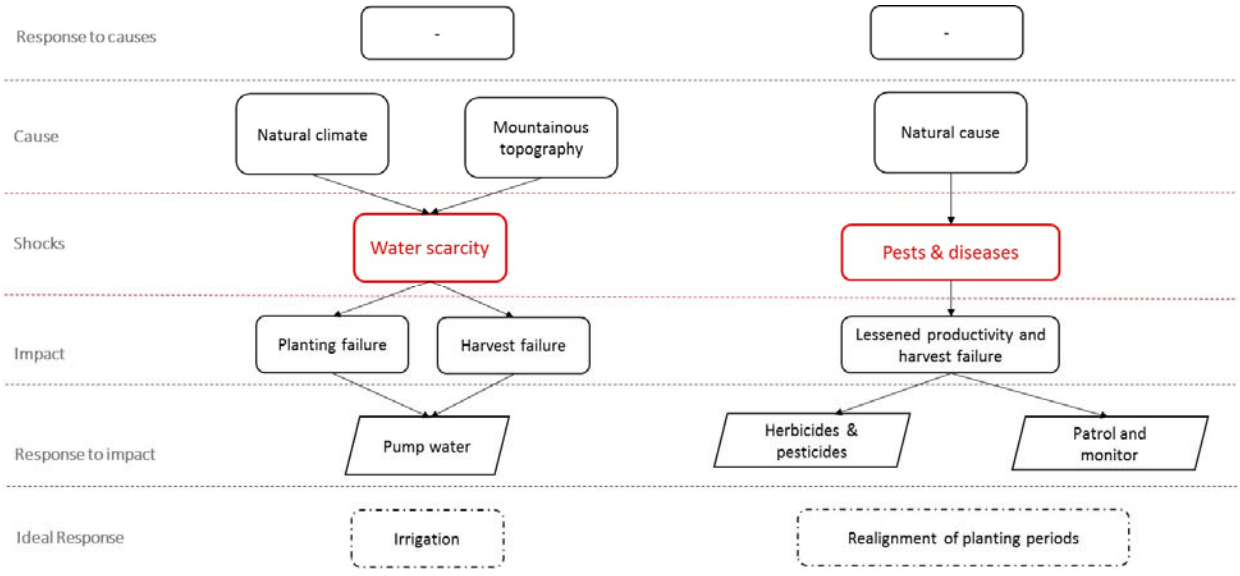

Figure 2. Male group perceptions of shocks, exposure, response and impact in the upstream cluster

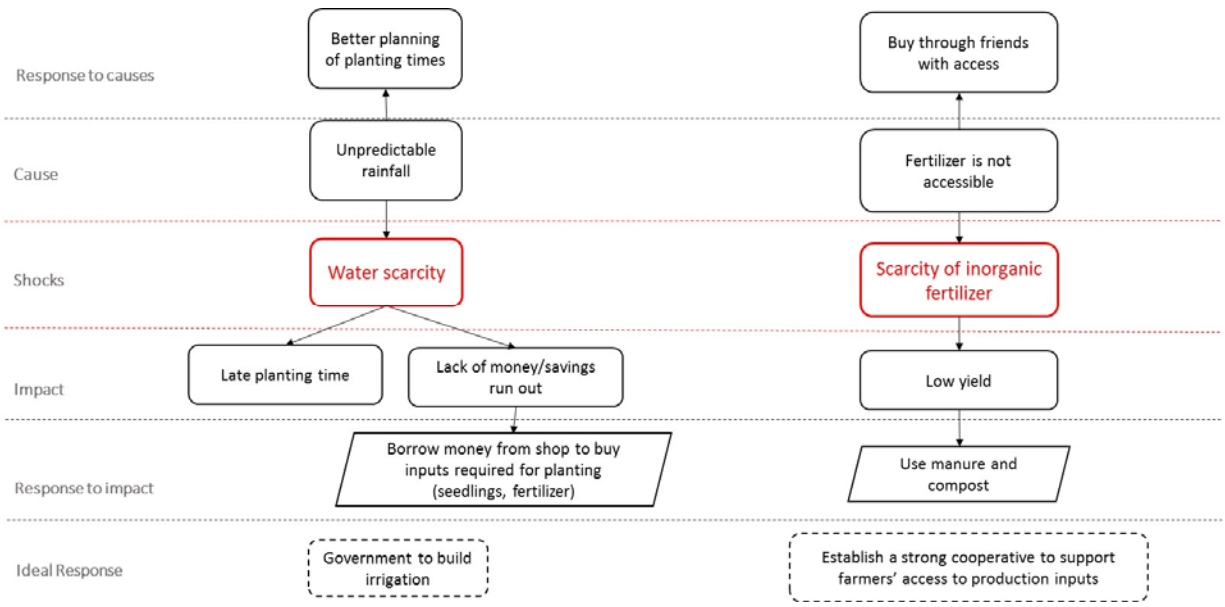

Figure 3. Female group perceptions of shocks, exposure, response and impact in the upstream cluster

In the midstream cluster, male and female groups indicated that pests and diseases and flood were the main issues influencing their agricultural activity, particularly, planting and harvesting. Both groups perceived that the change in weather patterns, particularly drought for the female groups, contributed to attack by pests and diseases.

The ideal solutions offered were improvement of the agricultural extension program by the government, such as the quality of knowledge and more frequent visits and consultations by extension workers. Another ideal response was similar to that of the upstream cluster, namely, the coordination of planting periods. However, the farmers in the midstream cluster understood that it would need a strong effort to synergise the planting periods of many smallholders even in one landscape, since one landscape can be managed by many smallholders with plots typically below 0.5 ha. Another ideal response, also related to the government, was government provision of production inputs to cope with pests and diseases, such as pesticides and herbicides. Similar to the upstream cluster that was dominated by migrants, the migrant farmers in the midstream cluster often borrowed money from non-family members, such as money lenders and shop owners, during extreme events to procure financial capital for planting inputs in the new season and to fulfil their daily needs.

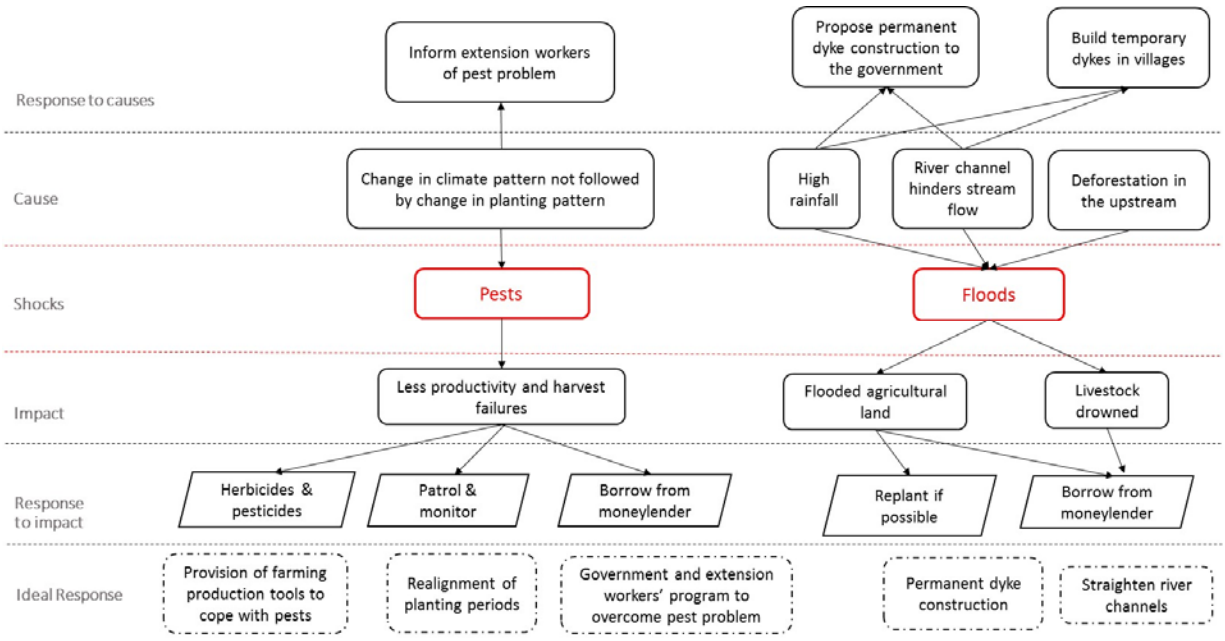

Figure 4. Male group perceptions of shock, exposure, response and impact in the midstream cluster

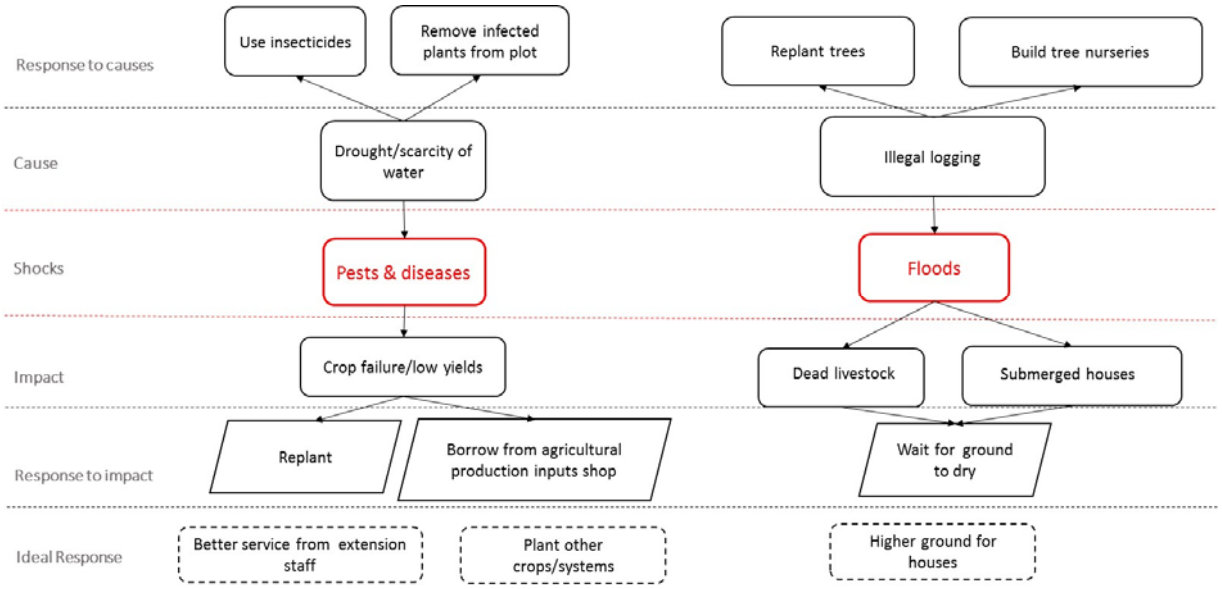

Figure 5. Female group perceptions of shocks, exposure, response and impact in the midstream cluster

Both groups perceived that one of the contributors to flooding was the deforestation further upstream. The male group also added that the high rainfall and meandering nature of the Buol River also contributed and perceived that two technical solutions—construction of a new dyke and alteration of the river meander—could overcome the problems (Figure 4). These technical solutions, however,

needed to be researched because, in some cases, straightening of a river can also increase the stream flow and contribute to flash flooding.

In the coastal cluster, the male group perceived that pests and diseases, particularly of cacao and clove, were their main issues. They considered that a lack of good management contributed to the problem and proposed support for technical and agricultural inputs, particularly from the government, to improve their commodity management. Different from the upstream and midstream cluster, the coastal communities preferred to borrow money from their relatives because their relatives also lived in the area. This cluster also had more options during extreme events, such as fisheries and mining (Figure 6). They also indicated that problems caused by mangrove degradation often disrupted their livelihoods because coastal abrasion reduced the living space of their village and affected their agriculture land.

The female group in the coastal cluster suggested that unstable agricultural prices were the main issue, followed by pests and diseases. This group perceived that the limited infrastructure to support their agricultural activities contributed to higher transportation costs and often reduced their bargaining power with intermediaries (Figure 7).

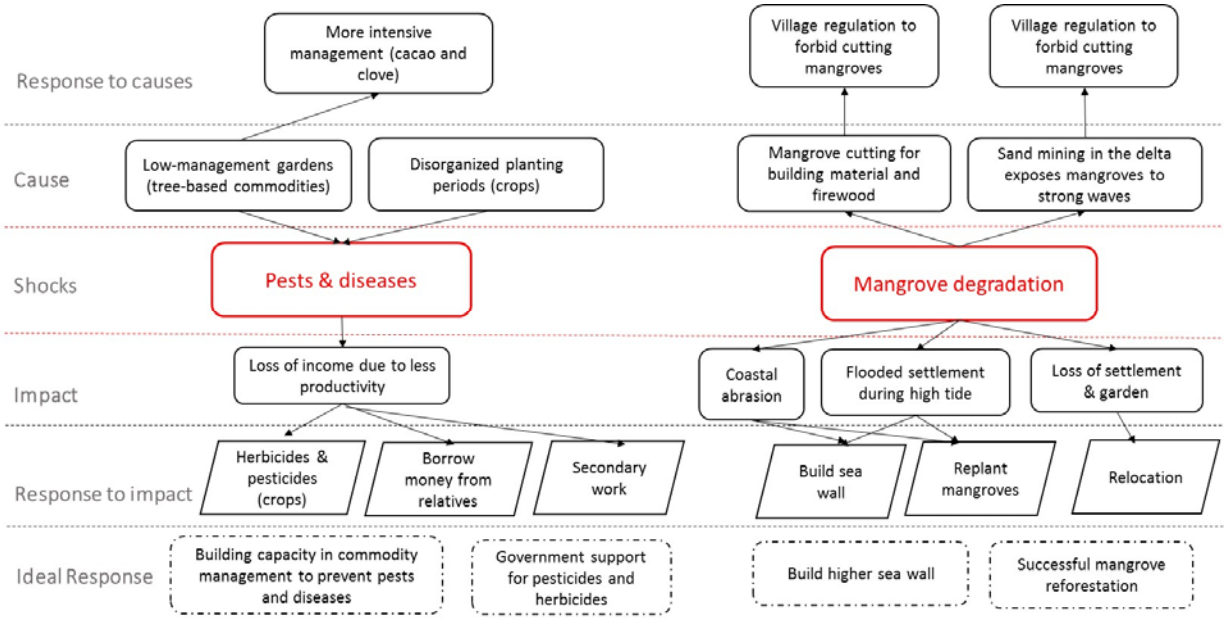

Figure 6. Male group perceptions of shocks, exposure, response and impact in the coastal cluster

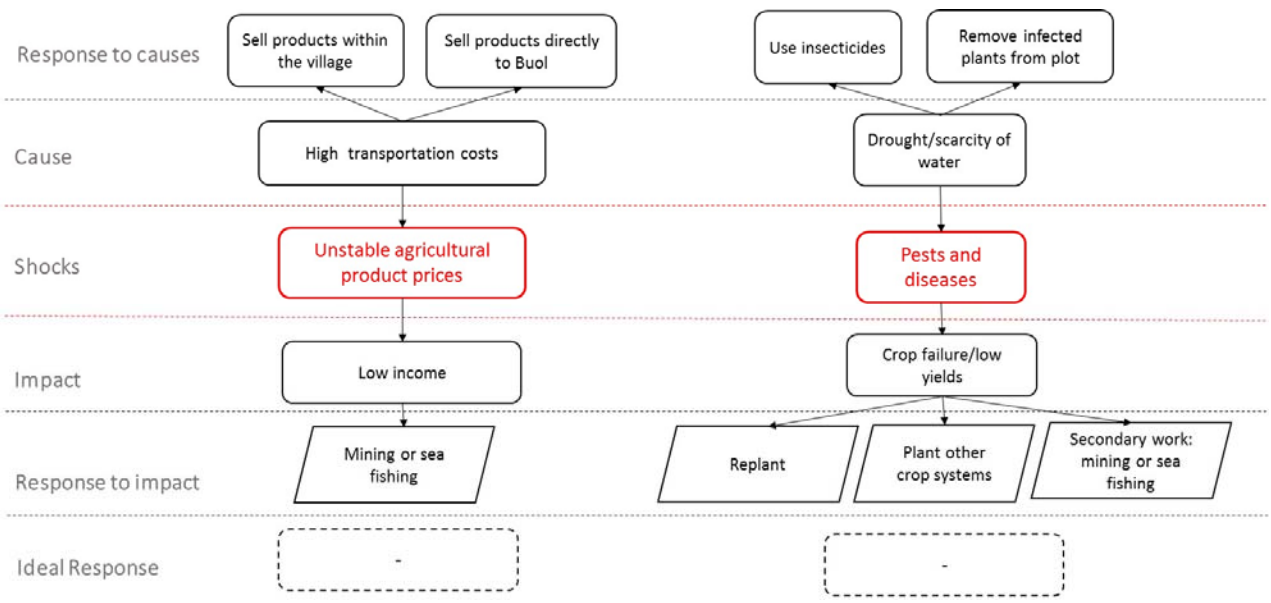

Figure 7. Female group perceptions of shocks, exposure, response and impact in the coastal cluster

Smallholders' criteria and preferences for trees and crops

The upstream groups mentioned 'low water consumption' as a factor when considering selection of tree and crop species, which related to their frequent problem of water scarcity. The coastal female and male groups specifically mentioned 'ease of maintenance' and 'short harvest period'. The availability of different options for their livelihoods in the coastal cluster led to the smallholders preferring to work in other sectors rather than intensively manage their agricultural land. With the exception of cacao, the other tree commodities planted by smallholders on the coast—such as clove and coconut—did not require intensive management. 'Ease of maintenance' was not considered by the midstream as the smallholders there were used to intensively managing their trees and crops and could depend on irrigation for their agriculture activities.

The smallholders in the upstream and midstream clusters were more dependent on their agricultural crops, thus, they selected 'domestic consumption' as an important criterion. Owing to the limited livelihoods' options available in the two clusters, during difficult times they mostly become more reliant on subsistence activities. This criterion was not considered by the coastal smallholders because they had more options apart from agriculture.

The 'marketability' criterion was mentioned in the midstream and coastal clusters, both of which have relatively good road access. In these clusters, the groups actively sold their commodities rather than managing them for self-consumption and/or waiting for middlemen to buy their harvest.

The 'good price' and 'stable price' criteria were mentioned in the upstream and midstream clusters because commodity prices can be highly volatile, particularly, during the harvesting season because

they depended on middlemen to buy their harvests. These criteria were not mentioned in the coastal groups, possibly owing to two factors: 1) coastal smallholders had more livelihoods' options, such as fisheries and mining; and 2) during commodity-price movements they didn't experience fluctuations as extreme as smallholders in the upstream because of their closer access to the city to market their commodities and because their systems were mostly dominated by tree-based commodities, for which prices did not fluctuate as greatly as for annual crops.

In the upstream cluster, price fluctuations triggered farmers to convert their commodities. They tended to follow price trends without longer-term consideration of the supply and demand of the commodities. For example, farmers converted their rice and cacao to patchouli when they learned that patchouli was highly priced. However, this price trend only lasted a year; the following year the patchouli price decreased. Farmers who did not have the skills nor owned post-harvest machinery to process patchouli oil suffered economic losses and stopped growing it.

'Saving' was the least prioritized criterion; it was only mentioned by the groups in the midstream cluster. Based on the key-informant interviews and observation, the smallholders of the midstream cluster were relatively wealthier and had higher education levels compared to the other clusters. This characteristic might be linked to the 'saving' culture—preparing themselves for difficult times—although this assumption needs to be checked.

Table 8 summarizes the selection criteria for trees and crops by female and male groups in Buol District. The cluster group criteria is presented in Appendix 1.

Table 8. Smallholders' criteria for selecting trees and crops

Priority	Female and Male		Female		Male	
	Commodity	**Score**	**Commodity**	**Score**	**Commodity**	**Score**
1	Land suitability	24	Seedling availability	9	Land suitability	17
2	Household income	18	Ease of maintenance	9	Household income	11
3	Ease of maintenance	16	Short harvest period	7	Marketability	7
4	Seedling availability	15	Land suitability	7	Seedling availability	6
5	Good price	9	Household income	7	Good price	5
6	Short harvest period	9	Stable price	6	Ease of maintenance	4
7	Marketability	9	Planting knowledge	6	Low water requirement	3
8	Domestic consumption	7	Good price	4	Saving	2
9	Planting knowledge	6	Saving	3	Short harvest period	2
10	Stable price	6	Marketability	2	**-**	-
11	Saving	5	Domestic consumption	2	**-**	-

Based on Table 8, it can be seen that 'land suitability', 'household income', 'seedling availability' and 'ease of maintenance' were the most important criteria for selecting trees and crops. The smallholders in the study sites, particularly in the upstream and midstream clusters, depended for their livelihoods on agriculture, including being their main source of income. Hence, selecting the trees and crops that

were suitable to be cultivated on their land was extremely important for securing their livelihoods, thus, land suitability was the most important criterion.

'Seedling availability' represented the preference of smallholders to plant trees and crops with seedlings that were readily available. The smallholders had limited knowledge of nursery development, thus, farmers obtained their seedlings directly from the forests or from those which naturally regenerated, buying in markets and/or from government programs, particularly for crops. Figure 8 summarizes the criteria for selection, and preferences for, trees and crops from the differing perspectives of male and female smallholders in the upstream cluster.

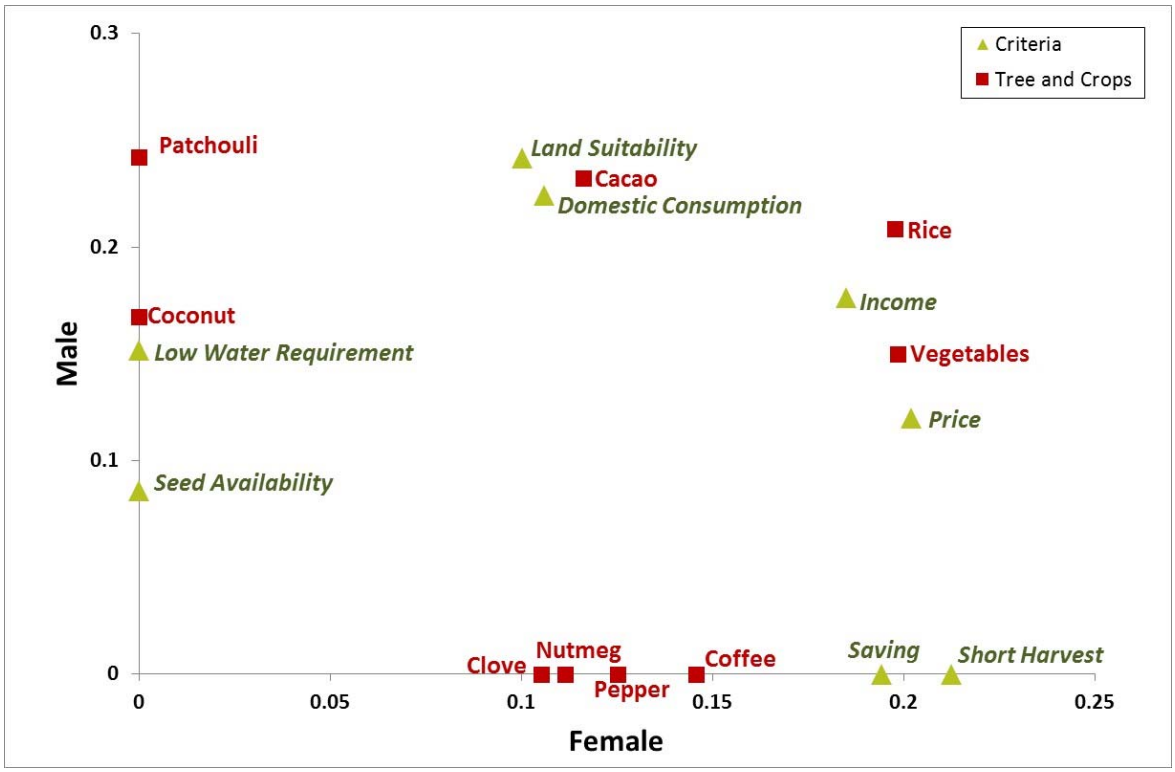

Figure 8. Criteria and preferences for trees and crops according to male and female perceptions in the upstream cluster

The culture of cultivating rice and annual crops was stronger in the upstream and midstream clusters compared to the coastal cluster (figures 8 and 9). This was reflected in the species' selections: rice and crops (that is, patchouli, pulse and sweet corn) were only mentioned in discussions with the upstream and midstream groups. Chili, a homegarden commodity, was mentioned in all female groups because it was regularly used by the female group members, particularly for domestic consumption but also providing a relatively small portion of additional income.

For the upstream cluster, in the absence of irrigation the main commodities grown in were seasonal crops that could survive minimal water supply. Rice was the number one commodity choice for males

and the second choice for females. However, there were several tree-based systems, such as cacao, coffee and coconut that had been cultivated for years.

As a result of the government's transmigration program, the forests in the upstream cluster were converted to agriculture and settlements. At the beginning of the transmigration program, in addition to cultivating rice and other annual crops, the first wave of migrants also planted cacao, in particular, and also clove. In the last five years, most cacao gardens had gradually been abandoned owing to high rates of disease and limited knowledge of how to deal with it. Farmers received almost no benefit from planting clove as their main commodity. In recent years, patchouli had become the main commodity, however, price uncertainty had led many farmers to replace their patchouli with other commodities, particularly, since 2010. Most farm households planted coconut, sold it as copra and also used it for domestic consumption.

In the midstream cluster, the male farmers preferred seasonal crops, such as rice, beans, corn and patchouli, while the female farmers selected tree-based commodities, such as oil palm, clove, rubber, coffee and cacao (Figure 9). Similar to the experience in the upstream cluster, in the 1990s and early 2000s, cacao was the main commodity, however, pests and diseases had decreased its productivity and encouraged the farmers to convert their cacao gardens to other commodities.

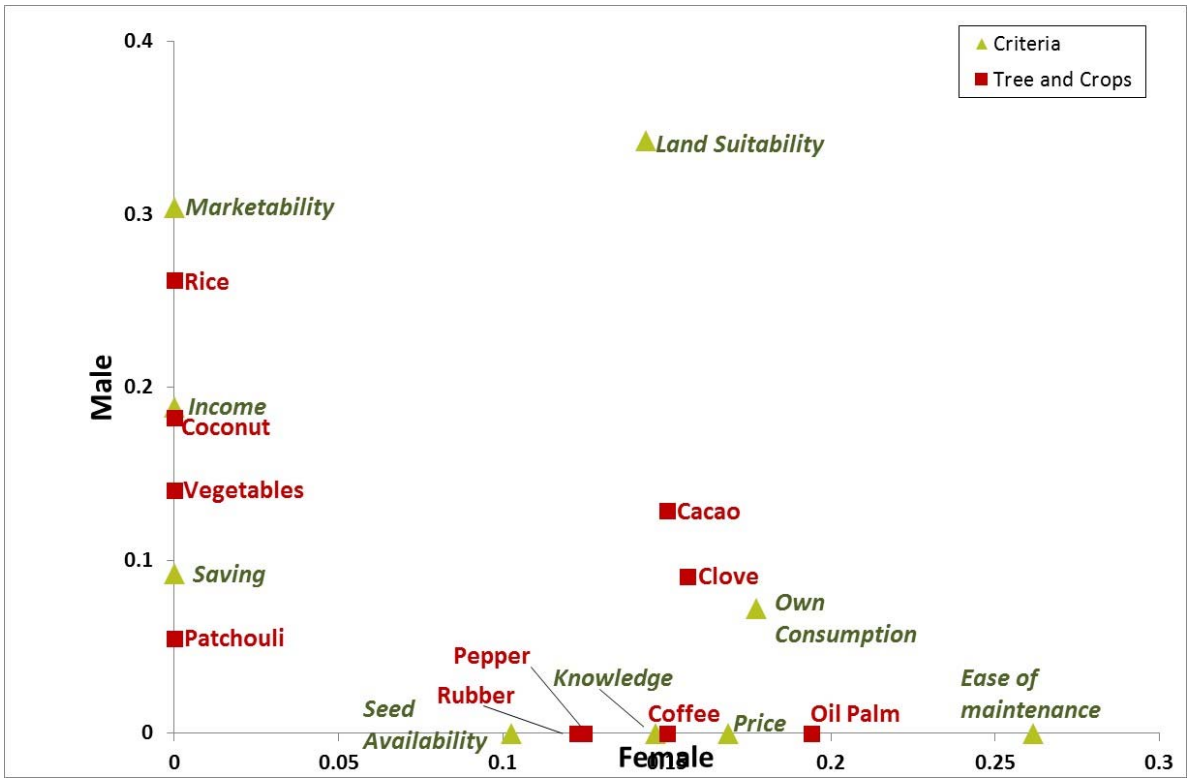

Figure 9. Criteria and preferences for trees and crops according to male and female perceptions in the midstream cluster

The coastal cluster was dominated by tree-based agriculture. The Analytical Hierarchical Process result indicated that coffee was the commodity that best met the selection criteria for male smallholders in this cluster (Figure 10). However, until recently, coffee was not the main commodity in the cluster. Cacao as the dominant commodity was the second preference, followed by other tree-based commodities, such as nutmeg, clove, coconut and agarwood. These commodities were perceived to be able to provide household income and savings with minimal maintenance. The females mainly preferred crop-based commodities, such as beans and pepper. They indicated their interest in growing oil palm, given its relative profitability in comparison with the other commodities they cultivated. The female group also perceived that 'ngantu', a local timber tree, could be used as a form of savings.

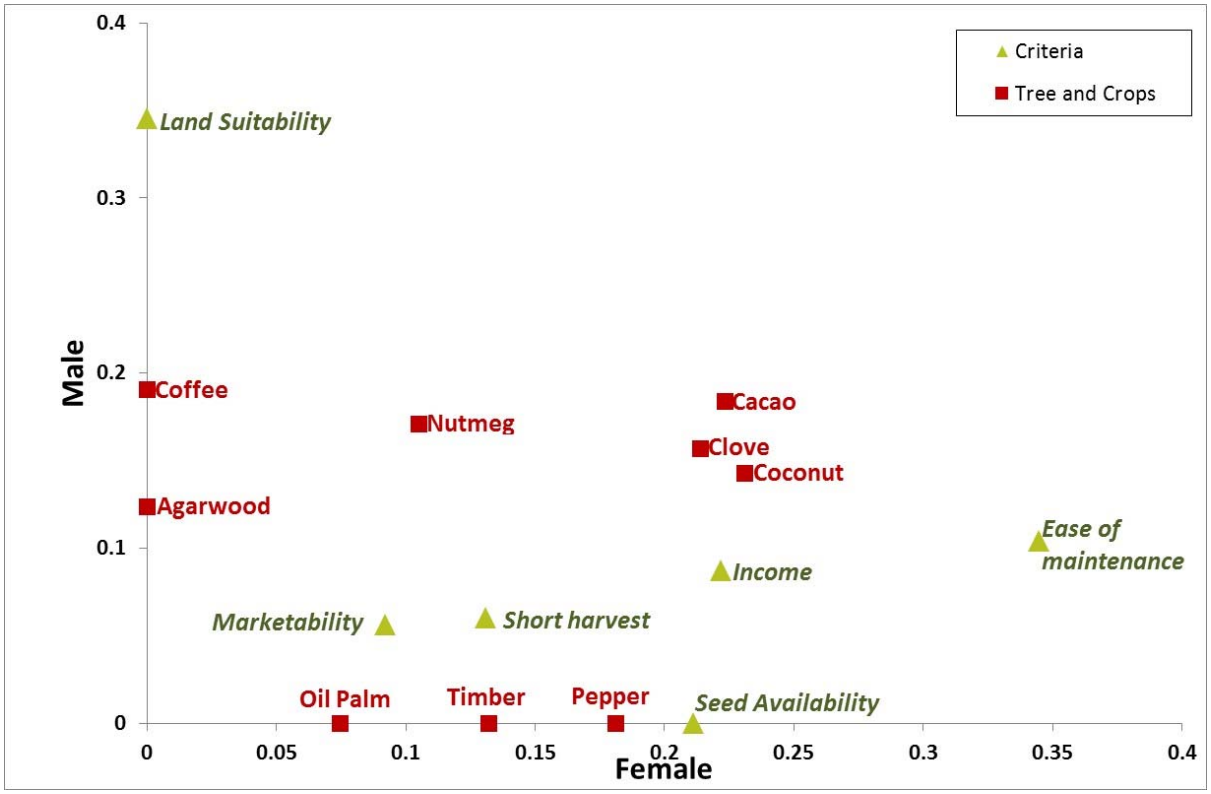

Figure 10. Criteria and preferences for trees and crops according to male and female perceptions in the coastal cluster

In figures 9 and 10, it can be seen that oil palm was the preferred tree commodity for female groups in the midstream and coastal clusters owing to its promising profit. Oil-palm plantations, including a newly-developed community-based plantation scheme (through the 'plasma' and 'core' program), were only located in the upstream cluster. Interestingly, the midstream and coastal male groups showed no interest in oil palm. In the midstream cluster, the farmers reflected on the experience of their neighbours in the upstream who had financially suffered owing to unfair contracts with large

estates when they were engaged in contract-farming schemes; and also on the limited land ownership of smallholders (less than 3 ha) who joined such schemes. In the coastal cluster, the male smallholders felt that oil palm might degrade their land.

Figure 11 illustrates the summary of criteria and preferences for trees and crops from female and male perspectives. Overall, land suitability was the most important criterion for the male farmers while 'ease of maintenance', 'source of income' and 'short harvest period' were the major criteria for the female farmers in all clusters. Savings, income and domestic consumption were the criteria shared between males and females. In terms of commodities, cacao, coconut, vegetables and rice were preferred by both males and females. Men preferred patchouli and agarwood while women preferred pepper, oil palm and rubber.

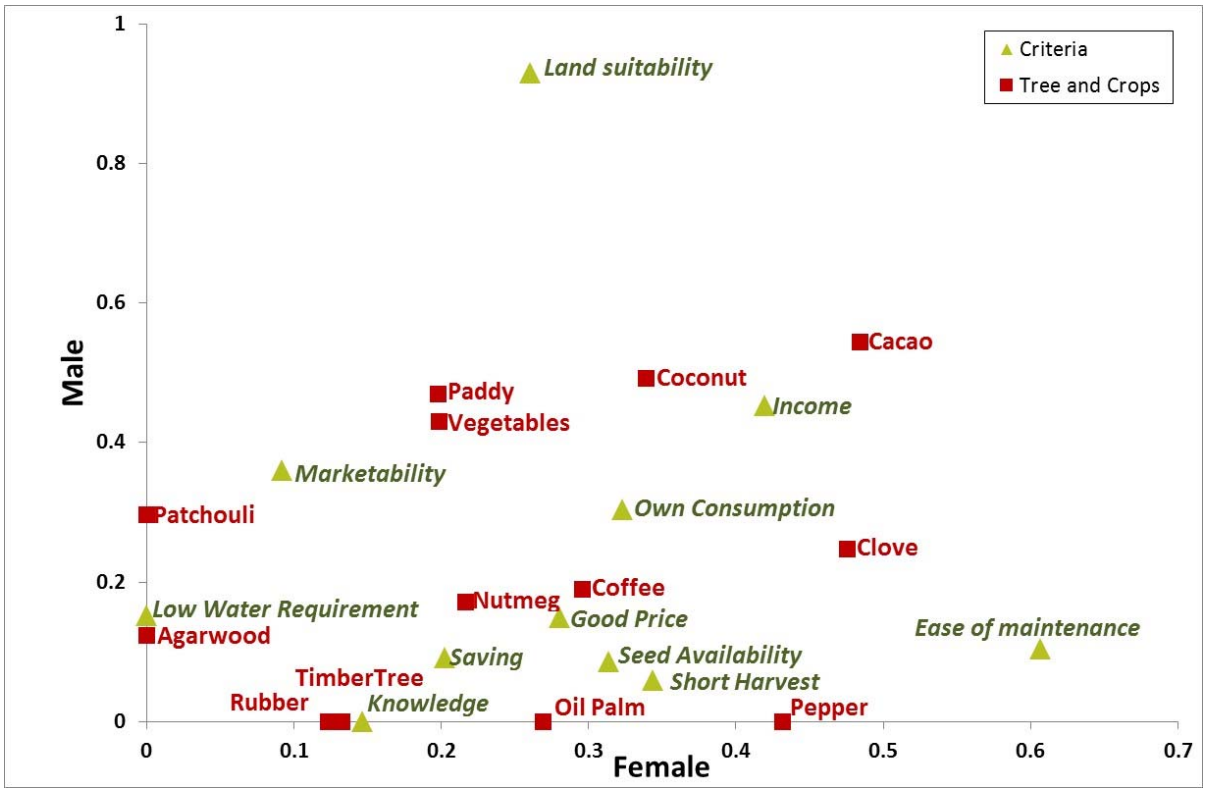

Figure 11. Criteria and preferences for trees and crops based on female and male perceptions in all clusters

Table 9 below summarizes the weighted average score of preferences for trees and crops across all clusters while Table 10 details the perception of suitability of trees and crops for each criterion.

Table 9. Smallholders' priority trees and crops

Priority Rank	Female & Male		Female		Male	
	Tree & Crops	Total Score*	Tree & Crops	Total Score	Tree & Crops	Total Score
1	Cacao	22	Clove	13	Cacao	12
2	Coconut	20	Cacao	10	Rice	12
3	Rice	18	Coconut	10	Coconut	10
4	Clove	16	Pepper	10	Coffee	6
5	Coffee	12	Oil palm	9	Patchouli	5
6	Nutmeg	11	Nutmeg	7	Nutmeg	4
7	Sweet corn	10	Sweet corn	7	Pulse	4
8	Chili	10	Rice	6	Clove	3
9	Oil palm	9	Coffee	6	Sweet corn	3
10	Patchouli	5	Rubber	3	Peanut	2
11	Pulse	4	Ngantu	3	Agarwood	1
12	Rubber	3	-	-	-	-
13	Ngantu	3	-	-	-	-
14	Peanut	2	-	-	-	-
15	Agarwood	1	-	-	-	-

* Score of a commodity based on its rank across the clusters

Across all clusters, cacao was considered the commodity that met most of the criteria, followed by coconut, rice, clove and coffee. Most of the species of trees and crops mentioned during the FGDs were already available in Buol. However, only coconut and cacao were cultivated in all of the villages in the three clusters.

Similar to the other districts in Sulawesi, from the 1980s to 2010 cacao was a prime commodity in Buol District. However, the cacao trees have aged and are more prone to diseases, which has decreased productivity and made the commodity less attractive to smallholders. However, farmers still preferred cacao owing to its high land suitability, their past experience and culture in cultivating cacao, relatively high and stable prices, and good marketability compared to other commodities.

Table 10. Commodity suitability with criteria across male and female groups*

Commodities	Land suitability	Household income	Seedling availability	Ease of maintenance	Good price	Short harvest	Market-ability	Domestic consumption	Planting knowledge	Savings	Low water requirement
Cacao	+++	++++	+++	+	+++	++	+++	+	+	++	+
Coconut	+	+++	+	-	-	++	++	+++	-	++	+
Rice	+++	-	+	+	+	-	+	+++	-	+	-
Clove	+++	+++	+++	++	++	+++	++	-	-	-	-
Coffee	+	-	++	++	+	++		-	+	-	-
Nutmeg	-	++	+	++	+	-	++	-	-	-	-
Sweet corn	+	-	-	+	-	-		+	+	-	-
Pepper	++	++	+	+	++	++	+	++	-	-	-
Oil palm	-	++	-	-	-	-	-	-	-	-	-
Pulse	-	-	-	-	-	-	-	-	-	-	-
Patchouli	-	-	-	-	+	-	-	-	-	-	-
Rubber	-	-	-	-	-	-	-	-	-	-	-
Peanut	-	-	-	-	-	-	-	-	-	-	-
Agarwood	-	-	-	-	-	-	-	-	-	-	-
Ngantu	-	-	-	-	-	-	-	-	-	-	-

*Degree of suitability based on the Score from Eigen value of each commodity from all groups. More + means more groups gave a high score to the commodity

As can be seen in Table 10, cacao was still perceived as being able to meet all criteria and was, thus, considered an important commodity for smallholders in Buol. It provided high household income (++++), fetched good prices, had good land suitability, and was marketable (+++). The other important commodities were clove, coconut and rice, ranging over 7–8 criteria. Clove was considered to be high in land suitability, contributed to household income, the seedlings were easy to obtain, and it provided faster yields compared to other trees, such as timber (+++). Rice was ranked high for domestic consumption and soil feasibility (+++) while coconut could be used for both household income and domestic consumption (+++).

Conclusion

Landscape characteristics drove the diversity of smallholders' agricultural problems and livelihoods' needs in the three targeted clusters in Buol District. In the upstream cluster, the main problem was water scarcity owing to the lack of a technical irrigation system, thus, farmers depended heavily on rainfall. In the midstream cluster, flooding was the main problem. It was perceived as starting after dam construction that altered the direction of river flow. Another perception about the cause of floods was the meandering form of the river, causing the water to sometimes become trapped in the lowland area. The people in the coastal cluster experienced sea-floods caused by mangrove degradation.

The coastal cluster, similar to the upstream and midstream smallholders, also perceived pests and diseases as one of the main problems. This owed particularly to the smallholders in the coastal cluster not being used to conducting intensive maintenance, particularly for tree-based systems. Because they lived on the coast, the smallholders also faced threats from coastal abrasion owing to mangrove degradation.

Regarding productivity fluctuation, coconut productivity was the most resilient during extreme events. This commodity could provide income and also be consumed by the smallholders. Cacao was the most vulnerable commodity because its productivity tended to fluctuate greatly during every extreme event.

Regarding the criteria used to select trees and crops, land suitability, household income, and ease of maintenance were the three criteria prioritized by all groups across all clusters. For the men, marketability was included as one of the main criterion. The women added seedling availability and short harvest periods as their main criteria for selecting trees and crops.

The five main commodities prioritized by farmers in all clusters were cacao, coconut, rice, clove and coffee. If we include the preferences of only male famers, pepper and oil palm are added to the list. The female farmers enriched the top-preference list by adding patchouli.

For each agricultural problem, the smallholders had already responded in several ways and were considering potential solutions. Recognizing these major problems and the ideal responses perceived by the farmers will be useful for providing effective solutions to enhance farmers' resilience in these clusters. Some of the perceived ideal responses, such as the alteration of river flow, however, needs to be scientifically tested owing to high uncertainty of its feasibility and further problem that the solution might bring about.

By recognizing the smallholders' problems and their preferences for tree and crops, the government could more easily develop a program that helped to address smallholders' interests and needs.

APPENDICES

Appendix 1. Smallholders' selection criteria for trees and crops

Table A. Female groups' selection criteria for trees and crops in each cluster

No.	Upstream cluster		Midstream cluster		Coastal cluster	
	Criteria	**Eigen value**	**Criteria**	**Eigen value**	**Criteria**	**Eigen value**
1	Planting knowledge	0.194	Stable price	0.221	Ease of maintenance	0.239
2	Seedling availability	0.178	Land suitability	0.155	Household income	0.164
3	Good price	0.155	Short harvest period	0.138	Seedling availability	0.151
4	Ease of maintenance	0.145	Savings	0.129	Short harvest period	0.094
5	Soil feasibility	0.111	Household income	0.109	Marketable	0.067
6	Domestic consumption	0.074	Domestic consumption	0.104	-	-

Table B. Male groups' selection criteria for trees and crops in each cluster

No.	Upstream cluster		Midstream cluster		Coastal cluster	
	Criteria	**Eigen value**	**Criteria**	**Eigen value**	**Criteria**	**Eigen value**
1	Land suitability	0.291	Marketability	0.285	Land suitability	0.343
2	Good price	0.225	Land suitability	0.285	Seedling availability	0.343
3	Household income	0.170	Household income	0.194	Ease of maintenance	0.106
4	Low water requirement	0.127	Domestic consumption	0.090	Household income	0.089
5	Domestic consumption	0.113	Savings	0.086	Short harvest period	0.060
6	Seedling availability	0.074	-	-	Marketability	0.059

Appendix 2. Smallholders' preferences for trees and crops

Table C. Female groups' preferences for trees and crops in each cluster

No.	Upstream		Midstream		Coastal	
	Commodity	**Eigen value**	**Commodity**	**Eigen value**	**Commodity**	**Eigen value**
1	Sweet corn	0.199	Oil palm	0.188	Cacao	0.205
2	Rice	0.160	Clove	0.131	Clove	0.144
3	Chilli	0.119	Coconut	0.117	Coconut	0.133
4	Coffee	0.113	Chilli	0.112	Nutmeg	0.051
5	Nutmeg	0.096	Rubber	0.111	Ngantu	0.049
6	Cacao	0.093	Coffee	0.103	Oil palm	0.040
7	Clove	0.077	Cacao	0.094	Chilli	0.092

Table D. Male groups' preferences for trees and crops in each cluster

No.	Upstream		Midstream		Coastal	
	Commodity	**Eigen value**	**Commodity**	**Eigen value**	**Commodity**	**Eigen value**
1	Rice	0.286	Rice	0.246	Coffee	0.259
2	Cacao	0.224	Coconut	0.192	Cacao	0.190
3	Patchouli	0.202	Pulse	0.137	Nutmeg	0.190
4	Coconut	0.153	Sweet corn	0.131	Clove	0.172
5	Peanut	0.134	Cacao	0.096	Coconut	0.134
6	-	-	Patchouli	0.081	Agarwood	0.055

Appendix 3. Tree and crops suitability across each criteria

Table E.1a Score for tree and crops suitability across each criteria based on community preference

Priority	Soil feasibility		Household income		Seed availability		Ease of maintenance		Good price		Fast yield	
	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score
1	Clove	20	Cacao	25	Cacao	15	Nutmeg	14	Cacao	17	Clove	17
2	Cacao	19	Coconut	17	Clove	15	Clove	13	Clove	11	Coconut	13
3	Rice	17	Clove	14	Coffee	9	Coffee	13	Pepper	9	Cacao	10
4	Pepper	13	Pepper	10	Nutmeg	9	Pepper	11	Rice	8	Coffee	10
5	Coconut	11	Nutmeg	8	Coconut	8	Cacao	10	Coffee	7	Pepper	10
6	Sweet corn	6	Oil palm	8	Pepper	8	Sweet corn	7	Nutmeg	7	Nutmeg	7
7	Coffee	6	Rice	7	Rice	7	Oil palm	6	Patchouli	7	Rubber	7
8	Patchouli	5	Coffee	6	Oil palm	3	Coconut	4	Coconut	5	Pulse	4
9	Oil palm	5	Peanut	4	Aloes	2	Aloes	3	Oil palm	4	Ngantu	4
10	Pulse	5	Patchouli	3	Pulse	1	Rice	1	Peanut	4	Oil palm	3
11	Nutmeg	4	Pulse	3	Ngantu	1	Pulse	1	Rubber	1	Aloes	2
12	Rubber	3	Ngantu	2	Sweet corn	0	Ngantu	1	Sweet corn	0	Sweet corn	1
13	Peanut	2	Aloes	2	Patchouli	0	Patchouli	0	Pulse	0	Rice	0
14	Aloes	2	Rubber	1	Rubber	0	Rubber	0	Aloes	0	Patchouli	0
15	Ngantu	0	Sweet corn	0	Peanut	0	Peanut	0	Ngantu	0	Peanut	0

Table E.1b Score for tree and crops suitability across each criteria based on community preference

Priority	Marketability		Own consumption		Planting knowledge		Savings		Less water required	
	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score	Tree/crop	Score
1	Cacao	19	Cacao	19	Sweet corn	7	Coconut	13	Cacao	7
2	Clove	12	Clove	12	Coffee	6	Cacao	8	Coconut	6
3	Coconut	11	Coconut	11	Pepper	5	Rice	7	Patchouli	5
4	Nutmeg	10	Nutmeg	10	Cacao	4	Clove	6	Peanut	4
5	Rice	7	Rice	7	Nutmeg	3	Coffee	6	Rice	3
6	Pepper	7	Pepper	7	Clove	2	Pepper	5	Clove	0
7	Coffee	5	Coffee	5	Rice	1	Sweet corn	4	Coffee	0
8	Sweet corn	3	Sweet corn	3	Coconut	0	Pulse	3	Nutmeg	0
9	Oil palm	3	Oil palm	3	Oil palm	0	Oil palm	2	Sweet corn	0
10	Pulse	3	Pulse	3	Patchouli	0	Patchouli	1	Pepper	0
11	Aloes	2	Aloes	2	Pulse	0	Rubber	1	Oil palm	0
12	Patchouli	1	Patchouli	1	Rubber	0	Nutmeg	0	Pulse	0
13	Ngantu	1	Ngantu	1	Peanut	0	Peanut	0	Rubber	0
14	Rubber	0	Rubber	0	Aloes	0	Aloes	0	Aloes	0
15	Peanut	0	Peanut	0	Ngantu	0	Ngantu	0	Ngantu	0

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