The Economics of Ecosystems and Biodiversity: Promoting Biodiversity and Sustainability in The Agriculture and Food Sector Through Economic Valuation

Activity 1.2_rev Deliverables Report

Scope Finalization of the Assessment and Scenario Development Options

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A. Scenario development options

We have conducted a series of stakeholder consultations: 1) Consultation with local government, representative of farmer association, private sectors in cacao industry and other related stakeholder. 2). Focus group discussion with cacao farmers from Luwu Utara District. In addition, field visits and literature reviews on the previous study on cacao agroforestry had been carried out. Based on the stakeholder and farmer consultations specified above and also supported by literature reviews, the following information were obtained:

1. Mostly cacao farming in Luwu Utara can be categorized as simple shade-trees or single tree species such as gliricidia, banana or durian or coconut. We called this system as simple agroforestry (SAF)
2. The existence of complex agroforestry (CAF), where cacao is mixed with multipurpose tree species (MPTS), is still rare
3. Previous research on the cacao farming system is dominated by 3 systems, namely cacao monoculture (CM), simple agroforestry (SAF) and complex agroforestry (CAF).
4. Cacao tree density is higher in cacao monoculture than that in cacao agroforestry.
5. Fertilizer use in cacao monoculture is higher than that in cacao agroforestry.
6. Most farmers have carried out tree pruning and have replaced aging cocoa plants
7. Cacao farming is competing with other land uses such as oil palm plantations and rice field development.

Based on this information and in consideration with our causal loop diagram (Figure 1), we have developed scenarios and policy interventions as shown in Table 1, i.e., a) Monoculture cacao in zone < 100 m (free competition with other land-uses such as oil palm, rice field, sagu) (no policy intervention), b) Simple agroforestry cacao (SAF) intercropping with cash and/or food crop in zone <100 m (such as maize, patch oil, etc), and c) Scenario 1 and local government support for development of complex agroforestry cacao (CAF) in social forestry area (>100 m) through PERDA (Local regulation). The SAF is an agroforestry with a single tree species such as gliricidia or banana, or durian and often intercropped with annual crops. Meanwhile the CAF is cacao mixed with multipurpose tree species (MPTS), and is still rare.

Table 1. Development of scenarios and associated policy interventions

Mid-Term Development Plan	Scenario and policy Interventions		Impact driver or dependency	Indicator
Promoting AF through the inclusion of agroforestry and agri-food systems in Indonesia's Mid-Term Development Plan (2020-2024), and within the 2020 Presidential Decree #18.	BAU	Monoculture cacao in zone < 100 m (free competition with other land-uses such as oil palm, rice field, sagu).	1. Household income 2. Soil erosion 3. Groundwater 4. Fertilizer and pesticide use 5. GHG 6. Water quality 7. Wildlife habitat 8. Labor	1. Resilient income 2. Nutrient loss through erosion 3. Groundwater recharge 4. Drinking water pollution 5. Carbon sequestration 6. Health (DALY) 7. Wildlife habitat
	Scenario 1	Simple agroforestry cacao intercropping with cash and/or food crop in zone <100 m (such as maize, patch oil, etc). Policy intervention: Good Agriculture Practices		
	Scenario 2	Scenario 1 and local government support for development of complex agroforestry in social forestry area (>100 m) through PERDA (Local regulation) Policy intervention: Local regulation		

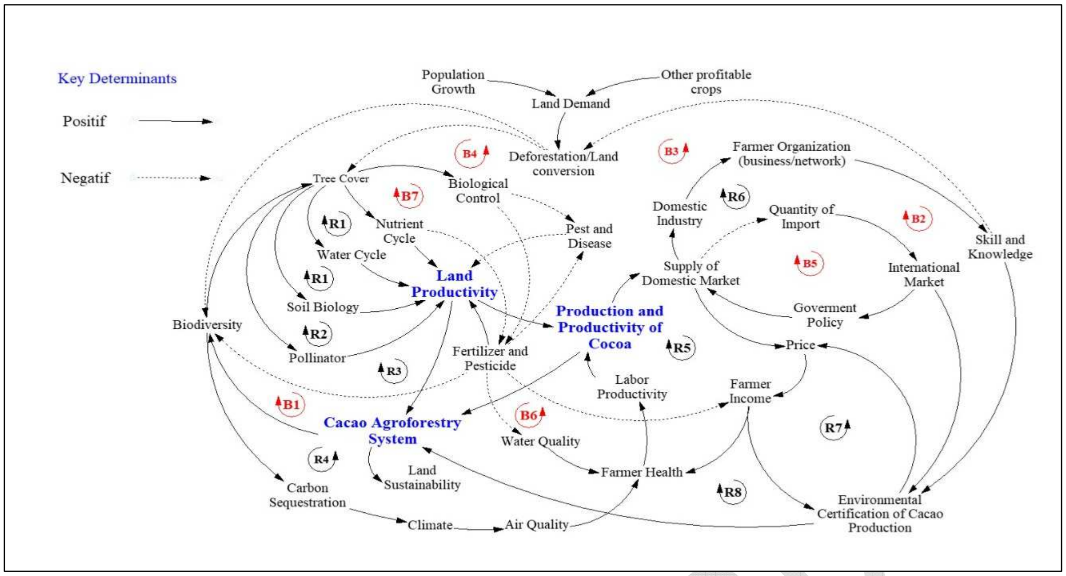

Figure 1. Causal loop diagram of complex agroforestry

The Monoculture and SAF cacao dominates the existing cacao farming in Luwu Utara. On the other hand, complex agroforestry (CAF) is characterized by the existence of more than one tree species (multi-tree species or MPTS) mixed with cacao trees. In the short term, the productivity of the monoculture or the SAF system is better than that of the CAF. Owing to the more diverse trees on the farm, in the long term the productivity of the CAF system is more sustainable than that of the monoculture or the SAF system (Rice et al., 2000; Obiri et al., 2007; Clough et al., 2011; Rajab et al., 2016; Clough et al., 2009; Belsky et al., 2003; Steffan-Dewenter et al., 2007, Johns, 1999). The problem is that most smallholder farmers have a short term view preferring the monoculture system. This preference poses a challenge to the adoption of the CAF system. Therefore, the adoption of the CAF system should be supported by appropriate policy interventions. The incentive in the policy intervention can be in form of: a) providing a high productivity and pest resistance cacao clone, b) providing farming inputs such as seedling for multipurpose tree species (MPTS), fertilizer and pesticide, c) providing training and extension service, and d) strengthening farmer association or cooperation for the implementation of GAP and premium prices. At the moment, the government of Indonesia support the inclusion of agroforestry and agri-food systems in Indonesia's stated in Mid-Term Development Plan (2020-2024), and within the 2020 Presidential Decree #18. This Decree can be promoted as a basis for those interventions.

The following impacts associated with the complex agroforestry cacao can be the reason for the government to support its implementation through various policy intervention:

a) Household income

Mixing monoculture crops with multipurpose tree species in the complex agroforestry system will enhance the resiliency of household income. A study from Niether et al. (2020) showed that despite higher productivity of monoculture cacao, the agroforestry cacao provides higher system yield due to the additional income obtained from multipurpose trees.

b) Sustainable long-term productivity

The complex agroforestry system sustains soil fertility through better soil organic carbon and soil moisture retention, regulate micro-climate reducing stress factors in cacao physiology and consequently sustain long-term productivity (Rice et al., 2000; Obiri et al., 2007; Clough et al., 2011; Rajab et al., 2016; Clough et al., 2009; Belsky et al., 2003; Steffan-Dewenter et al., 2007, Johns, 1999)

c) Nutrient loss through erosion

The complex agroforestry system promotes more diverse tree crops in the field and reduces erosion and nutrient loss (N, P, and Soil C-organik). In addition, higher soil C-organic and higher canopy cover increase carbon sequestration and reduce GHG (Loren and Lal,. Gusli et al., 2020).

d) Fertilizer and pesticide saving and water quality

The complex agroforestry system substitutes some cacao trees with multipurpose tree crops (MPTS). The MPTS is normally coming from fruit tree species and does not require fertilizer application. Consequently, the number of fertilizer used per ha is reduced. The reduction of the fertilizer application will reduce the water pollution caused by N and P nutrients. In addition, the fertilizer application saving will also improve farming benefit

e) Water flow regulation

The complex agroforestry system promotes better vegetation cover, producing more litter which in turn increases groundwater discharge. Better land cover in an agroforestry system can regulate water flow, so the discharge fluctuation during the rainy and dry season can be reduced to avoid flooding during the rainy season and drought during the dry season.

B. Including finance analysis into the scenarios

The CAF's implementation implies cost and benefit, namely: a) associated cost of policy intervention, b) benefit of CAF system (Figure 2). The associated cost for policy intervention can be in form of: a) providing a high productivity and pest resistance cacao clone, b) providing seedling for multipurpose tree species (MPTS), c) providing training and extension service, and d) strengthening farmer association or cooperation for the implementation of GAP and premium prices. Meanwhile, the potential benefit obtained from the CAF's implementation includes: a) additional income from MPTS, b) stable productivity until year of 2050, c) avoided social cost of carbon (USD 70 per tC), c) avoided flood abatement cost, d) avoided water treatment cost, and e) Fertilizer & Pesticides use saving.

Table 2. Structure of cost benefit analysis (CBA) for the time period of 30 years

Cost/benefit		Value (USD)		CAF in Social forest area
		SAF	CAF	
Provisioning	Cacao bean	x	x	x
	MPTS fruits (durian, coffee, etc)		x	
	Labor income	x	x	x
	Total provisioning			
Regulation	Nutrient loss through erosion	x	x	x
	Drink water treatment for removing N and P from water	x	x	x

Cost/benefit		Value (USD) SAF	CAF	CAF in Social forest area
	Groundwater recharge	x	x	x
	Health	x	x	x
	Carbon sequestration	x	x	x
	Total regulation			
Investment	Capacity building/extension		x	x
	Farmer institutions development		x	x
	Total investment			

C. Timeline scenarios

It will be important to identify the trade-offs between multiple timelines in the same scenario, as well as between different scenarios. The implementation of the CAF on the impact indicators shows a different time line (Table 4). The immediate impact can be seen on the productivity indicator. The complex agroforestry system prevents soil degradation, regulates micro-climate reducing stress factors in cacao physiology and consequently show immediate impact on the farm productivity.

Table 3 Expected timeline impact of scenario and the policy interventions

Affected indicators	10 years	20 years	30 years
Productivity	medium impact	medium	high
Flood reduction	low impact	medium	high
Soil fertility	medium impact	medium	high
Carbon sequestration	low impact	medium	high
Health	low impact	low	medium
Household income	low impact	medium	high
P and N removal	medium impact	medium	high

D. TEEBAgriFood Evaluation Framework

The cost and benefit of agroforestry implementation will be analyzed using the TEEB's framework which is a capital-based calculation, namely natural, social, human, produced capitals. For each scenario, stock, flows, outcomes and impact of each capital will be compared (Figure 2).

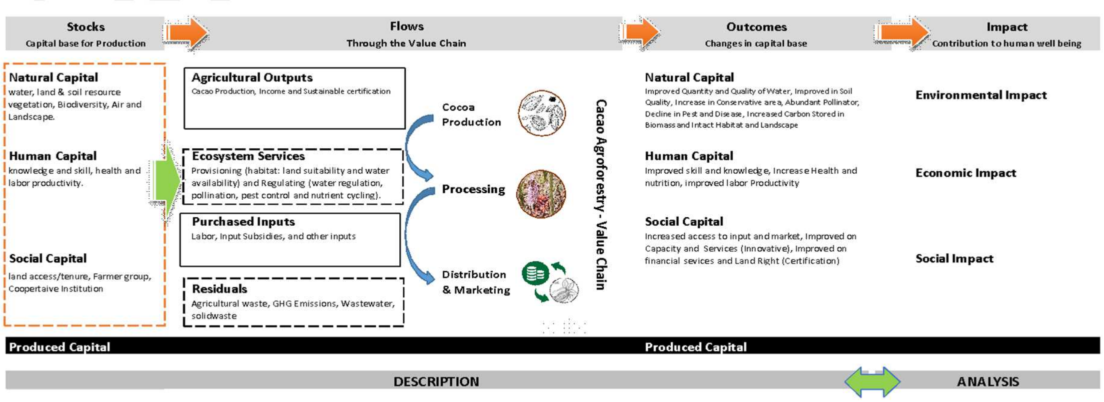

Figure 2. TEEB's Conceptual framework cacao agroforestry system

C1. BAU Condition

In the BAU condition, we will assess stock, flows, outcomes and impact of the monoculture/SAF cacao. The methods and model used in the baseline assessment are described in the Deliverable 2.1

C2. Promoting the CAF and associated policy intervention

In this scenario we assess the cost and benefit of implementing the CAF and associated policy intervention. Some benefits like groundwater recharge can only be assessed on a landscape scale. Therefore, all analyses will be carried out in watershed scale as geographical landscape boundary (Figure 3).

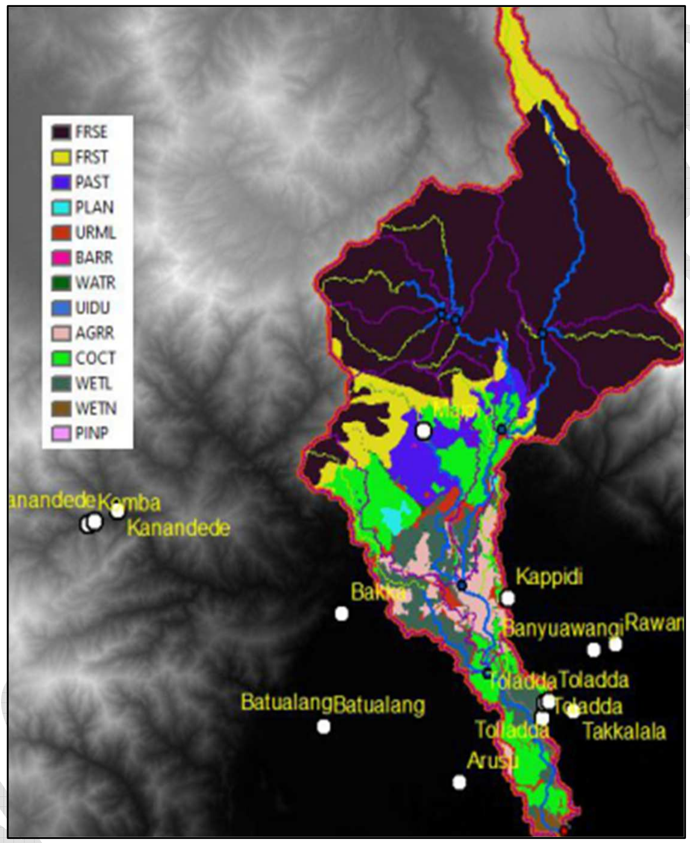

Figure 3. Mambasa watershed in Luwu Utara as a unit to asses the water relatedecosystem services

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