VCA4D
VALUE CHAIN ANALYSIS FOR DEVELOPMENT

agrinatura for European Commission

# Cocoa value chain analysis in Papua New Guinea


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The information and knowledge produced through the value chain studies are intended to support the Delegations of the European Union and their partners in improving policy dialogue, investing in value chains and better understanding the changes linked to their actions

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## ACRONYMS

| | |
|---|---|
| ACIAR | Australian Centre for International Agricultural Research |
| AROB | Autonomous Region of Bougainville (province) |
| AT | Archetype (1/2/3) of cocoa grower |
| CB | Cocoa Board of Papua New Guinea |
| CCI | Cocoa Coconut Institute |
| CPB | Cocoa Pod Borer |
| DB | Dry Bean (of cocoa) |
| DLIR | Department of Labour & Industrial Relations |
| DIS | Delivered-in-store |
| ENB | East New Britain (province) |
| ESP | East Sepik Province |
| EU | European Union |
| FOB | Free-on-board |
| FT | Fair Trade (certification) |
| GDP | Gross Domestic Product |
| IC | Intermediate consumption |
| ILG | Incorporated Land Group |
| ILO | International Labour Organisation |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| LUC | Land Use Change |
| MOMASE | Morobe-Madang-Sepik (provinces) |
| PGK | Papua New Guinea Kina |
| PMV | Public motor vehicle |
| PNG | Papua New Guinea |
| PPAP | Productive Partnership in Agriculture Project |
| RA | Rainforest Alliance (certification) |
| SABL | Special Agricultural and Business Lease |
| SG (1-2) | Seed Garden (cocoa hybrid) |
| SOC | Soil Organic Carbon |
| VA | Value Added |
| VCA | Value chain analysis |
| VCA4D | Value Chain Analysis For Development |
| WB | Wet Bean (of cocoa) |

# EXECUTIVE SUMMARY

## Overview of the cocoa industry in Papua New Guinea

Cocoa production has two important advantages for a country like Papua New Guinea (PNG). On the one hand, it provides activity and income to the rural population, which remains predominant throughout the country. According to the 2000 National Population Census, cocoa producing households represented 31% of households in the cocoa producing regions and 16% of the total number of PNG households. This represented approximately 151 000 households. This primary cash crop was grown on an estimated 130 000 ha in 13 coastal provinces either as a mono-crop or intercropped with coconuts or food crops.

On the other hand, cocoa exports provide tax revenues to the state. Since the 1950s, the promotion and uptake of export cash crops like cocoa, coffee and more recently oil palm have been viewed as the principal way to initiate rural development in PNG and to generate tax revenues through exports.

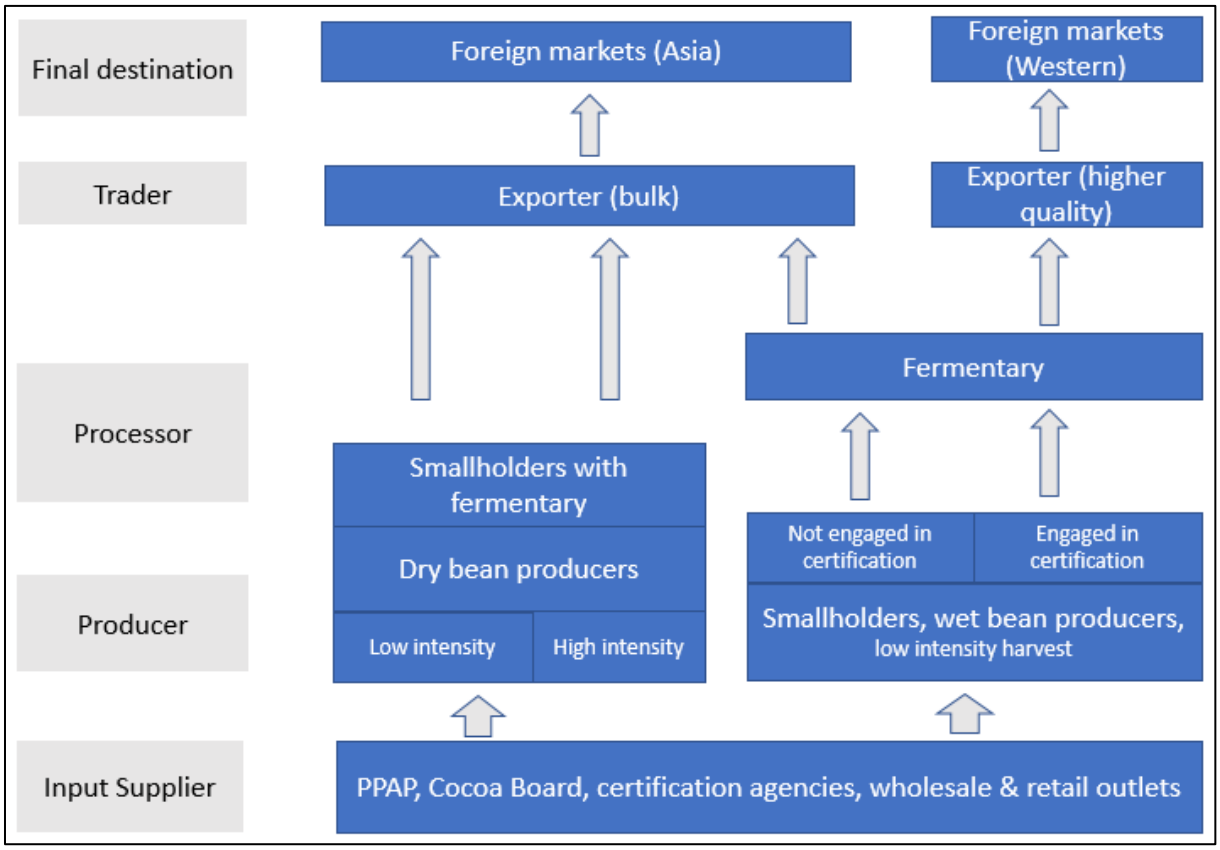
However, despite the political and financial support given to cocoa production during the latest decades, the performance of this industry has decreased by 20% since 2008, with only 40 000 tons exported in 2016. This trend is mainly due to the appearance of the Cocoa Pod Borer (CPB) (*Conopomorpha cramerella*) in PNG in 2006 and its devastating effect on the cocoa yields. Since the incursion of CPB, many smallholders have either abandoned or partially abandoned their cocoa holdings. The abandonment of cocoa production can be largely explained by highly labour intensive farm management techniques required to contain the pest.

In addition to the decrease in the quantity of cocoa produced, the quality of this product has also decreased in PNG. The main reason for the decline was the emergence of smallholders after the downturn of the plantation-based industry. Many smallholders have not maintained fuelwood or diesel drying-kilns well, so that the smoke comes into contact with the beans, replacing many of the desirable characteristics of PNG cocoa with an overwhelming smoky taste.

Significant work is being done to reverse these trends and the cocoa industry is seen as a promising source of development in PNG. The cocoa chain is supposed to contribute to shift from an economy that is currently dominated by the mining and energy sectors to one that is dominated by agriculture, forestry, fisheries, eco-tourism and manufacturing in 2050. However, all the predictions made by the administration on the growth of the cocoa industry have systematically proved too ambitious. The Cocoa Board targets of 200 000 tonnes over the next five years and of 310 000 tons in 2030, which seem hardly achievable in the light of the evolution of the sector over the past fifteen years. More realistically, under the current trends, the cocoa industry would likely grow to 60 000 metric tons in the next five years, with a maximum of 100 000 metric tons with major interventions.

## Functional analysis of the cocoa chain

A simplified image of the cocoa commodity chain in PNG was developed to focus on the main actors of the value chain. This simplified representation of the commodity chain covers 97% of cocoa production in PNG and almost all the people involved in this industry. It contends five operating levels, as depicted below.




There are two categories of suppliers for cocoa producers in PNG. On the one hand, these actors purchase a number of goods necessary for their work from retail or wholesale traders. These goods are the subject of a commercial transaction. On the other hand, small producers receive free and subsidized support from external operators, either from the Cocoa Board that is represented in all provinces to promote the development of the cocoa industry, or from the World Banks' project PPAP to increase the performance and the sustainability of value chains in cocoa-producing areas.

Three archetypes of cocoa producers were established, based on the available data from literature and from the field:

- Subsistence-oriented wet bean producers, who implement a low input strategy and sell wet beans to fermentary owners. A minor part of the producers is committed in a certification approach: they are a bit more efficient and get better price for their products.
- Subsistence-oriented dry bean producers, who adopt a low input strategy to grow cocoa but have easy access to low-quality fermentaries.
- Business-oriented dry bean producers, with three characteristics: (1) they resolutely engage in a strategy of high input farming in their plantations, which generate significant

productivity gains; (2) wet beans are transformed into dry beans thanks to easier access to fermentaries; (3) the production of dry beans is systematically sold to exporters to get a high price.

The main technical characteristics of the three producer categories are summed up in the table below.

| | Subsistence-oriented and low/moderate intensity input | | Business-oriented and high intensity input |
|---|---|---|---|
| Main characteristics | 1. Wet bean producers | 2. Dry bean producers (with fermentaries) | 3. Dry bean producers (with fermentaries) |
| | Dominant East Sepik (and Momase) | Dominant ENB and AROB | Present in ENB and AROB |
| Average surface (ha/HH) | 0.6 | 1.00 | 0.75 |
| Average yield of wet beans on a 8 year production phase (kg/ha/yr) | 857 | 950 | 4000 |
| DB Yield (kg/ha/yr) | 300 | 380 | 1600 |
| Pesticide and fertilizer inputs | none | none | Moderate or none |
| Road access | poor / not accessible | accessible to some extent | accessible |
| Cocoa varieties | Trinitario and hybrids SG | Hybrids (and some clones) | Hybrids and clones |
| External support | low with Cocoa Board | moderate with PPAP | high with PPAP |
| Number of households | 102 455 | 42 874 | 2 914 |
| Total surface of active production (ha) | 61 473 | 42 874 | 2 186 |
| Total production (t/yr) | 18 441 860 | 16 292 120 | 3 496 800 |

*MAIN CHARACTERISTICS OF COCOA PRODUCER'S ARCHETYPES*

The Cocoa Board enumerated 19 610 fermentaries nationwide in 2017, with 72% being unregistered. As a whole, around 40-50% are not active. Fermentaries are not evenly distributed among the cocoa-producing provinces since East New Britain and Bougainville experienced massive subsidy programs for fermentaries since the 1980s. The number of fermentaries in a province influences the strategy of dry bean production: a high number of fermentaries reduces the utilization rate of the fermentaries and consequentially, most fermentaries are not properly maintained, which reduces the quality of the cocoa bean.

Historically, there are about fifteen companies that export cocoa. The NGIP-Agmark company has dominated this sector for several decades but it must face the recent rise of Outspan, a subsidiary of the Olam group. These two companies now export 75% of the cocoa production made in PNG. All these companies provide at least the function of shipping cocoa containers to foreign markets. Medium- and large-size companies also provide logistical functions by establishing branches in several PNG locations and having a small fleet of vehicles to reach fermentaries. All these

companies only buy dry beans and do not have fermentation or drying equipment, except Agmark that does process wet beans in Kokopo besides purchasing dry beans from farmers. Agmark and Outspan have also developed many extension services to smallholders or by proposing a certification process.

As a whole, the cocoa value chain in PNG is relatively simple and is characterized by two commodities (dry versus wet beans) and two export (bulk versus certified markets) chains. The first characteristic of this industry is to be almost entirely oriented towards the export of little processed products. The small domestic market restricts the opportunities to add value by processing a primary product into a marketable product such as making chocolate for local sales.

Both the Cocoa Board (CB) and the private sector are promoting the business-oriented model and the parallel development of private certification. It has resulted in the creation of two classes of smallholders. On the one hand, a majority of smallholders produce small quantities of low quality beans, due to low harvesting rates in plantations and/or difficult access to fermentaries in good condition. On the other hand, a minority of producers benefit from significant support from the Productive Partnership in Agriculture Project (PPAP) and the private sector to greatly increase the yield of their plantations or to produce good quality beans - notably without smoky taint. Given the small number of producers now applying these improved practices, and under the assumption of the continuation of external aid, it will still be many years before there is a substantial increase in volume and an overall improvement in the quality of beans made in PNG.

## 1.1 Is the PNG cocoa chain sustainable?

### 1.1.1 FQ1. What is the contribution of the Value Chain to economic growth?

#### *CQ1.1. How profitable and sustainable are the Value Chain activities for the entities involved?*

The production and trade of cocoa in PNG appear to be profitable activities. The average net profit rate is 30% at the chain scale. And the more upstream in the value chain, the higher the profit, except for the subsistence-oriented dry bean producers. This is due to: (1) the very high ratio - around 80% - between the DIS purchase price to national producers and the FOB selling price in the international market; (2) the informal nature of a large part of cocoa bean production, which makes it possible to limit the cost of intermediate consumption and wages.

The certified-cocoa chain has slightly better financial performance than the uncertified sub-chain, in particular because of a better purchase price and logistical conditions. This is especially true for fermentary owners who also benefit from subsidies to establish and maintain their equipment.

Nevertheless, the high financial profitability of the cocoa industry is heavily dependent on three factors: (1) access to free labour, which constitutes a major cost that was not taken into account in our analysis; (2) subsidies received by several stakeholders; (3) exogenous variation in the price of cocoa on the international market, on which PNG has no influence.

### *CQ1.2. and CQ1.3. What is the contribution of the Value Chain to the GDP? What is the contribution of the Value Chain to the agriculture sector GDP?*

The cocoa industry generates a direct gross VA of 5 382 PGK per tonne of dry beans, which is also partly explained by the low weight of intermediate consumption (non-existent or subsidised) in the operating accounts of small producers. However, it is possible to estimate the indirect value added of the cocoa commodity chain from its links with other productive sectors of the PNG economy through the use of intermediate goods and services. Beyond its direct VA, the cocoa industry generates an indirect VA of around PGK 30 billion, i.e. a surplus of 15%. In total, the cocoa industry generates a direct and indirect VA of about 236 million PGK per year, which represents a direct contribution of around 3.78% to the GDP and a contribution of 20% to the VA of the agricultural sector (itself contributing 18.8% to the GDP). This ratio was 14% in 2006 for the direct VA only, which indicates a slight progress in the cocoa industry since then.

### *CQ1.4. What is the contribution of the VC to the public finances?*

The impact on public finances is estimated by comparing the amount of national government subsidies received by the cocoa industry and the amount of taxes generated by this value chain in PNG.

Total direct and secondary taxes amount to PGK 15 273 896 per year.

Smallholders and processors do not directly receive national subsidies but some public funds are used by the CB, PPAP and companies promoting certification to improve their practices. Among these supporting organisations, only the CB uses public funds from PNG, which can therefore be assimilated to a grant. The annual budget of the CB was 17 million PGK in 2016.

Overall, the tax/subsidy ratio stands at 90%, indicating a public finance deficit for the cocoa industry. This result is mainly due to the informal nature of a large part of cocoa production and the low level of export taxes. It is also explained by the choices of the government to favour the increase in rural incomes and to strengthen the price competitiveness of PNG cocoa on the international markets by weakly taxing the exports.

### *CQ1.5. What is the contribution of the VC to the balance of trade?*

The impact on the Balance of Trade is estimated by comparing the amount of exports of the cocoa industry with that of imports generated by this industry. Cocoa exports amounted 256 137 340 PGK in 2016. This commodity contributes 0.8% to PNG's exports, based on the Balance of Trade.
Imports attributable to the cocoa industry are derived from the calculation of the indirect effects of the sector. They represent 20 150 717 PGK in 2017, or about 0.15% of the total value of PNG imports estimated at 13.1 billion in 2016.

The cocoa sector therefore contributes very favourably to the trade balance, with a surplus of about PGK 236 million per year.

#### *CQ1.6. Is the VC viable in the international economy?*

Two main factors prevent the prices of goods and services used by the cocoa industry from being considered as reference prices of a pure and perfect competitive economy. On the one hand, goods and services imported into PNG or exported are submitted to various taxes and fees. On the other hand, many producers and fermentary owners benefit or have benefited from CB and PPAP support to carry out their activities. These subsidies can be substantial and sometimes greatly reduce the price of many material inputs (seedlings, equipment...) and real estate (fermentaries). We have therefore eliminated these subsidies, which increases the price of most equipment by 10-20%.

The application of these two international parity pricing processes makes it possible to calculate the economic performance of the cocoa value chain on the basis of reference prices and to compare them with those previously evaluated with current market prices. Several criteria show the relatively low efficiency of the PNG cocoa chain in the international economy.
On the one hand, the Domestic Resource Cost criterion is set at 0.53, which indicates that the value created is superior to the domestic goods and services involved in the value chain. This constitutes a benefit for the national economy. On the other hand, a Profitability Coefficient of 0.205 shows that the profitability of this sector could highly increase if producers accessed imported goods at their international prices and if export fees were removed.

### 1.1.2 FQ2. Is this economic growth inclusive?

#### *CQ2.1. How is income distributed across actors of the VC?*

The wet bean producers and the subsistence-oriented producers of dried beans (around 139 000 households) are the main beneficiaries of the revenues generated by the cocoa industry in PNG. Because of their number and the financial profitability of their activity, these two groups of actors make 38% of the total profit and receive 64% of labour remuneration. They also generate more than 64% of the total direct VA of the PNG cocoa chain.

The very favourable distribution of cocoa revenues to smallholders is explained by a very high ratio - around 80% - between the DIS purchase price to national producers and the FOB selling price in the international market.

From a macroeconomic point of view, such results would suggest that cocoa production is a financially attractive option for local populations in PNG. But from a microeconomic point of view, cocoa production is small in volume and a moderate source of income for a large majority of rural households. This crop is a subsistence strategy for most smallholders, where investment in the resource is low; moreover, yields and production levels can be expected to decline over time. Few of them have made the effort today to opt for a business orientation or to engage in a certification process and it is likely that many smallholders do not have the means or the will to improve their management systems even in the long term.

From a social perspective, many communities in PNG exhibit a marked preference for collectively accessible and inclusive development, in which activities that benefit specific stakeholders while

excluding others may become a risk for community cohesion. Individual entrepreneurial success, for example, often needs to be carefully negotiated as part of wider social relations in PNG, and likely involves local redistribution of benefits.

### *CQ2.2. What is the impact of the governance systems on income distribution?*

A feature of the cocoa industry in PNG is that marketing functions are carried out entirely by the private sector, and mainly by two companies. Their objective is to increase the traded volume and, to a certain extent, to improve the quality of the product in order to obtain a better price on the international market. This objective explains, on the one hand, that most exporting companies have developed direct relations with producers, by reducing the intermediate levels that would increase the cost of the product. The cocoa sector is composed of a small number of organizational levels, although the country is geographically fragmented and rural areas are often difficult to access. On the other hand, despite the near duopoly situation of Agmark and Oustpan, the price offered to dry beans producers remains attractive.

### *CQ2.3. How is employment distributed across the VC?*

First, employment is generally associated with full-time salaried jobs. If the positions offered by administrations and international projects are excluded, only export companies provide full-time salaried jobs for the majority of their staff. This wage employment has declined since the mid-2000s to around 300 people at present - excluding workers employed in the remaining large-scale plantations.

All companies also rely on casual staff during periods of intense activity, who work from a few days to a few months a year under a formal contract. This type of part-time employment concerned around 200 people in 2017.

Most of the work done by the cocoa industry is in fact in the informal economy and involves three categories of workers. First of all, there are about 150 000 households who benefit directly from the exploitation, processing or sale of cocoa. This profit can in reality be assimilated at least partially to a form of salary because these smallholders do not remunerate themselves for their work. However, these 150 000 smallholders do not rely solely on their labour force to conduct their activity and resort to two types of workers:

1. they pay local workers, especially during harvesting periods, and this cost exceeds PGK 21 million nationally. At 22 PGK per working day and 280 working days per year, this sum represents the equivalent of 3500 full-time jobs;
2. but most of the production activities - between 75% and 90% according to our assumptions - are carried out by members, friends and relatives of the household without payment. Self-employment would then be equivalent to 14 000 full-time jobs. It represents the most important production factor to grow cocoa in PNG.

### 1.1.3 FQ3. Is the PNG cocoa value chain socially sustainable?

#### *CQ3.1 Are working conditions throughout the VC socially acceptable and sustainable?*

Overall, working conditions in the value chain may be cautiously deemed socially acceptable and sustainable. PNG has ratified the 8 fundamental ILO conventions, although national labour legislation is still being reviewed towards better alignment with ILO conventions. Workers' rights in terms of fair and enforceable contracts, effective collective bargaining, and job safety, remain relatively weak. This assessment is not limited to the cocoa value chain. Companies involved in the cocoa value chain appear to respect national labour legislation, especially in relation to minimum wage regulations. Child labour is no major issue in the cocoa value chain in PNG.

Cocoa provides an attractive activity in smallholder production and informal rural labour arrangements, especially in view of little available income alternatives. Labour recruitment is mostly limited to household members and is based on notions of relatedness and reciprocal obligation when extending beyond the household. There are thus limitations for work opportunities in smallholder cocoa production. The attractiveness for the allocation of labour by women and youth in the household often depends on the remuneration and income distribution from cocoa sales by male household heads. A households' relative focus on cocoa is also determined by sales price fluctuations and relative attractiveness compared to alternative activities.

#### *CQ3.2. Are land and water rights socially acceptable and sustainable?*

The existing legal framework in PNG that acknowledges customary land ownership provides challenges (especially for external investment and credit access) but is arguably the best guarantor for equitable tenure rights and access to land in practice. This is due to the numerous access paths to local and temporal usufruct rights in the context of often multi-layered and sometimes overlapping ancestral land rights claims. Formalisation of tenure rights (in contrast to local and informal customary rules) risks introducing a new exclusivity of tenure rights and may in practice complicate access paths for more vulnerable groups and individuals.

The Voluntary Guidelines on the Responsible Governance of Tenure play no apparent role in PNG. While not applicable to the cocoa value chain in its current configuration, transparency, participation and consultation, equity compensation and justice are often inadequate in large scale agribusiness projects in PNG.

#### *CQ3.3. Is gender equality throughout the VC acknowledged, accepted and enhanced?*

More needs to be done to acknowledge, accept and enhance gender equality in the cocoa value chain in PNG. Gender equality constitutes a major challenge in PNG generally, and this is no exception in the cocoa value chain. Women are not per se excluded from specific segments in the cocoa value chain but are generally in subordinate positions in relation to decision-making, participation, control over income, and access to resources and services. Women are also strongly underrepresented in positions of leadership, both in producer organization of the cocoa value chain, and business and political leadership at large. Cocoa, as other perennial cash crops, is commonly regarded as a 'male' crop and men often retain control over major income derived from cocoa. While increased income from cocoa may in general be expected to significantly contribute

to improving women's situation overall, there may remain a residual risk that intensification of cocoa will require more labour input by women while men retain control over income. There is a tendency for increased intra-household cooperation in tasks traditionally associated with gender based labour division, overall workloads may not be regarded equal, however. Innovative approaches may be required to enhance gender equality in the cocoa value chain.

### *CQ3.4. Are food and nutrition conditions acceptable and secure?*

Food security can be deemed generally high in PNG, although with local variations. Areas in which cocoa is a major cash crop are less at risk of long term food insecurity through cash income derived from cocoa. Challenges remain especially with adequate nutrition through diets based on staple crops rich in carbohydrates. Cash income from cocoa can be expected to alleviate challenges associated with nutritional diversity, although more awareness and attention especially to nutritionally adequate diets for children may be required. There are risks to food security and nutrition through adverse weather patterns associated with El Niño phenomena, including severe droughts. Cash income and access to markets are arguably the most effective mitigating factors of risks to food supply in times of droughts that affect subsistence crops.

### *CQ3.5. Is social capital enhanced and equitably distributed throughout the VC?*

A variety of producer organisations are active in the cocoa value chain, although with regional variations and with mixed success. Many cooperatives face challenges to their sustainability based on inadequate knowledge and skills in cooperative management and lack of support or conducive relations with government institutions, where applicable.

Farmers struggle to cope with the Cocoa Pod Borer and often lack knowledge about managing the pest, especially outside East New Britain and Bougainville where exporters and PPAP have been active for longer in promoting relevant knowledge.

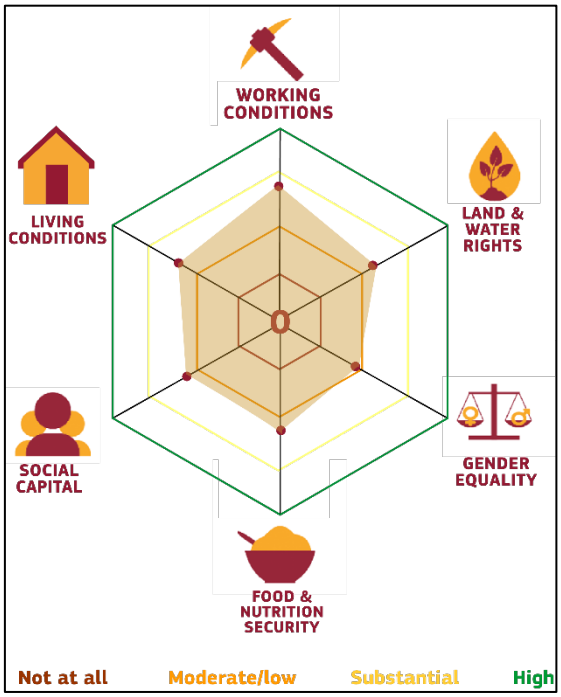
Lack of trust is a recurring theme in the cocoa value chain in interaction with different stakeholders. Lack of trust inhibits, for example, closer links between exporters and producers through the advance of services. Lack of trust also generally affects interaction between government, public service, and smallholders, and can negatively interfere in the establishment and operation of cooperatives among smallholders. While communities are highly autonomous in determining their livelihood strategies, within the structural constraints, there is often an insufficient involvement of communities in political and administrative planning processes that affect communities.

### *CQ3.6. To which standards are major social infrastructures and services acceptable and do the VC operations contribute to improving them?*

Availability, access and cost of health services generally cannot be deemed satisfactory in PNG. Housing and accommodation are less of a pressing concern in rural PNG. Access to primary education is generally good, but limitations for access increase with higher levels of education, especially tertiary education and training. Income from cocoa is a major contributor to households' access to healthcare and education in particular. Other notable challenges concern lack of

maintenance and limited reach in transport infrastructure, and widespread absence of financial services in rural areas. There is no direct contribution from cocoa value chain operations to improve these social infrastructures and services in PNG.

All these various social impacts of the cocoa chain in PNG are recapitulated in the graph below.




*SYNTHESIS OF SOCIAL IMPACTS*

### 1.1.4 FQ4. Is the PNG cocoa value chain environmentally sustainable?

*What are the most relevant environmental impacts of the current value chain of cocoa cultivation to export of dried beans in PNG?*

This life cycle assessment showed that the major environmental impacts are climate change due to land use changes and nitrogen losses, and land occupation for all three archetypes. These environmental impacts occur during the cultivation phase. The following phases in the value chain, fermentation & drying and transport & export, have comparatively low impacts. Impacts are summarized in the table below.

*CQ4.1 What is the potential impact of the VC on resource depletion?*

Fossil resource depletion is much larger than mineral resource depletion and is caused most predominantly by fuel use for transport of agricultural inputs into the cultivation areas and dried beans out of these areas.

*CQ4.2 What is the potential impact of the VC on ecosystem quality?"*

The most important impacts on ecosystem quality are the biodiversity loss due to land occupation, and to a lesser extent climate change impacts. For archetype 3 the toxicity impacts from insecticide use play a minor additional role. Several impacts on biodiversity, such as disturbance and infrastructure, are not included in Life Cycle Assessment.

### *CQ4.3 What is the potential impact of the VC on human health?*

The most important impacts on human health are climate change, and to a lesser extent fine particulate matter formation.

| Primary impacts | Climate Change | | Land Use |
|---|---|---|---|
| Impact Area | Human Health | | Ecosystems |
| Supply Chain Phase | Cultivation | | |
| Cause | Land Use Change | Nitrogen Cycle | Land Occupation |
| Recommendation | Prevent expansion; Improve yield on existing area | Improve yield, by reducing pest levels | |
| | | | |
| **Secondary impacts** | **Toxicity** | **Fine Particulate Matter** | **Fossil Resource Depletion** |
| Impact Area | Ecosystems | Human Health | Resource Depletion |
| Supply Chain Phase | Cultivation | Fermentary | Inputs & Transport |
| Cause | Insecticides | Wood fire | Fuel use |
| Recommendation | IPM | Fuel Efficiency | Improve yield; keep production centralized |

*QUALITATIVE SUMMARY OF ENVIRONMENTAL IMPACTS OF COCOA VALUE CHAIN IN PNG.*

Wet bean yield is the most influential parameter for the major environmental impacts, with the land conversion fraction and $N_2O$ emissions on a second place. These parameters are highly variable across PNG and within cultivation regions. This variability, along with methodological and value uncertainty, contribute to a clear overall uncertainty of the quantitative research results and at the same time points towards improvement opportunities because best practices are available. Land use dynamics are complex and Life Cycle Assessment takes a simple but balanced approach. It is unlikely that cocoa cultivation can store more carbon than common types of forest in PNG, so it cannot be argued that cocoa cultivation contributes to climate change mitigation. Additional data collection showed that the type and amount of land area converted can be highly variable and strongly region dependent. It is recommended to monitor land use in target regions of agricultural development projects.

The major recommendation for improvement of the environmental impacts is to increase yields to the abilities of the farmers. This can be achieved by more intensive management, at first without additional agricultural inputs. A next step in yield increase could be made by including insecticides in an integrated pest management strategy, and not necessarily fertilizers. One should be careful not to increase impact per area more strongly than the yield increase. It is furthermore recommended to improve the biodiversity within the cultivation system, for which agroforestry might be an option. For succesful implementation of such recommendations the farmers' social and economic incentives and constraints need to be taken into account.

## 1.2 What avenues for sustainable development of the cocoa industry in PNG?

The cocoa production model promoted today by public authorities, PPAP and companies consists in converting smallholders into business men specialized in cocoa growing and processing. This implies a strong intensification of production, an increase in material and labour inputs and the sale of large volumes of beans to exporting companies. This strategy aims at fighting against the CPB and at increasing producers' incomes. This model currently concerns a small number of producers relative to the total number of producers, with the hope that this proportion will increase in the coming years. Because low producing farmers outnumber the high producing farmers, a minor increase in total production is expected at the national scale. The current intensive cocoa production model has the disadvantages of requiring very large inputs of equipment and consumables, technical knowledge and manpower that very few households can provide in the absence of external support. Because of this massive investment in cocoa production, this model also tends to specialise households in this activity, which may be perceived as an unacceptable risk for a large part of the rural population.

Another production model is beginning to emerge, which is also supported by the two biggest private companies: the production of cocoa certified by Fair Trade or Rainforest Alliance. This model still relies on a modest number of producers and fermentary owners who have developed practices that allow the production of high quality beans for Western markets.

Therefore, the two models of cocoa intensification or certified cocoa production only affect an elite of producers and, because of their specific constraints, it might be difficult in the medium term to substantially extend their scope. It is likely that the majority of smallholders retain a subsistence-orientation and continue to produce small volumes of low quality cocoa. However, several measures can be envisaged to improve the performance of these smallholders but they differ according to their current specialization in the production of dry or wet beans.

The model of the subsistence-oriented dry beans producer arrives at the end of the cycle, with a low financial profitability, decreasing yields, and numerous fermentaries in very bad condition. In such circumstances, it is desirable to question the choice of these producers to use hybrid and cloned varieties which are not very efficient if they do not benefit from substantial inputs. It would be more appropriate to recommend to these growers to match their strategy with the feasible labour supply of their familiy: they can purchase cocoa varieties tolerant of relatively low labour inputs, and/or limit their seedling purchases to a quantity that can be effectively maintained given their household labour supply. Similarly, the reduction in the number of fermentaries in these regions could allow economies of scale and, for some fermentary owners, investment in the maintenance of their equipment in order to produce beans without smoky taste.

The subsistence-oriented wet beans producer model is often presented as retrograde and underperforming. In reality, it proves to be a cost-effective and resilient model that meets the expectations of most rural population. It is characterized by a low number of fermentaries, which allows economies of scale and easy control of cocoa quality, and which has made it possible to set

up a chain of custody. Moreover, this extractive and low-input model integrates the constraints of many rural households in their choice of agricultural production. In this perspective, cocoa production is integrated into a set of agricultural productions and it is on the basis of farmers' livelihood strategies that the expansion of cocoa growing must be considered. This reflection is still very little developed in PNG although it concerns the majority of cocoa producers. This low intensity production model is undoubtedly more resilient in the eyes of a large number of farmers, but it is difficult to estimate whether it can prevent the extension of the CPB.

In all cases, a complementary approach to the business-oriented production model, that would favor a multiple-crops cocoa-based agriculture, remains a relevant option for a large number of farmers in PNG, who have limited access to external and long-lasting supports. Rather than a "silo" promotion of cash crop cultivation, an approach favouring integrated production of food and commercial agriculture by farmers constitutes another healthy and sustainable basis for rural development in PNG.

# 2. The Functional Analysis - Introduction – Objectives And Approach Of The Cocoa Value Chain Analysis In Papua New Guinea

## 2.1 The VCA4D approach

This study is part of the "*Value Chain Analysis 4 Development*" (VCA4D) programme which aims to feed the European Union's (EU) thinking to support agricultural sectors that fight against poverty and promote sustainable development in tropical countries. This is exactly the case in Papua New Guinea (PNG) where the EU Delegation has been developing a project for two years to "*Support to Rural Entrepreneurship, Investment and Trade in Papua New Guinea*", focusing mainly on cocoa production.

The VCA4D approach has two peculiarities. On the one hand, VCA4D responds to the need for quantitative data and evidence-based indicators to inform decision-makers. These elements are often lacking. It intends to deliver evidence-based analytical content rather than a definite performance appraisal, so as to inform decision-makers and allow them to make their own judgement. This analysis is therefore mainly based on quantified estimates whose methods of calculation and assumptions are made explicit.

On the other hand, VCA4D embraces the three dimensions of sustainability at the country level. In the first instance, the approach starts with a detailed assessment of the organization of the chain (a functional analysis) in order to assess in a coherent and coordinated manner the economic, social and environmental impacts of the commodity chain at the national scale. Therefore, the VCA4D approach does not seek to establish a single indicator of the performance of the VC but it tries to answer a list of framing questions that document its multi-dimensional impacts. These framing questions and their respective criteria are presented in Table 1.

<table>
<tr><th colspan="3">Core Questions</th></tr>
<tr><td>Economic Analysis</td><td>Social Analysis</td><td>Environmental Analysis</td></tr>
<tr><td>FQ1. What is the contribution of the VC to economic growth?<br>CQ1.1. How profitable and sustainable are the VC activities for the entities involved?<br>CQ1.2. What is the contribution of the VC to the GDP?<br>CQ1.3. What is the contribution of the VC to the agriculture sector GDP?<br>CQ1.4. What is the contribution of the VC to the public finances?<br>CQ1.5. What is the contribution of the VC to the balance of trade?<br>CQ1.6. Is the VC viable in the international economy?</td><td>FQ3. Is the VC socially sustainable?<br>CQ3.1. Are working conditions throughout the VC socially acceptable and sustainable?<br>CQ3.2. Are land and water rights socially acceptable and sustainable?<br>CQ3.3. Is gender equality throughout the VC acknowledged, accepted and enhanced?<br>CQ3.4. Are food and nutrition conditions acceptable and secure?<br>CQ3.5. Is social capital enhanced and equitably distributed throughout the VC?<br>CQ3.6. To which standards are major social infrastructures and services acceptable and do the VC operations contribute to improving them?</td><td rowspan="2">FQ4. Is the VC environmentally sustainable?<br>CQ4.1. What is the potential impact of the VC on resources depletion?<br>CQ4.2. What is the potential impact of VC on ecosystem quality?<br>CQ4.3. What is the potential impact of the VC on human health?</td></tr>
<tr><td colspan="2">FQ2. Is this economic growth inclusive?<br>CQ2.1. How is income distributed across actors of the VC?<br>CQ2.2. What is the impact of the governance systems on income distribution?<br>CQ2.3. How is employment distributed across the VC?</td></tr>
<tr><td colspan="3">Addressing the 4 Framing Questions<br>Cross-cutting CQ. Which risks may affect the performance of the VC?</td></tr>
</table>

*TABLE 1 – VCA4D FRAMING QUESTIONS*

The environmental sustainability will be discussed through a structured analysis of different steps and impacts in the different practices observed in the value chain. The audience of this study is mainly policy makers, who need to understand how and where the environmental impacts occur. The main research question will thus be: "What are the most relevant environmental impacts of the current value chain of cocoa cultivation to export of dried beans in Papua New Guinea?" This study will identify which environmental impacts and subsections of the value chain are most impactful from the LCA perspective.

These questions constitute the logical framework of this Value Chain Analysis (VCA) and it is through this prism that this study may provide some insights on the design and application of the "*Support to Rural Entrepreneurship, Investment and Trade in Papua New Guinea*" project, which justified the launch of this work. However, our main objective is not to carry out a feasibility study of this programme or of the public policy for cocoa development in PNG, although we believe that some of the results could usefully feed into these initiatives.

## 2.2 Standard analytical methods

### 2.2.1 Economic analysis

Standard tools of economic analysis are called for to estimate the impacts of the cocoa chain on the stakeholders' welfare. They make possible to aggregate and compare the benefits and costs from the various agents in order to establish indicators of the financial and economic performance of this industry. However, this study has the specificity of having to be conducted at three levels of analysis:

- At the level of each group of agents, from a microeconomic perspective, to establish their operating accounts and understand their rationalities.
- At the value chain level, from a meso-economic perspective, to establish its profitability, the number of actors involved, their interactions…
- At the national level, from a macroeconomic perspective, to indicate the importance of this sector in the national and international economy.

At each of these levels, similar standard concepts (price, profit…) are used but they make it possible to produce criteria adapted to each level of analysis. The compilation and analysis of these data was done with the AFA (AgriFood chain Analysis) software, which was developed by CIRAD and is systematically used in the VCA4D studies. This software requires all products to be converted to dry bean-equivalent so that prices and volumes can be compared throughout the value chain. We therefore selected the dry bean tonne as the basic unit of measurement for the analysis. A container contains 15.24 tons. It takes 15.7 bags of 63.5kg to make one ton. And the production of a bag of dry beans requires between 170 kg (with the Trinitario variety) and 210 kg (with hybrid and cloned varieties) of wet beans.

### 2.2.2 Social analysis

The social analysis addresses the social sustainability of the cocoa value chain in PNG, and specifically explores six domains (working conditions, land & water rights, gender equality, food & nutrition security, social capital, and living conditions). As analytical procedure, the national context in these domains is correlated with their specific configuration along the cocoa value chain. Discussion of the six domains in relation to the cocoa value chain in PNG is an integration of a systematic literature review with data collected, surveys and interviews conducted during the field mission in PNG. The discussion of the six domains addresses their dynamics in relation to the cocoa value chain in PNG, including regional variations and the evolution of the value chain over time.
The social analysis is also summarized through a social profile, which represents a quantified scoring (high, substantial, moderate/low, not at all) of assessment questions about the six domains by means of a graphical radar. The quantified scoring of questions relating to the six domains and its graphic representation provides an easily assessable tool to depict change over time through follow-up value chain studies with the VCA4D methodology.

### 2.2.3 Environmental analysis

In this study an environmental impact assessment is done based on a Life Cycle Assessment (LCA). LCA is a technique to assess potential environmental impacts associated with the stages of a product's "life", from sourcing the required raw materials from nature to its waste treatment. From approximately eighteen environmental issues that can be routinely assessed with LCA, the relevant emissions to and extractions from the environment are mapped for the entire product's life. These emissions and extractions are translated to impact indicators. The four steps of this approach are shown in Figure 1.

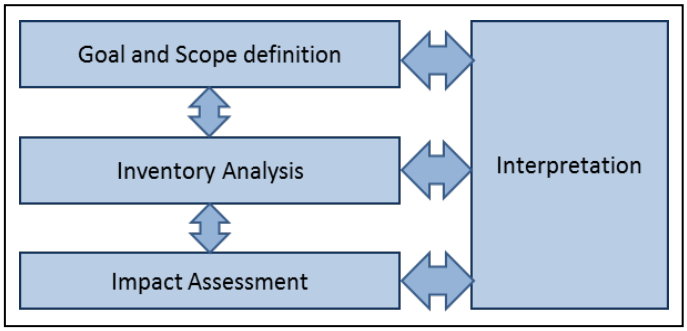



*FIGURE 1 - THE FOUR STEPS IN A LCA ACCORDING TO ISO STANDARD 14044*

First, the goal and scope of the LCA are defined, by translating the context of the study into specific choices regarding a defined study goal, study subject, system boundaries and methods of the study.

Next, the Life Cycle Inventory (LCI) is composed. The system that provides the product of focus is mapped and modelled, by collecting data and modelling the individual parts of the system. The outflows (emissions) from this production system to the environment are determined, as are the inflows to this system (i.e. resource extractions like water, energy and raw materials). The LCI is a long list of emissions and resource extractions.

Life Cycle Impact Assessment (LCIA) is the third step of LCA. The LCI is translated into impact indicators for selected environmental issues. For each environmental issue, the relevant emissions or resources are multiplied with a characterization factor which expresses its contribution to the environmental issues.

The final phase of LCA is Interpretation. The LCIA results and the study findings are reviewed and analysed critically in order to improve the life cycle model that provides the LCI and potentially to improve the LCIA steps and methods. Furthermore, such a review will give information about the robustness of conclusions that can be drawn from the LCA.

A broad set of environmental impact categories is preferred for this assessment to assess dominance of impacts as well as interactions between impact categories. This will generate insights for the audience of the study. The impact categories from the ReCiPe 2016 Impact Characterization method, version 1.00 (Huijbregts et al., 2017) was evaluated. The Hierarchist version of the ReCiPe 2016 method was used, defining the perspective for value choices in the methodology. SimaPro

8.4 was used to model the supply chain and to perform the life-cycle impact assessment. It should be noted that issues like biodiversity and occupational hazards are not included in this characterization method. The impact categories are listed in Annex 1.

The emissions of the pyrethroid insecticides were entered as the emissions of the natural counterpart pyrethrin, with similar molecular structure and physicochemical properties. This was the most feasible approach to connect the insecticide emission with a characterization factor from ReCiPe 2016.

Currently, there is no approach in LCA to assess environmental impacts on soil quality and on aspects of biodiversity. Aspects of biodiversity that are not covered consider disturbance on the direct surrounding of an agricultural field, disturbance or barrier creation from roads or other infrastructure, or structural changes in the landscape. Loss of species and loss of habitats may be covered in the impacts of land occupation. These limitations are elaborated in the discussion.

## 2.3 Data collection

Data collection was based on a review of the scientific and technical literature, interviews with key stakeholders, access to databases and field visits to the provinces of ENB and Sepik. These various activities began in January 2018 but were punctuated by two field missions: in February 2018, William Kerua carried out a preparatory tour in all the sites to be visited; in March 2018, the entire team went to PNG for almost three weeks to meet the stakeholders and sponsors of this study.

Cocoa production was the subject of numerous publications in the 2000s but by a relatively small group of researchers. Most of these publications are cited in the bibliography of this report. Unfortunately, since the arrival of cocoa pod borer around 2007 and its substantial impacts on the industry, there are very few scientific or technical publications. On the one hand, the Cocoa Board (CB) publishes its usual general statistics while the Cocoa Coconut Institute (CCI) releases very little new research papers. On the other hand, cocoa-support projects have focused on operational activities with little emphasis on data or lessons learned from their field actions. Overall, therefore, there has been very few recent publications on the cocoa sector.

The lack of recent data in scientific publications is also explained by the scarcity of databases on the cocoa industry. Despite our numerous contacts with both public and private actors, we were only able to access three databases: the CB database for general production and export data; the East Sepik CB database for monitoring these operations at the district level and the Wewak ACIAR database for monitoring producers. The latter database also had a significant number of inconsistencies that made it difficult to use and extrapolate these data.

Access to public accountancy data has also proved difficult for several reasons. First, PNG does not have an up-to-date official input-output model for public finance and the publication of basic statistics is the responsibility of several services that are not always clearly connected. Moreover, the data available today are rarely updated. For example, the calculation of GDP 2016 was not yet complete. In the absence of adequate data provided by PNG public services, we used the statistics compiled or extrapolated by the World Bank.

The identification of the data available in the literature or in the databases was completed by meetings with numerous stakeholders and field visits, which are enumerated in Table 2.

| Organisation |
|---|
| Agmark Kokopo |
| Agmark Wewak |
| Ambaku women's group in Maprik |
| CCI / ACIAR |
| Cocoa growers in Vutal, Utmel, Gavien, Balip, Maringe, Yangoru |
| DAL Angoram |
| Department of Agriculture and Livestock (DAL) |
| ENBP Deputy Provincial Administrator |
| FAO |
| French embasy (Trade officer) |
| Ilugi Cooperative |
| KVRTC (Univ of Natural Res. and Envir) |
| Maprik local government |
| NAQIA |
| National Statistics Office |
| OISCA |
| Outspan Maprik |
| Outspan Rabaul |
| Outspan Wewak |
| Paradise Food |
| PHAMA |
| PNG Forest Authority |
| PNG Forest Authority / FAO |
| PNGCB (Kokopo, eco-stats division) |
| PNGCB (Wewak Regional manager) |
| PNGCB (Wewak Senior field officer) |
| PPAP & Waiyu in Maprik |
| PPAP (Component II coordinator) |
| PPAP (Project manager) |
| Sepik saving and loan societies |
| UE Delegation |
| Waiyu Rabaul |
| Waiyu Wewak |
| Weni & Mandol Investment |
| World Bank |

*TABLE 2 – ORGANIZATIONS MET DURING THE EXPERTS' MISSION IN MARCH 2018*

Several survey methods were used with these stakeholders:

- The interviews with institutional actors were generally conducted in the form of an open discussion, addressing successively the main areas of interest of the experts.
- Economic data from enterprises, small producers and processors were collected using a standard questionnaire.
- Individual interviews were conducted at the production sites

- Focus groups were also organized in some villages and with small groups of producers.
- A rapid protocol for biophysical characterization of cocoa blocks and farming practices was administered in about ten cocoa farms.

All surveys guaranteed the anonymity of the respondents and the confidentiality of the individual information. To the extent possible, data were collected using 2017 as the reference year.
In total, the following main primary sources of data were used:

- Agricultural and social science surveys were conducted by four extension officers: 16 from the Maprik region and 10 from Angoram region (by two extension officers) in East Sepik Province (ESP), and 14 from a specific (business-oriented) sample in the Gazelle peninsula in East New Britain (ENB). This was set up during the preliminary mission by the local expert, and finished before the mission of the VCA team. Environmental and farm characteristics were collected, input usage and shading and other agricultural practices were tracked. Each farmer was also asked how their downstream chain looked, but this was hardly filled in. Suspicions arose that despite the instructions, the samples were not randomized, so that field data on yields and areas are only indicative.
- The extension officer from ENB and the coordinator of the two extension officers from Angoram were interviewed on environmental aspects in order to provide a qualitative perspective to the collected quantitative data.
- During the mission of the VCA4D team, farmers were interviewed during the eight planned farm visits: their agricultural practices were collected as well as their subjective perspective. Because the farm visits were planned, the farmers were not selected at random. Near Keravat in ENB, two business-oriented farmers were visited, of which one was supported by the PPAP and the other was not. Near Warangoi in ENB, the officers at the OISCA farm and the members of the Ilugi cooperative were interviewed. Near Angoram and Maprik, individual farmers located close to the meeting place from four organized farmer groups were interviewed. The farmer groups near Maprik were partially Rainforest Alliance certified. Except for the OISCA farm in Warangoi, the circumference of 3 – 6 trees per field was measured (the number dependent on tree thickness homogeneity), and sanitation and pruning practices were observed and discussed with the farmers.
- A baseline survey for a collaborative project with ACIAR was conducted in 2017 by CCI/DAL from Wewak, covering both East Sepik Province and Sandaun (the Western part of the Sepik). The 622 surveyed farmers were distributed equally over the survey region. Our data analysis showed that the yields that could be derived from this database were very high; we also concluded that none of the relevant farm properties (such as general health, level of pruning, shading, tree age, weeding, and cocoa pod borer (CPB) infestation) correlated with the yields in this dataset. There are indications that reports are unreliable because a traditional approach to cocoa farming without record keeping and that yields are generally underreported by farmers because of culture (which is contradictory for this database). Therefore, this dataset was used with the most caution.

The primary data contributed to the archetype definition, pesticide assessment, to field nitrogen and carbon balances and to qualitative aspects of this chapter, as shown in Table 3. Fermentary and logistics data were derived from visits during the VCA4D team mission to various actors in the chain, as explained in the functional analysis.

| Data source (below) & Use (right) | Archetype definition | Pesticide assessment | Field N and C balance | Qualitative aspects of this chapter |
|---|---|---|---|---|
| Survey (40 farmers) | X | X | X | X |
| In-depth interviews (2 interviewees) | X | | | X |
| Farmer interviews and observations (8 farmers) | X | X | X | |
| CCI/DAL baseline survey (600 farmers) | X | | | |

*TABLE 3 - OVERVIEW OF THE USE OF THE PRIMARY DATA COLLECTED FOR THE ENVIRONMENTAL ANALYSIS*

In addition to the literature collected for the functional analysis, literature was collected on nutrient contents and flows in cocoa farming and on carbon contents and land use change in cocoa farming. The IPCC guidelines documentation from 2006 (IPCC, 2006) contributed to nitrogen and carbon balances and to emission calculations for the fermentary. Furthermore, the PNG cocoa extension manual was useful for modelling nursery, nitrogen flows, and pesticide usage, and for cross-checks although it did not contain quantitative data on relevant practices such as pruning and shading.

## 2.4 Data gaps and uncertainties

Many data points such as transport distances and usage of basic inputs were collected during the VCA4D team mission from experts who did not specify the accuracy of something they said. It is likely transport distances, packaging reuse rates and cocoa waste percentages are expert estimates. This also applies to the agricultural data from surveys. The interviewed extension officers rarely responded to requests for clarification, and outreach to all stakeholders for comment on the typology received no response.

All quantitative data was not used directly in this LCA but combined with secondary sources and cross-checked with the other primary sources, in order to consider the possible errors, high variability and/or low data availability. This approach of averaging and cross-checking increases the accuracy but also decreases the precision and specificity of a data point, while variability within a production region is high already.

Furthermore, secondary data contains some uncertainty. For example, FAOSTAT crop areas over the past 30 years (FAO, 2018) can be uncertain: since areas under cocoa are highly uncertain for regions within PNG, with every organization providing different areas, it is reasonable to assume limited certainty of the national-level time series of areas from FAOSTAT. Additionally, scientific papers on carbon and nitrogen flows in cocoa often cited ranges from multiple preceding papers or from multiple observations, with little information on the distributions or on causes for variation.
Because the archetypes were derived from the regions that we visited, it is estimated that the selected archetype data is a reasonably representative average for the region it applies to. From

literature and from the field, it can be observed that the most important data, such as yield, is highly variable, even on the district level. Time and budget constraints did not allow for more detailed data collection, but under high variability, additional efforts would not have translated into reduced uncertainty. Data reliability needs to be increased before increasing sample sizes. A larger number of archetypes would not increase their specificity, and it would not allow reducing errors through averaging. Data that is not specific to the archetype was derived from national data where possible.

The lack of current data on the cocoa industry in PNG and the diversity of data collected from stakeholders have made difficult to establish an updated and relevant typology of smallholders. This central question for the functional analysis and subsequent disciplinary analyses generated many discussions over several weeks among the four experts. We reached a consensus, which is presented in the rest of the report, but this typology would deserve to be consolidated based on statistics collected in a homogeneous and rigorous manner in the producing regions. Ten years after the appearance of the CPB and significant changes in the international cocoa market, an exhaustive diagnosis of the current modes of cocoa production in PNG would improve our understanding of the real functioning of this industry and provide crucial information for the choice of any public policy to revive the sector.

# 3. The importance of the agricultural sector in PNG

## 3.1 The main occupation of PNG population

The total land area of PNG is 462 840 km². The 2000 National Census gave a total population of Papua New Guinea as 5.2 million, and about 4.2 million of these people lived in rural villages. Using an average rate of growth of about 2.5% per year, the estimated PNG population should be almost 8 million people in 2018, with probably more than 80% still live in rural areas. Bourke and Harwood (2009) estimated that around 66% of the total land area was not occupied by people, although some of this unoccupied land was used for hunting and collecting wild foods. A further 30% of the total land area was occupied at low population densities of less than 31 persons/km². Only around 12% of PNG's rural population live at high and very high population densities (>50 persons/km²), mainly in the Highlands, the East New Britain province and the Maprik area of the East Sepik.

Most of the rural population lives in isolated locations, with poor or very poor accessibility. An estimated 46% of the rural population live within four hours travel to a major service centre. A further 38% live within eight hours travel to a major centre (Bourke and Harwood 2009). Most farmers face strong difficulty accessing inputs and only have limited training in modern farming practices and trade on a commercial level. Subsistence is thus the main purpose of agricultural activities for most farmers, to produce food for consumption and to build their own shelter. Agricultural-based activities help to meet their everyday needs. They are practiced on land held under customary tenure.

But PNG has a dual rural economy and many agricultural products are also sold on local and international markets. The sale of agricultural commodities is the most significant source of income for rural people, in terms of both total income and the number of people who receive it. Cash cropping is one of the few opportunities to earn a regular income in rural PNG. Thus, most PNG smallholders maintain a diverse set of livelihood strategies by combining food gardening for household consumption, sale in local/domestic markets and trade of commodities in international markets.

Agricultural business vastly comes from smallholders activities, which remains out of the formal economy. Agriculture, fishing, community forestry, artisanal and small-scale manufacturing and mining are done by about 100 000-120 000 micro-enterprises, 12 000-15 000 small businesses, and 3 000-3 500 medium enterprises that need to evolve into the formal sector as described in the PNG Vision 2050 document.

## 3.2 A revenue-generating sector

Since the 1950s, the promotion and uptake of export cash crops like cocoa, coffee and more recently oil palm have been viewed as the principal way to initiate rural development in PNG (Curry et al. 2012). Nearly 90% of cash income in rural areas is from export cash crops and the local marketing of food crops and betel nut (Allen et al. 2001), with over two-thirds of this income from export cash crops. The three export crops of oil palm, coffee and cocoa are the primary sources of income for nearly half the nation's population.

But the strengthening engagement with the cash economy did not simply involve the introduction of new crops and farming practices, but also required changes in the lifestyles and values of the people themselves. Greater engagement with export cash crop production has introduced new livelihood uncertainties and a potential threat on income stability for smallholders. It is also indicative of how few alternative income opportunities are available to PNG rural households, especially off-farm and non-agricultural opportunities.

The expansion of cash crops by smallholders over the latest decades has not only an influence on rural livelihoods but also on the PNG Trade Balance. In order of importance by value, PNG's agricultural exports are palm oil, coffee, cocoa, copra and copra oil, vanilla, tea and rubber, as this was already the case thirteen years ago (Figure 2).

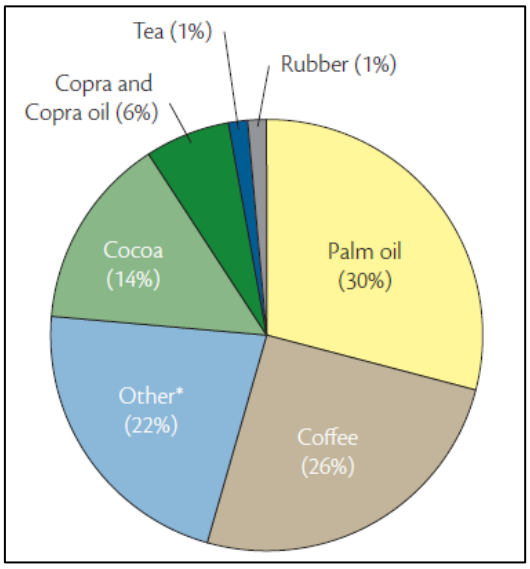



*FIGURE 2 - CONTRIBUTION BY VALUE OF THE MAIN CASH CROPS TO AGRICULTURAL EXPORTS, 2004 -2006 (CURRY ET AL. 2009)*

Agriculture sector's contribution to the country's Gross Domestic Product (GDP) was about 19% in 2010. For more than a decade, oil palm has become the highest income earning commodity crop in the agriculture sector. Despite the increase in agricultural commodities during the 2010s, the contribution of the agricultural sector to the GDP remains around 19% in 2016, due to (1) the recent rise of minerals (gold and copper), oil and gas exports, and (2) weak markets, poor weather conditions and untimely crop diseases.

The exact input to GDP is difficult to calculate precisely because of a lack of data surrounding the subsistence sector and its overall contribution to the agriculture industry. Rough estimates put its contribution between PGK 2bn and PGK 5bn annually (Oxford Business Group 2017).

The exchange rate is a key determinant of agricultural competitiveness, both for domestic and export markets. Before 1994, PNG maintained what was known as a 'hard kina' exchange rate policy, in which the exchange rate between the kina and major international currencies was deliberately maintained at a high level, which kept the cost of imports low (Curry et al. 2012). In 1994, the kina was allowed to float and it immediately fell in value. The decision to float the kina did a lot to stimulate agricultural commodities as they were better valued in international markets.

Despite free access to dynamic foreign markets, PNG's increase in agricultural exports faces several strong constraints at the national level: (1) poorly maintained transport infrastructure; (2) inadequate access to credit and working capital for middlemen, farmers and traders; (3) poor export quality of some commodities; (4) insufficient knowledge by producers of market requirements, (5) inadequate security for traders and producers, who are vulnerable to robbery and assaults; (6) poor dissemination of information and planting material. However, as the largest employment sector and the third-largest export revenue generator, agriculture is recognized as the country's best means of diversifying its basket of goods and easing reliance on extractive industries (Oxford Business Group 2017).

## 3.3 Medium and long term expectations

The long-term development objectives of the Government of PNG for the agricultural industry are expressed in the National Agricultural Development Plan, the PNG Development Strategic Plan and the PNG Vision 2050 document. The main challenge is to shift from an economy that is currently dominated by the mining and energy sectors to one that is dominated by agriculture, forestry, fisheries, eco-tourism and manufacturing between 2010 and 2050. The objective is to leverage for a 70:30 percent reorientation of the structure of the economy towards a renewable resource base, rather than its current heavy dependence on extractive industries. Beyond increasing production through better and innovative agricultural practices, the government aims to promote both downstream processes and the agricultural import replacement.

A land reform is planned to promote these changes. It targets that three percent more of total customary land is brought into production in the formal sector each year, which would increase GDP by 1.2% in real terms. This direction is expected to enable economic growth by 2050 to be broad based, ensuring that disposable household incomes will be much higher than at present.

# 4. Policies and dynamics for cocoa production in PNG

## 4.1 State of the cocoa industry in the 2000s

Cocoa production has two important advantages for a country like PNG. On the one hand, it provides activity and income to the rural population, which remains predominant throughout the country. On the other hand, cocoa exports provide tax revenues to the state. This sector has received much political and financial support for several decades, even if the performance of this sector has stagnated over the latest decade.

According to the 2000 National Population Census, cocoa producing households represented 31% of households in the cocoa producing regions and 16% of the total number of PNG households. This represented approximately 151 000 households, and this figure has been quoted in many reports since then. More recently, the Ministry of Agriculture and Livestock considers an updated estimate of 130 000 households in 2015. Around one million people in PNG depend on cocoa for their livelihood.

During the 2000s, 27% of rural villagers had an income from cocoa trade. At that time, cocoa income represented 10% of total income for rural households (Bourke and Harwood 2009). But export revenue from cocoa bean exports fluctuated greatly in the period from 1981 to 2004 in response to changing prices and climate conditions. Between 1981 and 1990 cocoa was second to coffee as the main export crop in PNG, with average annual export earnings of K47 million. From 1991 to 2000 export earnings from cocoa grew to an average of K60 million per annum, and from 2001 to 2004 increased to K205 million per annum. Annual export earnings for cocoa reached K258 million in 2003, which amounted to 19% of the total export earnings from agricultural products (Curry et al. 2009).

This primary cash crop was grown on an estimated 130 000 ha in 13 coastal provinces either as a mono-crop or intercropped with coconuts or food crops (Lummani 2006, Curry et al. 2011). The area of plantation cocoa in 1973 was 55 000 ha (Bourke and Harwood, 2009). Most PNG cocoa was produced in the north-east lowlands of the Gazelle Peninsula in East New Britain Province and on north-east Bougainville Island. Other provinces that contributed to cocoa production in 2006 were East Sepik and Madang. In 2016, the main producing regions remain more or less the same, but the order of importance has changed to the detriment of the East New Britain and Bougainville (North Solomons) provinces and to the benefit of the Morobe-Madang-Sepik (MOMASE) provinces (Table 4).

| Province | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| East New Britain | 16 930 | 21 640 | 8 279 | 6 207 | 7 193 | 4 061 | 4 704 | 5 174 | 5 357 | 6 449 |
| Bougainville | 16 305 | 16 144 | 22 414 | 17 945 | 17 743 | 13 121 | 12 543 | 8 119 | 8 406 | 10 554 |
| New Ireland | 710 | 1 628 | 1 222 | 979 | 1 199 | 484 | 431 | 272 | 282 | 340 |
| West New Britain | 708 | 1 362 | 1 564 | 1 252 | 1 439 | 898 | 510 | 1 020 | 535 | 820 |
| Manus | - | 8 | 9 | 7 | - | - | - | - | 2 | 2 |
| Madang | 3 884 | 4 257 | 2 049 | 1 641 | 1 918 | 5 076 | 5 880 | 6 108 | 6 844 | 6 922 |
| Morobe | 530 | 1 020 | 931 | 745 | 719 | 1 003 | 1 568 | 2 486 | 3 001 | 3 555 |
| East Sepik | 3 936 | 9 411 | 14 296 | 11 445 | 16 304 | 13 278 | 12 582 | 9 640 | 8 220 | 10 776 |
| West Sepik | 1 107 | 1 059 | 932 | 746 | 959 | 781 | 627 | 695 | 536 | 644 |
| Oro | 44 | 172 | - | 421 | 480 | 351 | 392 | 420 | 455 | 433 |
| Milne Bay | - | 1 | 5 | 4 | - | - | - | 10 | 10 | 10 |
| **TOTAL** | **44 154** | **56 702** | **51 701** | **41 392** | **47 954** | **39 053** | **39 237** | **33 944** | **33 648** | **40 505** |

*TABLE 4 – COCOA PRODUCING REGIONS OVER THE LATEST DECADE (IN TONS OF DRY BEANS; SOURCE: COCOA BOARD OF PNG)*

In the early 1980s, PNG decided to favour cocoa production by small farmers rather than through large-scale plantations. In 2006, smallholders accounted for 90% of national cocoa production. During the 2000s, national cocoa production varied between 40 000 and 50 000 tons per year, which were almost entirely exported as dried bean. PNG was and remains the biggest cocoa producer in the Pacific but this sector is dependent on foreign buyers' demands and has not developed secondary processing capacity.

## 4.2 Declining (quantity and quality) trends

Cocoa Pod Borer (CPB) (*Conopomorpha cramerella*) was first in ENB in March 2006. It was also detected in West Sepik Province (June 2006) and in Madang Province (April 2008). In 2006 an eradication programme was implemented in ENB which ended on January 2007. However, CPB re-emerged within the eradication zone in late February 2007. Since then, CPB has been spreading rapidly in ENB and the response has switched from an eradication mode to a management mode (Curry et al. 2011). Despite the efforts to restrict the impact of CPB and the widespread adoption of new genotypes over the past 20 years, cocoa production in PNG has decreased since 2008 (Figure 3). ENB was hit the hardest by the CPB, which traditionally has been among the strongest producers.

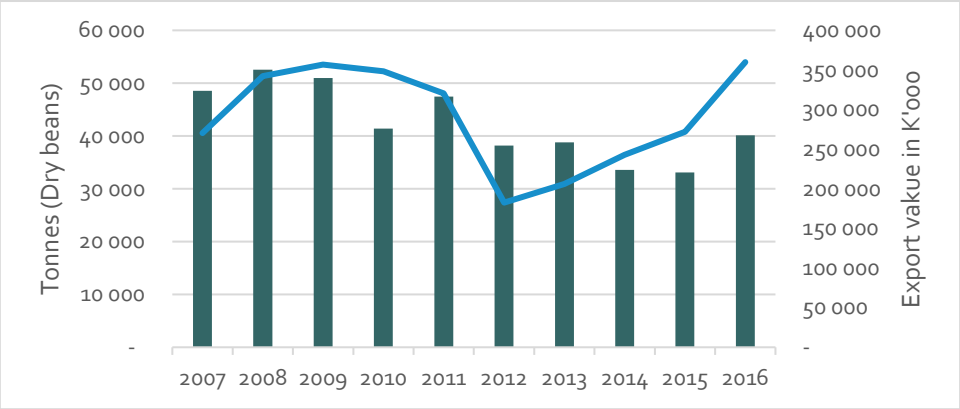



*FIGURE 3 – NATIONAL COCOA EXPORT VOLUME AND VALUE (SOURCE: COCOA BOARD OF PNG)*

Since the incursion of CPB, many smallholders have either abandoned or partially abandoned their cocoa holdings (Curry et al. 2012). The abandonment of cocoa production can be largely explained by highly labour intensive farm management techniques required to contain the pest. This new management system requires weekly harvesting of all mature cocoa pods, removal and burial of all CPB-affected pods, regular pruning and shade control, weed control and insecticide spraying. The high labour requirements of this intensive CPB management strategy is in sharp contrast to the low labour input system typically practised by smallholders and explain why this strategy has not been effectively adopted by many farmers to date.

In addition to the decrease in the quantity of cocoa produced, the quality of this product has also decreased in PNG. Historically, cocoa beans are grown from three main varieties: forastero, criollo – a high-quality bean used in the best chocolate – and trinitario, a mix of forastero and criollo. As a major supplier of trinitario beans, PNG built a worldwide reputation based on the flavour of premium beans blended with the unique characteristics that infuse the beans grown in PNG soils. PNG cocoa used to be rated as 75 percent 'fine or flavour', attracting a premium quota. Until the 1991/92 cocoa year, over 90% of dry bean was exported to Western Europe and North America that mainly requires high-quality cocoa (Bourke and Harwood 2009). However, by the early 1990s, the introduction of hybrids of inferior flavour led to a decline in the premium paid for PNG cocoa, with PNG's 75% 'Fine or Flavour' rating being reduced to 25% (Johnson et al. 2004). But the main reason for the decline was the emergence of smallholders after the breakup of the plantation-based industry. Many smallholders have taken to using fuelwood or diesel drying-kilns that often smoke the beans, replacing many of the desirable characteristics of PNG cocoa with an overwhelming smoky taste (Bourke and Harwood 2009). The poor quality of cocoa today is combined with high costs, complicated logistics and lack of transparency to explain the bad reputation of PNG cocoa internationally and its low price (AECOM 2017).

## 4.3 Everlasting high expectations for the cocoa industry

Cocoa production has long been planned by the administration at the national scale, but these projections have systematically proven too ambitious. For instance, ten years ago, the PNG Government set a target of 100 000 tonnes of cocoa exports by 2016 (Bourke and Harwood 2009). More recently, the PNG mid-term development plan 2016-17 aimed at a production of 60 000 tons

in 2017. The Cocoa Board targets of 200 000 tonnes over the next five years and of 310 000 tons in 2030 seem to be hardly achievable in the light of the evolution of the sector over the past fifteen years.

These development objectives reveal a top-down and political vision of the administration, which appears rather disconnected from the practices of companies and of small producers. More realistically, under the current trends, the cocoa industry would likely grow to 60 000 metric tons in the next five years, with a maximum of 100 000 metric tons with major interventions and focus (interview of ***Basavaraj Mashetty in The National on the 04th January 2018).***

From mid-1970s to the late 1990s, government intervention in the cocoa industry had been mostly in price stabilisation and/or direct price support (Curry et al. 2007). This ended in 2000.

In response to the numerous challenges being faced by rural cocoa farmers and key stakeholders along the whole value chain, the PNG Cocoa Board develops today three key strategic programs: (1) a nursery program to promote higher yields per tree; (2) a freight subsidy program for remote areas to help farmers move their cocoa from local fermentaries to major townships or cocoa buying points – this program stopped in 2016; and (3) a cocoa quality and market promotion program, notably through grouping cocoa producers in cooperatives to facilitate access to processing facilities and to overcome market difficulties (Garnevska et al. 2014). The funding request by the Cocoa Board in 2017 was around 25 million Kina to support these programmes, which would be an increase of 48% in their current budget.

# 5. Functional analysis

## 5.1 The necessary simplification of the cocoa value chain in PNG

Any sector of activity is characterized by a multiplicity of often complex relationships between actors. The cocoa industry in PNG is no exception to the rule: the specific choices made by the various actors over several decades today result in a great diversity of practices, particularly at the level of small producers in the different provinces. The VCA exercise is not easily compatible with the recognition of this diversity of practices because it aims to quantify the performance of the system, which requires a simplification of its operation. The first task of the VCA is therefore to construct archetypes of actors that allow a coherent quantification of their performances while representing at best their real practices. We did this work in two stages.

First of all, the literature review and the interviews we conducted at the beginning of the mission enabled us to draw up an initial stereotypical representation of this sector which a priori integrates all stakeholders in PNG ( Figure 4).

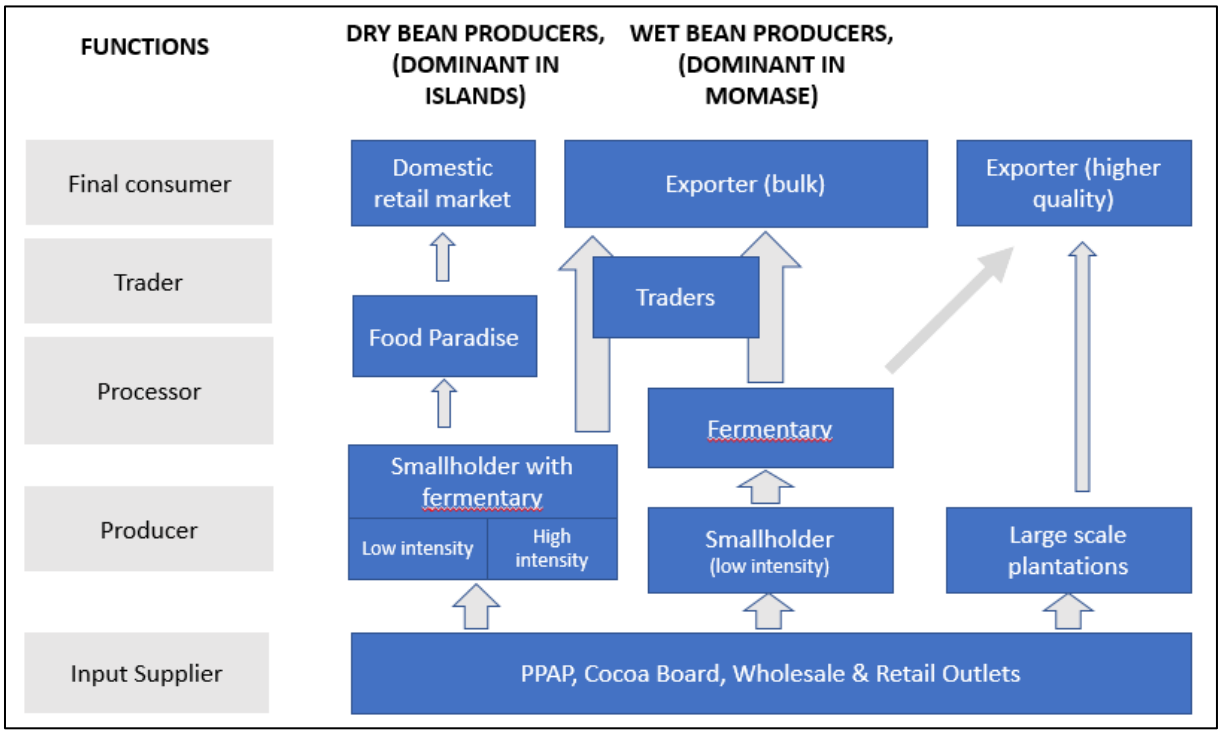



*Figure 4 – Description of the complete cocoa value chain in PNG*

Then, this representation of the cocoa sector underwent three simplifications in order to focus the VCA on the main elements of the sector. First, large scale plantations, which have historically been created and exploited by the state and some large companies, such as Agmark, have been excluded from the analysis for two reasons: (1) they now represent only about 2% of national production; (2) for thirty years, the government has decided to favour production by smallholders and large scale plantations are not a priority land use anymore.

Second, intermediate traders are no longer numerous and are almost always confined to remote areas (Cocoa Board 2017). Today, direct connections between smallholders and exporters are the rule, and a couple of exporters opened decentralised agencies and branches to better reach smallholders.

Lastly, the domestic retail market for chocolate has been discarded as it remains limited to one company, with small volumes: Paradise Foods only processed 70t in 2017, with a turnover for chocolate sales of 925 000 PGK. Moreover, this private company did not accept to participate in our survey and to disclose some of its technical and financial data.

In contrast to these simplifications, we were confronted in the field with many types of smallholder, which sometimes presented very different characteristics from those described in the publications of the 2000s. For example, while the average area of cocoa cultivated per household has decreased significantly, some farmers still grow cocoa on areas of up to 7 hectares. We finally kept the classic dichotomy between wet beans and dry beans producers, while observing that a significant part of dry bean producers adopted a subsistence logic (low intensity) and not a business orientation (high intensity). The latter are grouped into the business-oriented archetype. For wet bean producers, we kept also the dichotomy between producers engaged in certification and producers not engaged in certification.

In total, these different hypotheses make possible to construct a simplified image of this commodity chain, comprising five operating levels (Figure 5).

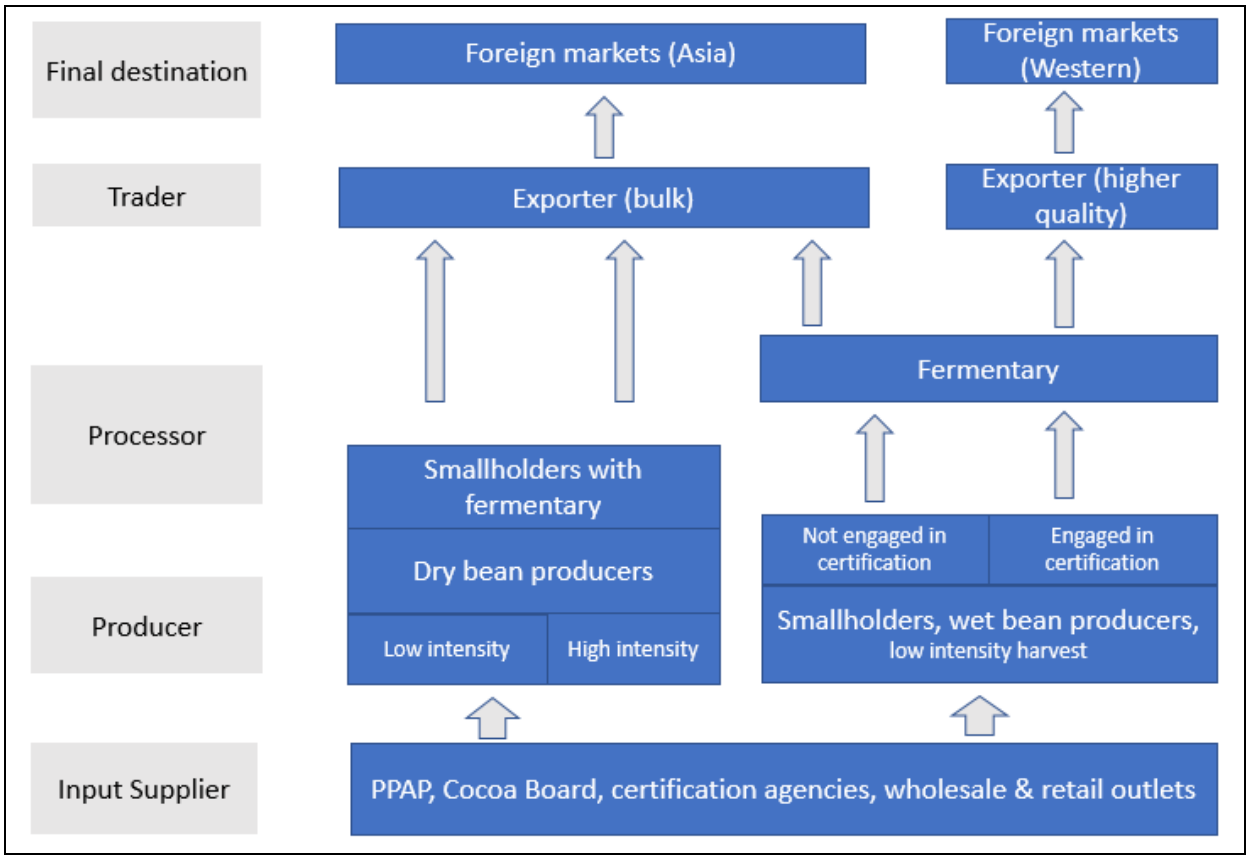



*FIGURE 5 - FRAMEWORK OF THE COCOA VCA IN PNG*

This simplified representation of the commodity chain covers 97% of cocoa production in PNG and almost all the people involved in this industry.

## 5.2 Upstream suppliers

There are two categories of suppliers for cocoa producers in PNG. On the one hand, these actors purchase a number of goods necessary for their work from retail or wholesale traders. These include tools, bags, chemicals, etc. These goods are the subject of a commercial transaction.

On the other hand, small producers receive free and/or subsidized support from external operators, which takes two forms. First of all, the Cocoa Board is represented in all provinces and its mandate is to promote the development of the cocoa industry. Its core function is to control that fermentary owners and the exporters comply with the regulation. But an important part of CB activity in rural areas is also to provide technical assistance to producers. However, these support interventions are considered special projects and depend on extra funding. For example, the District Cocoa Nurseries project received PGK 7 million under PNG's Public Investment Program. To the extent of available funds, the CB is expected to reach as many producers as possible and tends to focus on those not already supported by the Productive Partnership in Agriculture Project (PPAP). PPAP is a major project funded mainly by the World Bank since 2012. The development objective of the PPAP is to improve the livelihoods of smallholder cocoa and coffee producers through the improvement of the performance and the sustainability of value chains in cocoa- and coffee-producing areas respectively. This is being achieved through the implementation of various supports to facilitate linkages between smallholder farmers and agribusiness, and the provision of market access, technologies, hybrid clone seedlings, and services. PPAP states to reach about 25 000 cocoa-producing households, mainly in the provinces of ENB, Bougainville and East Sepik.

Because of the small size and informality of their business, cocoa farmers today depend very little on access to financial services. Except for a few districts in ENB, micro-credit is a poorly developed option in rural areas of PNG and access to banking services remains problematic in small towns.

## 5.3 Differentiated production strategies

There is a wide diversity of cocoa farming practices in PNG, which depend on natural conditions, on the personal preferences of small producers but also on public and private policies conducted for several decades in various ways in the different provinces. Based on a literature review and on our meetings with stakeholders, three discriminating factors allow to categorize cocoa primary producers. They are reviewed below to better justify our subsequent choice of categorization of cocoa producers in PNG.

### 5.3.1 Low-input versus high intensity farming strategies

Even before the appearance and extension of the CPB around 2007, Curry et al. (2007) showed that there existed two broad production strategies followed by smallholders: the low labour input *low-input* strategy in which cocoa is harvested and sold as wet bean, and the higher input *farming* strategy usually associated with dry bean processing.

In theory, these two strategies are successive and described in three stages by Curry et al. (2007). In stage I (< 3 years old), the cocoa is immature, productivity is low and the incidence of pests and diseases is low. Labour inputs are moderate, but the block is well maintained, mostly because of efforts being applied to intercropped food gardens. Any cocoa harvested is sold as wet bean due to the low yields.

In stage II (3–8 years old), the cocoa is mature, the vegetation structure is open and there are large quantities of ripe pods accessible, leading to high labour inputs and high productivity. This is the period in which cocoa may be sold as dry bean, leading to high income. Although income is good in stage II, it is generally not invested in block maintenance. The incidence of pests and diseases rises during this stage.

In stage III (7–8+ years old), the cocoa is senile and accessibility of ripe pods is low due to taller, denser vegetation and a high rate of diseased pods. Labour inputs and productivity are low, cocoa is mostly sold as wet bean and there are lower returns to labour. Lack of pruning and shade control, together with no pest and disease management, make the transition from stage II to III inevitable for most smallholders.

In practice, while all producers go through a farming phase to start their plantations, after the high yield phase, some farmers are satisfied with a low-input strategy without wanting to return to a farming cycle that would require major investments. Conversely, some farmers decide to revert to a farming practice when the cocoa tree reaches 8-10 years of age with rapidly declining production. The main characteristics of these two strategies are indicated in the Table 5 (after Curry et al. 2007).

| Cocoa production and labour characteristics | High-intensity input strategy | Low/moderate-intensity input strategy |
|---|---|---|
| *Labour inputs in block maintenance* | Relatively high labour inputs in grass slashing at beginning of flush periods. | Very little or no labour inputs in block maintenance. |
| *Harvesting strategy* | Farming harvesting strategy used through the year. Farmer may revert to 'low-input' during low crop non-flush periods | Low-input harvesting strategy' used throughout the year in flush and nonflush periods |
| *Harvest duration* | Long (>4 hours/day on multiple days) | Short (<4 hours/day). |
| *Harvest frequency and rates* | Fortnightly, especially during flush periods. Full harvesting. | Intermittent and partial/under-harvesting. |
| *Size of family work group engaged in harvesting during flush period* | Large (3+ labourers). | Small (<3 labourers). |
| *Purpose of income* | Deferred consumption. Large purchases and investment in other business. | Immediate consumption and small purchases (e.g., soap, kerosene, store foods). |
| *Importance of alternative income sources* | Low (cocoa is the primary income source). | High (labour often diverted to other economic activities). |
| *Re-investment of the cocoa-generated income* | Most or part of the money drawn from cocoa sale is re-invested to manage or regenerate the cocoa plantation | No investment in the cocoa plantation |
| *Smallholder's orientation* | Business-oriented | Subsistence-oriented |
| *Final products* | Usually dry beans (farmers have easy access to fermentaries) | Dry beans, wet beans for bulk cocoa, wet beans for certified markets |

*TABLE 5 – MAIN CHARACTERISTICS OF THE FARMING AND LOW-INPUT STRATEGIES*

These two strategies tended to be even more marked with the emergence of CPB, as its treatment requires a strong investment by the producer in his plantation to maintain production yield, especially when the SG1/SG2 hybrids and hybrid clones were planted. Further, depending on the level of CPB infestation, a low-input strategy may lead to a complete loss of yield and thus places the farmer effectively at a decision to either adopt a high intensity farming strategy of some level of more active crop management or to abandon the cocoa plots in question. A low-input strategy as it was described by Curry et al. (2007) before the spread of CPB in PNG is thus not viable any more today (Curry et al. 2012). The majority of farmers, however, continues to be subsistence-oriented and faces constraints in significantly increasing their labour input into cocoa blocks, thus

leaving similarly distinguishable characteristics between subsistence-oriented farmers with low-input management of cocoa plots and business-oriented farmers. The business-oriented farmers at the other end of the spectrum have adopted new varieties of hybrid clones and a high-input management regime that maximizes their productivity. While the two strategies identified by Curry at al. (2007) continue to underlie different orientations by farmers, both these strategies have grown in labour demand since the spread of the CPB: subsistence-oriented farmers need to keep actively farming their cocoa plots to continue counting with some yield, and business-oriented farmers seeking to maximize productivity and profit are facing higher labour requirements of the more CPB-tolerant hybrid clones promoted over the last years.

### 5.3.2 Dry beans versus wet beans production

During the 2000s, most authors equated farming producers with dry beans producers, while cocoa foragers specialized in the sale of wet beans (Curry et al. 2007). Ten years later, we have not found such a clear dichotomy on the ground or with the actors we met in the provinces of ENB and East Sepik. The expansion of the CPB and the various policies initiated to maintain cocoa production in PNG have undoubtedly modified the variables of choice for the producers to opt for a wet or dry bean production strategy. On the one hand, the major effort to be made by smallholders to combat this pest in order to maintain their production level had dissuaded a significant number of them from pursuing this strategy and reduced the interest in specialising in the production of large volumes of dry beans. In addition, several organizations such as the Cocoa Board and AusAID have developed major programmes for supplying fermentaries to farmers, particularly in the main producing provinces. In Bougainville for example, 33% of farmers owned a fermentary, although a large majority of their fermentaries were not registered (Kutan and Chand 2014). At the end of the 2000s, around 5 500 licensed fermentaries were operating throughout the country, with more than half in East New Britain Province (Bourke and Harwood 2009). In 2017, the Ministry of Agriculture and Livestock reports 15 723 registered fermentaries in PNG, i.e. about 3 times more than the 2009 figure, and mentions that there are many individually owned and unregistered fermentaries that are scattered in remote areas.

Today, access to fermentaries is probably the main reason for cocoa producers to specialise in the production of dry or wet beans. But access to fermentaries varies from province to province due to the policies of the Cocoa Board and some external partners. For example, the East Sepik province has 1 413 operating fermentaries in 2016. When the total cocoa production volume in 2016 is divided by the number of operating fermentaries, we get an average production around 7.6 t/yr/fermentary. This likely shows a wet bean production strategy for most farmers in this province, like in all MOMASE. At the opposite, the average volume of dry bean per fermentary is between 1 and 4 for ENB and AROB provinces, which tends to indicate a larger number of cocoa farmers are involved in dry bean production.

### 5.3.3 Certified versus not certified cocoa

In 2006, about 27% of cocoa produced in PNG was exported to the United States, 17% to Belgium, 16% to Malaysia, 16% to Singapore, 11% to Indonesia (Bourke and Harwood 2009). Access to western markets indicated the good quality of PNG cocoa in the mid-2000s. The trend has since

reversed, and most of the poorly fermented and dried cocoa from PNG is moving towards the bulk market driven by South East Asian countries, indicating a deterioration in the quality and the decrease in the unit price of this product. Given the high cost of shipping from PNG to Europe and the USA, it would be illogical to ship smoke tainted beans to these markets, especially as pricing would be much the same as the one proposed by the very competitive Asian grinders.

However, there are at least three niche markets alongside the bulk market. First, several international standards develop certificates for cocoa with particular characteristics. These include the Fair Trade (FT) and RainForest Alliance (RA), which are widely recognized, although not without criticism. These two standards are present in PNG via Outspan for RA and via Agmark for FT. They are also promoted by the CB. In 2017, Outspan exported 2500t of RA-certified cocoa, while Agmark exported 146t of FT-certified cocoa thanks to its Club 3000 in Madang Province. In addition to a premium paid to smallholders, cocoa certification involves technical support for fermentary owners and the reinvestment of part of the profits in community development projects.
The second niche market comes from several large producers (Mondelez, Hersheys, Blommer) that have decided to implement their own version of certification through their supply chains (AECOM 2017). These private initiatives are not active in PNG.

Lastly, in Europe/US/Australia/New Zealand, boutique businesses are looking for a specific flavour/quality. The global market for boutique beans is small, annually 500t for North America, 400t for Europe and 100t for Australia/New Zealand. Thus, out of 4.8 million tonnes of cocoa worldwide, 1000t of that has the potential to reach the boutique market (AECOM 2017). The relative scarcity of PNG beans in the market makes it ideal for the specialty market. Unfortunately, overall poor quality, high logistics costs and location also make it hardly accessible to prospective buyers. In 2015, this boutique industry in PNG comprises of some 64t (49t to Australia/NZ, 15t to the U.S), i.e. 0.2% of PNG production (AECOM 2017).

### 5.3.4 Categories of dry and wet beans producers in PNG

The main factors that are supposed to influence the choice of production model by smallholders are used to construct three categories of actors for this production function (Table 6). A fourth sub-category will be added as part of the economic analysis, to further understand the impact of private certification on farmers' income levels.

| | Subsistence-oriented and low/moderate intensity input | | Business-oriented and high intensity input |
|---|---|---|---|
| Main characteristics | 1. Wet bean producers | 2. Dry bean producers (with fermentaries) | 3. Dry bean producers (with fermentaries) |
| | Dominant East Sepik (and Momase) | Dominant ENB and AROB | Present in ENB and AROB |
| Average surface (ha/HH) | 0.6 | 1.00 | 0.75 |
| Average yield of wet beans on a 8 year production phase (kg/ha/yr) | 857 | 950 | 4000 |
| DB Yield (kg/ha/yr) | 300 | 380 | 1600 |
| Pesticide inputs | none | none | moderate |
| Fertilizer inputs | none | none | none |
| Use of income | subsistence | subsistence | partial or full reinvestment in cocoa plantation |
| Road access | poor / not accessible | accessible to some extent | accessible |
| Cocoa varieties | Trinitario and hybrids SG | Hybrids (and some clones) | Hybrids and clones |
| External support | low with Cocoa Board | moderate with PPAP | high with PPAP |
| Number of households | 102 455 | 42 874 | 2 914 |
| Total surface of active production (ha) | 61 473 | 42 874 | 2 186 |
| Total production (DB kg/yr) | 18 441 860 | 16 292 120 | 3 496 800 |

*TABLE 6 - CATEGORIES OF DRY AND WET BEANS PRODUCERS*

Each of these categories is described in more detail in the following sections.

## 5.4 Production of dry beans by the business-oriented smallholders

Intensifying cocoa production has been the main approach to developing the industry in PNG for twenty years. This model assumes a triple specialization of smallholders: (1) they resolutely engage in a strategy of farming their plantations, which generate significant productivity gains (Lummani 2006); (2) the wet beans harvested are transformed into dry beans thanks to easier access to fermentaries; (3) the production of dry beans is systematically sold to exporters.

This model seems adapted to the traditional production methods of cocoa in PNG, which is characterized by low yields. In addition, rural populations remain poor and dependent on cocoa production to increase their incomes in areas where there are few income opportunities. Finally, the intensification of cocoa production limits the impact on forest cover, the protection of which is the subject of several international agreements signed by PNG.

Since the early 1980s, this intensification policy has produced promising results. Gimbol et al. (1995) mentioned for example that the development and dissemination of new cocoa hybrids to farmers increased average production up to 2.5 to 3.0 tonnes per hectare. Lummani (2008) observed in the ENB province that cocoa yield increased by 70% to 620 kilograms per hectare in 1999 from 401 kilograms per hectare in 1998 and that about a quarter of the farms were producing cocoa at 1000 kilograms per hectare and above.

The legitimacy of this policy of intensification of cocoa production was reinforced by the appearance of the CPB. The arrival of CPB was a major disruption to people's livelihoods because it presented to farmers an all or nothing scenario—one had to become a modern, high-input farmer and adopt a technically advanced cocoa cropping system to continue as a cocoa farmer because the traditional low-input cropping system meant virtually no healthy mature cocoa pods were available to harvest (Curry et al. 2011, Curry et al. 2015).

The difficulty of this model lies in the resources needed to make it work satisfactorily, be it technical knowledge, labour or equipment.

This approach first requires new technical knowledge. This knowledge focuses primarily on improved plot sanitation and IPDM (Integrated Pest and Disease Management) techniques. Training is needed to show farmers the key elements of a CPB management regime that required weekly harvesting of all mature cocoa pods, removal and burial of all diseased and CPB-affected pods, regular pruning and shade control, weed control and insecticide spraying. Fertilizers are not part of this technical package. This new high-input cropping system to control CPB represented a large increase in farming inputs from the pre-CPB era.

The CCRI also insisted for commercial farmers that realistic yield estimates would be critical when deciding which varieties to select or how much input to purchase. Beyond, it is important for profit-oriented commercial firms to know the breakeven volume of sales, cost and income.

The implementation of these new production and management techniques implies a significant increase in the working time spent on cocoa production. Without a major intervention to raise smallholder investment of time and labour in their blocks together with the widespread adoption of CPB management techniques by smallholders, this intensification strategy cannot succeed. Ghodake et al. (1995) as well as G. McNally (pers. com.) assess that one full-time labour unit per 2.5-3 hectares is required to implement an effective cocoa management package. To reduce this labour investment, farmers were encouraged to reduce the area of cocoa from an average of 2.5 ha per household during the 1990s to around 1 ha per household, and to replace old and tall cocoa trees with new hybrid clones that were smaller, easier to manage and higher yielding than their old cocoa trees (Curry et al. 2007).

But cocoa farming in a CPB environment requires more than a large increase in labour inputs; it also requires financial investments in tools, insecticides, cocoa varieties and equipment. New varieties of hybrids (SG1, SG2) and, more recently, clones more tolerant to CPB are made available to farmers. But they have the disadvantage of having a much shorter production cycle (7-8 years)

than the old Trinitario variety (up to 20 years) (Curry and Koczberski 2009). Moreover, these new varieties seem to degrade the conversion ratio between wet beans and dry beans. In the 1990s, dry beans were 40 % of the weight of wet bean (Gimbol et al. 1995) whereas this ratio has diminished to 30% today with the new hybrid clones (McNally, pers. com.).

Several national and international organizations have done much to facilitate farmers' access to fermentaries, particularly in the provinces of Bougainville and ENB, but the low maintenance of these facilities remains a problem and maintains the poor quality of cocoa beans in PNG.

In total, the inputs needed to adopt a strategy of intensive cocoa production remain beyond the reach of farmers. It is impossible to re-start cocoa investment without a substantial external support. The small proportion of farmers who have successfully adapted their cropping systems to manage CPB were members of farmer or cooperative groups which had the financial resources to invest in their farms or were linked to comprehensive training and support programs (Curry et al. 2007). The findings are the same today and justify most of the support provided to cocoa producers by national and international organizations (Daniel and Guest 2011, Anderson 2018).

Despite this external support for cocoa production intensification, few farmers have adopted this strategy, although many producers have received technical support or training to adopt this new production model. Only a small proportion of farmers successfully adopted the new labour-intensive strategies to control CPB. When attempts were made to implement the new CPB control techniques it became apparent that plot management was not of a sufficiently high standard for effective control of CPB, though there was a slight improvement in standards on pre-CPB times (Curry et al. 2007, PPAP EA 2010, Curry et al. 2012). For instance, according to the World Bank, the PPAP only reaches around 8 per cent of the households producing cocoa in Bougainville (Anderson 2018). Our interviews and our estimation of the current cocoa production indicated even a lower order of magnitude in the ENB province.

Apart from theoretical projections of the expected performance of this production model, there are few real estimates of the results achieved by farmers who have opted for this business-oriented strategy. Our estimates therefore use the figures indicated by the PPAP in the ENB province, with an average yield of 1600 kg/ha/year of dry beans, on average areas of 0.75 ha of plantation per household. All of these producers are supported by PPAP, in collaboration with the CB, often for several years. The stagnant volume of cocoa production in PNG over the last ten years indicates that this very efficient production model in quantitative terms still concerns only a limited number of producers, probably around 3,000 households according to our simulations. It is likely that many other households (including those supported by PPAP) are currently being trained to implement this production model, but their quantitative impact on the national level of cocoa production is still limited. This situation could change in the coming years.

## 5.5 Production of dry beans by the subsistence-oriented producers

The multiplication of fermentaries in ENB and AROB over the past thirty years pushed most producers to dry their beans before selling them to exporters (Yarbro and Noble 1989, Lummani 2006). There, ninety per cent of fermentaries are owned by smallholders. By January 2003, PNG

Cocoa Board records showed there were 4,546 fermentaries, an increase of 107% over the 1990s. Today, in these two provinces, at least a third of all smalholders have their own fermentaries (Kutan and Chand 2014). But the maintenance of these often old or unregistered fermentaries is a key issue and hinders an increase in dry beans quality in PNG.

The possibility of producing dry beans did not lead these farmers to adopt or maintain a high input farming strategy for their plantations, mainly because of the cost of implementing this model, which further increased with the invasion of the CPB. In 2010, PPAP EA (2010) and Curry et al. (2011) already reported low rates of application of the four CPB management techniques for the growers who benefited from an external support in ENB: only 45% of growers complied with the protocol of centralised pod breaking, 32% with the pod burial recommendation, 41% with weekly harvesting, and only 11% with the insecticides protocol. Kutan and Chand (2014) make a similar observation in AROB.

In addition to the weakness or lack of extension support for small producers to implement a high-input farming strategy, the amount of work required was also a major obstacle to the adoption of this model. The use of hired labour to overcome household labour shortages is sporadic and most often restricted to large laborious tasks such as establishing and rehabilitating cocoa, and not for maintenance or harvesting (Ghodake et al. 1995, Omuru et al. 2001). Furthermore, as Lummani (2006) noticed, smallholders do not want to become full-time cocoa farmers. Most, if not all, would see this as a retrograde step where they become tied to cocoa production because of economic necessity.

These factors explain why, despite the ease with which wet beans can be converted into dry beans thanks to the availability of numerous fermentaries in several provinces, many growers have adopted a permanent production strategy of very low labour inputs and low production levels.

This development has had an impact on the areas actually harvested by producers. While the average plantation size of dry beans producers was between 1.5 and 5 hectares per household in the 2000s (Omuru 2001, Lummani 2006, Curry et al. 2007, Bourke and Harwood, 2009), the return to subsistence farming has drastically decreased the size of the harvested blocks (Curry et al. 2011). It is established around 1 ha/household today, on the basis of CB data in ENB – that still include a few percents of large scale producers.

Given the diversity of the configurations, it is difficult to have a precise estimate of the yield of these “extractive” cocoa farms. Curry et al. (2007) and Bourke and Harwood (2009) reviewed these returns a decade ago and concluded that the mean smallholder yield of dried cocoa is typically 200–400 kg/ha, and up to 600 kg/ha (with varieties of Trinitario, SG1/SG2 hybrids). At that time, the CCI used 250 kg/ha as a working average for smallholder yield. The PPAP, which started in 2012, has provided some support to thousands of these smallholders and this has probably resulted in an increase of cocoa yield. We assume an average annual yield of 380kg/ha for the subsistence-oriented dry bean producers.

With this low return, smallholders seem to be less concerned with maximising profits from cocoa production than with sustainability of yields and incomes over the longer term to cover part of their cash needs (Lummani 2006). Under these conditions, reinvestment into cocoa farms is very low and often inexistent (Omuru 2001).

However, the deliberate or forced choice in favor of a low-input farming strategy by many cocoa growers was not associated to a return to the production of wet beans, as thought by Curry and Koczberski (2009), for two reasons. The first is the ease of access to fermentaries in ENB and AROB for most small producers. The second reason is the ever more attractive price of dry beans, which varies according to the international price (with upward trend over the last decade), unlike that of wet beans that has remained relatively stable around 1PGK/kg in recent years. These two factors explain why many producers manage to dry their beans on fermentaries that are easily accessible but poorly maintained, resulting in poor quality dried beans.

## 5.6 Primary production of wet beans by the subsistence-oriented producers

Despite the importance given by public policies over the past 30 years to the multiplication of fermentaries and the strengthening of farmers' capacities to intensify their production, the majority of cocoa smallholders has maintained a low-input strategy and aims at the production of small quantities of wet beans (Nelson et al. 2011). This finding is explained by a combination of obstacles encountered by producers regarding household labour shortages, financial constraints, lack of access to training and information and a reluctance to make the lifestyle adjustments and labour investments required for more intensive management of their cocoa holdings (Curry et al. 2012). Also, in many parts of PNG, land is often planted to perennial cash crops as a way to lock it up to meet the future livelihood needs of the family. Cocoa blocks planted for this reason could be expected to have low maintenance levels, but low levels of maintenance are common across all tenure types (Curry et al. 2007).

This model of wet beans production by the subsistence-oriented smallholders is even more predominant in regions that were still relatively low cocoa producing in the 2000s and received little support from national and international institutes to develop fermentaries or to combat CPB, which arrived later than in ENB. In these provinces, such as Sepik, Morobe or Madang, the smallholders' limited access to quality extension training and support programs has made the extractive production of wet beans almost the only model available.

Besides a low level of technical knowledge (Lummani 2008), it also does not require a significant investment in equipment. On one hand, many farmers continue to rely or have returned to look after plots planted with the Trinitario variety that has much greater longevity and yield consistency over a longer period, while seemingly being more CPB tolerant than the SG1 and SG2 hybrids. Its processing ratio from wet bean to dry bean is also a bit more productive (300-350kg of wet beans for 100kg of dry beans) than for the hybrids (400kg of wet beans for 100kg of dry beans). But some modern varieties of cocoa such as the SG1 or SG2 hybrids are sometimes used, especially when the seedlings were proposed by extension services (Curry and Koczberski 2009). On the other hand, the types of tools used by smallholders in producing cocoa are simple and easily accessible:

bush knives, spades, axes, grass knives, pruning saws, pruning shears, harvesting knoves, wheelbarrows and knapsack sprayers.

The difficulty of recruiting a regular workforce in rural areas also explains the resistance of the wet beans production model. Household labour constraints result from a range of interacting factors, including demographic characteristics of the household, reluctance of some family members to commit labour to cocoa production, a reluctance to recruit hired labour, and competing economic and non-economic demands on household labour and time (Curry et al. 2007).

The main difference between this type of producer and subsistence-oriented dry bean producer is that wet beans are not processed into dried beans. In this model, the production function stops at the sale of wet beans to fermentary owners, sometimes through intermediaries when the fermentaries are distant (Anderson 2018). There are several transaction possibilities between wet beans producers and fermentary owners ranging from individual sales, the collective sale of several producers or the sale within a cooperative. In the province of Manus for instance, most wet bean producers brought their cocoa to their cooperative or cooperative group which was then processed, stored, transported and sold as bulk dry cocoa at reduced transaction costs (Garnevska et al. 2014).

Transporting wet beans to fermentaries is sometimes a significant cost of cocoa production, especially when fermentaries are few and far. But a limited number of fermentaries also offers the possibility of improving the quality of dry beans by more easily checking the performance of these fermentaries and limiting the risk of smoky taste of the beans. Unlike dry beans producers who have a large number of fermentaries but are almost all in poor condition, wet bean producers can sell their products to a small number of fermentary owners, some of whom maintain their equipment and produce high quality dry beans (AECOM 2017). Thus, the supply of FT- or RA-certified beans nowadays only goes through the production of wet beans which are then sold to fermentaries regularly controlled by the certifying bodies.

## 5.7 Fermentaries (with and without certification commitments)

The conversion of wet beans to dry beans requires two stages, fermentation and drying. Each of them takes 5-7 days and they are carried out in fermentaries which are also used to dry the beans. Drying is almost always done by burning firewood, despite numerous attempts to promote solar dryers or a combination of wood burning and solar energy (Johnson et al. 2004).

The Cocoa Board enumerated 19 610 fermentaries nationwide in 2017, with as many as 72% being unregistered. As a whole, around 40-50% are not active. Fermentaries are not evenly distributed among the cocoa-producing provinces since ENB and AROB experienced massive subsidy programs for fermentaries since the 1980s (Yarbro and Noble 1989, Lummani 2006, Kutan and Chand 2014). This effort has been much less intense in the MOMASE provinces, which now produce most cocoa in PNG.

Fermentaries' maintenance is a major problem in PNG and is considered to be the main factor in bean quality degradation. Some projects like PPAP or companies like Outspan and Agmark support

producers to renovate or maintain their fermentaries, but these efforts affect only a small percentage of producers nationally. The majority of dried beans in PNG therefore has a smoky taste, which can only be sold on bulk markets.

However, there is a good quality cocoa sub-sector based on efficient and regularly controlled fermentaries. This sector is based on RA-certification with Outspan in East Sepik and on FT-certification with Agmark in the Madang province. These two initiatives have certified fermentaries, 250 for RA and 110 for FT.

It is today very difficult for small cooperatives and fermentary owners groups to undertake certification without the logistical and financial support of larger export companies. The latter are the only ones able to coordinate the production of smoke free cocoa among thousands of producers, to arrange logistics, to comply with complex procedures, to cover standard annual audit costs and to have a good knowledge of the international certification-sensitive markets.

## 5.8 Exporters

Historically, there are about fifteen companies that export cocoa. The NGIP-Agmark company has dominated this sector for several decades but it must face the recent rise of Outspan, a subsidiary of the Olam group. These two companies now export 75% of the cocoa production made in PNG (Table 7). They are followed by 3 companies exporting between 1000 and 3000 tons of cocoa, then a dozen companies that export at best a few hundred tons per year.

| Metric tons | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| Agmark Pacific | 18 311 | 15 894 | 12 795 | 13 496 | 16 382 |
| Outspan Ltd | 6 282 | 6 150 | 7 485 | 11 718 | 13 905 |
| Globe Manufacturing | | 1 350 | 1 590 | 1 795 | 2 700 |
| Waiyu Mining | 3 405 | 3 061 | 2 302 | 870 | 2 395 |
| WRC Carpenters | 575 | 859 | 1 400 | 1 110 | 1 095 |
| PNG Breit Limited | 2 451 | 2 553 | 1 823 | 625 | 763 |
| Sankamap Exporters | 615 | 1 705 | 555 | 870 | 705 |
| ENB Dev. Corporation | 1 267 | 1 440 | 750 | 720 | 510 |
| ABC | | 300 | 316 | 705 | 497 |
| Kimbe Bay Shipping | 240 | 75 | 420 | 270 | 430 |
| Weni & Mandol | 1 170 | 915 | 360 | 195 | 360 |
| Morobe Cocoa Exports | 195 | 195 | 210 | 300 | 330 |
| Elliven Limited | | | | | 133 |
| ATS Boo Pty Ltd | 75 | 75 | | | |
| Cassell Agencies | 135 | 30 | | | |
| Eseem Agro Export Ltd | 195 | 405 | | | |
| Kalam Cocoa Ltd | | | 60 | 105 | |
| Kieta Commodities | 135 | 331 | | | |
| Mamo Cocoa Exports | | 15 | | | |
| Markham Farming | | | 103 | | |
| Monpi Cocoa Exports | 3 702 | 3 612 | 3 393 | 364 | |
| Pacific Agro Commodity | | 30 | 15 | | |

*TABLE 7 - EXPORTING COCOA COMPANIES IN PNG*

All these companies provide at least the function of shipping cocoa containers to foreign markets. Medium- and large-size companies also provide logistical functions by establishing branches in several PNG locations and having a small fleet of vehicles to reach fermentaries. All these companies only buy dry beans and do not have fermentation or drying equipment.

Finally, Agmark and Outspan have also developed many extension services to smallholders, notably thanks to PPAP funds, or by proposing a certification process. Their objective is to encourage small producers to increase cocoa production, if possible by also improving the quality of dried beans, since most of their production will ultimately be exported by their companies and will contribute to increasing their turnover.

## 5.9 Governance of the cocoa chain in PNG

The cocoa value chain in PNG is relatively simple and is characterized by two production and two export chains (Figure 6).

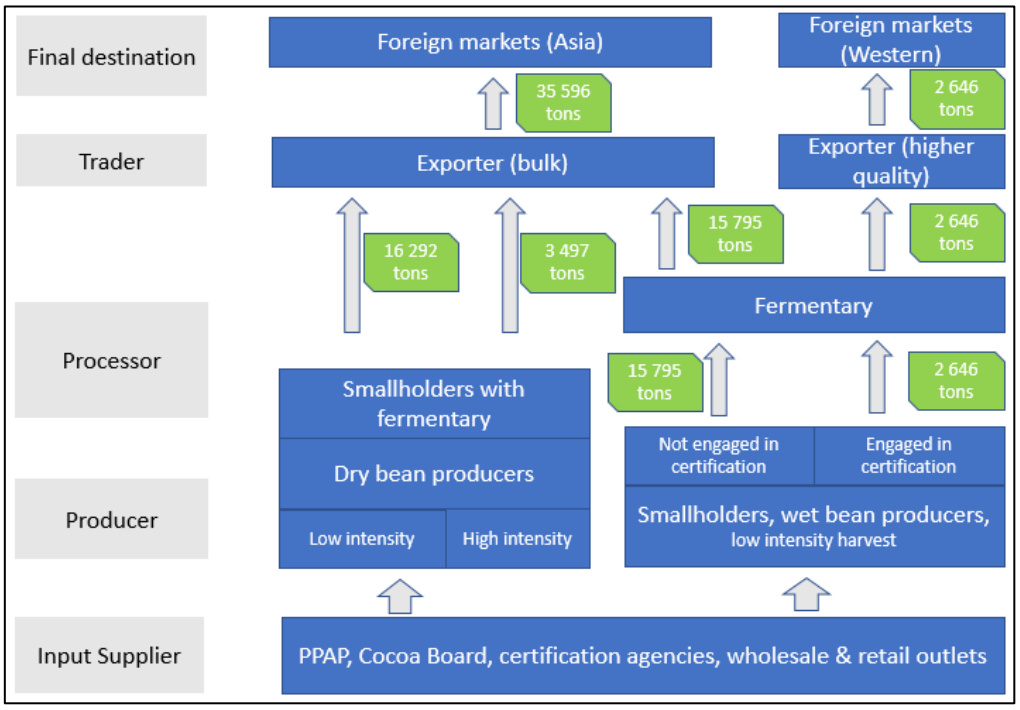



*FIGURE 6 - COCOA VALUE CHAIN AND PRODUCTION VOLUMES (IN DRY BEAN TONS)*

The first characteristic of the cocoa chain in PNG is that it is almost entirely oriented towards the export of little processed products. The small domestic market restricts the opportunities to add value by processing a primary product into a marketable product such as making chocolate for local sales. There is currently little support in PNG for developing secondary or tertiary processing of cocoa for domestic or foreign markets.

An associated feature of the cocoa industry is that marketing functions are carried out entirely by the private sector, and mainly by two companies. Producer groups do not yet have the capacity to export themselves: they lack basic business skills and business structure, and often growers may not speak sufficient foreign languages to be able to communicate with prospective buyers, nor do they have reliable telecommunications (AECOM 2017). Moreover, the CB regulations require a minimum export volume of 1000t per annum in order to retain an export license. Regulations and high costs of business mean that the industry structure lends itself to larger businesses that can achieve economies of scale.

Nowadays, only a small number of companies have the capacity to export significant volumes of dry beans from PNG. Their objective is to increase the traded volume and, to a certain extent, to improve the quality of the product in order to obtain a better price on the international market. This objective explains, on the one hand, that most exporting companies have developed direct relations with producers, by reducing the intermediate levels that would increase the cost of the

product. The cocoa sector is composed of a small number of organizational levels, although the country is geographically fragmented and rural areas are often difficult to access. On the other hand, despite the near duopoly situation of Agmark and Oustpan, the price offered to dry beans producers remains attractive and is directly connected to international market prices. The economic governance of the cocoa chain has changed little over the past twenty years and the marketing system has competitive pricing at each stage of the value chain (Bourke and Harwood 2009). This competitive marketing system has resulted in low marketing margins and relatively high returns to growers, as we will show later. It is an economic model similar to that developed by Indonesia in the 1990s (Ruf and Yoddang 1998).

The second characteristic of the cocoa industry governance is the major role allocated to the CB to regulate and promote the sector. This industry remains considered as a key agricultural sector to diversify PNG's economy and as such enjoys real political support. To achieve this objective, the CB has agencies and branches in all producing provinces and can also rely on the CCI – now integrated into the CB. However, these structures do not have a budget commensurate with their objectives: they focus on their functions of fermentaries/export monitoring and production of statistics - with collection and analysis protocols that should be consolidated. Support for the development of the sector is in fact provided by external financing and resources, notably by PPAP or by certain export companies.

However, these public and private organisations share a common vision of the production model to be promoted in PNG. This is the third characteristic of the current mode of governance of the cocoa sector. Every effort is now being made to encourage small producers to specialize in intensive cocoa production for foreign markets. This business model is detailed in the description of archetype three of our VCA. It is considered by government, donors and export companies as the best possible response to CBP expansion, but this approach has been little discussed with small producers, who still struggle to adopt it. Moreover, its financial and economic performance does not seem to have been estimated.

The promotion of this business-oriented model, and the parallel development of private certification, have resulted in the creation of two classes of small cocoa producers: business-oriented dry beans producers and certified subsistence-oriented wet beans producers. This is the fourth characteristic of the cocoa industry governance in PNG. On the one hand, a majority of smallholders produce small quantities of low quality beans, due to low harvesting rates in plantations (subsistence-oriented wet beans producers) and/or difficult access to fermentaries in good condition (subsistence-oriented dry beans producers). Very important efforts will be necessary to get out of this low quality/quantity trap, especially in the formerly highly productive regions, like ENP and AROB. On the other hand, a minority of producers has really put in practice the technical support provided by the PPAP and the private sector to greatly increase the yield of their plantations or to produce good quality beans - notably without smoky taint. Given the small number of producers now applying these improved practices, and under the assumption of the continuation of external aid, it will still be several years before there is a substantial increase in volume and an overall improvement in the quality of beans made in PNG.

# 6. Economic analysis of the cocoa value chain

The economic analysis is based on the functional analysis to answer a series of specific questions grouped into two sections. First, the economic analysis details the operating accounts of each actor involved in the chain, and lists and evaluates the benefits and costs they bear for their activities. This micro- and meso-economic financial analysis answers the question « How profitable are the VC activities for the entities involved? » (CQ1.1.). It is based on current market prices.
Several conventions are established to perform these calculations and make them homogeneous:

- Each operating account is calculated for an average agent, who is representative of its stakeholder group, for a year of full production.
- Income consists of revenues from the sale of cocoa and self-consumption. The latter is non-existent for cocoa.
- The costs are financial and relate only to actual expenses incurred in cash or in kind. They therefore do not include unpaid work.
- Public funds used by the CB, PPAP and companies promoting certification are not considered subsidies because they do not constitute a source of cash flow for producers or processors. However, they are taken into account when estimating some production costs (provision of seedlings, training, equipment, etc.) as their unit prices have been reduced to integrate the cost of this free of charge technical support.
- The minimum wage is of 3.5 PGK per hour in 2018 in PNG, i.e. a daily salary of 22 PGK.
- The average price of a ton of dry beans on the international bulk market in 2017 was 2 028 USD (ICCO source), i.e. 6 542 PGK/ton.
- The average exchange rate PGK – USD for 2017 was 0.31.
- The Internal Revenue Commission applied a 10% tax for all purchase of goods and services in the formal economy. The tax is recovered by the formal entreprises, like a current value-added tax recovery mechanism, but the primary producers and processors are not able to get back this money.

In a second stage, a macro-economic analysis of the value chain is carried out on the basis of the actors' operating accounts and national statistical data. On the one hand, the overall contribution of the cocoa industry to the national economy is assessed and allows to answer questions on the share of the sector in the GDP and in the agriculture sector (CQ1.2 & CQ1.3.), and on the distribution of incomes and employment among the VC actors (CQ2.1. & CQ2.3.). On the other hand, the analysis estimates the impact of this commodity chain on certain macroeconomic aggregates such as public finance (CQ1.4.) and the balance of trade (CQ1.5.). It concludes on the competitiveness of this sector in the international economy (CQ1.6.) on the basis of international parity prices.

## 6.1 Micro-economic analysis of the stakeholders' operating accounts

### 6.1.1 Primary production of wet beans by subsistence-oriented producers

**Listing and assessment of benefits and costs**

This type of producer farms 0.6 ha of cocoa, with an average yield of 857 kg of wet beans per hectare per year, i.e. an annual production of 514 kg of wet beans. In 2017, the average price of a kilogram of wet beans of standard quality was 1 PGK, once delivered to fermentary owners.
Around eleven thousand wet bean producers are today engaged in the production of FT- or RA-certified cocoa. Their operating methods are little different from those that are not certified, but their harvest is about 30% more intensive (i.e. 669 kg/year), by being more systematic in the harvesting of beans from trees and more motivated by higher prices and better logistical conditions. They sell their beans at a minimum price of 1.15 PGK to fermentary owners, which is guaranteed by the certification standards (AECOM 2017).

These producers do not derive any other income from their activities but they receive support from the Cocoa Board around 25 PGK/year, in the form of seedling donations (estimated at 19 PGK, thanks to the implementation of the District Cocoa Nurseries project) and training (estimated at 6 PGK, based on what is currently practiced in the Wewak district). This subsidy covers a very small part of the production costs of these farmers. Wet beans producers engaged in a certification process also receive support from Agmark or Outspan, estimated at 15 PGK/year for the nursery establishment and 11 PGK/year for capacity building.

Primary production of wet beans, as a low-input approach in often old cocoa plantations, requires relatively little effort from producers, both in terms of time and financing. These operations and their cost estimates are derived from internal data provided by the CB and from several publications (Omuru and Fleming 2001, Lummani 2006, Bourke and Harwood 2009). They correspond to the amount of work to be provided during a year of full production for 0.6 hectare of cocoa used extractively:

- Maintenance operations are limited to a little pruning of cocoa trees, a little weeding and of harvesting, breaking and bagging, for about 28 man-days of work.
- Transportation of wet beans to fermentaries takes 10 man-days of work and costs around 100 kinas to use public motor vehicles (PMV). A 10% goods and services tax is charged on this expense.
- Tools and equipment are little used and are depreciated over 10 years.
- Certified bean producers must pay an annual fee to the certification group.

We assume that 90% of the labour is not paid, as most smallholder households rely on unpaid family labour for cocoa production (Yarbro and Noble 1989, Ghodake et al. 1995, Lummani and Nailina 2001).

### Operating account of wet beans producers for bulk and certified markets

The combination of these operations makes possible to establish the operating account of an average wet bean producer, either he is certified or not (Table 8, Table 9).

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Wet beans | kg | 1 | 514 | 514 |
| Transportation to fermentaries | trip | 9 | 10 | 93 | Sale of service | | | | 0 |
| New seedlings (from CB) | | | | 0 | Subsidy* | | | | 0 |
| Training (from CB) | | | | 0 | Self-consumption | | | | 0 |
| **Value added** | | | | | | | | | |
| Salary occasional staff | | | | 83 | | | | | |
| Financial charges | | | | 0 | | | | | |
| Goods and services tax (10%) | | | | 10 | | | | | |
| Gross profit | | | | 328 | | | | | |
| Depreciation of tools | | | | 116 | | | | | |
| Net profit | | | | 212 | | | | | |

*TABLE 8 - OPERATING ACCOUNT OF A STANDARD SUBSISTENCE-ORIENTED WET BEAN PRODUCER*

[*Public funds used by the CB and PPAP are not considered subsidies because they do not constitute a source of cash flow for producers or processors. However, they are taken into account when estimating some production costs (provision of seedlings, training, equipment, etc.) as their unit prices have been reduced to integrate the cost of this free of charge technical support.]

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Wet beans | kg | 1.15 | 669 | 769 |
| Transportation to fermentaries | trip | 10 | 14.0 | 140 | Sale of service | | | | 0 |
| New seedlings (from CB) | | | | 0 | Subsidy* | | | | 0 |
| Training (from CB & certif) | | | | 0 | Self-consumption | | | | 0 |
| Fee for membership | | | | 70 | | | | | |
| **Value added** | | | | | | | | | |
| Salary occasional staff | man-day | 22 | 4 | 93 | | | | | |
| Financial charges | | | | 0 | | | | | |
| Goods and services tax (10%) | | | | 14 | | | | | |
| Gross profit | | | | 451 | | | | | |
| Depreciation of tools | | | | 116 | | | | | |
| Net profit | | | | 335 | | | | | |

*TABLE 9 - OPERATING ACCOUNT OF A CERTIFIED SUBSISTENCE-ORIENTED WET BEAN PRODUCER*

[*Public funds used by the CB and PPAP are not considered subsidies because they do not constitute a source of cash flow for producers or processors, but they are taken into account when estimating some production costs as their unit prices have been reduced to integrate the cost of this free of charge technical support.]

There are not significant financial differences between these two groups of producers. The net profit rates are close (41%-43%) as well as the value added per ton of dry beans, between 2050-2130 PGK/t. The income generated for households engaged in this activity remains low in absolute terms, as is generally the case for the sale of wet beans (Lummani 2006, Kutan and Chand 2014), but it requires little effort on the part of producers and depends little on external support. In addition, certification bodies such as FT invest part of their cocoa revenues in community development projects (building of school teacher houses, aid-post building, school desks, water supply or catchment…) that do not appear as profits in the operating accounts of certified cocoa producers.

In the two cases, the breakeven price is around 0.6-0.7 PGK/kg (40% below current price), which indicates the financial robustness of these productive models.

However, these production models are only profitable if most labour costs are borne by the household. Assuming that the work is fully remunerated at the current market rate, the production

of wet beans would no longer be profitable, with a deficit - 320 PKG per year for an average certified producer and of – 539 PKG per year for non-certified farmers.

### 6.1.2 Production of dry beans by subsistence-oriented producers

#### Listing and assessment of benefits and costs

This type of cocoa producer use the same managing method as wet bean producers but on a slightly larger area, around 1 ha, and an average yield estimated at 950 kg of wet beans per hectare per year. These producers have easy access to fermentaries that allow them to dry the beans. In 2017, the average price of one kilogram of average quality dry beans was 345 PGK for a 63.5kg bag delivered to export companies.

These producers derive no other income from their activities and receive only marginal support from the CB and the PPAP, mainly in the form of donation of seedlings and trainings. On the other hand, they often have small fermentaries whose construction was at least partially subsidized in the years 1990-2010, without being the object of a real maintenance since.

Primary production of wet beans, in a low-input approach of old cocoa plantations, requires a relatively small effort by producers, both in terms of time and materials. These operations and their cost estimates are derived from internal data provided by the CB, data collected in the field and from several publications (Yarbro and Noble 1989, Omuru 2001, Lummani 2008, Bourke and Harwood 2009, Curry et al. 2011). They correspond to the quantity of efforts to be provided to extractively harvest 1 hectare of cocoa, which is next processed into dry beans:

- The plantation maintenance operations are limited to a little cocoa tree pruning, a little weeding, and of harvesting, breaking and bagging, for about 46 man-days of work. Fermentation and drying of beans require another 12 days.
- Transportation of wet beans to fermentaries and of dry beans to exporters takes 8 man-days of work and costs around 152 kinas for PMVs.
- Tools, equipment and fermentaries are little used and are depreciated over 10 years. Minimal maintenance of fermentary costs 53 PGK per year.
- The goods and services tax is only charged for the use of PMVs. A majority of fermentary owners are registered and pay an annual licence.

Here again, we assume that 90% of the labour is not paid, as most smallholder households rely on unpaid family labour for cocoa production.

#### Operating account of the agent

The combination of these operations makes possible to establish the operating account of an average subsistence-oriented dry bean producer (Table 10).

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Dry beans (FAQ) | bag | 345 | 6 | 2 081 |
| Purchase of wet beans | | | | 0 | Sale of service | | | | 0 |
| Fuelwood | | | | 0 | Subsidy* | | | | 0 |
| Transportation in rural areas | | | | 54 | Self-consumption | | | | 0 |
| Transportation to exporters | | | | 98 | | | | | |
| Purchase of seedlings (from CB) | | | | 0 | | | | | |
| Training (from CB) | | | | 0 | | | | | |
| Purchase of tools | | | | 45 | | | | | |
| Fermentary maintenance | | | | 53 | | | | | |
| **Value added** | | | | | | | | | |
| Salary occasional staff | man-day | 22 | 7 | 145 | | | | | |
| Financial charges | | | | 0 | | | | | |
| Taxes (Fermentary licence) | | | | 182 | | | | | |
| Goods and services tax (10%) | | | | 25 | | | | | |
| Gross profit | | | | 1 479 | | | | | |
| Depreciation of equipment | | | | 116 | | | | | |
| Depreciation of fermentary | | | | 1 200 | | | | | |
| Net profit | | | | 163 | | | | | |

*TABLE 10 - OPERATING ACCOUNT OF A SUBSISTENCE-ORIENTED DRY BEAN PRODUCER*

[*Public funds used by the CB and PPAP are not considered subsidies because they do not constitute a source of cash flow for producers or processors, but they are taken into account when estimating some production costs as their unit prices have been reduced to integrate the cost of this free of charge technical support.]

This low input farming system obtains reasonable returns on their labour, with a net profit rate of 8%, and a VA of 4 672 PGK per tonne of dry beans. The break-even price of this type of production is 318 PGK per bag of dry beans, only 10% below the average price in 2017. This low price level indicates the financial fragility of this model.

The net profit of these producers is finally lower than that of wet bean producers. This is explained by the lack of a market for wet beans in regions where there are many fermentaries and by the high gross profit level of dry bean producers: the cash flow generated by the sale of dry beans is a more important criterion for these producers than the net profit which deducts the depreciation of already old and poor quality equipment.

Even if cocoa cultivation has become secondary for these smallholders, it remains a valuable source of income, which is due in particular to the attractive price of dry beans. However, this income level depends on two production factors that will deteriorate in the coming years. On the one hand, old hybrid plantations have decreasing yields. On the other hand, the virtual absence of fermentary maintenance keeps the low quality of dry beans. It is unlikely that the quantitative or qualitative development of the cocoa industry in PNG can rely on this type of production.

### 6.1.3 Production of dry beans by business-oriented smallholders

#### Listing and assessment of benefits and costs

This type of smallholder exploits 0.75ha of cocoa intensively, with an average yield of 1600kg of dry beans per hectare per year according to the PPAP, or an annual production of 1200kg of dry beans, or about 19 bags. In 2017, the average price of a bag of dry beans was 345 PGK, once delivered to exporting companies located in the country's ports.

These producers do not derive any other income from their activities, but they do receive significant support from PPAP. This subsidy averages 686 PGK per year per farmer (Martin Powell, pers. com.) although the costs are higher in the first and second years because the goods, community facilities, and training are implemented in those years. This subsidy is not considered as an additional income by these producers, but halves the financial cost of equipment (tools, clothings, chemicals, fermentary).

The production of such a quantity of dry beans requires many operations and an important investment of time for the smallholders. These transactions and their cost estimates are primarily derived from internal data provided by CB, and extracted from the CCI cocoa extension manual (CCI, 2018). They correspond to the quantity of work to be provided during a year of full production for 0.75 hectare of cocoa trees:

- Cutting out moribund or shade trees, trees pruning, chupon pollarding and grafting, replanting new clones in gaps, weeding, manuring, pod harvesting, breaking and bagging,

for about 199 man-days of work. We do the assumption that 75% of the labour is not paid, as the non-intensive tasks are done by the household members.
- Transportation of wet beans to fermentaries, firewood collection, fermentation and drying, transportation of the dry beans to the exporter, for about 59 man-days of work. Likewise, 75% of the labour is not paid, as done by the household members.
- Purchase of materials and equipment: bags, additional seedlings, tools, clothes, chemicals. Half of these costs are covered by the PPAP.
- Depreciation of equipment. Similarly, half of the depreciation cost is supported by external extension service, like the PPAP.
- General and specific taxes.

### *Operating account of the agent*

The combination of these operations makes possible to establish the operating account of an average business-oriented producer for one year (Table 11).

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| Intermediate consumption | | | | | Dry beans - Fair Average Quality | bag | 345 | 19 | 6 571 |
| Purchase of wet beans | | | | 0 | Sale of service | | | | 0 |
| Purchase of new seedlings | seedling | 3 | 10 | 0 | Subsidy* | | | | 0 |
| Purchase of chemicals | | | | 97 | Self-consumption | | | | 0 |
| Transportation to exporters | bag | 23 | 13 | 429 | | | | | |
| PPAP membership | | | | 70 | | | | | |
| Value added | | | | | | | | | |
| Salary occasional staff | | | | 1 843 | | | | | |
| Financial charges | | | | 0 | | | | | |
| Taxes (fermenatry licence) | | | | 324 | | | | | |
| Internation revenue commission | | | | 78 | | | | | |
| Gross profit | | | | 3 732 | | | | | |
| Depreciation of equipment | | | | | | | | | |
| Fermentary | | | | 750 | | | | | |
| Clothes | | | | 16 | | | | | |
| Tools and small equipment | | | | 148 | | | | | |
| Net profit | | | | 2 818 | | | | | |

*TABLE 11 – OPERATING ACCOUNT OF THE BUSINESS-ORIENTED DRY BEAN PRODUCER*

[*Public funds used by the CB and PPAP are not considered subsidies because they do not constitute a source of cash flow for producers or processors, but they are taken into account when estimating some production costs as their unit prices have been reduced to integrate the cost of this free of charge technical support.]

This activity has a net profit rate around 43% and generates a VA of about 1855PGK per ton of dry beans. The break-even price for this type of production is 197 PGK per bag of dry beans, i.e. within the range calculated by Omuru and Lummani (2001).

However, this mode of production is largely supported by the PPAP. Stopping these subsidies would reduce the profit level by 46%. Similarly, 75% of the labour required by this business-oriented model is supposed to be provided free of charge by the household and is therefore not considered a financial cost. However, the profitability of this model is very dependent on workforce. Assuming that labour was paid at the current market rate, this model would show a deficit of -2 709 PGK per year. Worse, if the subsidies were to stop and all labour paid, the profitability of this model would amount to PGK -3 938 per year.

Today, the business-oriented production of dry beans remains a very profitable model because, on the one hand, it depends on significant technical and financial support, which CB would not able to provide without external projects. On the other hand, the choice of farmers to invest their working time in cocoa production may change rapidly if other land uses provide more attractive returns on labour inputs. This is already the case with oil palm (Bourke and Harwood 2009).

### 6.1.4 Fermentaries (with or without certification commitments)

**Listing and assessment of benefits and costs**

Since all cocoa beans must be dry to be exported, it is necessary for wet beans producers to sell their products to fermentary owners who will ferment, dry and then ship them to export companies. There are at least 20,000 fermentaries in PNG, of which 360 are engaged in a traceability process for RA- or FT-certification.

The assessment of the benefits and costs of these agents is built on field data and on prices provided by Agmark and Oustpan. Most operations are similar for all fermentary owners, but the production volume (116 bags versus 30 bags per year) and price (420 PGK versus 345 PGK per bag) are much higher for those engaged in a certification process. In addition, the latter receive an estimated annual grant of 182 PGK/yr for fermentary and dryer rehabilitation from the certification-supporting companies.

The financial costs for a fermentary owner consist of:

- Collection of wet beans from producers and transportation of dry beans to exporters are the most substantial cost after the purchase of wet beans.
- Most labour is done by the household members and is unpaid.
- Tools, small equipment, communication are negligible expenses.
- Large equipement, like fermentary and cars, are depreciated over a 10 years period.
- Fermentary maintenance is a significant (but partly subsidized) cost for certified fermentaries, much less for the non-certified fermentaries.
- Internal Revenue Commission and fermentary licences are paid by all certified fermentaries and by 75% of the non-certified ones.

### Operating account of fermentary owners for bulk and certified markets

The combination of these operations makes possible to establish the operating account of an average fermentary owner, either he is certified or not (Table 12, Table 13)

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Dry beans | bag | 345 | 30 | 10 350 |
| Purchase of wet beans | kg | 1 | 5 443 | 5 443 | Sale of service | | | | 0 |
| Fuelwood | | 0 | | 0 | Subsidy | | | | 0 |
| Tools | tool | 25.2 | 2 | 50 | Self-consumption | | | | 0 |
| Transportation in rural areas | forfeit | 198 | | 198 | | | | | |
| Transportation to exporters | bag | 18 | 30 | 540 | | | | | |
| Communication | forfeit | | | 45 | | | | | |
| Fermentary maintenance | forfeit | | | 120 | | | | | |
| **Value added** | | | | | | | | | |
| Salary occasional staff | man-day | 15 | 8 | 120 | | | | | |
| Financial charges | forfeit | | | 0 | | | | | |
| Taxes (fermentary licence) | | | | 243 | | | | | |
| Goods and services tax (10%) | | | | 125 | | | | | |
| Gross profit | | | | 3 466 | | | | | |
| Depreciation of equipment | | | | | | | | | |
| Fermentary (10 yrs) | | 12 000 | | 1 200 | | | | | |
| Car (10 yrs) | | 10 000 | | 1 000 | | | | | |
| Net profit | | | | 1 266 | | | | | |

*TABLE 12 - OPERATING ACCOUNT OF A NON-CERTIFIED FERMENTARY OWNER*

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| Intermediate consumption | | | | | Dry beans - Fair Average Quality | bag | 420 | 116 | 48 720 |
| Purchase of wet beans | kg | 1.15 | 21 046 | 24 203 | Sale of service | | | | 0 |
| Fuelwood | | 0 | | 0 | Subsidy | | | | 0 |
| Tools | tool | 25.2 | 3 | 76 | Self-consumption | | | | 0 |
| Bags (for wet beans) | bag | 1.8 | 22 | 40 | | | | | |
| Bags (jute bags) | bag | 9 | 12 | 108 | | | | | |
| Transportation in rural areas | forfeit | 1040 | | 1 040 | | | | | |
| Transportation to exporters | bag | 18 | 116 | 2 088 | | | | | |
| Communication | forfeit | | | 135 | | | | | |
| Fermentary maintenance | forfeit | 1 752 | | 1 570 | | | | | |
| Value added | | | | | | | | | |
| Salary occasional staff | | 22 | 100 | 2 200 | | | | | |
| Financial charges | forfeit | | | 170 | | | | | |
| Taxes (fermentary licence) | | | | 324 | | | | | |
| Goods and services tax (10%) | | | | 472 | | | | | |
| Gross profit | | | | 16 296 | | | | | |
| Depreciation of equipment | | | | | | | | | |
| Fermentary (10 yrs) | | 18 000 | | 1 800 | | | | | |
| Car (10 yrs) | | 10 000 | | 1 000 | | | | | |
| Bags (5 yrs) | | 1 181 | | 236 | | | | | |
| Net profit | | | | 13 496 | | | | | |

*TABLE 13 - OPERATING ACCOUNT OF A CERTIFIED FERMENTARY OWNER*

The involvement in a certification process, and the production of high quality beans, has a direct impact on the net profit rate of fermentary owners, which stands at 28% against only 12% for

standard fermentaries. This is a direct effect of the (partly subsidized) professionalization of these agents in a superior quality equipment, whose performances can be all the more easily controlled and maintained as there are relatively few certified fermentaries.

However, again, the financial profitability of this model depends on access to free family labour.

### 6.1.5 Exporters (with or without certification commitments)

**Listing of benefits and costs**

The most obvious function of exporting companies is the shipment of dry beans received from smallholders and fermentary owners to foreign markets. There is a relatively significant cost that is partly linked to compliance with procedures and payment of levies imposed by national regulations. It is also a labour-intensive operation and requires heavy equipment to handle the thousands of tons of cocoa.

Beyond the function of shipment, exporting companies play a major role in coordinating the cocoa industry by maintaining permanent links with producers through the dissemination of information, access to equipment, training... which requires numerous staff and significant means.

These two functions involve a substantial wage bill, the purchase and maintenance of many vehicles, and the full payment of taxes since this activity is entirely part of the formal economy.
To cover these expenses, exporting companies derive their income from the sale of dry beans (and, very secondarily, by-products such as cocoa nibs) on international markets. PNG beans are generally classified as "Fair average quality" (FAQ) and intended for the bulk market. A small proportion estimated at 2.5% of the beans reaching exporting companies from small producers does not meet this standard and is rejected.

Companies based in PNG play a marginal role on the international bulk market and are price-takers. Cocoa prices for this product were estimated by the International Cocoa Organization to average PGK 6 542 in 2017. However, the price of certified cocoa is higher, around PGK 8 820 per tonne, with a minimum price obligation of PGK 7 419 per tonne paid to primary producers.

**Operating account of exporting companies for bulk and certified markets**

The combination of these operations makes possible to establish the operating account of an average exporting company, either it is certified or not (Table 14,

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Dry beans (FAQ) | ton | 6 542 | 2 800 | 18 317 419 |
| Purchase of dry beans | bag | 345 | 44 094 | 15 212 598 | Raw nibs | bag | 208 | 70 | 14 539 |
| Tools, small equipment | forfeit | | | 1 200 | Sale of service | | | | 0 |
| Bags (jute) | bag | 2 | 44 094 | 88 189 | Subsidy | | | | 0 |
| Consumables | forfeit | | | 9 600 | Self-consumption | | | | 0 |
| Electricity | month | 1 440 | 12 | 17 280 | | | | | |
| Water | month | 1 440 | 12 | 17 280 | | | | | |
| Fuel, oil | month | 5 400 | 12 | 64 800 | | | | | |
| Communication | forfeit | | | 5 200 | | | | | |
| Maintenance of the building | month | 9 440 | 12 | 113 280 | | | | | |
| Renting of containers | container | 1 098 | 184 | 201 732 | | | | | |
| Health control - Fumigation | container | 380 | 184 | 69 816 | | | | | |
| Health control by NAQUIA | container | 350 | 184 | 64 304 | | | | | |
| Technical support - IT fixing | consultant | 1 800 | 4 | 7 200 | | | | | |
| Technical support - Accountancy | consultant | 1 800 | 2 | 3 600 | | | | | |
| Transporation (internal) to ports | bags | 7.2 | 44 094 | 317 480 | | | | | |
| Supports to producers | forfeit | | | 15 000 | | | | | |
| **Value added** | | | | | | | | | |
| Salary Permanent staff | year | | | 48 600 | | | | | |
| Salary Casual staff | year | | | 4 000 | | | | | |
| Financial charges | year | | | 16 444 | | | | | |
| Export levy | ton | 40 | 2 800 | 112 000 | | | | | |
| Trading licence fee | forfeit | | | 2 225 | | | | | |
| Customs fees for shipment | container | 380 | 184 | 69 816 | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Goods and services tax (10%) | year | | | 41 586 | | | | | |
| Gross profit | | | | 1 828 727 | | | | | |
| Depreciation of equipment | | | | | | | | | |
| Delivery Truck (10 yrs) | | 3 | 140 000 | 42 000 | | | | | |
| Car (10 yrs) | | 3 | 120 000 | 36 000 | | | | | |
| Forklift (10 yrs) | | 2 | 80 000 | 8 000 | | | | | |
| Computer (4 yrs) | | 4 | 3 000 | 3 000 | | | | | |
| Winnower (10 yrs) | | 5 | 50 000 | 12 500 | | | | | |
| Air conditioner split (4 yrs) | | 5 | 6 200 | 7 750 | | | | | |
| Dryer (10 yrs) | | 1 | 16 000 | 533 | | | | | |
| Printer (4 yrs) | | 3 | 2 000 | 1 500 | | | | | |
| Excavator (10 yrs) | | 1 | 105 000 | 10 500 | | | | | |
| Grader (10yrs) | | 1 | 300 000 | 30 000 | | | | | |
| Net profit | | | | 1 676 944 | | | | | |

*TABLE 14 - OPERATING ACCOUNT OF A NON-CERTIFIED EXPORTING COMPANY*

| EXPENSES | Unit | Unit price (PGK) | Number | Value (PGK) | INCOME | Unit | Unit price (PGK) | Number | Value (PGK) |
|---|---|---|---|---|---|---|---|---|---|
| **Intermediate consumption** | | | | | Dry beans (FT/RA) | bag | 560 | 20 835 | 11 667 402 |
| Purchase of dry beans | bag | 420 | 20 835 | 8 750 551 | Sale of service | | | | 0 |
| Tools, small equipment | forfeit | | | 5 500 | Subsidy | | | | 0 |
| Bags (jute) | bag | 5 | 20 835 | 93 756 | | | | | |
| Consumables | forfeit | | | 4 800 | | | | | |
| Electricity | month | | | 25 200 | | | | | |
| Water | month | | | 3 600 | | | | | |
| Fuel, oil | month | | | 4 400 | | | | | |
| Maintenance/rent of the building | month | | | 37 800 | | | | | |
| Communication | forfeit | | | 3 600 | | | | | |
| NAQIA fees | ton | 224 | 1 323 | 296 352 | | | | | |
| Shipment | ton | 156 | 1 323 | 206 388 | | | | | |
| Supports to producers | forfeit | | | 9 500 | | | | | |
| **Value added** | | | | | | | | | |
| Salary Permanent staff | year | | | 39 800 | | | | | |
| Salary Casual staff | year | | | 9 000 | | | | | |
| Financial charges | year | | | 8 029 | | | | | |
| Export levy | ton | 40 | 1 323 | 52 920 | | | | | |
| Export licence | forfeit | | | 5 000 | | | | | |
| Goods and services tax (10%) | year | | | 6 137 | | | | | |
| Gross profit | | | | 2 105 069 | | | | | |
| Depreciation of equipment | | | | | | | | | |
| Delivery Truck (10 yrs) | | 140 000 | 1 | 14 000 | | | | | |
| Car (10 yrs) | | 120 000 | 1 | 12 000 | | | | | |
| Forklift (10 yrs) | | 80 000 | 1 | 8 000 | | | | | |
| Computer (4 yrs) | | 3 000 | 1 | 750 | | | | | |
| Printer (4 yrs) | | 2 000 | 1 | 500 | | | | | |
| Net profit | | | | 2 069 819 | | | | | |

*TABLE 15 - OPERATING ACCOUNT OF A CERTIFIED EXPORTING COMPANY*

The net profit rate from export activity is relatively low (around 9% for uncertified cocoa and 17% for certified cocoa) compared to those obtained for upstream levels of the value chain. This is

explained by the high overall cost of salaries, equipment consumables and taxes, which is little offset by the difference between the Free-on-Board (FOB) selling price abroad and the Delivered-in-Store (DIS) purchase price to producers.

The estimated value added per tonne provided by the export companies is also relatively low for uncertified cocoa, around 758 PGK/ton. It rises to 1 683 PGK/ton for certified cocoa, due to an increased profit and a higher wage bill dedicated to the promotion of this product. Agmark and Outspan's commitment to private certification builds on an efficient pre-existing organization, which reduces the overall cost of improving the management and tracking system for this niche production.

## 6.2 Macro-economic analysis of the cocoa value chain

### 6.2.1 Contribution to the PNG economy

#### Contribution to GDP

Table 16 summarizes the inputs and outputs needed for the current functioning of the cocoa industry in PNG, based on stakeholders' operating accounts and the number of actors involved at these different production levels for a total production volume of 38,230 tons. The net operating surplus are also calculated.

| | Final output | Product sold in sector | Consumable off sector | Consumable in sector | Service | Salary | Taxes | Financial costs | Capital depreciation | Net Operating Surplus | Value added |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet Bean producers (without certification) | 0 | 45 126 320 | 0 | 0 | 8 775 000 | 7 277 985 | 0 | 0 | 10 179 000 | 18 894 330 | 36 351 315 |
| Wet Bean producers (with certification) | 0 | 8 824 410 | 0 | 0 | 2 830 070 | 1 113 621 | 0 | 0 | 1 334 504 | 3 546 215 | 5 994 340 |
| Subsistence-oriented Dry Bean producers | 0 | 88 954 320 | 4 201 621 | 0 | 7 331 400 | 6 130 937 | 7 803 011 | 0 | 56 421 770 | 7 065 581 | 77 421 299 |
| Business-oriented Dry bean producers | 0 | 19 093 620 | 282 674 | 0 | 1 620 860 | 5 385 380 | 944 190 | 0 | 2 663 549 | 8 196 968 | 17 190 087 |
| Fermentaries of Wet Beans (without certification) | 0 | 86 240 700 | 1 454 803 | 45 126 320 | 7 731 237 | 1 005 892 | 2 020 098 | 0 | 18 288 950 | 10 613 410 | 31 928 350 |
| Fermentaries of Wet Beans (with certification) | 0 | 17 500 640 | 764 360 | 8 824 410 | 1 294 278 | 789 851 | 116 324 | 61 034 | 1 090 066 | 4 560 322 | 6 617 597 |
| Exporters of Dry Beans | 232 873 700 | 0 | 3 961 762 | 194 288 600 | 8 706 305 | 668 710 | 1 497 598 | 209 054 | 2 203 818 | 21 337 810 | 25 916 990 |
| Exporters of certified Dry Beans | 23 263 640 | 0 | 343 950 | 17 447 720 | 1 031 680 | 124 600 | 88 335 | 16 058 | 70 500 | 4 140 793 | 4 440 286 |
| TOTAL | 256 137 340 | | 11 009 170 | | 39 320 830 | 22 496 976 | 12 469 556 | 286 146 | 92 252 157 | 78 355 429 | 205 860 264 |

*TABLE 16 – ECONOMIC INPUTS AND OUTPUTS OF THE COCOA INDUSTRY AT THE NATIONAL SCALE (IN PGK)*

This global analysis allows to take stock of the current economic state of the cocoa industry in PNG, with three comments. First of all, the turnover of the sector of 256 million PGK is lower than those declared by the CB in 2015 and 2016, but it corresponds to the figure used to prepare the 2018 national budget. This is mainly due to the fall in the price of bulk cocoa on the international market, since the production volume has remained broadly the same over the last three years. This demonstrates the cocoa industry's strong dependence on foreign markets, particularly the bulk cocoa market.

Export to the most demanding cocoa quality markets accounts for 9% of the sector's total turnover. This is a slow but steady increase over the last three years.

Secondly, the production and trade of cocoa appear to be profitable activities. The average net profit rate is 30%; and the more upstream in the value chain, the higher the profit, except for subsistence-oriented dry bean producers. This is due in particular to the informal nature of a large part of cocoa bean production, which makes it possible to limit the cost of intermediate consumption and wages. But we will show further on that this economy is fragile and could struggle to develop, despite its attractive profit rates.

Finally, the cocoa industry generates a direct gross VA of 5 382 PGK per tonne of dry beans, which is also partly explained by the low weight of intermediate consumption (non-existent or subsidised) in the operating accounts of small producers.

However, it is possible to estimate the indirect value added of the cocoa commodity chain from its links with other productive sectors of the PNG economy (Table 17).

| in PGK | Direct VA | Indirect VA | Total |
|---|---|---|---|
| *Imports* | 20 150 717 | 0 | 20 150 717 |
| Labor | 22 496 976 | 14 252 598 | 36 749 573 |
| Tax | 12 469 556 | 2 804 340 | 15 273 896 |
| Financial cost | 286 146 | 2 582 293 | 2 868 440 |
| Depreciation | 92 252 155 | 5 315 367 | 97 567 522 |
| Net profit | 78 355 429 | 5 062 426 | 83 417 855 |
| TOTAL VA | 205 860 262 | 30 017 024 | 235 877 286 |

*TABLE 17 – DIRECT AND INDIRECT VALUE ADDED OF THE COCOA CHAIN IN PNG*

Beyond its direct VA, the cocoa industry generates an indirect VA of around PGK 30 billion, i.e. a surplus of 15%. In total, the cocoa industry generates a direct and indirect VA of about 236 million PGK per year, which represents a direct contribution of around 3.78% to the GDP and a contribution of 20% to the VA of the agricultural sector (itself contributing 18.8% to the GDP). This ratio was 14% in 2006 for the direct VA only (Curry et al. 2009), indicating a slight progress in the cocoa industry since then.

### Distribution of income and of direct Value Added among stakeholders

The subsistence-oriented producers of wet and dry beans are the main beneficiaries of the revenues generated by the cocoa industry in PNG. Because of their number and the financial profitability of their activity, these two groups of actors make 33% of the total profit and receive 59% of labour remuneration (Table 18).

| | Final Output | Consumable off-sector | Service | Salary | Financial costs | Taxes | Depreciation | Net Operating Surplus |
|---|---|---|---|---|---|---|---|---|
| Wet Bean producers (without certification) | 0% | 0% | 22% | 32% | 0% | 0% | 11% | 24% |
| Wet Bean producers (with certification) | 0% | 0% | 7% | 5% | 0% | 0% | 1% | 5% |
| Subsistence-oriented Dry Bean producers | 0% | 38% | 19% | 27% | 0% | 63% | 61% | 9% |
| Business-oriented Dry bean producers | 0% | 3% | 4% | 24% | 0% | 8% | 3% | 10% |
| Fermentaries of Wet Beans (without certification) | 0% | 13% | 20% | 4% | 0% | 16% | 20% | 14% |
| Fermentaries of Wet Beans (with certification) | 0% | 7% | 3% | 4% | 21% | 1% | 1% | 6% |
| Exporters of Dry Beans | 91% | 36% | 22% | 3% | 73% | 12% | 2% | 27% |
| Exporters of certified Dry Beans | 9% | 3% | 3% | 1% | 6% | 1% | 0% | 5% |

*TABLE 18 – DISTRIBUTION OF INCOME AND COSTS AMONG THE STAKEHOLDERS OF THE VALUE CHAIN*

They also generate more than 56% of the total direct VA of the PNG cocoa chain (Figure 7).

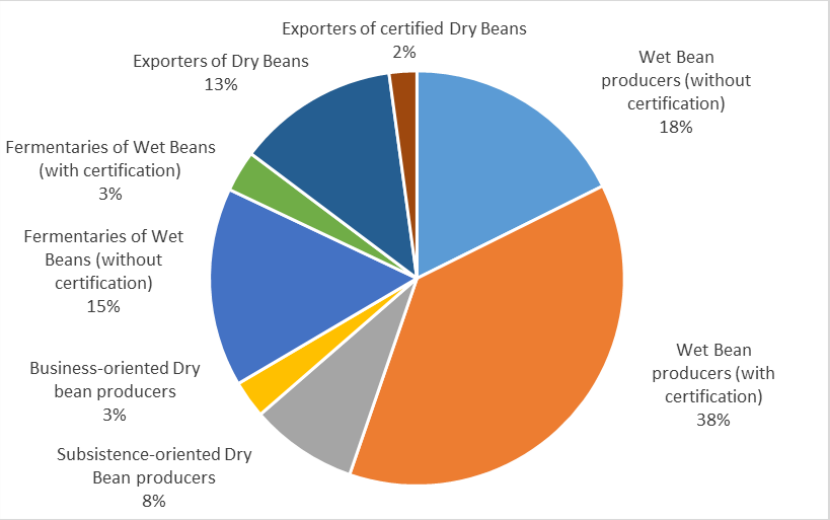



*FIGURE 7 – DISTRIBUTION OF THE VA AMONG THE STAKEHOLDERS*

The very favourable distribution of cocoa revenues to smallholders is explained by a very high ratio - around 80% - between the DIS purchase price to national producers and the FOB selling price in the international market (Figure 8).

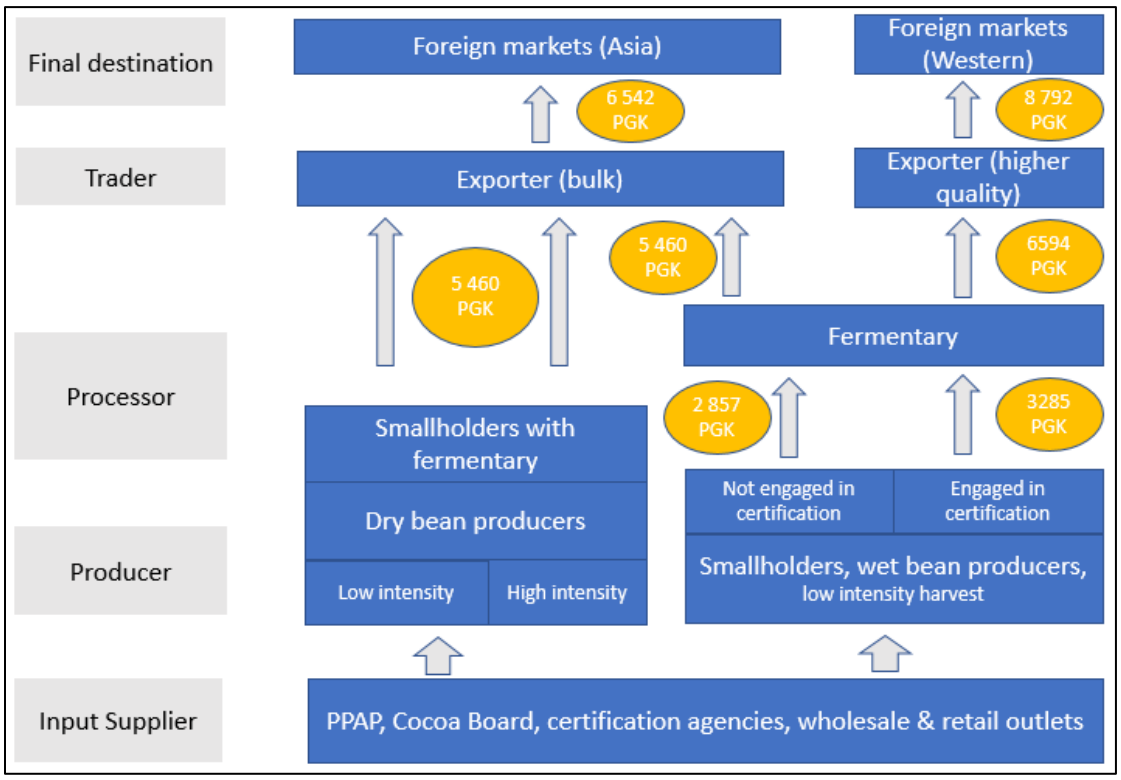



*FIGURE 8 - BREAKDOWN OF THE PRICE OF A TON OF DRY BEANS THROUGHOUT THE VALUE CHAIN*

In general, cocoa producers have very high VA/turn over ratios (Figure 9). This is explained, on the one hand, by the low inputs made by a large majority of smallholders to collect and process cocoa beans and, on the other hand, by the subsidies provided to cover most intermediate consumptions for the business-oriented dry bean producers.

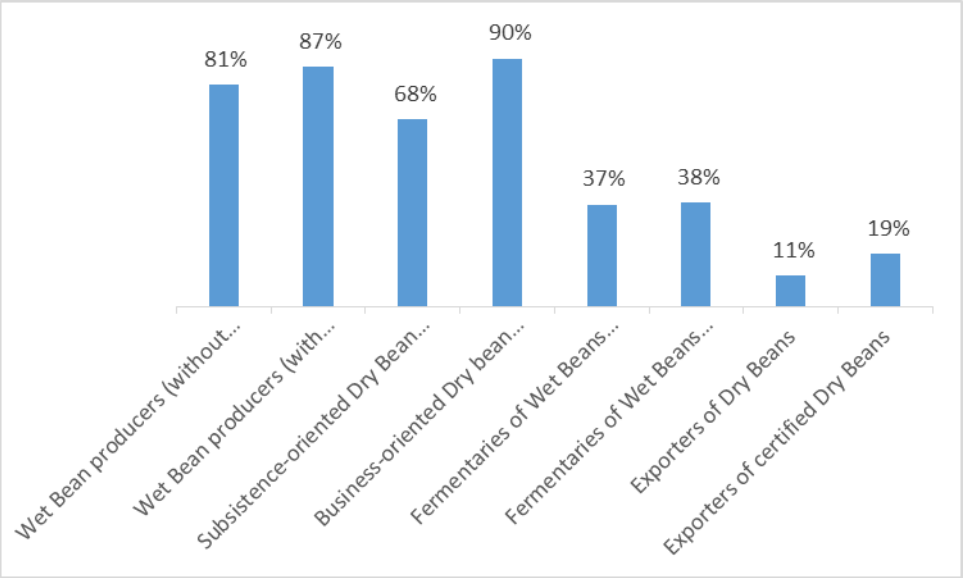



*FIGURE 9 – RATIO VALUE ADDED / TURN OVER*

From a macroeconomic point of view, such results would suggest that cocoa production is an attractive financial option for local populations in PNG. But from a microeconomic point of view, cocoa production is small in volume and a moderate source of income for a large majority of rural households. This crop is a subsistence strategy for most smallholders, where investment in the resource is low; yields and production levels can be expected to decline over time. Few of them have made the effort today to opt for a business orientation or to engage in a certification process and it is likely that many smallholders do not have the means or the will to improve their management systems even in the long term.

### Employment

It is difficult to estimate the employment provided by the cocoa industry in PNG because this term has various meanings. First, employment is generally associated with full-time salaried jobs. If the positions offered by administrations and international projects are excluded, only export companies provide full-time salaried jobs for the majority of their staff. This wage employment has declined since the mid-2000s to around 300 people at present - excluding workers employed in the remaining large-scale plantations.

All companies also rely on casual staff during periods of intense activity, who work from a few days to a few months a year under a formal contract. This type of part-time employment concerned around 200 people in 2017.

Most of the work done by the cocoa industry is in fact in the informal economy and involves three categories of workers. First of all, there are about 150 000 households who benefit directly from the exploitation, processing or sale of cocoa. This profit can in reality be assimilated at least partially to a form of salary because these smallholders do not remunerate themselves for their work. However, these 150 000 smallholders do not rely solely on their labour force to conduct their activity and resort to two types of workers:

3. they pay local workers, especially during flush periods, and this cost exceeds PGK 21 million nationally. At 22 PGK per working day and 280 working days per year, this sum represents the equivalent of 3500 full-time jobs. ;
4. but most of the production activities - between 75% and 90% according to our assumptions - are carried out by members, friends and relatives of the household without payment. Self-employment would then be equivalent to 14 000 full-time jobs. It represents the most important production factor to grow cocoa in PNG.

### 6.2.2 Impacts on macro-economic aggregates

#### Impact on public finance

The impact on public finances is estimated by comparing the amount of national government subsidies received by the cocoa industry and the amount of taxes generated by this value chain in PNG.

*THE SPECIFIC TAXES PRODUCED BY THE COCOA INDUSTRY ARE DERIVED FROM THE CONSOLIDATED FINANCIAL ANALYSIS OF THE SECTOR (*
Table 16) and the indirect effects of the sector (Table 17). These two estimates do not include the Goods and Services Tax that is paid back to companies. Total direct and secondary taxes amount to PGK 15 273 896 per year.

Smallholders and processors do not directly receive national subsidies but some public funds are used by the CB, PPAP and companies promoting certification to improve their practices. Among these supporting organisations, only the CB uses public funds from PNG, which can therefore be assimilated to a grant. The annual budget of the CB is 17 million PGK in 2016, of which about 3.6 million PGK are used to provide subsistence-oriented farmers with seedlings and trainings.

Overall, the tax/subsidy ratio stands at 90%, indicating a public finance deficit for the cocoa industry. This result is mainly due to the informal nature of a large part of cocoa production and the low level of export taxes. It is also explained by the choices of the government to favour the increase of the incomes of the small producers and to strengthen the price competitiveness of PNG cocoa on the international markets by weakly taxing the exports.

#### Impact on the balance of trade

*The impact on the Balance of Trade is estimated by comparing the amount of exports of the cocoa industry with that of imports generated by this industry. Cocoa exports are extracted from the consolidated financial analysis of the sector (*
Table 16), for an amount of 256 137 340 PGK. This commodity contributes 0.8% to PNG's exports, based on the 2016 Balance of Trade.
Imports attributable to the cocoa industry are derived from the calculation of the indirect effects of the sector (Table 17). They represent 20 150 717 PGK in 2017, or about 0.15% of the total value of PNG imports estimated at 13.1 billion in 2016.

The cocoa sector therefore contributes very favourably to the trade balance, with a surplus of about PGK 236 million per year.

### Competitiveness of the PNG cocoa chain within the international economy

Two main factors prevent the prices of goods and services used by the cocoa industry from being considered as reference prices of a pure and perfect competitive economy. On the one hand, goods and services imported into PNG or exported are submitted to various taxes and fees:

- for exports: each shipping company must get an annual export licence about 1500 PGK and pays an export levy of 40 PGK/ton of cocoa;
- for imports: each importing company must get an import licence of about 1000 PGK/year and a 10% Goods and Services Tax is imposed for imported goods.

The prices of most goods manufactured in PNG and of exported cocoa beans are therefore different to their international prices.

Secondly, most producers and fermentary owners benefit or have benefited from CB (national funds) and PPAP (international funds) support to carry out their activities. These subsidies can be substantial and sometimes greatly reduce the price of many material inputs (seedlings, equipment...) and real estate (fermentaries). We have therefore eliminated these subsidies, which increases the price of equipment by 10-20%.

The application of these two shadow pricing processes makes it possible to calculate the economic performance of the cocoa value chain on the basis of reference prices and to compare them with those previously evaluated with current market prices, in a policy matrix analysis (Table 19).

| | Tradable output | Tradable input | Labour | Capital | Net income |
|---|---|---|---|---|---|
| Market price | 260 206 890 | 77 450 650 | 58 018 450 | 103 812 626 | 20 925 165 |
| Reference price | 260 206 890 | 44 282 167 | 51 315 602 | 62 367 686 | 102 241 436 |
| Transfer | 0 | 33 168 483 | 6 702 848 | 41 444 940 | -81 316 271 |

*Table 19 – Policy matrix analysis of the cocoa chain in PNG*

Several criteria drawn from this matrix show the uncertain efficiency of the PNG cocoa chain in the international economy.

First, the ratio between domestic resources (i.e. labor+capital at the market prices) and the value added (tradable output – input at the market prices) is set at 0.89, which indicates the substantial contribution of the national non-tradable goods and services to the existing value chain, due to the low use of manufactured goods in the upstream levels of the chain. Such a Domestic Resource Cost criterion moves to 0.53 with the reference prices. It shows that the cocoa industry generates benefit to the national economy as the value added is superior to the domestic goods and services used in the value chain.

Finally, a Profitability Coefficient of 0.205 reveals that the profitability of this sector could highly increase if producers accessed imported goods at their international prices and if export fees were removed.

# 7. Social analysis

## 7.1 Social sustainability of the value chain

### 7.1.1 Working conditions & labour

The value chain of cocoa in PNG provides direct income and employment opportunities in smallholder agriculture, family-run commercial agricultural farms, cocoa fermentary/drier operations, cooperative producer organisations, and in local trading and export businesses. Indirect income and employment are provided in the transport sector, agricultural input wholesale and retailers, shipping ports, and various state agencies and non-governmental organization performing work related to the cocoa value chain.

The majority of beneficiaries of the cocoa value chain in PNG are smallholder farming households (130.000-150.000), with upward potential for the adoption of cocoa in new areas, especially in parts of the PNG highlands provinces where trials are showing promising results. Fermentaries/driers are operated by a segment of cocoa-growing households, sometimes through cooperative producer organizations (more detail on cooperatives in section 6.1.5). Cocoa export businesses provide a limited number of full-time jobs in direct employment. These are in the order of magnitude of about 300 jobs nationwide (see Economic Analysis), besides casual employment in cocoa flush periods. Traders play an insignificant role in the cocoa value chain for most parts of PNG today (see Functional Analysis).

### 7.1.2 Labour rights

The majority of exports are handled by a small number of enterprises, both national and multi-national entities (see Functional Analysis). As much as could be determined, export enterprises comply with national labour legislation in PNG, especially as concerns minimum wage regulations.

On a general level, labour rights are often difficult to enforce from the perspective of employees. The PNG Department of Labour and Industrial Relations (DLIR) does not have the staff manpower to inspect compliance with labour legislation by individual entities, and only reviews compliance in response to received complaints. For employees at minimum wage level, a formal complaint may usually not be regarded as a promising pathway. Also, the industrial relations dispute arbitration tribunal at the DLIR has a slow turnover of cases, years at times, which is not practical for employees in dispute with employers. Throughout this study, in any case, no specific cases of individual or collective labour disputes could be observed in enterprises active in the cocoa value chain.

National labour legislation, also in relation to labour rights, is currently under review by DLIR. Policy review includes further alignment to the 8 fundamental ILO labour conventions, which PNG has all ratified by 2000 (conventions nos. 98, 29 & 105 were ratified in 1976). The DLIR is currently also engaged in processes to improve compliance with ILO monitoring and reporting requirements, which PNG meets unsatisfactorily to date.

### 7.1.3 Child Labour

Child labour is no acute concern in the cocoa value chain in PNG. Children help with activities related to cocoa production as part of household activities, and as deemed appropriate by guardians in relation to their age. This does not involve hard labour and is generally not interfering with children's school attendance (particularly at primary level). Children are not exposed to harmful jobs, although it is vital to assure adequate awareness about health risks associated with application and storage of pesticides as their use increases in cocoa cultivation.

### 7.1.4 Job safety

Workplace safety standards in warehouses of exporters are not always conforming to desirable practices. In many warehouses, no protective gear or work clothes are worn. Major exporters engage in actively promoting workplace safety, as the poster below mounted at a warehouse entrance indicates.


The value chain in general does not present major hazards for job safety. At the cocoa producer level, the major risk for health damages may be presented by the increased promotion of pesticides

(insecticides for Cocoa Pod Borer control and other pests, herbicides for weed control) in the context of little knowledge about safe handling and application of pesticides among smallholders in PNG.

### 7.1.5 Attractiveness

In formal employment in the export sector, remunerations are usually of local standard in terms of complying with minimum wage regulations. The currently applicable minimum wage is 3.50 Kina/hour (Minimum Wages Determination No. 1 of 2014). Exceptions apply to plantation operations, e.g. Agmark (see Box: Cocoa plantation remnants and plantation workers).

Informal labour opportunities include casual work in smallholder cocoa blocks and in fermentary/drier operations. Labour for work in cocoa blocks is usually hired on a per day basis, recruited among extended family, and is commonly paid 10 Kina per day, additional to the provision of food, or organised as reciprocal help among families. Fermentary/drier operators hire labour on a fortnightly basis in cocoa flush periods, offering about 200 Kina fortnightly pay.

Cocoa constitutes the major source of income in many rural areas where cocoa is grown. While this status is partly called into question by Cocoa Pod Borer infestations, lack of comparable income alternatives maintains cocoa's status as a highly attractive source of income.

Labour shortage is a key constraint in smallholder cocoa productivity. There is a reluctance of farmers to use hired labour, which is usually limited to the extended family. This impedes adequate crop husbandry for labour intensive cocoa management tasks when family labour is not available and limits rural employment opportunities. To hire labour, and to perform hired labour, often follows social values of relatedness and obligation more than labour demand in crop husbandry or the offering of labour force in exchange for income (see following subsection on further considerations on labour in the PNG cocoa value chain). Under-payment (or non-payment) of family labour is further limiting the supply of labour in cocoa (Curry & Koczberski 2009). This poses a constraint for the attractiveness to work in cocoa blocks especially for women and youth in blocks planted and controlled by male household heads.

A major deterrent to the attractiveness of cocoa and sustained attention to cocoa management are the fluctuations in sale prices. In the minor cocoa flush period in early 2018, prices offered for a bag of cocoa dry beans went as low as 200 Kina, while after the flush period prices recovered to levels around 400 Kina[1]. Some farmers in East New Britain who had placed commercial emphasis on more singular attention to cocoa production in recent years expressed feeling discouraged at the low prices gained in the cocoa flush period in beginning of 2018 and admitted being rethinking their singular reliance on cocoa through a commercial and input-intensive farming approach.

[1] These price fluctuations are in accordance with world market prices. Producers do at times voice the suspicion, however, that prices are manipulated by exporters based on local supply dynamics.

Attractiveness for youth (and women) in cocoa production is variable based on arrangements with the male household head. In areas where direct patrilineal inheritance is practiced (see Section 6.1.2), especially on the PNG mainland, attractiveness for male youth in particular is higher as men may allocate land for their sons to plant their own cocoa.

### Cocoa plantation remnants and plantation workers

Plantations were the major source of cocoa production in colonial PNG. Smallholder cocoa production surpassed that of plantations soon after PNG's Independence in 1975, and the role of cocoa plantations continued to decline since. While several attempts were made to revive and to consolidate the plantation since Independence, none of these efforts made a long-term impact to reverse the trend of increasing smallholder production and the declining role of plantations. Today, the plantation sector is of negligible importance for PNGs cocoa production and has little future prospects (see Functional Analysis).

Remnants of plantations exist, however, whether idle or operating at reduced level, and with them the families of plantation workers who live on the plantations for generations. These families often cannot return to their original communities, as they did not maintain claims to land through presence and activity in the community. As a result, many families of plantation workers continue to live on plantation lands regardless of their level of operation and complement or shift their sustenance to subsistence gardening on plantation land.

Inability to provide continuous employment to plantation workers who have nowhere else to go results in changing labour conditions. Agmark, who accounts for about a quarter of the remaining cocoa plantation output in PNG (250 of 1.000 tons) obtained a minimum wage exemption from the DLIR that allows paying half the minimum wage to its 360 plantation workers (1.75 Kina/hour). Agmark further shifted from full-time employment to paying hourly wages for the time plantation workers decide to work on the plantations, which allows plantation workers to diversify livelihood strategies and seek alternatives to plantation work.

While plantation operations are of limited viability and little attractiveness for workers, many plantation workers have nowhere else to go, and thus depend on the remaining income possibilities from plantations and to live on and from plantation lands while family members seek alternative opportunities.

### *Other considerations on labour in the PNG cocoa value chain*

Overall, labour availability is one of the most important constraints in smallholder cocoa production in PNG. Smallholder farmers engage in an array of different activities, on- and off-farm, and cocoa constitutes but one area in subsistence and income-oriented activity. As previous research on cocoa in PNG amply demonstrated (Curry et al. 2007), low productivity in cocoa production was for many smallholders a deliberate production strategy that best balanced minimum labour input with acceptable returns (see Functional Analysis). Curry et al. (2007) called this a 'low-input' strategy, of hardly any cocoa management and occasional sales of low amounts of wet bean to complement diets and for other immediate household expenditure needs. Only some farmers were willing and able to invest more labour, relying mostly on extended family, for a minimum level of more consistent crop husbandry (such as occasional weeding), and to undertake concerted efforts for harvesting and dry bean production in flush periods, constituting more of a cocoa 'farming' strategy.

The feasibility of these production models was drastically reduced since the incursion and spread of the Cocoa Pod Borer in PNG from 2006 onwards. Effectively managing the Cocoa Pod Borer requires considerably increased labour input and rethinking production practices. This includes removing and burying Cocoa Pod Borer infested pods, regular pruning of cocoa and shade trees, more consistent weeding, rehabilitation of old cocoa trees, and potentially the use of pesticides.

In East New Britain, where the Cocoa Pod Borer appeared first and quickly spread throughout the province, many farmers abandoned cocoa and focused increased attention on subsistence and short-cycle crops such as peanuts for survival and financial needs (Curry et al. 2011). While many farmers returned to cocoa with the help of extension services such as provided through PPAP, others abandoned cocoa for alternatives, such as oil palm. In 2016, cocoa production in East New Britain remained below a third of its 21.640 tons pre-Cocoa Pod Borer but has an upward trend again.

Positive effects from the PPAP will only emerge more comprehensibly in the coming years. Agronomically, there is considerable scope for high yields with PNG-developed hybrid clones that are more tolerant to the Cocoa Pod Borer than the previously favoured SG1 and SG2 hybrids. The question that cannot be satisfactorily answered yet is, however, for how many farmers the high-input and labour-intensive management of high-yielding hybrid clone varieties will prove a viable production model. Interaction with farmers suggests that availability of labour is likely to prove the primary constraint for adopting such model. Additional research on labour allocation and availability within overall agricultural and livelihood strategies in the cocoa value chain is desirable.

Further, there is considerable doubt among farmers, extension workers, and researchers (Curry & Koczberski 2015, Kerua & Glyde 2016), whether the implied transition from farming strategies centred around subsistence strategies with a diversified portfolio of crops and activities, including social values and obligations, towards a more entrepreneurial business approach to farming focused on a singular crop such as cocoa will be successful and take hold among PNG smallholders. Some farmers in East New Britain that have adopted such an approach over the last years with a singular focus on cocoa voiced concern over a lack of adequate returns for cocoa purchasing price fluctuations and expressed plans to diversify their farming activities again. A singular focus on commercial cocoa production also runs the danger of reducing a principal element of farmers' subsistence strategies, which is a diversified production that reduces the risk of relying on single crops or income streams, which also has potential implications for food security (Section 6.1.4).

It is thus yet to be seen in how far hybrid clone cocoa farming that requires high labour and external input proves a viable model to be incorporated alongside farmers' diversified production and subsistence strategies. As noted by Bourke & Harwood (2009), while there is a reasonable amount of research on agriculture in PNG, there is a lack of studies that address labour input for specific crops. The availability and understanding of labour in rural areas are also based on several factors of social relatedness and local social values, which cannot be compared with notions of formal employment relations (Curry & Koczberski 2009, Imbun 2014, Martin 2018). Martin (2018) exemplifies how cocoa

growers in East New Britain are, however, increasingly eager to classify work of extended family members as remunerated 'labour'. This applies especially to farmers planting cocoa on blocks obtained through Land Settlement Schemes (LSS) or land purchased from customary landowners (see section 6.1.2). By classifying and remunerating work by extended relatives as 'labour', farmers seek to differentiate such work from traditional 'help' by extended relatives that carries expectations for future reciprocal obligations, including claims on the land. In the specific context of East New Britain, LSS land blocks and purchased land can be inherited directly to cocoa farmers' children, whereas customary land is commonly inherited by the family of a matrilineal niece, who fosters a claim on the land through 'helping' in cocoa blocks and other activities. To pay maternal relatives as labourers for cocoa work rather than as part of reciprocal help, thus aims at preventing their future claim on the land.

On a more encompassing and abstract level, people's obligations to one another based on notions of relatedness is referred to as the 'wantok system' in PNG (Schram 2015). This refers to people classifying each other as 'wantok' (literally 'one talk', a reference to speaking the same language), which is associated with claims to mutual relatedness, reciprocal support, and solidarity when in need. The wantok system is both valued as a mechanism of social support and poses challenges for the expectation of favours and preferred treatment in what often becomes linked to notions of nepotism and corruption in PNG. Overall, the social reality of the 'wantok system' is crucial to consider in PNG.

### *Summarised findings on working conditions & labour*

Overall, working conditions in the value chain may be cautiously deemed socially acceptable and sustainable. PNG has ratified the 8 fundamental ILO conventions, although national labour legislation is still being reviewed towards better alignment with ILO conventions. Workers' rights in terms of fair and enforceable contracts, effective collective bargaining, and job safety, remain relatively weak. This assessment is not limited to the cocoa value chain. Companies involved in the cocoa value chain appear to respect national labour legislation, especially in relation to minimum wage regulations.

Cocoa provides an attractive activity in smallholder production and informal rural labour arrangements, especially in view of little available income alternatives. Recruitment of labour in rural cocoa production cannot, however, be compared to the formal labour market. Labour recruitment is mostly limited to household members and is based on notions of relatedness and reciprocal obligation when extending beyond the household. There are thus limitations for work opportunities in smallholder cocoa production. The attractiveness for the allocation of labour by women and youth in the household often depends on the remuneration and income distribution from cocoa sales by male household heads. A households' relative focus on cocoa is also determined by sales price fluctuations and relative attractiveness compared to alternative activities.

Reluctance of farmers to hire external labour, and vice versa the reluctance of rural households to engage in hired labour outside notions of relatedness and reciprocal obligations, contributes to a shortage of labour in cocoa production. Shortage of available labour to allocate to cocoa is a limiting

factor in cocoa production and a major constraint for adequate crop management. Constraints for labour allocation to cocoa can be linked to farmers' diversified livelihood strategies in which cocoa only constitutes one activity among many that compete for labour time. Labour shortage for cocoa crop management became a more pronounced challenge since the incursion and spread of the Cocoa Pod Borer over the last decade, requiring more labour allocation to cocoa to prevent crop loss.

### 7.1.6 Land and water rights

The vast majority of land in PNG is under customary landownership[2]. The PNG Constitution recognizes customary landownership, usually in the absence of formal land titles or state records on customary tenure arrangements, extent of area they cover, or competing claims between groups. Customary tenure of land is often nested in a hierarchy of group segments and alliances, which are dynamic and changing in their constitution over time, including due to long-term mobility in settlement patterns[3]. Land claims are asserted through different levels, and in practice through a combination thereof, such as: individuals, family lineages, clusters of families traditionally sharing stewardship of sections of land, exogamous 'clan' units, and larger alliances based on the tracing of common ancestry (phratries in the PNG mainland, matrilineal moieties among the Tolai of East New Britain) or territorial defence. Competing land claims, involving previous land transactions or the assertion of land rights based on active involvement on the land, are dealt with through local conflict resolution and mediation practices, parastatal local courts, and official village courts who count with a land mediator.

Arrangements and dynamics surrounding customary tenure are diverse. For understanding the most important dynamics in cocoa smallholder production, however, two major systems of landownership might be distinguished in simplified terms, corresponding to different regions of PNG: (1) direct patrilineal inheritance, and (2) matrilineal corporate groups providing temporary usufruct rights to families that, however, cannot be directly inherited by children. The description of these below are idealised simplified models, while actual practices of land inheritance and transaction are more complicated and diverse.

Direct patrilineal descent is commonly regarded as standard principle and practice in mainland Papua New Guinea, such as the Sepik provinces, Madang, Morobe, and the highlands provinces of Eastern Highlands, Simbu, Jiwaka, and Western Highlands, where cocoa is being trialled and/or introduced, and Oro Province in the Papuan region. Most commonly, male children inherit land from their fathers, including cocoa trees where present. This provides a certain continuity of inheritance relevant for investment in cocoa blocks.

[2] often specified at 97% even in recent publications, although this figure derives from the time of PNG's Independence in 1975 and may not be an entirely accurate representation of contemporary reality

[3] For example, people moving closer to roads, schools, and other services and economic opportunities over the last decades.

Matrilineal corporate groups that prevent direct inheritance to children of families are characteristic of island provinces of New Britain and parts of Bougainville. In this context, usufruct rights to land are commonly transferred to the family of maternal nieces, and thus not directly passed on by those planting cocoa trees (male household heads) to their children. This has implications for the investment into cocoa blocks on such customary owned land. Male household heads, for example, may see little value in investing to maintain or rehabilitate cocoa blocks that cannot be inherited by their children. Youth, on the other hand, may be actively discouraged to allocate labour to such cocoa blocks for not developing a claim to the land themselves, or may equally see little attractiveness in maintaining or rehabilitating cocoa blocks that they may lose access to in the future. Conversely, this context has also given rise to land transactions in which a male household head purchases customary land from matrilineal groups so as to pass it on to his children, especially sons.

There is a different dynamic involving the individual lease of state land in Land Settlement Schemes (LSS) in the larger context of these matrilineal inheritance practices in East New Britain, and also permanent resettlement land given to families following a volcanic eruption in Rabaul in 1994. Land Settlement Schemes (LSS) offer a 99-year lease of a block of land to successful applicants. LSS involve an annual lease fee and are often tied to certain conditions of a minimum area to be covered with specific cash crops such as cocoa, rubber, or oil palm, for example (Bourke & Harwood 2009). Such blocks, or their usufruct rights, are inherited in a patrilineal way. In some instances, however, they become usurped in the dynamics of inheritance claims by corporate matrilineal groups (as detailed in 6.1.1).

In general, introduced tree crops such as cocoa, coffee and oil palm pose a specific challenge to customary tenure arrangements and access to land. In contrast to short-cycle garden crops, the planting of tree crops such as cocoa require long-term access to land. This places barriers on planting cocoa through local arrangements where access to land is granted on a short-term basis to extended relatives and community members, or when land ownership is contested between parties (Crook et al. 2016). This context leads to calls for land tenure reforms to enhance formal security of tenure (Kutan & Chand 2014). This debate is discussed in more detail further below.

### *Incorporated Land Groups and Special Agricultural Business Leases*

Besides the dynamics surrounding inheritance and land tenure security, another challenge is the mobilisation of land for formal business ventures and investment. This is of limited relevance to the smallholder cocoa sector in its current configuration. However, as the PNG government has ambitious plans to increase cocoa production and associated export revenue, it may be relevant to consider questions around land mobilisation for large-scale agribusiness projects.
A common practice for establishing the legal context to facilitate land mobilisation for formal business ventures and large-scale agribusiness projects with private sector partners is for landowners to establish Incorporated Land Groups (ILGs). ILGs are legal entities and thus provide a vehicle for customary landowners to mobilise land for the formal economy. The Land Groups Incorporation Act

was initially passed in 1974, prior to PNGs Independence in 1975, partly motivated by the need to establish a legal framework for returning colonial plantations to customary landowners. Amendments to the Act formulated in 2009 came into force in 2012, motivated by the need for improved provisions to ensure inclusive membership and representation of customary landowner interests in ILG-based enterprises.

ILGs form the backbone for leasing land to private sector investors for large-scale agribusiness projects, known as Special Agricultural and Business Leases (SABLs). SABLs are facilitated through a lease-leaseback scheme provided for in the Land Act of 1979 (Filer 2017). Formally, customary landowner organisations, such as ILGs, can lease their land only to the state. Through the lease-leaseback scheme for SABLs, ILGs lease their land to the state, and the state in turn leases it back to the ILG as SABL with approved private sector investment.

SABLs have been a vehicle promoted by the PNG government to facilitate large scale agribusiness development especially in the 2000s, commonly granted for 99 years. This scheme has reportedly been made use of in particular for oil palm projects. The PNG government has placed a moratorium on SABL's in 2011 following reports of misuse of the scheme, principally for pursuing logging rather than agricultural investment, irregularities in the agreements with landowners such as absence of informed consent, and ensuing conflicts among landowners and between landowners and private sector investors (Filer 2017). The government terminated ongoing SABLs in 2014, but this has not been followed by the cancellation of individual lease licenses. An ongoing SABL in Oro Province, for example, is embroiled in considerably national controversy over logging under the alleged pretence of developing a commercial cocoa project (Post-Courier, April 6 2018 https://postcourier.com.pg/house-becomes-rowdy-illegal-logging-issue/).

Challenges remain to achieve adequate prior disclosure of project-related information to local stakeholders in agribusiness projects in PNG (World Bank 2017). By experience, many ILGs that were formed towards enabling large scale agribusiness investments were also found not to act in the inclusive interest of individual members, or at times are not inclusive in membership of all relevant stakeholders in the first place. Factors are corruption in the Lands Department, illiteracy among stakeholders, inadequate knowledge on ILGs functioning, and remaining issues with the legal framework of ILGs in the first place (Karigawa et al 2016). A lack of adequate provisions to address stakeholder complaints and arbitration in large scale agribusiness projects have also been reported (Lattas 2011, Allen & Monsoon 2014).

Consideration of this broader context may be relevant in view of potential future large scale agribusiness projects involving cocoa, whether state-led or through private sector investors. The relatively high labour requirements and the current state of remaining cocoa plantations (see Box above) make cocoa an unlikely crop for large-scale agribusiness projects. The PNG government, however, seems to be exploring such options recently towards its ambitious plans for the increase in cocoa production and export revenue. More specifically, there is ongoing debate about ideas to

mobilise land in the Sepik plains for agribusiness projects, including options to incorporate cocoa in such plans.

### *Customary tenure versus formalisation of landownership debate*

The benefits and disadvantages of existing land tenure arrangements are subject to significant debate in PNG, ranging from the defence of the status quo of customary tenure arrangements to calls for a formalization of landownership including individual land titles (Curtin et al. 2003; Fingleton 2004, 2005; Gosarevski et al. 2004; Lea 2009, 2013). Calls for a reform and formalisation of land tenure arrangements are also voiced in relation to the cocoa value chain in Bougainville specifically (Kutan & Chand 2014). Arguments for widespread reform and land tenure formalisation suggest that a solid regime of formalised land titles will allow for business development through enabling investment and access to credit by providing for land to be used as collateral security. These arguments are countered by warnings that formalisation of land tenure interferes with a dynamic system of land rights and access paths to land that many people rely on for their agricultural subsistence and food security. Despite occasional attempts to introduce policy reform towards mobilising more land for the formal economy, such measures are viewed with scepticism in the population for concerns that formalisation of tenure may be a first step towards land alienation (Bourke & Harwood 2009).

Formalised property of land establishes an exclusivity of rights that is usually absent in customary arrangements, and the process of formalizing ownership through identifying or establishing particular corporate group structures as exclusive owners is changing the otherwise inclusive dynamic of claims and usufruct of land in a new way. Beyond the risks associated with changing PNG's customary land tenure arrangements, the difficulty of identifying or establishing exclusive owners is also a complex and potentially conflictive endeavour (Bourke & Harwood 2009). Official determinations of land ownership for compensation and royalty payments in mining operations, for example, have proven contentious (Golub 2014), and are just recently again proving a major obstacle to the social sustainability of resource extraction projects (Main & Fletcher 2018). The very process of identifying landowners for compensation and royalty benefits can also lead to violent conflict (Main & Fletcher 2018).

### *Summarised findings on land & water rights*

The existing legal framework that acknowledges customary land ownership provides challenges (especially for external investment and credit access) but is arguably the best guarantor for equitable tenure rights and access to land in practice. This is due to the numerous access paths to local and temporal usufruct rights in the context of often multi-layered and sometimes overlapping ancestral land rights claims. Formalisation of tenure rights (in contrast to local and informal customary rules) risks introducing a new exclusivity of tenure rights and may in practice complicate access paths for more vulnerable groups and individuals.

### 7.1.7 Gender equality

*Economic activities*

Women are active in the cocoa value chain primarily as producers, and to some extent as employees in the export sector. Women also participate in operating fermentaries/driers. Many smallholder families suggest that activities are conducted cooperatively in the household. Women are not per se excluded from specific segments of the value chain, but women's role in the cocoa value chain is often subordinate to that of men.

Perennial cash crops, including cocoa, are usually the domain of male household heads (Bourke & Harwood 2009). Cocoa production depends on additional household labour provided by women and youth, and thus male household heads' decisions about cocoa production requires considering the amount of labour other household members, especially women, are willing to contribute. Women's willingness to contribute labour to cocoa production also depends on the distribution of income from cocoa. Selling of cocoa, especially when of significant quantities in flush-period harvests and when sold as dry bean, is often done by men. Men's ability to motivate other household members or extended family to help in cocoa production depends on the adequate remuneration of their labour. This holds especially for the income distribution within the household. An exception is the sale of small amounts of wet bean, which may be collected and sold by women for everyday household expenditures (Curry et al. 2007). Tensions regularly emerge around income distribution of cocoa within families, especially between women and men following major cocoa sales by men.

It is difficult to generalize the intra-household arrangements for tending to cocoa and the sharing of its benefit, in any case. When men commute for formal urban employment, for example, women are more likely to be in charge of cocoa and to also retain control over income. Different scenarios are conceivable in the context of intervention towards an intensification of cocoa production. Improved household income through cocoa can be expected to have a generally positive effect on people's livelihoods and thus also to improve women's situation overall. Interventions enhancing cocoa production may thus in general be expected to economically empower women. Based on the literature on perennial cash crops (Bourke & Harwood 2009), and cocoa in PNG (Curry et al. 2007), and current practices of male control of income from cocoa sales that were especially reported by farmers in the Sepik, there also remains, however, a residual risk that an intensification of cocoa could have a different outcome: if men keep retaining control over income with inadequate benefit-sharing within the household while women dedicate more work to intensified cocoa production, the intensification of cocoa would effectively widen rather than narrow the gap of benefits for women and men from cocoa, and thus increase conflicts of gender inequality. Such a risk, if and where applicable, may be more pronounced in the provinces of the Momase region where the control of land traditionally remains with men, whereas in the Islands provinces of New Britain and Bougainville more women farmers that control land and cocoa crops may be expected.

One approach to counter conflicts around income distribution and to empower women in cocoa production is through what is referred to as 'mama kakao' in Bougainville, where women are planting cocoa seedlings separately from men. The planting of crops is an important aspect for claiming their ownership. With women planting their own cocoa seedlings, women are in charge of looking after them, recruit required labour within the family, and retain control over the income from cocoa sales from the trees they planted. According to Cocoa Board officers, this also improves the conditions and attractiveness to work in cocoa for other household members, as male and female household heads compete in motivating labour support by youth and extended family members, which results in more consistent remuneration of their work. Ambaku women's group in Maprik (East Sepik) also suggested the planting of cocoa by women as a way to retain control over some portion of cocoa and its income. This does not seem commonly practiced currently in the Sepik region, but could be an innovation towards women's empowerment in the cocoa value chain.

### *Access to resources and services*

As with tree crops, or export cash crops in general, larger transactions of wealth and money often still remain the domain of men, congruent with traditional exchange practices. Men thus also tend to claim ownership of larger movable assets, such as motor vehicles (women also rarely drive in rural areas).
In most parts of PNG, land is also passed on dominantly patrilineal, from father to son (see section 6.1.2.). Despite the commonly voiced ideal of patrilineal inheritance, actual pathways to access land in practice are much less straightforward. It is much more difficult for women to assert rights over land in comparison to men in most parts of PNG, however. This is different in the matrilineal societies in East New Britain and Bougainville, where women traditionally control land.

Access to credit is generally limited in PNG, although it can be expected that the limitations to obtain credit are comparatively even more pronounced for women. In recent years, several initiatives were started with the aim to increase access to financial services specifically for women. These include the Women's Micro Bank launched in 2014, a Women in Business programme established by the National Development Bank of Papua New Guinea in 2010, and a Women's Chamber of Commerce that started operating in 2013 (Crook et al. 2016).

Generally, women in the rural smallholder sector handle lower amounts of money compared to men, and earnings of women are frequently used for immediate household expenditures. Women are not per se excluded from financial services but are more unlikely to individually engage with financial services than men.

### *Decision making*

Women do take part in decisions related to cocoa production, especially as women's willingness to invest labour input to cocoa is an important consideration for cocoa producing households. There is a wide array of women's participation in household decision-making, while in ultimate instance women have considerably less power over decision-making than men in relation to cocoa production. A factor in this, besides gender inequality generally affecting households and PNG society at large, is that

commodity cash crops such as cocoa are often regarded as 'male' crops, planted, looked after, and generating income that is principally controlled by men. As indicated above, however, this is difficult to generalize and ultimately depends on internal household arrangements that can take diverse forms - there is, in any case, no rigid conventional social system in PNG that prevents a stronger role of women in decision-making.

Women are usually highly autonomous in the organisation of their work. Women thus also engage in economic activities on their own to gain income that they retain control over. This commonly takes the form of marketing garden produce in local markets (Curry et al. 2007, Bourke & Harwood 2009). Women's relative income through such activities is generally lower than the income that men tend to retain control over, such as from cocoa and other cash crops. Outside coordinated harvests of cocoa flush periods, and in some low-maintenance cocoa blocks generally, small numbers of cocoa pods are collected by women and sold as wet bean for household expenses. Women 'control' this income, although it is usually spent on immediate household needs (complementing diet through purchased food, or other household requirements).

### *Leadership and empowerment*

Women are part of cocoa producer societies, cooperatives, and women's groups (where they exist). Most operational activities of farmers' organisations are conducted by men, however, and women members are usually underrepresented in farmers' organisations (Bourke & Harwood 2009). While women are not specifically barred from leadership positions in such organisations, women are even stronger underrepresented in them. None of the rural farmer cooperatives or marketing societies visited counted with women in leadership positions. While people spoken to insist that women may hold such leadership positions, it is men who in practice occupy them in the vast majority.
Women do speak in public, although less frequently than men. Common gender ideologies in PNG often hold that men do representative work in the public arena, including important traditional exchange relations. While women are not per se excluded from speaking in public, it is often much more difficult for women to assert themselves in public in what is ideologically an overwhelmingly male domain.

### *Hardship and division of labour*

Households work as a unit in PNG, and overall workloads are often relatively equal. There is a gendered division of labour, although this is increasingly less pronounced. In cocoa, women especially help in clearing undergrowth and harvesting, while men often perform pruning and application of pesticides where applicable. There are indications that with increasing intensification of agricultural production, women tend to perform more of the additional labour of attending to crop husbandry tasks, thus increasing the burden on women compared to men (Bourke & Harwood 2009). It is difficult, however, to ascertain this dynamic for smallholder cocoa production, but it could be a potential risk that women's labour input in cocoa rises with intensification while men retain control over income distribution. In cocoa, work performed by household members, including and especially by women, often depends on adequate income sharing by male household heads. As tree crops such as cocoa are often crops for which men claim responsibility, household decisions about the intensification of

cocoa production tends to stronger depend on men's assessment of labour availability in cooperation with women. This is in contrast to horticultural crops that are primarily looked after by women who retain control over the sale of excess produce in local markets.

In East New Britain, Curry et al (2007) found that when farmers sell wet beans, there seems to be relatively equal time spent on labour in cocoa by women and men, whereas when farmers processed beans and sold dry bean, men invested more of their labour time in cocoa compared to women. Different aspects may be relevant to consider in this regard. The process of fermenting and drying is relatively labour intensive. Men often take charge of and coordinate these efforts, and also market dry beans and retain control over the income from dry bean sales. Farmers that sold wet beans, in contrast, often do not engage in coordinated efforts to harvest and process beans, but rather harvest more intermittently for selling to processors. Such intermittent harvests and sales of wet beans are often conducted by women individually rather than by men or coordinated harvests. Women may in such instance also retain control over the relatively low income, often spent on immediate household expenses.

The study by Curry et al. (2007) was conducted before the outbreak of the Cocoa Pod Borer, however, and studies after the spread of the Cocoa Pod Borer suggest that with people adopting improved block maintenance to combat the Cocoa Pod Borer, wet bean harvests have been more frequent and substantial (Curry et al. 2011). It is difficult to ascertain the relative distribution of increased labour input by women and men into blocks that previously saw little maintenance for low levels of wet bean sales. It may be expected, however, that men tend to take over more of the marketing activity and control over income with higher quantities of wet bean harvests following increased attention to block maintenance. This may be congruent with practices in the East Sepik Province, where farmers mostly sell wet beans to processors, with men also retaining control over the income.
Women in East Sepik repeatedly suggested the desire for smaller cocoa trees to ease harvesting of cocoa pods. The grafted hybrid clones already distributed in East New Britain and Bougainville, and yet to reach farmers in East Sepik through PPAP, ACIAR, and government nurseries, should be well received in this regard. Through the grafting process, the hybrid clones do not have high stems such as the previously promoted SG1 and SG2 hybrids. To keep them low and easy to harvest, however, pruning has to be performed adequately.

### *Summarised findings on gender equality*

Gender equality constitutes a major challenge in PNG generally, and this is no exception in the cocoa value chain. Women are generally in subordinate positions in relation to decision-making, participation, and control over income. Women are also strongly underrepresented in positions of leadership, both in producer organization of the cocoa value chain, and business and political leadership at large. Improving income from cocoa can generally be expected to have a positive impact on women. Depending on the control women are able to exert over cocoa production and income distribution within the household, to increase income opportunities from cocoa may positively

contribute to women's empowerment. Currently, cocoa and other perennial cash crops are often regarded as 'male' crops, however, with men in many instances tending to retain control over income deriving from them. Innovative approaches may be required to enhance gender equality in the cocoa value chain.

### 7.1.8 Food and nutrition security

Food security can, arguably, be regarded as generally high in PNG, especially given the diversity of foods cultivated by smallholder farmers that make up the vast majority of the population. Food security also has significantly improved over the last decades in PNG, due to the adoption of new food crops in smallholder production systems, and access to income through cash crops (such as cocoa) that allows to complement dietary diversity and offset seasonal variations in food production through purchased food (Bourke 2000, Bourke & Harwood 2009).

Nevertheless, a significant number of people continue to face long-term food insecurity, and there remain widespread issues with nutritional quality and variety in diets that are mostly based on staple crops rich in carbohydrates (Omot 2012, Bourke 2017). Long-term inadequacy of diets, especially for children, are associated with limited access to protein, fats, and oil, and other essential nutrients (Bourke 2017, McGlynn et al 2018). Short term risks to food security include seasonal weather variations, especially the El Niño Southern Oscillation weather phenomena associated with excessive rainfall in some years and prolonged droughts in other years, as for example in 1997 or 2016.

Issues with long-term food insecurity, nutritional quality and diversity of diets, and the impact of El Niño related weather phenomena, are less pronounced in places with commodity cash crops that provide income, and road infrastructure that enable local food markets. Risks and vulnerabilities in terms of food security in PNG are thus less pronounced in areas where cocoa is a common cash crop for smallholders. In the drought in 1997, for example, rice imports in PNG increased based on local demand, offsetting food shortages to some extent (Bourke 2000), and a similar effect could be observed in 2016 (Bourke 2017). Important factors alleviating local food shortages throughout droughts are cash availability to purchase food on local markets, either by people themselves or relatives in urban areas, and proximity to roads enabling the marketing of cash crops, local cash flow in general, and availability of goods to purchase. The spread of the Cocoa Pod Borer in PNG over the last decade and the associated disruption to many people's income from cocoa, however, can be expected to have reduced the food security of people for whom cocoa is (or has been until then) the major source of cash income.

Other specific risks to food security in the cocoa value chain come from another direction. Following the widespread Cocoa Pod Borer infestation of cocoa in PNG, some farmers in East New Britain have adopted a singular focus on cocoa production through a more input and management intensive business-oriented production system (especially through the support of PPAP). This concerns a small percentage of farmers that made a shift from subsistence-based farming with diverse crops to business-oriented farming of a single or few commodity crops, occasionally going as far as abandoning

all food production. In this case farmers expose themselves to new risks by abandoning the very principle on which food security in PNG is built: a diverse cropping pattern that is most resilient to buffer varied shocks.

Farmers with singular focus on cocoa were themselves reconsidering other crops again. In one case a farmer who had abandoned all food production is thinking to plant some bananas again. In another instance, a farmer who was disappointed by the low price offered for cocoa in a flush period (below 300 Kina/bag dry bean in early 2018) mentioned that a singular focus on cocoa was not worth the effort given the unpredictability of price fluctuations.

A devaluation of the PNG Kina in 1994 had a negative impact on food imports, which was offset by local food production. The current macro-economic situation of PNG, including a shortage in foreign exchange reserves, can also be expected to impact prices and availability of imported food. Recent data is not yet available, but consumer price indices have been rising consistently (136 in 2016 with baseline 100 in 2010, according to World Bank data), affecting relative consumer prices. Earlier analysis also pointed to the rise of relative consumer prices between 1980 and 2005, especially following the devaluation of the Kina in 1994 (Bourke & Harwood 2009).

Food prices, especially fresh food produced locally, fluctuate considerably according to season and shocks in weather patterns.

#### *Summarised findings on food & nutrition security*

Food security can be deemed generally high in PNG, although with local variations. Areas in which cocoa is a major cash crop are less at risk of long term food insecurity through cash income derived from cocoa. Challenges remain especially with adequate nutrition through diets fundamentally based on staple crops rich in carbohydrates. Cash income from cocoa can be expected to alleviate challenges associated with nutritional diversity, although more awareness and attention especially to nutritionally adequate diets for children may be required.

### 7.1.9 Social capital

#### *Cooperative producer organisations*

Different kinds of farmer organisations and cooperatives participate in the cocoa value chain. In 2009, Bourke & Harwood reported that most cooperatives, historically associated with cash cropping, are defunct. This assessment may primarily relate to the cooperative sector established in colonial PNG, although more recent cooperative initiatives also have been of limited longevity and success. Cooperatives did not play a significant role since PNG's independence in 1975, until stronger emphasis to revitalize cooperatives was undertaken again since 2000. Cooperatives take varied forms and have achieved mixed successes (Garnevska et al 2014). Farmer organisations and cooperatives have been established in response to specific opportunities or external factors, e.g. projects and government

benefits channelled through cooperative structures, or stress factors such as the decline in cocoa yields following the spread of the Cocoa Pod Borer, as observed in East New Britain.

Success of cooperatives depends on cooperative management skills, a strong operational structure and cooperative constitution, and conducive relations with governmental institutions for the formal registration process to be eligible for government support channelled to cooperatives where applicable. A study of cocoa cooperatives in Manus Province by Garnevska et al. (2014) suggests that these aspects were in place only in one of four cooperative groups studied. The other cooperatives had only a management committee without a Board of Directors, and the process of formal registration seemed too lengthy and expensive for the smallholder producers to pursue, thus limiting their access to governmental support schemes for cocoa rehabilitation.

Nevertheless, cocoa cooperatives in Manus were generally found to alleviate constraints in marketing, problems associated with land tenure insecurity, small land holdings, poor infrastructure, and lack of access to capital (Garnevska et al. 2014). There is considerable promise in cooperative development, although the major constraint is training in cooperative management skills.

In the East Sepik province, one form of organisation of some importance are cooperative marketing societies. These are cooperative groups that serve the purpose of marketing cocoa with Rainforest Alliance certification, facilitated through Outspan (one of two main cocoa exporters in PNG). Other groups formed are clusters of 25 farmers that appoint a lead farmer among them for the partnerships between farmers and private sector stakeholders under the PPAP project (with one extension officer per 10 clusters of farmers). Current ACIAR projects apply a similar approach of working with clusters of 25 farmers with one model farmer among them as main contact point. These farmer clusters of cocoa intervention projects are often overlapping with previously existing cooperative groups, such as the marketing societies in East Sepik Province.

Other cooperatives are formed independently from immediate external incentives and take on their own specific forms. One such cooperative visited in ENB is Ilugi cooperative society. This cooperative formed in 2009 to collectively react to the loss of cocoa following the spread of the Cocoa Pod Borer. The cooperative purchased land to grow cocoa through the cooperative besides purchasing wet beans from members to process in its fermentary/drier. Ilugi cooperative society has been internationally recognized for the quality of its cocoa but has not been able to secure direct links with overseas buyers in the boutique market. The cooperative faces different constraints, including inadequate fermentary/drier capacity to increase output by processing a higher share of members' cocoa in a consistent quality. It further experiences financial difficulties since 2013. While this example points to the potential promise of cooperatives, it also exemplifies the challenging states in which many cooperatives operate that threaten their sustainability.
Management capacity and accountable leadership is a particular constraint in cooperative producer organisations. In some instances, cooperatives fail to become consolidated entities for the lack of

management capacity. In other instances, they fail for lack of accountable leadership and mismanagement for personal gain.

### *Information and confidence*

Farmers in the areas visited usually had good knowledge of the purchase price of cocoa offered by exporters but expressed lack of knowledge of international cocoa prices. This leads to suspicion among farmers that exporters manipulate the price to take advantage of producers. In the minor cocoa flush period in early 2018, for example, the price for a bag of dry bean dropped below 300 Kina, while it climbed above 400 Kina after the flush period. This left many farmers frustrated and suspicious of exporters. Some farmers in East Sepik also voiced suspicion that fermentary owners manipulate scales to pay farmers less for wet bean cocoa.

There is a general lack of cocoa management knowledge and extension services for coping with the Cocoa Pod Borer. This is more acute outside ENB and Bougainville where the PPAP project has been active for longer already.

Trust is relatively low among stakeholders in the cocoa value chain, although current partnership models between farmers and private sector stakeholders (as promoted by PPAP for example) may go some way in improving trust between producers and exporters. An indication of decreasing levels of trust over the last decade is the abandoning of experimenting with advances in goods and services provided by traders and exporters (as reported by staff of the Kairak Vudal Resource Training Centre in East New Britain). Graham McNally at Agmark also confirmed that any arrangements that advanced services to farmers that would later be taken off the purchasing price were stopped by Agmark, as such practice did not prove successful in binding producers to sell their cocoa to Agmark.

Lack of trust between farmers, industry stakeholders, and government institutions is also apparent in comments that farmers often appear reluctant to form Incorporated Land Groups (ILGs, see section 6.1.2). These comments were made by CCI/CB staff in Wewak in relation to attempts to mobilize farmers for cocoa projects in the Sepik plains. Such scepticism from farmers relates to different aspects, such as inadequate information about details and anticipated benefits of projects, experience or hearsay about lack of inclusive benefit-sharing, transparency, and accountability by those assuming leadership positions, and factors of political allegiance when driven by government actors.

### *Social involvement*

Rural communities, if not subject to large scale development that involves expropriation, effective land alienation, or downstream river pollution, have high autonomy in determining their local livelihoods (within the infrastructural constraints). When agribusiness and state investment are at stake, however, these often lack transparent governance, inclusive decision-making, and effective grievance mechanisms. Risks are associated with this for government driven cocoa value chain intervention plans.

### *Summarised findings on social capital*

A variety of producer organisations are active in the cocoa value chain, although with regional variations and with mixed success. Many cooperatives face challenges to their sustainability based on inadequate knowledge and skills in cooperative management and lack of support or conducive relations with government institutions, where applicable.

Farmers struggle to cope with the Cocoa Pod Borer and often lack knowledge about managing the pest, especially outside East New Britain and Bougainville where exporters and PPAP have been active for longer in promoting relevant knowledge.

Lack of trust is a recurring theme in the cocoa value chain in interaction with different stakeholders. Lack of trust inhibits, for example, closer links between exporters and producers through the advance of services. Lack of trust also generally affects interaction between government, public service, and smallholders, and can negatively interfere with the establishment and operation of cooperatives among smallholders.

## 7.1.10 Living conditions, infrastructure & services

### *Health*

Health facilities (local aid posts, regional health centres, urban/provincial hospitals) are unevenly distributed, for many locations at considerable distance, and frequently in a state of underequipped disrepair, including irregular availability of essential medical supplies. Health services reaching out to communities are sketchy in provision. Health centres undertake community outreach visits, especially for immunisation campaigns, including other services to different extent. Community visits are usually infrequent, and hampered by shortages of staff, equipment, and supplies. Health services remain expensive despite free healthcare plans by the government, and costs for health services constitute a high burden on households in case of illnesses, including curable diseases.

Care for sick family members, especially by women, has been identified as a significant potential constraint to labour availability and consistency of cocoa block maintenance (Curry et al. 2007). Income of cocoa, on the other hand, is essential for meeting the costs of medical needs where little other income opportunities exist. Specifically, the impact of HIV/AIDS on smallholder farming households and productivity should not be underestimated. UNAIDS, for 2016, estimates a HIV prevalence rate of 0.9%, of which only about 52% receive ART, and 19% of people living with HIV are estimated to not know their status.

### *Housing*

There are significant regional variations in PNG in the relative share of modern houses built by 'permanent' material (e.g. frequently seen in parts of the Gazelle peninsula in ENB), and houses/huts of locally available material that require more frequent maintenance or rebuilding (more common in

Sepik and other main island provinces). Lack of housing quality is not a priority concern for many rural dwellers and can on general average be cautiously deemed satisfactory.

In some areas people express a preference for housing of cheaper locally available material to avoid 'standing out' by displaying wealth, and thus risk inviting envy in the context of markedly egalitarian ideologies where reciprocal relations oblige to redistribute rather than to accumulate wealth (see Section on Inclusiveness). Sometimes houses of permanent material also become a target in local unrest, such as between supporters of different factions following elections.

### *Education*

Net primary school enrolment was estimated at 87% in 2012 (World Bank). Since the renewed introduction of a Tuition Fee Free education policy by the PNG government in 2012, school enrolments significantly increased throughout PNG. Primary education is today accessible to the vast majority of households in PNG. Exceptions remain in the most remote areas, but these are usually not the areas actively involved in the cocoa value chain. Generally, school attendance is highly valued and given much importance in households in PNG, and children overwhelmingly attend primary schools where primary schools are within reach.

Secondary schools (high schools for grades 9-10 and secondary schools for grades 11-12) are more unevenly distributed and significant challenges remain to access secondary schooling in many areas of PNG, including those relevant to the cocoa value chain. Many secondary schools are admitting student numbers beyond their capacity, and admission is increasingly competitive for limited space. Despite the Tuition Fee Free education policy of the government, parents are also often charged (illegally) a fee for school upkeep not covered in governmental budget grants (or made necessary for late grant disbursal to schools). In areas of high competition for places in secondary education these fees can be higher.

While access to secondary schools has significantly improved in the last years, access to vocational education remains much more limited. Vocational education, and tertiary education in general, is costly and limited admission places lead to high competition. Some areas, such as parts of the Gazelle peninsula in ENB, offer relatively more educational opportunities and count with an influx of students from other parts of PNG to attend educational institutions. Educational opportunities in the Sepik provinces, in comparison, are much more limited.

As with health, many smallholders active in the cocoa value chain rely on income from cocoa to enable their children to attend secondary and potentially tertiary education.

### *Mobility and transport infrastructure*

Many roads in rural areas, from national highways to rural feeder roads, are in a state of disrepair and require maintenance. While parts of the country with the highest population densities are usually

served by roads, vast areas of the country remain inaccessible by road. This poses a constraint to smallholders that would otherwise increase or adopt cocoa production for cash income. Road access is especially crucial for cocoa for timely access to fermentaries/driers and transport to exporters, so to not compromise cocoa quality in humid conditions. The need to carry cocoa bags to the nearest road, river or coast for transport further limits production volumes in such instances. Some cocoa farmers that do not count with road access and fermentaries/driers engage in provisional sun-drying before transporting cocoa to town for sale. As transport is expensive, and as people then often have to spend at least a night in town before returning home with associated spending, lack of transport infrastructure is a major deterrent for actual and potential cocoa farmers that are at considerable distance from transport access. This is an issue, for example, for farmers on the south-eastern side of the Sepik River.

Transport bottlenecks are also experienced on islands in the Milne Bay province and the Karimui district of Simbu province. The Cocoa Board for some years offered a freight subsidy to traders to airlift cocoa from such locations, though these subsidies were discontinued in recent years (see Functional Analysis).

Transport is expensive, and distance to exporters is a significant factor for the profit margin of cocoa producers and fermentary/drier operators even where roads exist, especially when relying on public transport rather than own vehicles (which only few smallholders have). Public transport operators are reported to hike fees per bag of cocoa according to prices offered by exporters.

On some major roads, such as in the Sepik, hold-ups and roadside robberies are frequent, thus especially posing challenges to conduct business and travel with cash between rural areas and urban centres. In the cocoa value chain, this poses risks both for producers selling cocoa to traders/exporters in urban centres, and for traders/exporters to buy cocoa in rural areas. This reduces the scope for exporters to purchase and collect cocoa directly at fermentery/drier locations, thus passing on the risk to producers and fermentary owners. Widespread absence of financial services (banking) outside urban centres compounds this problem.

Law and order problems constraining peoples' mobility are also experienced in other contexts. Farmers from locations at some distance from road access towards the Sepik province's east coast reported that women and children are afraid to go working in cocoa blocks for the threat of harassment and rape, which farmers also associated with the widespread consumption of locally brewed alcohol by male youth. In this context, better road access could improve income opportunities and law and order within communities.

### *Financial services*

Access to financial services is very limited in rural PNG, including for farmers active in the cocoa value chain. Financial literacy is low, few farmers have bank accounts and even far less have access to credit.

The provision of financial services is mostly limited to urban centres. Overall, PNG has an exceptionally low microcredit demand and loan-to-savings ratio (http://www.devpolicy.org/low-demand-for-microcredit-in-papua-new-guinea-20180424/).

Several organisations provide financial literacy trainings, funded by the Asian Development Bank for example. Trainings often include the opening of bank accounts for participants, such as a program implemented by MiBank in the East Sepik Province.

A specific limitation for credit access in smallholder agriculture is the lack of land titles that could be used as security collateral. Assessment of loan applications thus considers movable assets such as vehicles, TV sets, laptops, fridges and deep freezers. Few smallholders possess such assets. Initial loans to smallholders by MiBank are capped at 15.000 Kina. Higher loans are given after successful repayment of initial loans.

The case of MiBank in East Sepik is instructive to consider for the further rolling out of financial services to rural smallholders. MiBank has operated in East Sepik since 2008 but experienced a series of setbacks in the last years for break-ins and a daylight robbery at gunpoint last year. Since then, MiBank stopped handling cash and placed on hold all services other than financial literacy trainings and recovery of active loans. At the time of fieldwork, the Board of Directors was considering whether to continue or cease operations in East Sepik. The example of MiBank exemplifies the challenging conditions for rolling out financial services in the Sepik provinces for the financial inclusion of smallholders, especially in terms of law and order issues.

#### *Summarised findings on social infrastructures & services*

Availability, access and cost of health services generally cannot be deemed satisfactory in PNG. Housing and accommodation are less of a pressing concern in rural PNG. Access to primary education is generally good, but limitations for access increase with higher levels of education, especially tertiary education and training. Income from cocoa is a major contributor to households' access to healthcare and education in particular. Other notable challenges concern lack of maintenance and limited reach in transport infrastructure, and widespread absence of financial services in rural areas.

### 7.1.11 Overall social sustainability of the cocoa value chain

The cocoa value chain is generally socially sustainable but is not without specific and general (cross-sectional) challenges. Cocoa is the most important income-earning crop for smallholder farmers in regions suitable for cocoa production in Papua New Guinea, thus facilitating access to healthcare, education, and to complement dietary diversity through purchased foods. Specific challenges include labour availability for allocation to cocoa (especially for increased labour demand to effectively manage the Cocoa Pod Borer) besides maintaining a diverse portfolio of agricultural activity and livelihood strategies. General challenges not limited to the cocoa value chain include gender equality and access to infrastructure and services. Overall, the cocoa value chain in Papua New Guinea can be

regarded socially sustainable, and interventions in the cocoa value chain benefiting smallholders can be expected to have significant positive impacts on social development.

## 7.2 Inclusiveness of economic growth

Economic growth associated with the cocoa value chain is characterised by a high upstream inclusiveness of benefits (see Functional Analysis & Economic Analysis). For the overall social sustainability of the cocoa value chain, inclusiveness of interventions among smallholder communities is an important aspect to consider. Many communities exhibit marked egalitarian ideas and values, which manifest in locally varied ways.

A sentiment of considerable social leverage and importance in PNG is envy, in local Tok Pisin often referred to as 'jealousy'. Socio-economic differences within communities need to be negotiated, especially social pressures for the redistribution of wealth. Traditionally, wealth is redistributed in cycles of reciprocal obligations, rather than accumulated for future needs or reinvestment into agricultural or entrepreneurial activity. This can limit the possibilities for entrepreneurial activity and is a factor in what is locally referred to as a lack of 'saving culture'. Financial literacy training and enhancing access to banking and financial services is one possible strategy to address this. Local dynamics surrounding emergent socio-economic differences, however, should always be considered. Increasing socio-economic differences in processes of global economic integration are linked to heightened fears about sorcery and witchcraft in PNG. Fears of becoming a target of sorcery and witchcraft often accompany economic success and perceived envy by others who may expect more redistribution of wealth (e.g. Kerua & Glyde 2016, in specific relation to cocoa growers in East New Britain). In recent years, PNG sees increasing reports about tensions and violence in communities following accusations of sorcery and witchcraft (Forsyth & Eves 2015). This is an issue of pressing concern throughout PNG, which also spread to areas where sorcery and witchcraft had not been a concern traditionally. Victims of violence following accusations of sorcery and witchcraft are often, although not exclusively, women.

Specific concerns about inclusiveness in relation to cocoa value chain interventions were voiced by staff of the PPAP office in Maprik (East Sepik Province). PPAP staff reports tensions in communities where some farmers benefit from PPAP while others do not. Such tensions have manifested in one woman's (a widow) cocoa seedlings being destroyed, and a cocoa nursery being vandalised. PPAP staff in Maprik mentioned the question of inclusiveness and spread of benefits from the PPAP project as a major challenge in project implementation. Different stakeholders, including farmers, seconded similar concerns about inclusiveness of projects benefiting cocoa farmers.

PPAP staff in Kokopo also mentioned the suspicion that farmers underreported their income and profit as a result of project interventions, so as to downplay their income vis-à-vis other farmers. This is another aspect possibly relevant to consider in value chain intervention and monitoring that arises from egalitarian values and the fear of envy directed at one's family.

### *Summarised findings on inclusiveness of economic growth of the value chain*

Economic growth in the cocoa value chain can generally be regarded as inclusive. In light of specific socio-cultural dynamics and contemporary processes of social change associated with increasing social differentiation and inequality, to maintain social inclusiveness is an important consideration for interventions to ensure the overall social sustainability of the cocoa value chain. In practical terms, this means that many communities in PNG exhibit a marked preference for collectively accessible and inclusive development, in which models that target specific stakeholders with intervention support and benefits while excluding others may become a risk for community cohesion. Entrepreneurial success, for example, often needs to be carefully negotiated as part of wider social relations in PNG.

# 8. Environmental analysis

## 8.1 Goal and scope of the environmental analysis

### 8.1.1 Goal

The goal of this study is to map the environmental impacts in PNG and provide a perspective for actors in PNG. The following objectives were derived from the general VCA4D core questions. For the supply chain in Papua New Guinea, we aim to:

- Determine major environmental problems with the largest impacts in the three areas of protection, and determine the most relevant environmental problem from this top three.
- Determine the most important value chain stage and specific activities that have the largest contributions to these impacts.
- Provide a brief perspective outside the Life Cycle Assessment:
    - On environmental problems that are related to but not covered in LCA
    - On potential developments and improvements in the future

### 8.1.2 System boundaries

Given the goals of the study, all parts of the supply chain within PNG that are part of the functional analysis are in the scope of the LCA. Furthermore, all impacts from the cradle of resources to the inputs used in the supply chain in PNG are included because significant environmental impacts might occur in that part of the supply chain, and might be influence by actors in PNG. Hence, the scope is from cradle to the port of export in PNG. Cultivation systems can be compared according to this scope delineation and comparisons with products outside PNG are not envisioned.

The impact of transport vehicles, production infrastructure and buildings (known as capital goods) were excluded in general, because it was expected that they would have a low overall environmental impact. One exception was the nursery construction, which was included to check if the initial estimation of low environmental impact was correct.

The functional analysis further defines which variations of the supply chain are modelled. It excluded processing of dried cocoa beans because of its minor importance in PNG.

The cultivation types identified in the functional analysis are 1) Subsistence “Wet Bean” producers 2) Subsistence “Dry Bean” producers and 3) Business-Oriented Dry Bean producers. In the chapter, we will refer to these archetypes with “AT” for archetype and their number. Note that for AT1 and AT2 the wet and dry bean characteristic imply that these farmers tyipically have a difficult and easy access to a fermentary, respectively. Fermentary ownership is dominant in AT2 and so is lack of ownership in AT1, but both farmer types contain farmers selling dry beans and wet beans. Anyhow, fermentation and drying is always done across the archetypes, under very similar conditions and with very similar

results. The most differentiating characteristics between the archetypes are the yields and the level of pesticide use. Plantations have been excluded from the LCA like for the functional analysis.
The functional analysis demonstrated that impacts during fermentation and drying and during export activities are not differentiated along the three archetypes. The logistic chains of the three archetypes show some variation in number of middlemen and transport distances and modes; these have been connected to the cultivation archetypes studied and are further analysed in the variability analysis (Figure 10).

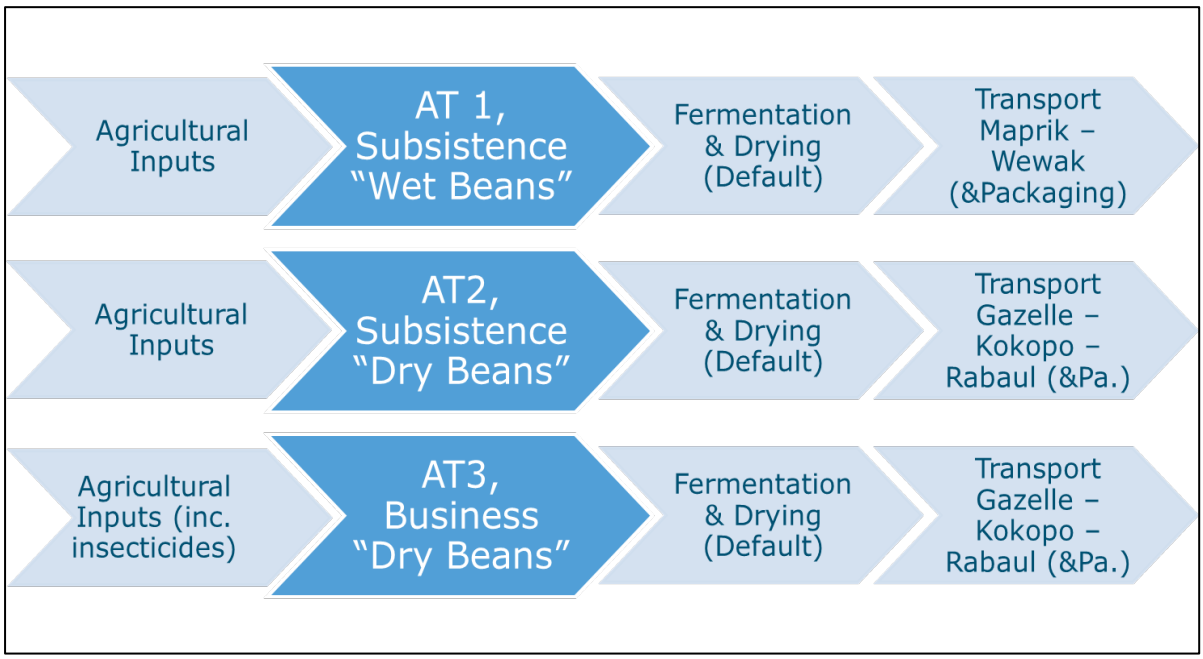



*FIGURE 10 - SUMMARY OF THE SUPPLY CHAINS MODELLED: THREE VARIATIONS CORRESPONDING WITH THE ARCHETYPES*

### 8.1.3 Functional unit

A declared unit of 1 kg dried beans (DB) ready for export was selected as the functional unit. All dry beans are packaged in jute bags, stacked on pallets for transport in containers, and have the same shelf-life. Most cocoa is exported as bulk cocoa with the same flavour characteristics. To make the comparison with the small fraction of fine flavour cocoa fair, one could search for a functional unit that corrects for the quality difference, but this was not feasible.

### 8.1.4 Multifunctionality

No major points of multifunctionality have been identified in the studied value chain. Most cocoa is grown in monoculture system, in which food cropping is done, yielding comparatively low quantities, mostly before the cocoa becomes productive. Mixed cultivation in "agroforests" of various complexities does occur as exceptions; in the case of PNG, these are low cocoa yielding systems. Cocoa is combined with cocoa with betelnut, coconut, banana, and to a lesser extent vanilla, timber, tree fruits like mango and papaya, etc. Cocoa is the main source of income, but the value of these other

crops for household nutrition and cash income can be significant. The diversity in crop combinations is very high and the production levels are highly variable. It could not be estimated how much of additional crops is taken from an agroforest. The forest-type cultivation is discussed in the variability analysis and all three cultivation archetypes are assumed to be fully monoculture.

## 8.2 Life Cycle Inventory

A description of each model component is given below. Attention is given to the most impactful components of the model, and other parts have been modelled with secondary data from EcoInvent 3.3 (Wernet et al. 2016) and AgriFootprint (Blonk Agri-footprint bv. 2014), and have been summarized. The most important parameters for the model are listed in Annex 1.

### 8.2.1 Land conversion before cultivation

Land conversion from forest to cocoa cultivation contributes to climate change. The estimation of the carbon loss and nitrogen loss is described in the first and second section respectively. The land conversion fraction (how much land has been converted per year due to cultivation on one ha)[4] is described the third section. Alternative perspectives are discussed in Annex 2.

### 8.2.2 Carbon balance

The carbon balance is the amount of carbon lost upon the conversion of 1 ha of forest to cocoa cultivation. This loss is determined by assessing the carbon content of the reference forest and that of the cocoa cultivation system. IPCC (2006) provides guidance about this and was used as a starting point. Because more detailed data was available from the missions and from literature, more specific data was used. The carbon loss consists of three components: Soil Organic Carbon (SOC), aboveground biomass and belowground biomass.

A distinction was made between two observed systems. “Open cultivation”: The most dominant system was cocoa monocropping under gliricidia after clear cutting forest trees and some years of food cropping. All three archetypes are modelled as this system. “Forest cultivation”: An alternative system in archetype 1 is cocoa cultivation mixed with other productive trees, under original forest canopy. The forest canopy is changed over the years to betelnut and other shading trees, and a small number of forest trees is always maintained. Forest cultivation will be discussed in the variability analysis.
The following method choices were made:

- IPCC (2006) suggests to account for no soil organic content change for perennial crops or for agroforestry. There are indications that SOC changes under permanent cropping (Agus et al.,

[4] The land conversion fraction also reflects the extent of biodiversity impacts from land conversion. The biodiversity impacts from the actual land occupation is accounted for in the cultivation stage, and the land conversion fraction is not relevant for this.

2013; Tondoh et al., 2015) so that these changes were considered. For forest cultivation, the SOC was kept the same.

- Calculated carbon losses are country averages for typical situations. Global or continent data from IPCC (2006) is replaced with more specific data applicable to cocoa, from both PNG and other cocoa producing countries, and with variable time frames (+/- 10 yrs). Hence, some spatial and temporal extrapolations were made to be more specific for cocoa.
- Peat oxidation is disregarded because cocoa grows on well drained soils; they do not contain peat. If the soil did contain peat in the past, it has been drained already and the carbon has been lost during the previous land use. Peat oxidation was raised as an important point of attention in Agus et al. (2013), but can be disregarded according to IPCC (2006).
- Given the available detail, a cultivation cycle average carbon storage could be calculated. Because of the time dependence of this carbon storage, it is more uncertain than the carbon loss. This number is not included in the LCA but is interpreted with caution in section 7.5.1.1.

By combining different data sources for the reference forest and the cocoa cultivation system, different carbon losses can be calculated. The reference forest was modelled as disturbed by human activity, given the knowledge from PNGFA and FAO (2015) and PNGCCDA (2018), elaborated in Annex 2. The ranges determined for the three separate components are listed in Annex 3.

### *Nitrogen balance*

The nitrogen lost upon the conversion of 1 ha was derived by assuming a C/N ratio of 30, as a low estimation from IPCC (2006). The C amount of SOC change was thus divided by 30 to come up with the nitrogen loss for Open Cultivation. Since no SOC change was included for Forest Cultivation, the nitrogen loss was assumed to be 0. Applying the C/N ration resulted in a loss of 1667 kg / ha, which is still larger than 800 kg / ha reported by Tondoh et al. (2015). The nitrogen loss was distributed over the species ammonia, nitrous oxide, nitrogen oxides, molecular nitrogen with nitrate as the balancing term following the approach for European Commission (2017).

### *Land conversion fraction*

The standard LCA method to calculate land conversion fraction supported by a wide consensus (European Commission, 2017; Ponsioen & Van Der Werf, 2017) takes a 20-year time horizon and a national geographic level. The most important principles are that each hectare of cocoa in a PNG is responsible for the expansion of cocoa on natural land in PNG, regardless of the land conversion processes in a particular hectare. This principle holds up well in open land markets, where the cultivation of each crop be shifted to other plots in the country. It is assumed the net expansion takes place on natural ecosystems, and it is assumed all ecosystem area is composed of one type of reference forest. The method consists of the following steps:

1. The cultivation areas of all major crops of the country are taken from FAOSTAT (FAO, 2018). The data was available until 2016, and the areas of 2017 and the current year were extrapolated by linear extrapolation from the 1985 – 2016 period.

2. The average annual increase in cultivation area for each crop was calculated for the period of 1998 – 2018. For cocoa in PNG, this was 1203 ha.
3. The contribution of each crop to the gross cultivation area increase (including only crops with increasing cultivation areas) is calculated. Relative to a gross increase of 13691 ha, cocoa caused 9% of the total expansion.
4. The net cultivation area expansion (including all crops with declining cultivation areas) is determined. For PNG as a whole, the net increase in cultivation area of all crops was 9755 ha.
5. The net expansion (from step 4) is distributed over the crops with increasing areas according to the allocation percentages (from step 3). Cocoa in PNG was responsible for 857 ha of natural land conversion.
6. The allocated expansion (from step 5) is divided over the total cultivation area of a crop, to arrive at the area growth on natural ecosystems per ha cultivation area. For cocoa, 857 ha represents 0.7% of the total area under cocoa in 2018.

### 8.2.3 Cultivation

#### *Exclusion of manual labour and exceptional practices*

Several practices require large amounts of manual labour, which is commonly kept out of scope in LCA. Furthermore, no mechanization on farm was observed. Practices that required manual labour andthose that were recommended but not followed were not modelled. Below are examples of practices that require manual labour and/or are not followed:

- Many pest management and sanitation practices are available in literature (a.o. PNG Extension Manual), and from extension (e.g. the PPAP program), but they are not often followed ((Curry, Koczberski, Omuru, & Nailina, 2007), also observed and from survey).
- Weed management consists of grass slashing, it is common for small trees ((Curry et al., 2007), also observed) but often stops if no food is grown between the cocoa trees.
- Transport from the field to the fermentary is done in buckets or bags or wheelbarrows, and all transport is man-powered. In places with high fermentary densities, like ENB, transport distances are generally small (some km).
-

#### *Pesticides*

It was observed that pesticide use was not adopted broadly because they are expensive for smallholder farmers. This confirmed PPAP (2010) and Curry et al. (2007). According to PPAP (2010) some farmers use herbicides, while Curry et al. (2007) stresses the lack of herbicides. A tendency not to prefer pesticide use was observed in ESP among farmers and advisors (Toli, 2018).Only for Archetype 3, insecticide use was observed and was included in the model. Although herbicide use was mentioned in the Extension Manual (PNG Cocoa and Coconut Institute, 2017), it was not observed and thus not included in the model. Farmers use one to three types of insecticides with standard dosages. The names of pesticides collected in the agricultural survey and the farmer interviews did not all correspond with known pesticides and not with the names in the PNG extension manual. The ones

that did correspond with the extension manual and that could be found in the public Pesticide Property Database (University of Hertfordshire, 2018) were selected as proxies for all types of insecticides used by farmers. The application frequency and dosage were estimated from the farmer surveys and farmer interviews. Auxiliary chemicals were assumed to have negligible impacts. To calculate emissions, the PEF guide (European Commission, 2017) was followed : 90% of the applied insecticide amount goes to air, 1% goes to water and 9% goes to soil.

### *Cacao cultivation induced nitrogen cycling*

Pruning is done at variable levels, from quarterly to weekly, with and without consistent strategies, according to field observations and the farmer survey. This means that activities dedicated to cocoa cultivation affect the nitrogen cycle.[5] Manure or fertilizer application was observed only once during the VCA4D team mission and was confirmed to be sporadic (Pikop, 2018; Toli, 2018) The nitrogen balance that feeds into the LCA parameter list are described below.

van Vliet and Giller (2017) is the basis of N inputs, flows within the system and outputs: The main inputs are N deposition to the soil (10 kg N / ha*yr) and N fixation by Gliricidia (35-60 kg N / ha*yr).[6] The nitrogen fixed by gliricidia goes to the soil through root turnover and pruning of the Gliricidia shade. Large amounts of N are cycled between living matter and the soil, so that it ends up in the soil "once a year":

- The largest annually cycled amount is litter from cocoa and Gliricidia (93-130 kg N / ha*yr) (de Vries, 2017); A simple linear function[7] was used to distribute the literature range over the yield range.
- Cocoa tree prunings are assumed to be 10-25% of shoot and leaf N masses from Alpizar, Fassbender, Heuveldop, Fölster, and Enriquez (1986).
- Rainwash (8 kg N / ha*yr, (van Vliet & Giller, 2017)) from vegetation
- Cocoa pod husks (3-15 kg N / ha*yr; PNG Cocoa and Coconut Institute (2017), adjusted to archetype yield) are piled up in the field, and equal distribution over the field is assumed.

The total N flow to soil ranges from 122-245 kg N / ha*yr ranging from the alternative forest cultivation in archetype 1 (described in 1.4.1.1) to archetype 3. The following losses of N were determined:

- Based on the gross N flow to soil, $N_2O$ emissions were calculated with the emission factor 0.1 kg $N_2O$-N / kg N from IPCC (2006).
- The $NO_x$ emission was calculated as a fraction of the $N_2O$ emission with a factor of 0.21 kg $NO_x$-N / kg $N_2O$-N (Ponsioen, 2018), and subtracted from the $N_2O$ emission.
- The N in wet beans (6-32 kg N / ha*yr; PNG extension manual, adjusted to archetype yield) and N in the permanent growth of the cocoa tree (4 kg N / ha*yr; (van Vliet & Giller, 2017)) are losses from the system too.

[5] The carbon released from prunings is biogenic and was very recently fixed, and it is not assessed.

[6] Under Forest cultivation, the nitrogen fixation from forest trees may benefit the cocoa, but this could not be quantified.

[7] N in Litter = a * Yield + b: with Litter(Yield = 0)=84: low end of range, with Litter(Yield=3200)=175: high end of range at twice the yield of $AT_3$

- A base nitrate loss, as recommended by European Commission (2017), is unlikely under nitrogen poor conditions in systems without manure application and was excluded.Because all ammonia is directly taken up by roots and microorganisms in the soil under nitrogen-poor conditions, an ammonia loss was not included. All nitrogen flows and calculation constants are differentiated according to cultivation archetype (including the AT1 Forest Cultivation) in Annex 5.
- If a positive N balance results after subtraction of all losses, this amount is assumed to be lost as $NO_3$ from the soil.

### *Other data*

The following additional data was used for modelling the wet bean cultivation.

- The number of seedlings used was set equal to the tree density of the archetype (625 per ha for AT1 and 833 for AT2 and AT3), assuming no seedling losses. A productive phase of 20 years with an annual yield of the archetype for each year was assumed. The seedlings are assumed weigh 3 kg and to be transported for 30 km to the farm, since nurseries are quite scattered. The impact of soil sourcing is not considered, since soil is locally sourced. Polybags containing the soil were included as 5 g LDPE per seedling. Fertilization and generic fungicide application were included according to recommendations (2 g of generic NPK fertilizer and 0.05 g of generic fungicide per seedling (CCI 2017).
- The nursery construction used for seedling production was modelled according to the heaviest construction that we visited, near Angoram. Photographs were taken and quantities of all materials (concrete blocks, wooden beams, steel wire, shading screen) were estimated conservatively. These materials were distributed over the nameplate capacity of the nursery (twice 40.000 seedlings per year) times a conservative lifetime (5 years), accounting for the observed low utilization rate.
- Reuse of plastic bags for wet bean transportation to fermentary was 20 times. The use of plastic woven bags was observed and it was assumed fertilizer bags were a suitable proxy.
- A transport scenario accounting for import of plastics, fertilizers and pesticides from abroad was included. It was assumed all of these inputs come from Malaysia (like the fertilizers, according to (McNally, 2018)), so that they were transported for 150 km in the country of origin and in PNG by truck, and for 6000 km by sea ship.

## 8.2.4 Fermentary

Wet beans (WB) are fermented and dried in a small construction called a fermentary (for more details, see the functional analysis). The amount of wet beans used depends on the conversion factor (kg DB / kg WB) defined in the archetypes and on the loss and rejects rate of 1% assumed in the economic analysis.

The pulp from the wet beans serves as the substrate of fermentation (Caligiani, Marseglia, & Palla, 2016) and through chemical conversions to gases and liquids is entirely removed from the fermentary construction. Nothing else is used during fermentation. These liquid and gaseous emissions from the

process arise from some aerobic and some anaerobic breakdown processes. The emissions were estimated as follows:

- The carbon and nitrogen content of pulp were calculated from the composition data in Caligiani et al. (2016).
- The aerobic scenario was modelled following European Commission (2017), using agricultural soil as proxy.
- The anaerobic scenario followed the guidance on waste water treatment from Caligiani et al. (2016) as a proxy to calculate $N_2O$ and biogenic methane emissions, and the other N emissions were derived from the PEF guidance on agricultural soil modelling.
- The aerobic scenario was chosen because liquefied pulp will leak from the fermentation boxes into the soil, so that it is exposed to aerobic conditions for most of the time. However, as a conservative estimate, a biogenic methane emission of 1 g / kg DB produced was included to test for sensitivity (1/30 of the emission from the anaerobic scenario).

The drying is done by heating an eight cm layer of beans on a frame with a wood fired kiln. Sun drying is possible in PNG, but not practiced widely, and was left out of the assessment. The fermented beans need to be dried from 41% moisture content to 6–7% (Caligiani et al. 2016, PPAP 2010). The following aspects are included:

- Emissions from the fire are modelled according to the process of burning hardwood from EcoInvent 3.3[8].
- Cleft hardwood timber from EcoInvent 3.3[9] is used as a proxy for the hardwood fuel, collected from forests and from cut down shade trees (and to some extent cocoa trees).
- The amount of fuel wood needed is averaged from observations during the VCA4D team mission at two farm visits and a visit of CCI Tavilo. Fuel wood efficiency (MJ for water removed from 1 kg DB / MJ fuel wood used for 1 kg DB) ranges from 7 – 70%[10] and fuel wood efficiency of 30% was selected, amounting to 0.5 kg fuel wood needed for 1 kg DB production.

The fermentation part of the construction consists of wood and the dryer consists of steel and concrete. The demands for construction materials for the fermentary were estimated from the kiln in which the hard wood was burned according to EcoInvent 3.3. The dried beans are packaged in jute bags of 63.5 kg, which are reused 20 times (dry bean sellers get their jute bag back at the dry bean buying point).

[8] Heat, central or small-scale, other than natural gas {RoW}| heat production, mixed logs, at wood heater 6kW | Alloc Rec, U

[9] Cleft timber, measured as dry mass {RoW}| hardwood forestry, mixed species, sustainable forest management | Alloc Rec, S

[10] Cocoa is dried in the sun for part of the time at most. In the field, the days of sun drying during the drying cycle is counted to estimate fuel wood reductions. Given the large uncertainty in the fuel efficiency, possible reductions fit within the uncertainty range.

### 8.2.5 Transport & Export

In the final phase of the supply chain, dry beans are transported to exporters in major towns and made ready for export. Transport distances are taken from the VCA4D team mission: for AT1, a scenario from Maprik or Angoram was used (both about 130 km by road to Wewak), and for AT2 and AT3, a scenario from Kerawat or Warangoi was used (both including 5 km from farm to depot and 30 km from depot to exporter). The distance to the harbour itself was estimated to be short in Wewak (5 km (VCA4D team mission) but was significant in ENB (30 km from Kokopo to Rabaul (surveys). At the exporters, 2.5% of the beans is rejected or lost, the dried beans are packaged in fresh 63.5 kg jute bags and piled onto pallets for export in containers. The pallets are modelled as Europallets from EcoInvent 3.3, with local transport, since they are made locally (McNally, 2018).Containers are checked for export by the quarantine authority NAQIA, and no losses or other reasons for environmental impacts are observed during the export process. The model was designed to accommodate transport over water and through air for variability analyses.

## 8.3 Results: Environmental impacts

### 8.3.1 Endpoint indicators for the cocoa value chain in PNG

*Human health impacts are caused by climate change impacts*

Over 90% of the impact on human health is due to impacts through climate change (Figure 11). An additional contribution is due to fine particulate matter formation. Remaining environmental impacts affect human health to a minor extent, namelyozone depletion, nuclear radiation, smog formation, and water consumption. Neither does toxicity due to insecticide use impact human health.The differences between the three archetypes are most strongly influenced by the yield differences. This is elaborated in the sensitivity analysis.

The human toxicity impacts modelled in LCA refer to the potential impact to the general public and not to occupational hazards for labourers. Since labourers are in close contact with insecticides for extended periods of time, because of the use of the knapsack sprayer and limited protection use, it is estimated that these occupational hazards can be substantial in Archetype 3.

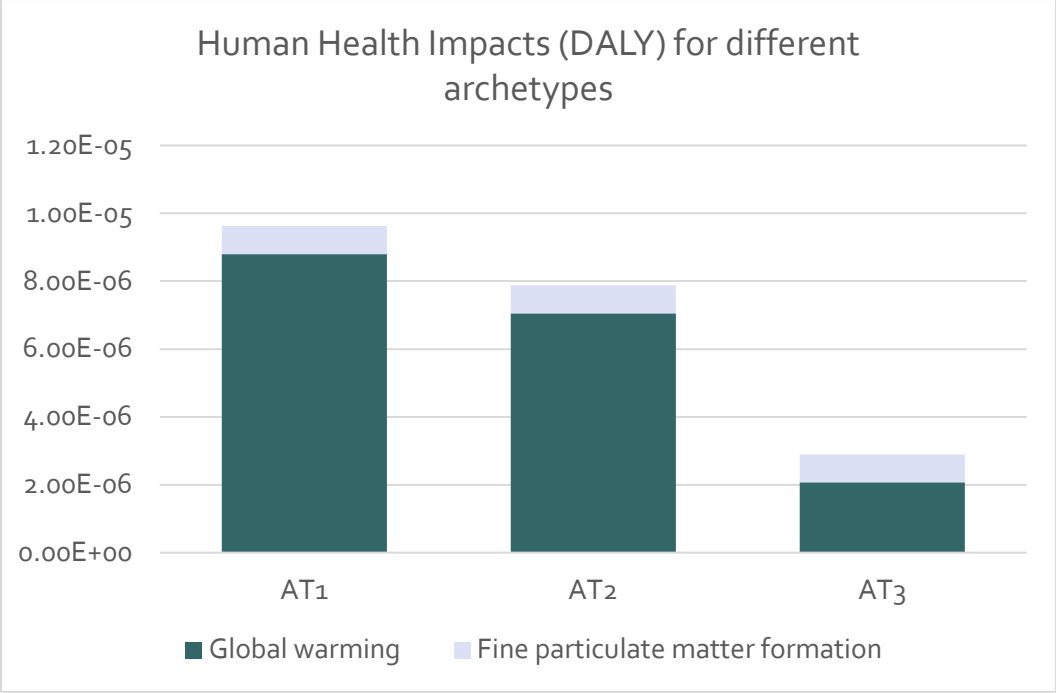



*Figure 11 Human Health Impacts in DALY for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB.*

### *Ecosystem quality is predominantly impacted by land use*

In the ecosystem quality endpoint category, the land use from the cultivation is most significant, with contributions from global warming and terrestrial acidification (Figure 12). All of these impacts are related to the cultivation on the land, so that they are directly coupled to the yield. Thus AT2 has a 21% lower ecosystem impact from land use than AT1 and AT3 has an 80% lower impact. In AT3, insecticide use will have a marked contribution. Midpoint impacts contributing ecosystem impacts that have a small impact in this case are ozone formation, water consumption and freshwater eutrophication.
There are also ecosystem impacts not covered by the impact categories. There are varied biodiversity impacts such as disturbance and habitat changes, which may be the largest ecosystem impact. Marine eutrophication might be an issue because large amounts of nitrates from land conversion and nutrient cycling may be transferred to the sea, but these nitrates may be fixed in the soil or groundwater. Furthermore, it was mentioned in field surveys on ENB that contract labourers sometimes dispose insecticides by emptying their knapsack contents into water streams or at the edge of the field. This would increase the ecosystem impact through aquatic toxicity manifold and it reduces the yield since the CPB is not managed.

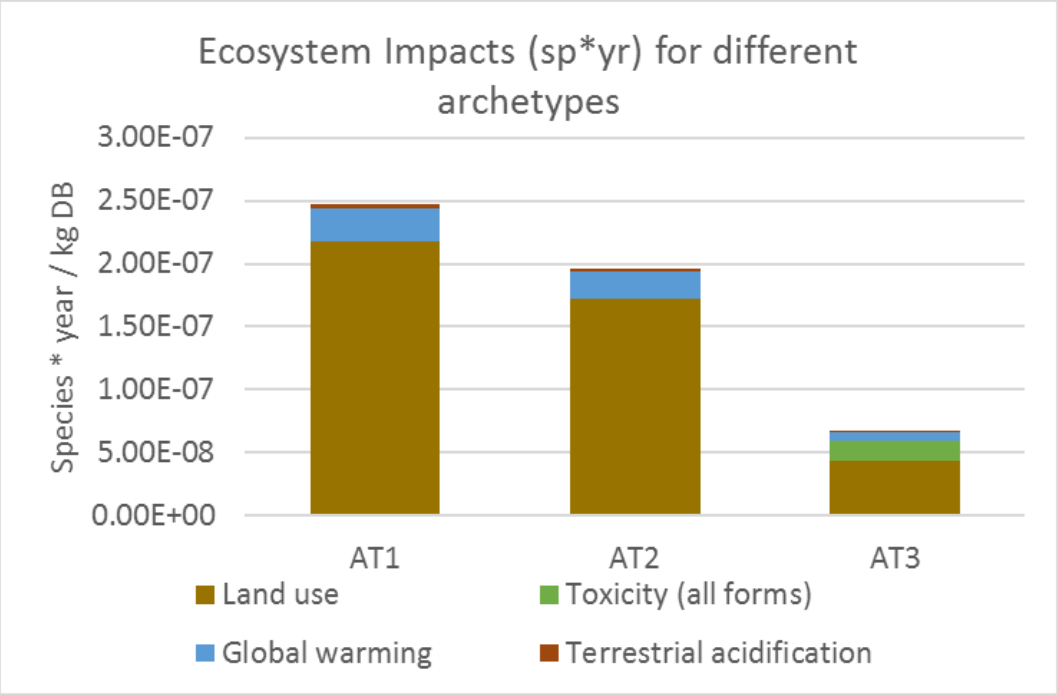



*Figure 12 Ecosystem Impacts in species*year for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB.*

### *Resource depletion equals fuel use in LCA, but there are other impacts*

The resource depletion endpoint category includes mineral and fossil midpoint categories. Fossil resource depletion is about 200 times larger than the mineral resource depletion, which is not exceptional in cases like these, with low utilization of equipment and long transport distances (Figure 13). Given the dominance of fossil depletion, a detailed study of the equipment and infrastructure requirements in all operations in this supply chain would not change this view. The difference between AT1 and the others is caused by the longer transport distances in ESP compared to ENB. The difference between AT2 and A3 is caused by the yield difference, requiring less transport of seedlings to produce 1 kg of dried beans.

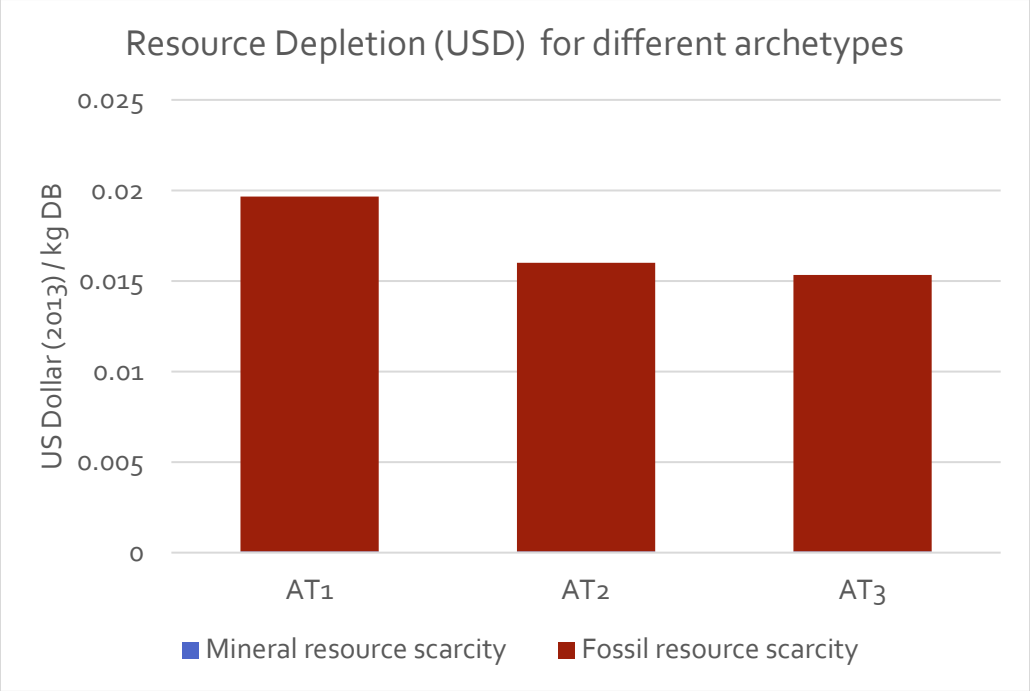



*Figure 13 Resource Depletion in USD (2013) for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB.*

### *Identification of most important impact categories*

The contributions of the different environmental impacts are depicted in the preceding figures. Each endpoint is impacted most strongly by one midpoint category, which isidentified as the most important impact category: climate change for human health, land use for ecosystems, fossil resource use for resource depletion.Furthermore, fine particulate matter can be identified as secondary environmental impacts, contributing about 10% to human health and ecosystem impacts respectively, to subsistence farmers (AT1 and AT2). Climate change also contributes to ecosystem impacts. Because climate change and land use impacts are much smaller for the commercial DB farmer (AT3), the contribution of fine particulate matter formation is larger. Furthermore, toxicity impacts to ecosystems are significant for AT3.

### 8.3.2 Identification of most important processes

The midpoint impacts contributing to ecosystem impacts are directly related to yield and insecticide use in the cultivation phase. Figure 14 shows that with an endpoint perspective the cultivation stage causes the most environmental impact. For human health and ecosystem impacts, the other impacts are comparatively small. Resource depletion, which is dominated by fossil resource depletion, is caused by the transport and fermentary stages. The midpoint impacts contributing to human health and resource depletion receive more attention in the following sections.

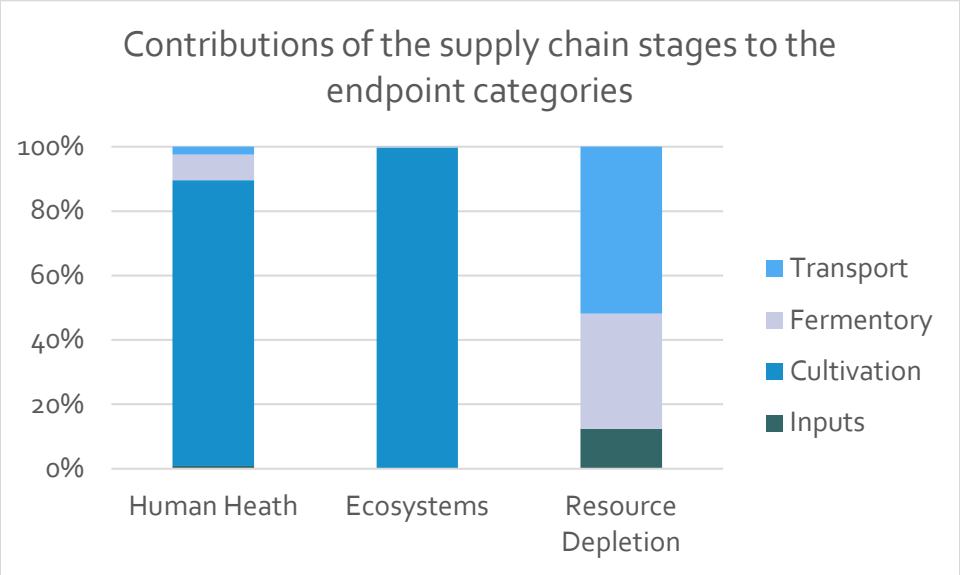



*FIGURE 14 CONTRIBUTIONS OF THE SUPPLY CHAIN STAGES TO THE ENDPOINT CATEGORIES*

#### *Land use conversion and nitrogen cycling determine climate change*

Land use conversion causes substantial climate change impact according to the accepted LCA method. In the LUC assessment, this method showed that a hectare planted to cocoa causes 0.007 ha of land use conversion. This small area releases 2.0 t CO2 upon conversion, as 1 ha of converted reference forest causes a carbon loss of 79 t C / ha. Since this emission is distributed over the cocoa yield per ha, causes up to 7.1 kg CO2eq / kg DB (under the low yield of Archetype 1), amounting to 75% of the climate change impact (Figure 15).

A second contribution consists of $N_2O$ emissions from nitrogen inputs to the soil.[11] Large amounts of nitrogen are cycled through the soil during cocoa cultivation, because of litterfall and pruning. Emissions of the potent greenhouse gas nitrous oxide can arise, ranging from 2.0-3.2 kg $N_2O$ / ha from AT1 to AT3. These emissions are not exceptional for permanent cultivation with low nitrogen inputs and high nitrogen cycling, and may actually be lower than in forested areas. Although the cultivation

[11] This was not expected during the missions, since no fertilizer or manure use was observed, and no attention was given to this during the debriefing presentations.

is man-made, it is not common to attribute this emission to the cocoa cultivation,. Because the yields from AT1 are relatively low, the climate change impact becomes 2.0 kg CO2eq / kg DB for AT1. Higher yields from AT3 translate to 0.6 kg CO2eq / kg DB. Smaller contributions to climate change impact are kiln drying the beans, the use of jute bags, the sawing and transport of fuel wood.

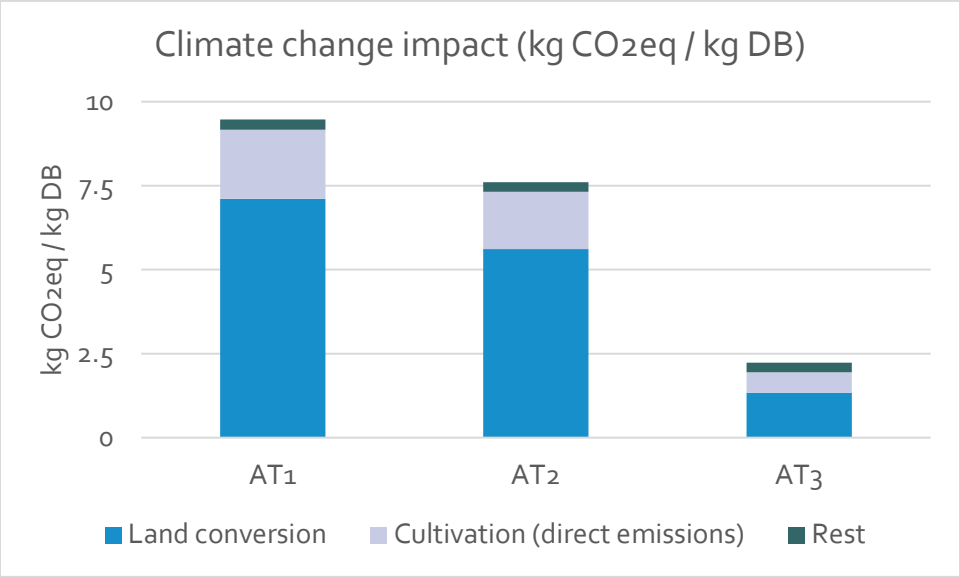



*Figure 15 Climate change impact contributions in kg CO2eq / kg DB for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB. "Rest" represent all other contributions in the cultivation, fermentation & drying and the transport & export.*

### *Kiln drying of beans and jute bags cause particulate matter formation*

Particulate matter can be formed during combustion processes and some "dusty" industrial processes like sawmilling, but also emissions of small molecules contribute to aggregation into fine particles in the air. $NO_x$ is an important contributor to fine particulate matter formation, along with sulphur based compounds. In this study, the $NO_x$ from the cultivation of cocoa hardly contributes to the fine particulate matter formation (Included in "Rest" in Figure 16). The main contributors are the kiln drying of the cocoa beans, producing soot and $NO_x$, and the production of jute bags. Smaller contributions are collection and sawing wood for the kiln drying, the polybags for seedlings, and diesel production.

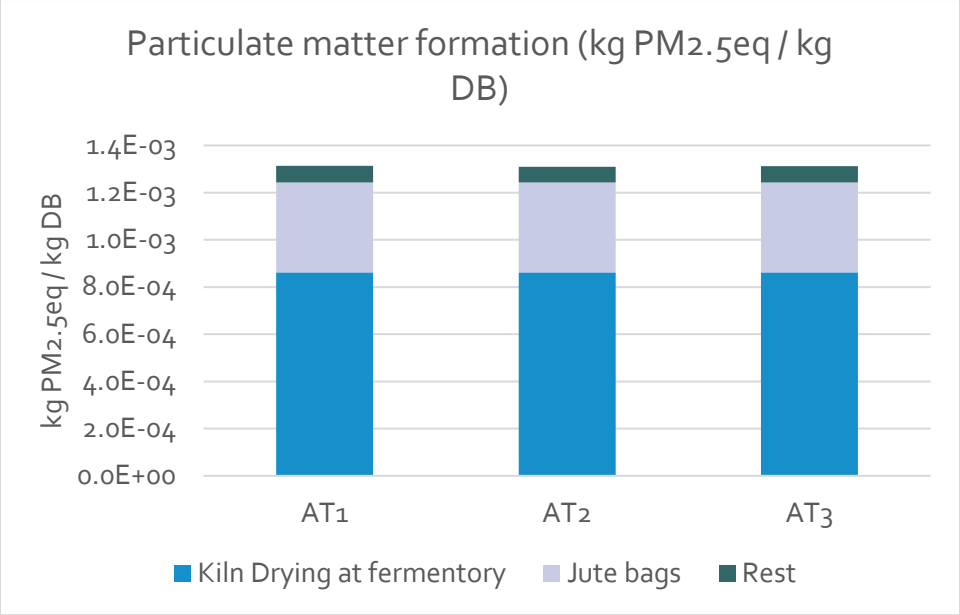



*Figure 16 Particulate Matter Formation contributions in kg PM2.5eq / kg for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB. "Rest" represent all other contributions in the cultivation, fermentation & drying and the transport & export.*

### *A range of materials and transport depletes fossil resources*

Most of the fossil resources are used as fuel, burned for transport and production processes. Wood collection involves chainsaw use and requires up to 40% of the fossil resource use (Figure 17). Jute production involves mechanized agricultural operations resulting in a 30% contribution. Direct diesel use within the value chain requires from a fifth to a third of the fossil resource depletion in this supply chain, and occurs during the transport of dried beans but also during transport of agricultural inputs and seedlings. Transport distances vary strongly:

- In ENB, the distance from a fermentary on the Gazelle to the port of Rabaul through Kokopo ranges from 35 to 200 km.
- In East Sepik, the distance from Maprik or Angoram to the port of Wewak is about 130 km, while transport from the south of the Sepik can add transport by small boat of 150 km.

The contribution of all this transport to other environmental impacts like climate change is relatively small, because the cultivation impacts are larger.[12] Additional impacts to fossil resource use are fuel wood collection and jute bags.

[12] It was expected that the transport in the long supply chains with small transport batches would have the largest environmental impact; but climate change and land use from cultivation are more substantial than presented at the debriefing presentations. Transport contributes 1.8% to climate change at most.

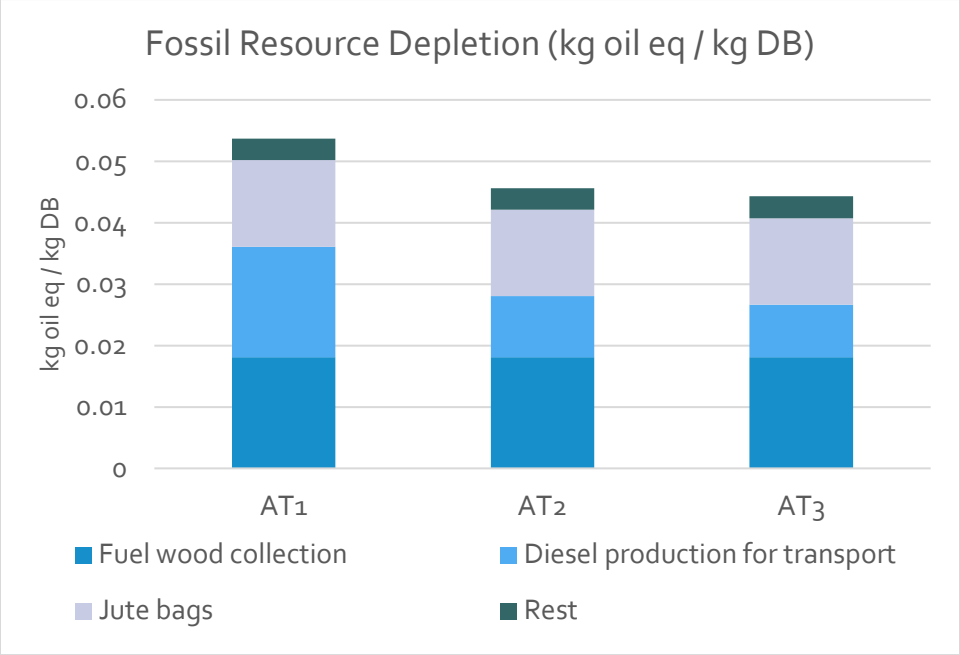



*Figure 17 Fossil resource depletion contributions in US Dollars (from 2013) / kg DB for the three value chains of the different cultivation archetypes. AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB. "Rest" represent all other contributions in the cultivation, fermentation & drying and the transport & export.*

### 8.3.3 Other environmental impacts

#### *Nitrogen losses*

There are nitrogen losses from the soil that can be attributed to cocoa cultivation, also if a more forest-type system would be employed. These losses are replenished by nitrogen fixation from gliricidia shading in open cultivation, and may be replenished by forest trees in the forest cultivation. There are no indications of a nitrogen deficit from this analysis. The $N_2O$ and $NO_x$ emissions are not substantially larger than in natural systems (Pronk, 2018), and may be smaller than in forests with higher N cycling (Meier, 2018). The planting and pruning of cocoa however leads to an altered N cycling which is attributable to cocoa cultivation.

The annual losses are shown in Figure 18 on a hectare basis and a kg of dry bean basis. Because yields are low in AT1 and AT2, the N loss from harvest is limited in those situations. The nitrogen that is not used in regrowth and not lost through $N_2O$ and $NO_x$ emissions or harvest, is leached from the soil into freshwater and groundwater. The large yield from AT3 causes a large nitrogen loss per ha, but on a kg basis, this loss looks less impactful.

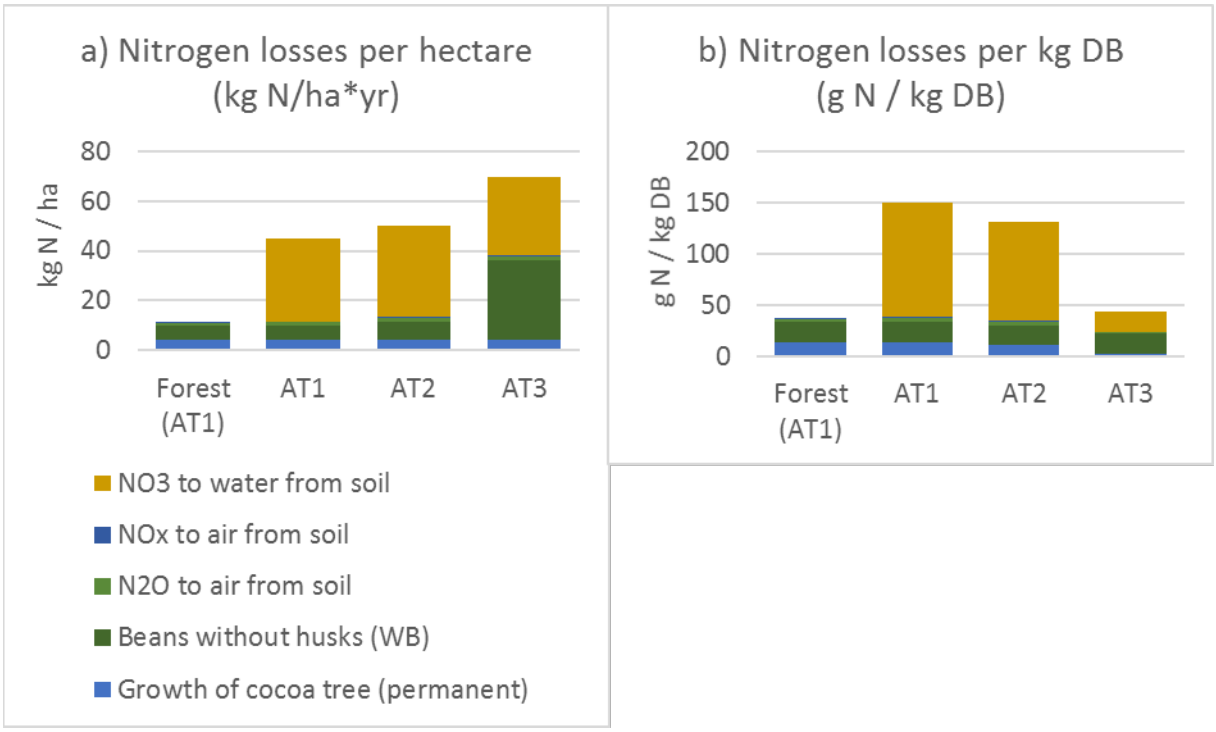



*FIGURE 18 THE CONTRIBUTIONS TO NITROGEN LOSSES ON A HECTARE BASIS, PER YEAR (A) AND A KG DRY BEAN BASIS (B) FOR DIFFERENT ARCHETYPES: AT1 = SUBSISTENCE, WB; AT2=SUBSISTENCE, DB; AT3=BUSINESS-ORIENTED, DB. FOREST CULTIVATION IS AN ALTERNATIVE FORM OF AT1 CULTIVATION. THE FOREST (AT1) TYPE HAS NOT INCLUDED N FIXATION FROM FOREST TREES AND IS LIKELY TO HAVE NO3 EMISSIONS AS WELL (NOT SHOWN).*

A study from Nelson et al. (2011) does indicate that nitrogen deficiencies in cocoa leaves are common across PNG, indicating a limited availability of nitrogen to the cocoa roots. Their assessment could be improved by mapping critical levels of leaf nutrient concentrations in manipulative trials. Yield reductions are not apparent in collected quantitative data, nor were they mentioned by experts or in literature for the PNG case. Incidentally, trees were identified with visual signs of nutrient deficiencies. Other limiting factors, especially CPB, are currently stronger, but in the long run, nitrogen deficiencies could result in reduced yields.

Nitrogen emissions also occur during fermentation. The amounts per functional unit are very small, compared to nitrogen losses from cocoa cultivation, so they do not show up in the LCA results (as $N_2O$ losses in Climate Change or $NO_3$ losses in terrestrial acidification). These emissions are however concentrated at the fermentary constructions, but effects of such local concentration cannot be modelled with LCA and were not observed in the field. Since the capacity of each fermentary is currently at most the WB supply of several tens of farmers, local nitrogen issues are expected to be limited. Nitrogen may be volatilized for the breakdown of carbon based molecules in the pulp, but nitrogen might also be in excess. That would result either in nitrogen depletion or nitrogen leaching, very locally, under the fermentary. If leached pulp is allowed to flow directly in to waterways, it can cause eutrophication (Ntiamoah & Afrane, 2008). If fermentation is done on a larger scale, the amounts of pulp are not absorbed by the soil but create a wastewater treatment issue.

### *Carbon storage in cocoa does not compensate losses*

It is sometimes argued that permanent agriculture mitigates climate change by storing carbon as dead matter in the soil and living matter above and below the ground. Cocoa cultivation does store carbon, but such carbon storage will never compensate the carbon lost due to conversion from forest. In Figure 19, the evolution of carbon storage in the open cultivation of the modelled archetypes and in the forest type cultivation is demonstrated as an illustrative example. In the open cultivation, the shade is halved in year 7 and removed in year 10, explaining the jumps. Year 0 represents the starting situation of the reference forest (198 t C / ha in total). The cultivation cycle-averaged carbon storage for the open cultivation is 144 t C / ha, with the shading tree storing much carbon whereas they are often removed halfway the cultivation cycle. The time-averaged carbon storage for forest cultivation is estimated to be 264 t C / ha, but the reference forest for agroforestry has a carbon content of 291 t C / ha.
For ENB, it could be argued that land conversion is not recent (well before 20 years ago) and that forest cannot be seen as the reference situation. This would imply cocoa had been growing where cocoa grew before. In that case, the carbon storage would not differ from one cultivation to the previous. Hence there is no net benefit in growing cocoa. The carbon storage of cocoa stands can be improved, but such effort would need permanent maintenance. Furthermore, increased canopy above the cocoa trees increases shading and may reduce the yield.

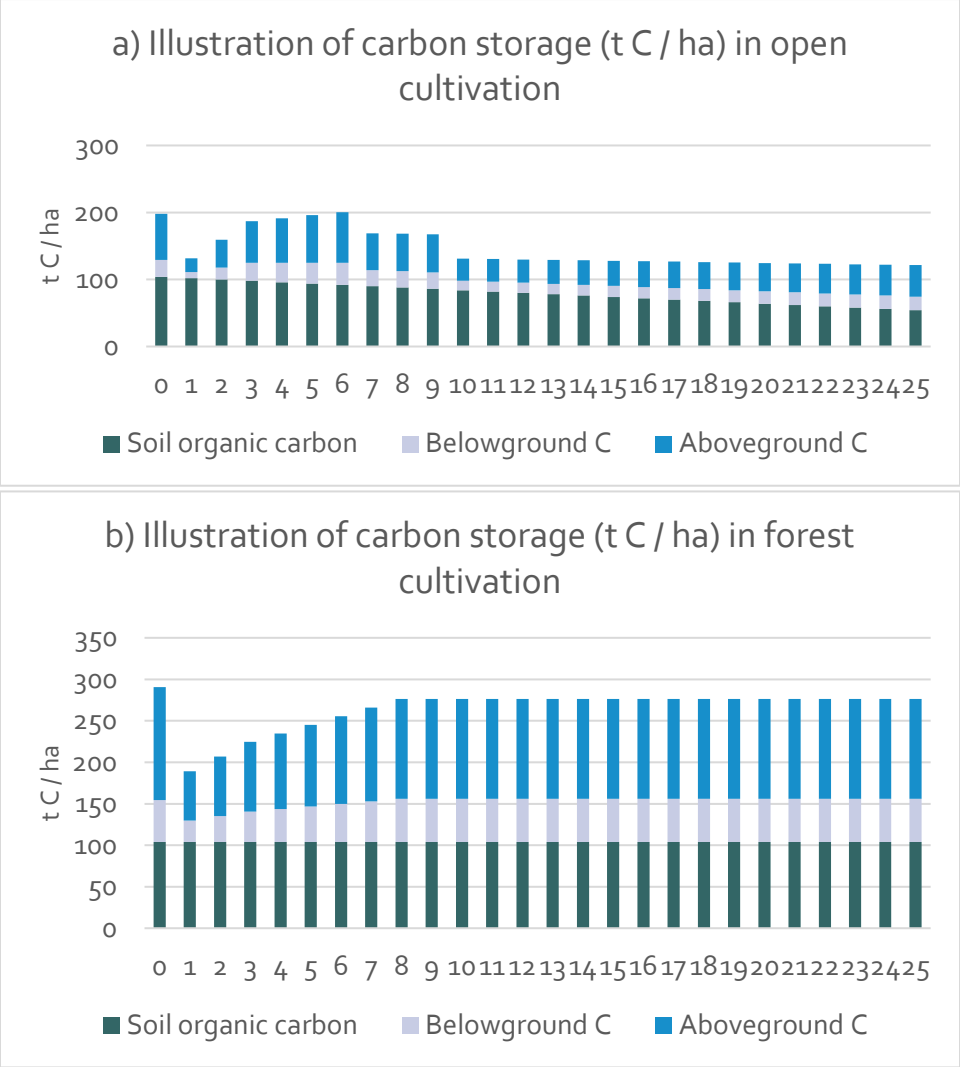



*Figure 19 Carbon storage in a reference forest (year 0) and development over the cultivation cycle of cocoa for two cultivation types: a) the typical open cultivation and b) the alternative forest cultivation; illustrative hypothetical examples*

## 8.4 Discussion

### 8.4.1 Main uncertainties

By combining the results from section 7.3.2. and the discussion on data quality in section 1.4., the most important uncertainties and assumptions can be identified.

- The wet bean yield will be a determining factor for both human health and ecosystem impacts: the drivers of climate change, land conversion and nitrogen emissions, act on the agricultural field, and are distributed over the yield. The land use that drives the ecosystem impact is almost equal to the inverse of the yield. The yield is taken from the typology developed in the functional analysis. It is clear that these are generalizations to simplify a highly variable and uncertain situation in the field. The yields for AT1 and AT2 are based on literature, given the limited reliability or sample size of primary data. The yield of AT3 was based on personal communication without primary validation. The yield differences are caused by differences in management strategies and manual labour input. The use of insecticide only increases yield in combination with these factors.
- There are substantial uncertainties in carbon loss and land conversion fraction. Measurements of carbon contents of vegetation systems are difficult and not widely available. An effort was made to be more specific than IPCC (2006), as described in section 1.4.1.1. Although the LCA method to calculate the land conversion fraction has become a consensus over the recent years, it can be seen as a source of methodological uncertainty outside the LCA field. Furthermore, there is the data uncertainty in FAOSTAT data described in 1.3.7.
- There are clear uncertainties in nitrogen modelling of cultivation. Specific modelling choices were made in drafting the balance, which increased accuracy beyond compliance to IPCC (2006) and European Commission (2017), but leave room for discussion.:
    - An approach was chosen that took the nitrogen inputs to the soil as a starting point and subtracted the nitrogen outputs from the soil. LCA models often look at the total N input and do not consider soil processes sufficiently; an annual N input is not used by the crop within in the year but contributes to the soil nitrogen. It was concluded in the review phase of the study that an alternative method, focued on the mineralization induced by nitrogen demand from the crop, would have been more scientifically accurate. It would result in larger nitrogen losses, ditributed differently over the nitrogen species. This approach would avoid the discussion whether the nitrogen losses from the system should be attributed to cocoa cultivation, and how the losses relate to the natural reference situation.
    - In the current approach, 100% mineralization of the inputs is assumed, whereas the alternative method would enable to derive N losses higher than the input amount. Furthermore, an emission factor was now reuiqured to convert N inputs to the $N_2O$ emission. This factor was relevant for compost and crop residues according to IPCC (2006), but its applicability can be challenged.

    - Smaller uncertainties could also be identified: 1) It can be disputed whether rainwash is actually applicable in open cultivation of cocoa, 2) nitrogen leaching might arise from piles of cocoa pod husks, 3) estimate of litterfall could be made more accurate and less yield dependent, and 4) estimates of N storage in permanent growth could be more accurate to include N stored in permanent roots.
    - It would have been interesting to study the effects of heavy rain events (common in the tropics) on the soil nitrogen balance, but this required a more advanced nitrogen model.
- The estimations of pesticide use and the inputs to the nursery stage are uncertain but do not affect the overall results. The nursery stage has a small contribution to all environmental impact categories and pesticides are only used for the marginal archetype 3.

### 8.4.2 Sensitivity analysis

After the contribution analysis, it was clear which processes contribute most to the different environmental impacts. The sensitivity of the four most influential factors was checked.

- The wet bean yield was marked as the most influential parameter.
- The land conversion fraction (area converted from forest per ha of cocoa planted) is another influential parameter, and also reflects variation in the carbon loss per area of land converted.
- $N_2O$ emissions from the field are the second driver of climate change.
- Transport distances from the fermentary to the port of export influence the diesel use and are a driver of fossil resource depletion. Other parameters also contribute to fossil resource depletion.

The sensitivity of the three most important impact categories of their four drivers was tested by running the archetypes AT2 and AT3 with a -20% deviation and a +20% deviation in these parameters. Yield, land area converted from forest per ha of cocoa planted and $N_2O$ field emissions were varied individually. The transport distances were varied collectively, since an overall impression was required. The quantification is shown in Table 20.

*Table 20 - Sensitivity of climate change impact, land use and fossil resource depletion to +20% and -20% deviations for archetype 2 and Archetype 3 in the key parameters: Wet bean yield (WByield), land area converted from forest per ha of cocoa planted (LUC_area), $N_2O$ field emissions (N2O), and all transport distances (allTDs). Red to green scale reflect the size and direction of the effect and not a value judgment.*

| | | AT2 | | AT3 | |
|---|---|---|---|---|---|
| | | -20 | +20 | -20 | +20 |
| Climate Cl | WByield | 24% | -16% | 22% | -15% |
| | LUC_area | -15% | 15% | -12% | 12% |
| | N2O | -4% | 5% | -6% | 5% |
| | allTDs | 0% | 0% | 0% | 0% |
| | | | | | |
| Land use | WByield | 25% | -16% | 23% | -16% |
| | LUC_area | 0% | 0% | 0% | 0% |
| | N2O | 0% | 0% | 0% | 0% |
| | allTDs | 0% | 0% | 0% | 0% |
| | | | | | |
| Fossil reso | WByield | 2% | -1% | 1% | -1% |
| | LUC_area | 0% | 0% | 0% | 0% |
| | N2O | 0% | 0% | 0% | 0% |
| | allTDs | -3% | 3% | -4% | 4% |

As expected, climate change is most sensitive to the yield and the land conversion area and to a lesser extent to $N_2O$ emissions. Land use is defined by the yield and nothing else. Fossil depletion shows some sensitivity to the downstream transport distances, but other factors must be influential as well. The yield also influences the fossil resource depletion, because agricultural inputs and seedlings are transported to the cocoa field.

### 8.4.3 Variability analysis

The consequences of likely variations were changed through a scenario analysis. The main uncertainties were thus further studied. The effects of these scenarios on climate change and fossil depletion were assessed. The larger effects on these impacts are shown in Figure 20 and Figure 21.

### 8.4.4 Forest cultivation

A small share of cultivation in AT 1 is done as a forest cultivation. It was studied how archetype 1 would look under forest cultivation, by assessing the effect of the reduction in carbon loss and assessing the effect of an altered N balance (including less carbon lost). Because forest-type cultivation causes less carbon loss (22 t C / ha) compared to open cultivation (79 t / ha), this type of cultivation results in a 54% reduction of the climate change impact thanks to less carbon loss from the system, and another 5% reduction thanks to an altered N balance.

### 8.4.5 Less deforestation

There are indications that there is less land conversion than calculated, and the strongest indications are for the case of ENB. If no land conversion is assumed at all for the most common archetype in ENB, AT2, this would reduce the climate change impact by 71%. This points at the possible minimum value

of the climate change impact. However, the LCA method is fair in the sense that each hectare of cocoa cultivation receives some impact of the overall cocoa cultivation area expansion. The underlying meaning for ENB would be that cocoa cultivation in ENB causes cocoa area expansion elsewhere in PNG.An individual farmer may also convert a secondary forest to a cocoa plot, so that 100% of the area is converted. The climate change impact would increase 100-fold; this situation is not representative or fair, because a farmer who does this is driven to this area by societal and economic incentives. A country-level land conversion fraction is a way to average out such imbalances.

### 8.4.6 Nitrogen

There are arguments to exclude the nitrogen emissions from the manmade cultivation of cocoa: especially because some nitrogen emissions will arise also without cultivation, in a forest environment. This may be the case for all archetypes, so nitrogen emissions were excluded for all archetypes. These changes result in reductions in climate change impacts ranging from 22% (AT1) to 28% (AT3). On the other hand, an alternative approah to nitrogen modelling would increase the $N_2O$ emissions from 1.2 kg N / ha to 1.5 for AT1 and from 1.9 to 2.5 for AT3 (with AT2 in between). Such changes would increase the climate change impact 9-13%, and mean that N losses are a larger contribution to climate change, still second to land conversion.

### 8.4.7 Lower yield

The yield in Archetype 3 is quite optimistic, since it represents the potential effect of a farmer switching entirely to a business-orientation as promoted by the PPAP. We had no quantitative data to reduce this yield, but for this scenario analysis, it was lowered from 1600 kg DB / ha to 1000 kg DB / ha, which still represents a substantial yield improvement. Such a yield would increase the climate change impact by 53% and the fossil resource depletion by 2%.

### 8.4.8 Transport

Transport distances could be substantially longer than the archetypical models for AT1 and AT2, so these were adjusted. For East Sepik Province, 150 km boat transport (using the smallest size class of sea transport from AgriFootprint) was added to the transport in the AT1 scenario to account for cocoa from south of the Sepik River (DAL Wewak). This does not affect climate change but would increase the fossil resource depletion by 5%. A small amount of cocoa is produced in Karimui and airlifted out of the region to Lae (CB Kokopo). This alternative scenario was drafted by assuming 20 km of road transport to the airfield, 300 km of air transport and 30 km of transport from airport to seaport. This would increase the climate change by 3% and the fossil resource depletion by 175%. The effects of the transport of surrounding islands to the official port of export of Rabaul on ENB (McNally, 2018) will be similar to the boat transport effects for AT1.

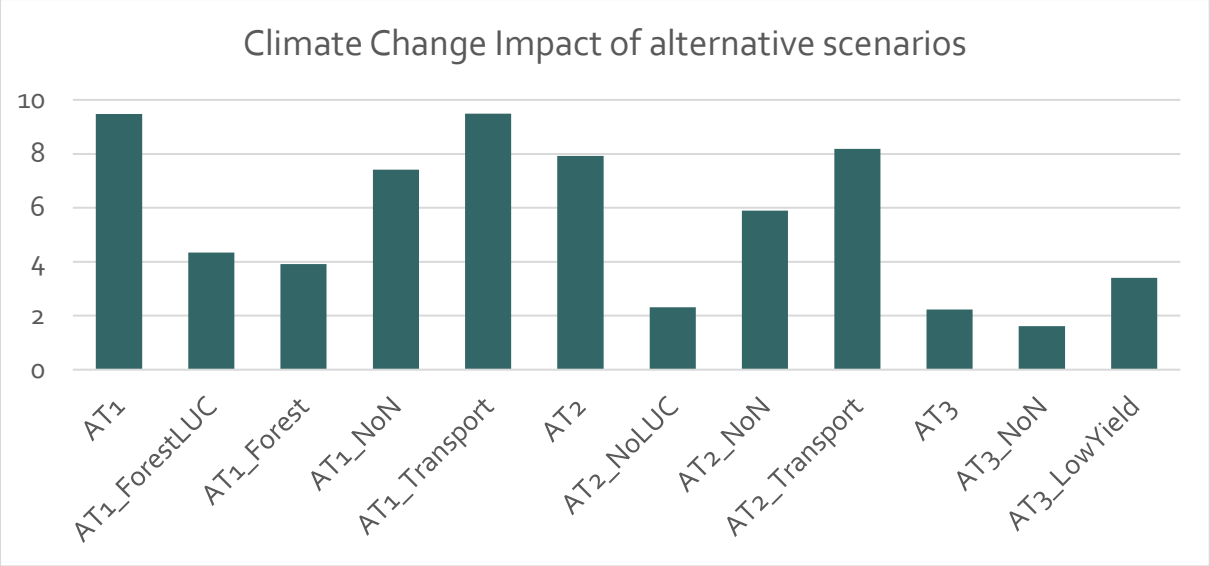



*Figure 20 Climate Change Impact (kg CO2eq / kg DB) of different alternatives to three archetypes: AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB. Forest=Forest cultivation; LUC=only considering carbon loss and not N balance change; NoN=No Nitrogen Impacts; NoLUC=No Carbon Loss from land conversion; LowYield=Reducing a high yield.*

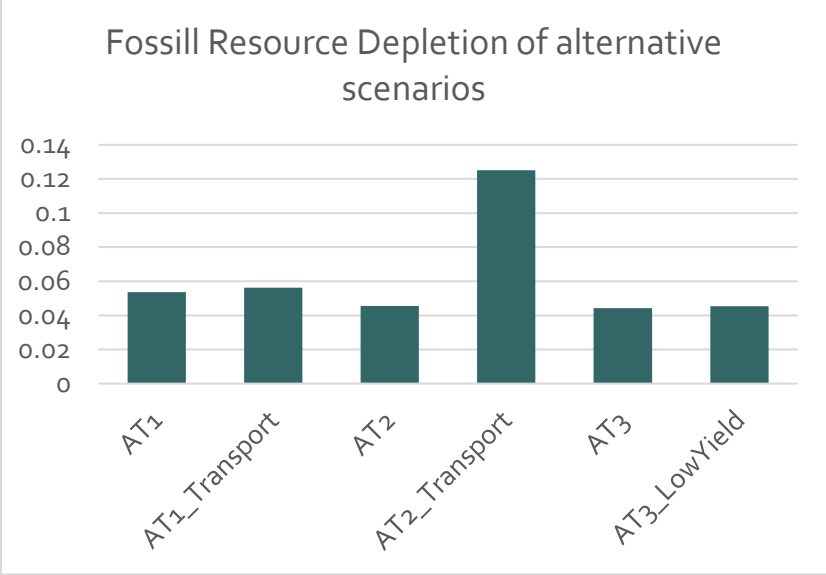



*Figure 21 Fossil Resource Depletion (US Dollar in 2013 / kg DB) of different alternatives to three archetypes: AT1 = Subsistence, WB; AT2=Subsistence, DB; AT3=Business-Oriented, DB. Transport=Longer distance transport scenario; LowYield=Reducing a high yield.*

### 8.4.9 Representativeness

Representativeness of the environmental impacts for other provinces in PNG is reasonable. It is believed that the three archetypes present the extremes on a spectrum from low management, subsistence-level to high management and higher inputs on business-oriented level, so that all cocoa cultivation of PNG lies in between. The type of farmer that each archetype represents occur in the

other provinces to varying extents. Each archetype represents a wide range of yield and agronomic practices that cause a wide range of values on all environmental impacts. The variability within the other provinces (those that were not visited) is estimated to be substantial. The functional analysis determined the production levels of the archetypes in each province, so that the average environmental impact of each province can be calculated. These averages will lie between the environmental impacts of archetype 1 and 2. The effects of land use change are a country average and link local situations to the country-level land dynamics. Alternative perspectives are discussed in Annex 3.

Representativeness for seemingly different systems than the three archetypes is reasonable as well. Rainforest Alliance or Organic certified production is covered in the two subsistence oriented archetypes, because the current practices are extensive and in several cases eligible for certifications. From field observations, it was understood that both forest cultivation and open field cultivation are eligible for Rainforest Alliance certification, because the open field farmer can still protect surrounding forests.

### 8.4.10 Methodological limitations

Life Cycle Assessment is a common method for the environmental assessment of food production, but has some limitations. Relevant issues with land use change, agricultural emissions, the function of food and with allocation were pointed out by Ponsioen and Van Der Werf (2017). In addition, LCA often relates the environmental impact to a produced quantity, while this does not address an important aspect of sustainability: an activity should not exceed the local carrying capacity of the environment. A way to define the carrying capacity of a place is to assess whether the ecosystem still functions: Does the system still provide sufficient ecosystems services for production? LCA does not address local conditions in detail. In this study archetypes 1 and 2 might have a lower impact on their direct surroundings (per unit of area) because of low yields and low insecticide use, but land conversion and nitrogen losses are the same per unit of area for all archetypes. If archetypes 1 and 2 (subsistence farming) would conserve the ecosystem function, archetype 3 (high intensity farming) may be seen as a form of ecological intensification, but this cannot be supported with field observations. It is more likely that archetypes 1 and 2 also significantly reduced ecosystem functioning. It may be worthwhile to investigate how ecosystem functioning can be increased in all cultivation systems.

In the category of resource depletion, natural resources like land, water, ecosystem services or soil quality are not included for different reasons: They may be considered renewable or not finite, or they may be considered part of the modelled system (the technosphere) instead of the affected system (the environment). Reduced availability of water or cropland of sufficient quality is addressed by technical improvements within the technosphere. The effects of using water and land are included in the other two endpoint categories.

The Impact Characterization phase of LCA aggregates dissimilar environmental impacts with models of variable methodological quality.The land use related impacts on biodiversity should be pointed out.

Habitat loss and species loss are reasonably covered, conceptually, because they relate to the area occupied, but the quantification is strongly sensitive to the valuation of species in the reference situation and end-situation after conversion. It was observed in the field there is a large variation of species diversity within cocoa plots, thanks to man-made and natural circumstances. This variation could not be covered in the current impact characterization approach.
Moreover, other land-based biodiversity effects are not included in the impact assessment model, such as disturbance of the surroundings, the construction and presence of infrastructure and the creation of other barriers for species movement. LCA cannot inform completely on how to shape a landscape to optimize biodiversity and livelihood of the inhabitants.

### 8.4.11 Outlook

The results focus on three archetypes from the functional analysis, in order to have a framework for a structured analysis and discussion. An attractive and limited conclusion would be that all PNG farmers should adopt the practices of the third archetype of a business-oriented farmer, since this has the lowest environmental impact. Of course, the climate change impacts from land conversion and nitrogen cycling are distributed over a larger yield, and less land use implies less ecosystem damage. Furthermore, impacts on an area basis are not higher for archetype 3 either.

However, yield increase to the reported level of archetype 3 may not be achieveble for all farmers. It is not likely that all farmers will shift towards this business-orientation, as explained in the economic and social chapters. Therefore, the question is rather how individual farmers can make their cocoa production more environmentally sustainable, and several options are listed below.

Firstly, farmers would improve their environmental impact with each kg of cocoa yield that can be gained without additional agricultural input, also if they do not reach 1600 kg DB / ha. Stakeholders and field observations in ESP seemed to indicate that reasonable yields can be achieved under integrated pest management without insecticides, but this requires further research. There are indications that low intensity cocoa cultivation with lower labour input has the same return on labour than intensive open cultivation (Armengot et al., 2016). However, this may imply that labour inputs need to be higher than the current levels in PNG.

Secondly, additional agricultural inputs are acceptable if the yield increases faster than the environmental impact per area, although attention should be paid to impacts that are hard to quantify, such as impacts on biodiversity and ecosystem services. It is highly likely that including pesticides in an integrated pest management approach would be worthwhile in this perspective. Conversely, it is undesirable to increase yield while increasing environmental impacts through inefficient input usage. It should be assessed if this is the case of introducing cocoa cultivation on the Sepik plains, because this would require significant amounts of fertilizers.

Yield increases will probably be sufficient to avoid planting new areas to cocoa. Farmers may not have clear incentives to expand their area of cocoa if their livelihood is good, but they may also have other

incentives to expand, such as land claims. Land use dynamics are complex, and cocoa cultivation might rather be a consequence of deforestation than a driver. Increasing cocoa yields instead of increasing cocoa area does not necessarily reduce deforestation, since cocoa production is only a minor driver of deforestation. Other uses can occupy the available land if cocoa area does not expand. Of course it is wise to decouple increase in cocoa production from deforestation. It is recommended to monitor land use in target regions of agricultural development projects (Abe, 2018).

A third option for the farmers is to improve the biodiversity within their cultivation system, by introducing a larger diversity of food crops and shade trees. Mixed cultivation in "agroforests" of various complexities does occur as exceptions in PNG, and are low cocoa yielding systems with a lower biodiversity than pristine forests. Cocoa is combined with cocoa with betelnut, coconut, banana, and to a lesser extent vanilla, timber, tree fruits like mango and papaya, etc. The economic return from these crops can compensate the lower income from a lower cocoa yield (Armengot, 2016). Such an agroforestry system might fit with local PNG traditions. Moreover, farmers can increase the carbon storage of their cultivation system, also if they are not in a forest cultivation. In any case, farmers should be enabled to reap other benefits from a changed cultivation system if cocoa yield is sacrificed. From another perspective, the current environmental impacts can be seen as low, and the question would be how farmers can improve their livelihood while maintaining their low environmental impact. Because the path to business-orientation is not realistic for all farmers, the question of inclusiveness also relates to the environmental impact: how can an approach be developed to include all farmers in a path of development and environmental sustainability?

## 8.5 Conclusions

*"What are the most relevant environmental impacts of the current value chain of cocoa cultivation to export of dried beans in Papua New Guinea?"*

This life cycle assessment showed that the major environmental impacts are climate change due to land use changes and nitrogen losses, and land occupation for all three archetypes. These environmental impacts occur during the cultivation phase. The following phases in the value chain, fermentation & drying and transport & export, have comparatively low impacts. Impacts are summarized in Table 21.

*"What is the potential impact of the VC on resource depletion?"*

Fossil resource depletion is much larger than mineral resource depletion and is caused most predominantly by fuel use for transport of agricultural inputs into the cultivation areas and dried beans out of these areas.

*"What is the potential impact of the VC on ecosystem quality?"*

The most important impacts on ecosystem quality are the biodiversity loss due to land occupation, and to a lesser extent climate change impacts. For archetype 3 the toxicity impacts from insecticide

use. Several impacts on biodiversity, such as disturbance and infrastructure, are not included in Life Cycle Assessment.

*"What is the potential impact of the VC on human health?"*

The most important impacts on human health are climate change, and to a lesser extent and fine particulate matter formation.

| Primary impacts | Climate Change | | Land Use |
|---|---|---|---|
| Impact Area | Human Health | | Ecosystems |
| Supply Chain Phase | Cultivation | | |
| Cause | Land Use Change | Nitrogen Cycle | Land Occupation |
| Recommendation | Prevent expansion; Improve yield on existing area | Improve yield, by reducing pest levels | |
| | | | |
| **Secondary impacts** | **Toxicity** | **Fine Particulate Matter** | **Fossil Resource Depletion** |
| Impact Area | Ecosystems | Human Health | Resource Depletion |
| Supply Chain Phase | Cultivation | Fermentary | Inputs & Transport |
| Cause | Insecticides | Wood fire | Fuel use |
| Recommendation | IPM | Fuel Efficiency | Improve yield; keep production centralized |

*TABLE 21 - QUALITATIVE SUMMARY OF ENVIRONEMENTAL IMPACTS OF COCOA VALUE CHAIN IN PNG.*

All environmental impacts are strongly determined by the yield. The yield in AT1 and AT2 is not limited by environmental or material factors but by labour input. It is attractive to focus on a strategy of yield improvement through higher labour input, but social and economic factors should be considered. Yields may be increased through integrated pest management strategies with and without insecticides against CPB. It is expected significant gains can be achieved without the additional use of fertilizer.
Land use dynamics are complex and LCA takes a simple but balanced approach. Our refinements of the analysis showed that the type and amount of land area converted due to cocoa cultivation can be highly variable and strongly region dependent.

Both carbon storage in cocoa stands and reference land uses can be variable. It is unlikely that cocoa cultivation can store more carbon than common types of forest in PNG, so it cannot be argued that cocoa cultivation contributes to climate change mitigation.

# 9. Challenges

## 9.1 The influence of non-price variables on micro-economic decisions to grow cocoa

Public and private policies that promote cocoa production in PNG have made profit maximization the key decision criterion for smallholders. This objective is achieved by increasing both the produced volume and the quantity of inputs, the price of cocoa - but also those of inputs - being an exogenous variable that comes from the international market. This desire to maximize individual producers' profits is sometimes associated with accompanying measures (in the form of investment in collective infrastructure) at the community level by PPAP or firms involved in certification. Nevertheless, the impact of these efforts at the producer or village level is not monitored and no one knows how effective these investments are in developing rural cocoa farming in PNG.

However, the level of profit derived from cocoa production is only one of the micro-economic variables that influence the choice of the individual producer. Aipi et al. (2012) show that three economic factors affect the farmers' decisions on how much, when and why they produce cocoa.

First, the price of cocoa is usually considered a major variable to influence producers. This importance is probably exaggerated in rural areas of PNG. On the one hand, the price of wet beans has been stable for several years, which has not led to a decrease in production by subsistence-oriented farmers. On the other hand, the volatile price of dry beans is not known and almost unpredictable by smallholders when they decide to harvest. Overall, Aipi et al. (2012) show that the supply response to changes in international prices is inelastic in the cocoa industry: supply of cocoa by smallholders has an elasticity of 0.23, which means that a kina change in the price of cocoa will result in a 23% change in the supply of cocoa. This implies that 77% of the variation is caused by other independent factors.

Second, the cultivation of other crops and prices of other commodities also influence the choice to invest production factors in cocoa cultivation. As the price of other competing cash commodities increase, producers divert some of their resources to the production of cocoa beans. A percentage in the price of copra relative to the price of cocoa would result in a variation in the production of cocoa by 0.11% (Aipi et al. 2012). Also, the fluctuating nature of the price of cocoa enables the smallholders to balance out their income by switching to alternative food or commercial crops that they produce. This flexibility of the agricultural production system is rooted in the typical Melanesian system of swidden cultivation. Cocoa plots are not monocultures of cocoa; they are often interplanted with other perennial crops such as fruit trees, bananas and coconut palms and with patches of annual crops where cocoa trees have died (Curry et al. 2015).

Finally, the labour input - and return on labour - is the third major variable that influences the economic choice of small producers. Labour is a basic input in household cocoa farming but its use is very flexible, because traditional use of labour is not driven only by the logic of labour as a commodity.

Labour is still being accessed and put to use in fulfilling all kinds of life sustaining customary and socio-cultural obligations in the community and in catering for subsistence activities (Lummani 2006). As a consequence, labour shortages in both crops and poor block maintenance were found to be key constraints on smallholder productivity with the non-payment or under-payment of family and hired labour as a key factor limiting the supply of labour (Lummani and Nailina 2001, Curry and Koczberski 2009). Labour constraints may be temporary or they may be more enduring because of household demographic factors, such as an elderly household head without co-resident sons. Sometimes family members are discouraged from providing labour when they feel they are not being adequately remunerated for their labour. For instance, women often divert their labour away from export crop production when they, or their family as a whole, are not benefiting from the income earned. Similarly, a son seeking economic independence from his father may resent giving labour which he believes is not being remunerated fairly (Curry and Koczberski 2009).
Financial analysis of cocoa production models takes very little account of labour factor and focuses on monetary remuneration in rural economies where most work is provided without payment. It would be useful to take better account of the amount of labour required in the different cocoa production patterns - and more broadly in food and cash crops - in order to better understand how this variable influences the microeconomic choice of producers.

## 9.2 The importance of non-economic variables to decide to grow cocoa: the need of a livelihoods approach

Cocoa constitutes but one element in peoples' diversified farming activities and livelihood strategies. The extent to which rural smallholder households incorporate cocoa into their diversified portfolio of livelihood activities depends on numerous factors. Among them are the availability of family labour, household priorities and objectives that require cash income such as education or other entrepreneurial activities, access to and availability of land and other resources, the relative importance of cocoa vis-à-vis other livelihood activities and income opportunities, and the approach taken to cocoa farming in terms of levels of input investment (Curry et al. 2007).

Further, subsistence food gardens, often including ceremonially important crops, and activities related to socio-cultural obligations not only provide a safety net of food and social relations but are connected to a way of life that provides status, identity and a moral order (Curry et al. 2012, Curry et al. 2015). This constitutes an important basis for peoples' livelihoods and is highly resistant to change. From a livelihoods perspective, it could be said that farmers at times tend to prioritize social ends over economic goals (Lummani 2006).

To understand and appreciate peoples' diversified livelihood strategies in relation to their relative focus on cocoa is especially critical in view of the challenges faced for the spread of the CPB in Papua New Guinea since 2006. It will yet have to be more systematically appraised how smallholders react (or will react) to the higher input investment required to profitably grow recently distributed hybrid clones that are more tolerant to the pest. Farmers are eager to receive hybrid clones (where these are

not yet distributed or available) and management advice. There is a risk for research and extension services, however, to overemphasize cocoa farming practices that require a shift to commercial cocoa farming at the expense of other livelihood activities. A successful and sustainable adoption of hybrid clones and CPB management may instead rely on a better understanding of farmers' labour availability and other constraints and preferences to calibrate the extent and production model of cocoa that is suitable to incorporate into diversified livelihood activities.

It is not yet clear how this can be achieved for the majority of subsistence-oriented farmers in PNG, and thus whether increased production with hybrid clones and a high input farming system will prove successful in Papua New Guinea in the long term (Curry et al. 2015). In East New Britain, for example, which has been the source of almost half of the cocoa produced in PNG before the appearance of the CPB, production levels of cocoa have not yet recovered, and some farmers have abandoned cocoa. The Momase region became more important for cocoa in the last decade, although farmers do not yet have access to hybrid clones. In the East Sepik Province, people reported that they returned to manage their cocoa plants of the relatively low-yielding Trinitario variety, which is less susceptible to the CPB than more recent hybrids (SG1, SG2). For some farmers, sticking to the low-yielding Trinitario variety with a low-input management regime may in the long-term prove preferable to adopting high-yielding and high-input hybrid clones.

There are strong arguments for maintaining a diversity of income sources (Curry et al. 2012). The process of income diversification could begin by strengthening the informal economy and reinforcing livelihood diversification in extension messages as well as by promoting new forms of non-farm employment. Such strategies might include the upgrading of facilities at roadside markets, training in book keeping for small businesses, and, where appropriate, the intercropping of export cash crops with food crops and fast-growing high value cash crops.


PNG
COCOA BEANS
AGMARK

# 10. Conclusion - What avenues for sustainable development of the cocoa chain in PNG?

The cocoa production model promoted today by public authorities, PPAP and companies consists in converting smallholders into business men specialized in cocoa growing and processing. This implies a strong intensification of production, an increase in material and labour inputs and the sale of large volumes of beans to exporting companies. This strategy aims at fighting against the CPB and at increasing producers' incomes. As we have shown, the business-oriented production of dry beans is very profitable in a few provinces in PNG. However, despite the efforts undertaken over the past six years by PPAP, this model only concerns a small number of producers and has not enabled total cocoa production to be boosted yet, even in the concerned provinces. It has the major disadvantages of requiring very large inputs of equipment and consumables, technical knowledge and manpower that very few households can provide in the absence of external support. Because of this massive investment in cocoa production, this model also tends to specialise households in this activity, which may be perceived as an unacceptable risk for a large part of the rural population. These risks for rural households were probably insufficiently analyzed since we did not find any feasibility or follow-up study of the financial and social impacts of the implementation of this intensive production system. This is an area of future study for CCI.

On the other hand, this approach is probably the most suitable to effectively combat the effects and spread of CPB and other pests, at least from a technical point of view. It also promotes an intensification of cocoa cultivation, which would limit the risk of an extension of this crop to the detriment of forest areas, even if this correlation has not been demonstrated in PNG.

Another production model is beginning to emerge, which is also supported by the two biggest private companies: the production of cocoa certified by FT or RA. This model still relies on a small number of producers and fermentary owners who have developed practices that allow the production of high quality beans for Western markets. It is only implemented in the Momase provinces, and to some extent by Agmark in ENB, and runs counter to the policy of the 2000s at ENB and AROB of multiplication of fermentaries by favouring a small number of certified fermentaries which ensure the quality of bean processing and facilitate product traceability. This approach limits smallholders to producing wet beans but at a higher price. This new model presents a good profitability today and develops year after year. It does not require a major change in the way wet beans are produced, but it requires an efficient organisation of the chain, where the fermentary owner plays a key role at the interface between the producers' groups and the exporting companies, while ensuring the quality of the fermentation and drying processes. Because of its complex operation, this model will only be able to reach a limited number of producers, who are capable of operating in a network, i.e. with human resources and without significant distances between cocoa blocks and certified fermentaries. Moreover, even if this certified market has been growing for several years, there is currently a risk of stabilization or even reduction of these certified markets by independent organizations since several international firms set up their own labelling systems.

Therefore, the two models of cocoa intensification or certified cocoa production only affect an elite of producers and, because of their specific constraints, it will probably be difficult in the medium term to substantially extend their scope. It is likely that the majority of smallholders retain a subsistence-orientation and continue to produce small volumes of low quality cocoa. However, several measures can be envisaged to improve the performance of these smallholders but they differ according to their current specialisation in the production of dry or wet beans.

The model of the subsistence-oriented dry beans producer of ENB and AROB arrives at the end of the cycle, with a low financial profitability, decreasing yields, and numerous fermentaries in very bad condition. In such circumstances, it is desirable to question the choice of these producers to use hybrid and cloned varieties which are not very efficient if they do not benefit from substantial inputs. It would be more appropriate to recommend to these growers that they purchase cocoa varieties tolerant of low labour inputs, and/or limit their seedling purchases to a quantity that can be effectively maintained given their household labour supply (Curry et al. 2007). Similarly, the reduction in the number of fermentaries in these regions could allow economies of scale and, for some fermentary owners, investment in the maintenance of their equipment in order to produce beans without smoky taste.

The subsistence-oriented wet beans producer model is often presented as retrograde and underperforming. In reality, it proves to be a cost-effective and resilient model that meets the expectations of most rural population. It is characterized by a low number of fermentaries, which allows economies of scale and easy control of cocoa quality, and which has made it possible to set up a chain of custody. The net profit rate of the stakeholders involved in this model is attractive, even without certification. Moreover, this extractive and low-input model fully integrates the constraints of rural households in their choice of agricultural production. On the one hand, farmers face a limited amount of labour, which use is not free even when it is unpaid. A labour-intensive activity is therefore a risky choice for a majority of farmers. On the other hand, specialization in cocoa cultivation runs counter to a diversified crop system that provides subsistence and some income to rural households, whatever the hazards that may affect these crops. In such a configuration, cocoa production is integrated into a set of agricultural productions and it is on the basis of farmers' livelihood strategies that the expansion of cocoa growing must be considered. This low intensity production model is undoubtedly more resilient in the eyes of a large number of farmers, but it is difficult to estimate whether it can prevent the extension of the CPB. According to interviews we conducted with producers in the East Sepik province, in a context of low inputs to production, old cocoa varieties seem to be less affected by this pest than the SG1/SG2 hybrids that were increasingly promoted before the appearance of CPB, but this hypothesis needs to be proven or relativized.

In all cases, a complementary approach to the business-oriented production model, that would favor a multiple-crops cocoa-based agriculture, remains a relevant option for a large number of farmers in PNG, who have limited access to external and long-lasting supports. Rather than a "silo" promotion of cash crop cultivation, an approach favouring integrated production of food and commercial

agriculture by farmers constitutes another healthy and sustainable basis for rural development in PNG.

## References


Abe, H. (2018). [Communication on land use dynamics in Papua New Guinea]. Personal communication to R.J.K. Helmes

AECOM, 2017. *Papua New Guinean Specialty Cocoa*. Technical report 107, for the Pacific Horticultural and Agricultural Market Access (PHAMA) Program, Fortitude Valley, Australia.

Agus, F., Gunarso, P., Sahardjo, B. H., Harris, N., van Noordwijk, M., & Killeen, T. J. (2013). Historical CO2 emissions from land use and land use change from the oil palm industry in Indonesia, Malaysia and Papua New Guinea. *Roundtable on Sustainable Palm Oil, Kuala Lumpur*.

Aipi B., Irau T., Aur Aba L., 2012. *Supply Response of Cocoa in Papua New Guinea*. Bank of Papua New Guinea, Working Paper 2012/02. Port Moresby, PNG.

Allen, B.J., Bourke, R.M. and Hanson, L., 2001. Dimensions of PNG village agriculture. In Bourke, R.M., Allen, M.G. and Salisbury, J.G. (eds). *Food Security for Papua New Guinea. Proceedings of the Papua New Guinea Food and Nutrition 2000 Conference*. ACIAR Proceedings No. 99. Australian Centre for International Agricultural Research, Canberra. pp. 529–553.

Allen, M., Monson, R. 2014. Land and Conflict in Papua New Guinea: The Role of Land Mediation. *Security Challenges* 10(2):1-14.

Alpizar, L., Fassbender, H. W., Heuveldop, J., Fölster, H., & Enriquez, G. (1986). Modelling agroforestry systems of cacao (Theobroma cacao) with laurel (Cordia alliodora) and poro (Erythrina poeppigiana) in Costa Rica. *Agroforestry Systems, 4*(3), 175-189.

Anderson D.J., 2018. *Inception and Final Report for the Bougainville Cocoa Value Chain Diagnosis*. PLGP project, PNG.

Armengot, L., Barbieri, P., Andres, C., Milz, J., & Schneider, M. (2016). Cacao agroforestry systems have higher return on labor compared to full-sun monocultures. *Agronomy for sustainable development*, 36(4), 70.

Blonk Agri-footprint bv. (2014). *Agri-Footprint - Part 2 - Description of data - Version 1.0*. Retrieved from Gouda, The Netherlands.

Bourke, R. M. 2000. An Overview of Food Security in PNG. In: *Food Security for Papua New Guinea. Proceedings of the Papua New Guinea Food and Nutrition 2000 Conference*, R. M. Bourke, M. G. Allen, & J. G. Salisbury (eds.). Australian Centre for International Agricultural Research.

Bourke, R. M. 2017. *Food Security in Papua New Guinea: An Overview*. 11th Conference of the European Society for Oceanists.

Bourke R.M. and Harwood T. (eds), 2009. *Food and Agriculture in Papua New Guinea*. The Australian National University, Canberra, Australia.

Caligiani, A., Marseglia, A., & Palla, G. (2016). Cocoa: Production, Chemistry, and Use.

Cocoa Board, 2017. *2016/2017 registered dry beans dealers*. Cocoa Board of PNG, internal document, Port Moresby, PNG.

CCI, 2018. *PNG cocoa extension manual*. PNG CCI, Tavilo, East New Britain province, PNG.

Crook, T., Farran, S., & Röell, E. 2016. *Understanding Gender Inequality Actions in the Pacific: Ethnographic Case Studies and Policy Options*. Publication Office of the European Union.

Curry G.N., Koczberski G., Omuru E., Nailina R.S., 2007. *Farming or Low-input? Household Labour and Livelihood Strategies Amongst Smallholder Cocoa Growers in Papua New Guinea.* Black Swan Press, Curtin University of Technology, Perth, Australia.

Curry, G., Koczberski, G. 2009a. Relational Economies, Social embeddedness and valuing labour in agrarian change: an example from the Developing World. *Geographical Research* 50(4): 377-392.

Curry G.N., Koczberski G., 2009b. *Improving productivity and the participation of youth and women in the Papua New Guinea cocoa, coconut and oil palm industries*. ACIAR report, Canberra, Australia.

Curry, G.N., Lummani, J., Omuru, E., 2009. *Social and Economic Impacts of Cocoa Pod Borer in East New Britain Province, Papua New Guinea*. Strategies for Restoring Livelihoods. Research Unit for the Study of Societies in Change, Curtin University of Technology.

Curry G.N., Lumanni J., Omuru E., 2011. *Socioeconomic impact assessment of cocoa pod borer in East New Britain province, Papua New Guinea*. ACIAR report, Canberra, Australia.

Curry G.N., Koczberski G., Lummani J., Ryan S., Bue V., 2012. Earning a Living in PNG: From Subsistence to a Cash Economy. In M. Robertson (ed.), *Schooling for Sustainable Development: A Focus on Australia, New Zealand, and the Oceanic Region.* Schooling for Sustainable Development 3, Springer Science+Business Media Dordrecht, the Netherlands.
Curry G.N., Koczberski G., Lummani J., Nailina R., Peter E., McNally G., Kuaimba O., 2015. A bridge too far? The influence of socio-cultural values on the adaptation responses of smallholders to a devastating pest outbreak in cocoa. *Global Environmental Change*, 35, 1–11.
Curtin, T., Holzknecht, H. & Larmour, P. 2003. *Land registration in Papua New Guinea: competing perspectives*. State, Society and Governance in Melanesia Discussion Paper No. 2003/1. Australian National University.
Daniel R., Guest D., 2011. *Enhancing Papua New Guinea smallholder cocoa production through greater adoption of disease control practices*. ACIAR technical report, Canberra, Australia
European Commission. (2017). PEFCR Guidance document, - Guidance for the 13 development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3.
FAO. (2018). FAOSTAT. Retrieved from http://www.fao.org/faostat/en/#data/QC
Filer, C. 2017. The Formation of a Land Grab Policy Network in Papua New Guinea. In: *Kastom, Property and Ideology*, S. McDonnell, M. Allen & C. Filer (eds). Australian National University Press.
Fingleton, J. 2004. Is Papua New Guinea viable without customary groups? *Pacific Economic Bulletin* 19(2):96–103.
Fingleton, J. (ed.). 2005. *Privatising Land in the Pacific: A Defence of Customary Tenures*. Discussion Paper Number 80. The Australia Institute.
Forsyth, M., & Eves, R. (eds.). 2015. *Talking it Through: Responses to Sorcery and Witchcraft Beliefs and Practices in Melanesia*. Australian National University Press.
Garnevska E., Joseph H., Kingi T., 2014. Development and challenges of cocoa cooperatives in Papua New Guinea: case of Manus province. *Asia Pacific Business Review*, 20(3), 419-438
Ghodake, R.D., Cook, K.E., Kurika, L., Ling, G., Moxon, J.E. and Nevenino, T., 1995. *A Rapid Rural Appraisal of the Cocoa and Coconut Farming Systems in the Northeast Lowlands of the Gazelle Peninsula of East New Britain Province*. Technical Report 95/1, Department of Agriculture & Livestock, Konedobu.
Gimbol K.C., Battese G.E., Flemin E.M., 1995. Technical Efficiencies of Smallholder Cocoa Producer in Papua New Guinea: A Stochastic Frontier Analysis. *Quarterly Journal of International Agriculture*, 34, 337-357.
Golub, A. 2014. *Leviathans at the gold mine: creating indigenous and corporate actors in Papua New Guinea*. Durham: Duke University Press.
Gosarevski, S., Hughes, H. & Windybank, S. 2004. Is Papua New Guinea viable with customary land ownership? *Pacific Economic Bulletin* 19(3):133–136.
Huijbregts, M. A., Steinmann, Z. J., Elshout, P. M., Stam, G., Verones, F., Vieira, M., van Zelm, R. (2017). ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. *The international journal of life cycle assessment,* 22(2), 138-147.
Imbun, B. Y. 2014. Struggling or in Transition: Small Household Growers and the Coffee Industry in Papua New Guinea. *Asia Pacific Viewpoint* 55(1):24-37.
IPCC. (2006). *2006 IPCC guidelines for national greenhouse gas inventories* (Eggleston H.S., Buendia L., Miwa K., Ngara T., & T. K. Eds.). Japan: IGES.
Iuda, O. (2018). [Interview on deforestation and land use conversion in PNG]. Personal Communication to R.J.K. Helmes
Johnson G.I., Iswanto A., Ravusiro J., Keane P.J., Hollywood N., Lambert S.V., and Guest D.I., 2004. Linking Farmers with Markets: the Case of Cocoa. In *Agriproduct Supply-Chain Management in Developing Countries*. Editors: G.I. Johnson and P.J. Hofman. Proceedings of a workshop held in Bali, Indonesia, 19–22 August 2003, 179-187.
Karigawa, L., Barbarinde, J. A. & Holls, S. S. 2016. A Comparative Analysis of Customary Land Associations and Sustainability Issues in Papua New Guinea. *Land Tenure Journal* 1(2016):89-120.
Kerua, W., & Glyde, S. 2016. Beyond the Cocoa Farm: A New Look at Farmers' Choices in Livelihood Activities and Impact on Productivity in Selected Areas of Papua New Guinea. *Rural Extension & Innovation Systems Journal* 12(1):1-11.
Kutan L., Chang S., 2014. *Security of Tenure for Tree Crops: The Case of Cocoa in Bougainville*. The National Research Institute, Issue Paper # 6, Boroko, PNG.

Lattas, A. 2011. Logging, Violence and Pleasure: Neoliberalism, Civil Society and Corporate Governance in West New Britain. *Oceania* 81:88-107.
Lea, D. 2009. New Initiatives in the Development of Customary Land: Group versus Individual Interests. *Pacific Economic Bulletin* 24(1):49-64.
Lea, D. 2013. A Critical Review of the Recent Amendments to the Customary Land Tenure System in Papua New Guinea. *Social Development Issues* 19(3):63-81.
Lummani, J. 2006. *The social influences on the economic decision-making of smallholder cocoa producers in Papua New Guinea: the case of processing, transport and marketing*. MA Dissertation. School of Social Sciences, Curtin University of Technology, Perth, Australia.
Lummani J., 2008. *Socio-Economic Considerations in Smallholder Cocoa Production*. Cocoa Nutrition Workshop, 3 – 5 March 2008, PNG CCIL, Tavilo/Kerevat, PNG.
Lummani, J. and Nailina, R. 2001. *Tri-Annual Survey Results for Cocoa and Coconut Smallholders in East New Britain.* Occasional Paper 6, PNG Cocoa and Coconut Research Institute, Keravat and the University of New England, Armidale, NSW.
Main, M. & Fletcher, L. 2018. *On Shaky Ground: PNG LNG and the Consequences of Development Failure*. Jubilee Australia Research Centre.
Martin, K. 2018. Wage-labour and a double separation in Papua New Guinea and beyond. *Journal of the Royal Anthropological Institute* 24(S1):89-101.
McNally, G. (2018). [Communication on the supply chain of PNG cocoa]. Personal Communication to R.J.K. Helmes
McGlynn, P. J., Renzaho, A. M. N., Pham, M. D., Toole, M., Fisher, J. & Luchters, S. 2018 Critical Examination of Evidence for the Nutritional Status of Children in Papua New Guinea: A Systematic Review. *Asia Pacific Journal of Clinical Nutrition* 27(1):1-18.
Meier, M. (2018). [Comments on draft VCA4D report on Cocoa from PNG]. Personal Communication to R.J.K. Helmes
Nelson P.N., Webb M.J., Berthelsen S., Curry G.N., Yinil D., Fidelis C., 2011. *Nutritional status of cocoa in Papua New Guinea*. ACIAR technical report 76, Canberra, Australia.
Ntiamoah, A., & Afrane, G. (2008). Environmental impacts of cocoa production and processing in Ghana: life cycle assessment approach. *Journal of Cleaner Production, 16*(16), 1735-1740.
Omot, N. 2012. *Food Security in Papua New Guinea*. AARES 56th Annual Conference.
Omuru, E. 2001. *Estimates of smallholder cocoa and copra yield profiles and cost of production in Papua New Guinea*. Occasional Paper 3, Understanding the Smallholder Cocoa and Coconut Sector in Papua New Guinea, Cocoa & Coconut Research Institute, PNG, University of New England, Australia.
Omuru, E. and Fleming. E. 2001. *A profile of labour inputs and gender relations in the smallholder cocoa and coconut-based farming systems in PNG. Understanding the smallholder cocoa and coconut sector in Papua New Guinea*. Occasional Paper 5, PNG Cocoa and Coconut Research Institute, Keravat and the University of New England, Armidale.
Omuru, E. and Lummani, J. 2001. *Cocoa and coconut plantation cost of production 1997 and 1998*. Economic Section Discussion Paper 7, PNG Cocoa and Coconut Research Institute, Keravat.
Oxford Business Group, 2017. Agriculture and fisheries. In *The Report: Papua New Guinea 2016*. Oxford, UK, 147-160.
Pikop, G. (2018) *Interview on ENB cocoa cultivation/Interviewer: R. Helmes*. VCA4D.
PNGCCDA. (2018). *Papua New Guinea's National REDD+ Forest Reference Level - Submission for UNFCCC Technical Assessment in 2017*. Retrieved from
PNGFA, & FAO. (2015). *Forest and Land Use in Papua New Guinea 2013 - The findings of Collect Earth assessment*. Retrieved from
Ponsioen, T., & Van Der Werf, H. (2017). Five propositions to harmonize environmental footprints of food and beverages. *Journal of Cleaner Production*.
Ponsioen, T. (2018). [Communication on nitrogen modelling]. Personal Communication to R.J.K. Helmes.
PPAP Environmental Assessment, 2010. *Environment Impact Assessment (vol 1)*. Port Moresby, PNG.
Pronk, A. (2018). [Refinement of nitrogen balance for PNG cocoa cultivation].

Ruf F., Yoddang, 1998. The cocoa marketing sector in Sulawesi. A free market and “almost perfect” competition. *Plantations, recherche, développement*, mai-juin 1998, 170-175.
Schram, R. 2015. Notes on the Sociology of Wantoks in Papua New Guinea. *Anthropological Forum* 25(1): 3-20.
Toli, C. (2018) *Interview on ESP cocoa cultivation/Interviewer: R. Helmes*. VCA4D.
Tondoh, J. E., Kouamé, F. N. G., Guéi, A. M., Sey, B., Koné, A. W., & Gnessougou, N. (2015). Ecological changes induced by full-sun cocoa farming in Côte d’Ivoire. *Global Ecology and Conservation, 3*, 575-595.
University of Hertfordshire. (2018). PPDB - Pesticides Properties DataBase - University of Hertfordshire. Retrieved from https://sitem.herts.ac.uk/aeru/ppdb/en/
van Vliet, J. A., & Giller, K. (2017). Mineral nutrition of cocoa: a review. In *Advances in Agronomy* (Vol. 141, pp. 185-270): Elsevier.
Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., & Weidema, B. (2016). The ecoinvent database version 3 (part I): overview and methodology. *The international journal of life cycle assessment, 21*(9), 1218-1230.
World Bank. 2017. *Consultation, Participation & Disclosure of Information*. Emerging Lessons Series No. 4.
Yarbro S. and Noble S., 1989. *Smallholder Production, Processing and Marketing of Cocoa and Copra in Papua New Guinea*. Working Paper No. 10, Project 8734, Australian Centre for International Agricultural Research, Canberra.

# 11. Annexes

## 11.1 Annex 1. Environmental Impact Categories in ReCiPe 2016

| Impact Category | Unit | Damage to Human Health (DALY) | Damage to Ecosystems (species*year) | Scarcity of Resources (USD2013) |
|---|---|---|---|---|
| Global Warming | kg CO2 eq | Included | Included 2x: for Terrestrial and Freshwater Ecosystems | |
| Water Consumption | m3 | Included | Included 2x: for Terrestrial and Freshwater Ecosystems | |
| Acidification | kg SO2 eq | | Terrestrial Ecosystems | |
| Eutrophication | kg P eq | | Freshwater Ecosystems | |
| Particulate Matter Formation | kg PM 2.5eq | Included | | |
| Land Use | m2a crop eq | | Terrestrial Ecosystems | |
| Stratospheric Ozone Depletion | kg CFC11 eq | Included | | |
| Ionizing Radiation | kBQ Co-60 eq | Included | | |
| Ozone Formation | kg $NO_x$ eq | Included | Terrestrial Ecosystems | |
| Toxicity | kg 1,4-DCB eq | Carcinogenic and Non-carcinogenic | Included 3x: for Terrestrial, Marine and Freshwater Ecosystems | |
| Fossil Resource Depletion | kg oil eq | | | Included |
| Mineral Resource Depletion | kg Cu eq | | | Included |

*Table 22 - Impact categories in ReCiPe; Midpoint in the left column, Endpoints indicators are the midpoint indicators converted to damage for the three categories on the right three columns. The human health impact is expressed in DALY: Disability Adjusted Life Years. The ecosystems impact is expressed in the number of species that potentially disappeared in a year. The scarcity impact is expressed as the surplus costs of future resource production in U.S. Dollars from the year 2013.*

## 11.2 Annex 2. Summary of key parameters in LCA Model

| | | | | AT1 | AT2 | AT3 |
|---|---|---|---|---|---|---|
| **Land Conversion** | | | | | | |
| | luc_area | Share of surface area of farm that has caused indirect land use change (conversion from secondary forest to cocoa) | ha / ha | 0.007 | 0.007 | 0.007 |
| | deltaC_Open | change in mass of carbon upon land conversion in an open cultivation system | t C / ha | 78.5 | 78.5 | 78.5 |
| | deltaC_Forest | change in mass of carbon upon land conversion in an forest cultivation system | t C / ha | 22.3 | 22.3 | 22.3 |
| | shareforest | Share of Forest Cultivation Type instead of Open Cultivation with Gliricidia | - | 0 | 0 | 0 |
| **Cultivation** | | | | | | |
| | WByield | Wet Bean Yield | kg / ha*yr | 857 | 950 | 4000 |
| | tree_density | Planting Density of Trees | n/ ha | 625 | 833 | 833 |
| | NH3 | ammonia emission (from N additions to soil in all forms) | kg / ha | 0.0 | 0.0 | 0.0 |
| | N2O | nitrous oxide emission (...) | kg / ha | 2.0 | 2.1 | 3.2 |
| | NOx | nitrogen oxides emission (...) | kg / ha | 0.71 | 0.74 | 1.1 |
| | NO3 | nitrate emission (...) | kg / ha | 148 | 163 | 140 |
| | ins_per_appl | mass of active ingredient in insecticide, applied each time | g / ha | 0 | 0 | 8 |
| | appl_per_year | number of applications of insecticide per year | n / yr | 0 | 0 | 32 |
| | reuse_WBbag | transport | n | 20 | 20 | 20 |
| **Fermentory** | | | | | | |
| | WBtoDBconvers | the "well-known" conversion efficiency of WB to DB of the fermentory | kg DB / kg WB | 0.35 | 0.4 | 0.4 |
| | CH4ferm | methane emission (from C contained in fermented pulp) | g / kg DB | 1.0 | 1.0 | 1.0 |
| | NH3ferm | ammonia emission (from N additions of fermented pulp to soil, under fermentory) | g / kg DB | 0.092 | 0.092 | 0.092 |
| | N2Oferm | nitrous oxide emission (...) | g / kg DB | 0.0098 | 0.0098 | 0.0098 |
| | NOxferm | nitrogen oxides emission (...) | g / kg DB | 0.0034 | 0.0034 | 0.0034 |
| | NO3ferm | nitrate emission (...) | g / kg DB | 2.7 | 2.7 | 2.7 |
| | reusebag | reuse rate of a jute bag used for DB transport | n | 20 | 20 | 20 |
| | share_sundry | the share of the time that beans are dried in the sun | - | 0 | 0 | 0 |
| | WBwastefactor | factor accounting for the waste percentage of WB in the fermentory | - | 1.01 | 1.01 | 1.01 |
| **Transport & Export** | | | | | | |
| | DBwastefactor | factor accounting for the waste percentage of DB at the exporter | - | 1.025 | 1.025 | 1.025 |
| | TDLstage1 | transport distance over land (between fermentory and next transfer point) | km | 130 | 5 | 5 |
| | TDAstage1 | transport distance through air (...) | km | 0 | 0 | 0 |
| | TDWstage1 | transport distance over water (...) (small and large boats) | km | 0 | 0 | 0 |
| | TDstage2 | transport distance over land (between transfer point and exporter (optional)) | km | 0 | 30 | 30 |
| | TDstage3 | transport distance over land (between exporter and port of export) | km | 5 | 30 | 30 |

## 11.3 Annex 3. Alternative perspectives on land conversion

### 11.3.1 Bottom-Up Perspective: Understand local land use dynamics

Through a more geographically specific approach, increased understanding on land conversion can be gained. By understanding the local land use dynamics, more specific claims might be made on how much land conversion is caused by a hectare of cocoa cultivation.

The Gazelle Peninsula of ENB has a long history of cocoa cultivation with low current rates of deforestation and carbon loss. All primary forest has been turned into secondary forest over past 90 – 50 years, followed by shifting food cultivation and cocoa plantations. The Environmental Statement of the PPAP indicates that no logging or deforestation takes place (PPAP, 2010). The interview with the extension officer shows us (Pikop, 2018):

- Currently, much cocoa is planted in a repetitive land use pattern: Tree crops providing food (banana, some coconut, mandarin), and betelnut are planted first; Gardening is done in between for the first 1 – 2 years (pumpkin, tomato, eggplant, yam); cocoa is planted benefiting from shadow from food crops and from newly planted gliricidia. After less than 20 yrs, the cocoa is chopped down for different reasons, and the cycle starts again.
- Leaving land fallow is not common. Numerous plots of secondary forest and overgrown cocoa across the peninsula were observed.[13] Land disputes is mentioned as the main reason for not using land but it is unclear whether this explains the current landscape.
- There are no officially protected areas on the Gazelle peninsula, because most of the land is customary.[14]
- In the recent years, palm oil cultivation starts to claim substantial areas that were previously planted to cocoa.

The impression of stability in the landscape can hide dynamics that do change the carbon contents of the soil and the living matter. It should be noted that overgrown cocoa and secondary forest does have a biodiversity value and is estimated to contain larger amounts of carbon than open and cultivated plots of cocoa. In ENB, the deforestation rate and the subsequent carbon loss are probably lower than the national average.

The province of East Sepik is a larger area and will exhibit more variation in terms of deforestation and carbon loss. Cocoa and other plantation crops have been planted in the 1980s and 1990s, probably on secondary forest or on regrowth less like forest.

- The land use pattern has not (yet) repeated itself; cocoa is often the first permanent crop after a food cropping cultivation pattern: near Maprik, people typically farm yams, rice and peanuts

[13] Overgrown cocoa stands create a habitat for the cockatoo. These endemic birds come from forest stands, and their migration might indicate the reduction of secondary forest on the Gazelle Peninsula. Cockatoos consume cocoa pods and banana, but also peanuts, cassava and taro by digging them up. They can make 30-50% of the pods in a cocoa block unsuitable for harvest.

[14] There are spiritual areas of land, where local belief did not allow women to enter. These areas were kept bush. Due to population growth, that belief is less dominant. This land is also cleared, since women are now allowed to work on it.

after each other, while near the Sepik River, the sequence is typically bananas followed by gardening (yams, pumpkins, vegetables) (Toli, 2018).

- Primary forest does exist in East Sepik and some area has been lost in the past 30 year (PNGCCDA, 2018), but most cocoa is planted in the densely populated area along Sepik Highway on recently cleared land that went through a food cropping phase (Toli, 2018).
- It was observed that some smallholders plant cocoa in forests, after selective logging, without a food garden phase in between. They mix cocoa with other forest crops.

There are plans to plant cocoa on the "Sepik Plains" which are covered by grasses. There is a need to assess and protect the biodiversity value of secondary forest and of the Sepik Plains. In ESP, the deforestation rate and the subsequent carbon loss might be lower than the national average. It is hard to prove that this is connected to cocoa cultivation.

### 11.3.2 Intermediate perspective: FAO Forest Inventory

In Port Moresby, the VCA4D team visited the PNG Forest Authority and the FAO project to create a national forest inventory. The project employee Oala Iuda was interviewed and additional data was received from the project officer Hitofumi Abe. This information provides a different perspective on the land conversion due to cocoa cultivation than the FAOSTAT data used for the top-down method. From the two reports received from Mr. Abe, we identified the following points:

- The land cover of PNG is 80.4% is forest, and 8.4% (3.9 million ha) is cropland (PNGFA & FAO, 2015). This cropland consists of subsistence agriculture mostly (83.1%) and only 0.7% is planted to cocoa. The area planted to cocoa is 27300 ha.
- A share of the forest is used (40% on average): Firstly, mixed forest including cocoa trees cannot distinguished from primary forest with the satellite data. (Iuda, 2018, pers. comm.). The forests on the lower altitudes (where cocoa is grown, 0-400 masl) are disturbed or logged for 20 – 30% of the area and another 20-30 % of the forests is affected by gardening and "other" activities.
- In the last 16 years, about 261,528 ha of forest has been cleared and converted to other land use (PNGCCDA, 2018). This is 0.7% forest loss in 16 years, equating to 49,643 ha. Among the Forest converted to Cropland, the main driver of deforestation are shifting cultivation (63%) and Oil Palm plantation (30%). Cocoa does not play a role, it is covered in the classification "Other", which contributes only 1% to all deforestation
- However, cocoa is included in shifting cultivation patterns (Iuda, 2018; Pikop, 2018; Toli, 2018). It cannot be seen as a driver of land conversion but as a consequence: It is likely that cocoa will eventually take a place in the landscape in suitable regions, this implies that regions with high deforestation rates such as West Sepik Province (Abe, 2018, pers. Comm.) would have a larger cocoa expansion rate.

The area of land converted for cocoa cultivation occupied would be at most 1% of 49,643 ha: 496 ha. This is 2% of the 27300 ha planted to cocoa in PNG. The deforestation due to cocoa here is overestimated, and the area under cocoa is underestimated because of unidentified agroforestry, so this 2% is probably lower. The carbon loss due to identified (open) cocoa production might be less than for shifting food crop cultivation because of maintenance of some SOC and build-up of living

matter under permanent cultivation. The carbon loss due to unidentified (agroforest) cocoa production is probably higher than no transformation of the forest.

## 11.4 Annex 4. Carbon loss calculations for land conversion

| | Reference situation | Citation | Carbon mass | Resulting situation | Citation | Carbon mass | Change in C mass |
|---|---|---|---|---|---|---|---|
| **Soil Organic Content** | **Disturbed upland forest** | **Agus et al., 2013** | **104** | **Mixed Tree crops** | **Agus et al., 2013** | **54** | **-50** |
| | | | 104 | Cropland | Agus et al., 2013 | 11 | -93 |
| | Any tropical forest | IPCC, 2006 | n.a. | Permanent tree crop | IPCC, 2006 | n.a. | 0 |
| | Rainforest | Tondoh et al., 2015 | 24.1 | 20 yr old Cocoa Plantation | Tondoh et al., 2015 | 12.8 | -11 |
| | | | | | | | |
| **Aboveground Carbon** | **Logged (Disturbed) PNG rainforest** | **Fox et al., 2010 ftc. PNGFA/FAO (2015)** | **69** | **Plantation on reference situation (100 t dm / ha)** | **IPCC, 2006** | 47 | -22 |
| *(using 0.47 t C / t dm from IPCC, 2006)* | Primary PNG rainforest | Fox et al., 2010 ftc. PNGFA/FAO (2015) | 105 | | | 47 | -58 |
| | Moist Deciduous Forest in SE Asia (290 t dm / ha) | IPCC, 2006 | 136 | | | 47 | -89 |
| | | | 136 | Sustainably managed agroforest in SE Asia & Observed forest cultivation | IPCC, 2006; Field observations | 120 | -16 |
| | | | 136 | Empirical averages; Open Cultivation | Field measurements | 102 | -34 |
| | Rainforest (541 t dm / ha) | IRAD 1997, ftc. Duguma 2001 | 254 | Cocoa Agroforest (304 t dm / ha) | IRAD 1997, ftc. Duguma 2001 | 143 | -111 |
| | | | | | | | |
| **Belowground Carbon** | **Derived from Logged (Disturbed) PNG rainforest** | **Fox et al., 2010 ftc. PNGFA/FAO (2015)** | **25** | **Derived from Plantation on reference situation (100 t dm / ha) & cocoa specific shoot-root ratio** | **IPCC, 2006 & Smiley et al., 2008** | **19** | **-7** |
| *(using a shoot-root ratio of 2.7 from IPCC, 2006, and cocoa specific ratio of 2.54 from Smiley, 2008)* | Derived from Primary PNG rainforest | Fox et al., 2010 ftc. PNGFA/FAO (2015) | 39 | | | 19 | -20 |
| | Derived from Moist Deciduous Forest in SE Asia (290 t dm / ha) | IPCC, 2006 | 50 | | | 19 | -32 |
| | | | 50 | Derived from Sustainably managed agroforest in SE Asia & IPCC shoot-root ratio | IPCC, 2006 | 44 | -6 |
| | | | 50 | Derived from aboveground empirical averages & cocoa specific shoot-root ratio | Field measurements & Smiley et al., 2008 | 40 | -10 |
| | Derived from Rainforest (541 t dm / ha) | IRAD 1997, ftc. Duguma 2001 | 94 | Derived from Cocoa Agroforest (304 t dm / ha) & IPCC shoot-root ratio | IRAD 1997, ftc. Duguma 2001 | 32 | -62 |
| | | | | | | | |
| **Totals** | **Current Open Cultivation** | | **198** | | | **120** | **-79** |
| | Worst case scenario | | 452 | | | 186 | -267 |
| | Best case scenario | | 211 | | | 173 | -34 |
| | Forest Cultivation | exc. SOC | 187 | | exc. SOC | 164 | -22 |

## 11.5 Annex 5 Key parameters for N balance calculations

| | Forest (AT1) | AT1 | AT2 | AT3 | | |
|---|---|---|---|---|---|---|
| *unit: kg N / ha*yr, unless stated otherwise* | Subsistence, WB | Subsistence, WB | Subsistence, DB | Commercial, DB | Literature value | Reference |
| | Forest | Open | Open | Open | | |
| Yield (kg / ha) | 300 | 300 | 380 | 1600 | | Archetypes |
| **Inputs to system** | | | | | | |
| Nitrogen Deposition to Soil | 10 | 10 | 10 | 10 | 8 - 12 | Van Vliet, 2017 |
| Nitrogen Fixation by Gliricidia | 0 | 35 | 40 | 60 | 35 - 60 | Van Vliet, 2017 |
| **Flows within system** | | | | | | |
| Litter to soil | 93 | 93 | 95 | 130 | 84 - 175 | Van Vliet, 2017 |
| Gliricidia to Soil (root turnover) | 0.0 | 24 | 24 | 24 | 23 - 24 | Van Vliet, 2017 |
| Rainwash to Soil (from | 8.0 | 8.0 | 8.0 | 8.0 | 8 | Van Vliet, 2017 |
| Cocoa tree to prunings to soil | 8.7 | 8.7 | 8.7 | 22 | | Alpizar, 1986 |
| Gliricidia to prunings to soil | 0.0 | 12 | 17 | 37 | | |
| Husks to Soil | 2.9 | 2.9 | 3.6 | 15 | | |
| **Total N to Soil** | 122 | 157 | 165 | 245 | | |
| Cycled back from soil to biomass | 122 | 122 | 127 | 211 | | |
| **Outputs to system** | | | | | | |
| Beans without husks (WB) | 6.0 | 6.0 | 7.6 | 32 | | |
| Growth of cocoa tree (permanent) | 4.0 | 4.0 | 4.0 | 4 | 3 - 4 | Van Vliet, 2017 |
| N2O to air from soil | 1.0 | 1.2 | 1.3 | 1.9 | | IPCC, 2006 |
| NOx to air from soil | 0.3 | 0.3 | 0.3 | 0.5 | | IPCC, 2006 |
| Balance (If positive: NO3 to water from soil) | 0.0 | 33 | 37 | 32 | | |

| **Constants** | | **Reference** |
|---|---|---|
| Beans without husks (under 1000 kg/ha yield) | 20 | PNG Extension Manual |
| Husks (under 1000 kg / ha yield) | 10 | PNG Extension Manual |
| N2O emission factor for N in soil (kg N-N2O/kg N) | 0.010 | IPCC (2006) & PEF (ref) |
| NOx emission factor, rel. to N2O from soil (kg N-NOx/kg N-N2O) | 0.21 | PEF (ref) |