The Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEBAgriFood) in Indonesia

Agroforestry Rapid Assessment

November 2019

Contact person: salman.hussain@unep.org

Executive Summary

This rapid assessment suggests that cacao agroforestry production can be sustainably intensified, increasing yields significantly without expanding cultivated area, meanwhile providing social and environmental benefits. As such, it can play an important role as an efficient land use system that can contribute to both national and community development. cacao agroforestry coupled with strategies to capture value addition in farming communities can diversify incomes and protect vulnerable small farmers from price fluctuations. cacao agroforestry using good agricultural practices provides higher levels of ecosystem services (such as soil retention and carbon sequestration) than some other types of agriculture. Policies should target practices with fewest trade-offs between increased productivity and long run impacts, and spatial planning and regulation should be implemented to transition monoculture crops to agroforestry systems and promote agroforestry as a restoration land cover in degraded areas.

Objectives of the Policy Action

1. Increasing the yields of estate crops
2. Improve the productivity of small-holder farmers
3. Add value in the agricultural value chain
4. Promote sustainable agriculture to ensure long-run livelihoods and protect provision of environmental services, which tend not to be reflected in the price of agricultural commodities

Recommended Policies

Improve cacao **yields per hectare** by:

- Promoting and incentivizing proven intercrop agroforestry systems (e.g. coconut-cacao)
- Promoting and incentivizing replacement of old and unproductive plants and using best proven density of intercrop systems

Increase the provision of knowledge and training to small-holder farmers, with sustained extension service and monitoring following the successful models of the private sector, leading to the adoption of **Good Agricultural Practices** (GAP) including:

- Appropriate type and timing of fertilizers and pesticides
- Integrated pest management
- Efficient water management
- Preventing soil erosion and building soil organic matter and soil nutrients

Conduct spatial planning of agroforestry production of agroforestry production and optimize the allocation of agri-environment measures for cacao to provide evidence on the potential trade-offs between ecosystem services, biodiversity and productivity. This includes:

- Replacing existing cropland and degraded land instead of expanding into forested areas
- Discouraging farming in areas with potential risk to water quality and biodiversity
- Providing the economic case for the viability of very small cocoa farms (<1ha) through better use of labor (such as grafting), as well as sustainability certification; together, aim to achieve positive benefit-cost ratios when environmental impacts are internalized.

Add value by:

- Increasing cacao quality (fermentation or improved varieties)
- Supporting local processing
- Supporting traceability and certification schemes

Table of Content

Executive Summary………………………………………………………… 1
Objectives of the Policy Action……………………………………………... 1
Recommended Policies……………………………………………………….. 1

Table of Content.. 3

I. Introduction……………………………………………………………………..6

II. Methods………………………………………………………………………….7

III. Literature Review……………………………………………………………….9

IV. Spatial Assessment…………………………………………………………..14

V. Life Cycle Assessment…………………………………………………………23

VI. Conclusions and Recommendations…………………………………………….33

VII. Appendices…………………………………………………………………….35

VIII. Bibliography…………………………………………………………………...47

I. Introduction

Context for this report

1. Tropical commodities such as oil palm, coconut, rubber, and cacao are a core part of the Indonesian economy and development strategy, from small-scale farmers to large agribusinesses
2. Agricultural commodities globally and in Indonesia have been a driver of deforestation and associated greenhouse gas emissions, air pollution, erosion, water pollution, and loss of biodiversity
3. Indonesia has been losing yield, labour and land productivity. The cacao sector faces challenges in terms of production efficiency, quality, price fluctuations, lack of expertise, and access to capital
4. Because of rising demand and existing investments in the value chain, Indonesia wants to boost cacao yield, add value, increase incomes and increase exports, while improving sustainability
5. cacao agroforestry has a variety of strengths, weaknesses, opportunities, and threats compared to other agricultural commodities

For the reasons highlighted above, BAPPENAS should support reform of commodity production and in particular collect evidence to inform agroforestry policies. It is consistent with the objectives of the Government of Indonesia to create coherent, effective policies to increase the yields of estate crops, improve the productivity of small-holder farmers, add value in the agricultural value chain, and promote sustainable agriculture.

Indonesia is concerned about cacao production, which has been decreasing in recent years due to a variety of factors including aging plants, pests and disease, depleted soil, and farmers transitioning farms to produce other commodities. Studies suggest that most cacao farmers operate their farms relatively inefficiently and face challenges in terms of productivity, quality, and lack of expertise and financial capital. Furthermore, despite efforts to encourage reform, the cacao sector is currently ecologically unsustainable (FAO/INRA 2016). Three core challenges are:

1. chemical use for pest & disease management is largely excessive and unregulated with potential future impacts on agrobiodiversity and farmer health;
2. soil nutrient depletion due to poor land management practices and excessive dependence on synthetic fertilizers - leads to plot abandonment and forest clearing; and
3. cacao production continues to expand into natural forests, with implications for water systems, soil erosion, landslides, biodiversity, carbon etc.

This report summarizes a rapid assessment of cacao agroforestry, which, if supported by correct policies, may offer an opportunity to increase cacao yields significantly without expanding cultivated area, meanwhile providing social and environmental benefits. The research was focused on determining if and how cacao agroforestry can play a role as an efficient land use system that contributes to both national and community development. The report considers the entire value chain, i.e. not just on-farm yields and on-farm sustainability but also the potential to improve value-added and livelihood outcomes, and to reduce biodiversity impacts, across the value chain.

TEEBAgriFood

TEEB for Agriculture & Food (TEEBAgriFood), an initiative hosted by the United Nations Environment Programme (UNEP), provides a framework and technical assistance for evaluating all visible and invisible impacts of agriculture & food systems. The TEEBAgriFood Framework is a tool to evaluate or acquire scientific evidence to support policy making, such as BAPPENAS development plan for sustainable agricultural commodities. Indonesia has an opportunity to implement TEEBAgriFood, to promote biodiversity and sustainability in the agriculture and food sector through agro-ecological research and economic valuation.

II. Methods

This rapid assessment follows an internationally agreed methodological framework - the TEEBAgriFood Evaluation Framework - which provides a comprehensive and universal approach to capture all the positive and negative impacts and externalities across the entire agri-food value chain. The TEEB AgriFood Evaluation Framework therefore contributes to a new more holistic, multi-dimensional, systems-thinking paradigm. The analysis in the current project will provide an example for future evaluations to support food and agriculture policies in Indonesia.

Justification: measuring what matters in agriculture & food systems

Developing policies to create sustainable and equitable food systems requires understanding the vast and interrelated complex of ecosystems, agricultural lands, pastures, inland fisheries, labor, infrastructure, technology, policies, regulations, institutions (including those involved in making policies, framing regulations and providing markets), cultures and traditions that are involved in growing, processing, distributing and consuming food. Evaluating such complexity with (for example) a yardstick as narrow as “per-hectare productivity” of a single crop might appear naïve, and yet dominates the discourse on food systems. Per hectare productivity *remains important*, but it is not the sole metric we should rely on or try to maximize if we are interested in improving sustainable livelihoods.

Moving from per hectare productivity as a single metric to multiple metrics associated with eco-agri-food systems may appear challenging. It is. But equally it is *necessary.* Further, TEEBAgriFood has developed an Evaluation Framework that allows us to do just that, a Framework that the TEEB Office is applying in more than 15 countries to stimulate concrete policy uptake to improve livelihoods and biodiversity outcomes. This Evaluation Framework, which may use a combination of many methodological approaches to assessment, lies at the heart of TEEBAgriFood implementation.

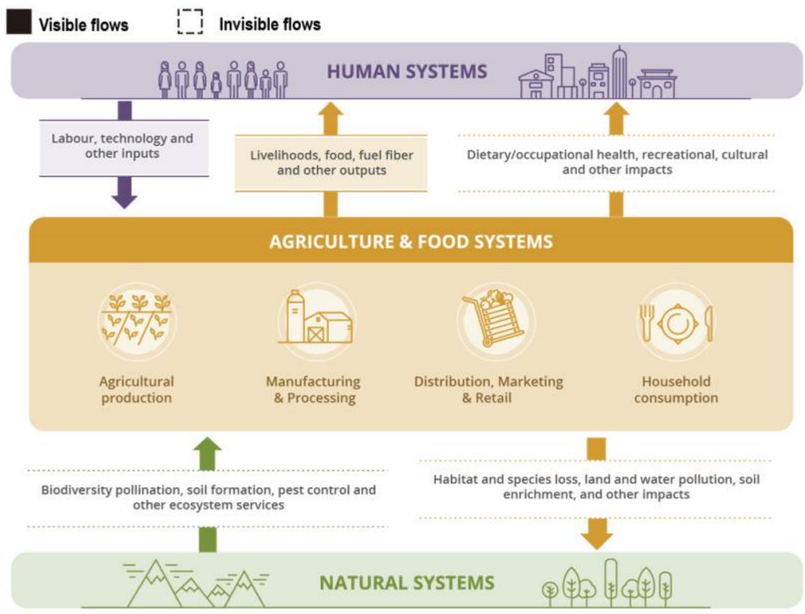


Figure 1: Diagram of visible and invisible inputs and outputs along the value chain of food systems (TEEB, 2018).

Combining multiple methods for gathering evidence

Implementing the TEEBAgriFood Framework and generating defensible, scientific evidence for the many visible and invisible impacts and dependencies of food systems requires combining many assessment methods and modelling tools.

This rapid assessment uses literature review, stakeholder consultation, spatial modelling of ecosystem services, and Life Cycle Assessment (LCA) to evaluate the impacts and dependencies in the cocoa value chain and arrive at the recommendations contained herein. The literature review focuses primarily on peer-reviewed scientific literature that evaluate agroforestry and cocoa value chains around the world. It also includes recommendations from Indonesian based cacao stakeholders.

Human benefits from natural ecosystem functions, called Ecosystem Services, are mapped by combining maps of land cover with information about the attributes of the land cover using geographic information systems (GIS). The spatial analysis (section IV) has been conducted by the World Conservation Monitoring Center (WCMC https://www.unep-wcmc.org/) in collaboration with the The International Center for Tropical Agriculture (CIAT https://ciat.cgiar.org/). Modelers used WaterWorld and Co$ting Nature, programs developed to facilitate spatial analysis of ecosystem services from relatively few data inputs (http://www.policysupport.org/home).

LCA is a “Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle”, as defined by ISO 14040/44:2006. These standards also have been adopted by Indonesian Standardization Body (BSN) in 2016 and 2017 respectively. Currently LCA have expanded into environmental LCA, social LCA and Life Cycle Costing (LCC). LCA consists of four iterative steps i.e. goal and scope definition, inventory analysis, impact assessment and interpretation. In addition to environmental impact assessment, social life cycle assessment (S-LCA) evaluates both potential and negative impacts of products toward social and sociological aspects along its life cycle. There are four main stakeholder groups in social LCA that can be considered, e.g. workers, users, local communities and small-scale entrepreneurs.

To promote sustainability, apart from the final products, stakeholders also play an important role in the life cycle of a product. The social aspects of a product life cycle may have a direct or indirect impact on the various stakeholder groups involved in the life cycle of a product. Consequently, this calls for social impact assessment in connection with certain stakeholder groups. One of the challenges is to make product social impacts visible and measurable throughout the value chain. The ultimate goal of social life cycle assessment (S-LCA) is to systematically identify the social conditions of a given product and promote improvement opportunities (Indrane, 2017).

Social topics for workers	Social topics for local communities
1.1 Health and safety 1.2 Remuneration 1.3 Child labour 1.4 Forced labour 1.5 Discrimination 1.6 Freedom of association and collective bargaining 1.7 Work-life balance	3.1 Health and safety 3.2 Access to tangible resources 3.3 Community engagement 3.4 Employment
Social topics for users	**Social topics for small-scale entrepreneurs**
2.1 Health 2.2 Product safety 2.3 Responsible communication 2.4 Privacy 2.5 Inclusiveness 2.6 Effectiveness and comfort	4.1 Meeting basic needs 4.2 Access to services and inputs 4.3 Women's empowerment 4.4 Child labour 4.5 Health and safety 4.6 Land rights 4.7 Fair trading relationships

Figure 2: Stakeholders and social topics in social LCA.

III. Literature Review

The TEEB office conducted a rigorous review of literature that suggests that cacao agroforestry production can be sustainably intensified in order to increase yields, providing local social and economic benefits while simultaneously protecting important ecosystem services and biodiversity. This review is organized according to the recommendations made above.

1) Improve cacao yields per hectare by promoting and incentivizing proven intercrop agroforestry systems, while encouraging farmers to replace/rejuvenate old and unproductive cacao plants;

Full-sun monocrop cacao cultivations have proven to increase short-term yields, making the approach attractive to small scale farmers to implement in hope of high cash-crop returns (Abou Rajab et al. 2016, Schneider et al. 2016). Most cacao plantations in Indonesia therefore are grown under full-sun or light shade conditions (ca 70% of plantations in Sulawesi), and there is an ongoing trend to remove shade trees. However, full-sun plantations require more inputs as physiological stress increases alongside the susceptibility of pests and diseases, which risks jeopardizing the future productive potential of the farmers' cacao stock (Clough et al. 2009). The intensification of cacao production systems though shade removal i.e. intensive mono-cropping full sun systems, therefore reduces the crop's ecological resilience just at a time when resilience is imperative due to increasing environmental changes and climate extremes (Schneider et al. 2016).

Crop intensification typically has negative consequences for associated biodiversity but **introducing shade trees** into cacao plantations has been proposed as a possible solution to the compound challenges of expanding sustainable cacao production, preventing deforestation, and securing against the boom and bust cycles that have plagued cacao cultivation during the past century (Ruf, 2011). Benefits range from higher long-term yields, biodiversity and ecosystem services conservation, climate change mitigation and improved farmer livelihoods (Schroth et al. 2015, Sonwa et al. 2018, Vaast and Somarriba, 2014).

Experts have recommended developing diverse and structurally complex canopy layers in agroforestry systems that combine native and exotic species in order to cultivate legumes for soil fertility enhancement and to provide increased climate change mitigation by introducing trees with high timber or carbon sequestration values (Abou Rajab et al. 2016, Mortimer et al. 2017, Vaast and Somarriba, 2014, Vandermeer, 2011). Diverse agroforestry systems also provide increased landscape connectivity and therefore allow for a higher level of biodiversity in both planted and natural areas, in comparison to conventional plantations (Beenhouwer et al. 2013). In addition to maintaining biological control through high levels of animal and plant diversity, including pest-feeding species, it has been suggested to introduce non-native tree species to act as natural barriers stopping pests and diseases from spreading from one cacao field to another (Vaast and Somarriba, 2014). Furthermore, studies have illustrated that agroforestry systems can improve nutrient cycling processes, accelerate decomposition, reduce the exposure to drought and physical stress, enhance soil productivity and minimize soil erosion which all help contribute to an increased productive lifetime of the cacao trees (Abou Rajab et al. 2016, Jose, 2009, Wartenberg et al. 2019).

Implementing shade trees into cacao plantations might produce lower annual yields per hectare but does ensure more stable yields and is therefore considered a more productive method in the long-term. In addition to environmental benefits, agroforestry systems can also offer socio-economic benefits through increased income security to farmers from intercropped species such as timber, fruit or other marketable goods. In this way, when illness strikes or when cacao prices drop, the intercropped species can provide additional income to the farmers through diversified revenues that are better shielded from fluctuating cacao prices (Abou et al. 2016, Vaast and Somarriba, 2014).

A recent study found that **shade trees** had a positive net effect on soil fertility, a negative effect on cacao tree growth, and lastly that the cacao yields were not significantly affected. The conclusion of the study was that including shade trees into cacao plantations is a viable approach to increasing sustainability measures, especially when shade trees are planted at low densities (Wartenberg et al. 2019). However, some species of shade trees compete with other crops for light, water and nutrients, creating trade-offs that are difficult to measure. Shade tree species that do not compete directly with cacao should therefore be selected, and for this, further agronomic research may be required. The most common intercropped shade trees in Sulawesi are gliricidia, rambutan, langsat, durian, jackfruit, jabon, guava, mango, petai, coconut and gmelina (ibid) intercrop tree species. Studies have revealed that one of the most successful types of **intercrop** is coconut-cacao, illustrating lower environmental impacts than in cacao monocultures and in cacao-rubber agroforestry systems in terms of global warming, acidification and eutrophication, as well as highest yields due to improved conditions for stimulated plant growth (Utomo et al. 2016). As such, coconut can help improve the efficiency of land use and sunlight and therefore maximize space with a lower impact than other comparable systems. Intercropping cacao with coconut could offer income diversification for small farmers, although research finds that the high cost of processing coconuts into copra result in small profit margins (Adam et al. 2017, Utomo et al. 2016).

Cacao plants are only productive for a maximum of 25 years. Between 1990 and 2000, a cacao planting boom took place in Indonesia, meaning that by 2015, many cacao trees began approaching the end of their productive life and productivity levels started to decline. Older cacao plants are also more susceptible to pests and diseases, and with the high price volatility of cacao, many farmers choose to convert their plantations into other commodities with higher income prospects (Nasution et al. 2019). In addition, many growers are older (38% over 50 years), revealing an apparent lack of interest in growing cacao, presumably linked to the high labor intensity of the crop, the fact that cacao typically is not the primary source of farmer income but is rather seen as a security crop, and the temptation of converting to other more lucrative and profitable crops such as coconut or palm oil (Daymond et al. 2017).

Experts recommend **rehabilitating** existing plantations rather than abandoning old plantations, as abandoned plots can lead to increased fire threats and expansion into natural forests causing further deforestation. Failure to sustain cacao production in current cultivation areas would presumably entail a shift to new areas such as West Sumatra and Papua which would involve accelerated deforestation (Clough et al. 2009). As pests and diseases represent major challenges to cacao production, experts frequently stress the importance of using superior genotypes with increased resistance levels, as they can help reduce the occurrence of pests and diseases and contribute to boosting cacao yields (Cilas et al. 2018, Vaast and Somarriba 2014).

Rejuvenating cacao plots through various grafting techniques has also been recommended, in order to increase the production of older cacao plants and ensure the genetics of seedlings. Grafting also allows the host tree to continue producing cacao beans during the time required for the graft to develop into a pod-producing branch (Moriarty et al. 2014). Grafting techniques are growing in popularity as replacing old, unproductive cacao plantations with resistant varieties is relatively expensive and requires both experience and knowledge. Decreasing yields and ecological instability from unshaded plantations are intensifying just as the next farmer generation begin taking over the cacao farms (Clough et al. 2009). Therefore, providing farmers with knowledge and training is fundamental to the sustainable future of the Indonesian cacao industry.

2) Increase the provision of knowledge and training to small-holder farmers, leading to the adoption of Good Agricultural Practices (GAPs):

Global cacao demand has been growing steadily during the past decades, particularly in emerging markets like Asia, and in response, the industry has been promoting the intensification of cacao cultivation to be able to meet demands (Blommer, 2011). The overarching dilemma in the cacao sector currently, therefore, is how to increase production in a sustainable way in order to meet a growing demand, without expanding the cacao cultivation area. A multitude of efforts from the Indonesian government, the private sector, NGOs, development organisations, researchers etc. have all through different initiatives aimed at increasing cacao yields while ensuring long-term sustainability and farmer income through improved farming practices. For instance, a tax on exporting unprocessed cacao beans was introduced in 2010 to incentivize the export of value-added processed cacao. A national program was recently launched to boost cacao bean production to 600 000 tons by 2024. However, there has been limited progress overall over the last decade in terms of farmers adopting recommended practices, suggesting that new interventions and technical innovations are needed to be able to intensify production in today’s producing regions, interventions and innovations that are tailored towards small, family-managed cacao farms. It appears that relying on researchers’ ideas of appropriate technologies alone is insufficient in terms of encouraging adaptation from farmers and that “bottom-up” interventions are needed (FAO/INRA 2016). Inappropriate intensification practices could result in an increased usage of more intense and less environmentally friendly inputs, and/or the replacement of cacao with other agricultural crops.

Accordingly, challenges have arisen in the Indonesian cacao sector due to a multitude of reasons, many of which seem to have occurred due to the nature of the sector being predominantly small scale with limited government involvement or formal education. Farmers take example of neighbouring farmer practices, which are not necessarily the recommended best practices (Clough et al. 2009). Studies have illustrated that there are large variations in yield per hectare and in bean quality between both farms and islands in Indonesia, and that the declines in quality are primarily related to inappropriate agricultural practices concerning shade and water management, use of pesticides and fertilizers, plant density and age, soil fertility, loss from animals and the occurrence of pests and diseases (e.g. cocoa stem borer and cocoa black pod disease). Chemical use for pest and disease management is to a large extent excessive and unregulated, and despite limited evidence of negative long-term impacts, it is likely that the excessive reliance on synthetic fertilizers has environmental and human health effects (FAO/INRA, 2016). Poor land management practices have led to consequences including soil nutrient depletion and the loss of organic matter from farms which in turn has led to plot abandonment and further forest clearing (Gockowski et al. 2013). Continued deforestation undeniably has implications for water systems, biodiversity conservation, soil erosion and carbon storage, as well as possible long-term impacts on societal wellbeing (FAO/INRA 2016).

For the cacao crop to remain competitive in comparison to other crops, therefore, it must be highly productive and provide sufficient income to farmers. Cacao can be profitable and of high quality under the right conditions and as such, farmers must be made aware of how to facilitate this through various management techniques. Hence, providing farmers with the **appropriate knowledge on good agricultural practices (GAPs)** is critical. Farmer field schools (FFS) and cacao development centres (CDCs) have been used by various bodies in Indonesia, as a group-based learning program merging concepts, methods and techniques from various constituencies to explain the reasons behind yield losses and help farmers learn about GAPs. GAPs can include management techniques on the dosage and timing of fertilizer and pesticide application, pruning practices, harvesting and sanitation methods, shade tree management and more. It has been estimated that when implementing GAPs by using appropriate types and amounts of fertilizers (organic and inorganic) and pesticides, compost, planting materials etc., yields could increase significantly (NewForesight, 2013). NewForesight Consultancy conducted a study in 2013 upon request from the Cacao Sustainability Partnership (CSP) to deliver a roadmap towards a future sustainable Indonesian cacao sector in 2020 (NewForesight, 2013). The roadmap was built around the 2020 Targets for the Indonesian cacao sector, as formulated by CSP members. They believed that the Indonesian cacao sector could become viable and profitable again if farmers doubled their productivity and improved the quality of their cacao in a sustainable way. They predicted that if farmers implemented GAPs, quality inputs and high-quality planting material, sustainable development could be achieved as well as an opportunity for farmers to make a competitive profit which in turn would attract the next generation of cacao farmers. These GAPs would cover the appropriate use of agro-inputs and planting materials, business and management skills, nursery management, pests and disease management, rehabilitation-, replantation- and grafting techniques, post-harvest product management and shade tree management.

Consequently, the main recommendations from their roadmap findings involved two interrelated components. The first, “Professional Farmer Package”, involved increasing the appropriate use of higher quality agro-inputs and planting materials at scale, in combination with teaching farmers about GAPs, financial management and farmer organization. The second component, “Enabling Environment”, involved various modes of delivery and organization for the adoption of agro-inputs and knowledge, access to financial resources including various models for agri-finance and the roles of banks and value-chain partners, as well as the role of the government. According to the study, all farmers should implement basic GAPs as doing so could lead to significantly increased yields without colossal financial investments or environmental pressures (Figure 3 and Figure 4). In addition, training farmers in business management skills would enable them to understand the business case for productive cacao farms and act accordingly, which in turn, would reveal the potential investments needed to increase the efficiency and productivity of their cacao farms. The study argued that the average Indonesian farmer that refrains from implementing any kind of GAPs or inputs, tend to have very low yields (ca 350 kg/ha) and that trees become increasingly susceptible to pests and diseases, whereas if GAPs are implemented, including appropriate fertilizer use and improved cacao varieties, yields could potentially increase to as much as 2200 kg/ha, in areas with optimal growing conditions (NewForesight, 2013).

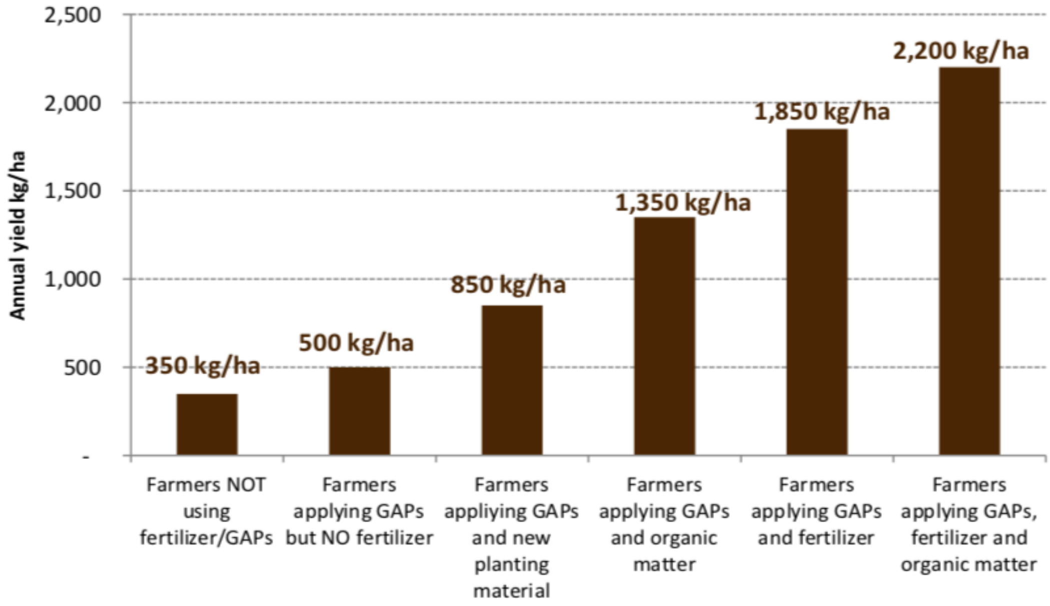


Figure 3: Estimated income of a 1 ha farm on an average year (no rehabilitation costs). (NewForesight, 2013: 5).

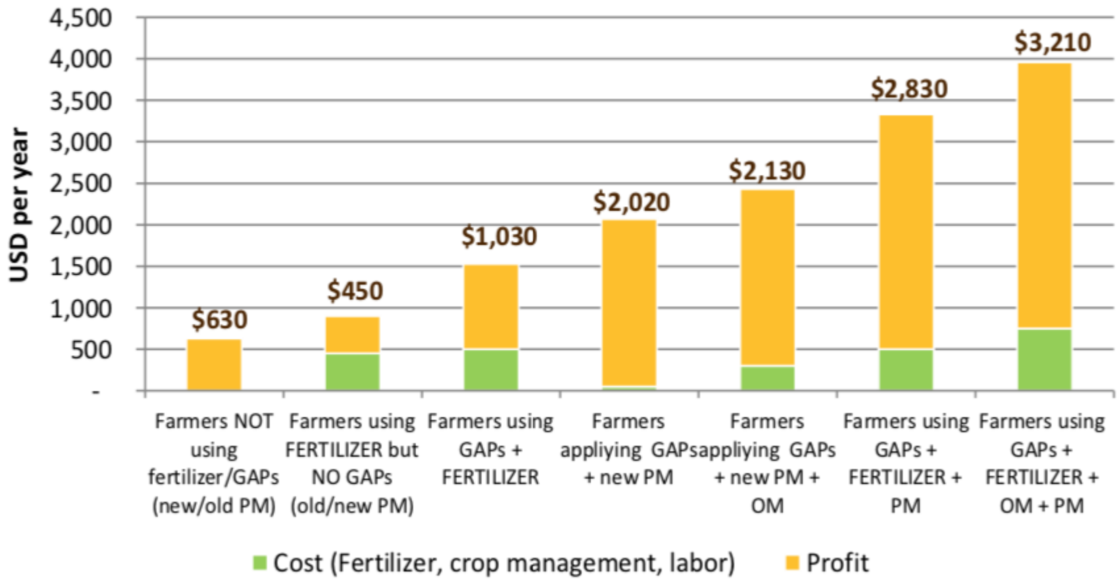


Figure 4: Projected yields according to inputs and management (NewForesight, 2013: 51).

Accordingly, by informing farmers, they can gain skills to make informed decisions, solve problems and develop future business plans, to be able to develop sustainable agricultural practices while generating larger incomes (NewForesight, 2013, Moriarty et al. 2014). Effective and impactful schemes are needed not only to improve farming and land use planning and practices through GAPs, but also to provide farmers with information on natural resource management, biodiversity conservation, and to encourage safer working conditions and improved storage, handling and disposal of agrochemicals. Studies have also suggested that sustainable cacao development should be closely linked to community development programs, as enhancing the capabilities of farmer communities can help farmers collectively carry out actions to add value and improve marketing processes etc. with increased long-term resilience and performance (Nugraha et al. 2019). It is thus important to include farmers in the decision-making process so that their local knowledge as well as their aspirations and goals can be taken into consideration in the management and planning of the system (Anglaaere et al. 2011).

In summary, studies such as the above-mentioned report conducted by NewForesight, and other sustainability initiatives developed by different stakeholders (e.g. SwissContact's training guidelines in their Sustainable cocoa Production Program), could function as a set of comprehensive guidelines to train farmers in GAPs, boost financial returns and sustainably intensify cacao production.

3) Analyzing the economic viability of very small cacao farms

An important consideration for agroforestry policies is the profitability of very small farms. In contrast to other tropical commodities such as rubber and palm oil that are cultivated by large plantations, the majority of cacao production occurs on small-holder farms. In 2016, 97% of cacao production in Indonesia occurred on smallholder plantations (Nasution et al. 2019). Indonesia cacao farms in particular are relatively small, the average size of an Indonesian cacao farm 0.7 hectares is less than half the size of African cacao farms (Daymond et al. 2017). Facing perennial global competition and limited market power, commodity producers depend upon economies of scale to survive amidst small profit margins and price fluctuations. In short, it is challenging to make very small commodity farms economically viable. *The benefits of agroforestry are not short-run profit maximization, but rather income security and food security, sustaining long-run production by reducing soil depletion, minimizing input costs, and decreasing pesticide, fungicide, and fertilizer pollution*. Less-input intensive agroforestry systems are a *land sharing* strategy rather than a *land sparing* activity, and as such may be better suited to larger farms and/or as a corridor land use between or around protected forest.

A recent study by Nasution et al. (2019) found that in North Sumatra many small cacao farms in recent years have transitioned to growing palm oil because net farm incomes are higher. However, because cacao farming is labor intensive but not input intensive, the study found that the revenue to cost ratio is higher for cacao farming. This means that farmers with limited land and financial resources, despite these limitations, could still increase incomes in cacao farming through better use of labor through activities such as grafting (Nasution et al. 2019). Small cacao farms may also be well suited for sustainability certification, which has shown positive benefit-cost ratios when environmental impacts are internalized (van Beukering, Kuik, and van Drunen, 2014). The value added from certification is multiplied in the processing and manufacturing components of the value chain, adding further incentive to invest in those downstream activities.

IV. Spatial Assessment

1) Conduct spatial planning of agroforestry production to maximize benefits

There are many important spatial dimensions to cacao farming, including the total land area used, the size of cacao farms, where cultivation is located, where cacao production has expanded or contracted, and where cultivation could and should or should not occur in the future. These spatial dimensions, and more importantly the impact of these dimensions upon communities, households, and their environment should be considered in the development of agroforestry policies. The multiple spatial dimensions of food production are often neglected in favor of simpler measures of yield per hectare. TEEBAgriFood has argued that yield per hectare is not the best measure by which to evaluate a farming sector (TEEB, 2018). Instead, multiple diverse measures of the wellbeing of farmers and wellbeing of farming communities should be evaluated simultaneously.

For example, a TEEBAgriFood study of agroforestry systems in Africa highlighted the food security benefits of agroforestry systems in contrast to intensive, "high tech" production systems (Namirembe et al. 2015). At first glance one can see that the high-tech systems produced more cacao per hectare, but this does not mean high tech farmers are better off than agroforestry farmers. The sum of many food products produced by agroforestry systems was much higher than the value of cacao output from high tech systems (Figure 5) when subtracting the high input costs of the intensive systems (Figure 6).

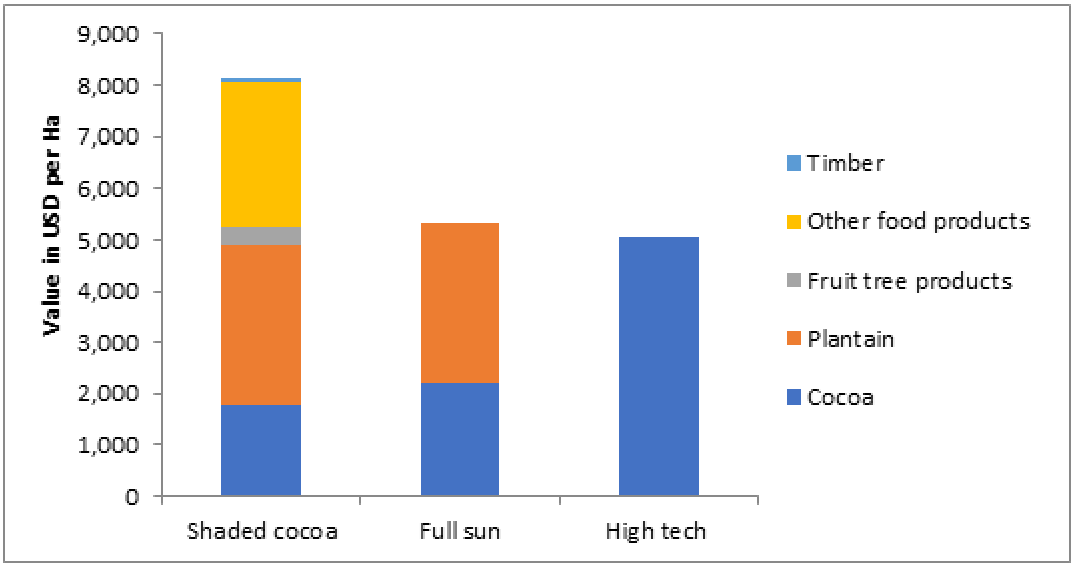


Figure 5: A comparison of the agricultural and food outputs among the three cacao production systems in Ghana (Namirembe et al. 2015).

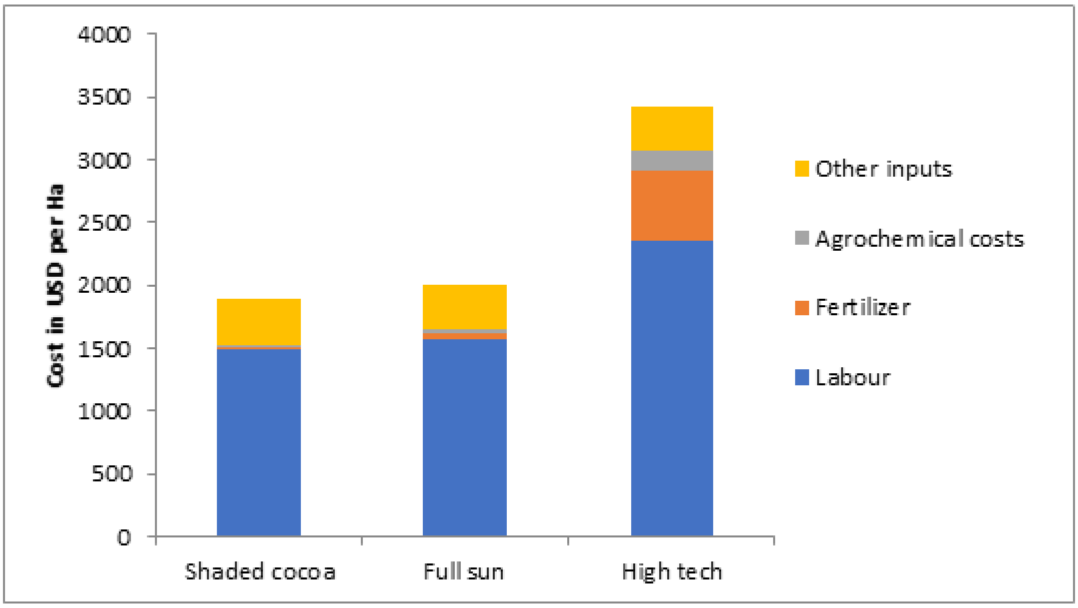


Figure 6: A comparison of input costs in the cacao production by cacao system (Namirembe et al. 2015).

There are also a variety of non-market ecosystem goods and services that can be produced by agricultural ecosystems ("agro-ecosystems"), including carbon sequestration, water regulation, biodiversity habitat, erosion control, and soil nutrient cycling. These goods and services offer tangible benefits to cacao farming communities and to the country of Indonesia. For example, soil fertility, achieved through decomposition of organic matter in an agroforestry system, can boost cacao yields providing direct benefits to farmers (Barrios et al. 2012). Agroforestry systems can also capture and store carbon dioxide from the atmosphere, helping Indonesia contribute to climate regulation globally. Although this may not have a local benefit to farmers, it is a measurable benefit of agroforestry systems that should be valued by policy makers. The value of these non-market goods and services should be recognized in addition to the profitability of the agro-ecosystem. However, it should be noted that there is an optimum shading to balance the cacao productivity and other benefits.

The total value of ecosystem services may be irrelevant – policy makers need to know how impacts vary between potential scenarios, such as agroforestry compared to monoculture cacao, or monoculture cacao compared to monoculture palm or rubber. In other words, ecosystem services need to be measured relative to a counterfactual scenario. The single most important factor influencing the value of ecosystem services throughout the value chain of commodity production is the location where production occurs and what land cover it is displacing (van Beukering, Kuik, and van Drunen, 2014).

To measure these services researchers must model landscapes and compare scenarios of land cover and land use practices. The World Conservation Monitoring Center, in collaboration with the International Center for Tropical Agriculture (CIAT), have made a preliminary assessment of ecosystem services in Indonesia with a focus on potential cacao growing regions. More detailed land cover data is required to compare differences between agroforestry systems, but this rapid assessment highlights areas where cacao expansion could offer the greatest benefits and where it poses the greatest threat to ecosystem services.

2) Spatial context for cacao in Indonesia

2.1. Land cover map for Indonesia

The land cover map for Indonesia (Figure 7) was created using data from Indonesia's Ministry of Environment and Forestry for the year 2017, obtained from Global Forest Watch (GFW, 2017). Spatial data on agroforestry or cacao specifically was not available within the land cover dataset. Data on forest management, which includes agroforestry and plantation crops is however in preparation through the Naturemap project (Lesiv et al. in prep.) and will become available in the near future.

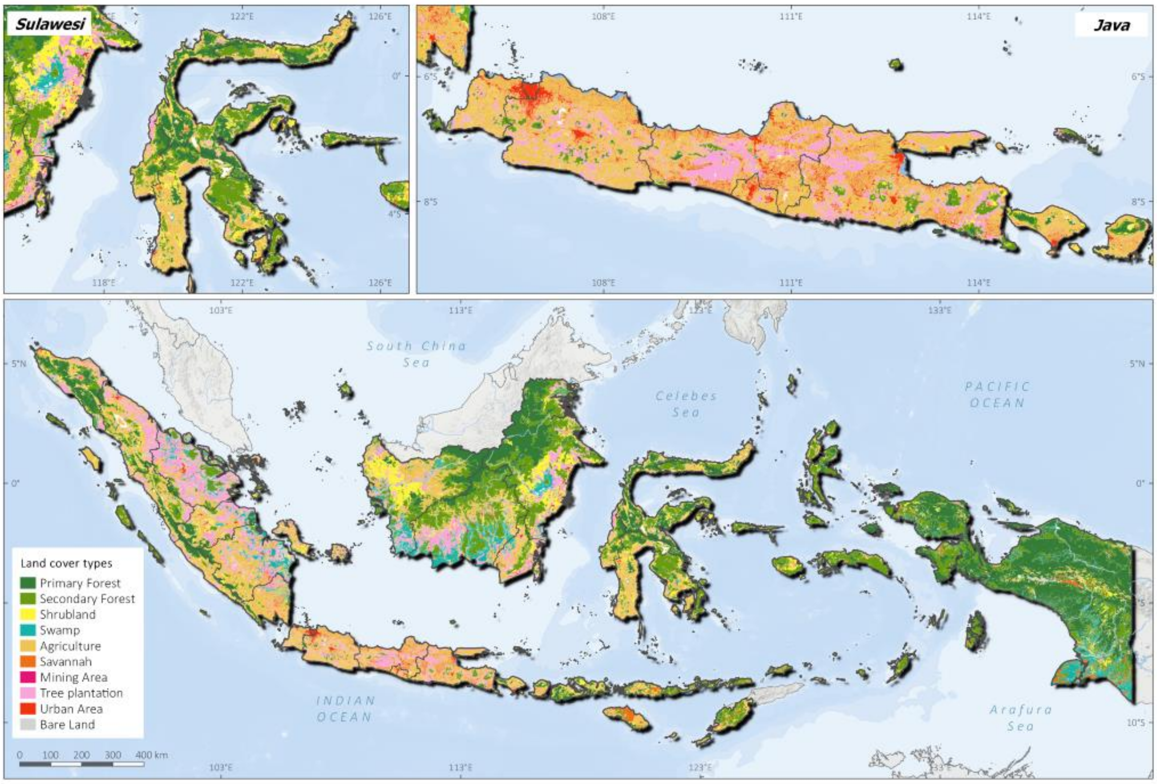


Figure 7: Land cover map of Indonesia (data source: Ministry of Environment & Forestry, 2017 obtained from GFW (2017).

The map in Figure 8 shows the distribution of climate zones that are characteristic of areas where cacao is currently grown in Indonesia (purple colour) and climate zones that are considered potentially suitable for cacao even though there is little cacao now (orange colour, based on data from Bunn et al. (2017). These latter areas are lowland areas, where temperatures are higher than in areas where currently most cacao is grown.

Most of Sumatra, Papua and Sulawesi are likely to be suitable for cacao production under current climatic conditions. Kalimantan and Java were found to be partially suitable.

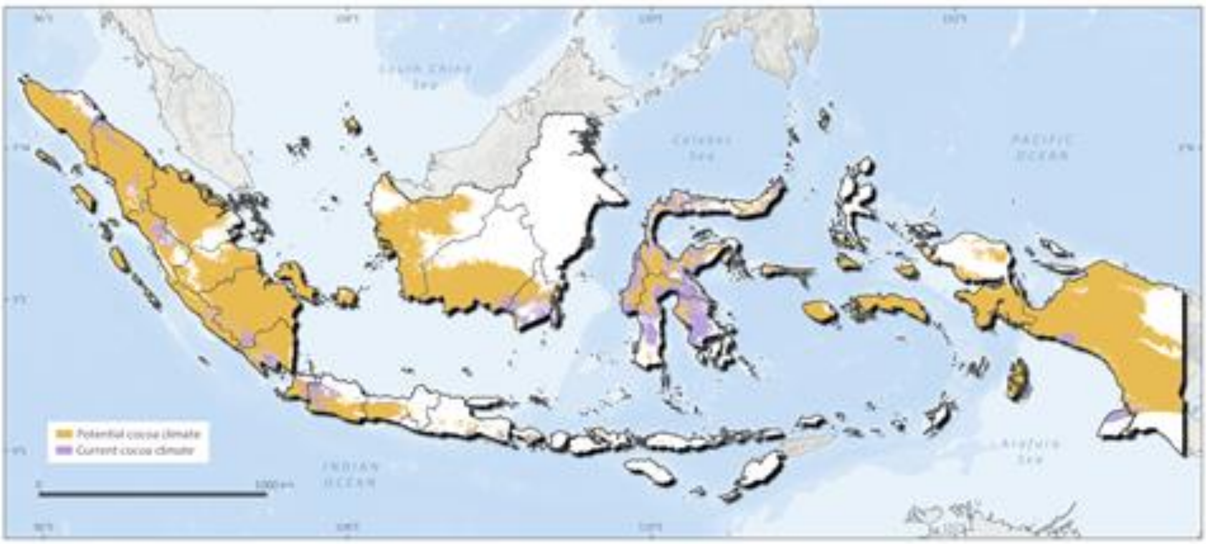


Figure 8: Current distribution of cacao climate zones in Indonesia (adapted from data by Bunn et al. 2017).

2.2. Spatial planning: mapping biodiversity, carbon stocks and sequestration, erosion risk and water quality

Biodiversity

The maps below show two spatially explicit measures of biodiversity: a biodiversity intactness index and a weighted species richness-based index (called Range Rarity). The maps allow the identification of important biodiversity areas which may be at risk of being converted to cacao plantations, given that they are located in climatically suitable areas and are not currently protected. They are mapped for the country as a whole (Appendix 4.1 map 1 and map 2) as well as only for natural habitat areas in areas currently suitable, in terms of climate, for cacao (Figures 9 and 10), with insets of the 2 interest areas: Sulawesi and Java.

The Biodiversity Intactness Index is based on modelled estimates of impacts to biodiversity intactness (change in the community composition of native species from a pristine baseline) caused by land use conversion. Biodiversity data was extracted from the PREDICTS database (https://data.nhm.ac.uk/) and comprises data on vertebrates, invertebrates, plants and fungi.

The range rarity index is a weighed (by endemism-so smaller range species get higher weight) index based on refining species ranges from IUCN red list data (mammals, amphibians, birds) (IUCN, 2017) using species specific habitat preferences, land cover data from the ESA Climate Change Initiative (ESA CCI, 2015) and land cover elevation data from GMTED2010 (Danielson and Gesh, 2011).

Protected area boundaries originate from the World Database of Protected Areas (UNEP-WCMC and IUCN, 2019).

Natural habitat areas are the result of a reclassification of the Ministry of Environment and Forestry map (2017) into natural vegetation classes and artificial classes (urban areas, crops, etc.) present in climatically suitable areas for cacao (both current and potential) in present time. Protected areas are overlaid on the top, allowing to visualize which areas may be more at risk of land use conversion (Figures 9 and 10).

Indonesia is characterised by biodiversity hotspots with extremely high species richness and endemism (range rarity) values (Appendix 4.1 map 1). Biodiversity intactness can be considered in light of land use (see Figure 7 in combination with Appendix 4.1 map 2): for example, intactness is low in the largely agricultural areas of Sumatra and Java. Java shows widespread loss of intactness throughout the island. Sumatra and Kalimantan are more diverse; regions of concentrated oil palm plantations in the centre of the islands (not shown on maps) display the lowest values of intactness recorded, whereas northern regions are largely intact. There are of high biodiversity intactness and species richness in suitable natural areas for cocoa that are not protected (e.g. in Sulawesi, the Banda Arc, and Papua) (Figures 9 and 10). This means that they may be at risk of conversion from cocoa expansion if these areas are not protected

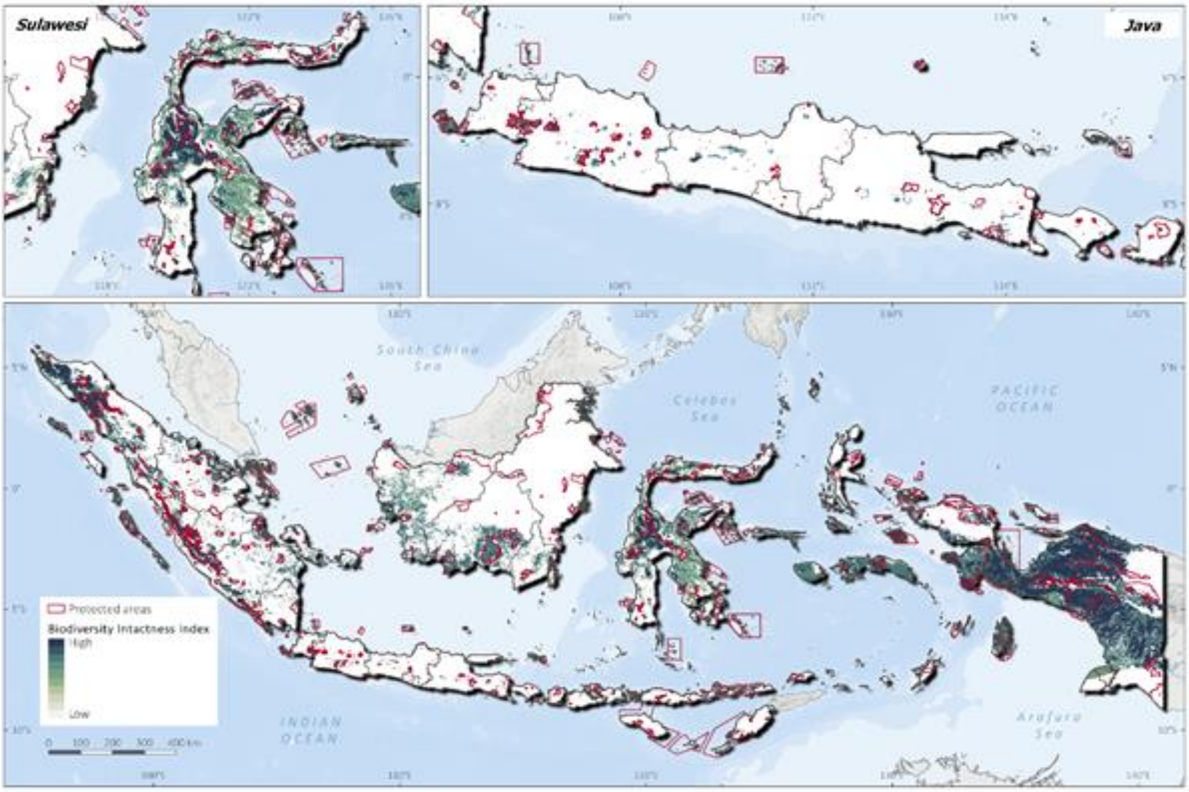


Figure 9: Biodiversity intactness map for Indonesia in natural habitats in currently climatically suitable areas for cacao production.

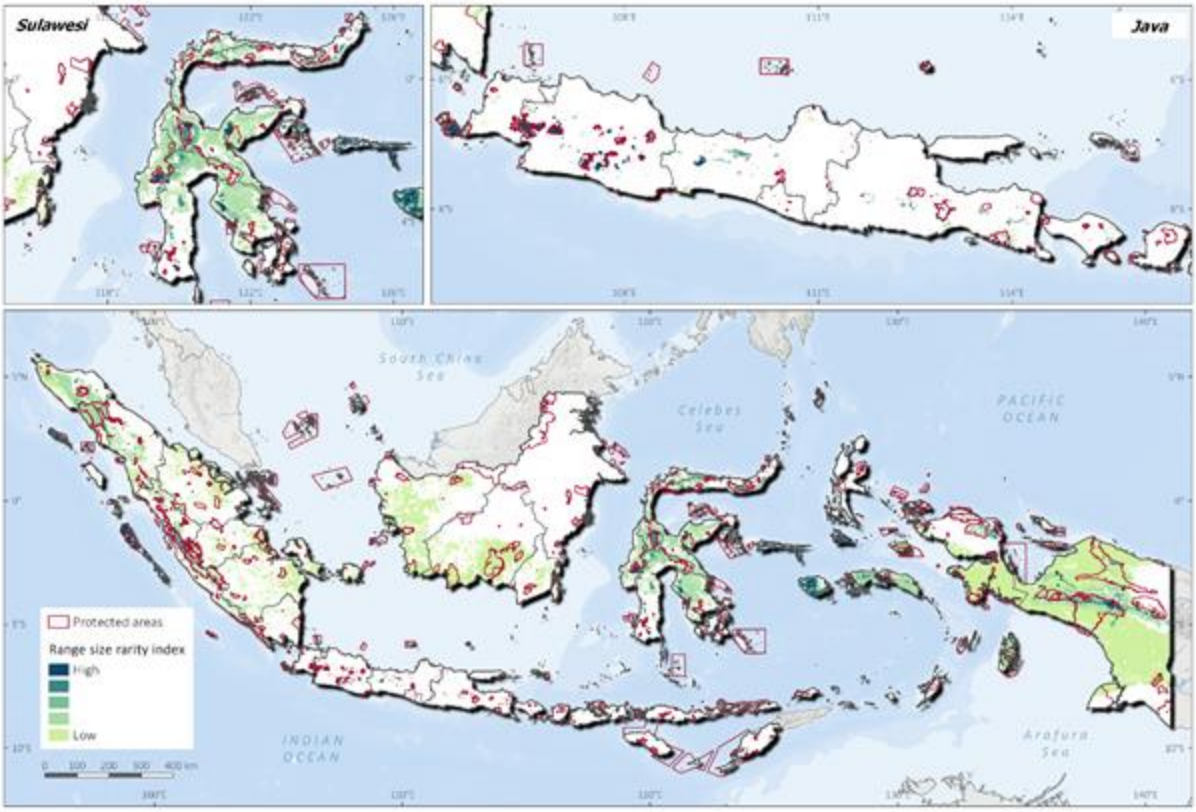


Figure 10: Range rarity index for biodiversity in natural habitats in currently climatically suitable areas for cacao production.

Ecosystem services by land cover and use type

The land cover classes for primary forest, secondary forest, plantation and cropland from the Ministry of Environment and Forestry (2017) (Figure 7) were aggregated using the same grouping as described on the GFW website:

- Primary Forest: Primary dry land forest, primary mangrove forest, primary swamp forest
- Secondary Forest: Secondary dryland forest, secondary mangrove forest, secondary swamp forest
- Plantation Forest: Plantation forest
- Cropland: Estate crop plantation, dryland agriculture, shrub-mixed dryland farm, rice field

The aggregated classes were then overlaid on the baseline ecosystem service maps (Appendix 4.2) modelled with Co$tingNature (Mulligan et al. 2010) and WaterWorld (Mulligan, 2013) and mean values for each were calculated. Figure 11 shows the mean ecosystem service delivery for each land use type. To assess the differences of ecosystem service production in different land use types spatially, the modelled ecosystem services were masked using the extent of each land cover type: primary forest, secondary forest, plantation forest and cropland (Appendix 4.2).

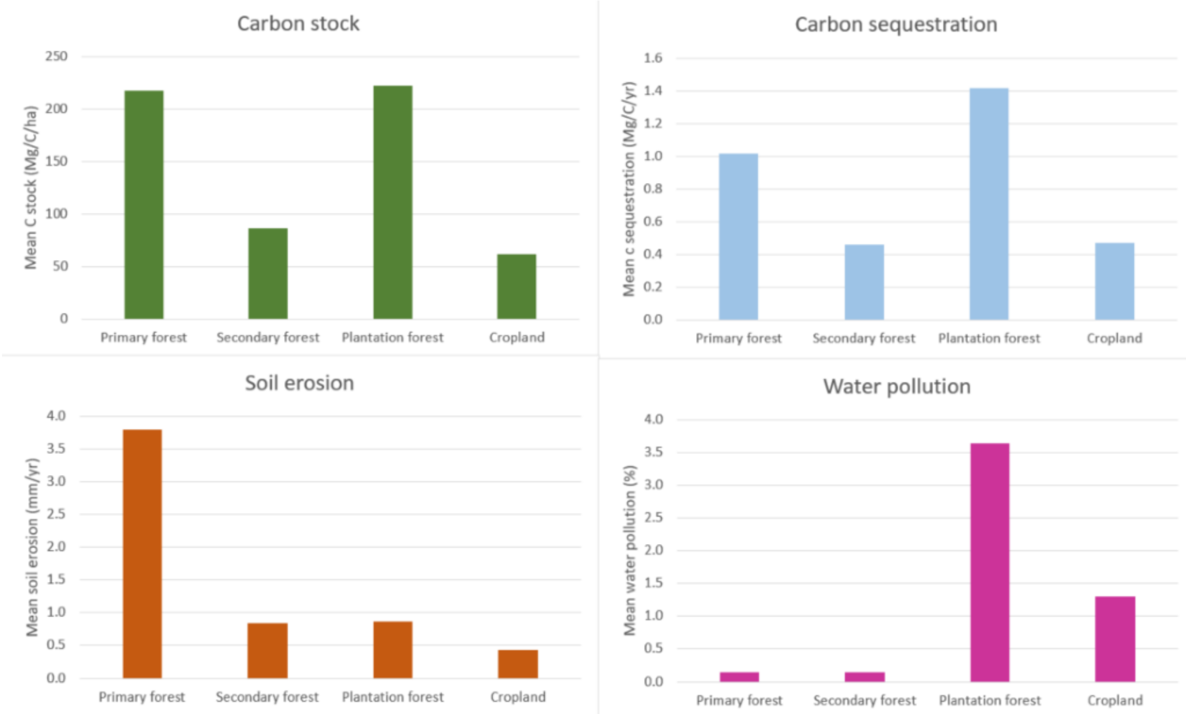


Figure 11: Mean ecosystem service delivery by land use type for four ecosystem services.

3) Scenarios for cacao expansion under current and future climate conditions

We considered different scenarios for potential cacao expansion: one where cacao would expand into existing cropland, one where it would expand into degraded lands and one where expansion of cacao would occur into secondary forests. Under current and future climatic conditions.

An exploration of the expansion of cacao agroforestry into (non estate/plantations/perennials) cropland revealed little effect at the scale of analysis used here. Areas were very small as we did not consider replacing rice (we did not think this plausible). Also, we could not access to spatial data on degraded lands. Therefore, we did not pursue these two scenarios.

Because cacao is typically grown in (formerly) forested areas, often in a system of gradual thinning and replacement of the original forest, or in secondary forest areas, we considered a potential expansion of cocoa to be most plausible in areas that are currently secondary forests. The scenario analysis focused on Sulawesi because most cacao is currently grown in that region and any near future expansion is likely to take place in this region. We considered expansion under current climate and future (2050) climate conditions. For both scenarios, expansion was constrained by cacao suitability.

<u>Scenario 1: convert secondary forest to cacao in Sulawesi under current climatic conditions</u>

Modelling results are shown in Figure 12. Water quality decreases under this scenario with a mean increase of 0.21%, although some areas see an increase in potential pollution of 33%. Water quality reduces mainly in the areas converted but do have downstream impacts, e.g. areas around the city of Kendari are not projected to be converted but river water in the Sungai Konaweha all the way to the outflow in the sea (some 100km away from the converted areas) is projected to increase in pollution by a few percent. In West and South Sulawesi this affects several rivers, e.g. the Sadang river, the Mamasa river, the Sungai Karana and a few smaller ones.

Total aboveground carbon for Sulawesi under this scenario reduces with a total of 32,129,200 tonnes. The largest changes are found in West and South East Sulawesi. Soil carbon is projected to reduce with a total of 20,781,500 tonnes for the whole of Sulawesi but mostly affecting West Sulawesi. Overall, the mean total carbon stock change is -0.26 tonnes/C/ha. Mean carbon sequestration is projected to reduce by -0.2 tonnes/C/ha/yr under this scenario. Biodiversity intactness decreases in areas where secondary forest is converted to cacao. Cacao agroforestry hosts less biodiversity than forests, in particular forest fewer specialist species, but it is much more similar to secondary forests than to monoculture cropland in terms of species composition (UNEP-WCMC, unpublished data).

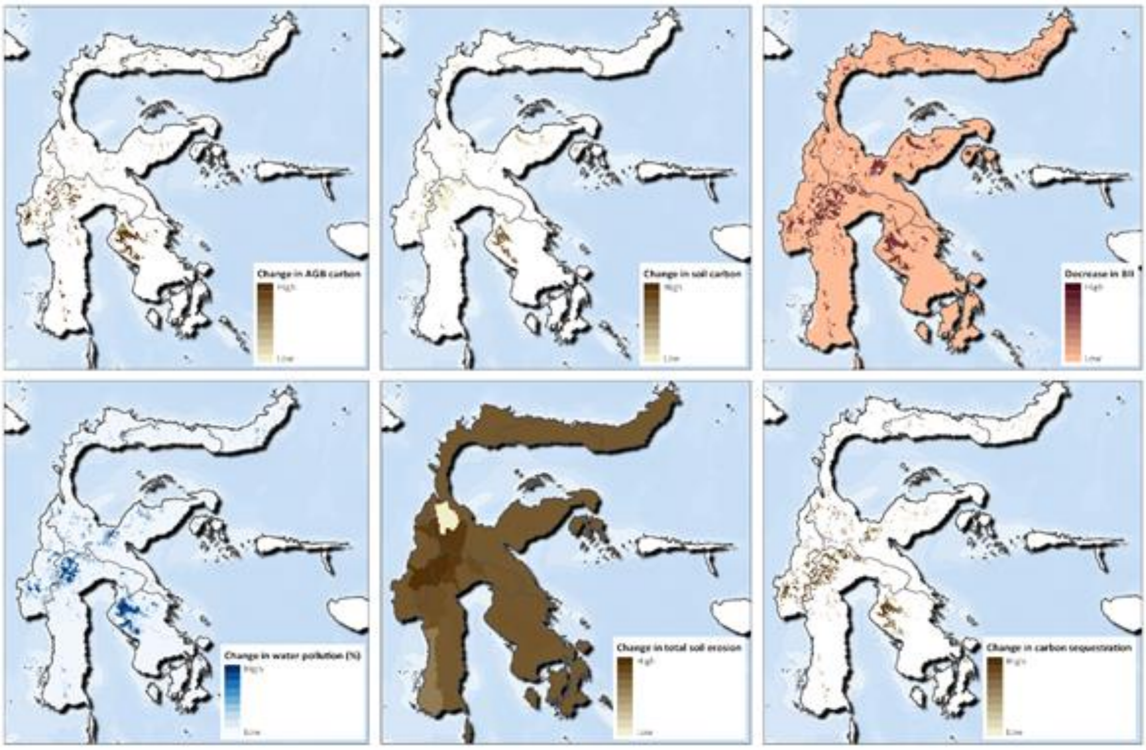


Figure 12: Changes in ecosystem services modelled for the scenario converting secondary forest to cacao on Sulawesi (AG Carbon is in tonnes C/km2, Soil carbon tonnes C/km2, C sequestration Dg/ha/day, loss in BII in %, change in water pollution (% contamination), change in soil erosion in mm/year).

A key thing to note in this analysis is that we have modelled changes/losses compared to retaining secondary forest. We would *expect* a reduction in ecosystem service provisioning, water quality etc. The key question is this: If cacao production is to expand, where is it best to target that expansion? We always need to be aware of and model *the switch*, i.e. the marginal change.

Scenario 2: convert secondary forest to cacao in Sulawesi in areas suitable under climate change (2050)

The map in Figure 13 shows the modelled distribution of climate zones for cacao in Indonesia in 2050 (RCP 6.0 scenario, Masui et al. 2011), based on data from Bunn et al. (2017). The model used a combination of 19 GCMs, using downscaled scenario data from WorldClim (Hijmans et al. 2005). This map shows a change in the characteristics of the cacao climate zones. The current cacao climates (purple colour) almost disappears, and the climate areas available for cacao will be mainly those that were classified as "potential" under current climatic conditions (see Figure 8). On Sulawesi (and also Sumatra), there seems to be a large loss of suitable areas (white areas). The impact of temperatures on cacao are not straightforward and there is still some uncertainty in the models. However, the results show that it is important to consider the potential impacts of future climate change when devising policy on the development of cacao production in Indonesia. Different coping strategies might include transformation out of cacao, adaptation or expansion into newly suitable areas. These strategies will have different impacts on the environment, the ecosystem services it provides and farmer livelihoods. For example, we found that areas that are potentially suitable for cacao in 2050 on Sumatra are currently oil palm. In light of the findings by Nasution et al. (2019) that revenue to cost ratio is higher for cacao farming than for oil palm, especially for small farms, this poses the question: would it be sensible to seek to promote cacao agroforestry in areas that are now (smallholder) oil palm? This would depend on a careful consideration of the gains and losses in terms of ecosystem services, livelihoods, resilience to further climate change etc.

Figure 13: 2050s distribution of climate zones for cacao in Indonesia in the RCP 6.0 scenario. Modal classification across 19 GCMs.

This scenario combines a conversion and climate change scenario for areas of secondary forest that overlap with areas potentially suitable for cacao under a climate change scenario (RCP6.0) in Sulawesi. Precipitation under this scenario is only projected to increase with around 10 mm/yr. Mean annual temperature is projected to increase by 1.1 deg C. The combination of rainfall and temperature changes with changes in tree cover as a result of the conversion of secondary forest to cacao leads to a mean increase in evapo-transpiration (water loss to the atmosphere) of 8.5 mm for the whole of Sulawesi. However, in areas converted to cacao there is generally a decrease, leading to some areas experiencing less water in rivers, e.g. the Sungai Konaweha near Kendari and other areas experiencing significant increases in water, e.g. Sungai Karana in West Sulawesi.

Since the potential for cacao under climate change on Sulawesi is very small (~ 5600 km2), relatively little secondary forest gets converted and impacts on water quality and soil erosion are small. Water pollution in this scenario is projected to increase on average by 0.07%, although some areas see increases of water pollution of up to 90% while some areas see decreases in pollution, due to more water availability overall and thus pollution dilution. Soil erosion overall increases by around 0.02 mm/yr for the whole of Sulawesi but in converted areas, these increases can be as high as 54 mm/yr.

This scenario shows that 1) Sulawesi is currently important for cacao production but according to the models, there is hardly any suitability in the future. 2) The model only looks at monthly means and thus does not incorporate (projected) increase in frequency of extreme (rainfall) events that will exacerbate soil erosion and flush through additional pollutants used in cacao plantations. 3) Assessment of areas for expansion of cacao should take into account the climatic suitability under a variety of climate scenarios as well as looking at differences in impacts on ecosystem services by modelling the combined scenario of land use and climate changes as shown here.

V. Life Cycle Assessment

In this section, we aim to understand the current impact of the cocoa value chain to the social and environment within the cradle-to-gate system boundary. We conduct a life cycle assessment across three different value chains; Cultivation, Pre-Processing, and Industrial Processing, within a certain timeframe.

For the social LCA, we identify the stakeholders for each value chain component (Figure 14). S-LCA was performed for each value chain from cacao production in Indonesia based on data collected from the stakeholders. The S-LCA was conducted using methodology and measurements adopted from Product Social Impact Assessment (Goedkoop et al. 2018). The output of this assessment provides an in-depth overview of the social conditions of each value chain within a certain timeframe, which will be beneficial to identify further improvements that need to be completed.

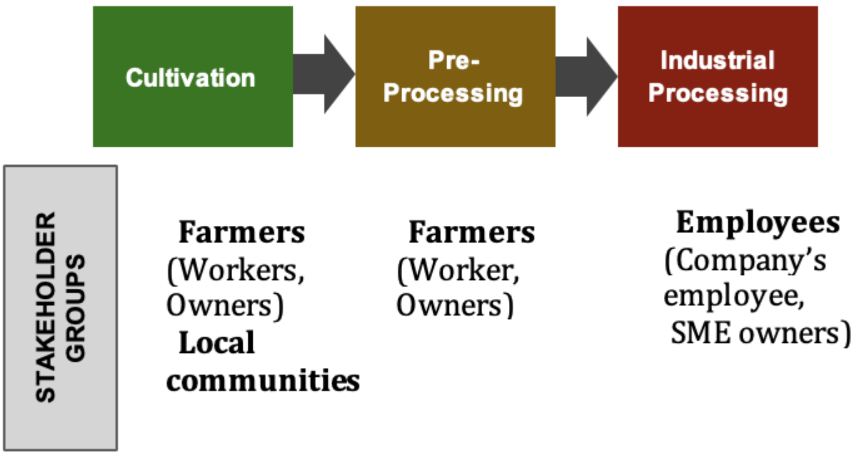


Figure 14: Stakeholder groups across the value chain.

Every stakeholder has specific topics and priorities. These topics are based on an analysis of the interaction between companies and society:

1. They are dependent on the way society functions (social dependencies)

2. They affect the way society functions (social impacts)

The impacts and dependencies that companies have on stakeholders influences human well-being.

The Area of Protection (AoP) for the stakeholders, or endpoint in ISO 14044 terminology, is defined as ‘human wellbeing’. The concept of human wellbeing for each of the stakeholders can be defined as follows:

- Workers: job satisfaction and engagement
- Local communities: healthy communities
- Users: wellbeing
- Small-scale entrepreneurs: livelihood.

Based on the Focus Group Discussion and literature review, we have selected 4 stakeholders along the value chain that is relevant to cacao sector, namely farmers, small medium enterprises (SME), employees, and local communities. The farmers from cultivation and pre-processing processes as well as small medium enterprises in the industrial processing were classified as stakeholders from small-scale entrepreneurs. Each of the stakeholders were asked relevant questions derived from the key social topics in the Product Social Impact Assessment report. Overall, there are seven social topics for farmers in cultivation and pre-processing, six social topics for SMEs in industrial processing, four social topics for employees in industrial processing, and three social topics for local communities in cultivation and industrial processing. Appendix 5 shows details of social topics related to stakeholders in each process. There are 7 topics that are being measured across stakeholders with different indicators to be measured as shown in Table 1.

Table 1: Social topics analysed for Cacao Stakeholders.

No.	**Topics**	**Cultivation - Farmer**	**Pre-Processing - Farmeri**	**Processing - SME**	**Processing - Worker**
		Mark	**Mark**	**Mark**	**Mark**
1	Meeting Basic Needs	V	V	V	
2	Access to services and inputs	V	V	V	
3	women's empowerment	V	V	V	
4	Health and safety	V	V	V	V
5	Child labour	V	V	V	
6	Fair trading relationship	V	V	V	
7	Land rights	V			

A scoring-based approach is applied to each of the topics to measure the social condition quantitatively. Ranging from (-2) to (+2), each score represents certain social conditions that correspond to the topic assessed. Negative scores depict a condition that is non-compliant with local laws and international standards, zero score depicts a condition where the local laws and international standards are met, and positive scores depicts a condition that is beyond-compliance with local laws and international standards. These measurements also refer to Product Social Impact Assessment (PSIA) report. The key components of social assessment methodology according to PSIA is shown in Figure 17.

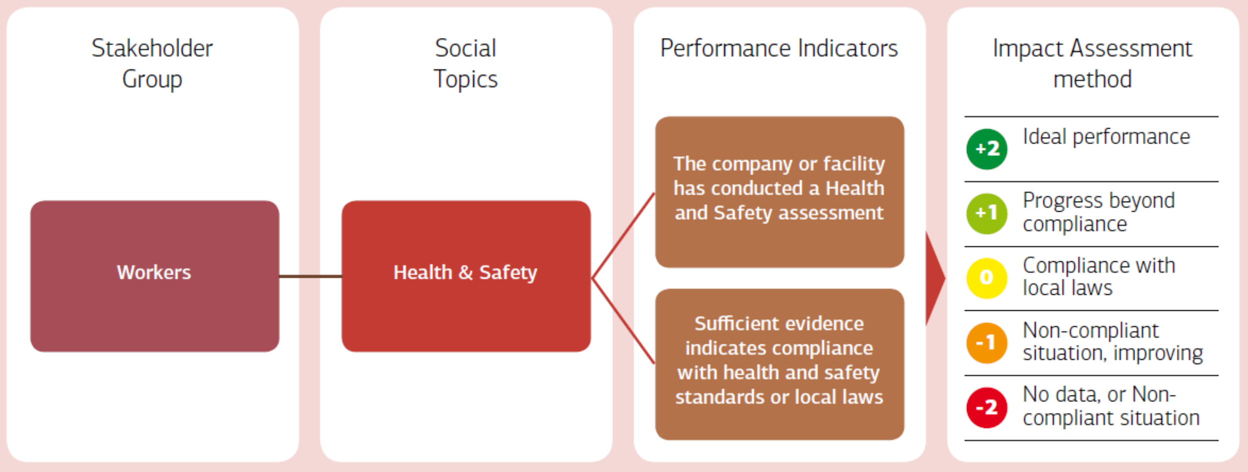


Figure 15: Example of Key Components of PSIA Methodology (Goedkoop et al. 2018).

The scale-based approach for social assessment allows both negative and positive performance within the production process. It helps to identify potential hotspots for each stakeholder. In this study, the result of social assessment will be illustrated by a spider chart with the scale-axis ranging from -2 to +2 to represent the performance of each social topics.

SOCIAL LCA DATA COLLECTION AND ASSESSMENT

The inventory data used to obtain social LCA (S-LCA) was gathered through surveys, focus group discussions (FGD), and literature review. The survey was performed by distributing questionnaires and interviews to farmers, owners of SME or industry, research organizations, extension services, and other relevant stakeholders. Three FGDs were attended, one in Solok and two in Jakarta. While surveys and FGDs were conducted to obtain primary data for S-LCA, the availability of the primary data is very minimum. Therefore, an assessment of the existing studies on cacao were performed to complement the social analysis and assessment.

A total of ten studies and articles were collected, all of which focus on the cacao cultivation process in different time periods (2010-2018). The references used for the assessment are based on the cacao projects occurred from 2010 to current. Unfortunately, no literature regarding the social aspect of pre-processing and industrial processing in Indonesia was found. The references analysed in this project are considered to demonstrate the best practices sustainable cacao development programme(s). These practices cannot represent the whole picture of cacao cultivation in Indonesia.

A total of two survey forms regarding the cultivation process, three survey forms regarding industrial processing, and ten reviewed literatures/articles regarding the cultivation process were obtained and used as the input for S-LCA.

1. Survey

One method in social inventory data collection is performing surveys to the targeted stakeholders. A questionnaire (Appendix 2) that correlates with the topics for each of the stakeholders was developed and sent to 11 leading cacao associations and organizations in Indonesia, representing the stakeholders. Nonetheless, only three respondents filled out the questionnaires (<30% of the total respondents). This lack of response could depend on the respondents' data confidentiality considerations, as well as on the bureaucracy in requiring each respondent's Board of Directors approval.

Within these three respondents, a respondent filled the survey forms for all the three stakeholders in the industrial processing section (SME Owner, Worker, and local community). Overall, two survey forms from cultivation process and three survey forms from industrial processing were collected. The data quality of the five survey forms were then measured and shown in Table 2. Based on the Table, it can be concluded that most of the survey only provides qualitative data to answer the social topics. Some of them provide some quantitative data but not a sufficient amount needed for the quantitative assessment.

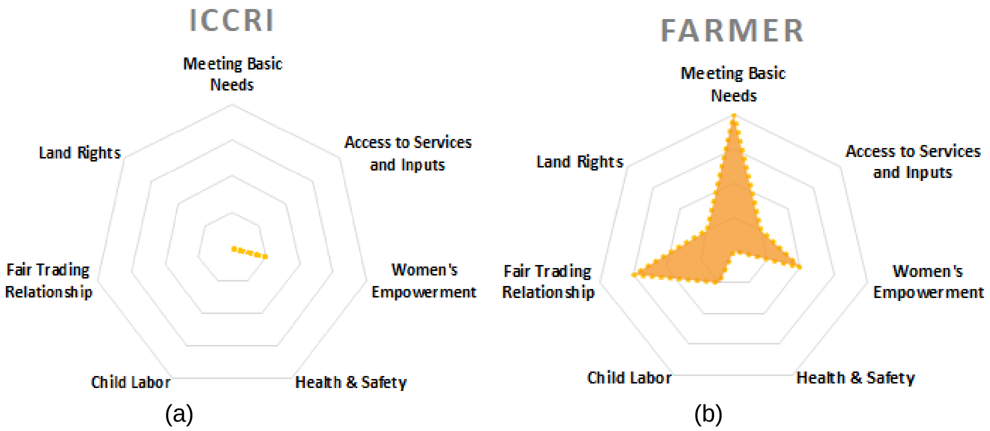
Table 2: Quality Data of Survey.

No	Respondent	Location	Process	Basic Needs	Access to Services & Inputs	Women Empowerment	Health and Safety	Child Labour	Fair Trading	Land Rights
1	ICCRI	Oveall Indonesia	Cultivation	n/a	*	*	*	*	*	*
2	Farmer	Kotamobagu, North Sulawesi	Cultivation	**	**	*	**	**	**	**
No	**Respondent**	**Location**	**Process**	**Basic Needs**	**Access to Services & Inputs**	**Women Empowerment**	**Health and Safety**	**Child Labour**	**Fair Trading**	
3	SME	Ngampilan, Jogjakarta	Industrial Processing_SME	**	n/a	**	**	**	**	
No	**Respondent**	**Location**	**Process**	**Health & Safety**	**Remuneration**	**Freedom of Association**	**Work Life Balance**			
4	SME	Ngampilan, Jogjakarta	Industrial Processing_Worker	**	**	*	*			
No	**Respondent**	**Location**	**Process**	**Access to Tangible Resources**	**Community Engagement**	**Employement and Skill Development**				
5	SME	Ngampilan, Jogjakarta	Industrial Processing_ Local Community	n/a	*	**				

Legend

n/a	no information
*	qualitative (a glimpse of program)
**	qualitative & a bit quantitative
***	complete

Based on the collected survey forms, the result of S-LCA in cultivation process from the two respondents are shown in Figure 16. The center of the heptagon indicates the lowest score (-2), the smallest heptagon represents the second lowest score (-1), and the largest heptagon represents the highest score (+2).



Figures 16a and 16b: S-LCA Results in Cultivation Process.

The data gathered from Indonesia Coffee and cacao Research Institute (ICCRI) respondent (Figure 16a) described the overall condition of cacao farmers in Indonesia in the cultivation area. The result shows that social issues on women's empowerment is the only topic that received a score of (-1), a topic linked to women's role in the household and the work environment is recognised and has equal rights and opportunities. Meanwhile, no information was given regarding the fulfillment of basic needs. The result for the remaining aspects shows that no actions (screening, evaluation, monitoring) have been taken to assess the conditions and evaluate improvement opportunities.

On the other hand, data from the respondent from Kotamobagu, North Sulawesi, shows different results. Based on Figure 16b, it can be seen that most of the basic needs required are already met. The respondent described that around 90% of people in the area already have access to clean water and around 50% of people already have access to proper sanitation, despite around 40% of people still suffering from the lack of food availability throughout the year. However, the interventions focused on improving water management, sanitation, hygiene and diverse diets are undertaken and continuously monitored to improve the current situation. In terms of social welfare, the average monthly income of a farmer in the area is around 1.5 million Rupiah. A good fair trading relationship of farmers in Kotamobagu is also depicted, proven with the ability of farmers to obtain price premium and also facilitated in joining cooperatives and farmer associations or groups. While around 40% of farmers are still lacking in understanding the standard quality, price structures, and premium requirements, there are opportunities for improvement in this aspect. Women's role is also recognised in Kotamobagu. Compared to ICCRI results, empowerment programmes or other interventions that focused solely on women are already promoted and carried out in Kotamobagu.

In terms of access to services and inputs, training and support (financial, fertilizer, seeds, etc.) are not given consistently and intensively. Around 20% of farmers are satisfied with the services and inputs offered. However, room for improvements have been identified and evaluated. In Kotamobagu, child labour issues have also been detected. However, no incidents regarding child labour have been reported. Furthermore, the actions to raise awareness of the issue, mitigate the risk of child labour, and support children's school education are already taken. In terms of land rights issue, only 40 % of farmers have already documented their land legally. No special attention is also given in health and safety aspects, proven with only around 10% of farmers have access to adequate PPE. Subsequently, the risks and opportunities for improving working conditions/occupational safety and farmers health are also unidentified.

In the industrial processing section, the results of S-LCA from a respondent representing SME are shown in Figure 17.

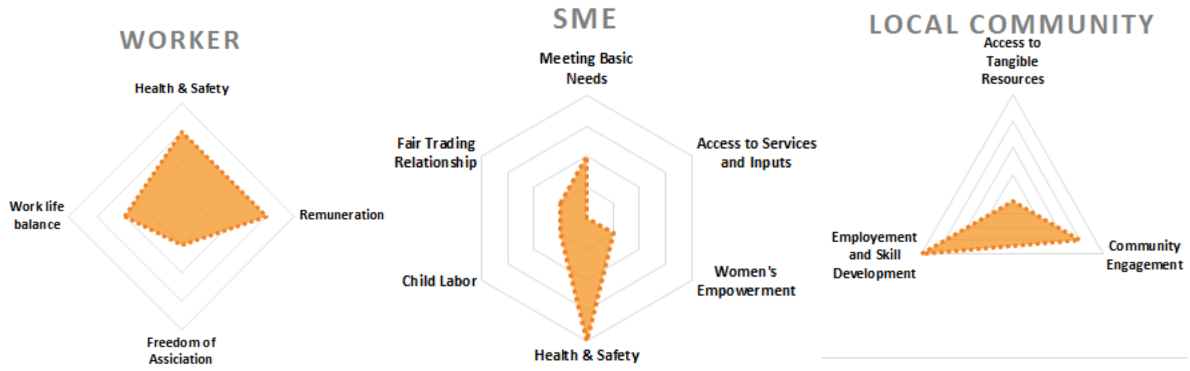


Figure 17: S-LCA Results in Industrial Processing.

The survey result shows that industrial processing (represented by an SME) has given special attention to health and safety as well as the remuneration of the workers. The company complies with health and safety standards or local laws and provides the workers with OHS training and PPE. The occupational health and safety of workers is monitored and the company has recognised the importance of the subject. In terms of remuneration, the wages of workers have met at least legal or industry minimum standards, specifically around 1.5 to 4 million Rupiah. In order to encourage healthy work-life balance, the industry enacts normal working hours in a week, not including overtime, that complies with the law or national standards. There is also a policy on flexible working arrangements/working hours/parental leave for the workers. In addition, to support the fundamental human rights of the workers, the company has a policy that allows freedom of association and collective bargaining but does not however have a system in place to enforce the policy.

The health and safety topic is also the highest score from the SME perspective. It is in line with the worker's social assessment results where the working conditions, practices and progress are regularly monitored. SME also has access to safe water sources, proper sanitation and has a sufficient food supply throughout the year. In the industry, there is around 73% female workers that shows women's role is recognised and have equal rights and opportunities. No child labour is also detected. Regarding access to services and inputs, no information is given from the respondent.

In terms of employment and skill development of local community, the company has committed to grow local employment or at least keep a stable workforce. The company also contributes to skill development in connection to the future need of staffing. Fair working conditions, fair salaries, non-discrimination for workers and grievance mechanism to handle complaints are the focus and commitment of the company. For community engagement, the company has a system or mechanism in place to enforce the policy to address the local community's queries and grievances. The company is also engaging in a dialogue with the community representatives and incorporates their views into management decisions. Meanwhile, no information was given regarding the access to tangible resources.

Nonetheless, the actual social conditions of cacao production in Indonesia cannot be fully depicted from these results due to the lack of primary data collected. However, these results provide partial view that indicate current social conditions in certain areas. women's empowerment, meeting the basic needs, and fair trading relationships are the social topics that have positive performance in cacao cultivation processes, meaning that the minimum standards conditions for those aspects are already met. Meanwhile, no actions (screening, evaluation, monitoring) have been taken to assess the conditions and evaluate improvement opportunities for the rest of the aspects. In industrial processing, health and safety of the workers is the social aspect with the highest performance where the company is committed to protect the workers from hazards and maintain safe working conditions. In addition, good engagement is already built between the company and the local community.

2. Assessment based on Literature Survey

Table 3 shows the summary of quality data from each literature. Out of all the seven social topics, most of the literature has no information regarding land rights, child labour, and health and safety. Meanwhile, for basic needs, access to services and inputs, women's empowerment, and fair trading, several literatures have quantitative data to support the social topics.

Table 3: Quality Data of Literature Review.

No	Literature	Year of Literature	Location	Process	Basic Needs	Access to Services & Inputs	Women Empowerment	Health &Safety	Child Labour	Fair Trading	Land Rights
1	Research by BAPPEDA & ICCRI	2010	District Pidie Jaya, Aceh	Cultivation	**	*	*	n/a	n/a	*	n/a
2	MARS	2011	South Sulawesi	Cultivation	n/a	*	n/a	* (only safety)	*	* (farmer knowledge)	n/a
3	Research by USYD	2012	Polewali Mandar West Sulawesi	Cultivation	**	**	**	**	n/a	**	**
4	Research by NREL	2014	West Sulawesi, South Sulawesi, South East Sulawesi	Cultivation	*	**	**	n/a	n/a	*	**
5	Mondelez	2015	South Sulawesi & Lampung	Cultivation	* (only for nutrition/ foods)	***	**	* (only health)	**	**	n/a
6	Cargill	2016/2017	Indonesia, Pantai Gading, Ghana, Cameroon	Cultivation	*	**	*	* (only health)	*	**	n/a
7	UTZ Evaluation in Indonesia Cocoa Sector	2016	Aceh, South East Sulawesi	Cultivation	n/a	**	*	**	n/a	**	n/a
8	SCPP	2016	Aceh, North Sumatera, West Sumatera, Lampung, Bali, NTB, South Sulawesi, West	Cultivation	*	***	***	* (only health)	*	***	**
9	SCPP	2017	Sulawesi, South-East Sulawesi, Central Sulawesi, Gorontalo	Cultivation	* (only for nutrition/ foods)	***	***	n/a	*	***	n/a
10	READSI	2018	Central Sulawesi	Cultivation	***	***	***	n/a	n/a	n/a	*

Legend

n/a	no information
*	qualitative (a glimpse of program)
**	qualitative & a bit quantitative
***	complete (but not seperated by location)

To capture the trend of the social conditions in cacao cultivation over time in Indonesia, the articles and literatures were reviewed chronologically. The results of S-LCA from the ten articles presented in the periodical order are shown in Figure 20.

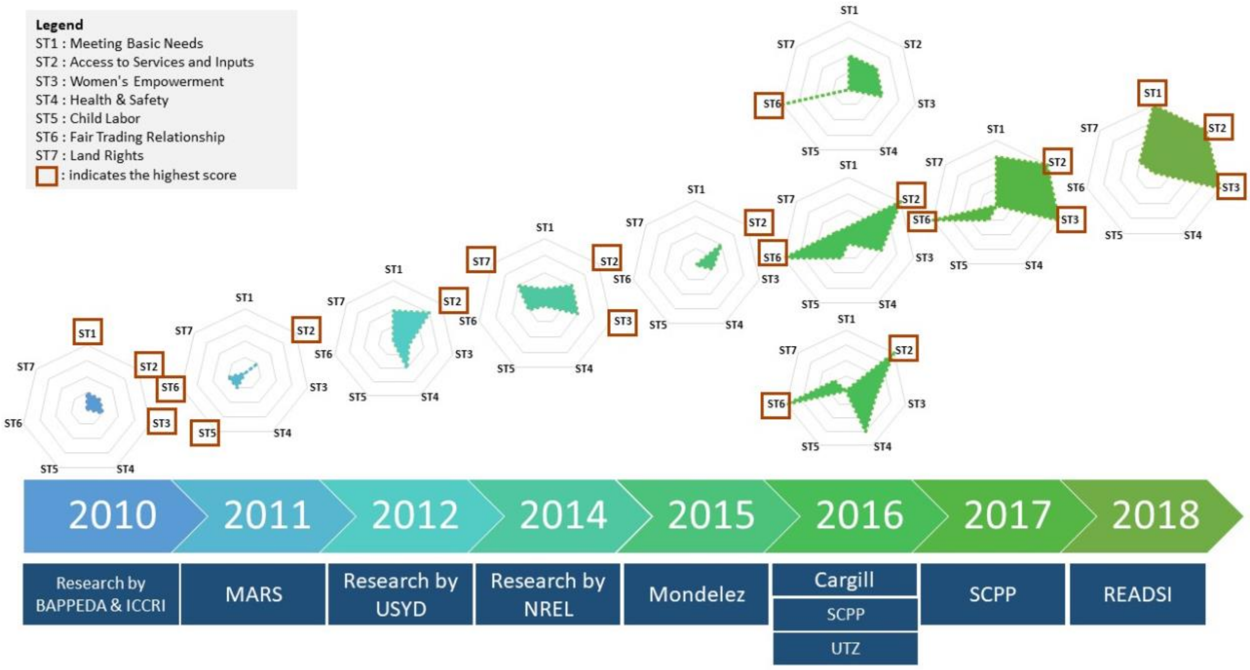


Figure 20: S-LCA Based on Literature Review.

From all of the gathered articles, the earliest study on social condition of cacao cultivation process was conducted by BAPPEDA and ICCRI in Pidie Jaya, Aceh (2010). The study presented mostly qualitative data with some quantitative data on how farmers can access the basic needs. Meanwhile, no data was found on health and safety, child labour, fair trading relationship and land rights issues, which resulted in a (-2) score in the S-LCA for each of the aspects. The aspects of meeting the basic needs, women's empowerment, and access to service and inputs score the highest with a value of only (-1). This concludes that in 2010, 59.61% of household including farmers are still classified as poor where the opportunities for improvement for access to basic needs (water, sanitation, food) have been identified, but no action has been taken. Moreover, no services and inputs were undertaken, and activities tailored specifically for women were not identified.

In 2011, Mars reported its Mars Cocoa Sustainability Initiative (MCSI) (World Agroforestry, 2012) project, a development program for cacao production (mainly in cacao cultivation) focused in South Sulawesi. Overall, the report only presented qualitative data with no information on farmers conditions in meeting the basic needs, women's empowerment, health issues, and land rights, resulting in an S-LCA with (-2) scores in those aspects. Meanwhile, the other three aspects gained a score of only (-1). This also depicts the farmers conditions in South Sulawesi in 2011 had identified access to services and inputs as well as the risk of child labor with no action undertaken, and only few farmers had knowledge on quality standards, price structure, and premium requirements.

Starting from 2012, studies are seen to give significant data especially on the farmers access to services and inputs, which translates that reports on the certification scheme and many cacao production sustainability development programmes are also started to be published. In 2012, researchers from the University of Sydney (Neilson, 2013) reported their pilot survey results that took place in Polewali Mandar, West Sulawesi. The report shows good qualitative data with some quantitative data provided for almost every social aspects assessed, except that no data was available on child labor topic. The S-LCA result shows that the farmers in the area had already good access to basic needs (food, water, and sanitation) as well as personal protective equipment (PPE), with lack of knowledge on premium cacao within the farmers and no land rights were legally documented. Meanwhile, researchers from the National Renewable Energy Laboratory (Moriarty, 2014) conducted a feasibility study of cacao production development project in targeted areas of West Sulawesi, South Sulawesi, and South East Sulawesi in 2014. Overall, the study presents qualitative information on five social topics, leaving health and safety and child labor issues with no data provided. The result of the S-LCA shows that farmers in the area have already been introduced to interventions to access to services and inputs, the role of female workers are evaluated, and most farmers (around 60%) have legally documented their own land.

Simultaneously, Mondelez group had been aiding the cacao farmers in Soppong, South Sulawesi and Lampung, Sumatra. The program, called Cacao Life, was started in 2013 and in 2017 they released their assessment of the project up to 2015 (Jones, 2017). Overall, Cacao Life did not disclose a lot of the actual data. The assessment shows that a lot of of service were given to the farmers, and some implementation of women's rights were in place, and child labour monitoring system was in place for 17 communities as a pilot project.

As seen in Figure 20, three studies that were published in 2016 (Swisscontact, 2017) show that fair trading relationship within farmers has the highest score (+2), which can be translated as the farmers in the study had thoroughly understand about premiums as well as gaining benefits from the scheme. Moreover, the farmers under study had also gained benefits from the services and inputs provided by cacao sustainable development programme(s), and activities focused on developing the productivity of female workers had been established. Looking solely on the report from SCPP (Swisscontact, 2018), it can be seen that an additional score was gained in terms of women's empowerment in the 2017 report. This means that the role of female within the scope of the study area was highly emphasized and support that correlates with this topic was already being monitored. Nonetheless, information and data on child labor and land rights issue still need to be clearly exposed. In 2018, reports from READ project (IFAD, 2019) presents that most farmers in Central Sulawesi had already gained significant benefits from the continuously monitored activities that deal with meeting the basic needs, access to services and inputs (trainings etc.), and women's empowerment. Meanwhile, no information was given in terms of health and safety, child labor, and fair trading relationship issue.

In comparison with the data collected from the survey, the results provided from recently published studies (2016 - 2018) are relevant to the survey data that depicts the condition of the cacao farmers in North Sulawesi, where high positive performances are seen in meeting the basic needs and fair trading relationships aspects. Within the reviewed studies, a high score in access to services and inputs aspect is also indicated as a result of the well-established sustainable cacao development programmes, in which only cover certain areas in Indonesia.

Thus, it could be safe to conclude that the recent studies can be used as indicators, however, cannot provide the full picture of actual social conditions in cacao cultivation process in Indonesia. These reports present the areas that has received interventions. However, for other areas that have not received any interventions, the conditions might be different.

Environmental LCA

To assess the environmental impact of the cacao production we use the EcoInvent database for cacao bean production in Indonesia. A calculation was performed using SimaPro LCA Software. Only 1 impact category is used for this calculation, which is the Global Warming Potential, calculated in kg CO2-eq. Table 4 shows additional data for each literature contained data of production, farmers, income of the farmers, selling price of cacao bean, and environment assessment based on the Global Warming Potential (GWP). The symbol (*) indicates that emission data use Ecoinvent database for 1 kg cacao bean production in Indonesia as general measurement.

The GWP is presented in a functional unit of 1 hectare of land to provide a comparative perspective of per hectare productivity. The results show that only SCPP program calculated the GWP and shared the results in the report. Since others did not provide such information, the calculation is made using the data from the database and calculated based on the production yield per hectare. Further research or primary data collection is required to know the actual value of global warming potential and other impact categories.

Table 4: Additional Data of Literature Review.

No	Literature	Year of Literature	Location	Production (kg/ha)	Farmers (house-hold)	Income (million rupiah/ month)	Selling Price (Rp/kg)	Global Warming Potential	
								(kg CO2 eq/kg)	(kg CO2 eq/ha)
1	Research by BAPPEDA & ICCRI	2010	District Pidie Jaya, Aceh	622	14,602	>4	20,000	41.19*	25,617.28*
2	MARS	2011	South Sulawesi	400	743	>6	n/a	41.19*	16,474.13*
3	Research by USYD	2012	Polewali Mandar West Sulawesi	407	158 people	0.6	18,000	41.19*	16,762.43*
4	Research by NREL	2014	West Sulawesi, South Sulawesi, South East Sulawesi	562	60,000 (target)	1.5-4	18,000	41.19*	23,146.16*
5	Mondelez	2015	South Sulawesi & Lampung	n/a	499	1	n/a	n/a	n/a
6	Cargill	2016/ 2017	Indonesia, Pantai Gading, Ghana, Cameroon	n/a	n/a	n/a	n/a	n/a	n/a
7	UTZ Evaluation in Indonesia cacao Sector	2016	Aceh, South East Sulawesi	675	n/a	<1.5	25,000	41.19*	27,800.10*
8	SCPP	2016	Aceh, North Sumatera, West Sumatera, Lampung, Bali, NTB, South Sulawesi, West Sulawesi, South-East Sulawesi, Central Sulawesi, Gorontalo	729	130,000	n/a	n/a	0.77	561.33
9	SCPP	2017		685	165,000	n/a	n/a	0.77**	527.45
10	READSI	2018	Central Sulawesi	630	45,000	1.5-4	27,500	41.19*	25,946.76*

**) assumes to be same as previous year

VI. Conclusions and Recommendations

This research revealed that numerous policies should be implemented in order to transition monoculture crops to agroforestry systems and to promote agroforestry as a restoration land cover in degraded areas. These policy recommendations primarily aim to achieve the following goals; 1) increase the yields of estate crops, 2) improve the productivity of small-holder farmers, 3) add value in the agricultural value chain, 4) promote sustainable agriculture to ensure long-run livelihoods and protect provision of environmental services.

The TEEBAgriFood Framework outlines a comprehensive method of evaluation of food systems, including analysis of four capitals - produced capital, natural capital, human capital, and social capital - and all the associated positive and negative impacts that arise when changes are made to these capitals. The recommendation of this report is that policies consider the full range of possible impacts from a policy scenario. There are many dimensions to cacao agroforestry that are not explored in this report, such as socio-economic dynamics and farm-level implementation. However, some conclusions can be drawn and recommendations made.

Data and models are available that can help plan the development of cacao production to avoid expansion in areas with potential risk to important ecosystem services such as biodiversity, carbon sequestration and water quality. Results from the spatially explicit scenario analyses illustrate that there may be (spatial) trade-offs and synergies among different ecosystem services. It is important to consider that outcomes on the ground may depend on the type of land cover or land use that cacao is replacing. For example whether cacao is replacing smallholder oil palm in mixed landscapes or large-scale oil palm plantations. The examples presented here show the potential for such analyses.

It is important to consider the potential impacts of future climate change on future cacao production in Indonesia. Bunn et al. (2017) found that climate change is threatening cacao production in areas of Indonesia. Different coping strategies might include transformation out of cacao, fast or incremental adaptation (for example by increasing shading) or expansion into newly suitable areas. These strategies will have different impacts on the environment, the ecosystem services it provides and farmer livelihoods. It is also important to consider the size of the farms that would be targeted by agroforestry policies and how the policies would impact the livelihoods of these farms.

The social condition within the cacao production value chain in Indonesia is evaluated using S-LCA method, with an adoption in methodology and measurements from Product Social Impact Assessment report (Goedkoop et.al, 2018). The results of the S-LCA show that within the cultivation process, cacao farmers have periodical improvements in terms of access to basic needs (water, sanitation, food), good knowledge of premiums cacao, and environment where female workers are recognized and gender equality is encouraged. Information from the best practices in various cacao sustainable development programmes, based on the reviewed articles, show that access to inputs and services (trainings, financial aids, etc.) have also been well-established on areas covered with the programmes. However, critical issues such as child labor and land rights are still rarely evaluated or exposed. In the industrial processing, health and safety topic is seen to have special attention where both workers and SME already had high awareness of safety and hygiene at work especially for the food industry. Moreover, health and safety standards for industrial processing seems to have more attention from Indonesian government and also international company for exporting cacao products rather than in cultivation processing. Nonetheless, the actual social conditions of cacao production in Indonesia cannot be fully depicted from these results due to the lack of primary data collected. However, these results may provide partial view that indicate current social conditions in certain areas.

RECOMMENDATIONS

This report is to feed into a wider (three-year, fully funded) TEEBAgriFood report and implementation of change on-the-ground in Indonesia and as such the project itself will take forward some of the recommendations set out below, particularly on gathering and ground-truthing information. But it is useful to document these recommendations at this stage:

1. On S-LCA: further evaluation and assessment of the actual conditions for all the social topics is recommended to identify improvement opportunities especially critical issues related to child labour, health and safety of the farmers, and land rights.

2. On the current findings of the S-LCA: An intensive program to improve access to services and inputs for farmers only applied on certain areas, and there is an argument that this should be applied evenly in more areas.

3. More primary data is needed to gain comprehensive results that can depict the actual conditions of the stakeholders in the value chain of cacao production especially in pre-processing and industrial processing where no literature was found to describe the social condition in these processes.

4. More detailed classification of spatial imagery that specifically identifies agroforestry and cacao would facilitate spatial modelling of water quality, carbon storage, and biodiversity habitat. These results could in turn permit valuation, specifically, the potential cost or benefit from predicted changes in land cover.

VII. Appendices

Appendix 1: Material Topics to BAPPENAS vs Issue Identified by Cacao Stakeholders

A materiality identification was held within the relevant internal stakeholders of Directorate Food and Agriculture of Ministry of National Development Planning (BAPPENAS). The materiality shows that the main topics to be prioritised will be seven i.e. natural capital, produced capital, human capital, social capital, agricultural and food outputs, purchased inputs, and ecosystem services. The table below summarises by classifying the topics into the important topics for BAPPENAS and issues identified by Cacao stakeholders. The issues identified were captured from direct interviews.

Topic material to Bappenas	Issues Identified by Cacao Sector Stakeholders
Spatial planning for natural capital, i.e. land suitability, land use change	•Land suitability •Land use change and land occupation •Agroforestry - Diversification with forest trees (pine, teak, Albizia Chinensis)
Seed Quality	•Lack of availability of local seeds •Anticipate Vascular Streak Dieback (VSD) (virus) •Anticipate Black Pod (phytophthora fungus) •Anticipate climate change (drought) •Seed productivity •Research and database of seed types vs. taste
Research and Development to improve agriculture production system (for produced capital)	•Application of technology in GAP •Research and database of seed types vs. taste •Waste management and utilisation
Education/Skills for human capital	•Knowledge of Good Agricultural Practice (GAP) •Implementation of GAP •Farmers' assistance/extension (Penyuluh) •Knowledge for Farmers •Aging trees •Pruning •Sanitation (Fungicide Application) •Fertilizer application •Fermentation techniques - increased risk of failure with inappropriate fermentation techniques) •Knowledge for Farmers
Local Spatial Planning for social capital (e.g. availability and distribution of local expertise)	•Aging farmers •Declining number of farmers •Farmers' assistance/extension (Penyuluh)
Soil Quality	•High soil acidity
Infrastructure development	•On-farm post-harvesting facility •Access to tangible resources for farmers (electricity, clean water,

	etc)
Health	•Potential health impact to human (farmers) due to fungicide/chemicals/fertilizer application
	•Health benefit of consumption of cacao - cacao culture
Food Security (Access/Distribution)	•Low income for farmers leads farmers to switch to other crops •Price indifference for fermented cacao on farmer level (no fair trade) •Farmers' assistance/extension (Penyuluh) - low income for extension-
Labour inputs (incl. skills)	•Aging farmers •Declining number of farmers •Knowledge of Good Agricultural Practice (GAP) and application of technology •Implementation of GAP •Farmers' assistance/extension (Penyuluh)
Water Quantity & Quality	•Agroforestry - Diversification with forest trees (pine, teak, Albizia Chinensis)
	•Knowledge of Good Agricultural Practice (GAP) and application of technology
	•Implementation of GAP

Appendix 2: Consultation results

Topic material to Bappenas	**Issues Identified by Cacao Sector Stakeholders**	**Policy Recommendation**
Spatial planning for natural capital, i.e. land suitability, land use change	- Land suitability - Land use change and land occupation - Agroforestry - Diversification with forest trees (pine, teak, Albizia chinensis)	- Spatial planning for cacao cultivation development or expansion - Agroforestry
Seed Quality	- Lack of availability of local seeds - Anticipate Vascular Streak Dieback (VSD) (virus) - Anticipate Black Pod (phytophthora fungus) - Anticipate climate change (drought) - Seed productivity - Research and database of seed types vs. taste	- Seed distribution/logistics - Development of local seeds and evaluation of its environmental impact throughout its life cycle
Research and Development to improve agriculture production system (for produced capital)	- Application of technology in GAP - Research and database of seed types vs. taste - Waste management and utilisation	- Collaboration with academics and research institution - Financial assistance to promote R&D - Best practice from private sectors
Education/Skills for human capital	- Knowledge of Good Agricultural Practice (GAP) - Implementation of GAP - Farmers' assistance/extension programme (Penyuluh) - Knowledge for Farmers - Aging trees - Pruning - Sanitation (Fungicide Application) - Fertilizer application - Fermentation techniques - increased risk of failure with inappropriate fermentation techniques) - Knowledge for Farmers	- Benchmarking with best practise on cacao assistance/extension program - Provide knowledge management tool (digitisation) for smallholder farmers

Local Spatial Planning for social capital (e.g. availability and distribution of local expertise)	- Aging farmers - Declining number of farmers - Farmers' assistance/extension (Penyuluh)	- Price policy for improving farmers livelihood - Development of local education or vocational studies - Proper Remuneration for farmers' extension/ assistance
Soil Quality	- High soil acidity	- Agronomy research
Infrastructure development	- On-farm post-harvesting facility - Access to tangible resources for farmers (electricity, clean water, etc)	- Facility location allocation - Acceleration of Rural Development
Health	- Potential health impact to human (farmers) due to fungicide/chemicals/fertilizer application	- Capacity building and knowledge management to farmers and workers – Farmers certification - Development of Occupational health and safety standards for farmers and workers
	- Health benefit of consumption of cacao - cacao culture	- Establish cacao culture consumption
Food Security (Access/Distribution)	- Low income for farmers leads farmers to switch to other crops - Price indifference for fermented cacao on farmer level (no fair trade) - Farmers' assistance/extension (Penyuluh) - low income for extension-	- Cooperative for farmers to improve the livelihood, knowledge sharing, and bargaining power (BUMDES) - Development of regulation on fair trade - Implementation of fair trading - Pricing policy for premium market
Labour inputs (incl. skills)	- Aging farmers - Declining number of farmers - Knowledge of Good Agricultural Practice (GAP) and application of technology - Implementation of GAP - Farmers' assistance/extension (Penyuluh)	- Cooperative for farmers to improve the livelihood, knowledge sharing, and bargaining power (BUMDES) - Development of local education or vocational studies - Proper Remuneration for farmers' extension/ assistance

Water Quantity & Quality	- Agroforestry - Diversification with forest trees (pine, teak, Albizia chinensis)	- Agroforestry
	- Knowledge of Good Agricultural Practice (GAP) and application of technology	- Life Cycle Assessment
	- Implementation of GAP	- Monitoring
Integration along the value chain	- Unsynchronized information between upstream and downstream (supply and demand) - Data discrepancies and reliability	- Development of mutual business partnership between farmers and private players (such as input suppliers and chocolate manufacturers) - Data tracking and integration

Appendix 3: TEEBAgriFood Evaluation and Implementation Roadmap

1. **Capacity development for implementing TEEBAgriFood**
    - Led by the UNEP TEEB office (Geneva)
    - To develop skills for evidence-based policy generation in agriculture and environment sectors
    - *August 2019 – December 2020*

2. **Rapid assessment policy brief**
    - Led by **Jacob Salcone** and **Jessica Hanafi**
    - Literature review and stakeholder consultation
    - Complete by *November 2019*

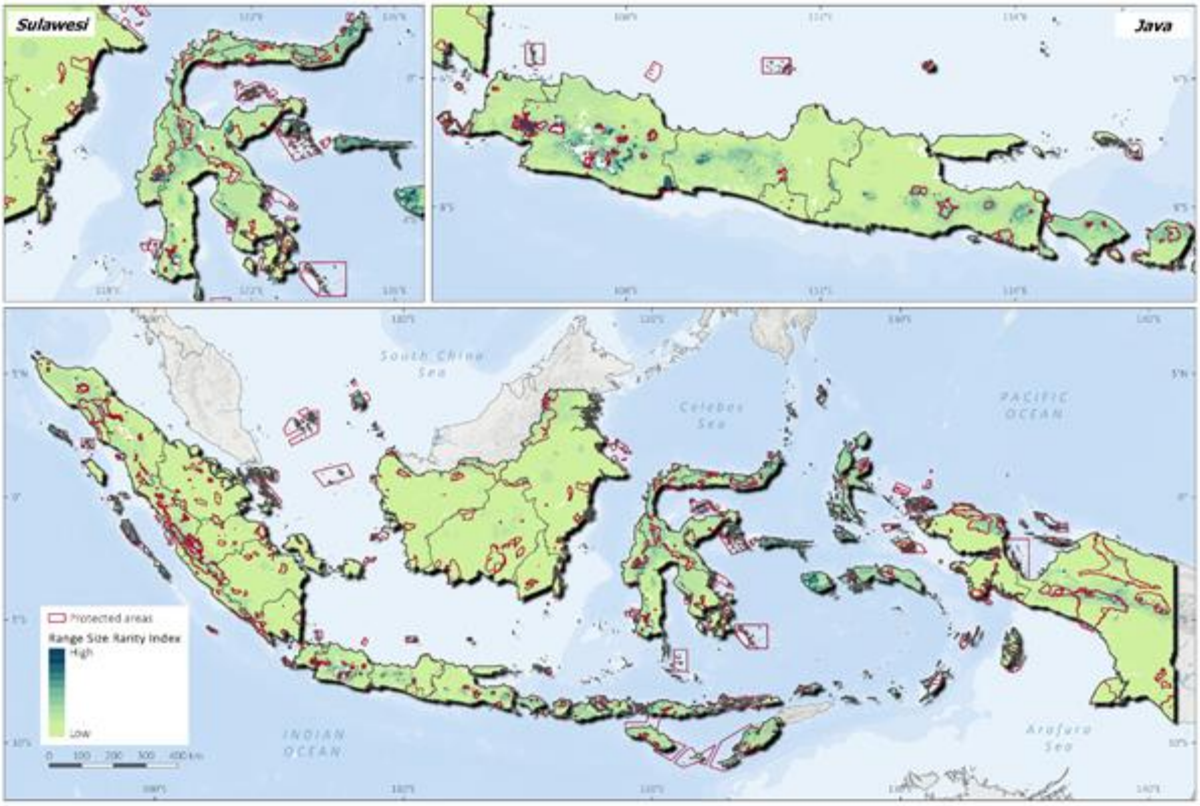
3. **Life-cycle assessment scoping**
    - Led by **Jessica Hanafi**
    - General results by *December 2019*

4. **Landscape level assessment of land use and land cover scenarios**
    - Led by **Jacob Salcone with support from BAPPENAS and WCMC**
    - Modelling and mapping of ecosystem services, focus on transition from monoculture in lowland areas suitable for cacao
    - Complete by *December 2020*

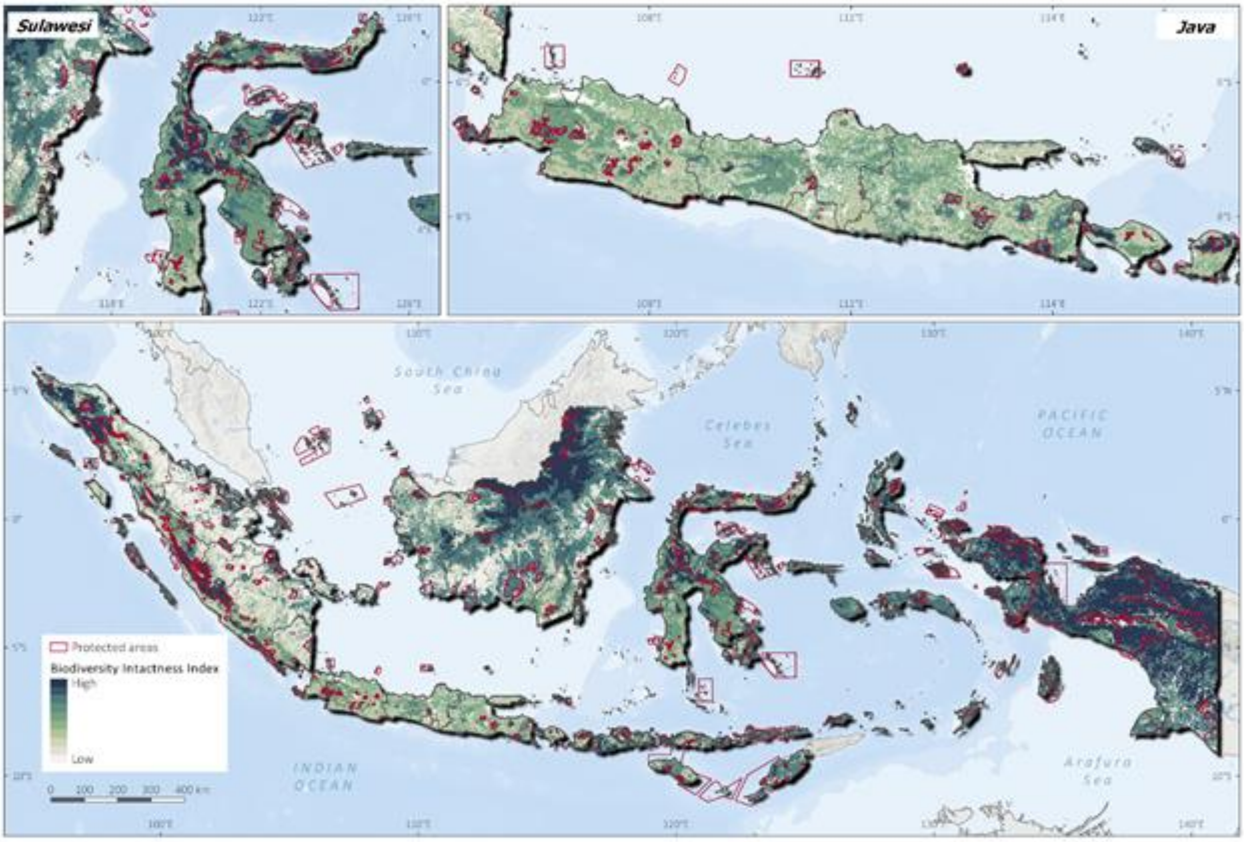
5. **Full TEEBAgriFood farm management practice comparison**
    - Led by **TBD**
    - Results to inform policies for input supports or extension services
    - Complete by *December 2020*

Appendix 4: Additional maps for section IV Spatial Assessment

4.1 Biodiversity in Indonesia



Map 1: Range rarity index for biodiversity for all Indonesia.



Map 2: Biodiversity intactness map (relative to a pristine state) for Indonesia, overlaid with protected areas.

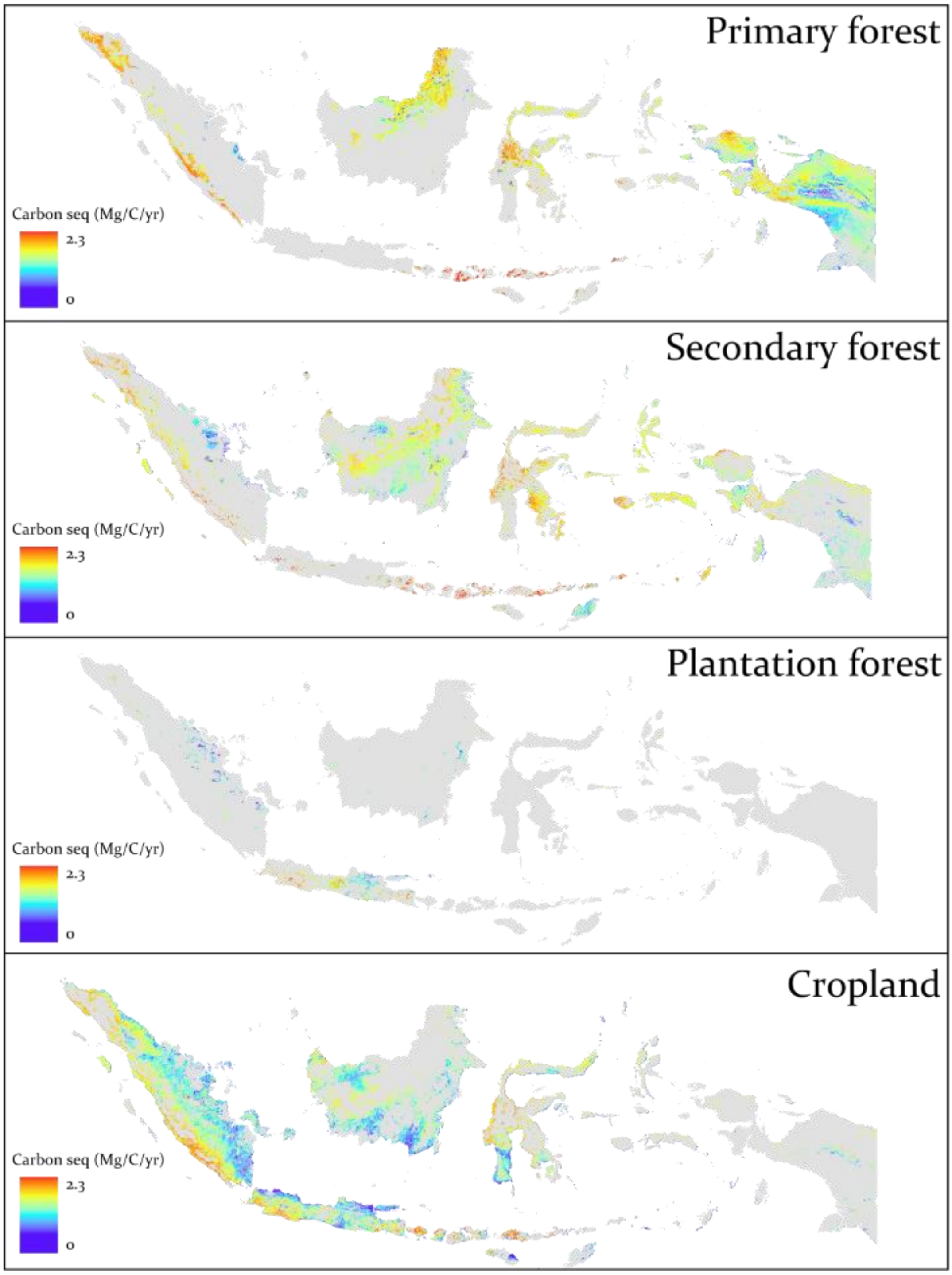
4.2 Maps of ecosystem services by land cover type in Indonesia

1. Carbon stock

Carbon stock includes total above and below ground stocks which were modelled with the Co$tingNature ecosystem services model (www.policysupport.org/costingnature) based on data from Saatchi et al. 2011, Ruesch and Gibbs, 2008, Scharlemann et al. 2009, Baccini et al. 2012. The highest mean values of carbon stock are found in primary forest and plantation forests. However, primary forest encompasses a much larger area (460,000 km2 vs 46,000 km2 for plantation forest). The high values in primary forest are mainly found in West Papua and West Sumatra. Plantation forest has some high carbon stock values in West Sumatra as well. These are mainly the result of high soil carbon.

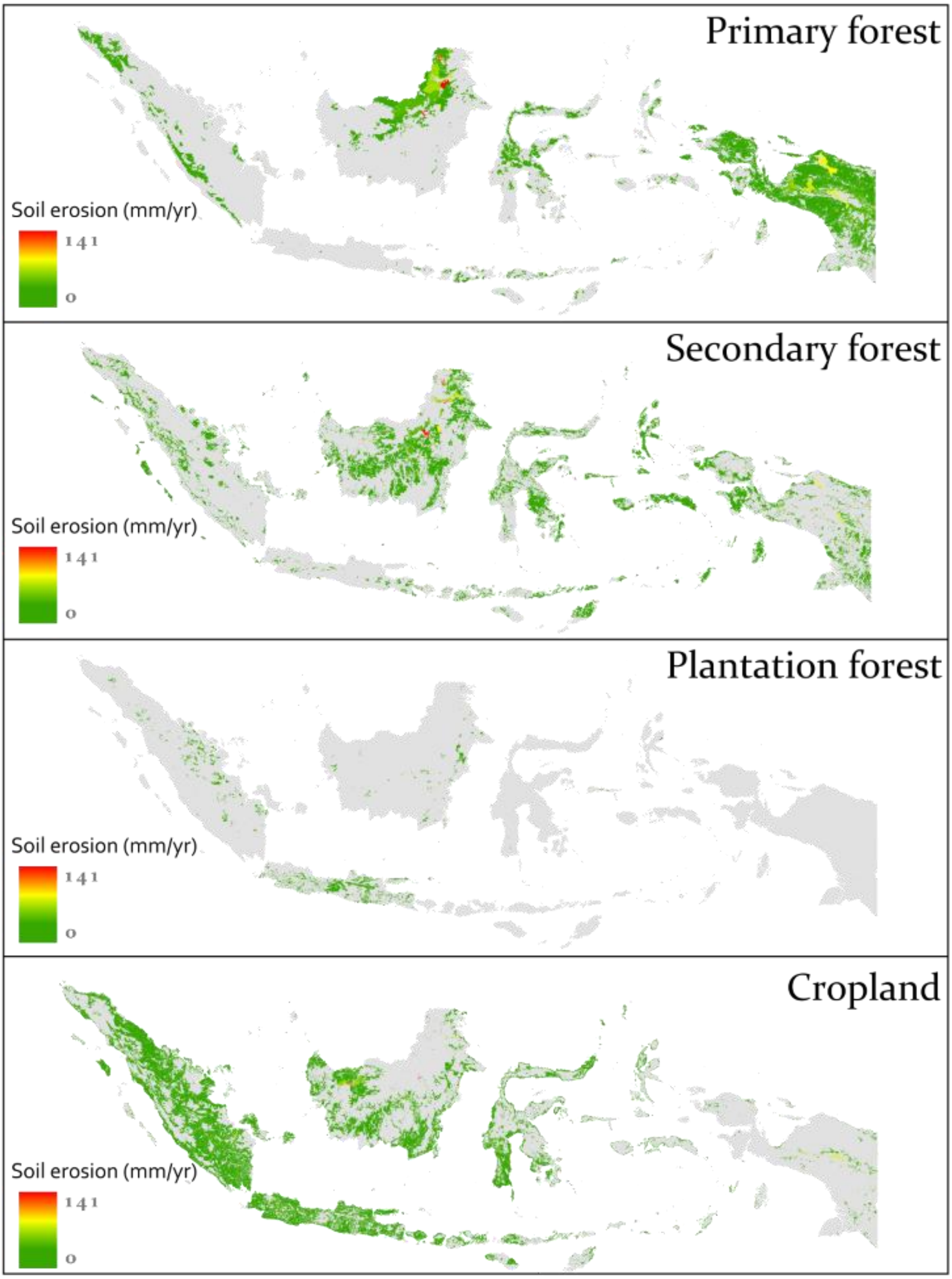
2. Carbon sequestration

Carbon sequestration modelled using Co$tingNature ecosystem services model based on mean dry matter productivity for 2013-2018 from PROBA-V data. Highest mean values for carbon sequestration are also found in primary forest and plantation forest, the latter being more productive but again for much smaller total area than primary forest.



3. Soil erosion

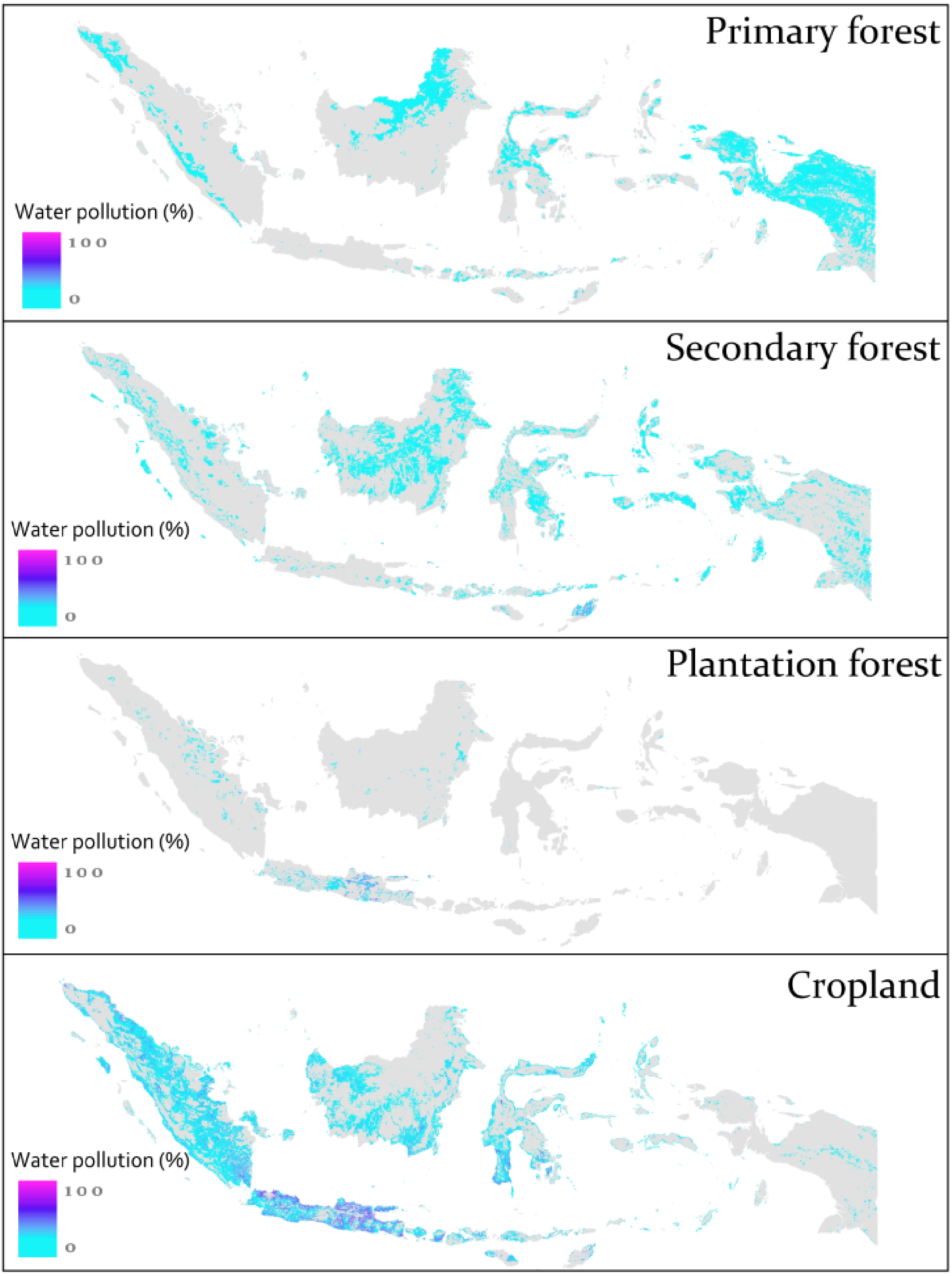
Gross annual soil erosion, modelled using WaterWorld V3 ecosystem services model in mm/yr. Highest soil erosion is found in primary forest, mainly in North Kalimantan and are the result of steep topography.



4. Water quality

Water quality is a metric of potential water pollution defined as the Human Footprint on water quality index, modelled using WaterWorld V3 ecosystem services model (www.policysupport.org/waterworld). This is an index of potential pollution taking into account point (e.g. mines) and diffuse (e.g. agriculture) sources of pollution in combination with a fully distributed hydrological model using downstream routing along a hydrological network derived from the Hydrosheds (Lehner et al. 2008) digital elevation model.

Mean potential water pollution is highest for plantation forest and croplands particularly in South Sumatra and Central Java.



Appendix 5

Table 5.1: Social Topics in Each Process.

No	Social topics	Types of capital	Assets & capabilities
Farmers in Cultivation and Pre-Processing			
1	Meeting basic needs	Human capital	Physical health, ability to work
		Natural capital	Access to water
		Physical capital	Sanitation, water supply system
2	Access to inputs and services	Physical capital	Inputs such as equipment, tools, seeds, information and communication technologies, roads
		Financial capital	Income, credit, trade
3	women's empowerment	Human capital	Skills, knowledge, health
		Social capital	Relationship of trust
4	Child labour	Human capital	Health of children, safety, education
		Physical capital	Schools
5	Health & Safety	Human capital	Physical health, ability to work, knowledge of safety procedures
		Physical capital	Personal protection equipment, quality of machinery or chemicals used
6	Land rights	Natural capital	Land
		Social capital	Relationship of trust
7	Fair trading relationship	Social capital	Relationship of trust to facilitate collaboration, membership of formalised groups, informal networks
		Human capital	Knowledge, education, skills
SME in Industrial Processing			

1	Meeting basic needs	Human capital	Physical health, ability to work
		Natural capital	Access to water
		Physical capital	Sanitation, water supply system
2	Access to inputs and services	Physical capital	Inputs such as equipment, tools, seeds, information and communication technologies, roads
		Financial capital	Income, credit, trade
3	women's empowerment	Human capital	Skills, knowledge, health
		Social capital	Relationship of trust
4	Child labour	Human capital	Health of children, safety, education
		Physical capital	Schools
5	Health & Safety	Human capital	Physical health, ability to work, knowledge of safety procedures
		Physical capital	Personal protection equipment, quality of machinery or chemicals used
6	Fair trading relationship	Social capital	Relationship of trust to facilitate collaboration, membership of formalised groups, informal networks
		Human capital	Knowledge, education, skills
Employee in Industrial Processing			
1	Health & safety	Human capital	Overall health of workers, number of injuries, knowledge of safety procedures, etc.
		Physical capital	Personal protection equipment, quality of machinery, ergonomic furniture
		Social capital	Interactions, office culture, company policies
2	Remuneration	Financial capital	Wages, benefits
3	Freedom of association &	Social capital	Interactions between

	collective bargaining		management & workers, office culture, Relationship of trust
4	Work-life balance	Human capital	Health and ability to work (i.e. no burnouts)
Local Communities in Cultivation and Processing Industry			
1	Access to tangible resources	Physical capital	Basic infrastructure: roads, water supply system, schools
		Natural capital	Land, water, forest, relevant non-renewable resources, ore, oil, gems
		Human capital	Knowledge
		Social capital	Relationship of trust that facilitates cooperation
		Financial capital	Access to financing, taxes from the company or facility that contribute to local economic development, financial infrastructure
2	Community engagement	Social capital	Interactions, relationship of trust that facilitates cooperation
3	Employment & skill development	Human capital	Skills and knowledge

VIII. Bibliography

Abou Rajab, Y., Leuschner, C., Barus, H., Tjoa, A. and Hertel, D. (2016), Cacao Cultivation under Diverse Shade Tree Cover Allows High Carbon Storage and Sequestration without Yield Losses. PLoS ONE 11 (2).

Adam, R. P., Panggeso, J. and Suardi (2017), Analysis of cacao and coconut intercrop farming on production centres in central Sulawesi Province. International Conference on Science and Technology (ICOSAT 2017) - Promoting Sustainable Agriculture, Food Security, Energy, and Environment Through Science and Technology for Development PB - Atlantis Press.

Aidenvironment (2016), Evaluation of UTZ in the Indonesian Cocoa Sector. Retrieved from https://www.utz.org/wp-content/uploads/2016/04/Evaluation-of-UTZ-in-the-indonesian-cocoa-sector.pdf

Anglaaere, L. C., Cobbina, J., Sinclair, F. L., McDonald, M. A. (2011), The effect of land use systems on tree diversity: farmer preference and species composition of cocoa-based agro-ecosystems in Ghana. Agroforestry Systems 81(3) 249–265.

Baccini, A. G. S. J., Goetz, S. J., Walker, W. S., Laporte, N. T., Sun, M., Sulla-Menashe, D., Hackler, J., Beck, P. S.A., Dubayah, R., Friedl, M. A. and Samanta, S. (2012), Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. *Nature climate change*, *2*(3), p.182.

Badan Perencanaan Pembangunan Daerah Kabupaten Pidie Jaya (BAPPEDA)(2010), Kajian pengembangan perkebunan kakao Kabupaten Pidie Jaya. Retrieved from http://www.pidiejayakab.go.id/layanan-publik/download-data/category/1-bidang-ekonomi.html?download=2:kajian-pengembangan-perkebunan-kakao

Barrios, E., Sileshi, G. W., Shepherd, K., Sinclair, F. (2012), Agroforestry and soil health: trees, soil biota and ecosystem services. In: Wall DH (ed) The Oxford handbook of soil ecology and ecosystem services. Oxford University Press, Oxford, 315–329.

Beenhouwer, M. D., Aerts, R. and Honnay, O. (2013), A global meta-analysis of the biodiversity and ecosystem service benefits of coffee and cacao agroforestry. Agriculture, Ecosystems and Environment, 175, 1-7.

Blommer, P. (2011), A collaborative approach to cocoa sustainability. Manuf Confect 91 (5), 19–26.

Bunn, C., Talsma, T., Läderach, P. and Castro, F. (2017), Climate Change Impacts on Indonesian Cocoa Areas. Report for the CocoaLife program. CIAT and Mondelez International. Retrieved from https://www.cocoalife.org/~/media/CocoaLife/en/download//article/Cocoa_Climate_Suitability_Indonesia_2017_CIAT_MDLZ.pdf

Cargill (2018), The 2016/2017 Cargill Cocoa Promise global summary report. Retrieved from https://www.cargill.com/doc/1432099950824/cargill-cocoa-promise-report-2016-17.pdf

Cilas, C., Sounigo, O., Efombagn, B., Nyassé, S., Tahi, M. G. and Bharath, S. (2018), Advances in pest-and disease-resistant cocoa varieties. In: Achieving sustainable cultivation of cocoa. Umaharan Pathmanathan (ed.). Cambridge : Burleigh Dodds Science Publishing, 345-363. (Burleigh Dodds Series in Agricultural Science).

Clough, Y., Faust, H. and Tscharntke, T. (2009), Cacao boom and bust: sustainability of agroforests and opportunities for biodiversity conservation, Conservation Letters 2 (2009), 197-205.

Danielson, J. J. and Gesh, D. B. (2011), Global Multi-resolution Terrain Elevation Data 2010. USGS Earth Resources Observation and Science (EROS) Center. Retrieved from https://www.usgs.gov/land-resources/eros/coastal-changes-and-impacts/gmted2010?qt-science_support_page_related_con=0#qt-science_support_page_related_con

Daymond, A. J., Acheampong, K., Prawoto, A., Abdoellah, S., Addo, G., Adu-Yeboah, P., Arthur, A., Cryer, N. C., Dankwa, Y. N., Lahive, F., Konlan, S., Susilo, A., Turnbull, C. J. and Hadley, P. (2017), Mapping Cocoa Productivity in Ghana, Indonesia and Côte d'Ivoire. International Symposium on Cocoa Research (ISCR), Lima, Peru.

ESA CCI (2015), European Space Agency - Climate Change Initiative Global Land cover map for 2015: via Centre for Environmental Data Analysis. Retrieved from https://www.esa-landcover-cci.org/

FAO/INRA (2016), Innovative markets for sustainable agriculture – How innovations in market institutions encourage sustainable agriculture in developing countries, by Loconto, A., Poisot, A. S. and Santacoloma, P. (eds.) Rome, Italy.

GFW (2017), Land cover map of Indonesia. Data from Indonesia's Ministry of Environment and Forestry for the year 2017. [online], November 2019. Retrieved from http://data.globalforestwatch.org/datasets/land-cover-indonesia.

Gockowski, J., Afari-Sefa, V., Sarpong, D. B., Osei-Asare, Y. and Agyeman, N. F. (2013), Improving the productivity and income of Ghanaian cocoa farmers while maintaining environmental services: What role for certification? International Journal of Agricultural Sustainability, 11(4), 331-346.

Goedkoop, M. J., Heijungs, R., Huijbregts, M. A. J., De Schryver, A., Struijs, A. and Van Zelm, R. (2008). ReCiPE 2008: A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., Jarvis, A. (2005), Very high resolution interpolated climate surfaces for global land areas. Int. J. Climatol. 25, 1965–1978.

Indrane, D. (2017). Small but complex: integrating smallholders within the handbook for product social impact assessments. (Master's thesis). Aalborg University, Aalborg, Denmark.

International Fund For Agricultural Development (IFAD) (2019), Rural empowerment and agriculture development scaling-up initiative supervision report. Retrieved from https://operations.ifad.org/documents/654016/b36a4275-f95a-41a6-93d2-b9b3e07b4f8a

IUCN (2017), IUCN Red List of Threatened Species (2017) Version 2017.3. Retrieved from http://www.iucnredlist.org. UNEP-WCMC and IUCN.

Jones, M., Petrin, R and Scott, L. (2017), Cocoa life: impact in Indonesia. Retrieved from https://www.cocoalife.org/~/media/cocoalife/en/download/article/cocoa%20life%20indonesia%20report_09-28-17.pdf

Jose, S. (2009), Agroforestry for ecosystem services and environmental benefits: an overview. Agroforest. Syst. 76, 1–10.

Lehner, B., Verdin, K. and Jarvis, A. (2008), New global hydrography derived from spaceborne elevation data. *Eos, Transactions American Geophysical Union*, *89*(10), pp.93-94.

Lesiv, M. et al. (in prep.). A global map on human impacts on forests. (In preparation).

Masui, T., Matsumoto, K., Hijioka, Y., Kinoshita, T., Nozawa, T., Ishiwatari, S., Kato, E., Shukla, P. R., Yamagata, Y. and Kainuma, M. (2011), An emission pathway for stabilization at 6 Wm− 2 radiative forcing. Climatic change, 109 (1−2), 59.

Moriarty, K., Elchinger, M., Hill, G., Katz, J. and Barnett, J. (2014), Cacao Intensification in Sulawesi: A Green Prosperity Model Project. Produced under direction of the Millennium Challenge Corporation by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-12-1866 and Task No WFQ9.1017.

Mortimer, R., Saj, S. and David, C. (2017), Supporting and regulating ecosystem service in cacao agroforestry systems. Agroforest Syst, Springer.

Mulligan, M. (2019), Global mean dry matter productivity based on SPOT-VGT and PROBA-V (1998-2018). Available at http://www.ambiotek.com/dmp

Mulligan, M. (2013), WaterWorld: a self-parameterising, physically based model for application in data-poor but problem-rich environments globally, Hydrol. Res., 44, 748–769.

Mulligan, M. A. Guerry, K. Arkema, K. Bagstad and F. Villa (2010), Capturing and quantifying the flow of ecosystem services in Silvestri S., Kershaw F., (eds.). Framing the flow: Innovative Approaches to Understand, Protect and Value Ecosystem Services Across Linked Habitats. UNEP World Conservation Monitoring Centre, Cambridge, UK. ISBN 978-92-807-3065-4.

Namirembe, S., McFatridge, S., Duguma, L., Bernard, F., Minang, P., Sassen, M., van Soersbergen, A., Eyerusalem A. (2015), Agroforestry: an attractive REDD+ policy option? Part of the TEEB for agriculture and food project.

Nasution, S. K. H., Supriana, T., Pane, T. C. and Hanum, S. S. (2019), Comparing farming income prospects for cocoa and oil palm in Asahan District of North Sumatera. IOP Conf. Series: Earth and Environmental Science 260, 012006.

Neilson, J. (2013), Sustainability impact assessment of a certification scheme in the Indonesian cocoa industry: 2012 Pilot Survey Results. 10.13140/RG.2.1.3370.2804.

NewForesight (2013), The 2020 Roadmap to Sustainable Indonesian Cocoa. Final Report Commissioned by the Cocoa Sustainability Partnership.

Nugraha, A., Heryanto, M. A., Wulandari, E. and Pardian P. (2019), Heading towards sustainable cacao agribusiness system (a case study in North Luwu, South Sulawesi, Indonesia), IOP Conf. Ser.: Earth Environ. Sci. 306, 012035.

Ruesch, A. and Gibbs, H. K. (2008), New IPCC Tier-1 Global Biomass Carbon Map For the Year 2000. Available online from the Carbon Dioxide Information Analysis Center [http://cdiac.ornl.gov] Oak Ridge National Laboratory Oak Ridge Tennessee

Ruf, F. (2011), The myth of the complex cocoa agroforest: the case of Ghana. Hum Ecol 39, 373–388.
Schneider, M., Andres, C., Trujillo, G., Alcon, F., Amurrio, P., Perez, E., Weibel, F. and Milz, J. (2016), Cocoa and total system yields of organic and conventional agroforestry vs. Monoculture systems in a long-term field trial in Bolivia. Expl Agric. Cambridge University Press.

Saatchi, S., Harris, N. L., Brown, S., Lefsky, M., Mitchard, E. T., Salas, W., Zutta, B. R., Buermann, W., Lewis, S. L., Hagen, S., Petrova, S., White, L., Silman, M., Morel, A. (2011), Benchmark map of forest carbon stocks in tropical regions across three continents. Proc Natl Acad Sci U S A. 2011 Jun 14;108(24):9899-904.

Scharlemann, J. P. W., Hiederer, R., Kapos, V. (2009), Global map of terrestrial soil organic carbon stocks. A 1-km dataset derived from the Harmonized World Soil Database. UNEP-WCMC & EU-JRC, Cambridge, UK.

Schroth, G., Bede, L. C., Paiva, A. O., Cassano, C. R., Amorim, A. M., Faria, D., Mariano-Neto, E., Martini, A. M., Sambuichi, R. H., Lôbo, R. N. (2015), Contribution of agroforests to landscape carbon storage. Mitig Adapt Strateg Glob Chang 20, 1175–1190.

Sonwa, D. J., Weise, S. F., Schroth, G., Janssens, M. J. J. and Shapiro, H-Y. (2018), Structure of cocoa farming systems in West and Central Africa: a review. Agroforestry Systems (2019), 93, 2009-2025.

Swisscontact (2017), SCPP annual report 2016. Retrieved from https://www.swisscontact.org/fileadmin/user_upload/COUNTRIES/Indonesia/Documents/Publications/Reports/SCPP/SCPP_Annual_Report_2016_Final100517.pdf

Swisscontact (2018), SCPP annual report 2017. Retrieved from https://www.swisscontact.org/fileadmin/user_upload/COUNTRIES/Indonesia/Documents/Publications/Reports/SCPP/Annual_Report_2017_full_-_English_-_Web_version.pdf

TEEB (2018), TEEB for Agriculture & Food: Scientific and Economic Foundations. Geneva: UN Environment.

UNEP-WCMC and IUCN (2019), Protected Planet: The World Database on Protected Areas (WDPA), October 2019, Cambridge, UK: UNEP-WCMC and IUCN. Retrieved from www.protectedplanet.net

Utomo, B., Prawoto, A. A., Bonnet, S., Bangviwat, A. and Gheewala, S. H. (2016), Environmental performance of cocoa production from monoculture and agroforestry systems in Indonesia. Journal of Cleaner Production 134: 583-591.

Vaast, P. and Somarriba, E. (2014), Trade-offs between crop intensification and ecosystem services: the role of agroforestry in cocoa cultivation, Agroforest Syst (2014) 88, 947–956.

Van Beukering, P., Kuik, O. J., and van Drunen, M. (2014), Valuing economic costs and benefits of the supply chain of soy, palm oil and cocoa. Amsterdam: Institute for Environmental Studies, VU University Amsterdam.

Vandermeer, J. H. (2011), The ecology of agroecosystems. Jones and Bartlett, Sudbury.

Wartenberg, A. C., Blaser, W. J., Roshetko, J. M., Van Noordwijk, M. and Six, J. (2019), Soil fertility and Theobroma cacao growth and productivity under commonly intercropped shade-tree species in Sulawesi, Indonesia. Plant Soil.

World Agroforestry Centre (2012), Cacao futures. Retrieved from
http://old.worldagroforestry.org/downloads/Publications/PDFS/B17121.pdf