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Uncertainties in the Bidirectional Biodiesel Supply Chain:
An Empirical Model Developed in Central-Kalimantan, Indonesia

Master's Thesis Supply Chain Management
University of Groningen, Faculty of Economics and Business

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Abstract

This study aims to identify the impacts of Raw Material Supply-, Transportation & Logistics-, and Production & Operations Uncertainty on the operational performance of Bidirectional Biodiesel Supply Chains (BBSC) under differing regional conditions, a topic largely overlooked by current academic literature. Contrary to unidirectional value chains, BBSC are characterized by their small-scale nature, and a core characteristic of these chains is the duality between input suppliers and output consumers. Applying a multiple case study approach, this study identifies several sources of BBSC uncertainty which have not been considered by previous scholars. Short-term time perspective and a lack of knowledge have been found to be core sources of Supply- and Production Uncertainty. Moreover, BBSC performance is closely interlinked with both fossil fuel supply chains and the marginal value of a labor hour for different occupations. For scholars, this study provides a first, directed insight into the impact of uncertainties a biodiesel supply chain under bidirectionality. For supply chain managers, the constructed empirical model gives guidance in the development of uncertainty minimizing strategies. Finally, the results urge policy makers to address those regional conditions which are most detrimental to local business performance.

Keywords: Bidirectional Supply Chain, Buyer-Supplier Duality, Biodiesel, Mobile Biodiesel Production, Regional Conditions, Uncertainty

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Pieter M. P. Bot
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Glossary of Acronyms

ABF	Agriculture Beyond Food
BAPPEDA	Provincial Development Planning Agency
BBSC	Bidirectional Biodiesel Supply Chain
CIMTROP	Center for International Cooperation in Sustainable Management of Tropical Peatland
EMRP	Ex-Mega Rice Project
ITB	Institut Teknologi Bandung
MBD	Mobile Bio-Diesel
NGO	Non-Governmental Organization
PM2L	Program of Development and Maintenance of the Village
Rp.	Indonesian Rupiah

Introduction

Research on production techniques and the organization of biodiesel supply chains has gained substantial momentum in the last decade (Iakovou et al., 2010). Of particular importance in this relatively new field is the identification of the operational uncertainties affecting these supply chains (Awudu & Zhang, 2011). As emphasized in the seminal work of Thompson (1967), the presence of uncertainties constrains rational decision-making and therefore directly influences the performance of the supply chain[1]. Persson et al. (2009) moreover, argue that this matter is particularly relevant for biofuel production as cellulosic fuels (biofuels) are more extensively exposed to weather conditions than fossil fuels. Consequently, the study of the impact of uncertainties on the operational performance of the biodiesel supply chain is highly relevant.

Indeed, several scholars conducted research in this regard and have acknowledged the influence of uncertainties on biodiesel value chain performance (Dautzenberg & Hanf, 2008; Cruz Jr. et al., 2009). However these studies, as well as the majority of the academic research on biodiesel supply chains, focus primarily on the production of bio-diesel on a large- or medium-scale basis (Ramadhas et al., 2005; Apostolakou et al., 2009; Skarlis et al., 2011). By doing so, it is often assumed that farmers are dedicated to growing biodiesel crops and transport their harvest to centralized processing units (Uslu et al., 2008). Himmel et al. (2007) even go as far as to argue that the general path forward involves the consolidation of biodiesel processing. Notably, recent studies have also highlighted the benefits of the cultivation of biofuel crops for smallholder farmers (Woods, 2006). Nevertheless, the underlying argument generally still focuses on the collective delivery of these crops to a centralized unit for industrial scale processing and sale of the final output on national or international markets (Arndt et al., 2008). Not all biodiesel supply chains operate in this manner however, and in fact, decentralized biodiesel production is argued to be beneficial for the development of rural areas (Ewing & Msangi, 2009).

Through the establishment of a circular, bidirectional process, a localized supply chain could reduce the region's dependence on imported fossil fuels and provide access to a more continuous flow of energy at a known cost (Francis et al., 2005). Specifically, the defining characteristic of 'bidirectionality' is the duality between input suppliers and output consumers. This infers that the initial suppliers of the biomass, the local farmers, are also the target 'customers' of the biodiesel output (Sampson, 2000).

The local nature of these supply chains, combined with the duality of the buyer-supplier, provides them with a unique structure which is considerably different than those of the more widely studied centralized supply chains. Several scholars have therefore specifically discussed the implementation of dual buyer-supplier systems in the biodiesel industry (Westby, 2002; Crooks & Dunn, 2006; Bijman et al., 2010). However, although it should be noted that Bijman et al. (2010) partially addresses the

[1] The supply chain consists of all organizations and actors involved in the transformation of raw materials into the final end product for the ultimate customer (Zailani & Rajagopal, 2005). Supply Chain *Management* thereby "extends the view of operations from a single business unit or a company to the whole supply chain" (Heikkilä, 2002, p. 749). Performance should therefore not be measured per organization in isolation but as the combined performance of the various actors making up the supply chain. Therefore, rather than speaking about the performance of supply chain actors, scholars in this field commonly speak about 'supply chain performance'. This terminology is also applied in the remainder of this paper.

issue of demand uncertainty, none of these studies systematically addresses the impact of uncertainties on the performance of the decentralized, Bidirectional Biodiesel Supply Chain (BBSC).

Interestingly, using fairly abstract terms, Verkruijsse (2013) already hints towards the importance of managing uncertainties in bidirectional supply chains. Using generic terms as 'government support' and 'technical feasibility' (p. 50), this author implicitly incorporates the impact of uncertainties in the Stimson (2009) Local Economic Development model, calling them 'Indicators of Success' (p.50). As such, the author clearly recognizes the importance of uncertainties on the performance of the BBSC. Nevertheless, he does not explicitly analyze the sources and impact of the different uncertainties nor does he address the influence of differing regional conditions on supply chain's operational performance. Overall, it can therefore be concluded academic knowledge on the uncertainties impacting this type of supply chains is still rather limited (Poku, 2002).

This study extends the academic literature on the influence of uncertainties on supply chain performance by investigating how the different supply chain uncertainties affect a BBSC. As described, this topic has yet received little attention in academic literature despite the proclaimed importance of localized production for regional development (Poku, 2002; Ewing & Msangi, 2009). The research question this study answers therefore is:

How do supply chain uncertainties impact the implementation and operational performance of a biodiesel supply chain characterized by supplier-buyer duality and how do regional conditions influence this impact?

Besides the relevance for academics emphasized previously, the insights provided by this research could prove highly relevant for practitioners as well. By offering an insight into the impact of different uncertainties on BBSC, operations and supply chain managers in the biodiesel industry could make a more adequate assessment of the (potential) performance of their business. Moreover, this study provides an understanding of the influence of regional conditions on the impact of uncertainties. This knowledge can be applied by managers involved in the operation of Bidirectional Biodiesel Supply Chains to make deliberate decisions on where to implement such a supply chain. Furthermore, it allows them to be better prepared for the potential effects of regional conditions on their supply chain's performance and stimulates the construction of strategies regarding the control of these variable elements in the chain's operations. Finally, the insights of this paper could be applied by governmental policy makers to design policies more directly targeted towards eliminating the key sources of BBSC uncertainty.

The remainder of this thesis is structured as follows. In section 2 the theoretical background of this study will be outlined and a conceptual framework which highlights the main generic uncertainties surrounding biodiesel supply chains is introduced. Next, chapter 3 discusses the methodology used to study this framework in the context of a bidirectional supply chain. This chapter also elaborates on the cases used in this thesis, which are selected from the Mobile Bio-diesel Project in Central-Kalimantan, Indonesia. In section 4 the data gathered during the case study is presented, followed by a discussion of the results in chapter 5. Finally, several recommendations are made related to the Mobile Bio-Diesel Project studied in section 6, and the conclusions of this study as well as directions for future research are summarized in the section 7.

Theoretical Background

This section outlines the theoretical background of the study by discussing the current academic literature on the topic. First, the biodiesel supply chain is explored and the concept of buyer-supplier duality is elaborated upon in order to provide a better insight into the specific characteristics of this particular localized, supply chain model. Thereafter, the different types of supply chain uncertainty are explored further in the light of a bidirectional supply chain. Finally, a theoretical framework is constructed which summarizes the theoretically proposed effects of these factors on the operational performance of this supply chain model.

2.1 Various biodiesel supply chain types

2.1.1 Traditional Supply Chains

"Traditional" biodiesel supply chains, aimed at the production of biodiesel for national or even international markets (Ericsson & Nilsson, 2004), are generally structured in a manner as depicted in Figure 1. Two alternative forms of supply chain organization can be identified.

Firstly, in a hybrid structure, biomass is initially pre-processed, or pre-treated (Cundiff et al., 2009), before transportation to the biodiesel refinery (Klose & Drexl, 2005; Carolan et al., 2007). Untreated, raw biomass contains a low energy density, and is in general perishable in nature (Sokhansanj & Turhollow, 2004; Carolan et al., 2007; Blackburn & Scudder, 2009). Pre-treatment is therefore performed in order to increase the transportability of the crop and to reduce its perishability (Eranki et al., 2011).

Alternatively, both the pre-processing as well as the refining stage of the supply chain take place in one central location (Johnson & Leenders, 2006; Carolan et al., 2007). In figure 1, this is visualized by the dotted box. Due to the economies of scale that can be achieved, this centralized processing is the primary type of biodiesel production used in Europe and North America (Majer et al., 2009).

Indicative about both hybrid and centralized biodiesel supply chains are the distribution of the end product to service stations (e.g. gas stations) where they can be purchased by customers (Iakovou et al., 2010). These customers could, but not necessarily have to, be the same as the initial suppliers of the biomass used to produce this biodiesel.

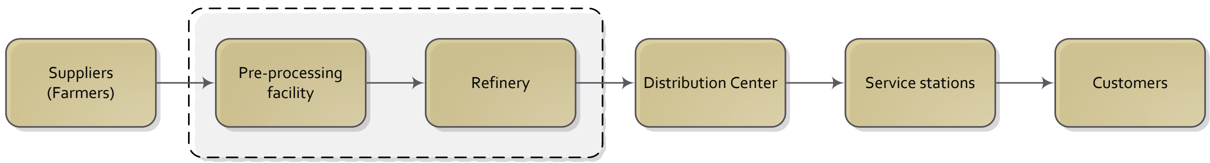

Figure 1: Traditional biodiesel supply chain (Adapted from Iakovou et al., 2010)

2.1.2 Buyer-Supplier Duality

Whereas the abovementioned forms of biodiesel processing are unidirectional in nature, localized supply chains posit bidirectionality as a result of customer-supplier duality (Sampson, 2000). This duality implies that "*customers are suppliers of significant inputs to the service production* *process*" (Sampson, 2000, p. 351). In other words, bidirectionality refers to the circular shape of the supply chain, where the suppliers of core inputs in the production process are also the designated consumers of the process' output. As a consequence, customers in bidirectional supply chains play a direct role in the quality of the final end product delivered (Fitzsimmons & Fitzsimmons, 2011). Figure 2 illustrates the concept of buyer-supplier duality.

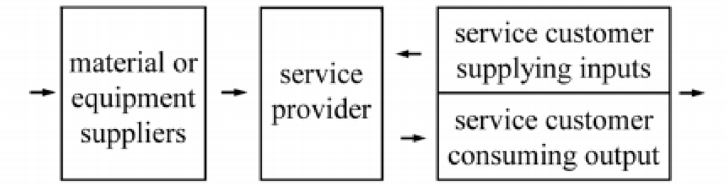

Figure 2: Customer-Supplier Duality (Sampson, 2000)

Due to their small-scale nature and promulgated benefits for local economic development (Fredriks et al., 2013), Bidirectional Biodiesel Supply Chains can primarily be found in remote rural areas. In fact, the capacity of each processing unit is generally designed to be able to cope with the specific biodiesel needs for a small region (Skarlis et al., 2012). Moreover, inputs are locally harvested crops, which are delivered to the unit by the local farmers. Supplier-buyer duality occurs in these supply chains when the proceeding biodiesel is redistributed to the suppliers (Dufey et al., 2007; Fredriks et al., 2013).

Contrary to unidirectional medium- and large-scale biodiesel production, a small-scale BBSC typically consists of only three stages: delivery of biomass input by the farmer, processing at the decentralized facility, and transfer of the output back to the supplier (Oliveira et al., 2009). While Sampson (2000) describes the rarity of bidirectional supply chains extending beyond these three stages, decentralized biodiesel chains do, on more than one occasion, consist of one additional stage. Specifically, farmer cooperatives are often established to manage the relationship between a large number of local farmers and the processing unit (Mangoyana & Smith, 2011). These fuel-sharing cooperatives collect the crops from a set of farmers, deliver them to the processing unit, collect the produced biofuel and undertake the redistribution of this output to their members (Svejkovsky, 2007). In doing so, a two-level bidirectional supply chain is established in which the buyer-supplier only interacts with the initial service provider, which is the cooperative, without having direct interaction with the ultimate service provider, in this case the biodiesel production unit (Sampson, 2000).

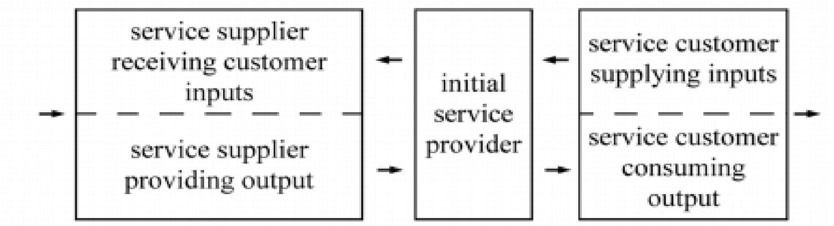

Figure 3: Two-level bidirectional supply chain (Sampson, 2000)

Finally, bidirectional supply chains can be further broken down into two groups: 1) those applying a stationary, and 2) those applying a mobile processing unit. This study will, for several reasons, particularly focus on bidirectional supply chains using a mobile processing unit. First of all, mobile processing is argued to have great potential for future small-scale biodiesel production, and research on the development and feasibility of this form of processing is being conducted in multiple countries among which Brazil (Oliveira et al., 2009), the United States (Keady, 2007; Morris et al., 2010), and Canada (Bhachu et al., 2005). Secondly, different from other production modes, this method reverses the traditional supply chain process. Instead of transporting the agricultural crops to the production facility, the processing unit itself is being moved to the location of the input (Oliveira et al., 2009). This mobile and inherently small scale nature of these supply chains results in extensive exposure to operational uncertainties. For these reasons, studying cases of mobile biodiesel production provides an interesting and valuable insight into the effect of uncertainties on the BBSC.

To summarize, decentralized biodiesel supply chains commonly contain bidirectional goods flows and are generally highly compressed in nature, characteristics which are particularly visible when the biodiesel production process is performed through a mobile unit.

It has to be acknowledged however, that decentralization, and the application of a mobile processing unit for that matter, does not immediately imply customer-supplier duality. As a matter of fact, several examples exist in which decentralized production is conducted on a commercial rather than bidirectional basis (e.g. Richard, 2010; Bruins & Sanders, 2012). In addition, next to non-commercial fuel-sharing cooperatives, Svejkovsky (2007) describes several profit-oriented cooperatives in which the produced biodiesel is sold on the market rather than redistributed to the farmers (e.g. Tilman et al., 2009; Awudu & Zhang, 2011). Contrary to the biodiesel supply chains studied here, these supply chains do in fact, function in a unidirectional manner and do not comprise supplier-buyer duality.

2.2 Uncertainties in biodiesel production

As mentioned previously, uncertainties have a potentially paralyzing effect on the performance of individual supply chain actors and the supply chain as a whole (Thompson, 1967) by bringing about the need to maintain expensive security measures such as safety stocks (Davis, 1993). Persson (1995) generalizes this remark by stating that the higher the degree of uncertainty in a process, the higher the level of waste incurred. As a result, the adequate management of uncertainties can lead to substantial supply chain performance improvement (Van Der Vorst et al., 1998).

A comprehensive definition of supply chain uncertainty is given by Van der Vorst and Beulens (2002):

"Supply chain uncertainty refers to decision making situations in the supply chain in which the decision maker does not know definitely what to decide as he is indistinct about the objectives; lacks information about its environment or the supply chain; lacks information processing capacity; is unable to accurately predict the impact of possible control actions on supply chain behaviour; or, lacks effective control actions" (Van Der Vorst & Beulens, 2002, p. 413).

This definition highlights several important aspects of supply chain uncertainties. First of all, unexpected events could occur during various moments in the supply chain process. However, these events become performance influencing supply chain uncertainties only at the time at which they affect the decision-making process of the supply chain actors (Brindley, 2004)[2].

Secondly, two important sources of uncertainty can be derived from the abovementioned definition: the lack of information of a certain supply chain actor about the activities performed in other stages of the supply chain, and his influence on these activities (Wilding, 1998). Building on this, Awudu and Zhang (2011) noted that with regard to unidirectional biodiesel supply chains, five generic sources of uncertainty are to be distinguished: (1) raw material supply, (2) transportation and logistics, (3) production and operation, (4) demand and price, and (5) governmental uncertainties (p. 1363). Taking the processing unit as the focal process, it can be observed that four of the uncertainties are caused by a lack of knowledge on actions taken by other supply chain actors (uncertainty 1, 2, 4, 5) whilst one is the result of unpredictability of the incumbent's own activities (uncertainty 3). Below, first the underlying elements of these uncertainties are outlined as described in academic literature. Subsequently, potential implications for the impact on Bidirectional Biodiesel Supply Chains are discussed.

Biomass Supply Uncertainty

Uncertainty in supply is the result of the variability of three factors: yield, quality and type (Awudu & Zhang, 2011). Unpredictability in weather conditions throughout the growing season, availability of water for irrigation, and the usage of pest management are all factors which could influence the yield and quality of the biomass delivered (Everingham et al., 2002; Zhang & Wilhelm, 2011). As a result, the raw material actually delivered to the processing unit can be smaller in quantity or worse in quality than expected at the start of the process planning horizon (Bassok & Akella, 1991). The challenge this posits for efficient production planning proves a common difficulty among agricultural supply chains (Ellram et al., 2006; Zhang & Wilhelm, 2011). To reduce the impact of this uncertainty, centralized input processing is often deemed suitable. Therefore, unidirectional biodiesel supply chains generally receive biomass inputs from a large number of suppliers which are spread out over a large region (Harvey, 2004). Due to this multiple-sourcing construction, these chains are less susceptible to fluctuations in yield and quality of a single farmer or region (Treleven et al., 1988).

Finally, in certain biodiesel supply chains, a third supply uncertainty exists, namely uncertainty in supply type (Elms & El-Halwagi, 2009). This uncertainty primarily arises in supply chains in which the processing unit is capable of processing multiple different biomass crops. In these situations, which feedstock is processed depends on the availability of each type at a given moment in time. However, as different processing configurations and input ratios are required for different biomass types, a lack of knowledge about quantity and availability of the various biomass types yields uncertainty in machine set up times and additional input quantity requirements (Elms & El-Halwagi, 2009). However, following the majority of biodiesel research (Iakovou et al., 2010; Mangoyana & Smith, 2011) I will treat this as a relatively specific situation and therefore leave it out of this analysis.

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[2] Applying an illustration of Davis (1993), while demand for many products is unknown, this creates a supply chain uncertainty upon the moment at which it necessitates a supply chain manager to hedge against this lack of information by maintaining safety stocks of raw materials and/or finished goods.

Transportation and Logistics Uncertainty

A second uncertainty which is particularly important in biomass processing is that of transportation. As argued by Dautzenberg & Hanf (2008), the costs of transporting biomass are the main factor driving biofuel cost. Therefore this uncertainty, which can be defined as the unplanned and unexpected "*inability to deliver both biomass raw materials and finished products in a timely and cost effective manner*" (Awudu & Zhang, 2011, p. 1363) is of particular importance to the performance of the chain.

Adequate transportation in biodiesel supply chains is complicated because of multiple factors. First of all, the low energy density of the biomass makes transportation a difficult and costly process (Sokhansanj & Turhollow, 2004; Woods, 2006; Eranki & Dale, 2011). Secondly, biomass is highly perishable, which limits its transportability (Blackburn & Scudder, 2009). In relation to the topic of raw material supply uncertainty, a long transportation lead time of unprocessed biomass causes degradation of its quality (Stank & Crum, 1997). Therefore, uncertainty in the transportation of raw materials has a multiplying effect on supply uncertainty as unexpected changes in transport time result in a lower than anticipated quality of the biomass delivered. Finally, regional conditions have an impact on this supply chain source due to the differing quality of infrastructure in various areas. Specifically, Fredriks et al. (2013) showed that in remote, BBSC areas the infrastructural quality and density differences can be substantial.

Production and Operation Uncertainty

Production and Operation uncertainty arises when a firm is unable to meet its planned quantity of production due to unanticipated events (Awudu & Zhang, 2011). In a manufacturing setting this form of uncertainty has been often studied as a rescheduling problem (Abumaizar & Svetska, 1997; Aytug et al., 2005; Schmitt et al., 2010). Aytug et al. (2005) summarize the main causes for production uncertainty in a general setting and group them under machine failures, arrival of urgent jobs and quality problems requiring rework. The causes of this uncertainty thus lay in the internal processes of the production facility. Nevertheless, they might be caused by actions of other supply chain actors. Firstly, poor biomass quality delivered by the farmers can cause a machine breakdown, result in rework, or result in uncertainty in processing times (Ocoa et al., 2010). Secondly, Richard (2010) highlights the influence of road quality on breakdowns of a mobile biodiesel unit. Lastly, the operation of the production unit as well as the resolution of machine failures indicate that production uncertainty is also related to the level of education of the inhabitants of the supply chain region, and the actors in the supply chain in particular (Aikman & Pridmore, 2001).

Demand and Price Uncertainty

Demand for biodiesel is largely dependent on the price of the alternate option, fossil fuels, which is uncertain in the long-term (Azam et al., 2005). Additionally, price uncertainty addresses the fact that the price of biomass and other inputs might change (Awudu & Zhang, 2011). Awudu and Zhang (2011) argue that both of these uncertainties need to be incorporated in supply chain management to be able to make deliberate estimations of future profits.

However, there is substantial difference in the degree of these uncertainties among different biodiesel production methods, particularly with regard to uncertainty about the price of biomass inputs. Biodiesel production from edible crops such as corn is highly exposed to unexpected price fluctuations. The price of these inputs varies both with the demand for biodiesel as with the demand for their alternative usage, for instance as nutrient for people or livestock (Gui et al., 2008).

Alternatively, biomass in the form of agricultural waste, such as left-over rubber seeds from a rubber farm, has no value outside the biodiesel production process (Iakovou et al., 2010) and therefore incurs less biomass price uncertainty.

Governmental Uncertainties

The final source of supply chain uncertainty consists of environmental uncertainties arising through unexpected governmental actions with regard to taxes (Rozakis & Sourie, 2005), sustainability (Hammond et al., 2008), and other regulations and policies (Yeh et al., 2008). Little is in fact known about governmental uncertainties in Bidirectional Biodiesel Supply Chains. However, Lima (2010) shows that although several governments have instituted policies in favor of BBSC, the beneficial effect of these programs varies. In fact, this scholar shows that some stimulation policies are outright detrimental to the financial well-being of participating smallholder farmers.

2.3 Proposed consequences for the bidirectional supply chain

From the previous discussion of bidirectional supply chains and supply chain uncertainties, it can be seen that a great deal of uncertainty affecting the operational performance of the biodiesel supply chain is incorporated in the actions of the various actors in the supply chain themselves. The focus of this thesis will therefore primarily lie on the assessment of the impact of these 'Operational Uncertainties' – raw material supply, transportation & logistics, and production uncertainty – on the performance of the BBSC.

Raw material supply uncertainty

While both centralized and decentralized biodiesel supply chains are subject to yield and quality uncertainty, the effect of supply uncertainty is proposed to be exaggerated under decentralized bidirectional production. Contrary to unidirectional supply chains, bidirectional supply chains rely on the input of a relatively small number of farmers, which increases the dependence on the output of each farmer and enhances the variability in supply (Iakovou et al., 2010).

Furthermore, supplier-buyer duality itself could potentially increase supply variability as the delivered input does not only depend on the availability of biomass but also on the biodiesel demand of the farmer (customer). As biodiesel processing in a bidirectional supply chain is in the first place performed to fulfill the need of the buyer-supplier, a low need for biodiesel could potentially reduce the quantity of biomass delivered. In other words, it is proposed that the duality between suppliers and buyers could cause raw material supply uncertainty due to the interrelation between the direct consumer demand and input supply.

Transportation & Logistics Uncertainty

Academic literature describes BBSC as being common in remote rural areas. Moreover, scholars have described the infrastructural quality as an important determinant of transportation uncertainty. As infrastructural connections are often relatively limited in remote areas (Dufey et al., 2007; Fredriks et al., 2013), this source of uncertainty is expected to be extensively present in BBSC. However, in contrast to unidirectional supply chains, transportation uncertainty in bidirectional supply chains is not in the first place proposed to be caused by the transport of biomass to the processing unit. Due to its decentralized nature, this transportation distance is relatively limited. Instead, the primary logistical uncertainty lays most likely in the delivery of additional processing inputs other than the biomass itself from more distant, industrial areas to the facility (Prater et al., 2001).

Finally, the application of a mobile processing unit could yield unexpected transportation costs or delays. Moreover, a delay of the processing unit itself directly postpones biodiesel production for the duration of the delay and thereby severely damages its entire chain. To summarized, it is proposed that the limited quality of the infrastructural network, the delivery of 'additional inputs' and the movement of the processing units itself are sources of transportation uncertainty in the Bidirectional Biodiesel Supply Chain.

Production & Operations uncertainty

One core source of production uncertainty in biodiesel supply chains is machine breakdowns. While these can be caused through internal machine failures, it is proposed that with regard to BBSC, several external factors have an important influence on this uncertainty as well. First of all, the usage of a mobile biodiesel unit puts pressure on the often limited infrastructure of the environment. Thus, the transportation of the unit over underdeveloped, poorly maintained roads might increase the number of machine breakdowns (Richard, 2010).

Secondly, as machine breakdowns bring all production activities to a halt, it is crucial to solve these disruptions as fast as possible to minimize their impact. However, in remote areas, such as those common to bidirectional production, the inhabitants often lack extensive schooling (Aikman & Pridmore, 2001) which is proposed to increase uncertainty about downtimes. Moreover, a lack of schooling might, in fact, also cause breakdowns through its effect of the quality of inputs delivered by suppliers. It is thus proposed to see higher production uncertainty when a region is more remote as both the quality of infrastructure as education is expected to decline.

Demand & Price Uncertainty

Bidirectional biodiesel production from waste products is proposed to incur only limited price uncertainty of biomass inputs as they do not currently posit value for other purposes. Moreover, BBSC eliminates the uncertainty of a customer with regard to fuel prices. This is because local farmers deliver biomass inputs to the mobile processing unit to be processed against a fixed fee (Fredriks, 2012) to fulfill their own consumption demand. Thereby, they are no longer subject to the market prices charged by commercial fuel companies and are expected not to play an important role in creating demand and price uncertainty. The prime price uncertainties retained are proposed to be inhibited in the share of 'excess' biodiesel farmers decide to sell on the open market, and in the price of additional uncertainties which are currently produced in industrial areas on a commercial basis.

Governmental uncertainties

Little is yet known with regard to governmental uncertainties in BBSC. However, similar to unidirectional biodiesel supply chains it can be proposed that unexpected changes in policies, taxes and legislation form sources of Governmental uncertainty which could be either beneficial or detrimental to the performance of the Bidirectional Biodiesel Supply Chain.

2.4 Conceptual Model

Figure 4 below visualizes the conceptual model derived from the literature study elaborated upon in this chapter. The inner square of the model illustrates the effects of the various uncertainties on the operational performance of the supply chain. In the outer square furthermore, multiple sources of the uncertainties are represented, as proposed in the paragraphs above. The grey area represents the fact that these sources are proposed to be influenced by regional conditions. As argued, this thesis will focus primarily on the operational uncertainties of the supply chain itself. For this reason, the conceptual model primarily focuses on how, and through what sources, the operational uncertainties influence supply chain performance (figure 4).

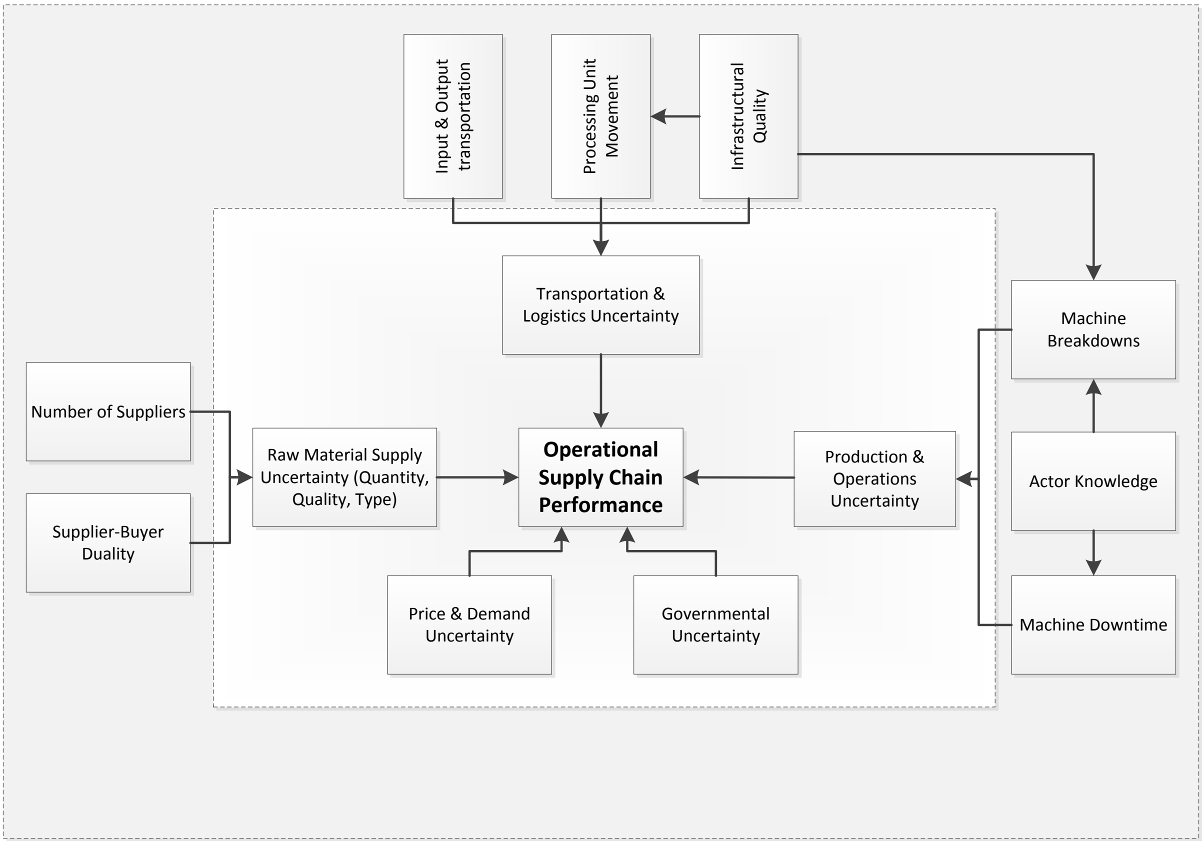

Figure 4: Conceptual model

Finally, in this research Supply Chain Performance is defined as the degree to which a Mobil Biodiesel Supply Chain is able to meet its expected biodiesel output quantity and quality within a given time period. In essence, performance is hereby measured through an assessment of the supply chain productivity (De Toni & Tonchia, 2001), a non-monetary performance measure. While performance is often measured in monetary terms (Melnyk et al., 2004), Maskell (1991) suggests that the measurement of day-to-day operational performance is better measured in non-monetary terms while monetary performance measures are primarily suitable for external reporting. Since uncertainties affect the day-to-day activities of the supply chain, it is therefore more applicable to assess their effect on Supply Chain Performance in non-monetary, output terms. Moreover, a survey among a wide range of British managers showed that in general, non-monetary performance measures are highly regarded to assess the performance of supply chain partners (Gunasekaran et al., 2004).

In the following section, the methodology which is used to test the conceptual model constructed in this chapter will be outlined.

Research Methodology

This study is aimed towards how various types of uncertainties affect the performance of the Bidirectional Biodiesel Supply Chain (BBSC) and how regional conditions play a role in this. Although Awudu and Zhang (2011) describe various sources of biodiesel supply chain uncertainties, Poku (2002) and Verkruijsse (2013) show that it is still unknown how these affect performance of a BBSC. Therefore, this study will use an inductive approach in order to build theory on this subject (Karlsson, 2008).

The research method applied in this study is a multiple case study approach, which has been shown to be particularly suitable for theory building (Yin, 1994; Handfield & Melnyk, 1998) through the provision of a rich source of data. Moreover, as case studies have been argued to be particularly well suited for the identifications of linkages between variables (Voss et al., 2002) which makes it a valuable instrument for identifying the impact of the different supply chain uncertainties on the chain's operational performance and the effect of differing regional conditions on this. Finally, as multiple cases allow for a cross-case comparison and a verification of the propositions by multiple interviewees this approach provides the robustness necessary to develop a sound theory (Eisenhardt & Graebner, 2007).

To summarize, this study will employ a case study approach with multiple cases. This method will both enhance the reliability of the data, allows for a between-case comparison of the results and establishes a basis for generalizability of the results (Voss et al., 2002; Eisenhardt & Graebner, 2007).

3.1. Unit of Analysis

Karlsson (2008) describes the unit of analysis as the "level of data aggregation during the subsequent analysis" (p. 106). Uncertainties occur in different stages of the supply chain and become apparent through the interactions among different supply chain actors, as described in the previous section. The unit of analysis of this study is therefore, the supply chain as a whole.

To illustrate the line of reasoning underlying the choice, figure 5 represents a process diagram indicating the points at which the different uncertainties occur in the bidirectional supply chain. In this figure, the green inner circle represents the operational environment of the bidirectional supply chain. The operational performance of the supply chain is directly influenced by uncertainty in raw material supply, transportation and logistics, and production and operations. This study focuses primarily on the effect of these three uncertainties on supply chain performance. Additionally however, the entire supply chain is influenced by two external factors, namely uncertainty in demand and price, and governmental uncertainties.

As this figure emphasizes, a unit of analysis smaller than the supply chain as a whole would yield an incomplete image of the uncertainties impacting its performance.

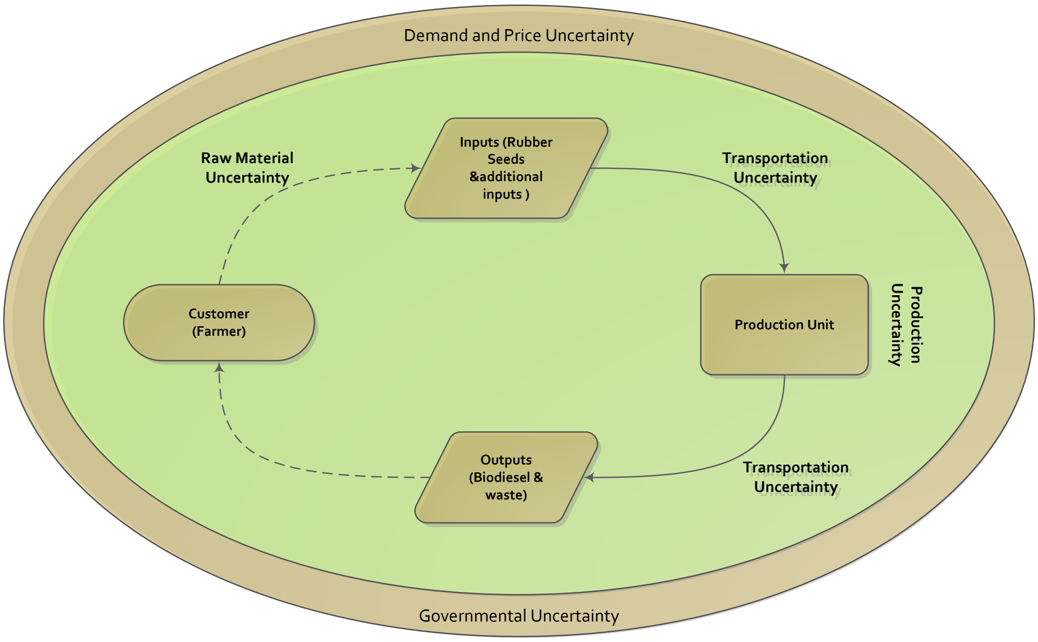

Figure 5: Process diagram bidirectional supply chain with uncertainty. Solid lines indicate movement of goods; dashed lines indicate within-actor information streams.

3.2. Case Selection

A project focusing on the development and implementation of a mobile biodiesel supply chain is the Mobile-Biodiesel Project (MBD). This project involves collaboration between six universities (three in the Netherlands and three in Indonesia) and is funded by the Netherlands Organization for Scientific Research (NWO). The goal of the MBD is to contribute to the sustainable development and reduction of poverty in the remote rural area of Central-Kalimantan, Indonesia, while simultaneously stimulating the transition of Indonesia into a bio-based economy with a lower dependence on fossil fuels (Agriculture Beyond Food, 2008). A major advantage of the MBD project for this study is the large size of the area it comprises (see Appendix A), as it offers the opportunity to select multiple distinctly different cases.

The following criteria are used to make a selection among these 'supply chain regions' and discern those presenting the most visible contrast, as to achieve insightful theoretical replication (Karlsson, 2008). To be clear, the aim is not to select cases consisting of individual communities, instead the focus is on deriving theoretical replication among groups of villages which could potentially comprise a bidirectional supply chain. Thus, the cases in this study are composed of multiple villages.

Baars (2010) describes the functioning of the PM2L program, which provides an overview of the development of a village based on a set of 15 criteria (see Appendix B). While not every aspect of this model provides a relevant indicator for the degree of uncertainty in the biodiesel supply chain, several criteria are used in this study to research the accuracy of the propositions in the previous section and derive an answer to the main question of this research.

- **Quality of the existing infrastructure:** In areas with a better infrastructure it is proposed that transportation times can be better estimated and the potential for breakdowns is smaller. This criterion therefore relates to the propositions made for transportation, and production uncertainty.

- **Educational Facilities:** A higher education is expected to affect the knowledge and capabilities of the supply chain actors, and thereby influences the raw material supply and production uncertainty as described in the previous chapter.
- **Region Population Density:** Supply chain regions with a higher population density have been argued to be more likely to have a developed local market (Fredriks, 2012) and have a larger supplier base. Thereby, they are expected to have a lower supply uncertainty as posited in the Theoretical Background. This criterion will be measured by the population of the villages in a region.

Finally, based on preliminary research in the Netherlands and Indonesia, one additional socio-economic criterion has been added:

- **Primary Occupation:** Farmers in different areas of Central-Kalimantan posit different sources of primary income as stated by MBD consultant Mr. De Leeuw (Interview De Leeuw, 2013). Prof. Simatupang of Institut Teknologi Bandung (Interview Simatupang, 2013) added to this that differences in primary occupation might influence people's opinion about, as well as incentives to participate in a Bidirectional Biodiesel Supply Chain project. A subsequent directed literature study indeed found research supporting this view (Oke & Gopalakrishnan, 2009). Based on this pre-case research, this final selection criterion has been added.

Based on the abovementioned selection criteria, two regions are selected which form the cases of this study. One is a relatively 'developed' area which scores highly on the first three criteria. Moreover, the primary occupation in this region is rubber farming. The second case comprises a 'less developed' region which scores worse on the first three selection criteria. Furthermore, its inhabitants switch occupation between rubber farming and gold mining. Using these two contrasting cases, it is possible both to determine how the different uncertainties affect supply chain performance in each case as to relate different regional conditions to differing operational uncertainties.

3.3. Uncertainty Definition Operationalization & Measurement

In order to measure how the various uncertainties influence the supply chain, the following operational definitions are used:

Raw Material Supply Uncertainty is in this study measured through the ability of field research interviewees, rubber farmers in particular, to provide coherent information about rubber seed harvesting period and quantity. Moreover, uncertainty is measured by the farmer's previous experience with rubber seed gathering. Inability to provide positive responses to these points represents a lack of knowledge of the product caused by the fact that the biomass currently represents waste to the suppliers (Iakovou et al., 2010). Thereby, a lack of positive responses to this definition indicates supply uncertainty.

Transportation Uncertainty is measured by the availability of year-round accessible infrastructure to the region. The PM2L data (Bappeda, 2013) highlights the type and accessibility of the infrastructure as one of the 15 key development indicators whereas Richard (2010) emphasizes the value of multiple infrastructural modes in securing efficient, reliable biofuel transportation. Uncertainty can therefore be said to increase if less infrastructural modes are available and when the available infrastructure is not continuously accessible.

Production Uncertainty can be operationalized through the level of education received by the actors in the supply chain. Education is shown by Aikman and Pridmore (2001) to be an important factor leading to externally caused machine failures, either through improper machine usage or by affecting the quality of inputs delivered (Ocoa et al., 2010)

Demand & Price Uncertainty: Following Azam et al. (2005) and Awudu & Zhang (2011), this uncertainty can be operationalized as the variability in price of the inputs, and of diesel, the competing substitute product, on the local market.

Governmental Uncertainty is measured by the variation in current (bio-)fuel legislation and current local economic development programs in the case study regions. As BBSC are argued to be beneficial to Local Economic Development (Dufey et al., 2007), the continuity of these programs, together with variability in current fuel legislation & policies (Hammond et al., 2008; Yeh et al., 2008), can be used as a measurement for governmental uncertainty.

3.4. Data Collection

The information gathered during semi-structured interviews comprises the primary source of data for this study. While directing the topics covered during the interview, the open structure of this approach provides the opportunity for the exploration of unexpected sources of uncertainties and linkages between them (Sampson, 1986). Previous research has indicated that a data gathering method composed of multiple stages proves beneficial results with regard to the creation of in-depth knowledge on the Mobile Biodiesel Project and its supply chain. Therefore, a multi-stage research method is applied, which is adopted from the approach used by these previous researchers (Van Kammen, 2010; Baars, 2010; Fredriks, 2012).

Phase One: Takes place in the Netherlands, and aims to develop an understanding of the theoretical background and existing literature on uncertainties in biodiesel supply chains. Interviews with Professors and PhD students involved in the MBD are conducted to obtain insights in the technical aspects and functioning of the mobile processing unit, and to gain an understanding of the background of the MBD project. Both project participants of the University of Groningen and the University of Wageningen are interviewed. This stage forms the basis for the further in-depth analysis conducted in the following phases.

Phase 2: Conducted in Indonesia, and includes expert interviews to derive a further qualitative as well as quantitative understanding of the Central-Kalimantan region. Professors of the Institut Teknologi Bandung (ITB) and University of Palangkaraya are contacted to provide academic as well as practical insights into the difficulties surrounding the implementation of a mobile biodiesel unit. In-depth interviews with representatives of (non-)governmental organizations are furthermore, held to obtain both objective quantitative data on regional resource endowments and biodiesel production, and qualitative insight into the characteristics of the MBD project area. This determines the final case selection which also takes place in this stage.

Based on the insights of the research performed during the first two stages, a brochure was developed. This brochure, which presents an adaptation of the tested and verified booklet used by Fredriks (2012), is used during the third stage to communicate the core message of the MBD project and highlight the sources of potential uncertainty (see Appendix E). The aim of this standardized booklet is to limit personal bias and reduce information asymmetry between the researcher and the interviewee, which represent common case study issues according to Voss et al. (2002).

Phase 3: Takes place in Central-Kalimantan, Indonesia, and aims to obtain primary quantitative and qualitative data through field research in the selected case areas. This phase includes the analysis of the results in order to derive an answer to the study's research question.

To cross-check the information of each interviewee, and adhering to propositions of Eisenhard and Graebner (2007), multiple interviews will be conducted in each case to ensure the robustness and reliability of the outcomes. The primary interview subjects are individual small-scale rubber farmers who, as suppliers, are most knowledgeable about the specifics of biomass production. Moreover, as prime customers of the produced biodiesel these farmers set the demand for biodiesel. To cross-check the results of these subjects, interviews are conducted with latex middleman, who also have direct knowledge about transportation of goods through the region. Finally, village leaders are contacted to, among others, gain insights into governmental uncertainties.

Besides these interviews, an important element of this stage is the personal observation of the researcher with regard to, among others, the method of rubber seed production and the infrastructural network.

Table 1 below shows the function and organization of the interviewees contacted for this study, organized by research phase. To summarize, interviews have been held with academics, regional governmental and non-governmental organizations, as well as with local leaders, smallholder farmers, and businessmen.

Research Phase and location	Interviewee function	Organization (# of interviewees)
Phase 1: The Netherlands	PhD Student	University of Groningen (2) University of Wageningen (1)
	(Assistent) Professor	University of Groningen (2) University of Wageningen (1)
	International Relations Manager – MBD project participant	University of Groningen (1)
	MBD Project Consultant – Former Director NESO Indonesia	siSinga Consultancy (1)
Phase 2: Bandung	(Assistent) Professor	Institut Teknologi Bandung (3)
	MSc. Student	Institut Teknologi Bandung (1)
Phase 2: Palangkaraya	Professor	University of Palangkaraya (1)
	Non-Governmental Organization	REDD+ (2) CKPP (1) Heart Of Borneo Rainforest Foundation (1)
	Regional Governmental Organization	Bappeda (2)
	Other	Local Hardwood Processing Factory (2)
Phase 3: Field Research	Case 1 – Pilang, Henda, Buntoi	Village Government (2) Rubber Traders (5) Rubber Farmers (6)
	Case 2 – Bawan, Tambak, Hurung, Manen Kaleka	Village Government (5) Rubber Traders (3) Rubber Farmers (3)
Total Number of Interviews Conducted		**45**

Table 1: Number & Type of Interviewees by phase

3.5. Data reduction & Analysis

Data gathered from interviews is transcribed and coded in order to condense the information and discern patterns (Voss et al., 2002). Coding is done by assigning the interviewee responses to the uncertainty types derived from the theoretical framework and, where possible and applicable, creating subcategories. This provides an in-depth insight into the root causes of the uncertainties.

Data analysis is subsequently conducted through a two-step process, following the recommendations of Eisenhardt (1989). Firstly, within-case analysis is performed in order to identify unique patterns in the data within each case. This step involves linking the coded interview data to quantitative data gathered from secondary sources, such as government documents, to make an assessment of the impact of supply chain uncertainties within each case.

Secondly, cross-case data analysis is performed by making a careful and deliberate assessment of the similarities and differences between the impacts of uncertainties on supply chain performance observed within the cases. By doing so, the influence of regional conditions on this impact can be determined. Moreover, similar to the value of cross-checking interview results across multiple interviewees, cross-data analysis enhances the reliability and generalizability of the conclusions (Voss et al., 2002, p. 214).

Finally, the gathered within and cross-case results are checked against the proposed effects to determine the accuracy of the theoretical model and derive the conclusions of this study.

3.6. Research quality

"Without valid research, one cannot expect to develop a 'good' theory" (Karlsson, 2008, p.73).

First of all, based on the recommendations of Yin (1994) an interview protocol has been developed to guide the semi-structured interviews (see Appendix D). This protocol has been tested during interviews with smallholder farmers and institutions in a pilot study on Central-Java which was supervised by Prof. Dr. Simatupang and Dr. Manurung of the Bandung Institute of Technology (ITB). Therefore, it forms a reliable framework which allows for the analysis of data across cases (Perry, 1998). Furthermore, to minimize the risk of observer bias, the interviews are, where possible, conducted by two researchers (Karlsson, 2008). Finally, to minimize the significant language barrier that exists due to the researcher's lack of knowledge of the local language and the interviewees' inability to communicate in English, each interview was conducted by a professional translator assigned to this research by the University of Palangkaraya.

Furthermore, validity can be split into multiple dimensions (Yin, 2008). Construct validity is ensured through triangulation of the data acquired, which is done in multiple ways. Interview data is transcribed and, where possible, sent back to the interviewee to confirm its accuracy. Moreover, triangulation is achieved through the use of multiple data sources among which: semi-structured interviews, personal observations, and secondary sources. This enhances construct validity by securing an objective representation of reality (Gibbert et al., 2008). Moreover, it improves internal validity as it allows the researcher to adopt insights from several different perspectives, thereby verifying the resulting theory through theory triangulation (Yin, 1994). Finally, in order to enhance both construct and internal validity, obtained data will be re-tested in subsequent interviews across cases to assess both similarities and differences among cases and ensure the presence of convergent validity (Voss et al., 2002).

Finally, it has to be acknowledged that limited generalizability is one of the key drawbacks of using a case study approach (Karlsson, 2008). Nevertheless, attempts are made to maximize the external validity of this research through the selection of multiple distinctly different cases which allow for the creation of theoretical replication (Stuart et al., 2002; Eisenhardt & Graebner, 2007).

The results of this research, obtained through the application of the abovementioned methodology, are presented in the following section.

Data Analysis

To maintain structure in the presentation of the results of this study this section is organized in the following way. Firstly, information collected during the first two, pre-case research, stages of the study are presented and analyzed. Secondly, the information gathered during the third, field research, stage is presented in a case by case manner.

4.1. Results pre-case research

Raw Material Supply Uncertainty

Through interviews with CIMTROP staff members, as well as a consultant to the MBD project (Interview Limin, 2013; Interview De Leeuw, 2013), it has been determined that two types of rubber plantation types can be distinguished. Hutan Karet (Rubber Forest) plantations form the traditional plantation type of Kalimantan's Dayak inhabitants. The number of trees per hectare is relatively large; however, these plantations incur little maintenance. A second plantation type is the Javanese plantation, Kebun Karet (Interview Limin, 2013). The number of trees on these plantations is smaller, and more attention is paid to the maintenance of the land[3]. These interviewees argue that the lack of maintenance of particularly the Hutan Karet plantations institutes that even when the theoretical supply is large; the realized biomass input collected will be substantially smaller as the available rubber nuts are hard to find between the other vegetation. Thus, especially when supplier-buyers harvest these plantations the uncertainty in the supply of biomass is considerable.

Furthermore, as stated by the representative of CKPP, a local NGO: "[Farmers] do not think about what they cannot see" (Interview Silvius, 2013). Potentially related to the limited education of many farmers, this interviewee states that, buyer-suppliers are primarily focused on fulfilling their immediate consumption need while diminishing the importance of their potential future needs. As long as fuel is still available in excess, there is perceived to be no need to acquire additional diesel. Therefore, supply uncertainty can be argued to be caused by the short-term vision of many supplier-buyers.

Transportation Uncertainty

Information provided by Bappeda, the Provincial Development Planning Agency, shows that the far majority of the communities in Central-Kalimantan is not yet connected by asphalt, or even gravel, roads (see figure 6 below).

[3] A third type of 'plantation' could be distinguished as described by one interviewee in the village of Pilang. Pak Mihing owns a small 'nursery' for Jelutung rubber trees. This indigenous rubber tree species is distinctly different from the rubber trees commonly farmed as it does not contain nuts but rather dispense its seeds through the wind. Consequently, this tree is unsuitable for biodiesel production. However, this tree is not generally planted in actual rubber plantations and is only tapped on a small scale by farmers in highly remote areas. All discussion with regard to rubber trees can therefore be considered to exclude Jelutung rubber trees.

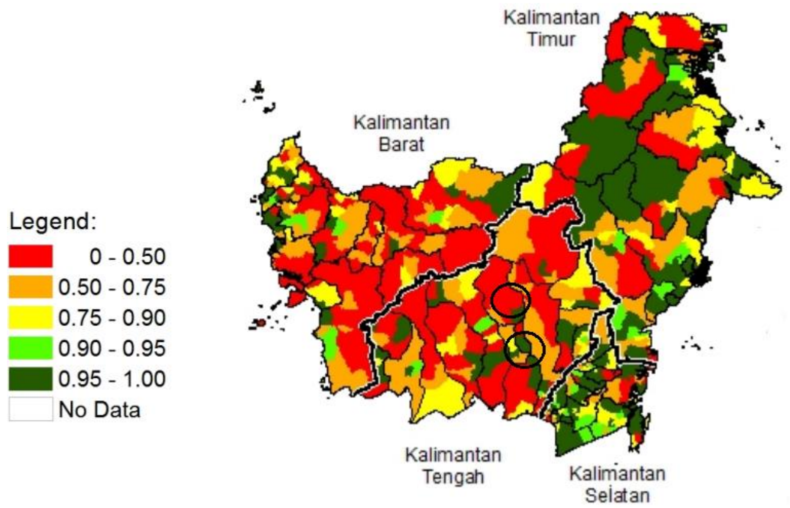

Figure 6: Share of Villages with Asphalt or Gravel/Stone Main Road (Source: Adapted from Sparrow & Vothknecht, 2012)
Note: Bottom circle represents Case 1: Developed Area; Top circle depicts Case 2: Less Developed Area

Furthermore, road development and improvement projects for a total of over 2400 kilometers are planned in the province in 2013 - 2017 (see Appendix E, table 6). However, these developments are argued to only target main roads while the 'real' remote villages lack any connection to the road network and are only accessible by boat. In fact, whereas nearly all villages are located next to a river (Interview Dowson-Collins, 2013), access to road networks is limited only to a minor percentage of communities. Subsequently, transportation uncertainty should be considered to be high, particularly in those villages not connected to the road network.

Production Uncertainty

Two prime sources of production uncertainty can be distinguished: internal and external machine failures. Due to failures internal to the actions and processes of the processing unit itself, a breakdown can occur, as stated by previous scholars. For instance, the movement of the mobile processing unit could institute machine failures. However, this can hardly been argued to be an uncertainty since "the machine can be made robust to cope with movement across bad roads" (Interview Kloekhorst, 2013).

Secondly, external sources can cause breakdowns. As figure 7 below shows, the educational facilities in Central-Kalimantan lack behind compared to more populated areas in the country.

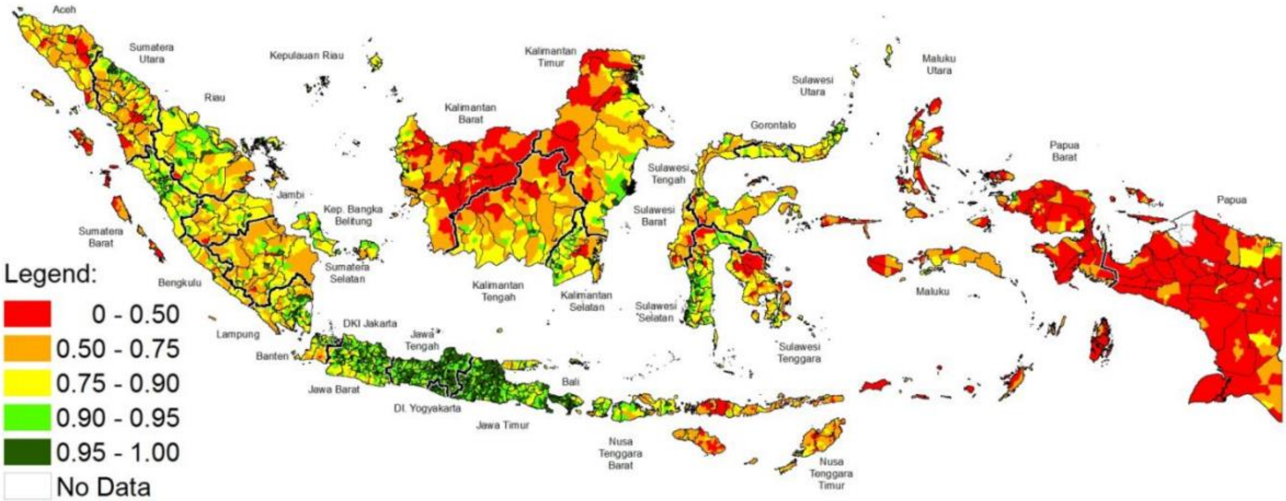

Figure 7: Composite Index of Education Supply Readiness Indonesia (Source: Sparrow & Vothknecht, 2012)
Note: Index is calculated based on multiple indicators which assess the availability, accessibility and quality of the educational facilities in the region. Maximum score is 1, minimum score is 0.

Specifically, not only do many villages in the province lack important educational facilities such as junior high schools within walking distance (6 kilometers – Sparrow & Vothknecht, 2012), the quality of the available facilities is below average. While a primary school is present in nearly all communities (Sparrow & Vothknecht, 2012; Own Field Research, 2013), 25% of the teachers in these schools have not obtained a bachelor's degree. Moreover, teachers in junior high schools did not finish university in, on average, more than 20% of the cases (see table 2 below). In fact, in remote areas these percentages can spike up to nearly 50%. Furthermore, even in those districts where qualitative characteristics appear to be positive at first sight, representatives of local NGO's (Interview Brönnimann, 2013; Interview Migo, 2013) state that the actual performance of the educational system often lacks behind. Teacher absence is generally high and weather conditions, especially in the wet season, strongly influence the opening times of the schools. These pre-case results therefore indicate a large potential for production uncertainty caused by a lack of knowledge caused by the low quality of educational facilities. Moreover, the collected data preliminarily indicate that indeed, the remoteness of an area influences the educational background, and thereby production uncertainty of its inhabitants.

District	BPS Code	Physical Availability			Teacher Qualification			Facility Characteristics				Composite Indices					
		ECED	*SMP (6)*	*SubIndex*	*SD S1*	*SMP S1*	*SubIndex*	*Lab SMP*	*Electricity*	*Water*	*SubIndex*	*Access*	*SMP 3km*	*Equal D.*	*PCA*	*OLS*	*CI*
Kalimantan Tengah		0.86	0.87	0.86	0.73	0.78	0.76	0.48	0.58	0.75	0.61	0.76	0.75	0.74	0.73	0.68	0.66
Kotawaringin Barat	6201	0.92	0.90	0.91	0.81	0.86	0.84	0.46	0.87	0.92	0.75	0.85	0.84	0.83	0.83	0.76	0.74
Kotawaringin Timur	6202	0.77	0.86	0.81	0.69	0.72	0.71	0.54	0.71	0.79	0.68	0.75	0.74	0.73	0.73	0.71	0.68
Kapuas	6203	0.80	0.88	0.84	0.79	0.82	0.81	0.41	0.46	0.70	0.52	0.74	0.72	0.72	0.70	0.67	0.65
Barito Selatan	6204	0.97	0.94	0.96	0.76	0.61	0.69	0.48	0.52	0.80	0.60	0.80	0.78	0.75	0.73	0.70	0.68
Barito Utara	6205	0.85	0.81	0.83	0.68	0.80	0.74	0.64	0.55	0.74	0.64	0.76	0.74	0.74	0.72	0.69	0.67
Sukamara	6206	0.90	0.73	0.81	0.85	0.87	0.86	0.50	0.81	0.81	0.71	0.79	0.77	0.79	0.79	0.72	0.72
Lamandau	6207	0.88	0.81	0.85	0.60	0.85	0.73	0.42	0.64	0.80	0.62	0.75	0.73	0.73	0.72	0.63	0.60
Seruyan	6208	0.85	0.81	0.83	0.52	0.75	0.63	0.27	0.58	0.64	0.50	0.69	0.68	0.65	0.64	0.55	0.52
Katingan	6209	0.81	0.83	0.82	0.52	0.85	0.69	0.40	0.61	0.73	0.58	0.72	0.70	0.70	0.68	0.60	0.56
Pulang Pisau	6210	0.89	0.93	0.91	0.93	0.79	0.86	0.63	0.61	0.81	0.68	0.83	0.81	0.82	0.80	0.80	0.79
Gunung Mas	6211	0.71	0.82	0.77	0.68	0.78	0.73	0.46	0.32	0.61	0.46	0.67	0.65	0.65	0.63	0.61	0.59
Barito Timur	6212	0.93	0.84	0.89	0.90	0.78	0.84	0.68	0.49	0.84	0.67	0.81	0.76	0.80	0.78	0.76	0.76
Murung raya	6213	0.92	0.78	0.85	0.55	0.71	0.63	0.46	0.31	0.56	0.44	0.68	0.67	0.64	0.61	0.55	0.53
Palangka Raya	6271	0.98	0.99	0.99	0.98	0.92	0.95	0.62	0.92	0.91	0.81	0.93	0.93	0.92	0.91	0.88	0.87

Table 2: Education Indicators and Composite Indices - District Level Scores Central-Kalimantan (Source: Sparrow & Vothknecht, 2012)
Note: The circled Pulang Pisau district comprises the primary case area of this study

Demand & Price Uncertainty

Due to the subsidization of fuel by the national government the price of fuel, both gasoline and diesel, for personal usage is currently fixed in the gas stations at approximately 45% of the actual cost (Interview Manurung, 2013). Nevertheless, due to the increase in kilometers driven and misusage of the subsidized fuel by enterprises for industrial purposes, the 638.000 kiloliters of subsidized fuel available to Central-Kalimantan last year, have been insufficient to satisfy local demand (The Jakarta Post, 2012). Moreover, the availability of official gas stations in Central-Kalimantan is limited to the main city which makes citizens of the rural areas in the province dependent on the sale of fuel from local roadside shops. Consequently, not only are the fuel prices higher in remote areas due to added transportation cost, the effects of fuel shortages and price changes in the urban areas are transferred to remote villages in a magnified manner. Furthermore, due to the lack in interregional communication, settlers only learn about external events at the moment in which the changed price affects them (Interview Brönnimann, 2013), thereby creating a high degree of fossil fuel price uncertainty.

Governmental Uncertainty

Uncertainty is first of all present in the sustainability of the current governmental fuel policies. The fuel subsidy was responsible for nearly 18% of the total governmental expenditures in 2012. Moreover, due to the steadily increasing price of oil (Table 8), the subsidy costs are expected to rise to Rp.274 billion this year (table 9). To control the expenses, the government has released plans to raise the subsidized fuel prices and restrict fuel quotas (Ministry of Finance, 2013). However, due to upcoming elections and the lobby of companies (illegally) benefiting from the subsidy, the plans have been delayed several times already.

Additionally, as stated by representatives from multiple NGO's as well as the regional government itself, a great lack of integration between the various institutions and departments exists. Consequently, uncertainty arises about the sustainability and legal validity of granted permits or financial government support. Regularly, a lack of interdepartmental communication leads to overlapping zoning allocations and concession rights. Appendix F elaborates on an illustrative case on this topic. Thus, governmental uncertainty at the national and regional level is caused both by insecurity about continuity of existing policies as well as the lack of integration between governmental departments.

4.2. Main Results Field Research

Using the selection criteria outlined in the methodology, 7 villages have come forward as being particularly suitable for this study. These communities comprise two supply chain regions; the cases for this study (see Appendix E, figure 15 for a geographical overview of the cases). The villages visited for the first case score relatively high on each of the three selected PM2L indicators and furthermore, the main occupation in this region was rubber farming. Thus, this case is deemed to comprise the 'Developed Area'. The second case villages in contrast, are relatively difficult to access and its inhabitants regularly shift occupation between gold mining and rubber farming. Subsequently, this case is deemed the 'Less Developed Area'. Detailed information, including the results of the individual villages on the selection criteria, can be found in table 3 on the following page.

Case	Village	Number of Inhabitants[1, 2]	PM2L Combined Score[3]	Development status PM2L[3, *]	Main Occupation[2]	Total hectare of Rubber Trees[2]	Available infrastructural modes[2, 3]	Highest Level of education available[2, 3]	Recent Development Programs[2]
Developed Area (Case 1)	Pilang	1247	42	Maju	1) Rubber farming (75%) 2) Fruits 3) Fishing	1000	- Asphalt Road - River	Middle School	Various activities by WWF, REDD+, and CIMTROP.
	Henda	612	38	Maju	1) Rubber farming 2) Fishing 3) Rice cultivation / Logging	100	- Asphalt Road - River	Middle School	Training to develop Rattan Wickerwork activities to support income (REDD+ Task Force & UNDP, 2013)
	Buntoi	2496	45	Maju	1) Rubber farming 2) Rice cultivation 3) Fishing	1000	- Asphalt Road - River	Middle School	Development Community Learning Center (Khan, 2013)
Less Developed Area (Case 2)	Bawan	1005	44	Maju	1) Gold Mining 2) Rubber Farming	250	- Asphalt Road - River	High School	1) Rubber farming training 2) Various Health and Forestry Improvement Programs
	Tambak	312	35	Tertinggal	1) Gold Mining 2) Rubber Farming	174	- River	Primary School	Yearly Rice Cultivation Training Program
	Hurung	335	35	Tertinggal	1) Gold Mining (70%) 2) Rubber Farming (30%)	80	- Dirt Road - River	Primary School	None
	Manen Kaleka	321	35	Tertinggal	1) Rubber farming (60%) 2) Gold Mining (30%) 3) Fruit Farming(10%)	100	- River	Primary School	None

* Maju = Developed, Tertinggal = Underdeveloped
[1] Source: Badan Pusat Statistik Indonesia, 2010
[2] Source: Own Field Research, 2013
[3] Source: Bappeda, 2013

Table 3: Summarized Data Case Study Villages

4.2.1. Case 1 – Developed Area

The villages incorporated in this case are located in Block B of the EMRP project area and lay between 70 and 100 kilometers South of Palangkaraya in the Pulang Pisau district (Appendix E, figure 15).

Raw Material Supply Uncertainty

While both Hutan Karet and Kebun Karet type plantations are found in this region, the second plantation type is most common. As rubber farming forms the primary occupation, villagers spend a relatively large amount of time on the plantations to perform maintenance and tap latex. Based on personal observations of the researcher, these lands indeed contain relatively little weeds and the trees are planted in a structured manner. These results provide potential for reliable input delivery as the targeted biomass input, the seeds from the rubber trees, are easy to be spotted and collected on these plots.

Nevertheless, several factors complicate biomass supply delivery. Firstly, both the latex and seed production are dependent on weather conditions. Specifically, rubber farmers do not visit the plantation during, and directly after periods of rainfall as these conditions render the rubber tapping infeasible. Therefore, rubber production in the rainy season drops by nearly 75% and farmers often have to take up alternative jobs. Moreover, in the middle of the dry season, the output of rubber diminishes as the available nutrition declines, causing a drop in farmer income (Own Field research Pilang, 2013). Furthermore, weather conditions affect the biomass itself. For instance, heavy rainfall is stated to influence the quality of the seeds by accelerating the rotting process.

Thirdly, the large majority of the rubber farmers indeed regards the seeds as what they currently are, waste. This results in a great lack of knowledge about the product illustrated by a great variation in responses with regard to the harvesting period and the number of seeds per tree. It should be noted that differences in weather conditions can partly explain this variation, as could the differences in size, age and health of the rubber trees of various farmers (Own Field Research Buntoi, 2013). However, given the current attitude towards the biomass product the responses provided by the smallholder farmers could best be described to be an educated guess. Consequently, it can be concluded that while Kebun Karet plantations common in this region provide opportunities for reliable input supply, farmers have highly limited knowledge about the biomass product which fuels supply uncertainty.

Transportation Uncertainty

Besides the asphalt road that connects each of these villages to the two main cities in the province, Palangkaraya and Banjarmasin, new bridges have been recently been constructed in the region to maintain accessibility during the rainy season. In fact, figure 6 (p.25) shows that over 95% of the villages in this sub-district are accessible by an asphalted, or at minimum, a gravel road. Next to this mode of transport, much of the short distance transportation of latex currently goes by river, from upstream to downstream villages. Thus, multiple modes of transportation are available in this region and moreover, the road network is relatively well developed and investments have been made to make it accessible year-round. Based on this, it can be concluded that transportation uncertainty is relatively low in this region.

Production Uncertainty

As shown previously (table 3, p.28), the educational facilities in this region are relatively well-accessible. Nevertheless, technical expertise by the smallholder rubber farmers can still be perceived as limited. Whereas interviewees state to have experience with the repair and maintenance of diesel generators, further knowledge of technical processes is absent. This enhances production uncertainty as local supply chain actors probably will show themselves unable to resolve most machine breakdowns. Additionally, the previously mentioned lack of knowledge with regard to the biomass also translates itself to uncertainty about the quality of the product delivered. Specifically, while suppliers have repeatedly voiced a difference to be present between 'good' and 'bad' seeds, they commonly showed inability to discern the origins of the quality differences. Moreover, Ir. Kloekhorst and MSc. Widyarani, experts with regard to mobile biodiesel production, state that input quality affects the quantity and quality of produced output. In addition, insufficient input quality could cause machine breakdowns (Interview Kloekhorst, 2013; Interview Widyarani, 2013). Based on this, it could be stated that production uncertainty is likely to be caused by below minimum quality inputs being delivered to the machine.

Demand & Price Uncertainty

A distinction here is made between price uncertainty of inputs and that of outputs. With regard to input price uncertainty, it has been stated before that the inputs are regarded as waste and have very limited value. While the government occasionally purchases rubber seeds from the farmers to be used in reforestation programs (Own Field research Pilang & Henda, 2013), and a small percentage of the seeds is used for growing new trees, farmers commonly have no structural use for the seeds. Therefore, there is little demand for this input and uncertainty with regard to the price of this input is limited. Compared to this, output price uncertainty is more prominently present due to the dependence on fuel from the main cities. Indeed, as pre-case research determined, fuel shortages in Palangkaraya are extended to these villages through prices that fluctuate largely, with villagers paying up to 75% above the fuel price in the city. Thus, while input Demand & Price Uncertainty is limited, the lack of official gas stations outside the city increases the output price uncertainty.

Governmental Uncertainty

A commonly heard response from local supplier-buyers is "It would be nice if it works. But first see, then believe" (Own Field Research Buntoi, 2013). This statement emphasizes the skepticism which many villagers have towards new projects. In the past, the villages in this region have been part of development projects but on multiple occasions, the government abolished the project preliminarily, or the objective was ultimately perceived to be primarily profit- rather than community-development oriented. Subsequently, village government representatives as well as local smallholder rubber farmers state that their participation in the project depends on the benefits of the project to the local community. Moreover, authority has been shown to be highly centralized, and is to a large extent held by the village leader. Thus, governmental uncertainty for bidirectional supply chains is incorporated in the extent to which project representatives possess the ability to obtain the support, or as the interviewees call it, the 'blessing' (Own field research Pilang, 2013), of the village leader. Given that several previous projects have been denied this blessing, and that the openness of the local government has been shown to be related to previous experiences with these type of projects, this uncertainty can be said to be moderately present.

4.2.2. Case 2 – Less developed area

The second case consists of four villages located approximately 90 kilometers North of Palangkaraya (see Appendix E, Figure 15 and Table 3).

Raw Material Supply Uncertainty

Similar to the results for the first case, farmers regard the seeds of the rubber trees as waste and have very little knowledge about the seeding of their trees. Estimations of both seeding season as well as the quantity per harvest vary widely, not only between but also within villages. Among the elements argued to play a role in the quantity and quality of the produced biomass are weather conditions and the structure of the plantation, with Kebun Karet plantations providing more seeds per tree as the trees have more space and are can collect more nutrients (Own Field Research Bawan, 2013). However, many plantations in this area are of the traditional, Hutan Karet type. Based on personal observations of the researcher during visit to such a plantation, the actual collection of biomass from these lands will pose complex these plantations are heavily overgrown with weeds and bushes. On these plots, the quantity harvested will greatly depend on the farmers' determination and endurance in the search and collection of seeds.

Furthermore, contrary to the Case 1 region where the inhabitants are primarily rubber farmers, the inhabitants of this region shift occupation between gold mining and rubber farming. Although the villagers still, first and foremost, consider themselves to be rubber farmers, stating that "gold mining is not forever" (Field research Tambak, 2013), rubber plantations are abandoned when the price of latex is perceived to be too low to fulfill the daily needs. Moreover, during periods of bad weather and heavy rainfall, rubber farming is stated to be infeasible and gold mining is picked up. As the price of latex was considered to be low during the period in which this research took place (May-June, 2013), the effects of price drops were highly visible in the societies. According to local rubber middlemen, the rubber production dropped by nearly 80% as the far majority of the farmers switched their occupation to gold mining. A large part of the rubber plantations therefore currently goes unused.

To summarize, the biomass quantity delivered depends on the plantation type and latex price, where unexpected fluctuations in the price and the dependence on the farmer's collection persistence create supply uncertainty. Additionally, the lack of supplier knowledge about the product, as well as weather conditions, creates supply uncertainty related to both quantity and quality supplied.

Transportation Uncertainty

Although the case area in general is connected to Palangkaraya through an adequate asphalt road; many villages in the area are not directly connected to it and remain less developed. In fact, less than 50% of the villages in the sub-districts included in this case are accessible by at minimum a gravel road (figure 6. p.25). Field research in this area has shown that even in the dry season, running from the end of April until October, damage done through heavy rainfall in the previous season impacts the accessibility of the area. On multiple occasions, roads have been severely damaged or become entirely inaccessible (Own field research Manen Kaleka, 2013). Furthermore, a substantial percentage of the villages in the region are only reachable by boat. However, sustained dry periods lower the water in the river to the level at which ships cannot dock in all villages anymore. As a result, supplies have to be hauled over to 'klotoks', small motorized canoes, for ultimate delivery to the settlers (Own field research Tambak, 2013). The lack of transport modes and the effect of weather conditions on the accessibility of the region therefore, create a considerable transportation uncertainty.

Production & Operations Uncertainty

Directly related to the development status of the villages, the education level in this region is in general limited. To illustrate, the village leader of Tambak describes that since the closest high school lays approximately 10 kilometers away, only 25% of the children have secondary school education and this percentage is expected to be even lower among adults (Own Field research Tambak, 2013). The lack of education poses an uncertainty in the operation of the machine as is furthermore acknowledged by a local latex middleman who claims that villagers have highly limited knowledge of technical processes more complicated than boat engines.

Moreover, as pre-case research already indicated, many people entail a strictly short-term perspective which affects the manner in which equipment is handled. For instance, since diesel was sold at a premium compared to gasoline during the period in which this field research took place, villagers powered their diesel engines with gasoline even though, as Pak Sindem states, "they are very much aware that it is bad for the engine" (Field research Hurung, 2013). The local perspective is best summarized by the owner of a hardwood processing factory in Central Kalimantan: "[Indonesians] do not care that much about the maintenance of their equipment. If it breaks in the future, this is not much of an issue for them today" (Interview Brönnimann, 2013). Combined with the largely absent knowledge of biomass quality measurement by the buyer-suppliers, these elements provide an important source of uncertainty in the occurrence and resolution of machine breakdowns, and with that, production uncertainty.

Demand & Price Uncertainty

As mentioned before, the price of fossil fuels and diesel in particular, is very high in these remote villages. Specifically, the prices in this relatively remote area spike to a level of 250% of the official fuel price charged in Palangkaraya. Moreover, fluctuations occur regularly depending not only on fuel shortages but also on the complexity in delivering the fuel to the village, as described previously, indicating substantial output price uncertainty. Interestingly, interviewees in this region for this reason state that, "such a [MBD] project can help us to become less dependent on the oil traders from the city [Palangkaraya]" (Own field research Manen Kaleka, 2013).

With respect to inputs on the other hand, smallholder rubber farmers consider the current value of rubber seeds to be close to none, as the seeds 'just lay there' (Own field research Bawan, 2013). The uncertainty with regard to demand and price of the input is therefore minimal.

Governmental Uncertainty

National and regional governments have been stated to play only a minor role in the daily life of these communities. Instead, local village governments take a central role in decision-making. The local latex middleman in Manen Kaleka summarizes this by stating "if the village leader agrees with a project, then everyone will follow" (Field research Manen Kaleka, 2013). As a result, among the sources of governmental uncertainty should also be the ability to gain support from the local government, which has here been shown to be central to the participation of the supplier-buyers.

4.2.3. Cross-Case Uncertainty Comparison

The results of the two contrasting cases outlined above clearly show the impact of regional conditions on the impact of the Bidirectional Biodiesel Supply Chain.

Raw Material Supply Uncertainty: First of all, it has become clear that throughout the entire region, the targeted biomass input is considered a waste product that is given little attention. However, a main difference between the cases is the primary plantation type. Hutan Karet plantations, which prevail in the Less Developed case, provide a significantly higher supply uncertainty as not only the knowledge about actual seed quantity but also the ability of the farmers to collect it is questionable. As a result, the estimations of the potential raw material supply vary widely across interviewees (Appendix E; table 10). Additionally, the between-case comparison shows that occupation switching behavior in regions where rubber farming is not the sole occupation enhances supply uncertainty as the price of latex, as well as the return of the alternative occupation determines whether a farmer visits his plantation.

Transportation & Logistics Uncertainty: Large differences have been observed between the two regions with regard to the ability in which the transportation times can be reliably estimated. Whereas the relatively developed region has received extensive infrastructural investments, the villages in the less developed region are hard to access. In fact, while in the first case the most reliable and efficient transport mode is the road, the inhabitants of the less developed region first and foremost transport themselves and their goods by boat. One cause for this is the total absence of roads to various villages and secondly, during the wet season heavy rainfall does extensive damage to the available roads. Therefore, it can be stated that indeed the quality of the infrastructural network plays affects the Transportation & Logistics Uncertainty. Moreover, that the movement of the unit itself is a source of this uncertainty as it is dependent on the road network which is unreliable, especially in less developed areas.

Production & Operational Uncertainty: Although differences in educational level exist between the villages – in the first case region, better educational facilities are present than in the second – it can be stated that many smallholder rubber farmers lack (technical) education throughout the remote areas. Indeed, it can therefore be stated that machine downtimes are uncertain as it is uncertain whether the local supply chain actors are capable of adequately performing repairs. Moreover, not only do the poor road conditions form a source of transportation uncertainty, a comparison between the cases learns that especially in less developed area it is indeed highly likely that this forms an important source of production uncertainty, which is responsible for causing machine breakdowns. In addition, interviewees in the less developed area show clear short-term behavior towards equipment maintenance which fuels uncertainty about machine breakdowns and preventive maintenance. This comment has been placed more generally in interviews with regional experts in the pre-research, who claim this to hold true for the entire region. Therefore, although research in the developed case area did not explicitly yield this result, it cannot be excluded that the short-term perspective is also present in this area.

Demand & Price Uncertainty: In both cases it came forward that the targeted biomass product currently has limited value and thus has low price uncertainty. However, unfortunately it has shown to be infeasible to determine the price uncertainty of the other inputs in this study. Nevertheless, it can be stated that with regard to supply chain output considerable uncertainty exists as the price of fossil fuel is highly variable, and the price fluctuations tend to magnify when the accessibility of a region declines. Notably, interviewees in the less developed region see a bidirectional supply chain as an opportunity to reduce this fossil fuel price uncertainty by reducing their dependence on external oil deliveries and fluctuations in the price of the product. Higher fossil fuel price uncertainty therefore poses as a stimulator to participation in a Bidirectional Biodiesel Supply Chain. Finally, this multiple case study shows that when a variety of income sources is available to supplier-buyers, uncertainty is furthermore incorporated in the fluctuations in return of the initial agricultural income, latex in this case.

Governmental Uncertainty: At a supply chain region level, the level applied in this case study; governmental uncertainty lies with the local village governments. Primarily, the uncertainty is incorporated in the acquisition of support from these individuals, something that in the past has shown to be detrimental to the success of (non-)governmental projects in the Developed Region.

Discussion

After the analysis of the gathered data in the last section, this section provides a discussion of the main findings of this study in relation to the current literature in this field. Summarizing, this section will end with an answer to the research questions stated in the Introduction Chapter: *How do supply chain uncertainties impact the operational performance of a biodiesel supply chain characterized by supplier-buyer duality to what extent is this dependent on differing regional conditions?*

5.1. Biomass supply uncertainty

Previous scholars have described various sources of supply uncertainty to be present in unidirectional supply chains. Specifically, they have identified three generic sources of this type of uncertainty: quality, quantity and type (Awudu & Zhang, 2011). This study indeed indicates a strong presence of the first two also in bidirectional supply chain. The third uncertainty can indeed be considered to be a relatively unique case (Iakovou et al., 2010; Mangoyana & Smith, 2011) and has not been found present in this study, although it cannot be ruled out to form a source of supply uncertainty in specific cases.

Moreover, in line with previous research (Bassok & Akella, 1991; Everingham et al., 2002) field research has shown a direct influence of weather conditions and tree growing conditions on biomass supply uncertainty. However, these elements affect primarily the quantity and quality of the biomass actually available. An at least equally uncertain factor is the quantity and quality of the available seeds that are collected. As Gui et al. (2008) already stated, this type of biomass is currently considered waste. Building on this, this study learns that as a result, suppliers have very limited knowledge of the product and lack experience in collection, or quality measurement. Not only this, the ability to collect biomass has shown to be related to the plantation structure. The lack of maintenance, especially in traditional Hutan Karet plantations, either through knowledge limitations or tradition, implies that even when the theoretical biomass availability is high; the realized biomass input collected is presumably far lower.

Finally, in addition to the sources of supply uncertainty already found in previous research, this study shows that particularly in less developed remote areas, in which BBSC are more suitable than unidirectional chains, the vision of many supplier-buyers should be regarded as short-term. Moreover, Bidirectional Biodiesel Supply Chains (BBSC) are often implemented as part of a local economic development program (e.g. Agriculture Beyond Food, 2008) and are contingent on the participation of the local community. This participation is due to the duality of buyers and supplier difficult to be formalized into a contract. A lack of contractual obligations combined with a short-term perspective of the supplier-buyers adds uncertainty by creating an interrelation between the supply of inputs and the immediate consumption needs at a given point in time. This empirically underlines the point made by Iakovou et al. (2010), who highlight the complexity in securing a continuous, 'uninterrupted' (p. 1864) stream of biomass supply, and confirms the expectations at the start of this research.

The sources of Raw Material Supply Uncertainty can be summarized as follows.

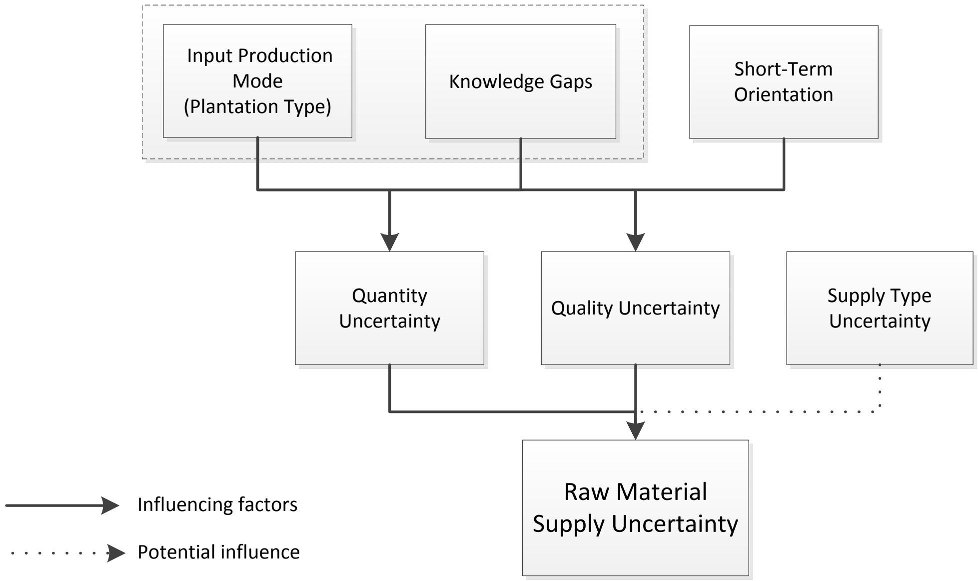

Figure 8: Sources of Raw Material Supply Uncertainty

5.2. Transportation & Logistics uncertainty

As has become abundantly clear during the field research phase of this study the extent of regional development is strongly related to the quality of a region's infrastructure, as has also been observed by previous researchers (Fredriks et al., 2013; Dufey et al., 2007). In contrast to these previous scholars, this study finds that transportation uncertainty is primarily present in the Less Developed area, while transportation times in the Developed Area can be fairly reliably estimated year-round. The reason for this is the lack of adequate infrastructure and the consequent impact of weather conditions on the accessibility of the communities in areas outside the reach of infrastructural development programs.

Unfortunately, the uncertainty in acquiring and transporting of 'secondary' inputs such as ethanol and glycerin could not be reliably estimated during this study. Consequently, no conclusion can be reached with regard to the uncertainty of additional input transportation in BBSC. Leaving this aside, the main transportation and logistics uncertainty is found in the movement of the processing unit itself rather than the movement of biomass by the buyer-suppliers, as was indeed proposed based on current literature. Consistent with the variation of infrastructural quality and variety, this uncertainty is highly affected by differences in regional conditions. In other words, movement of the processing unit poses uncertainty particularly in areas with a limited infrastructural network.

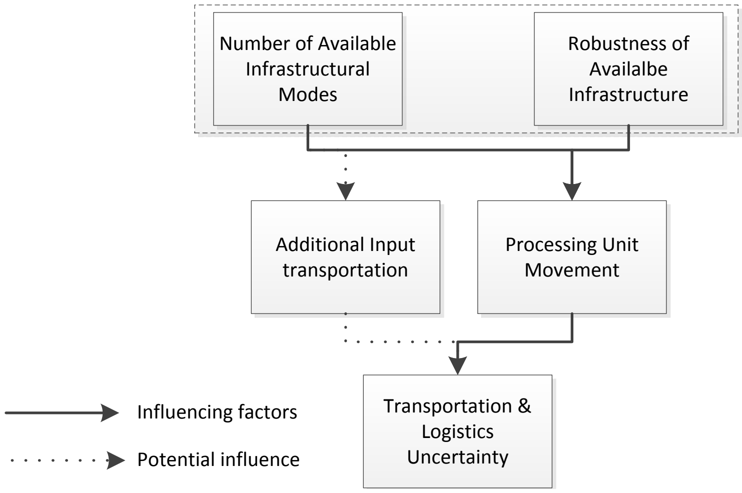

Figure 9: Sources of Transportation & Logistics Uncertainty

5.3. Production Uncertainty

This research finds that with regard to a biodiesel supply chain, production uncertainty is primarily resulting from the effects of external party behavior on the machine's processes. This is in contrast to previous research which describes internal factors as a prime source of production uncertainty (Aytug et al., 2005). In fact, although it should be noted that internal failures could in fact hamper the machine's ability to generate the expected output; this uncertainty is limited as this is anticipated upon in the development of a mobile processing unit. For instance, although bad road conditions could cause delays – a transportation uncertainty – the risk of a breakdown resulting from this can be considered low.

Instead, field research as well as interviews with developers of the processing unit has made clear that the prime source of production uncertainty lies in the impact of the supplier-buyer on the processing process. The uncertainty is caused by several factors. First of all, the lack of knowledge related to the measurement of biomass quality of the local buyer-suppliers was overwhelming, as discussed previously. This lack of ability to preliminarily assess the quality of a buyer-supplier's inputs creates the potential of unrealistic expectations about the quantity and quality of the output delivered. Moreover, pre-case research also revealed that biodiesel production is a delicate process which could break down through the application of poor quality inputs. Secondly, a lack of schooling received by the local stakeholders has become prevalent, particularly in more remote areas. Subsequently, the technical understanding and capabilities of the supply chain area inhabitants is limited which yields uncertainty with regard to downtimes in case a machine breakdown occurs. In line with the conclusions of Aikman and Pridmore (2001) and Ocoa et al. (2010), it should therefore be stated that lack of buyer-supplier knowledge forms an important source of production uncertainty and that this uncertainty increases when regional development declines.

In addition to existing literature, this study finds the current mindset of the inhabitants of remote rural areas to be primarily short-term oriented, as described previously. Due to this, (preventive) maintenance as well as optimal machine operation are not considered to be of high priority as they incur short-term costs while the pay-offs are not directly visible. The usage of gasoline in diesel engines observed in the village of Hurung (see p. 33) provides an illustrative example of perception regarding breakdowns and maintenance. To generalize this, previous scholars have primarily focused on the lack of knowledge of external supply chain actors as driving production uncertainty. This study shows that in addition to this, bidirectional supply chains are subject to production uncertainty created by the time perception of the inhabitants of the targeted remote rural areas. In other words, the lack of knowledge combined with the short-term orientation lead to lack of maintenance. Together with the uncertainty about input quality this creates uncertainty in the form of 'Externally Caused Process Failures' as shown in figure 10 below.

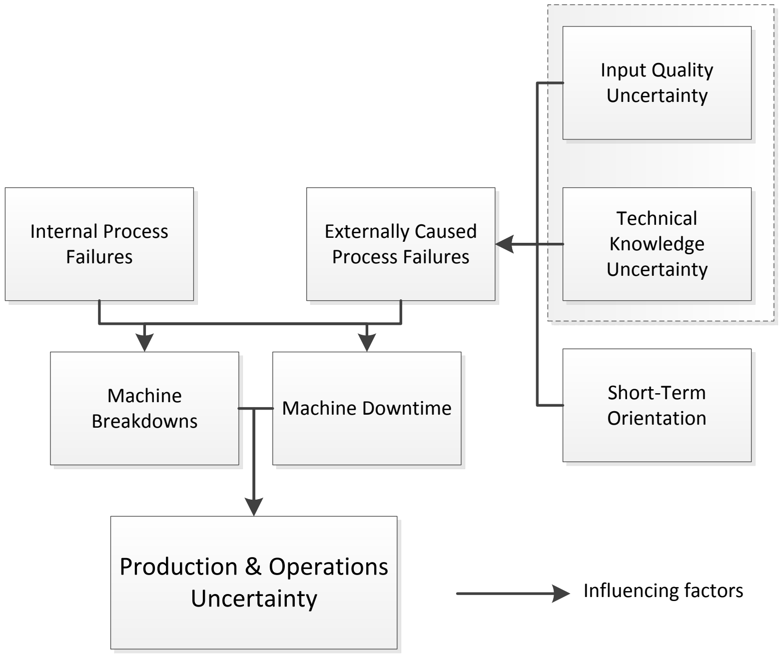

Figure 10: Sources of Production & Operations Uncertainty

5.4. Demand & Price Uncertainty

The primary input product, the biomass, is currently considered to be waste which for the great majority of suppliers incorporates close to no explicit value or structural use. A limited amount of the seeds however, has an implicit value as source of new trees, as other researchers also observed (Frederiks et al., 2013; Verkruijsse, 2013). Nevertheless, based on this research it can in general be stated that biomass from waste products indeed incorporates little price uncertainty. Unfortunately, this study has failed to obtain adequate information with regard to other input products and price and demand variation therein. Input price and demand uncertainty as a whole can therefore not be entirely discarded.

The second part of price uncertainty hinges upon the price of the substitute product, according to Awudu & Zhang (2011). The cross-case analysis (p. 34) shows that fossil fuel price uncertainty is highly dependent on regional conditions, and is directly related to the accessibility of a region. Specifically, more remote areas experience the higher the fossil fuel prices and larger fluctuations in this. Interestingly enough, while uncertainties in current literature are commonly described as detrimental to operational performance (Davis, 1993; Ellram et al., 2004; Persson et al., 2009), the uncertainty in fossil fuel prices in remote areas could promote the involvement of supplier-buyers in the bidirectional business supply chain, as shown during field research in a remote area of Central-Kalimantan, Indonesia. In addition to this, in areas where latex farming is not the primary income source, the quantity of biomass collected has shown to be subject to fluctuations in the price of latex as well as the alternative product. In other words, the amount of biomass gathered is subject to the marginal value of a labor hour for the different jobs.

Thus, this study adds to current literature by showing that besides price uncertainty in its own supply chain, Bidirectional Biodiesel Supply Chains are subject to uncertainties in related supply chains. Especially, price uncertainty in the fossil fuel supply chain can be beneficial to the performance of the BBSC, while price uncertainty of latex affects performance negatively.

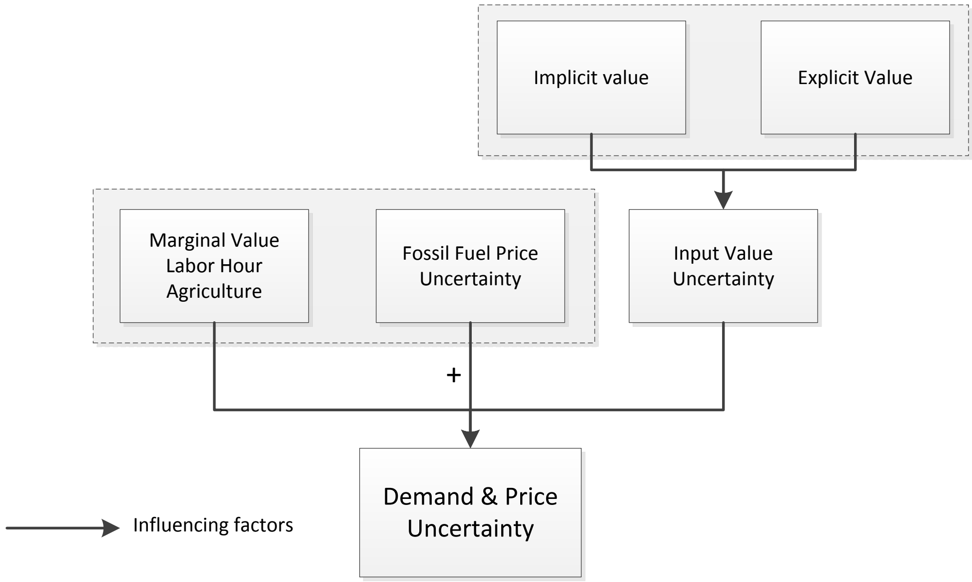

Figure 11: Sources of Demand & Price Uncertainty
Note: Unless otherwise stated, the influencing factors have a negative effect on uncertainty

5.5. Governmental Uncertainty

The remoteness of rural areas targeted by a BBSC have here shown to be, to a certain extent, independent from influences from regional and national government policies. Rather than focusing solely on relatively high level governmental uncertainties as has primarily been done by scholars (Rozakis & Sourie, 2005; Hammond et al., 2008), also the effect of local governmental uncertainty should be addressed. Specifically, leadership at a local level is centralized in the village government and the uncertainty in supply of biomass is to a large extent entangled with the ability to obtain compliance of the local government.

Governmental uncertainty at a regional and national government on the other hand, can be considered to correspond fairly accurately with those described to impact unidirectional biodiesel supply chains (Rozakis & Sourie, 2005; Yeh et al., 2008). In particular, policies related to fossil fuels, such as subsidies and quota, as well as bureaucracy and corruption, and the lack of integration of various governmental departments have in this study been found to add to regional/national governmental uncertainty.

A more in-depth discussion about the various governmental levels, and the control system required to minimize the associated uncertainties can be found in the thesis of Boon (2013, forthcoming).

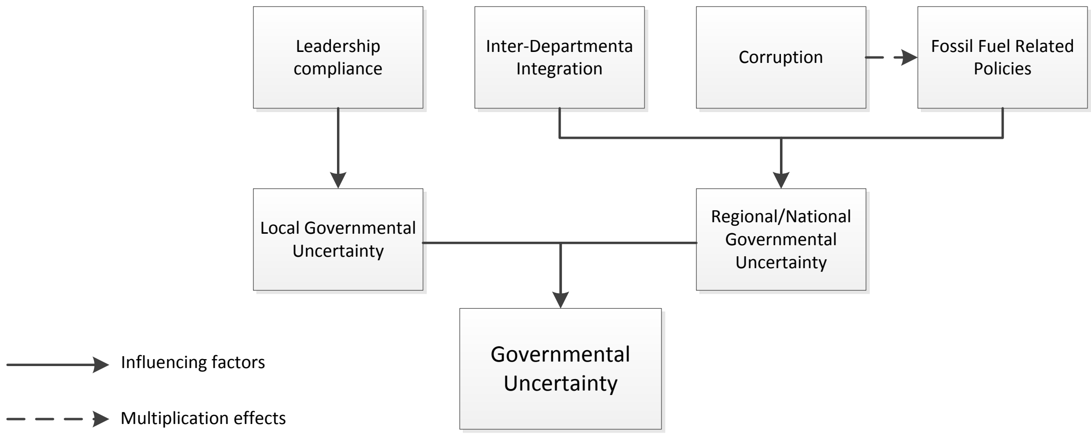

Figure 12: Sources of Governmental Uncertainty

5.6. Modeling Uncertainties under Bidirectionality

The discussion presented in this chapter highlights various sources of supply chain uncertainties impacting the performance of the Bidirectional Biodiesel Supply Chain. Moreover, it indicates that BBSC are prone to several uncertainties not found by previous scholars in the analysis of uncertainties in the unidirectional biodiesel supply chain.

The lack of knowledge of local supplier-buyers, both with regard to the biomass as to the maintenance and operation of the processing unit, fuels uncertainty in the BBSC. Furthermore, the duality between buyer and supplier combined with the short term perspective of the local stakeholders creates uncertainty in demand. Moreover, a prime uncertainty that should be taken into account in the BBSC is the demand & price of fossil fuels as well as the marginal value of labor hours for various potential occupations.

Finally, cross-case analysis provides a strong indication that the sources of Bidirectional Biodiesel Supply Chain uncertainty vary with regional conditions among which the level of education, the infrastructural network, and socio-economic conditions.

The sources and impact of supply chain uncertainties on the operational performance of the Bidirectional Biodiesel Supply Chain are summarized in figure 13 below.

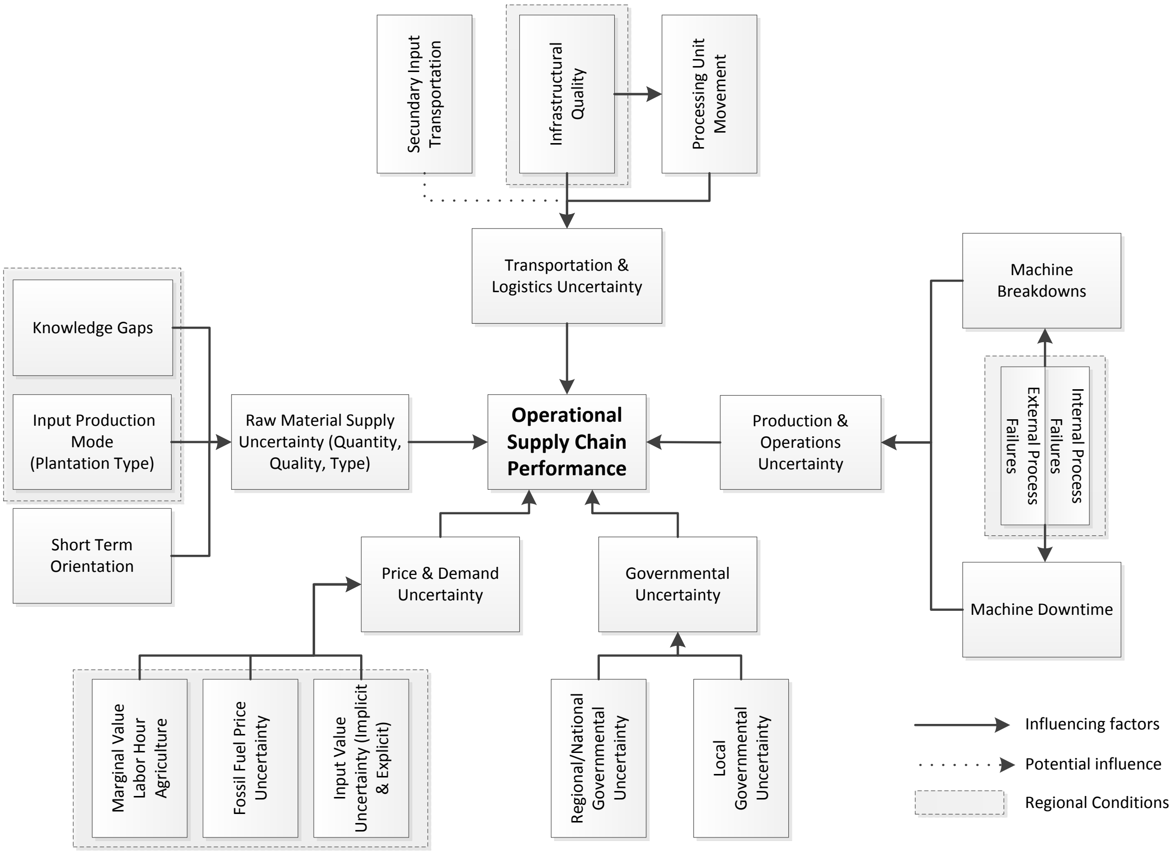

Figure 13: Empirical Model: The impact of uncertainties on the operational performance of the bidirectional supply chain

The MBD Project: Recommendations & Research Directions

In this section, several recommendations for the MBD Project, focused on the development of a mobile processing unit capable locally producing biodiesel, are presented. Although the suggestions made here are fairly specific to this specific project, in the following Conclusions section, some of these recommendations are generalized for BBSC in general.

First of all, the degree of uncertainty in the implementation process of the project remains considerable. As stated, the participation of farmers should initially be achieved by acquiring support from the local government. However, with regard to raw material supply two important uncertainties still remain. Firstly, the rubber seed related knowledge of farmers can be considered to be minimal. Even if a rough approximation of the theoretical production can be made and local government support can be obtained, biomass input is still uncertain and highly dependent on the project's perceived value in the eyes of the farmers. Moreover, the structure of the rubber plots, often better considered a forest than a plantation, complicates the seed collection and increases the supply uncertainty. To reduce supply uncertainty, it is therefore recommended to focus primarily on the supply of relatively well-maintained, Kebun Karet plantations during the start-up phase of the project. The supply can thus more accurately be estimated in these plantations.

Moreover, the actual movement of the processing unit itself, rather than the delivery of inputs[4] or the output, has been found to cause the largest degree of transportation uncertainty. As the availability of roads is fairly limited in Central-Kalimantan, many areas are difficult to access by truck. Moreover, interviewees state that during the wet season the accessibility is further reduced as many of the small, not asphalted roads and even parts of the villages, flood. For this reason, the fuel needs of many of the villages North of Palangkaraya are currently fulfilled by boat. An interesting research direction, for this and other projects, would thus be to investigate whether a 'floating processing unit' is a feasible alternative.

Additionally, in order to reduce the uncertainty in both supply and transportation, and thereby enhance the operational performance of the value chain, it is recommended to limit the maneuvers of the unit to solely those movements of which the time consumption and cost can be reliably estimated. Therefore, it is encouraged to place the processing unit in a (semi-) fixed location. This would furthermore, allow for the collection of inputs from a larger number of suppliers and thereby create a greater sourcing area which reduces supply uncertainty (Treleven et al., 1988). Field research has indicated that each region entails one or multiple 'central' villages which, due to their location, development or history, form a natural hub in the region. The accessibility of these villages is adequate, and the educational facilities are usually above average. Transportation and production uncertainty can therefore be reduced.

In the visited case areas four villages could be identified as hubs. In the North, the visited village of Bawan is a large and important central village, as well as the village of Hanua which is often mentioned by interviewees as the village where children go to high school and where a weekly market is held. In the South, Jabiren is a larger community near the visited villages of Pilang and Henda. Jabiren contains a high school and its village government closely cooperates with the leaders

[4] Note: the uncertainty related to the input of methanol and the catalyst could not be determined during this study

of both visited villages. In this area the visited village of Buntoi is furthermore, an interesting candidate as a weekly market is held here and it poses a hub of the latex industry in this region.

Finally, there is a large lack of adequate insight into both the quantity and quality of supply that will be delivered. Moreover, the extent to which production uncertainty will impact performance is unknown. Therefore, it is highly recommended to establish a small-scale pilot. To be able to collect plentiful information and eliminate part of the operational uncertainties it is recommended to set up a pilot in a high rubber producing region where villagers possess limited alternative occupation opportunities. By doing so, a 'best case' scenario can be constructed and the effective operational cost and benefits can be determined. The case 1 area, containing relatively developed villages where rubber farming forms the people's main occupation and who have experience with development projects, shows itself particularly suitable for this. Specifically, as a hub in the local rubber trade and with good connections by road and water, Buntoi is recommended as location for the pilot processing unit.

Conclusions

Taking a case study approach, this study has investigated how operational uncertainties affect the performance of a Bidirectional Biodiesel Supply Chain and what the effect of regional conditions is on this. It can be concluded that the five generic types of unidirectional biodiesel supply chain uncertainty identified by Awudu and Zhang (2011) indeed also affect performance of the bidirectional. Nevertheless, the remote rural areas in which bidirectionality takes place, add several sources of uncertainty to these types that have not been extensively studied by previous scholars. Among these are the short term perspective taken by local supplier-buyers as well as substantial knowledge gaps. This last point relates to both the targeted biomass product and to the capabilities of the local stakeholders to perform maintenance and repairs. Finally, an important insight derived from this research is the interrelation between the Bidirectional Biodiesel Supply Chain's performance and the uncertainty in demand and price of fossil fuels and alternative occupational opportunities. Moreover, cross-case comparison has shown that regional conditions indeed play an important role in creating and enhancing the impact of the various uncertainties on BBSC performance. Specifically, it can be concluded from the results of this study that in areas which can be considered to be less developed, the impact of uncertainties of BBSC performance is larger.

The results of this study provide various implications for academics, policy makers and practitioners. The empirical model developed in this study model provides a better insight in the various environmental and supply chain elements that affect the bidirectional supply chain. For practitioners this paper provides valuable guidance in analyzing the presence and extent of uncertainties in the Bidirectional Biodiesel Supply Chain. This research provides, to the best of the knowledge of the researcher, the first study primarily directed towards the identification of uncertainties in this type of biodiesel supply chains. While the sources of uncertainty developed here can therefore not be regarded as exhaustive, they allow managers of BBSC to more accurately define the core sources of uncertainty in their chain. In doing so, these decision-makers are offered a mainstay which enables them to develop supply chain strategies that minimize the impact of uncertainties and maximize supply chain performance.

For policy makers furthermore, the sources of supply chain uncertainty identified in this study should be analyzed and investigated in relation to the development of remote rural areas. Specifically, several regional factors such as lacking education and poor infrastructural quality have shown to pose severe uncertainties for the implementation of a BBSC. As BBSC are regularly implemented as part of a Local Economic Development program, these factors therefore effectively limit the development of a remote rural area. Policy makers from both regional and national governments are thus urged to take notice of the results of this study and the regional conditions influencing Bidirectional Biodiesel Supply Chain performance in order to design policies which stimulate the reduction of these uncertainty-enhancing factors.

Finally, the empirical model of this study highlights several sources of uncertainty not previously found in biodiesel supply chain uncertainty articles. Thereby, this paper empirically proves that although uncertainties in the unidirectional and Bidirectional Biodiesel Supply Chain to a certain degree overlap, several differences exist. In other words, the prime focus on unidirectional supply chains has instituted that several elements causing uncertainties in bidirectional supply chains have previously gone unstudied. This paper therefore adds to the relatively limited academic knowledge about uncertainties in the bidirectional supply chain and provides a building block for new research efforts more directly focused towards Bidirectional Biodiesel Supply Chains (BBSC), as will be further explained in the section below.

6.1. Limitations & Future Research

This research is subject to several limitations. First of all, the nuance and depth of the interview responses might be influenced by the language barrier between the researcher and the interviewees. Despite the fact that a translated and pre-tested booklet was used to present the concept of bidirectional biodiesel production and the topics of this research to the interviewees, and a professional translator was arranged through the University of Palangkaraya, a sizable barrier remained and might have reduced the profoundness of the gathered data.

Secondly, the lack of access to appropriate government documents appeared to be a complication in the research. The lack of integration of government institutions and departments created a severe difficulty in obtaining complete and detailed quantitative as well as qualitative data. Due to the absence of several key employees during the period of field visit, for reasons as maternity leave, illness or out-of-town obligations, certain potentially valuable government documents could not be acquired. In addition to the previous limitation, this could influence the richness of the data.

Furthermore, this case study has been conducted in a relatively small area near the city of Palangkaraya in Central-Kalimantan, Indonesia and involved the production of biodiesel from rubber seeds. The generalizability of this study to bidirectional supply chains based on other sources of biomass and to value chains that are implemented in other parts of the world is thus uncertain. It is therefore highly recommended that future researchers will further investigate whether the conclusions of this research can be generalized in a wider setting.

As mentioned previously, due to the researcher's inability to identify the producers of methanol and of the process catalyst, the transportation uncertainty with regard to these production inputs could not be determined. This poses a gap in the research which should be addressed by future researchers in order to complete the model.

Moreover, this study has presented a first insight into the impact of supply chain uncertainties on the operational performance of the Bidirectional Biodiesel Supply Chain. The conclusions derived from this research therefore create building blocks to be applied by future researchers to extend the current knowledge about supply chain uncertainties in the bidirectional supply chain. One fruitful direction would be the investigation and comparison of the impact of uncertainties in other types of bidirectional production supply chains to determine the uncertainties found are inherent to supplier-buyer dual supply chains in general or solely hold for bidirectional biodiesel value chains. Finally, this study highlights the impact of supply chain uncertainties and provides several practical suggestions to minimize their negative influence. However, restriction in time and focus of this research prevented the in-depth, structural analysis of uncertainty controlling mechanisms. Future researchers are highly encouraged to take up where this paper left and further investigate how the 'bidirectionality uncertainties' identified here can be effectively managed.

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Appendix A: EMRP Area

Figure 14: Ex-Mega Rice Project Area (Bappeda, 2013)

Appendix B: PM2L Program

The following section explains the PM2L Program as explained by Budianto (Interview, 2013) and Baars (2012). In 2008, Bappeda developed a new program, PM2L. "The program aims to develop and build villages, based upon a tailor-made approach" (Baars, 2012, p.74). The program assigns scores to the villages in Central-Kalimantan based on They give a score based on 15 variables, namely:

	Variable	Classification	Score
1	Main road type in village	• Asphalt • Stones, hard road • Land	3 2 1
2	Main activity of local people	• Agriculture • Non agriculture	3 4
3	Educational facilities	• Primary school • Secondary school • High school	2 3 4
4	Health facilities	• No facilities • (Community) health center • Other facilities than health center	2 3 4
5	Health workers	• Midwifes • Paramedicals • Doctors	1 2 3
6	Communication facilities	• No facilities • Post office OR public phone • Post office AND public phone	2 3 4
7	Population density per km2	• < 100 • 100-300 • > 300	1 3 4
8	Drinking water source	• Clean water source • A well • Raining water	3 2 1
9	Fuel source for cooking	• Gas/electricity • Wood or other	4 2
10	Percentage of people using electricity	• < 5 • 5-15 • 15-70 • > 70	1 2 3 4
11	Percentage of people living from agriculture	• < 65.0 • 65.0-80.0 • 80.0-87.5 • > 87.5	4 3 2 1
12	Economic situation	• Very poor • Poor • Ok • Rich	1 2 3 4
13	Ease to reach health facilities	• Easy • Quite easy • Hard • Very hard	4 3 2 1
14	Ease to reach a market	• Easy • Quite easy • Hard	4 3 2
15	Ease to reach shops	• Easy • Hard	3 2

Table 4: PM2L program (Baars, 2010)

Status	Total Score
Far Behind (Sangat Tertinggal)	15 - 20
Behind (Tertinggal)	21 - 35
Developed (Maju)	36 - 50
Very Developed (Sangat Maju)	≥ 51

Table 5: Construction PM2L Development Scores (Source: Bappeda, 2013)

As Table 4 describes, villages are scored from Far Behind to Very Developed. According to the program's guidelines, villages that are (Far) Behind are included in the development program, and within 5 years should lead to an upgrade to "Maju". The activities of the program include investments in education facilities, infrastructure and electricity availability.

The average score in Central Kalimantan is 39, up from 35 in 2010 (Baars, 2010) which indicates that on average, the villages are developed and moreover, that there is a strong upward trend visible. The scores of the case study villages are presented in table 3 in the main text.

Appendix C: Explanatory Brochure

The brochure which can be found below has been developed based on the booklet used and verified by Fredriks (2012). The brochure serves to present the core purpose and functioning of the Mobile Biodiesel Project to the interview subjects. By stepwise guiding the interviewees through the brochure and the clear explanation of each topic, information asymmetry between the researcher and interviewee is reduced. Furthermore, subjectivity and personal bias is limited as every interviewee receives the same objective information (Voss et al., 2002). Moreover, the booklet contains information regarding the topic of this research. This allows the interviewee to provide better and more accurate information as he/she has a greater understanding of the purpose of the study.

In order to integrate the research directions of this thesis, an adaptation to Frederiks (2012) booklet has been developed in close collaboration with Dr. Ir. Togar Simatupang of the Institut Teknologi Bandung. Specifically, rather than the focus on social franchising as used by Fredriks (2012), the second half of the booklet has been adjusted to incorporate an explanation of the sources of uncertainty in the supply chain as well as general research questions to be answered with regard to each uncertainty. The purpose of this last addition is to promote the thought process of the interviewees and establish a starting point for the semi structured interview.

Content Mobile Biodiesel Project

The development of local/community-scale biodiesel industry with the use of waste products in Central/South Kalimantan:

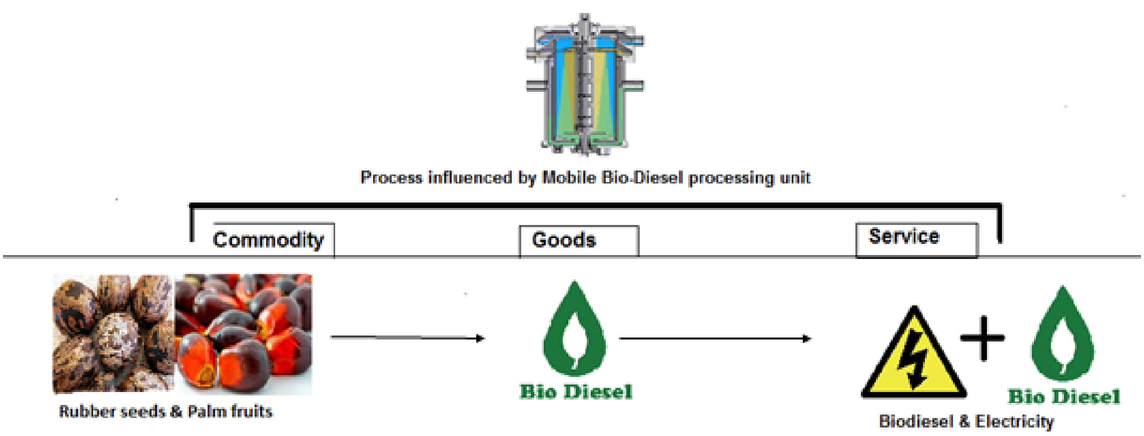
- Stimulate the local economy and particularly local agricultural activities by introducing a new bio industry focused on waste products
- Prevent further degradation of the environment and particularly that of sensitive peatlands
- Stimulate the transition of Indonesia into a bio-based economy
- Reduce the Indonesian dependency of fossil resources like crude oil

university of groningen

2

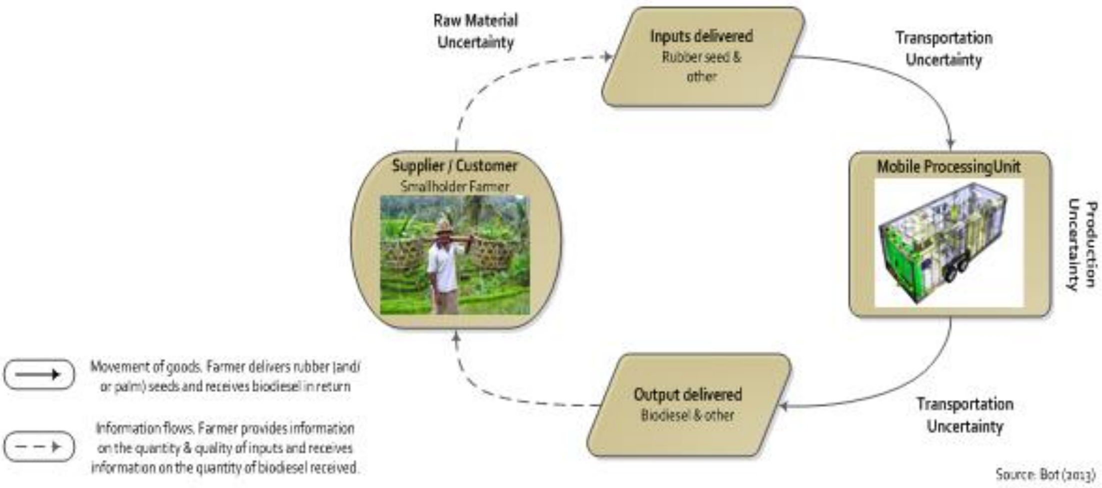
Mobile Bio-diesel processing unit (the concept)

SEE ADDITIONAL INFORMATION (last page)



3

Mobile Biodiesel Project (Concept)



4

Potential benefits for Smallholder farmers:

- Additional income from selling the bio-diesel (waste products → mobile processing unit → bio-diesel)
- Additional source of fuel for own usage
- Become partly owner (franchisee) and reap the benefits of additional learning, coaching and training: stimulate entrepreneurial activities
- Provide electricity

What do they need to do:

- Collect waste products, namely Rubber seed/ Palm seed (these products will be used in MBP processing unit)
- Dry the seeds to prevent rotting
- Learn how to mix the inputs in the MBP Processing unit and learn how to operate it

5

Uncertainties affect the success and profitability of the MBP

Raw Material Supply Uncertainty can be measured by unexpected variability in:

- Quantity of seeds delivered (due to farmer participation willingness and weather conditions which affect seed availability)
- Quality of seeds delivered
- Type of seeds delivered (rubber & palm seeds require different machine modifications and yield a slightly different biodiesel output)

Main questions to be answered:

- What is the volume of seeds (rubber and/or palm) that can be harvested in a certain region
- What is the quality of the harvested seeds (rubber and/or palm)
- How willing are smallholder farmers to collect and process these seeds
- How susceptible is the raw material supply to changing conditions (for instance changes in weather, alternative fuel prices)

6

Transportation uncertainty can be measured by:

- Unexpected delays in the delivery inputs to the mobile processing unit → difficulties in delivering other inputs to Central-Kalimantan
- Unexpected delays in the transportation of the processing unit → possibly as a result of road and weather conditions

Main questions to be answered:

- How developed is the infrastructural network in Central-Kalimantan?
- To what extent can transportation times from and to the area be reliably estimated?
- To what extent can the availability of fuel for the mobile unit be secured?

7

Production uncertainty means that:
The expected volume or quality of biodiesel cannot be produced due to:
- Breakdowns of the mobile processing unit
- Improper usage of the machine (for instance, using an inappropriate mixture of inputs)

Main questions to be answered:
- Are smallholder farmers capable and motivated to learn how to efficiently use the machine?
- Is the mobile processing unit robust enough to withstand the local conditions
- Can the input quality be estimated beforehand → in order to reliably estimate the volume of produced biodiesel

8

Cooperation between:

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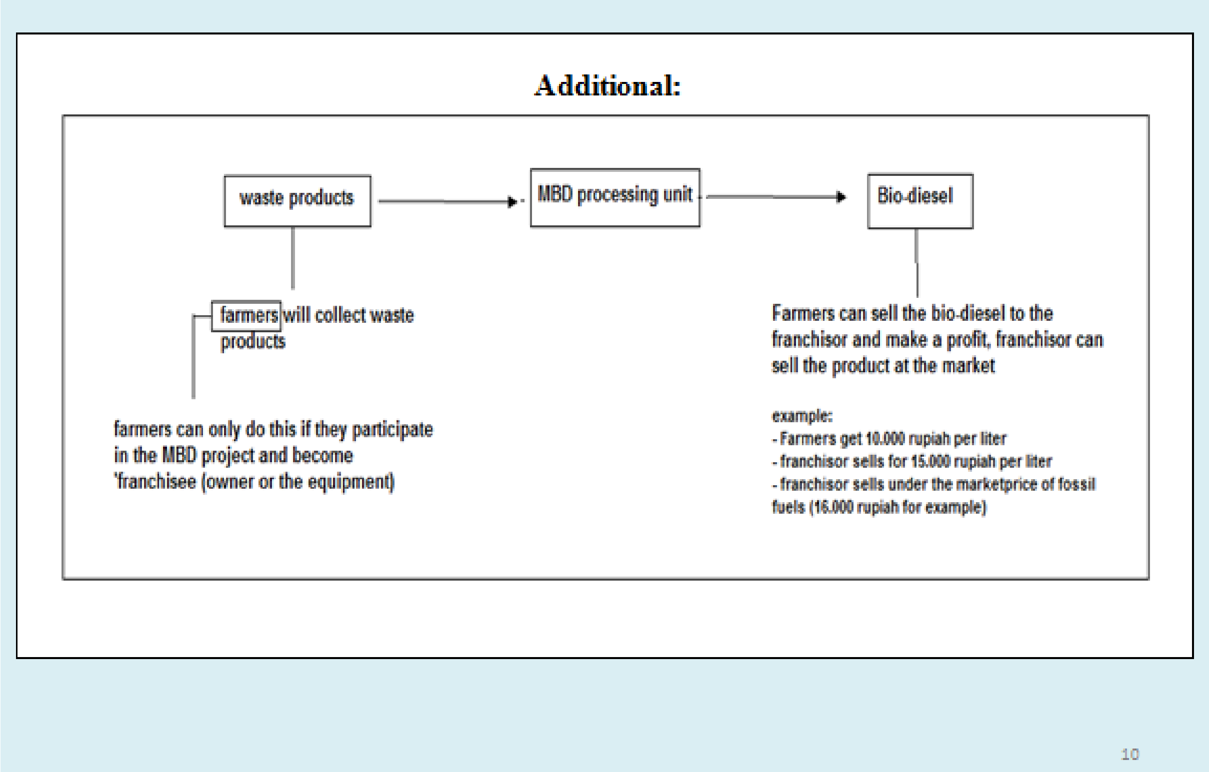
Additional:
waste products
MBD processing unit
Bio-diesel
farmers will collect waste products
farmers can only do this if they participate in the MBD project and become 'franchisee (owner or the equipment)
Farmers can sell the bio-diesel to the franchisor and make a profit, franchisor can sell the product at the market
example:
- Farmers get 10.000 rupiah per liter
- franchisor sells for 15.000 rupiah per liter
- franchisor sells under the marketprice of fossil fuels (16.000 rupiah for example)
10

Appendix D: Interview Protocol

Smallholder farmers (Main Topics):

General Situation Assessment:

1. What do you do on the land every day as a farmer?
2. Are you a member of a cooperation, work for a company/government or do you work independently?
3. If you work for a company, how do they help you (training or money for example)?
4. If you work alone, do other farmers in your village work for a cooperation?
5. Where do you sell your harvest and how far is that from your land?
6. What is the average income of people in this village?
7. What is the price of diesel in this area?
8. What do you use the fuel for and how much do you need?

Raw Material Supply Uncertainty:

Inform interviewee about the project; go through brochure page 1-6

1. How many (hectares of) rubber trees are you working on?
2. Are you harvesting rubber seeds already, and what do you do with them now?
3. How often per year can you harvest rubber seeds?
4. How many rubber seeds would you be able to collect per harvest and how variable is this?
5. What does the output primarily depend on?
6. What do you think of the MBP project (and the value it gives to your waste products)?
7. Given the explanation of the project, would you be willing to take the effort to collect and deliver the rubber seeds to the machine?
8. How long do you believe you will need to collect 1kg of rubber seeds?
9. Does the quality of the seeds go down rapidly?
10. What other plants than rubber do you harvest (e.g. palm)?

Transportation Uncertainty

Go through brochure page 7

1. What is the largest size vehicle that could travel through the MBP project area and reach your village?
2. Would it be capable of travelling through the entire region year round?
3. Does the quality of the roads vary a lot over the year (for example due to rainfall)?
4. Are their plans for the future development of the infrastructure in the region?

Production & Operations Uncertainty

Go through brochure page 8

1. What is the highest level of schooling that you received?
2. Have you ever received technical training (for example to repair engines)?
3. Is there a technician in this village?
4. Do you think you will benefit from receiving additional technical training?

Demand & Price Uncertainty

1. If you could use your rubber seeds to produce biodiesel, would you do so?
2. Would you produce solely for your own needs or would you also produce extra to sell it on the market?

Institutions (Main Topics):

General Questions:

1. What are the main characteristics of and differences between the different regions in the MBP project area, specifically with regard to economic development, education, primary source of income, infrastructure and ethnicity of the inhabitants?
2. What other biodiesel and/or local economic development projects have been conducted in this region? What was the result?
3. How is agriculture currently organized, is work done individually, through cooperations, or owned by larger investors/multinationals?
4. Where do farmers generally sell their harvest (on a local village market or on a more centralized regional market? And how are goods transported to this location?

Raw Material Supply Uncertainty

Inform interviewee about the project; go through brochure page 1-6

1. How many rubber trees are there on a hectare in different regions of the MBP project area? And how about palm trees?
2. How often can rubber seeds be harvested?
3. Under what condition do you think local farmers will be willing to take the extra effort to collect the rubber seeds and deliver them to the mobile processing unit?
4. Do you expect the willingness to depend on the direct current fuel need of the farmers? In other words, do you believe farmers have a long-term or short-term perspective when collecting seeds?
5. Do you believe the ethnicity of the farmers (Javan or Dayak) affects the farmer's perspective on this project? If yes, in what way does it influence their activities?

Transportation Uncertainty

Go through brochure page 7

1. What is the main type of road (e.g. asphalt, or dirt) in the different MBP project area regions and how dense is the road network?
2. How does this affect the transportation times through the region?
3. How often are the roads inaccessible through bad weather or other causes?
4. What is the largest size vehicle that could travel through the MBP project area regions?
5. Would it be capable of travelling through the entire region year round?
6. Are their plans for the future development of the infrastructure in the region?

Production & Operations Uncertainty

Go through brochure page 8

1. To what extent are local farmers capable of performing repairs on the mobile processing machine?
2. To what extent are local farmers capable of adjusting the settings of the machine to ensure a smooth process without breakdowns?
3. When given training, would farmers in fact use the gained knowledge or would they stick to their own beliefs and practices?

Demand & Price Uncertainty

1. How will the price of fossil fuels develop this year and the following?

2. Do you believe farmers are likely to gather seeds in excess of their personal needs to earn money by selling the biodiesel on the market?
3. Is it likely to assume that a market will arise for the rubber seeds themselves, outside their use for the MBP project?

Governmental Uncertainties

1. In what way are different governmental agencies (e.g. municipal, province, national, Bappeda) involved in the development of this region?
2. How will the government subsidy on fuel change in the future and how does his affect the price of regular gas in Central-Kalimantan?
3. What is the government policy on biodiesel production and what are the expectations for the future?

Appendix E: Data Analysis

Road development programs Central-Kalimantan

Source: Bappeda (2013)

Focus	Program / Activity	Location	Volume	Target / Objective	Target Completion 2013	2014	2015	2016	2017
Growth Centers Road Development	Completion of the Southern Cross	Batas Kalbar - Pangkalan Bun - Sampit - Palangka Raya - Pulang Pisau - Kuala Kapuas - Batas Kalsel	819,488 Km	Widening 6 meter		45,1 Km	72 Km	64 Km	64 Km
				Periodic		111,19 Km	39,41 Km	34,15 Km	34,15 Km
	Central Crossing	Ruas Tb. Samba - Rabambang - Tb. Jutuh - Tewah - Kuala Kurun - Sei Hanyu - Tb. Lahung - Sp. Muara Lahung	805,515 Km	Structural Improvement		174,75 Km	140 Km	141,47 Km	141,47 Km
	Improving/Establishing Connections	Ruas Tb. Talaken - Takaras - Sp. Sei Asam, Batas Kota Pangkalan Bun - Kumai, Ampah - Dayu - Tamiang Layang - Pasar Panas - Batas kalsel	292,392 Km			198,77 Km	198,77 Km	198,77 Km	198,77 Km
	Support for the MP3EI Program	Ruas Jalan Sampit - Samuda - Ujung Pandaran - Pelabuhan - Bagendang, Pangkalan Bun - Kumai - Pelabuhan Pelindo, Pulang Pisau - Pangkoh - Bahaur - Menuju Pelabuhan	212,20 Km	Widening Roads		10,25 Km	10 Km	9 Km	9 Km
				Structural Improvement		24,6 Km	24,6 Km	24,6 Km	24,6 Km
	National Strategy for Accelerated Developmend of Roads	Ruas Jalan Kalahien - Buntok - Ampah, Batas Kalbar - Tumbang Samba	270,59 Km			15 Km	15 Km	15 Km	15 Km
				Structural Improvement		38,5 Km	38,5 Km	38,5 Km	38,5 Km

Table 6: Road Development Programs 2013-2017 (Source: Bappeda, 2013)

Fuel Quota In Number of Kilo Liter (KL) per Year			
Year	Premium (Gasoline)	Solar (Diesel)	Quota Percentage of Previous Year
2013 (Proposed)	539.820	226.532	120%
2013 (Realized)	449.850	188.777	

Table 7: Fuel Quota Central-Kalimantan (Source: Adapted from MATRIK Konektifitas-Energi - Bappeda, 201

US$/Barel

Crude Oil Type	2004	2005	2006	2007	2008	2009	2010	2011	2012
SLC	36,30	53,92	64,24	72,94	99,90	64,14	81,44	113.63	120.59
Arjuna	36,90	55,07	65,52	72,38	97,61	61,18	78,91	112.47	116.82
Arun Condensate	37,40	54,62	64,85	72,94	94,27	60,33	78,76	109.02	111.28
Attaka	37,60	57,51	67,59	75,69	101,03	62,74	80,75	114.38	119.24
Cinta	35,00	51,81	61,77	70,33	94,58	59,74	77,02	110.50	118.10
Duri	30,40	46,62	54,93	59,89	84,57	55,12	75,07	107.57	117.19
Handil Mix	37,10	55,23	65,67	72,53	97,77	61,33	79,06	112.62	116.97
Lalang	36,40	53,13	64,29	72,99	99,95	64,19	81,49	113.68	120.59
Widuri	35,00	51,19	61,94	70,41	94,98	59,72	77,12	110.55	118.49
Belida	37,30	56,54	67,56	75,71	101,05	62,30	80,75	114.14	119.42
Senipah Condensate	39,95	54,62	65,57	73,03	94,27	60,33	78,76	109.02	111.28
Average[1)]	36,39	53,66	64,27	72,31	96,13	61,58	79,40	111.55	117.28

Sumber : DJ Migas, Diolah Pusdatin * Data Semester 1 2012

[1)] Average merupakan nilai rata-rata seluruh jenis minyak Indonesia

Table 8: Development of Crude Oil Prices 2004-2012 (Source: Ministry of Energy & Mineral Resources, provided by Bappeda, 2013)

CENTRAL GOVERNMENT EXPENDITURE, 2007–2013

(in billions rupiah)

Item	2007	2008	2009	2010	2011	2012	2013
	Audited	Audited	Audited	Audited	Audited	Revised Budget	Budget
1. Personnel Expenditure	90,425.0	112,829.9	127,669.7	148,078.1	175,737.9	212,255.1	241,606.3
2. Material Expenditures	54,511.4	55,963.5	80,667.9	97,596.8	124,639.5	162,012.3	200,735.2
3. Capital Expenditures	64,288.7	72,772.5	75,870.8	80,287.1	117,854.5	176,051.4	184,363.5
4. Interest Payment	79,806.4	88,429.8	93,782.1	88,383.2	93,262.0	117,785.4	113,243.8
a. Interest of Domestic Debt	54,079.4	59,887.0	63,755.9	61,480.6	66,824.9	84,749.3	80,703.3
b. Interest of Foreign Debt	25,727.0	28,542.8	30,026.2	26,902.7	26,437.1	33,036.1	32,540.5
5. Subsidy	150,214.5	275,291.4	138,082.2	192,707.1	295,358.2	245,076.3	317,218.6
a. Energy	116,865.9	223,013.2	94,585.9	139,952.9	255,608.8	202,353.2	274,743.0
b. Non Energy	33,348.6	52,278.2	43,496.3	52,754.1	39,749.4	42,723.1	42,475.6
6. Grant Expenditures	-	-	-	70.0	300.1	1,790.9	3,621.3
7. Social Assistance	49,756.3	57,740.8	73,813.6	68,611.1	71,104.3	86,028.0	73,608.8
a. Natural Disaster Rescue	1,888.9	2,939.8	2,223.6	2,681.0	3,978.3	4,000.0	4,000.0
b. Ministry/institution Assistance	47,867.4	54,801.0	71,590.0	65,930.1	67,126.0	82,028.0	69,608.8
8. Other Expenditures	15,621.2	30,328.1	38,926.2	21,673.0	5,465.4	68,535.0	19,983.4
Total	504,623.4	693,356.0	628,812.4	697,406.4	883,722.0	1,069,534.4	1,154,380.9

Table 9: Government expenditures 2007-2013 (Source: Ministry of Finance - Republic of Indonesia)

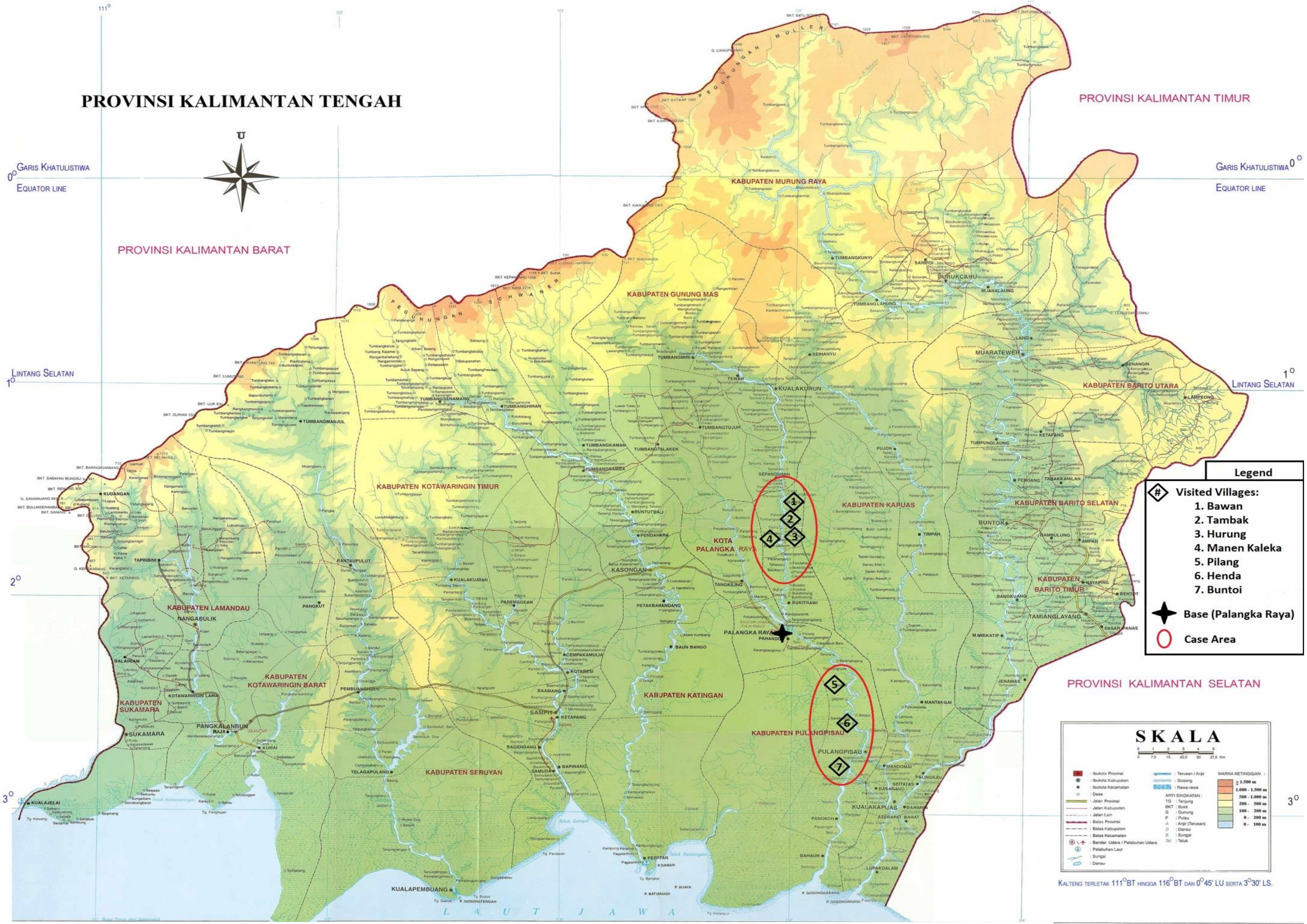

Figure 15: Map Central-Kalimantan including case areas (Source: Interview Holland, 2013)

	Scenario 1: Estimated Maximum*	Scenario 2: Estimated Minimum**	Scenario 3: Estimated Realizable 'Kebun Karet' Production***
Weight Rubber Seed	7	4	5
Number of Harvests Per Year	1	1	1
Number of Harvestable Seeds Per Tree	1000	100	400
Number of Trees Per Hectare	1000	300	500
Volume of Rubber Seeds Per Hectare Per Farm	7000	120	1000
Average Farm Size (Ha)	3	1	2
Volume of Rubber Seeds per Harvest per Farm	21000	120	2000
Crude Oil Yield as Percentage of Seed	20%	20%	20%
Crude Oil Yield Per Farm Per Year in Kilograms	4200	24	400

* Based on the assumptions that a farmer indeed has 1000 trees which all carry 1000 seeds and are capable of harvesting all. Moreover, the maximum seed weight as estimated by Widyarani (Interview, 2013) is used.

** Minimum oil yield for participating farmers. Based on the assumptions that a seed has the minimum weight estimated by Widyarani (Interview, 2013), trees only carry 100 seeds (e.g. young or very old trees) and the number of harvestable trees is limited. Moreover, using the assumption that farmers are only capable of harvesting seeds from 1 hectare of their land.

*** Based on the average seed weight estimation of Widyarani (Interview, 2013) and the most commonly stated tree, seed and average farm size numbers.

Table 10: Biomass supply Scenarios (Source: Interviews & Observations in Both Cases)

Appendix F: Mining & Forestry Case

The lack of governmental integration is illustratively represented by the miscommunication between the Department of Forestry and the Department of Mining of the province of Central-Kalimantan, as described by a REDD+ representative (Interview Migo, 2013).

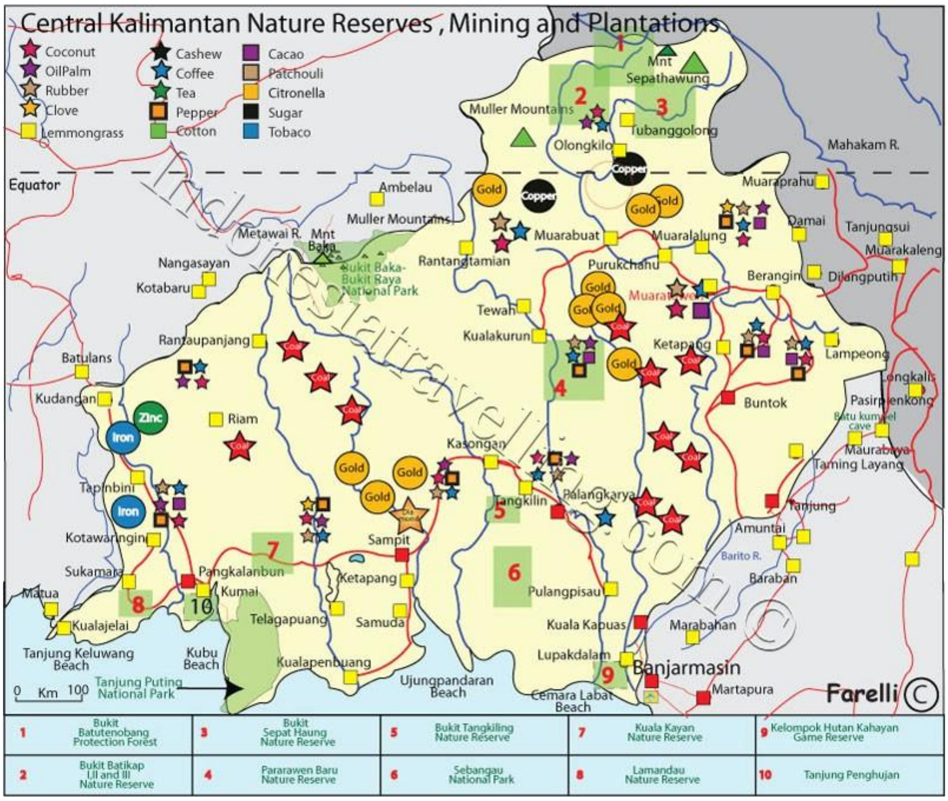

Figure 16: Central-Kalimantan Natural Reserves, Mining and Plantations (Source: Indonesiatravelling.com, 2013)

As the map above (figure 19) shows, both mining activities as plantations take place in the various areas of Central-Kalimantan. Notably, while the gold mining activities presented in figure 19 are legally registered enterprises, small-scale illegal gold mining activities take place throughout the region (Field research Hurung, 2013).

The presence of gold and coal in the province spurs requests by both regional as national firms to obtain a permit to excavate these natural resources. The processing of the mining permit applications falls under the jurisdiction of the Department of Mining of the province of Central-Kalimantan.

Additionally, many organizations among which the WNF, REDD+, and The Indonesia-Australia Forest Carbon Partnership focus on preserving the rainforest and replanting those areas which have been destroyed by fire or (il)legal logging (Interview Dowson-Collins, 2013; Interview Migo, 2013). The regional zoning with regard to forestry is the responsibility of the Department of Forestry.

Given the difference in objectives, both of these departments apply different zoning plans of the province. A severe conflict arises here through the lack of integration and communication between the two departments. As Pak Migo describes it: “*while the Department of Forestry assigns an area as* *forest land, this is poorly communicated to the Department of Mining, which subsequently grants companies a permit for mining activities"* (Interview Migo, 2013). Moreover, as mining companies consider trees on top of the mines are "*inconvenient"* (Interview Migo, 2013), a mining permit additionally allows them to cut the trees on top of the mining site.

Thus, the lack of communication and integration between governmental departments at a regional level, decisions are made at cross purposes. Several interviewees (Interview Migo, 2013; Interview Dowson-Collins, 2013) indicate that this causes conflicts between organizations about the validity of the permits or zoning allocations. Eventually, most of these conflicts are settled in court and result in the nullification of one of the party's permits or a change in the area's zoning. The potential for these type of conflicts, which not only arise solely between these two departments (Interview Migo, 2013), is a source of governmental uncertainty.