Working Paper

Management along a gradient: Southeast Sulawesi's cacao production landscapes

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World Agroforestry Centre

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Lisa C. Kelley is a PhD student at the University of California, Berkeley, in the Department of Environmental Science, Policy and Management. Her work focuses on conservation strategies and land-use transitions in Southeast Asia's agricultural landscapes. Prior to study at Berkeley, Lisa worked for The Nature Conservancy, The Wildlife Trade Monitoring Network (TRAFFIC) and The Center for People and Forests (RECOFTC). Her work with these organizations addressed questions related to forest governance and land use, with a particular focus on community forest management and REDD+ in Southeast Asia. Lisa received her BA in Ecology and Evolutionary Biology from Princeton University in 2008.

Abstract

Indonesia’s cacao production landscapes are increasingly important sites for supporting social and ecological sustainability. To inform these efforts, this study presents information on the history of cacao cultivation, current management practices, factors influencing these practices, and ongoing developments related to land in Southeast Sulawesi. Three findings are highlighted. First, despite the commonality of a full-sun growing strategy, a diversity of management practices persists, some of which challenge common renderings of socio-ecological trade-offs. Second, current levels of production loss suggest the potential transience of cacao as a livelihood strategy and source of wildlife habitat in Indonesia, highlighting the need to study socio-ecological trade-offs over a long time period and in relation to other cropping systems. Third, while many efforts to boost social or ecological sustainability assume that farmers make decisions on the basis of economic risk and return, management practices appear to be more often informed by the quality and orientation of institutional support farmers receive.

Keywords: cacao, cocoa, management practices, land-use dynamics, livelihoods, Southeast Sulawesi

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1. Introduction

Indonesia is the latest centre of the cacao boom and potential cacao bust. Since the late 1980s, more hectares of land have been converted to cacao production than anywhere else in the world (Clough et al 2009). Indonesia has become the third-largest producer of cocoa beans globally, producing a 15% share of the world supply, with exports amounting to over USD 0.9 billion annually (FAOSTAT 2013, WCF 2007, World Bank 2009). Despite this growth, widespread production losses have been observed in Indonesia since the early 2000s, reflected in oscillating export figures (AgroAsia 2012, Listiyorini 2012, Direktorat Jenderal Perkebunan 2012). Cacao farmers have experienced pest outbreaks, particularly the Cacao Pod Borer (Bos et al 2007, Klein et al 2002); irregular but pronounced droughts associated with the El Niño Southern Oscillation (for example, Schwendenmann et al 2010); and the spread of fungal pathogens, particularly Black Pod Rot and Vascular Streak Dieback (for example, Neilson 2007, Listiyorini 2011, Pardomuan 2011).

Much work analyzing cacao production landscapes in Indonesia has examined the socio-ecological trade-offs associated with different production practices. Cacao (*Theobroma cacao L.)* is an understorey tree species native to the Amazon that can be grown in complex multi-storey farms. Despite this, most cacao in Indonesia is cultivated under a full-sun monocultural strategy (Belsky and Siebert 2003). Attempts to explain why farmers choose a full-sun strategy generally emphasize the higher yields (and higher incomes) it is possible to obtain from a full-sun approach (for example, Tscharntke et al 2011, Steffan-Dewenter et al 2007). In contrast, analysts tend to suggest that farmers adopting a more diverse multi-storey cropping strategy accept potentially lower returns but do so because risk is also lower. Shade trees planted alongside cacao have been found to (i) provide resources that support the natural enemies of pests; (ii) protect cacao trees from physiological stress; and (iii) prevent the growth of a competitive weed bank that might harbour pests and diseases (for example, Bos et al 2007). This confers a degree of environmental resilience—sustaining yields and other ecosystem services more dependably than monocultural strategies in the face of environmental variability (Holt-Gimenez et al 2002, Lin et al 2008, Vandermeer et al 1998, Schwendenmann et al 2010)—as well as economic resilience, providing an additional source of livelihoods for farmers who find their incomes reduced from cacao (Tscharntke et al 2011).

The nature of these trade-offs and the extent to which they characterize actual farmer decision-making processes has important implications for efforts to support social and ecological sustainability in cacao production landscapes. In particular, many emerging certification programs (for example, Rainforest Alliance) aim to create incentives for relatively more diverse multi-storey farms on the basis of an assumption that (i) such farms provide a critical source of habitat for many endangered wildlife species; and (ii) certification can provide a price premium per hectare that will offset the disadvantages to smallholders' incomes associated with shading practices (Steffan-Dewenter et al 2007). Understanding the validity of these assumptions, however, is limited by three gaps in current analyses of socio-ecological trade-offs. First, it is often assumed that there is a neat correspondence between maintaining shade trees and providing wildlife habitat, failing to examine the other management practices that may shape biodiversity outcomes. Second, the longevity of cacao habitat in a landscape is often not incorporated in a discussion of socio-ecological trade-offs. This is particularly important given the potential of cacao ‘bust’ suggested by the current production losses. Third, and most importantly, almost all work done assumes farmers make decisions on the basis of risk and return, but very little work examines other, relatively more non-economic factors, which also shape farmers’ decisions.

To help build understanding and inform management debates, this study aimed to collect information on:

I. the history of cacao cultivation;
II. current cacao management practices;
III. factors influencing cacao management; and
IV. continuing developments related to land.

This paper presents data from interviews and participant observation conducted over two months in Sulawesi, Indonesia, in the context of the World Agroforestry Centre’s Agroforestry and Forestry in Sulawesi: Linking Knowledge and Action (AgFor) project. After briefly describing the sites selected for study and the data collection method, I share my initial findings and conclude with thoughts on implications and directions for future work.

2. Research Site and Methods

The field component of this research was conducted over six weeks from May to June 2012, with one week spent in each of four villages and two weeks spent in Kendari, Southeast Sulawesi, learning from staff of the AgFor project. The intended outcome of the AgFor project is improved equitable and sustainable agroforestry and forestry-based livelihoods’ systems for rural communities in Sulawesi. To achieve the outcome, the project focuses on improving awareness, access and skills related to natural resources and agriculture; developing equitable participatory governance mechanisms; and integrating management of sustainable landscapes and ecosystems. Cacao is a major income source for rural families in the project area (Roshetko et al 2013).

The province of Southeast Sulawesi was selected for study because the island of Sulawesi produces the majority of the cacao in Indonesia (~70%), with Southeast Sulawesi responsible for 16% of the total national production (Direktorat Jenderal Perkebunan 2012). Southeast Sulawesi is also the site of initial work on the ICRAF-led components of the AgFor project. Working alongside ICRAF project staff, four villages were selected from Konaweha district in Southeast Sulawesi for in-depth study on the basis of reported differences in cacao cultivation practices. Villages were selected to provide sufficient basis to examine local variation while enabling tentative hypotheses about the general directions of past and present changes.

Of the four villages, Lawonua and Wonua Hoa lie roughly at sea level in the mostly deforested lowlands while Ambondia’a and Asipakolie are situated on the Konaweha River in the mostly still forested uplands. Whereas Lawonua and Wonua Hoa are characterized by high numbers of Bugis migrants (56% and 37% respectively, according to village leaders), Ambondia’a and Asipako are characterized by nearly exclusively Tolaki populations. Bugis migrants’ management practices in the former two villages shaped cacao farming more broadly compared to the latter two (discussed further below).

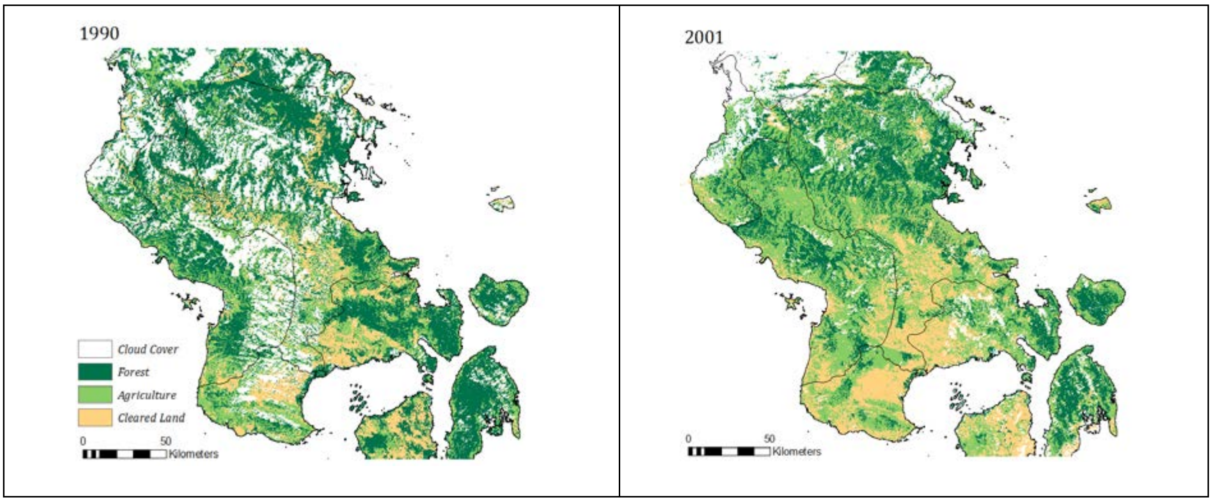
In each village, I spent 4–5 days conducting informal interviews with cacao farmers, village elders and village leaders. I also spent 2–3 days conducting participant observation. Over 100 cacao farmers, village elders and village leaders were interviewed, with interviews generally lasting 10 minutes when discussing farmer production strategies and management challenges but up to two hours when discussing the history of village governance and land use. Interviews followed a semi-structured format developed through initial focus-group discussions with farmer groups in the region, conversations with AgFor project staff, and a literature review. When interviewing farmers, farms were also visited to better contextualize their perspectives of production strategies. Participant observation included harvesting and field preparation activities with farmers and participation in community events.

Given time limitations, an opportunistic sampling approach was adopted. Farmers and other villagers were approached when in their fields or near their houses. Sampling was stratified to the extent possible, however, with roughly equal time devoted to conducting interviews in each of a village's neighbourhoods. I adopted a purposive strategy to interview village leaders, villagers in relevant government positions, and villagers with a long ancestry in the area.

3. Results

Section I. History of the transition to cacao

In each of the four villages, the majority of farmers I spoke with had made the transition to cacao farming in or around the late 1990s and early 2000s. The majority of land converted to cacao was previously in forest and, prior to that, where land history was known, was primarily used for either wet or dry rice cultivation. This finding is consistent with data collected in the context of the AgFor project, which suggests villagers consistently perceived an increase in cacao production between the 1990s and 2000s and a corresponding decrease in forest cover (Janudianto et al 2012). It is also consistent with initial land-cover change analyses for mainland Southeast Sulawesi over the time period 1990–2001, the time at which cacao would have initially been introduced (Figure 1).



	Area (1990)	% Cover (1990)	Area (2001)	% Cover (2001)	Absolute change	Annual change rate (%)
Forest	951,295	52.3	503,409	27.7	***-447,886***	***-2.2***
Agriculture	495,096	27.2	894,427	49.1	***399,331***	***+2.0***
Cleared Land	374,007	20.5	422,563	23.2	***48,555***	***+0.2***
Total	**1,820,399 hectares**	**100**	**1,820,399 hectares**	**100**	**-**	-

Figure 1. Changes by land-cover classification (mainland Southeast Sulawesi 1990–2001)

Note: Change mapping was conducted using LANDSAT composite imagery; a two-step unsupervised classification process in Erdas Imagine 2011; and spatial analysis in ArcView using the Patch Analyst extension. Data sources and methods are further elaborated in Appendix 1.

In Lawonua and Asipako villages, many villagers associated the rapid transition to cacao with the Sulawesi Rain-Fed Agricultural Development Program (SRFADP). SRFADP was a program funded by the Asian Development Bank, which operated in Sulawesi in the late 1990s with a budget of USD 43.8 million for the goal of encouraging upland development and conservation by supporting rain-fed agriculture. The project was initiated in 1995 but on-the-ground implementation only began in 1999. Through the project, spearheaded within Indonesia by the Directorate General of Estate Crops, roughly 31 000 ha of estate crops and 18 000 ha of food and horticultural crops were introduced.

The estate crops developed under the project were coconut, coffee, cacao and pepper, listed in order of total area planted (ADB 2003 p.1–3). SRFADP was found to operate somewhat differently in Lawonua and Asipako but, in both, officials from the Directorate General of Estate Crops provided farmers with seeds and compensation that helped to support the initial ‘cacao boom’ in these villages. This program also helps to explain a decline in forest cover over the period because while the program ostensibly supported upland conservation, farmers were also paid IDR 350 000 (± USD 30 in 2014 terms) per hectare to clear the land of all existing vegetation, including secondary forest.

In Lawonua and Wonua Hoa villages, many villagers (including the Bugis) also linked the transition to cacao to the arrival of Bugis migrants in the late 1990s. Bugis farmers I spoke with mentioned they left South Sulawesi because of land scarcity, often following family or neighbours to Southeast

Sulawesi upon hearing that fertile land was cheaply available. Both Tolaki and Bugis villagers in Lawonua and Wonua Hoa mentioned that while the Bugis were not the first to grow cacao, they were the first to grow monocultural cacao and on areas of land greater than one hectare. The Bugis often brought seeds with them from South Sulawesi.

Finally, many farmers described a process in which cacao farming quickly spread within a given area after farming practices were introduced and both knowledge and seedlings became relatively more available. Bugis migrants were one source of information and seeds, as were farmers in Kolaka Utara, the district immediately west of Konaweha. Many villagers noted that they were motivated to adopt cacao farming after seeing the financial success it brought that area. Seeds were often obtained from relatives in Kolaka Utara, especially among farmers in Ambondia'a and Asipako.

Section II. Current management practices

There was variation between villages in the structural complexity of farms but farming practices within a given village were generally consistent (Figure 2). In addition to cacao, pepper and sago were commonly cultivated. To varying degrees depending on the village, large- and small-scale corn farms, short-term vegetables (peanuts, spinach, eggplant, cassava), teak and white teak, patchouli, lemongrass and various trees used for fruits and seeds were observed (the latter included banana, coconut, coffee, mango, langsat, rambutan, papaya, durian, cashew, candlenut, betel nut and kapok trees) (Appendix 2). In Lawonua, more than 300 ha had recently been converted from teak and secondary forest to oil palm (this is part of more than 1000 ha in six villages that will be planted with oil palm). There are also several smallholder oil-palm farms in Wonua Hoa, with at least two other villagers raising oil-palm seedlings. This information is consistent with evidence that oil palm is an emerging crop in the region. To date, however, most oil-palm production has been concentrated in the neighbouring district of Kolaka (Janudianto et al 2012).

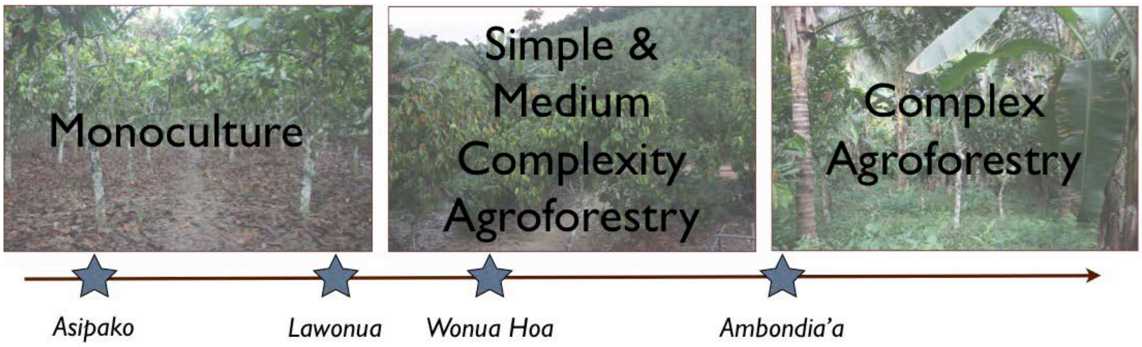


Figure 2. Production classifications in the study villages

In Asipako, cacao farms were structurally the simplest and were almost exclusively under monoculture. In Lawonua, while most farms were under cacao monoculture, a few shade trees were occasionally present. These included coconut, sugar palm, durian and langsat. More commonly, some gamal trees were incorporated into the farm to support peppercorn cultivation. In Wonua Hoa, the largest farms are managed by Bugis, who typically begin growing cacao by intercropping it with banana and occasionally plant other fruit trees such as langsat, durian and coconut. In Ambondia'a, farms were relatively complex, characterized by older durian, sago and coconut trees intercropped with cacao. Throughout all four villages, the most structurally diverse cacao farms visited were in home gardens. This land generally was not the farmer's primary land for cacao cultivation and included many trees used for home consumption.

Despite having adopted different growing strategies, villagers suffered from relatively consistent sources of production loss. The most commonly cited problems varied somewhat by village, but included fungal rot, PBK, wildlife pests (particularly monkeys and pigs) and fruit losses associated with heavy rains. Some farmers estimated that as much as 60% of their crop was affected; several said that cacao farming was no longer profitable; and many mentioned they were actively looking to move away from cacao.

To boost yields and reduce pressure from pests and pathogens, most farmers interviewed were using chemical inputs, including fertilizers, herbicides, pesticides and fungicides. These inputs were not necessarily all used in concert or even used at recommended dosages owing to economic limitations and other access barriers (for example, access to water to mix with pesticides). Facing economic limitations, most farmers said that pesticides were the most important input. Reflecting this, farmers in Asipako and Ambondia'a guarantee local cocoa buyers a portion of their harvest in exchange for upfront cash to buy pesticides. Fungicides were occasionally used in an attempt to reduce Black Pod Rot, but most farmers I spoke with about this felt that fungal pathogens were outside their control, controlled only by the volume and timing of rains. Pruning was also an important strategy, and while nearly all farmers pruned trees to some extent, several mentioned they did this deliberate to manage fungal levels, pruning heavily during the rainy season to allow sun to better dry fruits and trunks.

Farmers employed idiosyncratic methods of dealing with crop losses from monkeys (which are reportedly substantial in some areas of Wonua Hoa and in most of Ambondia'a and Asipako) and pigs, which are a source of crop losses in all four villages. To deal with monkeys, farmers primarily attempt to scare them, using air guns, scarecrows and remaining physically present and loud when monkeys visit their farm. In Asipako, where farms are often not adjacent to farmers' homes, many farmers stayed in temporary shelters on their land during peak harvest times so that they were present to scare the monkeys away. Some farmers in Ambondia'a also mentioned that they lace bananas with poison purchased from agricultural stores in Unahaa, but that this ran the risk of poisoning neighbours' livestock. To deal with pigs, farmers built a variety of traps and fences. Many farmers also mentioned that Balinese migrants from neighbouring villages came to hunt pigs and that this relaxed crop losses.

Section III. Factors influencing the adoption of shade trees

Farmers expressed or implied various reasons for adopting relatively more complex or relatively more monocultural production strategies. Some of these reasons, discussed below, appear to have a relatively straightforward effect on the inclusion or exclusion of shade trees from farms (Table 1). Other factors had a considerably more variable effect.

Table 1. Factors influencing the retention or elimination of shade trees

	+	-
Sale and consumption	Sale and consumption of fruits and seeds	Sale and consumption of timber
Customary and family-use arrangements	Separate ownership arrangements for trees vs. land (for example, durian, sago) Multiple use-rights to certain trees (for example, durian, sago)	
Past generations' legacy	Desire to preserve trees planted by parents or grandparents	
Agricultural extension		SRFADP program in the late 1990s paid farmers to clear land and instructed them to remove planted shade trees after four years GERNAS program since 2008 has distributed grafts, encouraging shade elimination to enhance graft survival
Perceptions of ecological function		Perceptions that shade trees lower yields; facilitate fungal pathogens, waterlogged fruits and bark moss; attract wildlife; and create water stress for cacao trees

Sale and consumption

Shade trees provide materials for sale and consumption and can be used to establish farm boundaries. Farmers commonly said something like, 'I keep the trees that give me income'. For consumption and sale, langsat, rambutan, durian, coconut, mango, nangka (jack fruit), banana, betel nut, papaya, sago, cashew, candlenut and kapok were observed growing on farms. Various trees were used to establish farm borders, including teak and white teak and kapok. Sale and consumption of timber, however, also motivated the elimination of shade trees, as when a market for coconut wood emerged and many old coconut trees were cleared from farms in Ambondia'a and Asipako.

Customary and family-use arrangements

In each of the villages visited, trees were not necessarily sold with the land. This was particularly true for durian and sago trees. As a result, trees might be maintained on a farm by an owner because that owner does not have the right to remove the tree. Additionally, while farmers said that trees were only owned by one family member, all family members claimed use rights. This may provide some motivation to keep trees.

Past generations' legacy

Villagers were evacuated from what are now Ambondia'a and Asipako villages during the period of Darul Islam, beginning in 1955. Villagers began returning to the area to cultivate land as early as the 1960s but the large majority of villagers only returned around 1995 when village-level government was established. Older villagers spoken with in Ambondia'a expressed a desire to preserve trees planted by previous generations, for example, 'I am so proud to come back here and just want to preserve what my parents and grandparents had before'. Villagers also often noted that the current generation does not plant such trees and that if they are cut down these trees will not exist in the landscape anymore. A similar motivation may be at work in Wonua Hoa, where many villagers mentioned that durian, coconut and sago trees on their land had been planted by their parents or grandparents.

Agricultural extension: SRFADP and GERNAS

The role of agricultural extension was pronounced but highly variable across the four study sites. One source of variability was the operations of the above-mentioned SRFADP program in the late 1990s. Importantly, SRFADP operated in Asipako when Ambondia'a was then part of the village not a separate entity as it is now. In or around 1995, Asipako's then village head negotiated with the owners of roughly 150 ha to redistribute it to villagers in equal parcels. This land (and not adjacent land in what is now Ambondia'a) was subsequently marked for participation in the SRFADP program. Through the program, farmers received IDR 350 000 per ha to clear the land of all existing vegetation, IDR 300 000 per ha for planting cacao and IDR 1500 for each tree planted. Farmers were instructed to plant one shade tree for every four cacao trees and to eliminate shade trees when the cacao trees began to bear fruit. This initial guidance had a clear impact on production strategies (Figure 3). For example, while Asipako is characterized by a full-sun monocultural strategy, multi-storey agroforests predominate in the adjacent village of Ambondia'a. A monocultural production strategy similarly prevails in another of the four study villages where SRFADP was operational: Lawonua.

Figure 3. Typical farm in Asipako with cacao monoculture showing evidence of eliminated gamal shade trees

In mid-2008, the Government of Indonesia announced its intention to pursue an increase in cacao production, targeting roughly 300 000 ha of already converted land for on-farm intensification (Direktorat Jenderal Perkebunan 2012). This national-level program, Gerakan Peningkatan Produksian Mutu Kakao Nasional (GERNAS/National Movement to Increase the Production and Quality of Cacao) involves the distribution of fertilizers and pesticides on farms younger than 10 years and the distribution of more disease-resistant grafts on farms older than 10 years, as assessed by officials from the Directorate General of Estate Crops. This program has been active in two of the four study villages—Lawonua and Ambondia'a—with activities scheduled to begin in Asipako by September 2012. In some cases, farmers were pruning shade and cacao trees heavily to provide newly established grafts with sufficient sunlight to survive. However, given anecdotal accounts that the graft survival rate is low and grafts may not actually be disease resistant, some farmers are leaving old fruit-bearing cacao branches in place to guarantee at least some income.

Perceptions of ecological function

Farmers commonly expressed that shade trees were bad for cacao production because they reduced yields. One farmer, when asked about how a sugar palm affected cacao, said that, 'It's bad for the cacao, but not as bad as a coconut tree', demonstrating with his arms how coconut tree branches grow horizontally and block sunlight from the cacao. Farmers also mentioned that shade trees reduced the effect of the sun in reducing water on fruit and trees after rain, resulting in more Black Pod Rot, more bark moss (which blocks the formation of new fruits) and more waterlogged young fruit. Shade trees also attracted more monkeys, a key source of production losses in areas with substantial remaining forests.

Labour scarcity and migrants' production practices

While not seeming to play a strong role in shaping the adoption or retention of shade trees, labour scarcity and migrants' production practices influenced management practices and are worth mentioning.

Particularly in Ambondia'a and Asipako, some older farmers mentioned that they were cultivating cacao as a 'pension'. These farmers often mentioned they lacked the labour power to sufficiently tend their farm, occasionally relying on children or hired help to make up the labour shortage. This situation could have varied impacts on farming practices. Managing pest pressure is time consuming, but managing wildlife and pruning were generally considered both more time consuming and more ineffective (these problems were those most commonly associated with shade trees).

Finally, the Bugis migrants brought with them various production practices, such as intercropping cacao with banana. It is unclear exactly what effect this has had on local land use though it seems reasonable to presume that the Bugis typically grow cacao in a more intensive manner than was common in the area prior to their arrival. This was suggested by local accounts indicating that while the Bugis were not the first to grow cacao, they were the first to grow cacao in monoculture and on areas of land greater than one hectare.

Section IV. Cacao in relation to continuing land developments

As discussed, in both Lawonua and Wonua Hoa, the transition to cacao has been driven by, and associated with, the arrival of a substantial number of Bugis migrants. In, Wonua Hoa, a substantial portion of land is also under some form of protection ('limited production forest', 'production forest' or 'protected forest').

One observation worth further investigation is that landholdings appear to have been consolidated over the past 10–15 years, with local transactions resulting in apparently high disparities between Bugis and Tolaki farmers. In keeping with this, Bugis farmers commonly reported managing 2–4 ha of land—in both villages—while Tolaki farmers reported an average of 1 ha. It is important to look at fallow landholdings to understand the disparity between this finding and that of Janudianto et al 2012. Yet this finding would be consistent with what has been observed by Li (2002) in Central Sulawesi and will likely interact with emergent oil-palm production in the region to create new incentives and oppositions, as suggested by a farmer in Lawonua.

> *Mostly, the people that are happy about the oil-palm plantation are the people that don't have land anymore or only have a little land. For people with a lot of land, the plantation doesn't change anything.*

Further, and potentially as a result of the many land transactions and restrictions on the further conversion of forested land, the value of land appears to have increased. It is unclear what effect this has had in the study villages though Belcher et al (2005) and others posit that an increase in land values often drives land-use intensification. In addition to contributing to potential land scarcity in Wonua Hoa, land under varying levels of protection has also created a situation of tenure insecurity in Wonua Hoa, Asipako and Ambondia'a. It is unclear what effect this has on farm practices. Ruf (2011) argues that insecure tenure has variable impacts depending on context; that better tenure security can increase incentives to intensify production but that intensification may also be undertaken to establish and protect land rights.

4. Discussion

The four study villages were characterized by diverse production strategies. While many villagers in the four study regions have adopted a full-sun, high-density farming strategy, this was not exclusively the case and diverse farming practices persisted. Cacao farmers have experienced widespread production losses across Sulawesi in recent years and losses in Southeast Sulawesi conform to these broader trends. Many farms visited within the four study villages were suffering from pest and pathogen outbreaks as well as production losses associated with wildlife and heavy rains. Farmers were almost ubiquitously reliant on heavy dosages of pesticides and fungicides regardless of their specific farming strategy. Notably, it was on the most structurally diverse farms that farmers were using poison to reduce losses from monkeys. This finding reiterates the importance of examining not just the presence of shade trees on a farm but the range of management practices, suggesting that there is far from the neat correspondence between diversified production strategies and biodiversity protection that is sometimes suggested (for example, Clough et al 2009).

Current levels of production loss also highlight the potential transience of cacao as a livelihood strategy and source of wildlife habitat in Indonesia. This is true not only because of current production losses but also because of emerging livelihood possibilities in the region. One notable development is the expansion of oil palm in Sulawesi, which is already shaping farming decisions in Lawonua. The long-term viability of cacao as a livelihoods' strategy will also be shaped by historical patterns of land transfer in relation to cacao. Land sales to incoming Bugis migrants may have generated both land scarcity as well as landlessness among Tolaki residents. Landlessness may lead some village members to seek waged labour, intensifying incentives for oil palm or other estate crops.

Finally, this study suggests that diverse non-economic factors shape farmers' management decisions. Looking simply at the role of shade trees, it is apparent that decisions to incorporate shade trees are characterized not only by the effect that shade trees have on yield but also by their value in terms of home consumption, ownership arrangements, and past generations' legacy. One interesting finding is that almost regardless of production strategy, farmers associated shade trees with greater ecological disservice than service. This contradicts many propositions within the ecological literature (see, for example, Tscharntke 2011). A second related finding is that farmers do not associate the structural or compositional diversity of farms with levels of pest pressure, though there is anecdotal and scientific data suggesting pest pressure may be lower on relatively more complex farms. This finding may suggest the relevance of looking at landscape complexity, particularly to understand the incidence of Cacao Pod Borer, a widespread pest in each of the four villages. Because the landscapes in which any one farm exists are now increasingly homogeneous, any one farmer's production decisions likely have a much more limited impact on overall pest and pathogen pressure than does landscape complexity (as per Tscharntke et al 2005). This finding also demonstrates the relevance of examining production contexts. In this area, many losses were due to rain and wildlife. In concordance with farmers' insights, this makes it likely that shade trees do contribute to production losses. It is possible to draw the broad implication from both findings that scientific understanding of the ecological services and disservices of shade trees are of little value isolated from farmers' perceptions and preferences.

In short, far from simply thinking about the economic incentives needed to support relatively more complex agroforestry systems over the short term, this study highlights the need to think about structural factors that may help to support farmers over a relatively longer time frame. Financial support is certainly needed for farmers struggling to earn sufficient livelihoods from cacao farming. Yet this study also makes clear the significant role that institutional support can play in cacao-farming communities. This is apparent not only from the significant way in which SRFADP shaped management practices but also from the sentiment frequently expressed by farmers that they did not know how to cope with production losses and needed guidance on how to rehabilitate their land if they were to continue farming cacao. While ideally the GERNAS program operational between 2008–2012 would have provided this support, it is clear that in many cases farmers have both mistrusted the inputs and the limited technical advice that went with them. This finding is substantiated by other work done in the context of the AgFor project and in the context of smallholder tree-based systems (for example, Martini et al 2012, Roshetko et al 2008) and suggests the importance of holistic strategies to support smallholders.

Future research directions

Indonesia's cacao production landscapes are in transition. Public-private partnerships, which have increased globally from one in 1984 to 55 in 2012 (Bitzer et al 2012), seem essential to understanding these transitions. To gain initial understanding of how these partnerships aim to reconfigure cacao production in Indonesia, interviews have been conducted with officials associated with Mars Symbioscience Indonesia, Indonesia Coffee and Cacao Research Institute, Universitas Hasanuddin, World Cocoa Foundation, Cacao Sustainability Partnership and the University of Reading, UK. Findings thus far suggest that Indonesia has come to be considered an important testing ground for new cacao production technologies, including new breeding and propagation techniques. Much of this work goes under the banner of corporate-led sustainability, though some of it, including GERNAS, appears more in the form of state-led agricultural extension.

Proposed dissertation research will trace how and why such partnerships have emerged and what are the implications for cacao producers and production landscapes in Indonesia. A case study approach is proposed to compare and contrast different approaches to boosting cacao production, including GERNAS. Field research is planned from June 2014 through June 2015, based in Southeast or South Sulawesi.

Appendix

Appendix 1: Land-change data acquisition, resolution and projections

Data	Source	Scale/ Resolution	Native Projection	Analysis Projection
Path: 112, Row: 63 (1990, 2001)	Global Land Cover Facility	30m	D_WGS_1984	D_WGS_1984
Path: 113, Row: 62 (1990, 2001)	Global Land Cover Facility & USGS Earth Explorer	30m	D_WGS_1984	D_WGS_1984
Path: 113, Row: 63 (1991, 2001)	Global Land Cover Facility & USGS Earth Explorer	30m	D_WGS_1984	D_WGS_1984
Forest Clearance (2004-2012)	Dan Hammer, PhD Student in Resource Economics	500m (based on MODIS data)	D_WGS_1984	D_WGS_1984
Administrative Boundaries	http://www.gadm.org/country		D_WGS_1984	D_WGS_1984

Note: Individual LANDSAT images were first prepared in ArcView by compositing individual spectral bands 1–5 and 7. Images were subsequently classified in Erdas Imagine 2011. After performing an unsupervised classification (20 classes and 12 iterations), 20 classes were re-coded into 5 classes (forest, agriculture, cleared land, water, and cloud cover). Using a 5,4,1 multispectral band combination, and toggling between satellite and classified images, classes were defined as follows: forest as areas of darkest red; agriculture as areas of lighter red; cleared land as areas of bare earth; water as ocean or lake; and cloud cover as areas for which heavy cloud cover rendered land cover classification impossible. All classified images were then smoothed using a smoothing neighbourhood of 7x7 pixels. After classification, the three relevant LANDSAT images for each time period were merged and clipped to create a land cover map for all of mainland Sulawesi Tenggara for the time periods 1990 and 2001. A series of raster calculations was performed to extract any areas masked by cloud cover in either 1990 or 2001. These calculations first determined all land for which there was data in both the 1990 and 2001 time periods; merged these two rasters and selected from this merged raster only those sites for which data was available in both 1990 and 2001. I then multiplied a binary raster (1 = data available, 0 = no data available) by the original rasters depicting land cover in 1990 and 2001. Rasters were then converted to shapefiles and landscape pattern analysis was performed using the Patch Analyst extension in ArcView.

Appendix 2: Primary crops cultivated in villages

Common name	Scientific name
Cacao	*Theobroma cacao*
Pepper	*Piper nigrum*
Sago	*Metroxylon sagu*
Peanuts	*Arachis hypogaea*
Spinach	*Spinacia oleracea*
Eggplant	*Solanum melongena*
Cassava	*Manihot esculenta*
Teak	*Tectona grandis*
White Teak	*Gmelina arborea*
Patchouli (nilam)	*Pogostemon cablin*
Lemongrass	*Cymbopogon sp.*
Banana	*Musa sp.*
Coconut	*Cocos nucifera*
Coffee	*Coffeaarabica, Coffea robusta*
Mango	*Mangifera indica*
Langsat	*Lansium domesticum*
Rambutan	*Nephelium lappaceum*
Papaya	*Carica papaya*
Durian	*Durio zibethinus*
Cashew	*Anacardium occidentale*
Candlenut	*Aleurites moluccana*
Betel nut (Areca nut)	*Areca catechu*
Kapok	*Ceiba pentandra*
Oil palm	*Elaeis guineensis*
Gamal	*Gliricidia sepium*
Sugar palm	*Arenga pinnata*
Nangka	*Artocarpus heterophyllus*

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