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Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand

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Table of Content

Abbreviations

EGAT	Electricity Generating Authority of Thailand
ES	Ecosystem services
FES	Forest ecosystem services
DDF	Dry Dipterocarp forest
DNP	Department of National Park, Wildlife and Plant Conservation
KMT	Kok Muang Tambon (subdistrict)
MEA	Millennium Ecosystem Assessment
NKPT	Nikom Pattana Tambon (subdistrict)
NTFPs	Non-timber forest products
PES	Payment for ecosystem services
PFES	Payments for forest ecosystem services
PK	Phu Kao
PKNP	Phu Kao – Phu Phan Kham National Park
RFD	Royal Forest Department
RID	Royal Irrigation Department
SAO	Subdistrict Administrative Organization
WTA	Willingness to accept
WTP	Willingness to pay

Project Overview

Project Duration	:	2 years
Funding Awarded	:	US$ 41,000 for Year 1; US$ 41,000 for Year 2
Key organizations involved	:	Institute for Global Environmental Strategies (IGES), Japan (Dr. Jintana Kawasaki, Dr. Henry Scheyvens, Dr. Binaya Raj Shivakoti, Dr. Brian Johnson) Khon Kaen University, Thailand (Dr. Adcharaporn Pagdee) University of Philippines Los Banos, Philippines (Dr. Canesio D. Predo) Papua New Guinea University of Technology, Papua New Guinea (Dr. Cossey K. Yosi) Foundation for People and Community Development, Papua New Guinea (Mr. Stewart Serawe, Mr. Mark Mameek Winai) Asian Development Bank, Philippines (Mr. Isao Endo)

Project Summary

Although it is widely acknowledged that forests provide critical ecosystem services for human survival and well-being, in the Asia-Pacific region forests are being converted to other land uses and degraded at alarming rates. One underlying factor for this destruction of forests is market failure. Forests are cleared for other land uses or degraded because their ecosystem services have no market value. Payments for forest ecosystem services (PFES) have been proposed as a way of overcoming this market failure, but PFES systems have been slow to develop in the region.

This project entitled, "Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand" aimed to strategically generate scientific knowledge on how payments for forest ecosystem services (PFES) could contribute to forest conservation in areas where forests are facing increasing pressures. The objectives of the project were 1. Identify a cost-effective and scientifically robust method to assess ecosystem services; 2. Identify the steps necessary to establish the institutional framework and activity for generating the ecosystem services; 3. Compare and contrast pricing and payment options, both voluntary and compulsory, based on the scientific quantification and valuation of forest ecosystem services; and 4. Strengthen the capacity of the stakeholders for the identification, assessment and delivery of forest ecosystem services. The project explored the potential to develop PFES systems at three research sites - community forest in PNG, sub-watershed forest in the Philippines, and protected forest in Thailand – that offered contrasts with respect to all key elements of PFES, i.e. the type of ecosystem services with potential for payments, the types of buyers and sellers, and the likely payment arrangements.

Keywords: *payment for forest ecosystem services, contribution of forests to climate change mitigation, forest carbon stocks, flood damage mitigation, water shortage damage mitigation*

Project outputs and outcomes

Project outputs:

1. Explored the potential to develop Payments for Forest Ecosystem Services (PFES) system at selected research sites that could deliver sustainable forest management system and conservation;
2. Organized project workshops to share the project objectives and research results and encourage networking across scientific groups, communities, and policymakers in the research sites;
3. Guidelines for establishing payment for forest ecosystem services in the research sites.

Project outcomes:

1. Relevant stakeholders, particularly local communities and government officials in the research sites, were informed about changes of forest ecosystem services and impacts of land-use changes on forest ecosystems;
2. Relevant governmental officials and communities in the research sites became highly aware of climate change impacts, particularly flooding and water shortage risks, and contributions of forests to climate change mitigation;
3. Relevant governmental officials and communities in the research sites were informed about the potential buyers and sellers, and guidelines for establishing the future payment for forest ecosystem services schemes in the research sites.

Key facts/figures

- In the case of Thailand, the finding revealed a decrease in dense forest areas of about 38% between 2008 and 2018 due to agricultural expansion and forest fires. These forest losses will affect the watershed forest structure, forest ecosystem services and the well-being of villagers.
- Payment for Ecosystem Services (PES) is a very new concept for all relevant sectors, from governmental authorities down to local administration and villagers. PES was introduced as an alternative approach for an effective forest projection at the research site in Thailand.
- The findings from the project workshops showed that local administration and governmental authorities, including Nongbua Lamphu Provincial Office of Natural Resources and Environment and Phu Kao – Phu Phan Kham National Park (PKNP), stated their support for the future PES-project development, including funding.
- Estimated amounts of willingness to pay (WTP) from ecosystem services buyer were 114 Baht/month/household (1,370 Baht/year), while the willingness to accept (WTA) from sellers were 206 Baht/month/household (2,477 Baht/year). The imbalance between demand and supply indicated unattainable markets unless financial subsidies are considered.

- In the case of the Philippines, the main causes of forest degradation and deforestation in the research site included a high demand for housing and agriculture and increasing population. Majority of downstream households were aware of the forest ecosystem services, they are currently receiving from the forests in the uplands of the subwatershed, particularly forest products and flood mitigation.
- The respondents indicated that extreme flooding events had caused damages and loss to such community's assets and health. The businesses of some of the household respondents, such as fish farm, rice farm and horticulture and gardening acquired great loss with the maximum of Php 309,250.00. They were also inquired on their suggested adaptation/mitigation measures that could combat severe flooding in their area. Chosen measures included Widening and Dredging of River (45.77%), Waste Management and Community Endeavour and Discipline (27.86%), Reforestation and Forest Protection (24.38), respectively.
- The results of the WTP estimates (Php59, Php71, Php250 and Php710) of the downstream households clearly show that there is a potential of generating funds for the conservation and improved management of forest and agroforest area that will eventually lead to the improved provision of flood mitigation service. However, the expected amounts of WTA from upstream household (PhP 337) were higher than the expected WTP (PhP 59, PhP 71, PhP 250) offered by the service buyers. The results of expected amounts of WTP&WTA must be presented to downstrem and upsteram households of the subwatershed and local government and to discuss the proper the payment levels to be used.
- The finding stated that it is important for the local government units, barangay staffs and the community to have a better understanding on the mechanics of the PES scheme and the benefits of the adopting tree-base system as sustainable forest management measures. Awareness of the farmers on sustainable farming should also be increased through the information and education campaign, in order for them to be more responsible with their actions that could result to externalities on the other parts of the subwatershed.
- In case of Papua New Guinea, commercial logging of Ugalingu forest at current standards will cause considerable harm to flora and fauna, degrade ecosystem services and reduce biomass. To estimate the total area that would be deforested for road construction in Ugalingu forest, the likely area to be cleared for roads in Ugalingu forest is 52.0 ha.
- The results of the sampling from the 12 sample of 35 X 35 m biomass plots were a range from 65.9 to 213.7 t C/ha across the 12 sample plots. The estimate of total avoided emissions over the first 10 years of a PFES project in the research site was 80,670 tCO_2e.
- The finding stated that there was no direct support for a community-based PFES scheme in PNG. PNG's National REDD+ Strategy allows project proposals from landholders, private sector

actors and NGOs; however, they must be able to demonstrate clear competencies within the areas of project development and a strong commitment to the ongoing support and development of communities within the project location, as well as secure long-term financial investment. Projects are also required to ensure that methodologies used for calculating their project-scale forest reference level (baseline) are in line with those used at the national level and that data can support national systems.

- There is a risk that the costs of establishing a PFES initiative could be very high if expertise from outside the country is primarily relied upon for technical inputs and project management. Transaction costs for a PFES scheme to support the protection of forest carbon stocks by the customary landowners from the logging of their forest was US$ 241,000. The average price of forestry and land use offsets traded in 2017 was US $3.2. However, the average price for improved forest management projects, which is more relevant to an avoided logging project, was US $9.32 (ibid.). This latter figure applied to the estimated net avoided emissions by protecting Ugalingu forest from logging generates gross revenue for a PFES project with Ugalingu of above US$ 700,000.

Potential for further work

The project assessed the potential of payment for forest ecosystem services (PFES) and explored the detailed contexts and arrangements in setting the PFES scheme in the selected research sites of three countries. Based on the lessons learned from the research sites, the project drafted the guidebook on design and implementation of payment for forest ecosystem services in the Philippines. This guidebook will be shared with relevance governmental officers and communities. In case of Thailand, although the concept of PFES is new for villagers, local administration, and governmental authorities, everyone wanted to try it. The workshop participants suggested that the first step is to increase understanding and awareness of PES to the locals and relevant sectors, especially villagers. Government authorities and local administrators will also have to understand their roles as a mediator and/or supporter of PES-project development. The village leaders and local government authorities are looking for funds and opportunities to develop the PES project in the research sites.

Publications.

Kawasaki, J. (2019). *Villagers' willingness to pay and accept for forest management of Phu Kao National Park*. Presentation at the workshop on Effective Model for Payment Mechanism for Forest Ecosystem Services in Thailand, 4 July 2019, Kok Muang Sub-District Administration Office, Nongbua Lamphu, Thailand.

Pagdee, A. (2019). *Valuation of ecosystem services from Phu Kao National Park*. Presentation at the workshop on Effective Model for Payment Mechanism for Forest Ecosystem Services in Thailand, 4 July 2019, Kok Muang Sub-district Administration Office, Nongbua Lamphu, Thailand.

Pagdee, A., Kawasaki, J., Phromma, I. (2019). *Payment for ecosystem services of Dry Dipterocarp Forest at Phu Kao, Nongbua Lamphu, Thailand.* Presentation at the 5th Environmental Asia International Conference on "Transboundary Environmental Nexus: From Local to Regional Perspectives", 13-15 June 2019, The Empress Hotel, Chiang Mai, Thailand

Pagdee, A. and Kawasaki, J. (2019). *Forest value and local perception on payments for ecosystem services at Phu Kao-Phu Phan Khaam National Park*, Thailand. Presentation at the 10th International Conference on Environmental and Rural Development, 15 Febuary 2019, Kasetsart University, Sakon Nakhon, Thailand.

Predo, C.D., Kawasaki, J. Macandog, D.B., Brian, J., Endo, I. (2018). *Effective model for payment mechanisms for forest ecosystem services in Philippines*. Presentation at the International Workshop on Advancing Practices in Climate Change Adaptation at National, Local and Sectoral Level, 31 January 2018, Discovery Suites, Manila, Philippines.

Scheyvens, H. (2018). *Methodology for Improved Forest Management project for Ugalingu Forest, Sogeram.* Presentation at the Payment for Forest Ecosystem Services Project Meeting, 9 April 2018, Lutheran Guest House, Madang, Papua New Guinea.

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Effective Models for Payment Mechanisms for Ecosystem Services from the Watershed Forest in Phu Kao-Phu Phan Kham National Park, Thailand

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1. Introduction

Photo 1. Deforested areas in Dan Sai, Loei, Northeast Thailand in 2007

Deforestation in Asia-Pacific countries remains high despite attempts for protection. In Thailand, for example, forest areas decreased from 22.17 million ha in 1961 to 12.97 million ha in 1998 (RFD, 2017). During this 37-year period, rates of deforestation were approximately 2.1% yr^{-1}, peaking in the mid-1970s with annual losses of 6.0% (RFD, 2017).

This trend changed after the DNP started using high-resolution images (Landsat-7 ETM+) at 1: 50,000 scale for forest mapping. The new procedure showed an increase in Thailand's forested areas from 25.3% in 1998 to 31.6% in 2017 (DNP, 2018; RFD, 2017). Agricultural expansion, infrastructure development, urbanization, logging, and NTFP harvesting are among the key drivers of deforestation and forest degradation. However, population growth, social-economic development, national plans and policies on alternative energy, and law enforcement are underlying causes of deforestation and land degradation.

Payment for ecosystem services (PES) has been proposed as an alternative approach for forest protection in many countries. It is derived from a basic economic principle: users pay for receiving benefits, so efficient utilization can be reached. Subsequently, deforestation and land degradation will decrease, so ecosystem service provisions can be assured (Secretariat of the Convention on Biological Diversity, 2010). The concept of PES was introduced to Thailand about two decades ago, in the early 2000s. The Thai government acknowledged PES in the Eleventh National Economic and Social Development Plan (NESDP) B.E. 2555-2559 (A.D. 2012-2016) as one of the key approaches for effective natural resource management. However, it did not mention the need for implementation strategies, rules and regulations, and legal systems to facilitate PES-projects. Lack of legislative support, accountability, and research expertise keep the number of PES-projects in the country at a low level. The majority of them are in the pilot stage.

This research project aimed to implement effective mechanisms for PES-project development in Thailand. Phu Kao (PK) in Phu Kao – Phu Phan Kham National Park (PKNP), Nongbua Lamphu province, was selected as the study site because of these key attributes. First, the forest helps to regulate water systems, which will affect sustainable operation of Ubolratana Dam, the largest dam in northeast, Thailand. It also provides NTFPs for villagers. These ecosystem goods and services are used as common-pool resources by local communities, rather than those being used by individuals on private property, especially private companies. In addition, PK is part of the protected area: PKNP, containing three villages. This situation complicates park management due to overlapping land use rights between the park and farmlands (Phromma et al., 2019). The PK case study will illustrate whether PES-project development is a feasible, efficient, and effective strategy for common-pool natural resource management in protected areas.

1.1 Objectives and scope of the study

The main purpose was to establish effective mechanisms for PES-project development in PK. In doing so, we examined key ecosystem services and their values, local perceptions toward PES, and willingness to participate in PES-project (i.e., WTP and WTA). We aimed to draw policy implications and implementation guidelines for PES-project development at PK. This will be an alternative for effective forest protection, especially in the context of a watershed forest inside a protected area where human settlements exist.

We defined the study analytical framework for PES-project development based on Wunder et al. (2008)'s five key elements of PES[1]. This study focused on water and NTFP provisions and drought mitigation as the key ecosystem services from the watershed forest. Water is used mainly for agriculture and household consumption. For water management purposes, in 2010 Hui Bong Dam was built for irrigation and drought mitigation, especially in KMT and downstream areas. We

[1] The Economy and Environment Program for Southeast Asia (EEPSEA) initiated a pilot research project to examine PES and PES-type projects in five countries: Cambodia, Indonesia, Malaysia, the Philippines and Thailand. Five criteria used to identify and classify PES projects in Thailand was given by Wunder et al. (2008), including: "(1) a voluntary transaction where (2) a well-defined environmental service (ES) or a land use likely to secure that service (3) is being 'bought' by a minimum one service buyer (4) from a minimum one service provider (5) if and only if the service provider secures service provision (conditionality)."

identified people of KMT as the main beneficiary of the study's target group. KMT consists of nine villages, seven located on the outskirts of PK, and two situated inside the park. Another village inside PK is Dongbak, part of Nikom Pattana subdistrict (NKPT). The seven villages outside PK were identified as service buyers, while the three communities inside the park were considered as service providers. Figure 1 depicts the study's analytical framework for PES-project development in the PK case study.

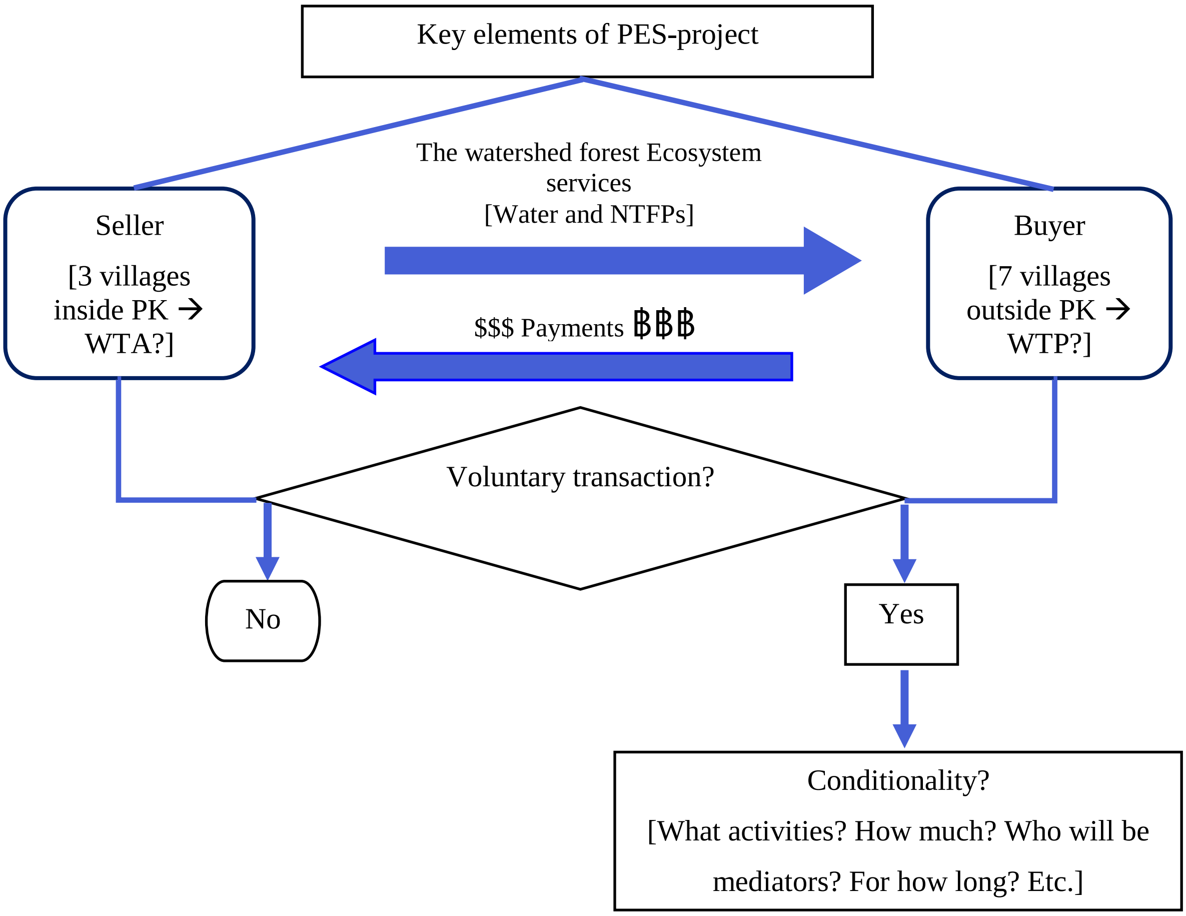


Figure 1. Analytical framework for PES-project development at PK.

1.2 PES scheme and policy context in Thailand

Payment for ecosystem services is referred to as "a *voluntary transaction for an environmental service (or a land use likely to secure that service), purchased by at least one environmental service buyer from at least one environmental service provider, if and only if the environmental service provider meets the conditions of the contract and secures the environmental service provision*" (Wunder, 2005). It is considered as a mechanism that promotes participatory natural resource management that integrates key stakeholders in the implementing site such as communities who protect natural resources, public sector groups that are resource users, and beneficiaries. PES-model development creates collective action through negotiations and design of a market-oriented mechanism that generates tangible economic benefits from natural resource conservation. In a PES transaction, the beneficiary makes a payment or provides another form of reward to the land owner or person – seller or provider, who has the rights to use the ecosystem (e.g., land, freshwater, biodiversity) for managing the ecosystem in a way that helps secure an ecosystem services (UN ESCAP, 2009).

Although PES is not new in Asia and the Pacific, Thailand is somewhat behind other countries in Southeast Asia in adopting the PES concept as an instrument for natural resource conservation. There are a number of activities that involve payments for ecosystem services, but they are missing several elements to be qualified as PES (Nabangchang, 2014). Moreover, many PES projects are just at the design stage, so can only be considered as "PES-like" projects (Jarungrattanapon et al., 2016). Nabangchang (2014) describes common practices of PES- or PES-like projects[2] in Thailand as follows:

1) The projects aimed to reduce environmental impacts/pressures created by local land use activities. By turning local villagers/farmers into service providers, the immediate threats are averted.

2) Ecosystem services providing "life supporting" functions (e.g., supporting and regulating services) are more difficult for the general public to understand and appreciate their connections to daily life activities when compared to provisioning services (e.g., food, freshwater, fuel and fiber). Subsequently, it is not easy to convince the public to participate in PES, especially when direct and short-term benefits are more evident than indirect and long-term ecosystem services.

[2] EEPSEA's pilot project to examine PES projects in Thailand include:

- the PES-like programs for wildlife conservation include: the Mai Khao Marine Turtle Conservation in Phuket province; the Adopting Elephant project; Gaur Conservation of the Khao Pang Ma Conservation Network; the Hornbill Adoption Program in the Budo-Sungai Padi National Park; and elephant conservation by the Elephant Conservation Network in Kanchanaburi.
- The PES-like projects for forest conservation include: a carbon sequestration project in Inpang Community Network in Northeast province (Carbon2Markets Program 2009); the Khlongrua Tree Bank in Chumphon province; and reforestation projects by private companies and state enterprise sectors including Toyota Motor Thailand Co. Ltd, The Coca-Cola Company (Thailand), The Petroleum Authority of Thailand (PTT) Public Company Ltd and the Electricity Generating Authority of Thailand (EGAT).

3) Villagers involved in conservation activities are normally waged workers and do not quite fit the definition of service providers but rather community volunteers or labors, except in the marine turtle and the hornbill conservation projects where villagers are provided with financial incentives. Furthermore, many conservation projects, including PES, are normally initiated by outsiders such as university researchers, governmental authorities (e.g., RFD and DNP) and international organizations (e.g., IUCN and WWF) rather than the community itself. As a result, the projects are usually ceased, especially when the projects' grants end.

4) A number of projects that illustrates all the components of PES are so small. Only Inpaeng Community Forest Network in the northeast was identified. Others are more likely Corporate Social Responsibility (CSR) projects. Despite technical assistances and incentives given to many local communities to engage in similar forest protection activities, the replication of Inpaeng's model elsewhere remains limited.

5) Existing PES-like projects are potential to be developed into PES projects. There are no objections to CSR investments, but since investors do not benefit from ecosystem services that they are paying for, donations are likely to be a one-time investment with no guarantee of continuity in funding.

Among the small number of PES-projects in the country, the majority of them involved forest protection. The Thai government has recognized deforestation as one of the key factors hindering country development so acknowledged it in the NESDP, especially since the 3rd NESDP (1972-1976). Reduction of deforestation, reforestation and forest restoration are among the NESDP main targets (Figure 2). The current NESDP, the 12th Plan (2017-2021), aims to increase the country's forest areas up to 40% by 2020, of which 25% shall be designated as protected areas and 15% as production forests. Different plans target higher numbers. Thailand Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality (1997–2016) aimed to increase forest covers to 50%, of which at least 30% is reserved for conservation forests and 20% as production forests.

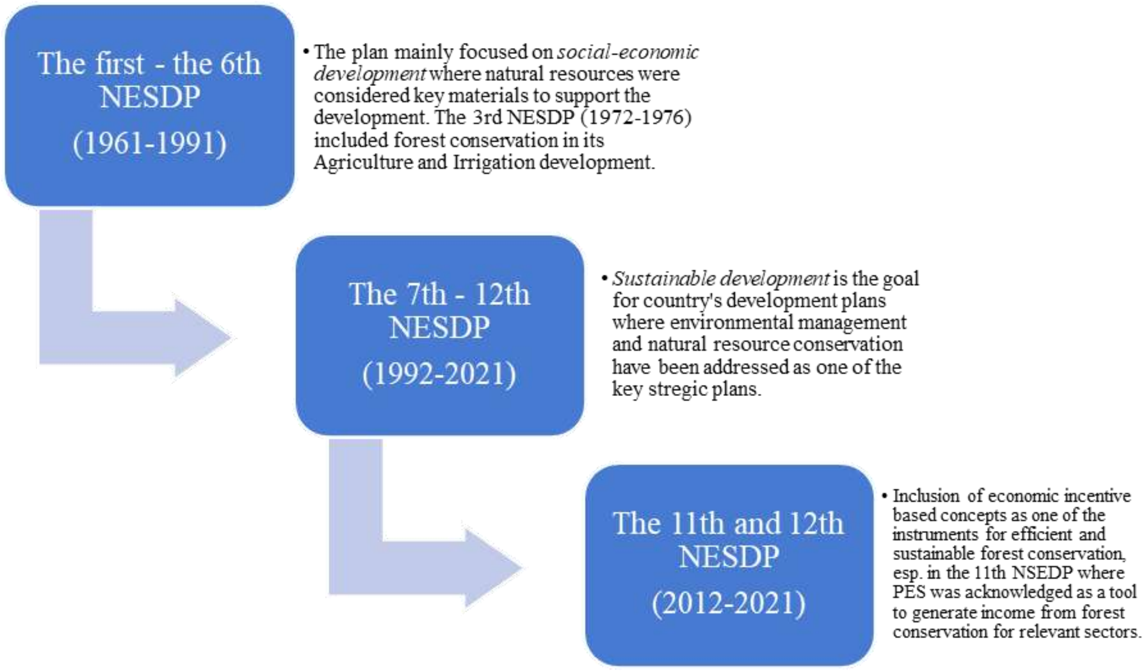


Figure 2. Timeline of Thailand's NESDPs relating to forest conservation and PES.

PES is acknowledged in several national policies and plans as one of the approaches to achieve forest protection targets, especially the 11th NESDP (2012-2016). In Chapter 8 Strategy for Managing Natural Resources and the Environment to Achieve Sustainability, the development guidelines for efficient and sustainable natural resource and environmental management acknowledged PES as a new instrument to generate income from natural resources and biodiversity conservation (page 130, item 5.8.6). The 11th NESDP aimed to include private sectors using forest ecosystem goods and services to involve in forest conservation through supply-demand payments. Although the 12th NESDP does not literally address PES in its development guidelines, economic incentive-based concepts still imbed in several development strategies. For example, Development Strategy 4: Strategy for Environmentally-Friendly Growth for Sustainable Development, development guidelines 3.1 – Conservation and restoration of natural resources and balance between conservation and sustainable use, addresses that economic evaluation of ecosystems is necessary as a baseline for effective conservation, as well as revenue generation in order to improve management efficiency.

In addition to the NESDPs, relating master and action plans e.g., the National Master Plan on Integrated Biodiversity Management (2015-2021) and the National Master Plan for Reduction of Deforestation and Land Encroachment and Sustainable Natural Resource Conservation (2014) have acknowledged PES as a tool for forest conservation. Particularly, the latter clearly states that PES shall be used as a tool for awareness building and public participation in forest protection. However, Thailand does not have a legal framework for PES implementation only relevant laws to specific types of land. Nabangchang (2014) documented that the majority of the PES and PES-like projects in Thailand located on public lands fall under different pieces of legislation e.g., the National Park Act 1961, the National Forest Reserve Act 1964, the Wildlife Protection Act 1992, the Land Code 1954 and the Treasury Act 1975. Moreover, several ministerial orders, rules and regulations grant usufruct rights and responsibilities to various types of public land, including access restriction and penalties for violation. For example, the Cabinet Solution on June 30, 1998 granted usufruct rights for communities settled before national park establishment to continue living in the protected areas. As a result, if PES projects will be developed, some amendments or exemptions are needed to allow service providers (i.e., local communities) to take actions.

2. Methodology

2.1 Overview of Phu Kao – Phu Phan Kham National Park

2.1.1 Location and boundaries

Phu Kao – Phu Phan Kham National Park is Thailand's 50^{th} national park, established in September, 1985. The park locates between latitudes 16° 46' – 17° 02' N and longitudes 102° 24'- 102° 43'E in two provinces in northeast Thailand (i.e., Khon Kaen and Nong Bua Lamphu). It covers approximately 32,200 ha (322 km^2), consisting of three main areas. The northwest section (51% of the park area) is located in mountainous areas, named Phu Kao, encircling an undulating valley. The eastern section (23%) is located in Phu Phan Kham mountain range, stretching north-south and tapering its southern side into a reservoir of Ubolratana Dam. The last section is part of Ubolratana reservoir, covering about 26% of the park area.

The study focused on PK in Nongbua Lamphu province since its watershed forests contribute to Pong River's tributaries i.e., Hui Bong and Lam Paniang. Pong River is where Ubolratana Dam, the largest dam in the northeast, is situated. Moreover, PK represents a unique location to be chosen as a study site. Three villages (i.e., Wangmon, Chaimongkon and Dongbak) were in existence 50 years before PKNP designation occurred. To resolve land use conflicts with park authorities, the government under the RFD authority granted villagers at these locations usufruct rights for their land according to the 1998 Cabinet Solution (June 30, 1998). As a result, villagers were able to use their land for specific, but limited agricultural activities within designated areas (i.e., 1,600 ha inside the national park).

2.1.2 Pong River, its tributaries and Ubolratana Dam

Pong River or sometime called Nam Pong is a tributary of Chi River, the tributary of Mekong River. Pong River Basin covers areas of about 12,560 km^2, partly in the provinces of Petchaboon, Loei, Chaiyaphum, Udon Thani and Khon Kaen (Petr, 1985). Geographically, the basin lies between 16°

and 17°30’ N and 101°15’ and 102°45’ E. The upper part of the basin is mountainous and covered with different forest types, including dry evergreen and dry Dipterocarp forests with shallow, well-drained clayey and loamy soils (Wilk, Andersson and Plermkamon, 2001). Some areas at high elevation are covered with rocks. The lower part consists mainly of paddy fields and is more heavily populated. Its topography is gently undulating and surface soils are mainly sandy loam, with sandy clay subsoils (Wilk, Andersson and Plermkamon, 2001). Five major tributaries, i.e. the Hui Som, Lam Paniang, Nam Pong (including Nam Mo and Nam Phuai), Hui Bong and Nam Choen (including Nam Phrom), enter the reservoir of Ubolratana dam (Petr, 1985, Figure 3).

Nam Pong or Ubolratana Dam impounding the water runoff from the Pong River Basin for power generation was completed in 1965. The reservoir at its maximum storage elevation of 182 m above mean-sea level (MSL) has a surface area of 410 km^2 with an average depth of about 16 m, and the maximum storage of 2,550 million m^3. At its minimum water level of 176 m MSL, its surface area is 160 m^2, and the average depth is about 12 m. The water discharged from the power house, or spilled, enters the Nong Wai diversion which irrigated 500 km^2 of land. In 1983, about 90% of this area was already irrigated (Petr, 1985).

Land surface in the watershed is generally undulating and sloping towards the east and southeast. The elevation of the relatively flat area around the reservoir is about 190 m MSL. The western watershed, from which the Nam Pong and the Nam Phrom originate, consists of many mountain ranges with an average elevation of 900 m MSL, and up to 1,300 m MSL at Phu Kradung. To the east of the western boundary, between the Nam Pong and the Nam Phrom, the Nam Choen originates from Phu Tham Porn, the elevation of which is about 260 m MSL. The Nam Pong and Nam Choen flow eastwards directly into the reservoir, while the Nam Phrom merges with the Nam Choen before discharging into the reservoir. In the north are mountains with the elevation of about 540 m MSL. The Lam Paniang originates from the western region of Phu Phan and flows southwards into the reservoir. The southern watershed boundary at Phu Khieo has an elevation of up to 1,000 m MSL (Figure 3).

The Ubolratana Reservoir is relatively shallow with a depth ranging from less than one meter to 20 m. The inundated land was mostly rice paddies interspersed with shrubs and trees. The downstream and the irrigating areas are level to gently undulating. The elevation ranges from 153 to 200 m MSL. Ubolratana Dam was Thailand’s first multipurpose dam constructed in 1960. It has been operating in generating electricity at the rate 55 mil. kWatt per hour (EGAT, 2017). The Dam provides water for irrigation via Nong Wai diversion built in 1987 approximately 35 km downstream of Ubolratana Dam to distribute water to irrigated areas. Nong Wai diversion receives raw water mainly from Ubolratana Reservoir (storage capacity 2,263.60 mil. m^3) where its recharge is approximately 14,000 km^2.

Irrigated areas cover approximately 418.14 km^2 (Royal Irrigation Department: RID, 2017b). Finally, the two dams also help prevent floods for communities and farmland downstream.

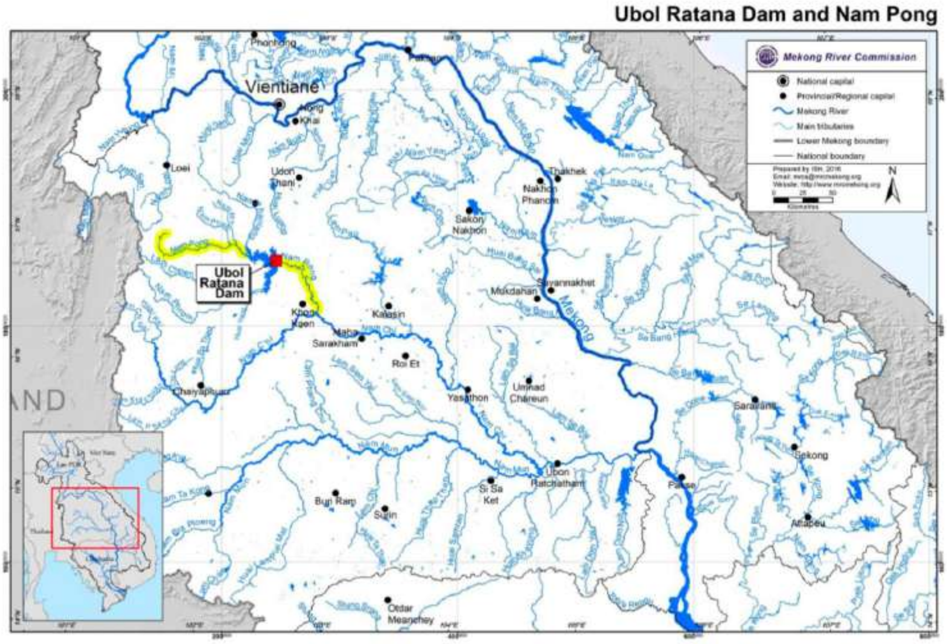


Figure 3. Locations of Pong River, its tributaries and Ubolratana Dam.

(Source: Praivan Limpanboon and Waranya Pimsri, 2015. RSAT Assessment of Ubolratana Dam in the Nam Pong river basin Khon Kaen, Thailand: Rapid Basin-wide Hydropower Sustainability Assessment Tool)

2.1.3 Habitats and vegetation

Phu Kao – Phu Phan Kham National Park consists of diverse landscapes, including sandstone mountains, undulating valleys, and vast floodplains of the Pong River. PK is among the important fossil sites where dinosaurs were discovered, dating from the Mesozoic era. It is promoted as one of Nongbua Lamphu's tourist attractions, especially PK dinosaur museum (Photo 2) and water-based recreation at Hui Bong Reservoir. PK's forests consist of class 1A, 2A, 3A and 4A watershed forests (Nongbua Lamphu Provincial Offices for Natural Resources and Environment, 2018). These watershed forests are designated and classified into different classes according to their locations, terrain and slope, and possible access by villagers. The watershed forest class 1A is the most pristine forest, locating in high terrains with limited access, followed by 2A, 3A and 4A, respectively.

Photo 2. Phu Kao dinosaur museum, one of the provincial tourist attractions.
(Picture courtesy: Issara Phromma)

Major vegetation includes dry Dipterocarp forest (DDF), covering approximately 70% of PK, followed by mixed deciduous forest and dry evergreen forest (Table 1; PKNP, 2017). The typical forest structure is open-like canopy with maximum of three forest layers – tree canopy and undergrowth flora. The averaged tree density was 1,416 tree ha^{-1}, and the mean total basal area was 20 m^{2} ha^{-1} (Popradit et al., 2015b). The forest floor is occupied by dense grasses and perennial herbs, especially Pek (*Vietnamosasa pusilla*), cycads (*Cycad sp.*) and Siam tulips (*Curcuma spp*.), which greatly adapt to wildfire prone habitats. These plants have underground rhizomes so preventing them from being burned by wildfires that occur almost every year (Photo 3). The PKNP's fire control station recorded 142 fires during 2010-2017, caused damage to approximately 336 ha of forest areas (Figure 4). Fire seasons usually start in January and continue on until April. Harvesting of NTFPs and slash and burn are considered the major causes of wildfire, especially slash and burn since it can damage vast areas of the forest (PKNP fire control station, 2018: unpublished data). Meanwhile, villagers believe that NTFPs, especially bamboo shoot, wild vegetables (e.g., *Melientha suavis* or Pak Wan – sweetleaf vegetable in Thai) and mushrooms, will flush when wildfires occur. Some said that it was easy to find NTFPs. Yet, these practices have not been scientifically proven only an anecdotal belief among villagers.

Table 1. Vegetation and biodiversity at PKNP.

Vegetation and biodiversity	Information	Source
Dry Dipterocarp forest	70% of PK	PKNP (2017)
Mixed deciduous forest	10% of PK	
Dry evergreen forest	10% of PK	
Woody plant diversity	148 species	Popradit et al. (2015b)
Plant diversity	159 species	Phromma (2017)
Wildlife diversity	Small number	PKNP (2017)
	At least 43 species of birds	Global Species (2017)
	At least 19 amphibian species and 22 reptiles	Chuaynkern et al. (2011)

Photo 3. An open-canopy of DDF in PK and wildfires observed during the field survey in March 2018.

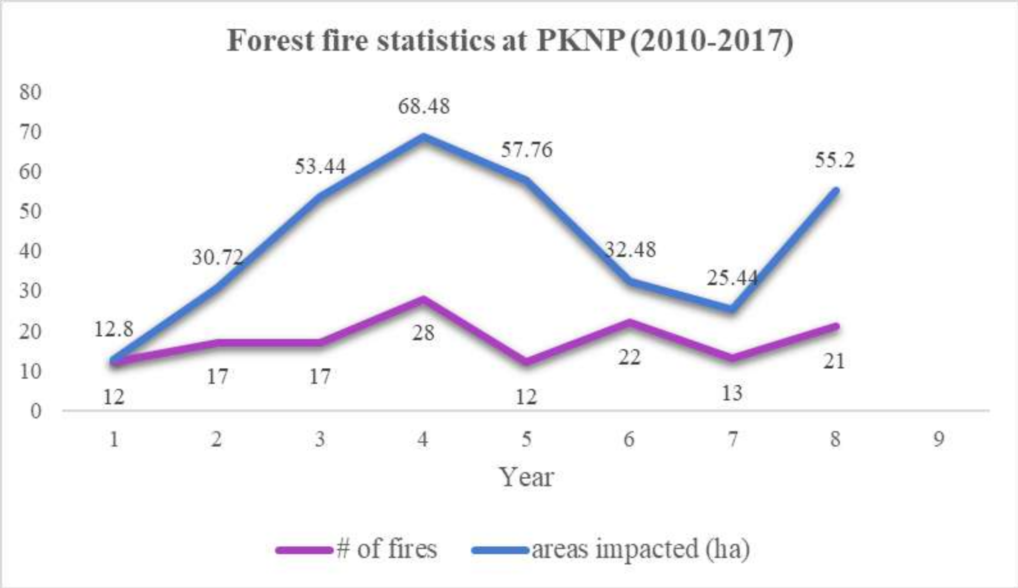


Figure 4. Forest fire statistics at PKNP: fire frequency and areas of impact (ha).

2.1.4 Biodiversity and conservation status

Northeast Thailand locates in a winter dry period climatic region (Koppen-Geiger climatic classification), and its geology is basically formulated with sandstone. These result in small amounts of rainfall, winter drought and limited soil moisture contents, especially in dry seasons, which greatly influence the region's vegetation and biodiversity. Dry Dipterocarp forest dominates the northeast's forests, including PK. It basically contains less biodiversity compared to other forest types. Furthermore, deforestation and habitat destruction at PK, caused by logging concession in the early 1970 before the park designation, illegal logging, agricultural expansion and harvesting of NTFPs, lead to biodiversity loss, especially wildlife.

Popradit et al. (2015b) documented at least 148 species of woody plants from 65 families of which *Cananga odorata*, *Pterocarpus marcocarpus*, *Bauhinia saccocalyx*, *Vitex pinnata* and *Xylia xylocarpa* are the dominant species. In addition, Phromma (2017, unpublished data) recorded at least 159 plant species, including 130 tree species and 29 undergrowth species. According to Popradit et al. (2015b) list of woody plants, two species: *Dalbergia oliveri and Afzelia xylocarpa*, are considered endangered; three species are vulnerable; and five species are listed as near threatened (IUCN Red List of Threatened Species, 2017, Table 2).

Table 2. IUCN Red List of threatened plant species in PKNP.

Status	Number of species	Species in concern
Endangered	2	*Dalbergia oliveri*
		Afzelia xylocarpa
Vulnerable	3	*Dipterocarpus turbinatus*
		Hopea odorata
		Dalbergia cochinchinensis
Near threatened	5	Hairy Keruing (*Dipterocarpus obtusifolius*)
		Gurjan (*Dipterocarpus tuberculatus*)
		Siamese Sal (*Shorea obtusa*)
		Burma Blackwood (*Dalbergia cultrate*)
		Velvet Tamarind (*Dialium cochinchinense*)
Least concern	6	Baing (*Tetrameles nudiflora*)
		Dark Red Meranti (*Shorea siamensis*)
		Sindora siamensis
		Cratoxylum cochinchinense
		Cratoxylum formosum
		Irvingia malayana
no data	132	
Total	148	

Only a small number of wildlife remains in the park due to hunting and habitat destruction (PKNP, 2017). Chuaynkern et al. (2011) reported 41 species of amphibians and reptiles in PKNP. According to IUCN Red List of Threatened Species (2017), the majority of recorded species are considered least concern and 17 species with no data (Table 3). However, at least one species, the Mekong Snail-eating Turtle (*Malayemys subtrijuga*), is considered vulnerable, while two species: Middle Back-stripe Bullfrog (*Kaloula mediolineata*) and Truncate-snouted Burrowing Frog (*Glyphoglossus molosus*), are identified as near threatened. Several factors, including habitat loss and climate change, may play a key role for species decreases, but hunting is the most evident driver pushing these amphibians, especially frogs, into threatened status. Our survey on local use of PK forest products identified that frog hunting is one of the key forest use activities. Not only for household consumption, villagers hunted frogs basically for income generation, making PK a well-known source for frogs in the vicinity and Nongbua Lamphu province.

Table 3. IUCN Red List of threaten amphibian and reptile species in PKNP.

Status	Number of species	Species in concern
Least concern	19	
Near threatened	2	Middle Back-stripe Bullfrog (*Kaloula mediolineata*)
		Truncate-snouted Burrowing Frog *Glyphoglossus molosus*)
Vulnerable	1	Mekong Snail-eating Turtle (*Malayemys subtrijuga*)
Not Evaluated (NE)	2	
No data	17	
Total	41	3

Biodiversity conservation is the park's main responsibility. Existing conservation practices consist of 1) biodiversity protection by laws (e.g., the National Park Act 1961, the Wildlife Protection Act 1992), 2) ecosystem maintenance and reforestation (e.g., check dam construction in the watershed area, reforestation and wildfire management) and 3) community participation in biodiversity conservation (e.g., community volunteer initiatives to help patrol the forest and watch out for wildfire, awareness and capacity building and community forests). Lam Paniang Watershed Management Unit is located in PK and responsible for watershed forest conservation. One of its conservation schemes is building small dams known as "check dams" to slow down runoff so increasing infiltration in the forests. At present, eight check dams were constructed in the watershed forests in PK.

Reforestation is another important activity for ecosystem maintenance and restoration. Particularly, PK was logged during the 1970s, together with deforestation caused by community and agricultural expansions. Reforestation projects are implemented on a regular basis. PKNP Reforestation Unit together with the Forest Development Project from the Royal Initiative are the two main responsible authorities. Approximately 104 ha of deforested areas were reforested, especially in the watershed forests. Local communities e.g., school students, villagers and volunteer groups are also involved in these reforestation projects. In addition to reforestation projects inside the park areas, PKNP also encourages communities to plant trees on public lands, school and farmlands.

2.1.5 Land use pattern and management

Phu Kao was designated as part of PKNP where the forest and biodiversity resources have been protected by laws enforced by the DNP. Intermixed within the park are Phu Kao National Forest Reserves covering approximately 16,500 ha (Nongbua Lamphu Provincial Forestry Office, 2000 cited in Royal Irrigation Department, 2017a). Access to the forest reserves is less restrictive when compared to the park lands due to different rules and regulations. Moreover, approximately 1,600 ha of the park were set aside for agricultural and residential use purposes as part of the 1998 Cabinet Solution to resolve land use conflict with villagers who claimed occupation before park designation. Villagers were granted usufruct rights for their land, so they can use the land for agricultural activities within designated areas inside the national park with a limitation of crop types for planting. Management authority over this area was transferred to local administrative organizations: KMT and NKPT of Non Sang District, Nongbua Lamphu province.

In addition to the 1,600-ha designated area for community use, another 588 ha were allocated for Hui Bong Dam and its reservoir built in 2010 for irrigation and drought mitigation purposes. Popradit et al. (2015a) documented that during the 20 years period (1991-2011) the size of three villages (i.e., residential area) expanded drastically from approximately 9 ha to 123 ha. In 2019 Phromma et al. reported that total residential area remained unchanged. However, satellite image interpretation in 2015 revealed that agricultural areas increased 66.0% from 1,092.2 ha in 2013 to 1,810 ha in 2015. The 2015 record is greater than the 1,600-ha designated area (blue line in Figure 5) with approximately 13.1% of agricultural expansion into adjacent forests i.e., PKNP and PK forest reserve, where protection and management fall under two different authorities, the DNP and RFD, respectively. The majority of land is devoted to cash crop plantations, especially cassava due to small amounts of maintenance and high price. As a result, cassava plantations increased rapidly from 497 ha in 2013 to 1,464 ha (80.9% of total agricultural area) in 2015.

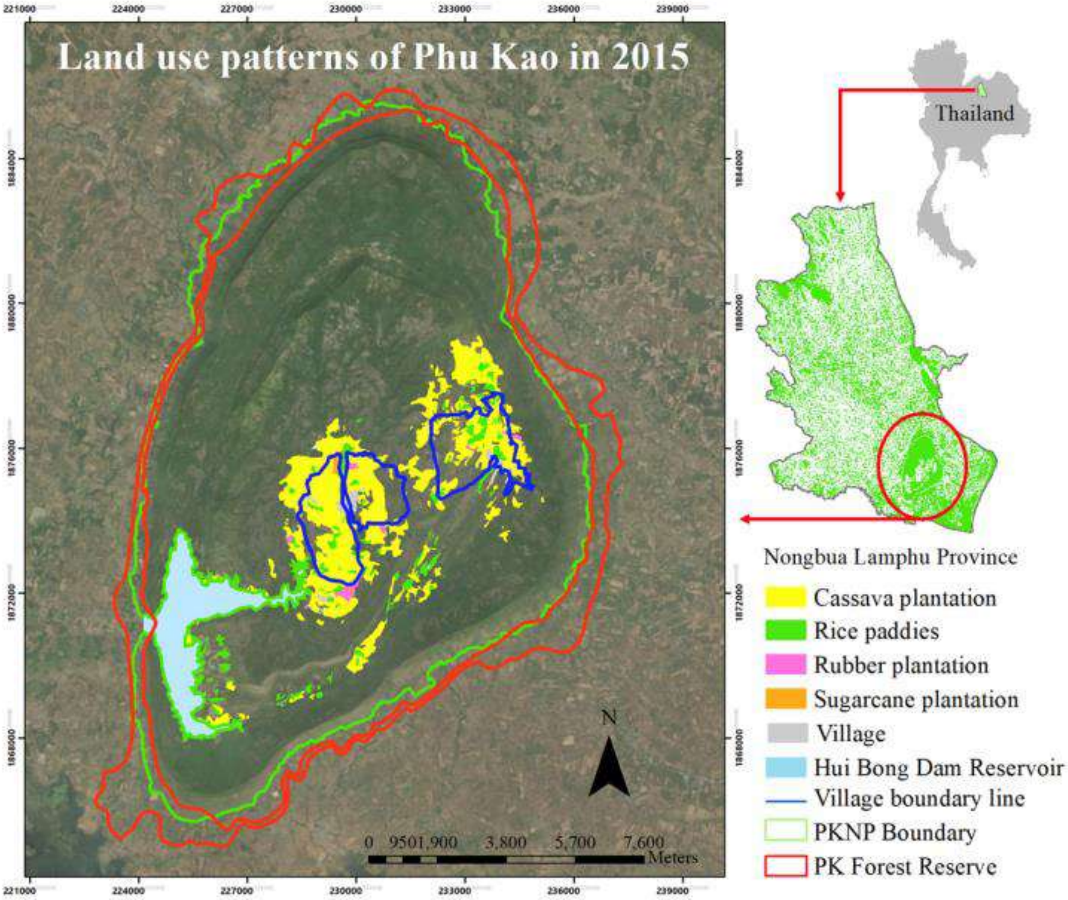
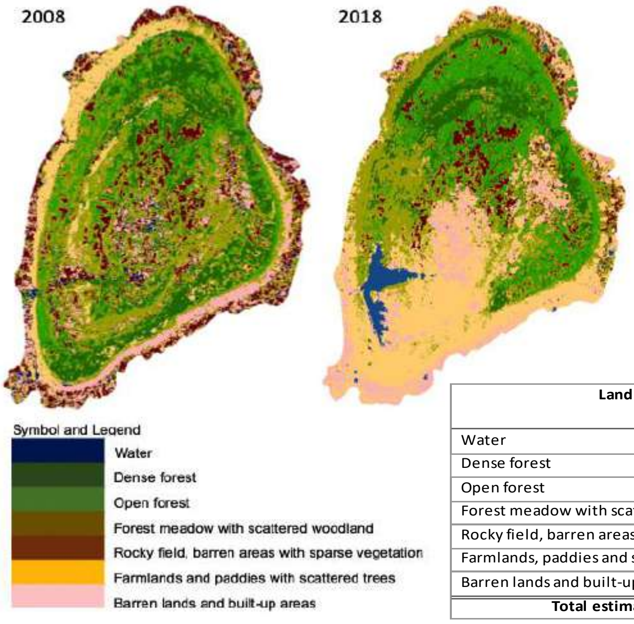


Figure 5. PK's Land use patterns in 2015.
(Source: Phromma et al., 2019)

Moreover, satellite image interpretation (Landsat 7 ETM$^+$C1 Level 1: USGS-EarthExplorer, using ArcGIS 10.4 with a maximum likelihood classification method) reveals approximately 38% decrease in dense forest areas between 2008 and 2018, while open forests and agricultural areas with scattered vegetation increased (36% and 111%, respectively, Figure 6). These land use changes will affect the forest structure, ecosystems services and people well-beings, especially at a local level.



Land use	Areas (ha) in 2008	Areas (ha) in 2018	% changed
Water	516.8	465.1	-10
Dense forest	2,974.9	1,857.3	-38
Open forest	2,398.9	3,271.8	36
Forest meadow with scattered woodland	6,597.9	4,825.9	-27
Rocky field, barren areas with sparse vegetation	2,441.3	1,278.5	-48
Farmlands, paddies and scattered trees	2,698.9	5,699.8	111
Barren lands and built-up areas	1,642.7	1,872.8	14
Total estimated areas	19,271.4	19,271.4	

2008-2018.

(Source: Earth Explorer, USGS)

2.2 Methods

2.2.1 Importance of the watershed forest and local perception toward PES

The study based on field investigations, including questionnaires, key informant interviews and two workshops. The first meeting in March 2018 aimed to create general understanding about the project and to gain community collaborations.

Photo 4. The concluding workshop at KMT SAO office on July 4, 2019

The final workshop on July 4, 2019 was to disseminate the study's findings and obtain community feedbacks on PES-project development and implementation guidelines. Key participants came from various sectors, including 1) local communities i.e., KMT and NKPT administrative organizations and village leaders; 2) governmental authorities e.g., PKNP, Nongbua Lamphu Provincial Office of Natural Resources and Environment, RID and Protected Areas Regional Office 10; 3) the Electricity Generating Authority of Thailand (EGAT); and 4) university researchers.

For valuation methods, we defined water provision and NTFPs as the key ecosystem services from the watershed forest. Two groups of direct beneficiaries of these ecosystem services include: 1) the three villages' members inside PK and 2) KMT's residents living on the outskirts of the park. These local villagers enjoy similar ecosystem services from PK for subsistence. But the group of KMT's villagers outside PK are expected to gain more benefits from the water provision, especially if Hui Bong Dam is fully operated. We estimated villager perceptions toward PES, importance of the watershed forest at

PK for household livelihoods, direct benefits gained from NTFPs and villager's willingness to participate in the PES-project. The first questionnaire was conducted in 2018, aimed at the group of villagers outside PK – the buyer and their WTP for PK forest protection. The survey in 2019 focused on the villagers inside PK – the seller and their WTA.

Following a semi-structured questionnaire, villagers were asked to identify importance of the watershed forest based on a list of key ecosystem services representing all four categories of the MEA's ecosystem service classification. The Likert's scale statements ranging from low to high (1-5 respectively) were used to score the level of importance. Response scores were averaged to identify and rank key ecosystem services that villagers perceived the watershed forest at PK contributing to their households and the community as a whole. For NTFP harvesting, villagers were asked a series of questions, including 1) forest access frequency, 2) harvesting purposes, 3) types and amounts of NTFPs harvested and 4) price and amounts of cash earned from selling NTFPs. Gross amounts of cash benefits earned from selling NTFPs were calculated.

All village leaders and local authorities, including: the head of PKNP, head of Lam Paniang watershed forest station, PKNP officers, KMT's chief executive, chief administrator and representatives, and the representative from EGAT at Ubolratana Dam, were interviewed to obtain information on forest and water resource management plans and policies, their perceptions toward PES, local participation in forest management, and roles of local authorities in forest management. On-site observations accompanied by village leaders and park officers were conducted in all villages. Figure 7 summarizes data collection and valuation procedures.

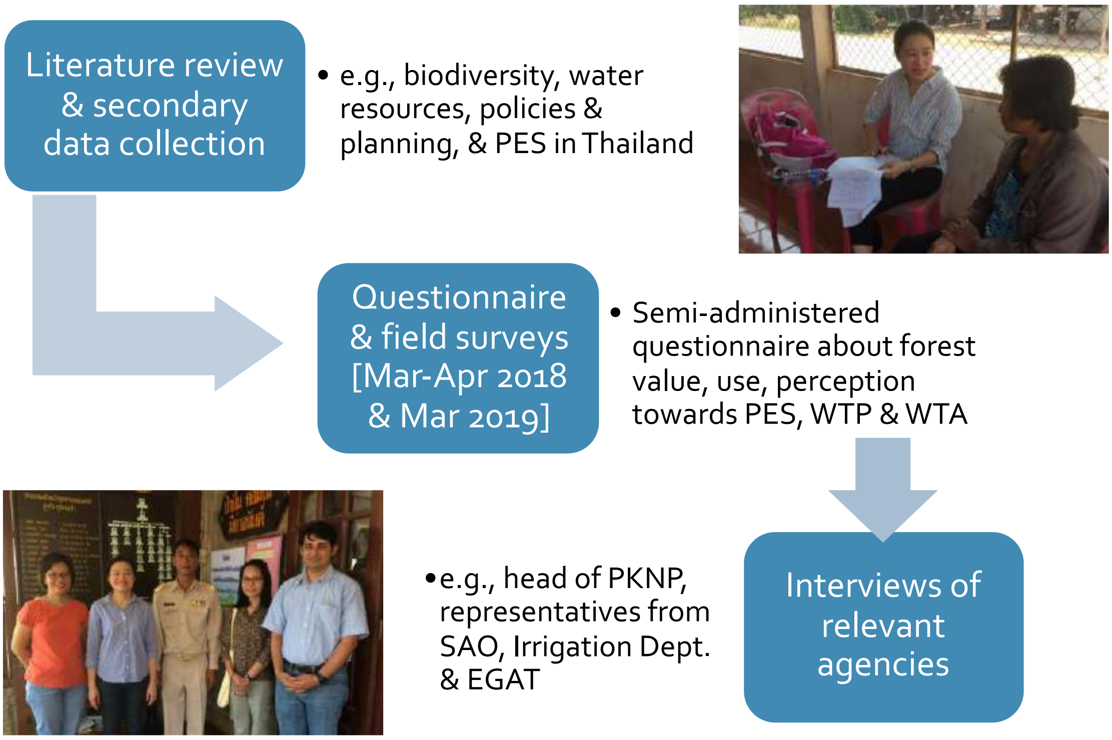


Figure 7. Data collection: key methods and target groups.

2.2.2 Villager's WTP and WTA for PK watershed forest protection

Key steps to develop PES deals include identifying service buyers and sellers, setting the price baseline, negotiating the deal and implementing management activities. Buyers are willing to pay if a service price is lower than inadequate water supply costs. Meanwhile, sellers will participate if a payment from buyers is higher than their forgone income or the costs of providing ecosystem services.

This study applied a Contingent Valuation Method (CVM) to estimate economic value of forest ecosystem services and to measure monetary amounts respondents are willing to pay for drought mitigation through watershed forest conservation. Dichotomous-Choice Approach or Closed-End Question was used to observing the respondent's agreement or refusal to pay an offered amount to conserve the forest. The respondent is only required to answer YES or NO, when asked if the respondent is willing to pay a given amount for drought mitigation. This amount of money is used to finance the cost of forest conservation and management in PK. The YES or NO response and respondents' socio-economic information were used to assess key variables affecting WTP and to estimate a mean value of WTP. In total, 204 household representatives were randomly selected for personal interview about their household socio-economics, perception on drought mitigation benefits from the watershed forest, drought impacts on farm production, and WTP for PK forest protection.

WTP is a maximum amount of money respondents are willing to pay for drought mitigation. A probability for respondents to pay for drought mitigation can be written in a logit model as follows.

$$\text{Prob}(\text{WTP=1}|\text{X}_i, \beta) = \frac{1}{(1+\exp^{-Z})}$$

Where WTP is the respondent's willingness to pay, which is assumed to depend on respondent socioeconomic characteristics (X_i), E is an error term. It is assumed to represent a logistic probability distribution. A WTP equation and variables used in this study are as follows (Table 4).

$$WTP = a + b_1BID + b_2AGE + b_3SEX + b_4NHH + b_5EDU + b_6\ INC + b_7FIC + b_8\ IMPFO + E$$

Table 4. Variables used in the WTP study.

Variables	Variable Description	Hypothesis
Dependent variable		
WTP	A dummy variable for the willingness to pay of the local population to drought mitigation through the PKNP forest conservation (1 = willing to pay, 0= otherwise)	
Independent variables		
BID	Offered bid amount for drought mitigation (THB per month per household)	As bid level increases, household's willingness to pay decreases
AGE	Age of respondents (years)	No priori direction. It is either positive or negative
SEX	A dummy variable for Sex of respondents (1 = male, 0 = female)	No priori direction. It is either positive or negative
NHH	Number of their households (persons)	Households with more household members are less willing to pay due to high level of household expenditure
EDU	Number of years of education (year)	Respondents obtained higher education, understood more the benefits of PKNP forest so were willing to pay more for forest management
INC	Monthly incomes of respondents (THB)	Respondents with higher monthly incomes are more willing to pay for improvement of forest management

FIC	Farm income lost incurred due to inadequate water supply during the past ten years (1 =income lost, 0= otherwise)	Those who had income lost due to inadequate water supply are more willing to pay for the improvement of the forest management
IMPFO	A dummy variable: 1 if the drought mitigation provided by forest is important, 0 otherwise	Those who perceived forest as important for drought mitigation are more willing to pay for the forest conservation of PKNP
E	Error term assumed to be normally independently and identically distributed	

The questionnaire in 2019 focused on WTA estimate with a group of villagers living inside the park. The questionnaire was conducted to estimate monetary amounts of WTA for PK watershed forest protection. In total, 200 household representatives from the three villages inside PK participated in the survey. A probability for respondents to accept compensation for forest conservation can be written in a logit model as follows.

$$\text{Prob}(WTA=1 | Xi,\beta) = \frac{1}{(1+exp^{-Z})}$$

Where WTA is the respondent's willingness to accept payment from buyers, which is assumed depending on their socioeconomic characteristics (X_i), while E is an error term. It is assumed to represent a logistic probability distribution. A WTA equation and variables used in this study are as follows (Table 5).

$$WTA = a + b_1BID + b_2AGE + b_3SEX + b_4NHH + b_5EDU + b_6\ INC + b_7INCF + b_8\ FOBE + E$$

Table 5. Variables used in the WTA study.

Variables	Variable Description	Hypothesis
Dependent variable		
WTA	A dummy variable for WTA for payment from buyers for PK forest conservation (1 = willing to pay, 0= otherwise)	
Independent variable		
BID	Offered bid amount for the forest conservation (THB per month per household)	As bid level increases, household's willingness to accept the payment to decreases the forest use
AGE	Age of respondents (years)	No priori direction. It is either positive or negative
SEX	A dummy variable for the respondent gender (1 = male, 0 = female)	No priori direction. It is either positive or negative
NHH	Number of household members (persons)	Households with more household members are more willing to accept the compensation due to high level of household expenditure
EDU	Number of years of education (years)	Respondents, who are more educated, understand more the benefits of PKNP forest and willing to accept the payment for forest management
INC	Monthly incomes of respondents (THB)	Respondents with higher monthly incomes are more willing to accept the payment for improvement of forest management
INCF	Cash earned from the NTFPs in the last year (1 =cash earned, 0= not earned)	Those who had income from the NTFPs are more willing to accept for the improvement of the forest management
FOBE	A dummy variable: 1 if the NTFPs provided by forest is important, 0 otherwise	Those who perceive forest as important for household incomes and food are more willing to accept for payment for the forest conservation
E	An error term assumed to be normally independent and identically distributed.	

3. Results and Discussion

3.1 Household socio-economics and community livelihoods

Photo 5. The modified pushing tractor attached on the wheel cart used in farming

During the two-year study, we interviewed totally 404 household representatives from 10 villages in KMT and NKPT. The majority of participants were female; averaged age was in the mid-50s; and nearly 50% moved in from elsewhere with approximately 36 years of residency. PK is the protected area with exceptions where local communities established before park designation is allowed to live inside the park. Before designation, a small group of households already settled in the area. In 1970, PK was declared a national forest reserve and logging concessions were granted under a project called "Mai Kraya Loei"[3]. Subsequently, communities expanded, especially from outsiders who worked for the logging companies. It diversified origin of villagers, including those from the central plain, different towns and cities from all over the northeast. This social setting is quite unique from elsewhere in the northeast where nearly all of the locals are native or locally born.

The 10 villages represent a typical rural community of the northeast. Villagers are basically farmers where wage labor is a supplementary occupation, especially during off farming seasons. Household income based on farm production alone is difficult to serve the family needs, forcing farmers to work outside farming to earn more income. Moreover, since the majority of farmers obtain only basic education, they invested on child education, hoping for their children to get high income jobs, especially outside farming. But the investment is high and often puts them into debts.

The two groups of villagers living outside and inside PK shared similar economic conditions. Averaged annual income was 98,659 Baht/household or approximately 8,200 Baht/month of which nearly 6,900 Baht/month went to household spending. Farming was identified as the main occupation but it contributed approximately 40-60% of the household income. Villagers also rely on off-farm activities, including wage labor and money provided by family members working in cities, as additional income sources. Being a farmer is an involuntary response because villagers grew up in a rural community and in a farming family, even though their income sources have shifted. Farming, especially rice cultivation, has rooted deeply in the rural culture and their well-beings.

Average household members were 4.3 of which 2.4 were identified as family labors. The households become more of a nuclear family and often consist of grandparents and grandchildren rather than parents and children. Young labors normally go out to work in a so-called "better and higher income job" in big cities and leave their children in a village with grandparents. We interviewed many families with aging members who no longer work in the farm. This family member combination becomes typical in the northeast rural communities, partly due to growing economy that often comes with economic hardship. Farming could not meet the family end needs. Young labors are forced to

[3]Thailand's logging was classified into two groups according to wood types: 1) valuable wood i.e., teak and 2) other types of wood beside teak called "Mai Kraya Loei."

work outside farming to supply the family with cash income, while the elderly continues working in the farm, basically growing rice for household consumption. The communities at PK have no exception.

Local livelihoods at PK depend on agriculture, especially cash-crop plantations including rice, cassava and sugarcane. Rice is planted basically for household consumption, especially the three villages inside PK due to limited amounts of land suitable for rice cultivation. Home-grown rice helps reduce family spending on rice consumption. It is the key necessity supporting rural families when cash earnings seem to be small, compared to those living in big cities. According to our questionnaire data in 2018, at least half amounts of annual rice production (approx. 1,551.18 kg) would be reserved for household consumption. With average of 40 Baht/kg[4] for sticky rice – the main staple of northeast locals, each household will save up to 62,047 Baht/year from buying rice, approximately 80.5% of their household income.

However, agricultural practices have shifted from those depending on animal and man labors to become more mechanized and realized on hired labor and chemicals due to high market demands for food and energy crops, labor mobilization and ageing. Subsequently, a number of wage labors on farm increased, especially among villagers with limited amounts of farmland. When finish working on their farms, these farmers will normally work as a hired man for others. Average amounts of land owned by villagers outside PK were 2.30 ha and 3.28 ha for villagers inside the park (Table 6). For the group outside PK, 26.5% of the respondents reported having a title deed, 22.4% obtained a certificate of exploitation or Nor Sor-3 K, 3.6% with Sor Por Kor 4-01[5], and 30.9% obtained usufruct rights without any issued documents to prove their holding over the land. Land ownership rights are totally different among villagers inside PK. Nearly all (98.5%) of them obtain only usufruct rights without any issued documents to prove their holding over the land. Yet, this land tenure insecurity may not seem to cause any severe land use conflict now. Villagers still use those lands for their farming. But evidence of agricultural expansion into the park via slash and burn can be observed. Some villagers expressed of land right transfer among villagers.

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[4] Average price was calculated from rice prices retrieved from the Ministry of Commerce i Service. Available: http://www.moc.go.th/index.php/rice-iframe-8.html. Access date: July 4, 2018.

[5] Nor Sor-3 K represents occupancy and use rights of the land for a prescribed time period. Holders of Nor Sor-3 K have the right to use, possess, sell, and/or transfer their land. They can also mortgage the land and apply for a freehold title. Moreover, Sor Por Kor 4–01 holders have possession rights to land allotted by the Land Reform Committee under the Agricultural Land Reform Act of 1975, which aims to address the high rate of tenancy in certain parts of the country, the large number of landless households, and encroachment of public lands for cultivation. Sor Por Kor 4–01 holders are beneficiaries of land allocation, including the right to transfer by inheritance only.

Table 6. Land use and land rights.

Land use and rights	Villagers outside PK (2018)	Villagers inside PK (2019)
1) Amounts of land owned	2.30 ha (n= 188)	3.28 ha (n= 189)
2) Amounts of land leased	1.54 ha (n= 29)	-
3) Types of land rights		
- Title deed	26.5% (n= 59)	-
- Nor Sor 3	22.4% (n= 50)	0.5% (n= 1)
- Sor Por Kor 4-01	3.6% (n= 8)	0.5% (n= 1)
- Usufruct right	30.9% (n= 69)	98.5% (n= 181)
- Land lease with EGAT (EGAT lease)	10.8% (n= 24)	-
- Landless	5.8% (n= 13)	0.5% (n= 1)

Increasing costs of rice cultivation, especially from hiring labors and chemical fertilizer application, influence farmer decisions to shift to other cash crops. Cassava and sugarcane plantations expanded because they required little maintenance with higher monetary returns. Furthermore, the two crops are among the primary cash crops promoted by the Thai government as potential sources of energy under the Alternative Energy Development Plans. Meanwhile, the main reason for villagers to continue growing rice is because it is part of their livelihoods. Rice consumption culture still holds them back from giving up all the rice cultivated areas. Some of the farmers expressed that buying rice might be cheaper and more convenient than continuing growing it. They would have time to do something else that brought more money to the family. Some villagers already lent their rice paddies for others and took some portions of the rice planted as a rental payment.

Another distinctive lifestyle of people in and/or around PK is their connections with the local forest resources. As a non-tangible benefit, villagers expressed their uniqueness as living in a "forest-surrounded community." The watershed forest at PK provides varieties of NTFPs: the important source for food and other basic necessities for the locals. Seasonal food from the forests, specifically mushrooms, bamboo shoot, vegetables, ant eggs and frogs, is considered delicacy and brings people from everywhere to PK for NTFPs harvest. Our questionnaire data reveal that the majority of villagers harvested NTFPs basically for household use, but approximately 20% of the villagers did for income generation. Gross cash-income was estimated 9,321 Baht/household/year or about 10% of the household annual income during 2017-2018.

Photo 6. A road passing through Dongbak: one of the three villages inside PK and its community settings

3.2 Ecosystem services from the watershed forest

PK is part of local livelihoods. It's a life-supporting system that creates forceful forest-people interconnections. Besides substantial benefits from numerous NTFPs and water resources, villagers expressed their uniqueness as living in a "forest-surrounded community." It's the intangible benefit with the highest-ranking score where villagers perceived of receiving from PK (Table 7). They are proud to be called a "PK-resident". Moreover, the watershed forest maintains soil fertility, regulates local climate and water systems, and homes of great biodiversity.

Table 7. Villager perceptions toward importance of PK watershed forest.

Statements	Averaged score of importance (Stdev)*	
	2018 response	2019 response
Provisioning services		
1) A source of NTFPs	**3.85 (0.467)**	**3.72 (0.586)**
2) A water source for farming activities	**3.57 (0.845)**	3.28 (0.924)
3) A water source for household consumption	2.77 (1.158)	**3.30 (0.913)**
Supporting and regulating services		
4) Helps fertilize the soil	**3.67 (0.608)**	**3.59 (0.682)**
5) Helps regulate local climate	**3.57 (0.729)**	3.26 (0.851)
6) Home of biodiversity	3.50 (0.778)	**3.49 (0.723)**
7) Helps improve crop productivity and reduce costs	3.35 (0.869)	3.16 (0.908)
8) PKNP is a watershed of Pong river	3.28 (1.130)	3.24 (1.061)
Cultural services		
9) Makes the local proud of their local uniqueness	**3.91 (0.374)**	**3.81 (0.528)**

10) Provide a local learning site	3.46 (0.738)	3.20 (0.917)
11) Important tourist site	3.28 (0.952)	3.29 (0.836)

Note: * Villagers were asked to rate the level of importance they thought the watershed forest at PK contributing to their households and the community as a whole. 1 = not sure on that aspect, 2 = slightly important, 3 = moderately important and 4 = highly important with the maximum score is 4.00.

3.2.1 Non-timber forest products

Photo 7. Villagers and their mushrooms gathered from PK

Provision of NTFPs is the greatest ecosystem services from PK supporting local livelihoods. The watershed forest is a source of household income and a local super market where villagers can obtain food, fuel and other necessities as needed. It contributes to local economies both inside and outside PK where villagers can reduce household spending and earn additional income. Approximately 80% of the interviewed villagers accessed the forest specifically for harvesting of NTFPs. These NTFPs were mainly used for household consumption, especially as a food source. A small portion of villagers (about 5% of the respondents) harvested NTFPs for income generation. Meanwhile, approximately 15% gathered NTFPs for household use but also traded them if markets demanded. These villagers did not normally sell their products at a market place but rather did so upon request from local traders. In contrast, villagers who harvested NTFPs for income generation usually sell their products at a village market and/or sub-district and district markets. Since demands for NTFPs, especially from city residents, increase, villagers are forced to obtain greater amounts of NTFPs to meet the market demands. Previously, they would spend longer time in the forest to search for more forest products. Nowadays, they go around villages to buy NTFPs from other villagers. This change will motivate more people to involve in the trade of NTFPs because it is easier for them to sell their products to traders without directly spending their time at the market.

Three important groups of NTFPs were harvested, including wild vegetables, mushrooms and wildlife and their products (e.g., frogs and ant eggs). Averaged total amounts of harvested NTFPs were 79 kg/household/year of which bamboo shoot, frogs and mushrooms were the three most common products. Although by weight frogs ranked the second after bamboo shoot, their averaged amounts of cash income were highest. Villagers expressed that PK is well recognized by the locals and outsiders as a place for frog hunting. Every year, start around June until August, a large number of people from different villages will come to PK for frog hunting. Our questionnaire survey reveals that some villagers could earn up to 10,000 Baht/year from selling frogs.

Mushrooms are another main NTFPs harvested, especially for household consumption, together with sweet-leaf vegetable or Pak Wan and ant eggs. Villagers consider these products as delicacy from the forest. It is a “must have” kind of food when their seasons come (Photo 8). And their popularity has grown nation-wide, especially among northeastern natives who live outside the region. Subsequently, demands and prices of these forest products increased. In early harvesting seasons, prices of Pak Wan can go up as high as 500 Baht/kg[6], 400 Baht/kg for ant eggs and 300 Baht/kg for mushrooms. Table 8 summarizes price ranges of NTFPs and amounts of cash income earned by households in 2018 and 2019. On average, the households received monetary benefits approximately 9,321 Baht/household from the trade of NTFPs, accounted for 10% of the household annual income. A rough estimate[7] illustrates that PK watershed forests have contributed to the local economy in terms of cash income with approximately 2.60 million Baht or USD83,957 per year.

Photo 8. The forest food – a local delicacy, (left) roasted ant queens and herbs and (right) Pak Wan soup with ant eggs, a (dry) seasonal cuisine from PK.

Table 8. Forest access, quantities and cash earned from NTFP harvesting.

[6] A minimum wage is 300 Baht/day.

[7] Calculated from the percent of villagers reported of harvesting NTFPs for household consumption and income generation (i.e., 15%), multiplied by the number of households in the surveyed villages (approx. 1,862 households in 2018) and multiplied by the averaged amount of cash income earned by households (i.e., 9,321 Baht/household). The exchange rate used is 1USD = 31.0081 Baht (Bank of Thailand, as of July 31, 2019).

PK forest access and use		**2018 data from HHs outside PK**	**2019 data from HHs inside PK**
1. Purposes of access	- NTFP harvest	83%	71%
	- Fuelwood collection	22%	23%
	- Medicinal plant harvest	14%	10%
2. Use purposes	- Household consumption	81%	74%
	- Income generation	3%	7%
	- Both	16%	19%
Type of NTFPs	Price in Baht/kg (during 2018-2019)	Cash income earned (Baht/household)	
		2018 for HHs outside PK	2019 for HHs inside PK
1. Mushrooms		**7,625 (29 kg/HH)**	**6,456 (41 kg/HH)**
- Ra-ngok	100-300		
- Kon	100-200		
- Kai	50-300		
- Poue	200-350		
- Mixed mushrooms	30-50		
2. Vegetables		**1,648 (64 kg/HH)**	**2,722 (46 kg/HH)**
- Pak Wan	100-500		
- Bamboo shoot	5-30		
3. Wildlife and products		**4,500 (14 kg/HH)**	**2,721 (20 kg/HH)**
- Ant eggs	150-400		
- Frog	100-200		
- Flying lizard	200		
Total		**9,491**	**9,151**
Averaged total amounts of cash earned		**9,321 (~10% of the HH annual income)**	

Note: HH = household

3.2.2 Water provision

Photo 9. Hui Bong Dam and its reservoir at Tad Hai Village

PK is the watershed forest of several streams, including Tad Kwauy, Bong Prag, Tad Fah and Lad Nok Katae, which support two main tributaries of Pong River, namely Hui Bong and Lam Paniang. The two tributaries provide water resources for household consumption and agricultural production. In 2010, Hui Bong Dam was constructed under His Majesty King Bhumibol Royal Initiative Project for irrigation and drought mitigation purposes, mainly in KMT and downstream areas. The dam is located at Tad Hai village in KMT, Nongbua Lamphu province (geographic coordinates 16° 54' 18''N and 102° 25' 02''E). It is a medium sized dam with a dead storage level 194.00 m MSL, average storage level 200.80 m MSL, maximum storage level 202.82 m MSL, dead storage capacity 2.18 million m^3, average storage capacity 20.80 million m^3 and maximum storage capacity 29.00 million m^3 (Nongbua Lamphu RID, June 2016). Hui Bong Dam and its reservoir cover approximately 588 ha inside PKNP. The project area's land use rights and management authorities have been transferred from the DNP to the RID.

Due to the area geology e.g., sandstone rock base, loamy sand soil and rock outcrops, together with steep mountains that encircle narrow undulating valleys, heavy runoffs from the forest cause flash flooding in a rainy season (May – September). Meanwhile, water shortage or drought usually occurs in dry seasons (October – April) because of soil incapability of retaining moisture and limited water availability. Subsequently, crop productivities in this area were relatively low due to drought and flooding. Hui Bong Dam is expected to provide water for approximately 2,552 ha of rain-fed rice cultivation and 576 ha of dry-season crop plantations, mainly in KMT. Dry-season rice cultivation alone will generate approximately 30.8 million Baht to farmers (Table 9). However, since the dam construction was recently completed in 2016; now it is in a water fill-up period, a water canal system has not yet constructed. From our interview with a leading engineer responsible for Hui Bong Dam operation, the canal system design has already finished and construction is expected to begin in the next two to three years (Thanakrit Paholtup – head of water distribution and maintenance 1, Nongbua Lamphu RID, personal interview on March 9, 2018).

In addition, Hui Bong Dam will also supply water for other uses including a village running water production (i.e., projected water amounts 5.40 million m^3/year), fishery, water-related recreation and forest conservation. The dam will store runoff water, retain water surface and increase water table in the area. Maintaining a water balance will improve soil moisture needed for vegetation growth. Nonetheless, since the majority of PK forests are DDF, they are well adapted to dry environments. Long-term ecosystem impact assessment is needed to examine whether Hui Bong Dam has any impacts on the watershed forest and its conservation.

Table 9. Water provision: projected quantities and monetary benefits, from PK.

Potential use of water under Hui Bong Dam operation	
1. Irrigation	Service areas: - 2,552 ha of rain-fed rice cultivation - 576 ha of dry-season crop plantations
	Projected benefits from dry-season/irrigated rice cultivation: - Avg yields at Nongbua Lamphu (2018) = **556 kg/Rai** (OAE as of June 19, 2018) - Projected rice production = **2,001 tons** - Avg price of KMD 106 (jasmine) rice = **15,400 Baht/ton** (Source: Khon Kaen farmer co-op market on Jun 19, 2019) - Projected benefits generated = **30.82 million Baht**
2. Village running water production	Available amounts of water provided = 5.4 million m^3 per year
3. Subsistence fishery	
4. Water-based recreation	
5. Forest conservation	

Note: 1 ha = 6.25 Rai

Photo 10. Rice paddies in/around PK areas

3.2.3 Drought mitigation and household adaptation

Water provision and NTFPs are key ecosystem services from PK that support local livelihoods, mainly in KMT villages – one of the many drought prone areas in the northeast. Deforestation and degradation of the watershed forest will influence water systems and their balance, leading to inadequate water supply for agriculture and household uses. Continuing water shortage or “drought” will affect farming – the main driver of community’s local economy, especially since it is mainly depended on rain and surface water. Thus, protection of the watershed forest means drought mitigation, another important ecosystem service from PK.

Data from reviewed literature (e.g., Phromma et al., 2019) and Google Earth satellite image interpretation during 2008-2018 revealed a decrease in forest areas, while farmlands increased. We questioned whether local villagers recognized those changes. And if so, what impacts they had encountered, particularly on farming activities. We asked if villagers were aware that PK watershed forests play a key role in local climate regulation, water provisioning and drought mitigation. Subsequently, we introduced a PES concept and examined villager’s perception toward PES-project development in PK, including WTP and WTA for the watershed forest protection.

The majority of villagers (with average age in the mid-50s and 36 years of residency) realized a decline in forest areas. But with current management measures from the park together with local collaboration, approximately 62% of the respondents perceived potential improvement of the watershed forest within the next 5-10 years, while 18% said the forest will deteriorate and 13% expressed unchanged conditions. Villagers understood that the watershed forest helps regulate local climate and water systems. Deforestation at PK will lead to water shortage and drought, so resulting in decreases in forest ecosystem services. Approximately, 77% of the respondents reported of experiencing drought-related issues, including decrease in crop productivity, water shortage and increase in forest fires. Nearly all of the villagers (98%) expressed the need for forest protect in PK, especially reforestation and effective water management (Table 10).

Table 10. Local perception toward PK watershed forests on drought mitigation.

<table>
<tr><th>Issues</th><th colspan="3">No. of respondents</th><th colspan="2">Percent of responses</th></tr>
<tr><td>1) Deforestation resulted in water shortage and decrease in forest ecosystem services</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>○ Agreed</td><td colspan="3">190</td><td colspan="2">93</td></tr>
<tr><td>○ Disagreed</td><td colspan="3">14</td><td colspan="2">7</td></tr>
<tr><td>2) It is important to protect the watershed forest</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>○ Agreed</td><td colspan="3">200</td><td colspan="2">98</td></tr>
<tr><td>○ Disagreed</td><td colspan="3">4</td><td colspan="2">2</td></tr>
<tr><td>3) Drought experiences of the respondents</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>○ Yes</td><td colspan="3">157</td><td colspan="2">77</td></tr>
<tr><td>○ No</td><td colspan="3">47</td><td colspan="2">23</td></tr>
<tr><td>4) Loss of household income (THB per household per time)</td><td colspan="2">Mean</td><td colspan="2">Min</td><td>Max</td></tr>
<tr><td>○ Decrease in agricultural productivity (total n = 26)</td><td colspan="2">17,880</td><td colspan="2">240</td><td>80,000</td></tr>
<tr><td>○ Decrease in household water use (total n = 5)</td><td colspan="2">5,180</td><td colspan="2">1,500</td><td>10,000</td></tr>
<tr><td>○ Decrease in water used in agriculture (total n = 13)</td><td colspan="2">12,923</td><td colspan="2">3,000</td><td>40,000</td></tr>
<tr><td>○ Increase in wildfires (total n = 3)</td><td colspan="2">10,667</td><td colspan="2">2,000</td><td>20,000</td></tr>
<tr><td rowspan="2"></td><td colspan="4">Percent of responses*</td><td rowspan="2">Averaged points (SD)**</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>5) Causes of drought</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>○ Deforestation in PK</td><td>2.2</td><td>15.6</td><td>13.3</td><td>68.9</td><td>3.49(0.843)</td></tr>
<tr><td>○ Climate change</td><td>10.2</td><td>8.2</td><td>36.7</td><td>44.9</td><td>3.16 (0.965)</td></tr>
<tr><td>○ Ineffective water management</td><td>19.5</td><td>17.1</td><td>12.2</td><td>51.2</td><td>2.95 (1.224)</td></tr>
<tr><td>6) Drought mitigation measures</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>○ Reforestation</td><td>2.1</td><td>14.9</td><td>8.5</td><td>74.5</td><td>3.55 (0.829)</td></tr>
<tr><td>○ Effective water management</td><td>10.0</td><td>6.0</td><td>20.0</td><td>64.0</td><td>3.38 (0.987)</td></tr>
</table>

Note: Data from the 2018 survey, N = 204 households
* 1 = not sure, 2 = slight, 3 = moderate and 4 = high
** the maximum point is 4.00

Photo 11. Sugarcane, one of the three major cash-crops, with drastic change in planted areas during the past 10 years due to price fluctuation and drought.

Villagers responded to climate change, specifically drought, by adjusting their land use patterns and crop selection. With limited amounts of farmlands, they reduced planting crops that required a large quantity of water.Villagers expanded planting areas of drought tolerant crops instead, because they required a small amount of farm maintenance. In the past ten years, some crop adjustments were reported (Table 11). Among the three major cash crops (i.e., rice, cassava and sugarcane), rice cultivation obtained the highest records of decrease followed by sugarcane plantations; while cassava plantations increased. Cassava required a small amount of maintenance and villagers could usually sell it for a high price, especially during 2012-2016 when cassava prices were relatively high averaging 147 Baht per ton. Meanwhile, prices of other cash crops, such as rice and sugarcane plummeted (OAE, 2017). For the next ten years, villagers expressed similar adjustments if drought persists (Table 12). They reported of expanding sugarcane plantations instead of cassava or rice cultivation, mainly due to expected increase in sugarcane prices while price of cassava started to decline. Table 13 summarizes key adaptation measures. Villagers said that they did what they can, mainly to maximize the use of land and expect for the greatest returns. They were aware of farming risks if droughts prolong.

Table 11. Land use change by crop types due to drought in the **past** ten years.

Issues	**Percent of responses***					**Averaged points (SD)****
	1	2	3	4	5	
Eucalyptus	-	-	33	-	67	4.333 (1.155)
Soybean	-	-	33	-	67	4.333 (1.155)
Rice	-	**88**	**67**	9	15	**3.304 (0.840)**
Sugarcane	**39**	**6**	**50**	6	-	**3.042 (0.859)**
Bean	-	-	75	25	-	3.250 (0.50)
Rubber plantation	-	20	60	20	-	3.000 (0.707)
Fruits			100			3.000 (0.000)
Cassava	8	-	**79**	**4**	**8**	**2.222 (1.060)**

Note: * 1 = greatly increased, 2 = slightly increased, 3 = unchanged, 4 = slightly decreased and 5=greatly decreased; ** the maximum point is 5.00

Table 12. Land use change by crop types due to drought in the **next** ten years.

Issues	**Percent of responses***					**Averaged points (SD)****
	1	2	3	4	5	
Eucalyptus	-	-	67	-	33	3.667 (1.155)
Soybean	-	-	67	-	33	3.667 (1.155)
Bean	-	-	67	33	-	3.333 (0. 577)
Cassava	**8**	**8**	**65**	-	19	**3.154 (1.084)**
Rice	4	4	**76**	7	9	**3.109 (0. 795)**
Rubber plantation	-	-	100	-	-	3.000(0.000)
Fruits	-	-	100	-	-	3.000(0.000)
Sugarcane	**47**	**5**	**42**	5	-	**2.053 (1.079)**

Note: * 1 = greatly increased, 2 = slightly increased, 3 = unchanged, 4 = slightly decreased and 5=greatly decreased; ** the maximum point is 5.00

Table 13. Villager's agricultural adaptation measures to drought.

Adaptation measures	% of responses
Increased amounts of organic fertilizers used on farm	59
Planted trees on farmlands/ forest borders	57
Used rice stump/ straw as green manure by plowing them rather than burning	55
Dug ponds as a water storage, especially in dry seasons	53
Mulched farmlands to reduce evaporation	43
Switched crop types required small amounts of water (e.g. sugarcane to bananas/cassava; rice to cassava/sugarcane; cassava to sugarcane, & longan to coconut)	32
Reduced planting areas for crops required large quantities of water	25
Applied agroforestry by planting diverse crops to maximize the use of farmlands	23
Installed a water dripping system on farmlands	15
Rotated crop types	15
Used testing kits to decide when and how much of fertilizers to be applied	4

Note: Data from 2018 survey, N = 204 households from all KMT's villages and one village from NKPT

3.3 Local perception toward PES-project development in PK

Photo 12. A workshop participant expressed his support on PES-project development for PK watershed forest

PES is a very new concept for all relevant sectors, from governmental authorities down to local administration and villagers. It's the very first time for the communities to learn about PES. What is PES? How does it work? Who will pay, for what and to whom? These are some of the basic questions before discussing WTP, WTA and PES-project development. However, we received positive responses on PES-project development from the communities. Local administration at KMT and governmental authorities, including Nongbua Lamphu Provincial Office of Natural Resources and Environment and PKNP, stated their support for PES-project development, including funding. They were optimistic about PES-projects at PK, but cautious over implementation since it required extensive assistance from outsiders who are familiar with PES and who are willing to work with the communities. It's a long road to go, but everyone wanted to try it.

3.3.1 Villager's WTP for the watershed forest protection

Approximately, 56% of villagers (n= 204) expressed their WTP for PK watershed forest protection, especially water provisioning and drought mitigation. Respondents who disagreed to pay said that income constraint was the number one factor hindering their WTP (46% of the respondents), followed by perceptions that forest protection is the government's responsibility, and lack of understanding and trust on how PES project will work (18% and 11%, respectively). Mean amounts of WTP[8] in 2018 were 114 Baht/month/household or 1,370 Baht/year, accounted for nearly 2% of the household annual income (Table 14). With approximately 1,862 households in KMT, total amounts of WTP were projected of 2.55 million Baht. Table 15 provides statistics of variables used in WTP estimation, and Table 16 summarizes results from the logit regression model used to estimate the amounts of WTP for PK watershed forest protection.

Table 14. Mean and total WTP calculation in 2018.

Calculation	
Mean WTP	$= -(a + b_2*AGE + b_3*SEX + b_4*NHH + b_5*EDU + b_6*INC + b_7*FIC + b_8*IMPFO)/b_1$ = -(0.04689 +0.00317*56.358+-0.11960*0.402+ -0.02489*4.407+ 0.14750*7.657+ 0.00008*8,042+ -0.00001*3,386+ 0.33909*0.275)/ -0.01672 = -(-1.909884123)/- 0.01672 =114 THB / month/ household = 1,370 THB / year/ household
Total WTP	= 2,551,780.79 THB

[8] Estimated using a bidding method with a logit regression model. Bid amounts started from 5 Baht up to 1,000 Baht/month/household

Table 15. Descriptive statistics of variables used in WTP estimation.

Variables	Mean	Std.Dev.	Min	Max
WTP	0.574	0.496	0	1
BID	91.078	68.025	20	200
AGE	56.358	10.121	28	84
SEX	0.402	0.492	0	1
NHH	4.407	1.797	1	10
EDU	7.657	2.913	0	19
INC	8,042	6,267	1,500	50,000
FIC	3,386	11,862	0	100,000
IMPFO	0.275	0.447	0	1

Table 16. Results from the logit regression model for WTP estimate.

(1) Bid only model				(2) Multivariate model			
Variables	Coefficient	Std. Error	P>z	Variables	Coefficient	Std. Error	P>z
Constant	1.89098	0.29036	0.000***	Constant	0.04689	1.35257	0.9720
BID	-0.01727	0.00268	0.000	BID	-0.01672	0.00285	0.000***
				AGE	0.00317	0.01771	0.8580
				SEX	-0.11960	0.36242	0.7410
				NHH	-0.02489	0.09501	0.7930
				EDU	0.14750	0.06804	0.030**
				INC	0.00008	0.00004	0.035**
				FIC	-0.00001	0.00001	0.4170
				IMPFO	0.33909	0.38730	0.3810
Log likelihood		-111.92651		Log likelihood		-103.68381	
LR chi^2(1)		54.52		LR chi^2(8)		71.01	
Prob > chi^2		0.0000***		Prob > chi^2		0.0000***	
Pseudo R^2		0.1959		Pseudo R^2		0.2551	

Note: ***, **, * denotes significance at 1% level, 5% level, and 10% level

For payment methods, a walk-in collector to villager households was the most preferable, followed by a collecting box placed in front of a village leader office and establishment of PK watershed forest protection funding (Table 17). Meanwhile, current administrative groups e.g., village leaders and community volunteer groups were suggested as the main responsible agency for payment collection, followed by PKNP officers, KMT SAO officers and an ad hoc committee established for PES-project (Table 17). Finally, the three most strongly recommended activities for PK watershed forest protection include: 1) awareness and capacity building, especially on PES and PES-project development procedures; 2) forest use zoning; and 3) NTFP harvesting management (Table 18).

Table 17. Preferred payment methods and responsible agencies for PES-project.

Payment methods	(n= 131)	% of cases	Responsible agencies	(n= 136)	% of cases
Walk-in collectors to villager houses	73	**56**	Current village administrative groups	52	**38**
Collecting boxes placed at each of the village leader offices	27	**21**	PKNP	36	**27**
PKNP fund	13	10	KMT SAO	27	10
Utility billing	11	8	Village ad hoc committee for WTP	13	10
Village fund	6	5	Non Sang or Nongbua Lamphu authority	3	2
Local taxes	1	1	Don't know	5	4

Table 18. Recommended activities for PK watershed forest protection.

Management activities	Percent of responses*				Averaged points (SD)**
	1	2	3	4	
1) Awareness and capacity building	-	-	-	100	**4.00 (0.000)**
2) Forest use zoning	-	-	-	100	**4.00 (0.000)**
3) NTFP harvesting management e.g., check points	-		44	56	**3.56 (0.527)**
4) Nature trail construction	8	11	12	69	3.42 (0.977)
5) Wildfire extinguishment gear maintenance	9	13	19	59	3.28 (1.005)
6) Reforestation projects	10	14	16	60	3.26 (1.032)
7) Clear demarcation of park boundaries	14	19	14	52	3.05 (1.137)
8) Construction of check dams	19	17	15	50	2.96 (1.191)
9) Improvement of forest patrol	17	15	24	44	2.95 (1.131)

Note: * 1 = not sure, 2 = low, 3 = moderate and 4 = high
** the maximum point is 4.00

Photo 13. Capacity building is the number one recommended activity for PES-project development.

3.3.2 Villager's WTA for the watershed forest protection

Protection of the watershed forest at PK implies forest restriction and trade-offs between present and future benefits. Service providers will participate in a PES-project if payments from buyers are higher than their forgone income or costs of providing ecosystem services. From 2019 survey of villagers inside PK – the service provider, we received approximately 55% of WTA (n= 200). Estimated mean amounts of WTA were 206 Baht/month/household (2,477 Baht/year), accounted for 2.2% of the household annual income (Table 19). Projected total amounts of WTA from KMT households were 4.61 million Baht in 2019, approximately 2.06 million Baht higher than the expected WTP offered by the service buyers. The imbalance between demand and supply indicated unattainable markets, unless financial subsidies are considered. Respondents who disagreed to accept thought that PES-projects would reduce their benefits from the watershed forest, especially food sources and income generated from NTFPs (44% and 29%, respectively). Table 20 presents statistics of variables used in WTA estimation, and Table 21 summarizes results from the logit regression model used to estimate WTA amounts for PK watershed forest protection.

Table 19. Mean and total WTA calculation in 2019.

Calculation	
Mean WTA	= $-(a + b_2*AGE + b_3*SEX + b_4*NHH + b_5*EDU + b_6*INC + b_7*INCF + b_8*FOBE)/b_1$ = -(-2.06339 +-0.01480*54.56+0.70334*0.37+-0.17494*4.295+ 0.10025*1.23+ 1.45e-06*11,1434.9+ 0.000048*2,287.7+ -1.41569*0.55)/ 0.01886 = -(-3.89331)/ 0.01886 =206 THB / month/ household = 2,477 THB / year/ household
Total WTA	= 4,612,524.76 THB

Table 20. Descriptive statistics of variables used in WTA estimation.

Variables	Mean	Std. Dev.	Min	Max
WTA	0.545	0.4992205	0	1
BIDWTA	427.025	493.052	25	2,500
AGE	54.56	14.29328	23	99
SEX	0.37	0.4840159	0	1
NHH	4.295	1.850703	1	10
EDU	1.23	0.7347101	0	6
INC	9,797.78	86,402.06	7,000	61,2000
INCF	2,287.72	7,676.561	0	60,000
FOBE	0.55	0.4987421	0	1

Table 21. Results from the logit regression model for WTA estimate.

(1) Bid only model				(2) Multivariate model			
Variables	Coefficient	Std. Error	P>z	Variables	Coefficient	Std. Error	P>z
Constant	-3.45324	0.49314	0.000***	Constant	-2.06339	1.45219	0.9720
BID	0.01734	0.00266	0.000***	BID	0.01886	0.00310	0.000***
				AGE	-0.01480	0.01915	0.8580
				SEX	0.70334	0.55285	0.7410
				NHH	-0.17494	0.13112	0.7930
				EDU	0.10025	0.29765	0.030**
				INC	1.45e-06	3.00e-06	0.035**
				INCF	0.000048	0.000035	0.4170
				FOBE	-1.41569	0.53865	0.3810
Log likelihood		-67.68189		Log likelihood		--60.99247	
LR chi^2(1)		140.27		LR chi^2(8)		153.65	
Prob > chi^2		0.0000***		Prob > chi^2		0.0000***	
Pseudo R^2		0.5089		Pseudo R^2		0.5574	

Note: ***, **, * denotes significance at 1% level, 5% level, and 10% level

3.3.3 Opportunity costs of different land use change

To estimate opportunity costs of different land use changes if a PES-project takes place at PK, we set up a hypothetical condition where agroforestry or a tree-based system was employed as a key mechanism to reduce forestland encroachment, especially due to agricultural expansion in the three villages inside PK (Wangmon, Dongbak and Chaimongkon). Agroforestry is a dynamic, ecologically based, natural resource management system that integrates trees, crops and/or animals on farms in the agricultural landscape so that diversifies and sustains agricultural production. Agroforestry also ensures ecosystem services provision. Effective agroforestry increases land use efficiency, prevents soil erosion, and improves soil and water quality. Yet, a small number of villagers practice agroforestry, especially tree planting (e.g., teak and fruit trees) on farmlands. Meanwhile, cash-crop monoculture, especially cassava and sugarcane, is common among villagers because of high market demands for energy crops (Phumee et al., 2018).

Monoculture entails high environmental costs with intensive chemical input, but switching from cash-crops to tree-based plantations also introduces opportunity costs due to decrease in cash-crop planting areas. Farmer interviewed data from the 2019 questionnaire on monetary costs and benefits under different land use types were used to estimate opportunity costs of land use using a Net Present Value (NPV) formula presented below.

$$NPV = \sum_{t=0}^{n} \frac{(Benefits - Costs)t}{(1+r)^t}$$

where: r = discount rate

t = year

n = analytic horizon (in years)

The NPV was calculated to estimate profitability of land use over 10 years. A discount rate used is 5% yearly and no discount rate applied for the years without profit. The NPV for each land use type is an accumulation of every year profit (revenues minus costs of material and labor inputs) minus discount rate.

In this study, we estimated opportunity costs occurred due to land use changes, including six scenarios of land use conversion namely: 1) paddy fields to tree plantations; 2) paddy fields to forestlands; 3) cassava plantations to tree plantations; 4) cassava plantations to forestlands; 5) sugarcane plantations to tree plantations; and 6) sugarcane plantations to forestlands. Average amounts of cash income from collecting forest products was about 582 Baht/ha/household (without payments). Table 22 presents costs and benefits under different land use types, including rice cultivation, cassava, sugarcane and mixed perennial plants (i.e.g, banana, longan and mango). Among different land use types, sugarcane plantations provide the highest amount of profits with the NPV of

346,645 Baht/ha, followed by cassava and rice plantations. The NPVs of mixed tree and perennial crop cultivation and forestlands were lower than rice and cash-crop cultivations.

These findings suggest that promotion of agroforestry and reforestation as part of the PES scheme will result in income losses for villagers participating in a forest conservation activity at PK (Table 23). Conversion from sugarcane plantations to forestlands obtained the highest opportunity cost (341,110.86 Baht per ha). Meanwhile, conversion from rice paddies to mixed tree-perennial crops plantations had the lowest opportunity cost (80,377.62 Baht per ha). Implementation of agroforestry needs also proper selection of tree species tolerant to drought, and those maximize villager economic returns. To reduce impacts from income losses, while giving villagers with incentive to participate in PES-project development, villagers must be provided with sufficient compensation and/or alternative income sources such as carbon offset.

Table 22. Costs and benefits under different land use patterns in one year.

Items	Rice	Cassava	Sugarcane	Mixed Perennials	Forest
1) Return (Baht/ha)	29,531.25	45,805.50	53,370.59	23,437.50	582.56
2) Cost (Baht/ha)	7,919.68	14,859.42	14,468.23	51,687.50	0
Labor	4,351.56	6,755.26	5,619.00	4,687.50	
Materials	3,568.12	8,104.16	8,849.23	47,000.00	
3) Net return (1)-(2)	21,611.57	30,946.08	38,902.36	-28,250.00	582.56
4) NPV (Baht/ha)	215,035.12	304,818.89	346,645.20	134,657.50	5,534.34

Note: Three villages consist of Wangmon, Dongbak and Chaimongkon

Table 23. Opportunity costs from adopting a tree-based system as part of a PES-project at PK over a 10 years period.

Forest Conservation & Agroforestry	Non-Tree Based System		
	Rice	Cassava	Sugarcane
Mixed tree and perennial crops	**80,377.62**	170,161.39	211,987.7
Forestlands	209,500.78	299,284.55	**341,110.86**

3.4 Local institutional roles in PES-project development

PES-project development requires high technical expertise, especially economic valuation and price estimates, to set up effective payment mechanisms to ensure long term service provisions. It's unlikely for community self-initiated. Thus, development of a PES project requires external experts with long-term commitments from all stakeholders. Table 24 lists key authorities/institutes and their roles in PES-project development, specifically in the case of PK. Start from local administration, namely Sub-District Administrative Organization (SAO), as a community representative reflecting local interests, needs and supports. KMT SAO clearly stated its support for PES-project development in PK, especially funding. It's a very positive sign from the local sector, a key actor for PES-project development.

For policy and legislative supports, PKNP and Nongbua Lamphu Provincial Office of Natural Resources and Environment also confirmed their supports. However, since Thailand does not have specific legal supports for PES-project development, including implementation guidelines, rules and regulations and responsible authorities, it's difficult for PES-projects to develop and grow. Legislative bodies such as the Office of Natural Resources and Environmental Policy and Planning need to set up policies and plans, especially implementation guidelines with legal supports for PES-project development. Finally, technical supports are needed. University researchers and research institutes have to work closely with local communities.

Table 24. Authorities/institutes and roles in PES-project development.

Institution	Roles
Department of National Parks, Wildlife, and Plants Conservation and Royal Forest Department e.g., PKNP, Lam Panaing Watershed Management Unit	Policy and technical supports, in the following issues: ▪ Forest and biodiversity conservation ▪ Watershed management ▪ Wildfire patrol and control ▪ Reforestation and restoration ▪ Sustainable use of forest resources ▪ Community awareness and capacity building ▪ PES-project mediators
Office of Natural Resources and Environmental Policy and Planning and Nongbua Lamphu Provincial Office of Natural Resources and Environment	Policy and legislative supports e.g., ▪ Natural resource and environment policy and planning ▪ National PES-project development guidelines ▪ Natural resource conservation ▪ Environmental education ▪ Community awareness and capacity building
Royal Irrigation Department	Water distribution and maintenance
Local administration e.g., KMT SAO, NKPT SAO and Nongbua Lamphu Provincial Administrative Organization	Local resource management policy and planning, including: ▪ Community development

	▪ Community awareness and capacity building ▪ Community participation ▪ Human resource and financial supports ▪ PES-project implementation e.g., mediators
Research Institutes NGOs-Pong River Conservation University researchers	Technical supports, including: ▪ Economic valuation and price estimate ▪ Research and development ▪ Ecosystem assessment and monitoring ▪ Community awareness and capacity building
EGAT	Corporate social responsibility

Finally, we proposed a design framework for PES-project development at PK (Figure 8). Active collaboration among all relevant sectors is a key for effective PES-project development. Local administration is a main driver, because it represents a potential service buyer. KMT SAO already expressed its financial availability. In addition, local administration can also function as a main responsible authority for monitoring and reporting PES-project progress to upper relevant authorities at regional and national levels. Governmental authorities such as the Ministry of Natural Resources and Environment, Office of Natural Resources and Environmental Policy and Planning, including Nongbua Lamphu Provincial Office of Natural Resources and Environment must provide implementation guidelines, human resources and capacity building courses, and funding sources both from national and international agencies (e.g., Green Carbon Fund, GIZ and UNFCCC).

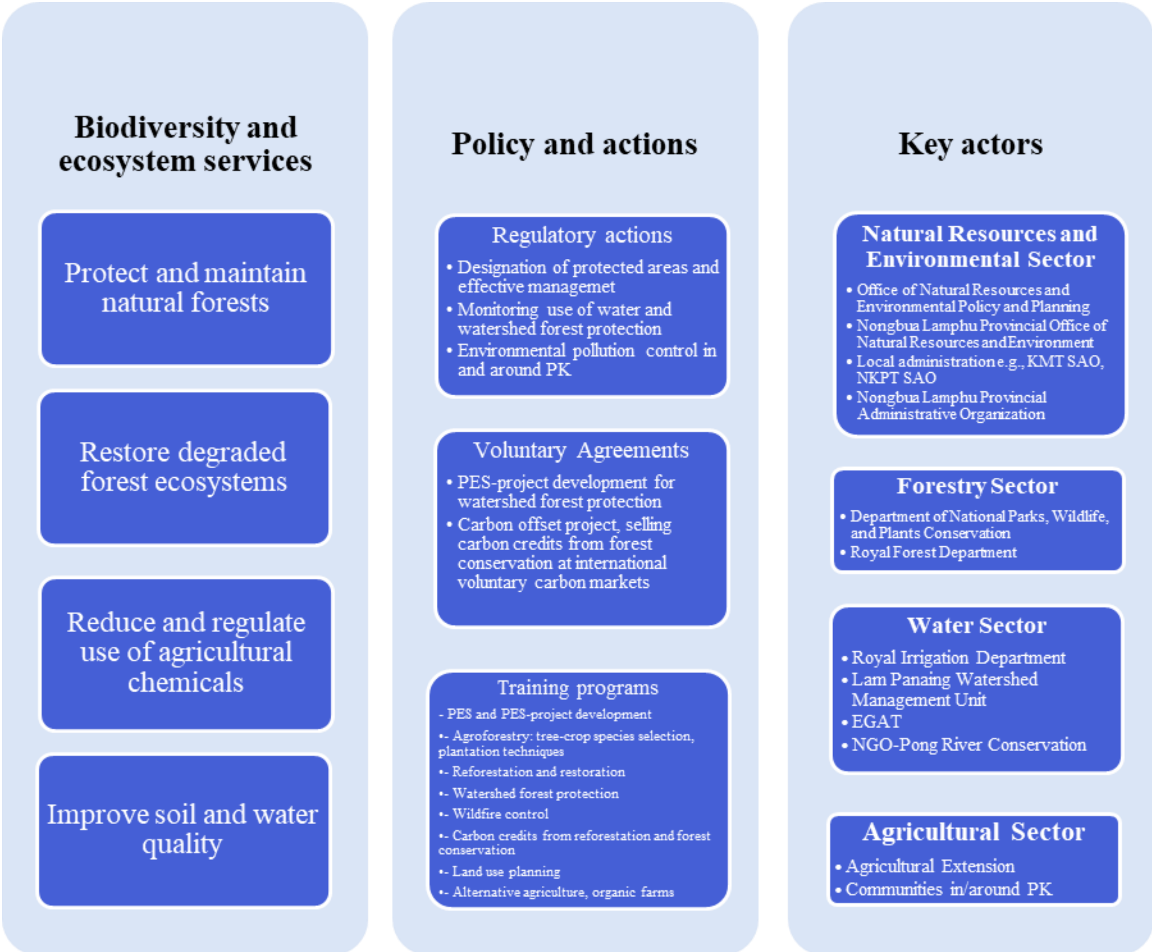

Figure 8. A design framework for PES-project development at PK.

4. Conclusions

Pathways to PES-project Development and Implications include:

4.1 Ecosystem services from the watershed forest

The watershed forest at PK provides numerous ecosystem goods and services that support local livelihoods. Water provision and NTFPs are the primary benefits villagers obtained for household consumption and income generation. Approximately 30.8 million Baht was projected from dry-season rice cultivation if Hui Bong Dam is fully operated. The trade of NTFPs contributed to household economy, approximately 10% of their household annual income. As a non-tangible benefit, villagers expressed their uniqueness as living in a “forest-surrounded community.” Phu Kao is a life-support forest because it maintains soil fertility and regulates local climate, including drought mitigation. Protection of the watershed forest means life-protection for PK residents.

4.2 Local perception toward PES and their willingness to act

PES is a very new concept for all relevant sectors at PK, including governmental authorities, local administration and villagers. What is PES? How does it work? Who will pay, for what and to whom? Not to mention what action steps and plan for success! Unexpectedly, we received positive responses on PES-project development from the communities with 56% of WTP and 55% of WTA. Estimated amounts of WTP were 114 Baht/month/household, while the WTA were 206 Baht/month/household. The imbalance between demand and supply indicated unattainable markets. Income constraint was the number one factor hindering villager's WTP, followed by perceptions that forest protection is the government's responsibility, and lack of understanding / trust on how PES project will work. Meanwhile, benefit reduction is the most concerning issue, making villagers hesitate to accept payments if a PES-project is to be established for PK watershed forest protection.

However, local administration at KMT and governmental authorities, including Nongbua Lamphu Provincial Office of Natural Resources and Environment and PKNP, stated their support for PES-project development, including funding. They were optimistic about PES-projects at PK, but also aware over implementation since it required extensive assistance from outsiders who are familiar with PES and who are willing to work with the communities. Although PES-project development has a long way to go, everyone said that they wanted to try it.

4.3 Pathways to PES-project development in PK

If divided PES-project development into three phases, namely 1) initial assessment and feasibility analysis, 2) project operation and maintenance, and 3) performance assessment and adaptation. The PK case is now at a very first step of phase 1. Hence, the proposed pathways focus on initial steps to PES-project development in PK.

Step 1: Increase understanding and awareness of PES to local communities

The most challenging task is to change villager perception that nothing is free, not even NTFPs that have supported their livelihoods for generations. Now, the term "payment" is introduced to compensate for ecosystem services through PES and hypothetical mechanisms between a service buyer and seller. On the buyer side, it is easy to understand since villagers can see themselves clearly as a service user. But on the seller side, ecosystem services are relatively invisible. Local communities are supposed to act as the service seller, but they also use the same services for payment by outsiders. Villagers are the buyer and seller simultaneously. This logic will be difficult for some villagers to follow since many of them are illiterate. Without clear understanding and awareness from the locals, PES-project development is unlikely, especially for long-term commitments.

Step 2: Build understanding and awareness of PES to relevant authorities

Government authorities and local administrators need to understand their roles, especially as a mediator and/or supporter of PES-project development.

Step 3: Make sure Step 1 and 2 are ready to launch a PES-project

Without clear understanding and awareness of PES from the two major sectors, it's impossible to establish a PES-project in the case of PK.

Step 4: Key stakeholder meetings for PES-project development

When key stakeholders, namely the local communities and relevant authorities, understand and perceive PES as an effective approach for PK watershed forest protection, conditionality – the final element of PES-project development can be negotiated. It includes management actions, project-time agreement, payment methods and key responsible sectors, conflict resolution mechanisms and sanctions.

5. Future Directions

PES may offer an alternative approach for effective forest protection through cost internalization because villagers must pay for what they use. However, PES-project development at PK is not likely to be community self-initiated. It requires high technical expertise, especially economic valuation and price estimates, to set up effective payment mechanisms to ensure long term service provisions. Full PES-project development requires external experts with long-term commitments from all stakeholders. Large financial investments and government intervention are needed.

It may sound environmentally-effective, but inefficient, since the roles of buyers and sellers must be defined clearly when using common-pool, natural resources. Thus, protected area co-management, the collaboration between governmental authorities and local communities, remains a promising approach for PK. Community-based forest protection is less expensive, requires less technical expertise and human resources, and most importantly, it is self-initiated and governed. The communities will act as long as they value the forest as part of their livelihoods since it is within their best interests to do so. On the other hand, they will take less actions (or simply do nothing) if it is too burdensome or costly.

Photo 14. A road to PK and a long way to go for PES-project development in PK.

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7. Appendix

Appendix 1: Summary of the 2018 national project workshop in Thailand

SUMMARY REPORT

2018 National Project Workshop of the joint IGES-KKU Project on
"Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand"
3-5 March 2018, Khon Kaen, Thailand

1.0 Background

Khon Kaen University (KKU) and Institute for Global Environmental Strategies (IGES), with the support of the Asia-Pacific Network for Global Change Research (APN), jointly organized the national project workshop "Willingness to Pay for Water Provisioning Services of Phu Kao Phu Phan Kham National Park (PKNP)" in Khon Kaen, Thailand from 3 to 5 March 2018. The workshop included two days of in-house discussion and one day to visit the Thai project study site, within/surrounding PKNP.

The objectives of the Workshop were

- Review the project goals and expected outcomes.
- Discuss and finalize the project methodology.
- Discuss and finalize the project work plan and responsibilities.
- Initiate the field work in Thailand.

Overview of the workshop

Saturday 3 March 2018: Workshop preparation

- Research team members meeting
- Team discussion for workshop preparation

Sunday 4 March 2018: Workshop

- Welcome Remarks

- Overview of the project, objective and study site
- Session I: Land use pattern and ecosystem services of PKNP
- Session II: Payment for ecosystem services and livelihoods
- Session III: Integration of policy

Monday 5 March 2018: Field visit to Phu Kao Phu Phan Kham National Park

- Group meeting with officials of PKNP and village headman within/surrounding PKNP to discuss problems, ideas and history of forest management
- Field survey observing village landscape and land use practices
- Review and discussion of the work plan and responsibilities

2.0 Participants

The workshop was attended by:

1. Institute for Global Environmental Strategies

   Dr. Jintana Kawasaki,

   Dr. Binay Raj Shivakoti
2. Department of Environmental Science, Khon Kaen University

   Dr. Adcharaporn Pagdee

   Miss Issara Phromma

   Miss Nanthika Dulnee

   Miss Natchaya Puangla

   Miss Janthiwa Kamjaturat

   Miss Natthamon Uthawong

   Miss Supaporn Chapitak

   Mr. Suppakrit Koocharoenpaisal

   Miss Wipada Faksara

   Miss Jariya Khamsommai

   Miss Patchareeya Jaipakdee
3. Department of National Park, Wildlife and Plant Conservation

   Mr. Arichai Vannasiri , Head of PKNP

   Mr. Chatchawal Namsaeng, Head of Lam Paniang Watershed Management Unit

   Mr. Ranya Sudtha, Assistant Head of Wildfire Control Station, Nong Bua Lamphu

   Head of Office of Forest Development Project from the Royal Initiative, Hui Bong, Nong Bua Lamphu Province

   Mr. Prodit Khankwa, Park Officer, PKNP
4. Kok Muang Subdistrict Administrative Organization (SAO)

Mr. Chom Suppamatr, Chief Executive

Mr. Thongchan Sudjarit, Deputy Chief Executive

Mr. Dusit Meekaew, Permanent Secretary, Office of the Permanent Secretary

Mr. Nakorn Phunikom, Chief Administrator, Office of the Permanent Secretary

Mr. Montree Nakornchai, Kok Muang Village Leader

Mr. Wimon Namkham, Kok Sri Rueng Village Leader

Mr. Thanakorn Saengpo, Kha Noi Village Leader

Mr. Kittisak Duangkhamchan, Kok Muang subdistrict and Mad Village Leader

Mr. Sompong Phromtria, Thad Hai Village Leader

Mr. Thana Pothiwong, Nong Ping Village Leader

Mr. Wittaya Wannaphet, Bung Bok Village Leader

Mr. Paijit Srisawad, Wangmon Village Leader

Mr. Aarwoot Thantrakul, Chaimongkon Village Leader

5. Royal Irrigation Department

   Mr. Thanakrit Paholtap, Head of Water Distribution and Maintenance Division 1, Nong Bua Lamphu Province

6. Nong Bua Lamphu Provincial Office for Natural Resources and Environment

   Mr. Kittikul Kaewprem, Director of Natural Resource Division

7. Electricity Generating Authority of Thailand (EGAT)

   - Miss Ammara Meethom, Senior Engineer, Ubol Rattana Dam, Khon Kaen

3.0 Summary of the Discussion

1. Dr. Adcharaporn Pagdee, Faculty of Science, Khon Kaen University warmly welcomed the participants to Khon Kaen. She highlighted the value of the project and that it complemented well with recent efforts the University is doing with regards to sustainable forest management, and invited all participants to briefly introduce themselves before beginning the presentations.
2. In the first presentation, Dr. Jintana Kawasaki gave an overview of the new joint project between IGES-KKU with the support of APN, titled “Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand”. As explained in the programme and project concept, the project will be of 2 year duration, starting from October 2017, and would include 3 main project sites in Papua New Guinea, Philippines and Thailand.
3. The aims of the Project are to generate scientific knowledge on how to design effective payment for forest ecosystem services (PFES) systems for specific contexts (sellers, buyers, type of service, etc.)

In simple terms, she explained that the core objectives of the project are:

(1) identify cost effective and scientifically robust method to assess ecosystem services;
(2) identify step necessary to establish the institutional framework and activity mechanism necessary to generate the ecosystem services; and,
(3) compare and contrast pricing and payment options, both voluntary and compulsory, based on the scientific quantification and valuation of forest ecosystem services; and,
(4) strengthen capacity of the stakeholders for the identification, assessment and delivery of forest ecosystem services under PFES.

Dr. Kawasaki also provided some of the key outputs to be expected from the research project, in particular: scientific assessment of main forest ecosystem services at each project site; review of policies, laws, practices and institutions for delivering ecosystem services; model PFES systems proposed for each research site; guidebook on design and implementation of payment for forest ecosystem services; and research reports for each site, policy brief and at least two peer reviewed papers in leading academic journals. Finally, it is hoped that the project would lead to increased face-to-face engagements between local communities, policymakers and scientific community on forest management and conserving forest ecosystem services.

Thailand Project Site: Phu Kao Phu Phan Kham National Park, Nong Bua Lumphu Province

Dr. Adcharaporn Pagdee presented an overview of the Thailand project study site:
Phu Kao Phu Phan Kham National Park (PKNP) is Thailand's 50th national park, established in September, 1985. The park locates between latitudes 16° 46' - 17° 02' N and longitudes 102° 24'-102° 43'E crossing three provinces in northeast Thailand (i.e., Khon Kaen, Nong Bua Lamphu, and Udon Thani). It covers approximately 32,200 ha (322 km^2), consisting of two main areas. The western section is located in the Phu Kao (PK) mountain range and the eastern section in the Phu Phan Kham mountain range of the Phu Phan Mountains. This study focuses on Phu Kao in Nong Bua Lamphu Province since its watershed forests contribute to tributaries of Pong River where the region's largest dam: Ubolratana Dam is located. Phu Kao Phu Phan Kham National Park consists of diverse landscapes, including sandstone mountains, undulating topography, and a vast floodplain of the Pong River, creating the Ubolratana Reservoir. It is among the important fossil sites where dinosaurs were discovered, dating from the Mesozoic era. The major vegetation is the dry Dipterocarp forest, covering approximately 70% of the park, followed by mixed deciduous forest (10%) and dry evergreen forest (10%)

Session I: Land use pattern and ecosystem services of PKNP

In this session, Dr. Pagdee presented land use pattern and types of ecosystem services of Phu Kao are as follows: Phu Kao was designated as part of PKNP where the forest resources have been protected under laws created and enforced by the Department of National Parks, Wildlife, and Plants Conservation (DNP). Intermixed within the park are Phu Kao National Forest Reserves covering approximately 16,500 ha. Access to the forest reserves is less restrictive when compared to the national park lands due to different rules and regulations. Moreover, approximately 1,600 ha of the park lands were set aside for agricultural and residential use purposes as part of the 1998 Cabinet Solution to resolve land use conflict with villagers who claimed occupation before park designation. These communities include Dongbak Village, Wangmon Village and Chaimongkol Village. Villagers were granted usufruct rights for their land, so they can use the land for agricultural activities within designated areas inside the national park with a limitation of crop types for planting. Management authority over this designated area was transferred to local administrative organizations of Non Sang District, Nong Bua Lamphu Province

In addition to the 1,600 ha designated area for community use, another 588 ha are areas of Hui Bong Dam and its reservoir built in 2011 for irrigation purposes. Popradit et al. (2015a) documented that during the 20 years period (1991-2011) the size of three villages (i.e., residential area) expanded drastically from approximately 9 ha to 123.2 ha. Furthermore, Phromma (2017, unpublished data) identified land use patterns in the 1,600 ha designated zone using Google Earth satellite imagery in 2015, including: 1) 123.2 ha of residential areas (5.6%) and 2) farmlands where 80.9% were cassava plantations. The agricultural area increased 46.4% during 2013-2015 from 1,235.7 ha in 2013 to 1,809.6 ha in 2015. Interestingly, the total land use area was identified 1,932.8 ha greater than the designated area. It found that at least 332.8 ha (20.8% of the designated area) overlapped the protected forests.

Types of ecosystem services in Phu Kao are:
Villagers within/surrounding Phu Kao used the forest as source for food, fuel and grazing ground. Non-timber forest products, especially mushrooms and wild vegetables are major forest products harvested by local villagers. Some could earn additional money from selling mushrooms approximately US$3.25 per day:

In addition to direct benefits accrued by local villagers at Phu Kao, the watershed forests support several tributaries (e.g., Hui Bong and Lam Pa Naing) of Pong River where Ubolratana Dam is located. Water from Ubolratana Reservoir has been used for irrigation and electricity generation that support people in the city of Khon Kaen—one of the biggest cities in the northeast. For electricity generation, Ubolratana Dam is capable of generating electricity at the rate 55 mil. kWatt per hour

(EGAT, 2017);

For irrigation used purposes, Nong Wai Dam was built in 1987 to distribute water to irrigated areas. It is located on Pong River, approximately 35km down stream of Ubolratana Dam. Nong Wai Dam receives raw water mainly from Ubolratana Reservoir (storage capacity 2,263.60 mil. m^3) where its recharge is approximately 14,000 km^2. Irrigated areas cover approximately 418.14km^2 (Royal Irrigation Department, 2017b).

Section II: Payment for ecosystem services and livelihoods

In this session, Dr. Kawasaki explained definition of an ideal payment for ecosystem services (PES) includes five main components: 1) a voluntary transition between providers and buyers, 2) well-defined and measurable ecosystem services, 3) existence of demand for ecosystem services by a minimum of one buyer, 4) provision of ecosystem service by a minimum of one seller, and 5) the conditionality of the payment wherein payment will be made upon the provision and ecosystem services over time. To develop the PES deals, the PES scheme requires four key steps: (1) Identifying ecosystem service prospects and potential buyers; (2) Assessing institutional and technical capacity; (3) Structuring agreements; and (4) Implementing PES agreements. The PES scheme achieves efficiency from the directness in its approach and implementation of management practices. In Thailand project site, the PES mechanism focuses on payment for conserving protected forests to secure adequate water supply in the drought prone areas of north-eastern Thailand.

With regard to methods of assessment, Dr. Kawasaki explain four important component: (a) Valuation methods of forest ecosystem services; (b) Estimating willingness to pay for drought mitigation; (c) Assessment of historical and future water supply of Phu Kao for storage in the dam; (d) Identifying potential buyers and sellers for engaging PFES and price of water will be paid by actual users plus fees for forest conservation in Phu Kao

Session III: Integration of policy

In this session, Dr. Kawasaki reviewed the current policy-debate on PES at the international level and development of PES mechanism in Thailand. The Tenth Meeting of the Conferences of the Parties to the Convention on Biological Diversity (CBD-COP10) at Japan, October 2010 has decided to encourage the development of international discussions on ecosystem services. At COP 10, the Economics of Ecosystem and Biodiversity (TEEB) launched a report on the economic value of ecosystem services, and highlighted the economic losses that would be incurred from their degradation. The World Bank launched its project on Wealth Accounting and Valuation of Ecosystem

Services (WAVES) for the integration of ecosystem services into National Accounts frameworks for improved decision-making based on the values of biodiversity. It aims to support the development of environment accounts in 6-10 countries by 2015, and to adopt and international guideline on ecosystem accounting.

The Government of Thailand proposed PES in the Eleventh National Economic and Social Development Plan (NESDP) B.E. 2555-2559 (A.D. 2012-2016) to generate community income from forest management and to reduce deforestation and forest degradation (NESDB, 2011). Department of National Park Wildlife and Plant Conservation (DNP) of Thailand in collaboration with United Nation Development Programme (UNDP) initiated assessment of ecosystem service valuation for effective management in the target protected areas and community participation in forest management. The Lowering Emissions in Asian Forests (LEAF) Program with support of USAID LEAF tested and developed an incentive-based mechanism of PES in the Mae Sa-Kog Ma UNESCO Man and Biosphere Reserve site in Chiang Mai Province of Thailand, and generated lesson learned to support sustainable forest ecosystem conservation. However, the PES systems have been slow to develop in Thailand due to insufficient understanding of PES concepts between stakeholders, limited collected data of ecosystem services valuation by local communities participatory, and lack of potential buyers.

Our project goes beyond development of PES mechanism, the project will develop and apply methodologies for identifying valuation of forest ecosystem services in the Phu Kao Phu Phan Kham National Park (PKNP), assess willingness to pay for conserving protected forests to secure adequate water supply in the drought prone areas of north-eastern Thailand, and propose appropriate PFES system to strengthen the conservation and management of forests, such as pricing and payment options for forest ecosystem services.

Field visit to *Phu Kao*

The field trip to Phu Kao, one of project sites in Northeast Thailand offered a good opportunity for the workshop participants to appreciate different land uses with their ecosystem services. The land use pattern is composed of forests, agricultural land **within designated areas inside the national park with a limitation of crop types for planting**, and village settlements surrounding Phu Kao. Forests are further divided into conservation forest and headwater, major vegetation in forests is the dry Dipterocrap forest. The field trip started off with the group meeting with head of Phu Kao Phu Phan Kham National Park Office to discuss the situation of deforestation and forest degradation in Phu Kao.

During the field trip, Officials of Phu Kao Phu Phan Kham National Park joined with participants to observe forests in Phu Kao and meet with villagers who living within/surrounding Phu Kao to interview about benefits of forest ecosystem and their incomes from forests. Villagers harvested mushrooms, wild-plants and animals. They could earn income from selling mushrooms and bamboo. Participants appreciated the villagers for their time to share their knowledge about forests in the village before departure.

Review and discussion of the work plan and responsibilities

Discussion on work plan started with review of an overall work plan for two years based on the project proposal prepared by IGES. It was agreed that five main outputs will be achieved in Year One, including (1) Assessment of forest ecosystem services from Phu Kao Forest, (2) Community perception on role of forest ecosystems in drought mitigation, (3) Pricing and willingness to pay for drought mitigation, (4) Review effective polices, laws and stakeholders for delivering payment for forest ecosystem services in Phu Kao, and (5) report of willingness to pay for water provisioning services at project site in Thailand. The discussion finalized the work plan for Year I from October 2017 to August 2018.

Finally, the workshop was closed with Dr. Kawasaki's remarks to thank KKU's excellent organization of the workshop as well as valuable inputs of all workshop participants.

List of participants

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Mr. Chom Suppamatr, Chief Executive

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Mr. Dusit Meekaew, Permanent Secretary, Office of the Permanent Secretary

Mr. Nakorn Phunikom, Chief Administrator, Office of the Permanent Secretary

Mr. Montree Nakornchai, Kok Muang Village Leader

Mr. Wimon Namkham, Kok Sri Rueng Village Leader

Mr. Thanakorn Saengpo, Kha Noi Village Leader

Mr. Kittisak Duangkhamchan, Kok Muang subdistrict and Mad Village Leader

Mr. Sompong Phromtria, Thad Hai Village Leader

Mr. Thana Pothiwong, Nong Ping Village Leader

Mr. Wittaya Wannaphet, Bung Bok Village Leader

Mr. Paijit Srisawad, Wangmon Village Leader

Mr. Aarwoot Thantrakul, Chaimongkon Village Leader

Department of National Park, Wildlife and Plant Conservation

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Mr. Ranya Sudtha, Assistant Head of Wildfire Control Station, Nong Bua Lamphu

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Royal Irrigation Department

Mr. Thanakrit Paholtap, Head of Water Distribution and Maintenance Division 1

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Appendix 2: Summary of the 2019 project conclusion workshop in Thailand

SUMMARY REPORT
2019 Project Conclusion Workshop
A joint IGES-KKU Project on
"Effective Models for Payment Mechanisms for Forest Ecosystem Services in Thailand"
July 4, 2019
Kok Muang Sub-district Administration Office
Non Sang, Nongbua Lamphu, Thailand

1. Background

Khon Kaen University (KKU) and Institute for Global Environmental Strategies (IGES), with a financial support from the Asia-Pacific Network for Global Change Research (APN), jointly organized a 2019 project conclusion workshop on "Effective models for payment for ecosystem services from the watershed forest in Phu Kao – Phu Phan Kham National Park, Thailand: local perception and willingness." The workshop was held on July 4, 2019 at Kok Muang Sub-district Administrative Organization (SAO) office in Nongbua Lamphu province, northeast Thailand. Its main objective was to disseminate the study's findings to relevant agencies and obtain their feedbacks, especially on PES-project development and implementation guidelines. Key participants came from various sectors, including:

1. Village leaders from Kok Muang and Nikom Pattana sub-district;
2. Local administration i.e., Kok Muang and Nikom Pattana SAO;
3. Governmental authorities i.e., Phu Kao-Phu Phan Kham National Park (PKNP), Nongbua Lamphu Provincial Office of Natural Resources and Environment, Royal Irrigation Department: Nongbua Lamphu office (RID), and Protected Areas Regional Office 10, the Department of National Park, Wildlife and Plant Conservation (DNP);
4. University researchers.

2. Workshop program

The workshop included several activities in an attempt to create active discussion among participants. Below is the workshop program.

Time	Activities	Speaker/responsible persons
8:30-9:00	Registration at Kok Muang SAO (KM-SAO) Office	Miss Issara Phromma and Miss Jitarree Saisema, KKU
9:00-9:30	Opening session	
	Project introduction and workshop objective presentation	Dr. Jintana Kawasaki, IGES
	Welcome speech by Chief Executive of KM-SAO	Mr. Chom Suppamatr Chief Executive of KM-SAO
9:30-10:30	Presentations on current forest protection at Phu Kao (PK) and water management	
	Current conditions of Phu Kao watershed forest: protection plans and policies from the DNP	Mr. Den Rattanachai Representative from PKNP
	Water management: Hui Bong Dam irrigation project	Miss Bunta Kunduangchan Representative from the RID: Nongbua Lamphu Office
	Community participation in Phu Kao forest protection: plans and policies from local administrations	Mr. Dusit Meekeaw Chief Administrator of KM-SAO
10:30-11:15	Presentations on project findings	
	Ecosystem services from Phu Kao watershed forest and PES-project development in the case of Phu Kao	Dr. Adcharaporn Pagdee, KKU
	Villager willingness to pay and to accept for Phu Kao water forest protection	Dr. Jintana Kawasaki, IGES
11:15-12:30	Group discussion on PES-project development at Phu Kao. Key discussion addressed these issues: Development opportunity Relevant agencies: their roles and responsibilities Payment mechanisms, including who will pay, for what and to whom? Protection activities for the watershed forest Strengths, weaknesses and obstacles for PES-project development Workshop conclusion	All participants Moderator: Dr. Adcharaporn Pagdee, KKU
12:30-	Lunch	All participants

13:30		
13:30- 16:00	Field visit to Hui Bong Dam and Phu Kao watershed forest	Research team, accompanied by a park officer.

3. List of workshop participants and roles

A total of 30 participants participated in the workshop. They came from various sectors from local communities to local administration, governmental authorities and university researchers. Below is the list of workshop participants and their agencies.

Sector/agencies	**Number of participants**	**Key roles**
Local communities. Leaders and villagers from the 10 villages involved in the study. Three villages inside PK Seven villages outside PK	11	Direct users of the watershed forest Local coordinators, especially with villagers
Local administration Kok Muang SAO Nikom Pattana SAO	5	Making plans/policies on community development and forest conservation Financial supporter, esp. KM-SAO
Governmental authorities The DNP PKNP headquarter PKNP Fire Control Station Protected Areas Regional Office 10 Lam Paniang Watershed Management Unit Forest Development Project under the Royal Initiative Nongbua Lamphu Provincial Office of Natural Resources and Environment RID: Nongbua Lamphu Office	8	The DNP is a main responsible authority for forest protection in protected areas. Nongbua Lamphu Provincial Office of Natural Resources and Environment is a governmental authority working on policy and planning, esp. in its responsible areas. The RID: Nongbua Lamphu Office is a main authority responsible for Hui Bong Dam irrigation project and water resource management.
University researchers from KKU and Valaya Alongkorn Rajabhat University, Pathum Thani	5	Conducting research projects Providing academic/technical supports

Institute for Global Environmental Strategies	1	Conducting research projects Providing academic/technical supports
Total	30	

4. Discussion Summary

Key discussion issues from the participants are as follows.

4.1) Water management.

Village leaders expressed their great concerns on water distribution. They mentioned of unfair distribution and ineffective water management. For example, weirs and water gates are located in their village (i.e., Tad Hai), but they don't get any benefits from the irrigation project only people downstream. The village leaders suggested the RID to have a community hearing before designing where to build weirs and water canals. Local communities must gain access to the water too not only downstream users.

4.2) PES-project development for Phu Kao watershed forest protection.

PES was introduced as an alternative approach for effective forest protection at PK. Water provision, drought mitigation and NTFPs are the main ecosystem services provided by the watershed forest. The three villages inside the park are considered potential service providers, while villagers benefit from Hui Bong Dam irrigation project represent potential service buyers. All participants agreed with the PES-project proposal. But they expressed that PES is a very new concept for all relevant sectors, from governmental authorities down to local administration and villagers. What is PES? How does it work? Who will pay, for what and to whom?

Local administration and governmental authorities, including Kok Muang and Nikom Pattana SAO, Nongbua Lamphu Provincial Office of Natural Resources and Environment and PKNP, stated their support for PES-project development, including funding. They were optimistic about PES-projects at PK, but cautious over implementation since it required extensive assistance from outsiders who are familiar with PES and who are willing to work with the communities.

Although the concept is new for villagers, local administration, and governmental authorities, everyone wanted to try it. The workshop participants suggested that the first step is to increase understanding and awareness of PES to the locals and relevant sectors, especially villagers. For some villagers it may be difficult to ask them to participate in PES-project due to income constraint and livelihood dependence on the watershed forest. However, the village leaders are confident that if giving them time and information on how forest protection can actually benefit their livelihoods, they will participate in the PES-project.

Changing the perception that nothing is free, not even NTFPs that have provided income for generations, is a mental barrier for many villagers. Now, the term “payment” is introduced to compensate for ecosystem services through hypothetical mechanisms between a service buyer and seller. On the buyer side, it is easy to understand since villagers can see themselves clearly as a service user. But on the seller side, ecosystem services are relatively invisible. Local communities are supposed to act as the service seller, but they also use the same services for payment by outsiders. In other words, they are the buyer and seller simultaneously. This logic will be difficult for some villagers to follow since many of them are illiterate. Government authorities and local administrators will also have to understand their roles as a mediator and/or supporter of PES-project development. Finally, although it’s a long road to go for PES-project development at PK, everyone wanted to try it.

5. List of participants: name and contact information

5.1 Local communities. Consist of 11 village leaders and/or representatives from 10 villages participated in the workshop, namely:

No.	Name and address	Telephone
1	Mr. Uthai Wannaphet Nong Ping Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-
2	Mr. Aekamorn Khlangklang Thad Hai Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	+66 090 549 8475
3	Mr. Phaijit Srisawat Wangmon Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-
4	Mr. Pradit Khankwa Wangmon Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-
5	Mr. Nappadol Bunkaeo Kok Srirueng, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	+66 093 664 8213
6	Mr. Montian Tapindang Kok Srirueng, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-
7	Mrs. Supaporn Poungprasert Kha Noi Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	+66 062 187 1694
8	Mr. Montree Nakhomchai Kok Muang Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	+66 095 652 1562
9	Mr. Arvut Tantrakool Chaimongkon Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-
10	Mr. Jit Pidpong Dongbak Village, Nikom Pattana Sub-District, Non Sang District, Nongbua Lamphu Province	-
11	Mr. Kittisak Duangkhamchan Kok Muang Village, Kok Muang Sub-District, Non Sang District, Nongbua Lamphu Province	-

5.2 Local administrations. Consist of key local administrative executives and personnel, namely:

No.	Name and address	Telephone
1	Mr. Chom Suppamatr Chief Executive ofKok Muang Sub-district, Non Sang District, Nongbua Lamphu Province	+66 985 645 6066
2	Mr. Dusit Meekeaw Chief Administrator of Kok Muang Sub-district, Non Sang District, Nongbua Lamphu Province	-
3	Mr. Nakhorn Phunikom Kok Muang Sub-district Administrative Organization personnel Kok Muang Sub-district, Non Sang District, Nongbua Lamphu Province	-
4	Miss Suangporn Bunbai Kok Muang Sub-district Administrative Organization personnel Kok Muang Sub-district, Non Sang District, Nongbua Lamphu Province	-
5	Mr. Saracrit Kumpitchoo Deputy Chief Executive of Nikom Pattana Sub-district, Non Sang District, Nongbua Lamphu Province	+66 098 590 1341

5.3 Governmental authorities. Consist of key personnel and/or representatives as follows.

No.	Name and address	Telephone
1	Mr. Den Rattanachai Representative of the Head of Phu Kao – Phu Phan Kham National Park, Department of National Parks, Wildlife and Plant Conservation	+66 093 069 7997
2	Mr. Chatchawan Namsang Head of Lam Paniang Watershed Management Unit Protected Areas Regional Office 10	+66 082 175 6031
3	Mr. Weerasak Photisiri Head of the Forest Development Project under the Royal Initiative Protected Areas Regional Office 10	-
4	Mr. Ranya Sudta Representative of PKNP Fire Control Station Phu Kao – Phu Phan Kham National Park Department of National Parks, Wildlife and Plant Conservation	+66 085 851 2905
5	Miss Bunta Kunduangchan Representative of the Royal Irrigation Department Nongbua Lamphu Office	-
6	Miss Natchaya Khunsri Representative of the Royal Irrigation Department Nongbua Lamphu Office	-
7	Mrs. Siriwan Sudachan Director of Nongbua Lamphu Provincial Office of Natural Resources and Environment	+66 042 316 707
8	Mr. Anuwatr Tipsuwan Officer, Nongbua Lamphu Provincial Office of Natural Resources and Environment	+66 042 316 707

5.4 University researchers. Consist of graduate students and researchers, namely:

No.	Name and address	Telephone
1	Dr. Adcharaporn Pagdee Department of Environmental Science, Faculty of Science, Khon Kaen University, Khon Kaen 40002 Thailand Email: adcpag@kku.ac.th	+66 087 225 7129
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4	Dr. Ananya Popradit College of Innovative Management, Varaya Alongkorn Rajabhat University, Klong Luang, Prathum Thani 13180, Thailand Email: Ananyaphd@gmail.com	+66 997 212 6415
5	Mr. Yutthana Nakhokwik College of Innovative Management, Varaya Alongkorn Rajabhat University, Klong Luang, Prathum Thani 13180, Thailand Email: nakhokwik@hotmail.com	-

5.5 International agency.

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6. Pictures from the workshop and site visit in Phu Kao


Dr. Jintana introduced the research project and workshop objectives.


Kok Muang SAO Chief Executive welcomes all participants.


Dr. Adcharaporn described the workshop program and expected outcome.


Assistant head of PKNP was presenting current situations of PK watershed forest and protection policies


A representative from RID was talking about irrigation project and water management plans.


Kok Muang SAO Chief Administrator expressed his support on PES-project

development.


Dr. Jintana was presenting her study on WTP and WTA for PK watershed forest protection.


Dr. Adcharaporn talked about PK ecosystem services and a concept on PES and PES-project development at PK.


Dr. Adcharaporn explained how PES-project works and asked the participants to share their thoughts on a project development opportunity at PK.


A village leader shared his perspectives about PES-project development at PK.


A village leader shared his perspectives about PES-project development at PK.


Kok Muang sub-district leader shared his perspectives about PES-project development at

PK.

A village leader shared his perspectives about PES-project development at PK.

Lam Paniang Watershed Management Unit shared his perspectives about PES-project development at PK.

A representative from PKNP fire control station shared his perspectives about PES-project development at PK.

Head of the Forest Development Project under the Royal Initiative shared his perspectives about PES-project development at PK.

A representative from RID shared her perspectives about PES-project development at PK.

A university lecturer and researcher, conducting research projects at PK shared her perspectives about PES-project development.

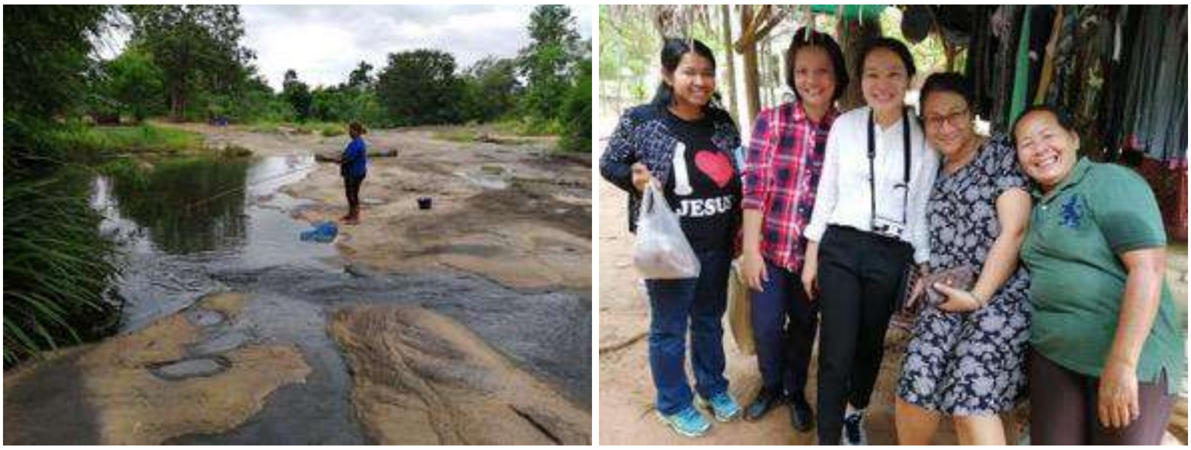
Director of Nongbua Lamphu Provincial Office of Natural Resources and Environment expressed her supports on PES-project development at PK.

Participants at the project conclusion workshop.

Participants at the project conclusion workshop.

Local landscape from the KM-SAO Office.

Participants discussed and shared their thoughts about PES-project development and possible collaborations during lunch.



Some pictures from the field visit at PK watershed forest: Tad Hway stream merging with Lam Paniang and a group photo with villagers and research team.

Road conditions passing through Phu Kao in Phu Kao – Phu Phan Kham National Park. These roads allow villagers and outsiders to commute in and out through the park area more easily.

Agricultural lands inside the park intermixed with forest areas: rice paddies and cassava plantations (left) and sugarcane plantation (right)

Effective Models for Payment Mechanisms for Forest Ecosystem Services: The Case of Upstream Communities in Sta. Rosa-Silang and Bay-Cambantoc Subwatersheds, Philippines

[1/]Canesio D. Predo and [2/] Jintana Kawasaki

[1/]University of Philippines Los Banos,Philippines;

[2/] Institute for Global Environmental Strategies (IGES), Japan

1. Introduction

Flooding is among the common natural disasters that cause devastating damages to vulnerable areas. Onwards the 20th century, flood strength and frequency are globally intensified as consequences of the anthropogenic factors and climate change (Carson, 2012). This affects most the continent of Asia which has the majority of flood-prone and high flood risk countries (Balica, Douben, & Wright, 2009). In the Philippines, aside from its geographical location that poses hazards to natural disasters, the country's current population growth, land conversion rates and deforestation contribute to higher flood vulnerability (World Bank, 2005; Center for Excellence in Disaster Management & Humanitarian Assistance, 2018). Alarmingly, with the occurrence of climate change, extreme weather events like flooding are feared to continue to worsen through time, if not appropriately mitigated. With that, such measures to manage and conserve the remaining forests are of pressing need in order to restore the forest ecosystem services that can mitigate the flooding disasters happening in the country.

Across the regions of the Philippines, the surrounding watersheds of Laguna Lake was mentioned to be among areas which experiences severe stress due to land degradation (Lasco & Pulhin, 2006). Accordingly, based on the study of Lasco & Pulhin (2006), there is only 26% remaining forest cover out of the 73,000 ha of the total forestlands in Laguna. This in which results to a great loss of forest ecosystem services that could have mitigated the disastrous floods. Among the surrounding watersheds in the Laguna Lake region is the Cambantoc Subwatershed that covers the municipality of Bay and is also one of the four subwatersheds of the Makiling Forest Reserve. However, despite of the subwatershed's inclusion to the protected area of the Mt. Makiling Forest Reserve, part of the Cambantoc Subwatershed still suffers from deforestation, land use conversion and increased upland settlements (Ardales, Espaldon, Lasco, Quimbo, & Zamora, 2015). In conforming with, the Laguna Lake Development Authority (LLDA) also stated that forestlands of the watersheds surrounding the Laguna Lake region were deforested rapidly, transforming forests into agricultural, industrial, commercial and residential lands, which also conjoins with the statements of the residents from Bay in the study of Ardales, et.al. (2015). With the occurrence of deforestation and forest degradation in the area, these cause to impairment of ecological services and hydrologic cycle that further leads to flooding disasters; as there is less forest vegetation that holds and stabilizes the soil and assists infiltration that minimizes surface run-off. And as it was mentioned on the Comprehensive Land Use Plan of Bay that some parts of the Cambantoc Subwatershed is really prone to high to moderate erosion; it only exposes a reasonable inference that forest vegetation therein plays an important role to the communities, and thus should be managed properly.

In a watershed setting, the upland areas serve as a recharge area for the entire watershed. With the degradation of the forests in upstream area, it causes imbalance in the entirety's hydrological cycle impacting the downstream areas, as voluminous water from the uplands will lead to flooding in downstream areas. This is due to the effect of forest degradation to soil quality that lessens the capacity of soil to hold more rain or storm water. Increase in built-up areas upstream will also lessen the infiltration capacity of the soil and thus leads to higher surface run-off going to the downstream. In the case of the municipality of Bay, it was described by Tiburan, et.al (2012) that the land-use in upstream area of the Cambantoc Subwatershed is generally agroforest and brushland. However, based on the CLUP of Bay, some forestlands in the upland area were already converted to settlements, agricultural lands, and other land uses. There are also patches of built-up areas in the uplands of Bay, based on the data by NAMRIA and MCME (2013) cited by Dida, Paquit, Boongaling, Magnaye, & Bantayan (2013). Moreover, due to the less vegetative cover and slope of the areas, some of the barangays in the uplands of Bay are susceptible to erosion. And with the increasing population pressure of the Philippines, it poses serious threats for the forests in the upland areas that are feared to be converted soon into residential lands and other land uses, especially if there is a lack of market value of it.

As it is evident that improper watershed management causes forest degradation and eventually leads to other environmental problems that affects the watershed as a whole, it is significant to implement sustainable land management strategies that targets the securement of the forest ecosystem services. But even if there are such strategies that can combat the forest degradation, it cannot be considered as sustainably effective due to its limited budget. One such approach for the proper provision of sustainable forest management and conservation is through the payments for forest ecosystem services (PFES). It is based on the principle that the beneficiaries from the downstream areas will be the one to pay for the ecosystem services they are receiving from the upstream areas. On the other hand, the compensation from the downstream areas will be used for sustainable watershed management activities for the conservation and continuous provision of ecosystem services from the uplands. However, some forest ecosystem services are not traded in markets and thus do not have market value. One appropriate tool to determine the value of a specific ecosystem service is through contingent valuation which encompasses on asking the willingness to pay of the people through a survey based on a hypothetical scenario and a depiction of a specified environmental service.

In this study, the basic assumption is that the compensation provided by the downstream households in Bay is used to avoid damage cost from flooding in their area, through the implementation of sustainable forest management activities in the uplands. As such, integration of tree-based system as nature based solution in the PFES program could be a viable tool in response to the degrading uplands. This in turn results to the continuous and sustainable provision of flood regulation services in the downstream of Bay.

1.1 Objectives

The project generally aimed to assess the main forest ecosystem services at each project site in order to provide a deeper understanding on crafting sound payments for forest ecosystem services, integrating appropriate systems based on its detailed settings. Whereas, the main objectives of this study was (1) to estimate the willingness to pay of the downstream households in Bay, Laguna and the willingness to accept of the upstream households support the conservation and maintenance programs for the forest and agroforest ecosystem for improved flood regulation services; and (2) to quantify the opportunity costs of adopting nature-based approach through sustainable farming systems in the upstream areas of Silang, Cavite and Bay and Los Banos, Laguna for the improved provision of flood mitigating service in Silang-Santa Rosa Subwatershed and Cambantoc Subwatershed, respectively.

Accordingly, the detailed objectives of the study were:

(1) Estimate the willingness of the downstream households in Bay, Laguna to support the conservation and maintenance programs for the forest and agroforest ecosystem for improved flood regulation services

- To assess the awareness levels and attitudes of the downstream households on the forest and agroforest ecosystem benefits and services;
- To identify the estimate values of the willingness to pay of the downstream households in support for the improvements in flood regulating service of the forest and agroforest ecosystems in the upland areas of the subwatershed;

- To analyse the factors affecting the willingness to pay of the downstream households for the improved flood regulation service;
- To identify and estimate the damage costs experienced by the downstream households due to flooding.

(2) Quantify the opportunity costs of adopting nature-based approach through sustainable farming systems in the upstream areas of Silang, Cavite and Bay and Los Banos, Laguna for the improved provision of flood mitigating service in Silang-Santa Rosa Subwatershed and Cambantoc Subwatershed, respectively.

- To estimate the values of the willingness to accept of the upstream households in support for the improvements in flood regulating service through conserving forests and adopting sustainable tree-based farming system;
- Estimate the financial profitability of the different farming systems adopted in the upland areas of selected subwatersheds;
- Assess the factors influencing the decision of farmers in adopting tree-based systems as nature-based approach for sustainable farming;
- Analyse and assess the levels of economic risks of the different farming systems applied by the farmers; and
- Draw policy implications for the enhancement of the PFES scheme related to improvement and application of sustainable farming system in the degraded uplands in order to achieve sustainability.

1.2 Review of Related Literature

1.2.1 Forest Ecosystem Services Valuation

The forest ecosystem is defined as the most basic unit level of the interdependent system of interacting living and non-living elements inside the forest (Department for Environment Food and Rural Affairs, 2007). Most of the services from the forest ecosystem—particularly flood regulation function—are also considered as public goods. Wherein, it is defined by Brander, Brouwer, & Wagtendonk (2013) that those beneficiaries of these ecosystem services cannot be exempted from receiving the service, and moreover, the consumption level by one beneficiary does not reduce the level of service that is received by another. Due to the consumption characteristics of this service, being non-excludability and non-rivalry, such potentials for sustainable management of the resources that provides the services is limited and its market do not exist (Brander, Brouwer, & Wagtendonk, 2013). Accordingly, it was found out by the Millenium Ecosystem Assessment that almost two-thirds of the ecosystem goods and services are in decline worldwide as the consequences of the increasing anthropogenic pressure over natural resources, which is mainly due to the lack of value of forest resources and ecosystem services that are common seen as free commodity (Department for Environment Food and Rural Affairs, 2007). Destruction of any of forest resources leads to damages on the whole system and the provision of its services to humanity. With this unawareness of the ecosystem services values, such importance of the forest resources as natural capital has also tended to be disregarded.

According to Pascual et.al (2010), values are attributed based on the society's preferences whether their needs and satisfaction are fulfilled. In order to assign economic values for the ecosystem services, there is a need to reframe the relationship between the society and resources produced through economic valuation. However, placing values on some ecosystem services can be challenging since some of them do not have a well-developed market (Pascual et.al, 2010). Among these ecosystem services include the regulating services and cultural services. Nevertheless, in response to this, there are such economic estimates to value a specific ecosystem service. And through valuation, complexities of human decisions are unravelled and thus serve as a significant basis on decisions regarding value for money, prioritization for funding and assessment for competing uses of resources (DEFRA, 2007).

1.2.2 Payments for Ecosystem Services in Watershed Scale

With the current deterioration of ecosystem services, the availability of literatures that employs economic valuation approaches are now expanding. DEFRA (2013) mentioned that development of market-based mechanisms is a viable and logical step in order to provide significant information in decision-making process. Payments for Ecosystem Services (PES), for one, serve as an advanced instance of market-based mechanism.

Based on the definition by DEFRA (2013), the PES is described as an economic arrangement in which the stewards or providers of the ecosystem services should be paid by the beneficiaries of it. Consequently, the PES scheme provides an opportunity for the un-priced ecosystem services to have a specific price (DEFRA, 2013). With this, it can be means of increasing the supply of ecosystem services by restoring the natural resources that provide these commodities. Funds generated from the beneficiaries are used for the conservation and management of the ecosystem with the objective of sustainable provision of ecosystem services.

In the developing countries, the use of PES programs as policy instrument in watershed protection is becoming widely used (Whittington & Pagiola, 2012). As mentioned in the study of DEFRA, 2013 and Whittington & Pagiola (2012), one crucial feature of any PES program is the price for the environmental services, in which this comprises the minimum and maximum payment. The minimum payment should be paid by the downstream beneficiaries of forest ecosystem service. Moreover, it should at least cover the forgone income by the farmer or stewards of the resources in the uplands as a result of their reduced unsustainable practices that destruct the ecosystem services provision (DEFRA, 2013). On the other hand, the theoretical maximum payment is the value of the received additional ecosystem services of the buyers (DEFRA, 2013). However, there is an inevitable tendency that some ecosystem service, other than the specific benefit that is supposed to be produced, are generated as well after applying the same management techniques. With this, such payment arrangements are agreed by the supplier and beneficiary of the ecosystem services and PES payments are set in order to have a settled median point between the minimum and maximum values (DEFRA, 2013).

1.2.3 Contingent Valuation Method

Designing PES programs requires such methodologies to estimate the maximum and minimum amount that the buyers of ecosystem services are willing to pay and the sellers of those services are willing to accept. In order to determine these values, most of the PES program designers applied the use of Contingent Valuation Method (CV) (Whittington & Pagiola, 2012).

The Contingent Valuation (CV) is a simple yet flexible valuation method that is used in valuing nonmarket goods (Venkatachalam, 2003). As mentioned also in the studies of Mitchell and Carson (1989) and Cummings et al. (1986), as cited by Venkatachalam (2003), the use of CV is widely applied in the context of environment cost-benefit analysis and environmental impact assessment.

In the context of PES applying the CV, Whittington & Pagiola (2012) mentioned that vast studies used the mentioned concept to estimate the willingness to pay of beneficiaries for the improved ecosystem services. And this is due to the CV's easier means of estimating the cost of provision of forest ecosystem services from the upstream stakeholders and stewards (Whittington & Pagiola, 2012). Meanwhile, the estimates encompasses the opportunity cost from unappropriate shifts of land uses in contrast to such activities that promotes sustainability of the land. And through the CV, it can aid in the evaluation of a feasible PES program. According to Whittington & Pagiola (2012), CV studies in PES can aid in assessing whether there is a possibility for a deal for the program. By means of the willingness to pay estimates, a cost-benefit analysis can be done so as to estimate probable increases for the society's welfare as a result from the improved provision of ecosystem services.

However, there are some issues regarding the validity of the use of CV. Carson (2000) cited that among these issues are the: rely on the involvement of passive-use or existence values in an economic analysis; and the results of CV studies should meet the economic criteria. While Whittington & Pagiola (2012) added that to further improve a CV-PES study, it should have the following elements: alternative information sets and its benefits and disadvantages should be discussed to the interviewees; alternative payment vehicles for collecting funds from the service users; justifications of the interviewees' answers regarding the survey; and valid estimates should be provided for the potential revenues that can probably be obtained from the beneficiaries of the ecosystem service. But still, despite of these issues, if a CV study is appropriately carried out, it can provide useful insights for the design of PES programs in most cases.

In the study of Calderon, Dizon, Sajise & Salvador (2016), CV is applied in estimating the local and foreign tourists' willingness to pay for the conservation of the Ifugao Rice Terraces in the Philippine Cordilleras. Such information component, including the detailed description of the resource to be valued, processes of the enhanced conservation program, payment vehicle, decision rule and etc., are among other things that were employed in their survey instrument. This is to lessen the biases on conducting the willingness to pay survey, as mentioned in the study and was described by Boyle (2003) (Calderon, Dizon, Sajise, & Salvador, 2016). However, Tuan (2006) in his study of "*Valuing the Economic Benefits of Preserving Cultural Heritage: The My Son Sanctuary World Heritage Site in Vietnam"*, contingent valuation and choice experiments were applied in estimating the economic benefits of nonmarketable goods. According to the study and as mentioned by Carlsson (2004), these two complements in acquiring such information. Herein, the contingent valuation method was employed in estimating the willingness to pay for a certain scenario, while the choice experiment was applied in estimating marginal willingness to pay for the improved services depicted in the scenario (Tuan, 2006).

1.2.4 Tree-Based Systems as Nature-Based Approach

As defined by the IUCN, Nature-based Solutions are mitigation approaches that intends to protect, sustainably manage and restore natural or modified ecosystems in adaptively and effective manner while concurrently providing benefits and services for the humanity and biodiversity (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). It also uses the benefits and services provided by the ecosystem in order to provide solution to the societal challenges, which includes natural disasters such as flooding (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). Among the measures of Nature-based Solution is the introduction of agroforestry systems or tree-based systems in restoration of ecosystem services.

Tree-based systems has proven itself to be considered as a potential alternative that can enhance the ecosystem services provision by mitigating land degradation while improving the productivity of the soil (Predo and Francisco 2008; Chittapur and Patil 2017; Place, Garrity and Agostini 2016). Related literatures also revealed that appropriate tree-based systems can help maintain soil organic matter and promote in nutrient cycling (Gama-Rodrigues 2011; Sanchez, 1987; Misra, 2011). These relatively indicate that tree-based systems can be definitely beneficial for the conjoining agricultural annual cash crops. Thereby with these environmental benefits, it can be assumed that majority of the farmers would definitely adopt this technology. However, rate of adoption of tree-based systems has been slow in the Philippines and also in other countries (Fortenbacher and Alave 2014; Alavalapati and Mercer 2004). Among the aspects affecting rate of adoption are economic and policy factors such as profitability and institutions dealing with tenure. As there are incomplete and unsecure property rights in some areas in the country, farmers tend not to invest on trees as investments. Based on the study of the GIZ (2012), as cited by Fortenbacher and Alave (2014), security of tenure in such parcel increases the probability of adopting tree-based system. While in terms of profitability, most upland farmers adopt monocropping of agricultural crops as it is the most profitable for them, however entails costs for the sustainability of the environment (Fortenbacher and Alave 2014). In the study of Snelder, Klein and Schuren (2007) on the preferences, uncertainties and opportunities of farmers in fruit-tree cultivation in Northeast Luzon, most farmers tend to consider fruit trees as a subordinate crop only as it were much less profitable than seasonal cash crops. This is accordingly due to the inadequate knowledge of farmers in tree management and species selection which contributes to the low growth rates and fruit production of fruit tree cultivation. With that, farmers tend to choose planting rice and corn varieties that are particularly high-yielding, as its management has already been known, despite of its having high amount of inputs of fertilizers and pesticides (Snelder, Klein, & Schuren, 2007). Meanwhile, integrating tree-based systems in such parcel has lesser maintenance, however, induces opportunity cost to local production of annual cash crops, as it will reduce the land available for growing annual cash crops (Snelder, Klein and Schuren 2007; Green, et al. 2005).

1.2.5 Payment for Ecosystem Services and Application of Nature-Based Solutions

According to Chittapur and Patil (2017), land conversion from forest to agricultural land is the prominent reason for soil erosion at many instances. While it is proven effective that in order to counteract such problem in a forest to agriculture converted area, trees are being reintroduced to effectively reduce surface run-off by serving as a barrier, providing a surface cover in the soil through its living and dead plant material in which it reduces the splash erosion and the velocity of surface runoff (Nair, 1993). However, as most of the country's rate of adoption of tree-based systems is low, there is a real need for enhancing the economic and policy research to increase the rate of adoption. In fact, Alavalapati and Mercer, 2004 cited that economics and policy were among the key areas of enhancing the impacts of tree-based systems or agroforestry, as mentioned in the first World Agroforestry Congress in June 2004 at Orlando, Florida. Thus, it is of real importance to have environmental policy tools in addressing such environmental issue.

Market-based instruments are considered to be a prevailing tool in environmental management and conservation that relies on directing regulation through market mechanisms (Boisvert, Meral, & Froger, 2013). An instance for that is the Payment for Ecosystem Services, in which it has been continuously applied in translating the values of ecosystems into incentives for the local actors or farmers who are providing the ecosystem services (Liang, 2012). Such sustainable land measures are applied by the land owners for the improved provision of ecosystem services, and they will be paid in turn by the beneficiaries who receive the ecosystem services. As mentioned by Carandang, Calderon, Camacho & Dizon (2008), this scheme resembles plow-back mechanism in which funds generated from the downstream areas will be used in the development and management of the forest and agroforest in the uplands to sustain the ecosystem service provision and the integrity of the subwatershed. Tree-based systems can be integrated in such sustainable management measures. Through Payments for Ecosystem Services, this can be a means to conserve the environment while providing incentives to the farmers for their application of such nature-based approach for the improved provision of flood mitigation services and to compensate for their loss of income for adopting the measure.

1.2.6 Valuation of Tree-Based Systems

Literatures on integration of socio-economic elements affecting adoption of tree-based systems have been considered to be vital as it affects the traditional biophysical agroforestry research. As trends nowadays focuses on adoption of Nature-based approaches, it is indeed crucial to determine the viability of the system for it to be adopted by the decision makers and land owners in a certain area. In conjoined with, according to Alavalapati and Mercer (2004), profitability, household benefits, equity, sustainability, soil conservation, environmental services, markets for inputs and outputs, gender and institutions are among that affects the nature and extent of tree-based system adoption. Such appropriate economic methodologies are used to extract information and come up with these variables or factor mentioned. Moreover, economic methodologies aids in assessing the mental calculus of a decision maker through models from the mehodologies can be viewed as abstract representations of the reality (Buongiorno and Gilless 2003; Alavalapati and Mercer 2004). Godsey, Mercer, Grala, Grado and Alavalapati (2009) summarized in their study the different economic methodologies that are commonly applied in assessing aroforestry systems. Farm budget models, for one, estimates the profitability of a farm by calculating economic indicators which are net present values (NPV), benefit-cost ratio (BCR), and internal rate of return. Another is through econometric models in which relationships among variables of the agroforestry system are determined and assessed in which are vital for decision-making in relevance to forecasting and policy analysis. On the other hand, values of environmental services in agroforestry ecosystems are estimated through nonmarket valuation models. Other economic approaches applied in assessing agroforestry systems include: risk assessment models, policy analysis matrix models, Faustmann and Hartmann models, linear and nonlinear programming models and regional economic models. In assessing such agroforestry system, combination of these models are crucial as each of the models has different strengths and weaknesses. Accordingly, these methodologies can be applied particularly in valuing environmental goods and services in agroforest ecosystem that can serve as inputs for decision making in PES scheme in determining the opportunity cost of adopting a sustainable land measure over the current system that contributes to the degradation of the environment (Department for Environment Food and Rural Affairs, 2007).

1.3 Conceptual Framework

1.3.1 Payments for Flood Damage Mitigation Benefits from Forest Ecosystem Services

People receive vast benefits from the forest and agroforest ecosystems. With the increasing population in the country, this also led to an increased demand for the forest ecosystem services. However, most of these services are neglected by economic markets (Kenter, Hyde, Christie, & Fazey, 2011). With this, it results to failure in considering non-marketed benefits as inputs on policy-decision making process and such environmental management programs (Economy and Environment Program for Southeast Asia, 2017). But despite of the importance of natural capital to humanity, societal demands tend to increase pressure on converting the natural capital that provide the service into other land uses, not realizing the impairment of ecosystem service as a consequence. Lack of market for the forest services and benefits accelerates the destruction of natural capital, leading to the destruction of ecosystem services as well.

In the case of the Cambantoc Subwatershed, the underlying population pressure, encroachment in the upstream and land use conversion intensify the risks for increased deforestation in the upland area. This further led to loss of provision of ecosystem services. With this, flooding is prominent in the area, particularly in the downstream areas that are traversed by the tributaries of the subwatershed. It was mentioned in some studies that this is the result of such anthropogenic malpractices both in the upstream and downstream areas, causing environmental degradation and deforestation that led to loss of ecosystem services and impairment of flood mitigating function of the forest (Ardales, et. al., 2015; Calzeta, Lansigan, Florece, Bantayan & Lapitan, 2014).

As evident, there’s a need for objective research in order to give solution to the existing deforestation and ecosystem services provision issues. With this, impacts of forest and agroforest degradation to downstream households and the worsening of environmental conditions were analysed. While according to S. A. Rahman, et. al. (2015) through conservation and proper management of forest and agroforest areas, these can provide as sources of ecosystem services and livelihood as well to such communities, however, markets for the ecosystem services should be created. Payment for Forest Ecosystem Services is a viable method for establishing a market-based mechanism while integrating the conservation, livelihood, and sustainability concepts in the upstream and downstream areas in the subwatershed. Hence, it was applied in this study and the demand for improved provision of flood regulating service was further valued and estimated.

There are such techniques in ecosystem services valuation. As mentioned in the study of Zhai (2006), contingent valuation method is mostly employed in estimating the value of a specific ecosystem service. Likewise in this study, the main focus is on the use of contingent valuation method to determine the willingness to pay of the downstream households for flood control. The assumption provided (Figure 1) indicates that such factors—including socio-economic characteristics, attitudes and behaviour and experiences from flooding—affect the downstream households' valuation for the provision of flood mitigation benefits from the forest and agroforest ecosystems. Correspondingly, there are such factors also that affect the willingness to accept of the upstream stakeholders. The generated willingness to pay and willingness to accept estimates will be then used for environmental policy program that targets the improved provision of flood mitigation service by applying sustainable management in the forest and agroforest areas. However, this study will just specifically focus in determining the willingness to pay. While therefore, through the Payments for Ecosystem Services (PES), market between the buyer and seller of certain ecosystem service is established. Moreover, deeper analysis on mitigation of the occurring environmental and deforestation problems is addressed.

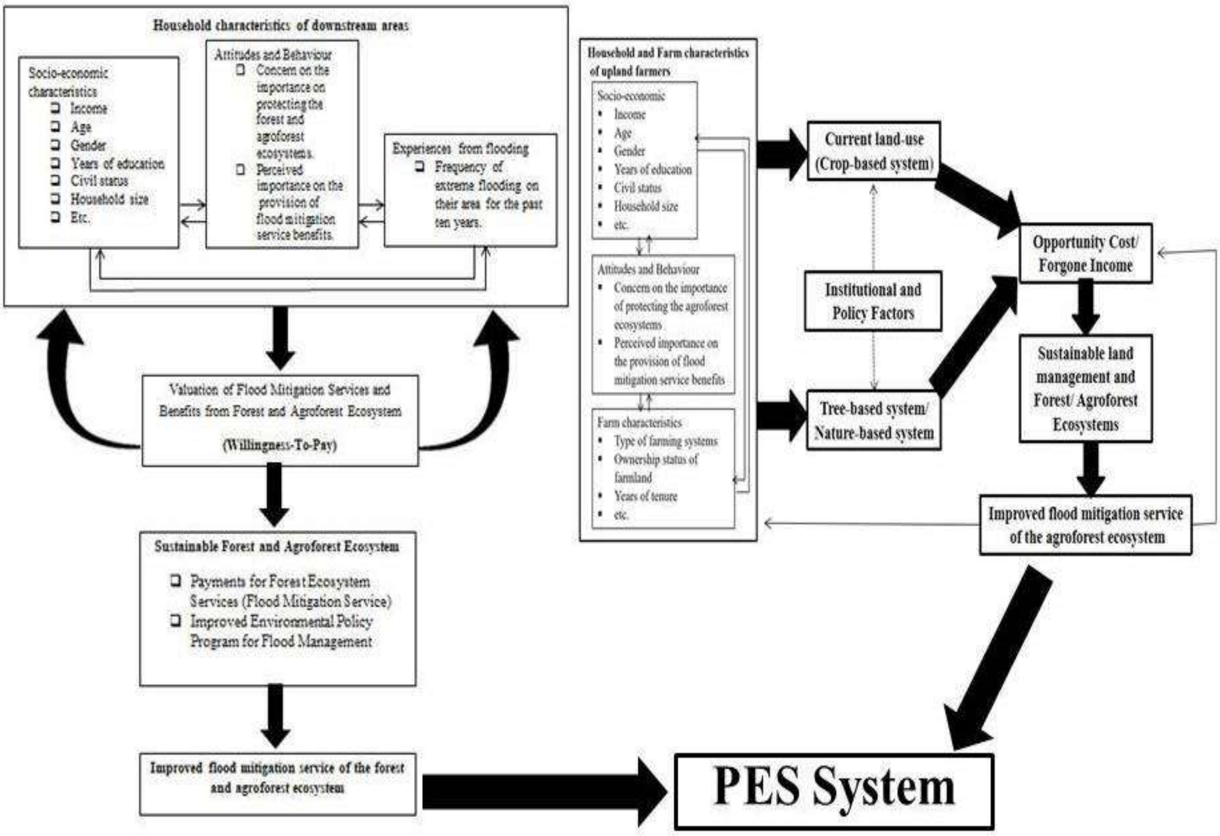


Figure 1. Conceptual Framework of the Payments for Flood Damage Mitigation Benefits from Forest Ecosystem Services

1.3.2 Opportunity Cost of Flood Mitigation Service from Agroforest and Forest Ecosystems

Silang-Santa Rosa Subwatershed and Cambantoc Subwatershed are among areas whose tributaries drain to Laguna Lake. According to Lasco & Pulhin, 2006, the surrounding watersheds in the Laguna Lake region are areas which experiences severe stress due to land degradation. They mentioned that there is only 26% remaining forest cover out of 73,000 ha of the total forestlands in Laguna. Deforestation and forest degradation resulted to the declination in provision of ecosystem services, including the flood mitigating service. With the current state of forest cover in the subwatersheds surrounding the Laguna Lake region, flooding in the province of Laguna has been further aggravated as the region is considered to be among of the top 10 of the most vulnerable to natural hazards such as typhoons and floods (Arias, Mendoza, Jr., G., & Dorado, 2014).

As the study focused in the sustainable provision of ecosystem services in a watershed setting, related literatures suggest the connection of land management in the uplands that affects the provision of ecosystem services in the downstream areas (Arunyawat and Shrestha, 2016; Rebugio, et. al. 2007).

However, with the increase in encroachment in the uplands and land use change, these promote shifts from forested area to agriculture, residential areas and eventually to urban development (Fortenbacher & Alave, 2014). Deforestation and forest degradation have resulted to decrease in soil infiltration, and eventually, excess water from the upland area of the subwatershed directly fall through the downstream areas leading to flooding.

Farmers, as one of the land owners in the upstream areas of the subwatersheds, can be agents for sustainable land management by adopting nature-based solutions such as tree-based systems or agroforestry. It is viewed in this study that through the adoption of tree-based systems among farmers will result to sustainable land use and improved provision of flood mitigation ecosystem service. Land-use practice of farmer is affected by its socio-economic conditions, behavioural and farm characteristics. Moreover, institutional and policy factors such as land tenure and market are among the underlying factors that also affect the land use systems applied by the farmers. Opportunity cost in shifting from current farming system to nature-based approach is inevitable. The forgone income of the producers of ecosystem services will then be used as a baseline on the application of nature-based approach as a farming system. This will result to sustainable land management of the forest and agroforest ecosystem, through the PES scheme. Further, this eventually lead to the improved flood mitigation service of the forest and agroforest ecosystem in the long run.

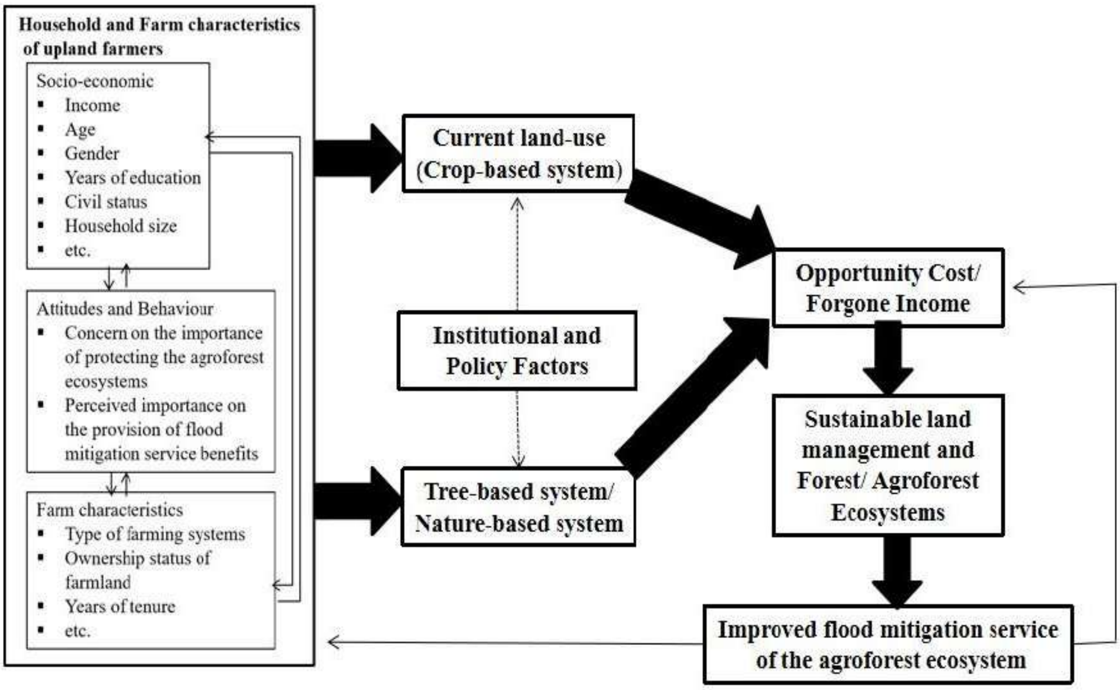


Figure 2. Conceptual Framework of the Opportunity Cost of Flood Mitigation Service from Agroforest and Forest Ecosystems

1.4 Theoretical Framework

It is assumed in the study that the function of $V(Y_0, E_0, S_0)$ represents the consumer's individual preferences for services beyond its explicit monetary value. The function is determined by factors that affect the willingness to pay, namely: income (Y_0), the prevalent flooding situation and environmental quality existing in the area (E_0). However, assuming that there is an improved environmental quality of forest in the Cambantoc Subwatershed, resulting to reduced flooding situation ($E_1 > E_0$), an individual consumer has an indirect utility function of $V(Y_0, E_1, S_0)$. While an individual will be willing to pay for an improvement of the quality if:

$$V(Y_0 - WTP, E_1, S_0) = V(Y_0, E_0, S_0)$$

WTP is considered as a random variable which is unknown to the researcher, however is known to an individual. While mean willingness to pay is estimated as the amount which the consumers are willing to pay for the improvement of the provision of ecosystem service such as flood mitigation or the amount they are willing to pay to prevent such flood damages. Assuming that the mean WTP is linear:

$$WTP_i = \beta X_i + \varepsilon_i$$

X_i – variable that determine WTP

ε_i – error term

Given a bid price (b_i) offered to respondent *i*, he/she accepts the bid if:

and reject bid offered otherwise.

This prob($Y_i = 1) = Prob(\beta X_i - b_i) \geq -\varepsilon_i$

$$= Prob(\beta X_i - b_i) \leq \varepsilon_i$$

Assuming a probability distribution for ε_i completes the econometric specification.

2. Methodology

2.1 Study Area

This study was conducted in the province of Laguna, which is among in the list of top 10 provinces in the Philippines that are considered to be most vulnerable to natural hazards, such as typhoons and floods, brought about by climate change (Arias, Mendoza, Jr., G., & Dorado, 2014). In particular, the study focused on two upstream areas of different subwatersheds in Silang-Santa Rosa Subwatershed and Cambantoc Subwatershed, which are in Silang, Cavite and Bay and Los Banos, Laguna, respectively. It accounts for 1, 171 ha of the reserve and drains into the Laguna Lake through the Maitim River (Tiburan, Saizen, & Kobayashi, 2012). These subwatersheds were chosen to be the study sites as these are among the subwatersheds that experiences severe stress due to land degradation (Lasco and Pulhin 2006).

With the increasing population rate and land use change in the country, these can promote degradation and deforestation risks for the forests in the upland areas of the Cambantoc Subwatershed, affecting the provision of flood mitigating service to the downstream areas. Bay is one of the areas in the province of Laguna that is considered as among the flood-prone municipalities, especially during heavy rains and typhoons when the excess water from the upland area of the subwatershed directly fall through the downstream areas. The premise in this study is that the ecosystem services are bought by the households and commercial owners in the downstream areas of Bay. While the upland farmers are the providers or sellers of the ecosystem services to the beneficiaries from the downstream areas. The barangays in the downstream areas included in this study are: Calo, Maitim, San Agustin, San Nicolas and Puypuy. These areas were chosen due to their proximity to the Maitim River, proneness to flooding and the household population.

Silang-Santa Rosa Subwatershed is about 40 km south of Manila, Philippines, flowing from the mountainous area of Silang, Cavite and passing through Silang-Santa Rosa river (Enggay-Gutierrez, 2015). The subwatershed's upstream area, Silang, Cavite depends on growing crops such as coconut, coffee, corn, banana, caimito, santol, jackfruit guava, avocado and majority on pineapple as their source of income. Some of the areas are characterized as rolling to undulating, having an elevation of 400 meters and slopes of more than 2% (Silang CLUP 2011). Meanwhile, it is implied in the study of Magcale-Macandog, et.al 2015 that in-migration and abaca planting has resulted to deforestation in the upstream of the subwatershed, and eventually led to increase in soil erosion. It was then followed by planting of rice, sweet potato, coconut, coffee and pineapple in the 1970s that resulted to increase in soil acidity in the upstream.

The criteria for selection of barangay were based on their inclusion in their respective subwatershed and whether the community is still practicing either agriculture or agroforestry. In Silang-Santa Rosa Subwatershed, as the upstream area composes only one municipality, barangays surveyed include: Bucal, Hukay, Munting Ilog, Pook 2, Pulog Bunga, Puting kahoy, Tartaria and Tibig. While in Cambatoc Subwatershed, there were 6 barangays surveyed, in which one of the barangays is covered by different municipality. Barangays covered in the upstream of municipality Bay are Bitin, Masaya, Paciano Rizal, Sta. Cruz and Tranca. Bagong Silang, a community inside the Mount Makiling Forest Reserve, is from the municipality of Los Banos.

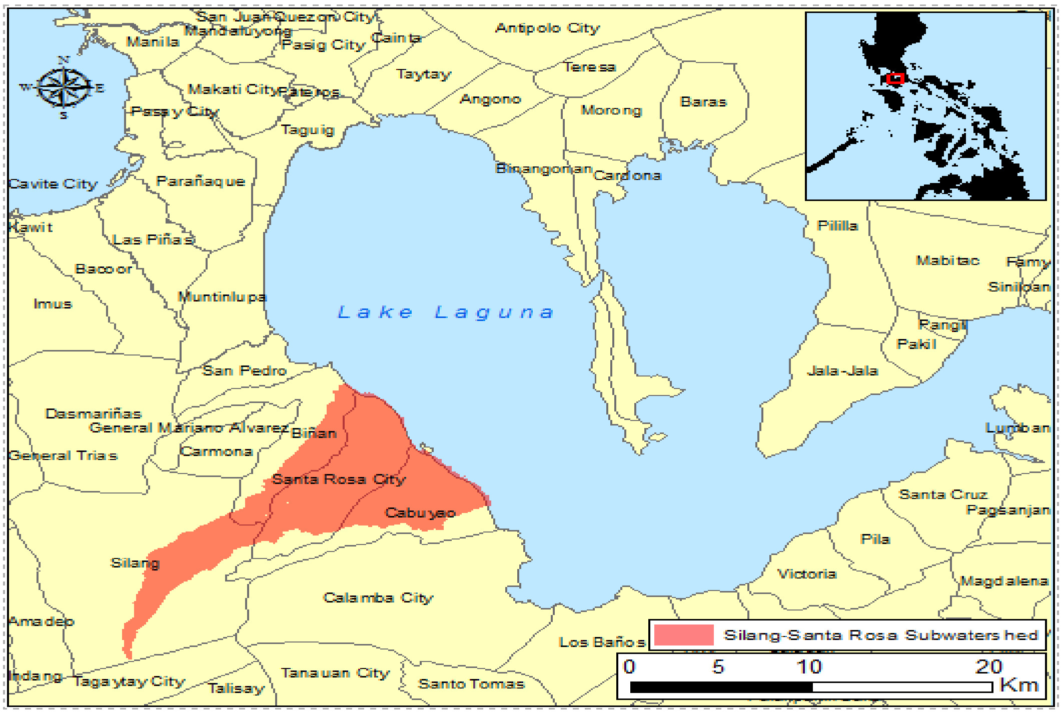


Figure 3. Location Map of the Silang-Santa Rosa Subwatershed

(Source: Macandog 2017)

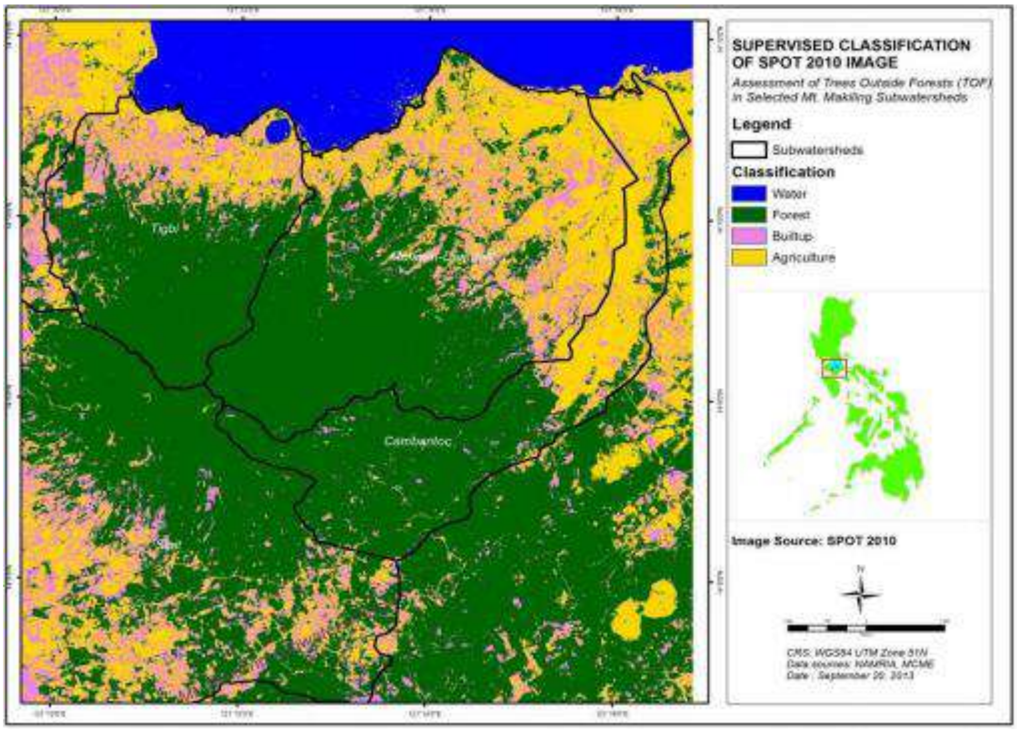


Figure 4. Location Map of the Cambantoc Subwatershed

(S*ource: Dida, Paquit, Boongaling, Magnaye, & Bantayan, 2013)*

2.2 Methods

2.2.1 Contingent Valuation Method Implementation

Stated preference approach is a technique that makes use of a questionnaire for cost-benefit analysis in environmental services, asking the respondent's willingness-to-pay for the ecosystem's improved provision of its benefits (Khuc, et al., 2016; Boyle, 2003; Pascual, 2010). One of its techniques, the Contingent Valuation Method, is commonly used to estimate non-marketed benefits (Bateman, et al., 2002; Calderon, Dizon, Sajise, & Salvador, 2016).

2.2.2 Design of Survey Instrument

Such factors that can influence the respondent's decision on their willingness to support the program were determined and included in the survey instrument. Among of the representations include: profile of the respondents, awareness and perception to Cambantoc Subwatershed and its benefits, attitude and behaviour of the respondent to the subwatershed and its flood damage mitigation benefits, flood damage assessment, and other socio-economic-related questions. Though there were available choices of answers in the survey instrument, the enumerators were required not to provide the written choices on the questionnaire when they were inquiring the respondents as these may cause biases in the respondent's answers. Moreover, there were such questions that have multiple responses included in the instrument (Figure 5). Answers were then ranked according to its importance and most prioritized by the respondent (Figure 5). While in the valuation section, background information on the state of the subwatershed was given before asking the respondent on the valuation question (Figure 6b). This was translated in Tagalog for the enumerators to properly deliver it to the respondent (Figure 6a). Different bid levels were randomly assigned to the enumerators and also to the respondents. Sureness of vote on their willingness to pay was also indicated so as to measure their level of confidence on their answer (Figure 7). Such questions also were asked in order for the respondents to justify their answers on WTP elicitation part (Figure 8) and also to determine the majority's suggestion on their preferred modes of payment and other detailed prerequisites (Figure 9).

8. What do you think are the causes of flooding in your area? *(Please check and rank 1-5, 1 as the highest)*	*Choices*	*check*	*rank*
	Lack of forest cover		
	Heavy rainfall	✓	1
	Land conversion	✓	2
	Poor Drainage Systems	✓	3
	Improper Waste Disposal		
	Others, Please Specify ____		

Figure 5. Sample of multiple response question with ranking

Background Information

Ang pag-baha ay isa sa mga malalang problema sa ibabang bahagi ng Bay-Cambantoc Watershed. Ito ay dahil sa dami ng tubig-ulan na nanggagaling sa itaas na bahagi ng lugar. Ang mga paraan ng paggamit ng lupa at ang bilang ng gubat at agroforestry ay kailangang ayusin at payamanin upang mabawasan ang pagbaha sa ibabang bahagi ng watershed. Ang mga may-ari ng lupa sa gubat (itaas na bahagi ng watershed) ay kasalukuyang gumagamit ng mga pamamaraang kayang sustenahan ang kanilang panandaliang pangangailangan sa pagkain at sa pagkakakitaan, ngunit ang mga pamamaraang ito ay nagdudulot ng mataas na lebel ng pagbaha, at pagkasira ng kalidad ng lupa sa itaas na bahagi ng watershed. Kung ang mga may-ari ng lupa ay gagamit ng mga pamamaraan na makakatulong sa pangangalaga ng watershed, maaari nitong mabawasan ang pagbaha sa ibabang bahagi ng watershed, at maiwasan ang pag-dulot ng pinsala sa mga naninirahan sa inyong lugar. Ngayon, kung ang "Watershed Management Council" ay nag bibigay ng plano upang bigyan ng insentibo ang mga nagmamay-ari ng lupa sa itaas na bahagi ng watershed, upang maudyukan sila na gamitin ang mga pamamaraang makakatulong sa pag-papabuti sa ating mga natitirang kagubatan at agroforestry, at gumamit ng mga pamamaraang mapapangalagaan ang paggamit ng lupa. Sa kabuuan, ang mga sambahayan sa ibabang bahagi ng watershed ay ang natatamaan ng mga problema sa pag-baha, sila rin ang mga kaunaunahang mabebenepisyuhan sa pagbawas sa panganib na dulot ng pagbaha. Sa kabilang banda, ang mga sambahanayan sa itaas na bahagi ay ang magdadala ng mga bayarin na may kaugnayan sa pagsasagawa ng pangangalaga sa kagubatan.

Valuation Question

Bibigyan po namin kayo ng isang halimbawa. Ipagpalagay po natin na ang pag-baha na inyo pong nararanasan ay mapipigilan sa pamamagitan ng pagpasasaayos ng kagubatan at agroforestry, at ng mga paggamit ng mga pamamaraan na magpapabuti sa lupa sa Bay-Cambantoc watershed. Ito ay mangyayari lamang kung ang subwatershed ay mapapangalagaan at maisasaayos. Bilang isa sa mga mag-bebenepisyo sa proyektong ito, kayo po ay isa sa mga mag bibigay tulong sa mga gastusin sa pagpapatupad ng proyekto na makakatulong sa pag pigil sa pag-baha at pag-guho ng lupa, na nagdudulot ng perwisyo sa inyong sambahayan. Ang desisyon po ninyo na mag bigay ay boluntaryo. Gusto po naming malaman kung kayo po ay nagnanais o hindi nagnanais na magbayad sa iminumungkahi naming proyekto. Tandaan po natin na ang ibabayad nyo po ay ang halaga para sa inyo upang mapigilan ang perwisyo ng pagbaha sa inyong sambahayan. Kung marami pong sambahayan sa inyong siyudad ang nais magbayad para sa proyektong ito, ang proyekto ay mapapatupad; kung hindi naman, ang kasalukuyan pong mga pangyayari ay patuloy parin pong mangyayari o maaaring mas lumala pa. Ngunit, alalahanin nyo po na kapag po kayo ay pumayag na mag-bayad upang maiwasan ang perwisyo ng pag-baha, ang pera po na inyong ibibigay ay hindi nyo na magagamit sa ibang pamamaraan. Maaari nyo pong sagutan ang mga suusunod:

Figure 6a. Background information and Valuation Question in Tagalog

Background Information

Flooding is one of the main problems in the downstream part of the Cambantoc Subwatershed due to high amount of runoff rainwater from the upstream part of the area. Land use practice and forest cover in the sub-watershed needs to be improved to mitigate or minimize flood damage downstream. Land owners upsteam in the sub-watershed currently adopt land use practices that favour meeting their short-term food and income requirements which results in high volume of surface run-off and low sediment retention in the uplands. If landholders adopt watershed conservation practices, it can reduce flooding downstream and mitigate flood damage to households and other sectors in your area (including you). Now, suppose that the "Watershed Management Council" is proposing a plan to provide rewards or incentives to landholders in order motivate them to adopt watershed conservation by improving forest cover and land use practices that significantly decrease surface run-off and consequently reduce flooding downstream. As it is the households and other sectors downstream who bear the burden of current problems and also the ultimate beneficiaries from flood risk reduction, the upland landholders are the target population to cover the costs related to the adoption of catchment and forest conservation.

Valuation Question

We are now going to ask you a hypothetical question. Suppose you were told that the torrential flooding you have been experiencing so far will be mitigated by improving forest ecosystem and land use practices at Silang-Sta Rosa Subwatershed. This could be achieved if the subwatershed is conserved and rehabilitated. As a beneficiary, suppose you are asked to contribute for the costs of implementing the required/proposed watershed measures that will mitigate surface runoff and increase sediment retention, which consequently mitigate flood damage to your household. The decision to contribute is on voluntary basis. We want to know if you are willing or not willing to pay for the proposed plan. The Payment amount will be added to your monthly water bill and the money that will be generated will be used solely for the forest and watershed improvement program, but a trusted organization will manage and facilitate the actual implementation of the plan. Remember that you are paying to mitigate flood damage to your household and if enough people are willing to pay enough money the plan will be implemented; otherwise the current situation will remain unchanged or even may deteriorate. But, bear in mind that when you pay to avoid flood damage, that money is not available to you anymore for other alternative uses.

If you would have to vote on a referendum for a program to improve forest ecosystem and land use practices in the uplands of Silang-Santa Rosa Subwatershed, please answer the following:

Figure 6b. Background information and Valuation Question in English

1. a. Would you be willing to pay PhP_____ per month for the 20% flood reduction in your area?		YES	1
		NO	2
b. How sure are you of your vote?	*Please choose: 1 – Very Sure,* *2 – moderately sure* *3 – Sure* *4 – Quite Not Sure* *5 – Not Sure*		

Figure 7. Sureness of vote

3. Please encircle/state your reason/s why you are **in favor** of paying for ecosystem services *(multiple answers)*	I get protection from the ecosystem services provided by sub-watershed	1
	I benefit from the ecosystem services provided by sub-watershed	2
	I get satisfaction in knowing that I am contributing to the conservation of forests and agroforests	3
	Others, please specify ______________	
4. For those who answered **NO**, please check your reason/s why you are **NOT** in favor to participate	I do not know about the benefits from ecosystem services provided by the sub-watershed	1
	I do not think the measure of conserving forest and agroforest will be effective	2
	I do not experience any benefits from ecosystem services	3
	I do not trust the people who will manage the payment funds	4
	I do not have enough money to contribute	5
	Others, please specify ______________	

Figure 8. Justification on WTP answer

3. a. If you answered **YES [20% or 50%]**, what would be your preferred payment vehicle? ***(encircle % of flood reduction)***		
	Direct payment	1
	Electric Bill	2
	Water Bill	3
	Others, Please Specify ______	

b. Please suggest organizations/authorities who can manage your money/payment, and reasons to choose these organizations

Name of Organizations	Please Check	Reason/s of Selection
Local Government Units		
Non-Government Organizations		
Private Company		
Others, please specify: ______		

c. Please suggest main activities that can be done using your payment/money

Activity	Please check
Reforestation (*i.e seeding, labour, planting*)	
Expenditure for forest conservation, green area protection	
Water Impounding System	
River Rehabilitation (*i.e dredging, river bank rehabilitation*)	
Drainage system	
Early Warning System (managed by the NDRRMC)	
Others, please specify: ______	

Figure 9. Modes and organization that will manage the payment and main activities that can be done using the payment

2.2.3 Data sources and Collection

The study used both primary and secondary data to obtain relevant information needed. In primary data collection, face to face interview were done to randomly selected household-respondents of the representative barangays and their corresponding *purok* or zone to acquire high response rate. Meanwhile, Cochran’s formula (5% margin of error) was used to determine the population to be sampled in the study area. Dichotomous choice format of elicitation was implemented in order to evaluate the WTP of the respondents.

Secondary data such as the physical and socio-economic attributes of the site were obtained from the various database of respective towns; official data and statistics from Philippine Statistics Authority; and related studies of the watershed. In addition, overall status of the selected site was evaluated through rapid ocular survey for added information.

2.2.4 WTP Model Specification, Analytical Procedure and Data Analysis

Two approaches were used in estimating the mean WTP of the respondents based on the assumption on the data’s distribution: parametric and non-parametric models. The logistic regression model (bid only and multivariate) was applied for parametric estimation approach and Turnbull estimator for non-parametric estimation approach.

The study also employed descriptive statistics and frequency distribution analysis to generate summary statistics and tabulation of survey responses.

In the logit model, the dependent binary variable is regressed to independent variables. In this study, the respondents' willingness to pay was specified based on Hanemann's formula:

$$Log\left(\frac{\Pr(WTP=1)}{1-\Pr(WTP=1)}\right) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n + e_1$$

where,

WTP = 1 is equivalent to the "yes" response, $X_1, \ldots, X_n$ are the independent variables, and e_1 = error term

The equation can also be expressed as:

$$Prob(WTP = yes) = \frac{1}{1+e^{-Z}}$$

where,

$$Z = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n + e_1$$

The mean WTP for the model with only the bid amount as the independent variable was determined using the formula:

$$Mean\ WTP = \frac{\alpha}{\beta}$$

where α is the constant and β is the coefficient of the bid amount variable.

Likewise, the mean WTP for multivariate model, where all the predictors where incorporated, was computed similarly but the numerator α was replaced by γ, computed as:

$$\gamma = \alpha + \sum_{i=1}^{p} \mu_i \beta'_i$$

where μ and β' was the average and coefficient of the i^{th} predictor other than the bid, respectively.

Unknown parameters α and βs were estimated using Maximum Likelihood Estimation (MLE) method to maximize the likelihood of reproducing the data given the parameter estimates. The log-likelihood function is:

$$logL=\Sigma k=1NIklnF(\Delta Vk)+(1-Ik)\ln(1-F\varepsilon(\Delta Vk))$$

Using the variable definitions in Table 1, the logit regression model was specified as follows:

$$Prob(WTP = 1)$$

$$= a + b_1 * bid20 + b_2 *age + b_3 * sexmf + b_4 *civstat + b_5 * numhh + b_6 * occup + b_7 * dwellnrr + b_8 * educyears + b_9 *affectprov + b_{10} * impprot\_rec + b_{11} * flood\ often + b_{12} * lnfloodcost + b_{13} * monthly\_exp\_total + e1$$

Table 1. Variables used in the WTP model

Variable	Variable Description	Expected Sign (+/-)
Dependent variable		
WTP20YN	A dummy variable for the willingness to pay of the downstream households: (1=willing to pay; 0=otherwise)	
Independent variable		
BID20	Offered bid level for 20% flood reduction	As bid level increases, household's willingness to pay decreases (-)
AGE	Age of the respondent (years)	No priori direction. It is either positive or negative (+/-)
SEXMF	A dummy variable for sex of the respondents: (1=male; 0=female)	No priori direction. It is either positive or negative (+/-)
CIVSTAT	A dummy variable for civil status: (1=married; 0=otherwise)	No priori direction. It is either positive or negative (+/-)
NUMHH	Number of household members	Households with more household members are less willing to pay (-)
OCCUP	A dummy variable for occupation: (1=employed; 0=otherwise)	Those who are employed have the capability and are more willing to pay for the improvement of the subwatershed management (+)
DWELNRR	A dummy variable for the ownership status of the house: (1=renter; 0=otherwise)	Households who are renting a house are less willing to pay than those who own their houses (-)
EDUCYEARS	Number of years of education	More educated respondents are more willing to pay for the

		provision of ecosystem services (+)
AFFECTPROV	A dummy variable: 1 if the respondents think that the provision of forest and agroforest ecosystem goods and services are highly affected by the forest and agroforest vegetation, 0 otherwise	Those who perceive that forest and agroforest vegetation highly affects the provision of forest and agroforest ecosystem goods and services (+)
IMPPROT_REC	A dummy variable: 1 if the flood protection provided by forest is important, 0 otherwise	Those who perceive forest as important for flood protection are more willing to pay for the improvement of the subwatershed management (+)
FLOOD_OFTEN	Number of time the respondents experience extreme flooding in the past ten to eleven years	Those who frequently experience flooding are more willing to pay for the improvement of the subwatershed management (+)
LNFLOODCOST	Total damage cost incurred due to flooding during the last ten years	Those who incurred higher damage cost and additional expenditures due to flooding are more willing to pay for the improvement of the subwatershed management. (+)
MONTHLY_EXPEN_TOTAL	Total monthly expenses of the household. Substitute variable for income.	Households with higher monthly expenditures (more income) are more willing to pay for the improvement of the subwatershed management (+)
e	Error term assumed to be normally independently and identically distributed	

The non-parametric approach eliminates the requisite to make any distributional assumptions for the data and the probabilities for WTP will depend solely on the bid amount. Procedure in calculating the mean WTP using Turnbull Estimator was based from Haab and McConnell (1997) and was computed as follows:

1. For j = 1 → M, calculate $F_j = N_j / (N_j + Y_j) = N_j / T_j$ for each bid value (B_j), where N_j and Y_j are the number of "no" and "yes" responses, respectively, to bid value B_j and their sum is equal to T_j.
2. Beginning with $j = 1$, compare F_j and F_{j+1}.
3. If $F_{j+1} > F_j$, continue. Otherwise, pool cells j and j+1 into 1 cell with boundaries (B_j, B_{j+1}] and calculate $F_j^* = (N_j + N_{j+1}) / (T_j + T_{j+1}) = N_j^* / T_j^*$.
4. Continue the pooling procedure until F_j^* values follow a monotonically increasing sequence.
5. Set $F_{M+1}^* = 1$ and $F_0^* = 0$.

6. Compute for $f_j^* = F_{j+1}^* - F_j^*$.
7. Estimated mean WTP will be equal to:

$$\sum_{j=1}^{M} (B_j)\left(f^*_{j+1}\right)$$

2.2.5 Data Analysis and Benefit Cost Analysis Application

Farming systems applied in the two study sites were identified and respondents were classified based on such farming system or land use (Table 2). This classification served as basis on the data analysis. Descriptive statistics and frequency distribution analysis were employed so as to generate summary statistics and tabulation of survey responses. Factors regarding the adoption of tree-based systems were analysed using logit regression model (Table 3). With this, dependent binary variable was regressed to independent variables. Economic model of the different farming system was implemented through the benefit-cost analysis framework.

Table 2. Description of farming systems considered in the study

Farming system	Description
Monoculture agriculture	Practice of pineapple or rice cropping system (100 percent of the area devoted to either of the crops)
Mixed agriculture	Farmer's current practice of mixed agricultural crops in a parcel
Agroforestry	Perennial species with agricultural crops
Mixed perennials	Mixed species of perennials in a parcel
Monoculture perennials	Perennial plantation land use system (100 percent of the area devoted to a single species)

A probability for respondents to accept compensation for forest conservation can be written in a logit model as follows.

$$\text{Prob(WTA=1| Xi,}\beta) = \frac{1}{(1+exp^{-Z})}$$

Where WTA is the respondent's willingness to accept payment from buyers, which is assumed depending on their socioeconomic characteristics (X_i), while E is an error term. It is assumed to represent a logistic probability distribution. A WTA equation and variables used in this study are as follows

Prob (WTA=1)

$=a+b_1*bid+b_2*age+b_3*gen+b_4*educyears+b_5*yrsfarming+b_6*parcel1\_area+b_7*topog+b_8*soilerosion$

$+ b_9*monthly\_exp\_total+b_{10}*own\_fl+b_{11}*numhh+b_{12}*aware6+b_{13}*aware7+el$

Table 3. Variables used in the WTA model and analysing the factors regarding the adoption of tree-based systems

Variable	Variable Description	Expected Sign (+/-)
Dependent variable		
WTA20YN	A dummy variable for the willingness to accept of the upstream households: (1=willing to pay; 0=otherwise)	
Independent variable		
BID20	Offered bid level for 20% flood reduction	As bid level increases, household's willingness to accept the payment to decreases the forest use
AGE	Age of the farmer-respondent (years)	No priori direction. It is either positive or negative (+/-)
GEN	A dummy variable for sex of the respondents: (1=male; 0=female)	No priori direction. It is either positive or negative (+/-)
EDUCYEARS	Number of years of education	Higher level of education of respondents highly affects the adoption of tree-based systems (+)
YRSFARMING	Number of years of farming	No priori direction. It is either positive or negative (+/-)
PARCEL1_AREA	Area of parcel	Those who have larger parcel areas are more willing to adopt tree-based systems (+)
TOPOG	A dummy variable for topography of parcel: (1=rolling to undulating; 0=otherwise)	Farmers with parcels that are rolling to undulating topographies are more willing to adopt tree-based systems(+)
SOILEROSION	A dummy variable for levels of soil erosion in the parcel: (1=average to high; 0=otherwise)	Higher levels of soil erosion in the parcel highly affects the willingness of the farmer to adopt tree-based systems (+)

MONTHLY_EXPEN_TOTAL	Total monthly expenses of the household. Substitute variable for income.	Households with higher monthly expenditures are more willing to accept for the improvement of the subwatershed management (+)
OWN_FL	A dummy variable for ownership of farmland: (1=owned; 0=otherwise)	Those who owned such parcel are more willing to adopt tree-based systems (+)
NUMHH	Number of household members	Households with more household members are less willing to adopt tree-based systems (-)
AWARE6	A dummy variable: 1 if Agroforestry or Tree-based systems help maintain and restore the productivity of the land, 0 otherwise	Those who perceive agroforestry or tree-based systems can help in maintaining and restoring the productivity of land are more willing to adopt (+)
AWARE7	A dummy variable: 1 if Agroforestry or Tree-based systems provide higher long run returns from the land than the traditional continuous annual cropping, 0 otherwise	Those who perceive agroforestry or tree-based systems can provide higher long run returns from the land than the traditional continuous annual cropping are more willing to adopt (+)
E	Error term assumed to be normally independently and identically distributed	

3. Results and Discussion

3.1 Socio-Demographic, Economic and Location Profile of the Downstream Household Respondents

A total of 201 household respondents were surveyed in this study. The number of respondents per barangay was determined through the Cochran's formula by estimating the proportion of the attribute present in each barangay's population (Table 4). Among their detailed socio-demographic and other characteristics were shown in Table 5 to Table 10.

Table 4. Number of household respondents per barangay

Barangay	n	%
Calo	53	26.37
Maitim	61	30.35
Puypuy	49	24.38
San Agustin	19	9.45
San Nicolas	19	9.45
Total	**201**	**100.00**

On the proportion between the male and female respondents, 74.63% of the interviewed respondents were female while there are only fewer male respondents composing of 25.37%. The number of respondents who were not employed was 42.29%, which consists of 72 females and 13 males. To elucidate, higher participation of female respondents is owing to the fact that there is a higher number of respondents who are mostly housewives and unemployed, who were usually left at home. Moreover, there were female respondents also that are small enterprise owners and *carinderia* owners. With that, the task of answering survey interviews was oftentimes delegated to them. The interviewed respondents were generally middle-aged (46 years old), and the set of minimum to maximum ages among the respondents was 16 to 91 years old. Almost half of them have reached secondary education (50.75%) and has minimum and maximum years of education of 1 to 20 years, respectively. While the number of members per household ranges from 1 to 12 and has an average of 4 members. Each of the respondents was asked to estimate or give the actual value of their household's monthly income and monthly expenses. These two variables were assessed to have less biased information regarding their true income. Accordingly, their monthly income and monthly expenses ranges were Php 1,000 to Php 130,000 and Php 1,000 to Php 137,500, respectively. Moreover, distances of houses from the river were also estimated, having an average of 0.209 km.

Table 5. Socio-demographic characteristics of the household respondents

Gender	n	%		Occupation	n	%
Male	51	25.37		Employed	116	57.71
Female	150	74.63		Unemployed	85	42.29
Total	**201**	**100.00**		**Total**	**201**	**100.00**
Civil Status				**Educational Attainment**		
Single	29	14.43		Elementary	54	26.87
Married	128	63.68		High School	102	50.75
Common-law	9	4.48		College	38	18.91
Widow/Widower	24	11.94		Vocational	7	3.48
Separated	11	5.47		**Total**	**201**	**100.00**
Total	**201**	**100.00**				

Table 6. Other socio-economic and location characteristics of the respondents

Variables	Mean	Std	Min	Max
Age	45.697	15.227	16	91
Household size	4.935	2.189	1	12
Distance of house from the river (km)	0.209	0.358	0.001	2
Number of years of education	9.522	3.576	1	20
Monthly Income (Php)	16115.04	19697.54	1000	130000
Monthly Expenditure (Php)	17518.37	17151.86	1000	137500

Table 7. Occupation of the respondents

Occupation	n	%
Professional (teacher)	3	1.493
Government employee	5	2.488
Clerk	1	0.498
Tricycle/Jeepney Driver	8	3.980
Carpenter/Laborer/Plumber	3	1.493
Street Vendor	9	4.478
Small enterprise owner/ Carinderia owner	18	8.955
Self-employed (businesses such as motorcycle accessories, water station, etc.)	16	7.960
Farmer/Gardener/Landscaper	16	7.960
Tailor/Hair dresser	3	1.493
Small Town Lottery	5	2.488
Land caretaker	3	1.493
Others (dance instructor, tutor, funeral parlour staff, delivery staff, security guard)	11	5.473
Factory worker	2	0.995
Utility worker	5	2.488

Laundrywoman	4	1.990
Overseas Filipino Worker	4	1.990
Housewife	59	29.353
Student	6	2.985
Retiree	4	1.990
None	16	7.960
Total	**201**	**100**

Table 8. Monthly Income and Expenses Range of the household respondents

Monthly Income Range	n	%		Monthly Expenditure Range	n	%
<1,000	1	0.5		<10,000	76	37.81
1,000-5,000	47	23.38		10,001-20,000	67	33.33
5,001-10,000	61	30.35		20,001-40,000	45	22.39
10,001-20,000	54	26.87		40,001-60,000	7	3.48
>20,000	38	18.91		60,001-80,000	3	1.49
Total	**201**	**100**		80,001-100,000	2	1
				100,001-120,000	0	0
				120,001-140,000	1	0.5
				Total	**201**	**100**

Table 9. Ownership status of dwelling

Status	n	%		Status	n	%
Owned	155	77.11		Non-renters	187	93.03
Given by relative or others to use	21	10.45		Renters	14	6.97
Provided by the government	1	0.5		Total	201	100
Rented	14	6.97				
Inherited	10	4.98				
Total	**201**	**100**				

Table 10. Ownership status of land

Status	n	%		Status	n	%
Owned	76	37.81		Non-renters	182	90.55
Given by relative or others to use	42	20.9		Renters	19	9.45
Provided by the government	47	23.38		**Total**	**201**	**100**
Rented	16	7.96				
Inherited	17	8.46				
Rent to own and provided by the government	3	1.49				
Total	**201**	**100**				

3.2 The downstream households' perception and awareness on forest ecosystem benefits and services provided in the upstream areas of Cambantoc Subwatershed

Variables associated with the respondents' knowledge and perception on ecosystem services and other related fields were also assessed, as these can also influence the willingness to pay decision of an individual. In terms of the awareness on their municipality's subwatershed, a fraction of 90.05% respondents were not aware of it. This can be due that most of the respondents do not know what a watershed is (81.09%) and others were not familiar with their subwatershed's name, since "*Cambantoc*" is an old name of one of the tributaries of the subwatershed, the Maitim River. However, majority (57.71%) were aware of the ecosystem services they are currently receiving from the forests in the uplands of the subwatershed. Among these cited ecosystem services were enumerated and analysed using multiple regression (Table 11). Responses were then ranked by the interviewees with 1 as highest, and then were summarized in Table 12. As shown, *Forest Products* was the most chosen ecosystem service by the respondents, with 36.82% of cases and rank of 1.554 average votes. It was then followed by *Water Purification* (20.90% of cases and 1.952 average votes), *Air Purification* (18.91% of cases and 1.974 average votes), and *Flooding Mitigation* (15.92% of cases and 2.063 average votes), respectively. Seeing that one of the main livelihoods of the municipality is agroforestry, most of the respondents tend to cite *Forest Products* among other ecosystem services. Likewise, water and air purification were apt to be chosen by the respondents since these are also among the minimum necessary to support life. And since their area is not yet too urbanized, they set more importance to clean air and pure water which they are enjoying at the moment. However, *Flooding Mitigation* though is still important and prioritized, only ranked as fourth since it is of lesser priority by the respondents considering that flooding is not a daily event.

Table 11. Respondents' choices on the forest and agroforest ecosystem services

Variable	n	% of cases
Water Purification	42	20.9
Forest Products	74	36.82
Protection from Typhoon	16	7.96
Flooding Mitigation	32	15.92
Climate Change Mitigation	7	3.48
Recreation	5	2.49
Microclimate	1	0.5
Habitat for wildlife	2	1
Air Purification	38	18.91
Livelihood	3	1.49
Not aware	85	42.29

*multiple response

Table 12. Ranking on the forest ecosystem services and benefits received

Variable	Obs	Mean	Std. Dev.	Min	Max
Water Purification	42	1.952	1.513	1	6
Forest Products	74	1.554	0.862	1	4
Protection from Typhoon	16	2.688	1.302	1	5
Flooding Mitigation	32	2.063	1.458	1	5
Climate Change Mitigation	7	2.571	1.272	1	4
Recreation**	5	2.200	1.304	1	4
Microclimate	1	3.000	.	3	3
Habitat for wildlife	2	2.500	0.707	2	3
Air Purification	38	1.974	1.026	1	5
Livelihood**	3	1.000	0	1	1
Not aware**	85	1.000	0	1	1

**cannot be ranked

On the other hand, the respondents' awareness on the current land use shifts in Cambantoc Subwatershed was also analysed, particularly on the main causes of deforestation and forest degradation in the upland area. Their most cited reason is due to *Logging* with 84.58% of cases, as this is always associated before converting forestlands into other land uses, such as subdivisions and agricultural lands with 15.92% of cases (Table 13). In terms of the ranking of prominent causes of deforestation, *Logging* remained as the most number of votes, with a mean of 1.082 (Table 14). Some of the respondents also blame the people's lack of discipline in the extraction of natural resources—having average votes of 2.000 (Table 14). According to the respondents, stones were extracted from the uplands, which results to the removal of forest vegetation in the site. Other than that, unsustainable use of timbers such as charcoal-making has been practiced in the uplands, without realizing that there is a need to replace the converted timbers, such that the area will not be left barren wherein there should have vegetation that will hold the soil. Forest vegetation in the uplands, by this means, were gradually stripped off resulting to open areas that have high chances to be occupied by housing establishments and be converted into agricultural lands. Moreover, as the population rate in the country is increasing, there were some that preferred to live in the uplands since the land is free and has resources that can be started with as a living. With this, it had resulted also to deforestation. As such, *High demand for housing and agriculture* was ranked as 2.031 and followed by *Increasing Population* with 2.250 average votes (Table 14).

Table 13. Perception on the causes of forest degradation and deforestation in Cambantoc Subwatershed

Variable	n	% of cases
High demand for housing and agriculture	32	15.92
Increasing Population	20	9.95
Urban Development	12	5.97
Promoting commercial crops by the government	1	0.5
Logging	170	84.58
Human Discipline (unsustainable extraction of natural resources; e.g. quarrying, conversion of timbers to charcoal)	27	13.43
Typhoon	9	4.48
Not aware	18	8.96

*multiple response

Table 14. Ranking on the percept causes of forest degradation and deforestation in Cambantoc Subwatershed

Variable	Obs	Mean	Std. Dev.	Min	Max
High demand for housing and agriculture	32	2.031	0.595	1	3
Increasing Population	20	2.250	0.910	1	4
Urban Development	12	3.000	1.044	1	4
Promoting commercial crops by the government**	1	2.000	.	2	2
Logging	170	1.082	0.296	1	3
Human Discipline (unsustainable extraction of natural resources, eg. quarrying, conversion of timbers to charcoal)	27	2.000	0.734	1	4
Typhoon**	9	1.222	0.441	1	2
Not aware**	18	1.000	0	1	1

**cannot be ranked

Anthropogenic activities in the uplands further led to flooding in the downstream areas. Among of these were also enumerated by the respondents and were also analysed using the multiple regression analysis. *Logging* was commonly mentioned having 86.47% of cases (Table 15). While in connection with logging, conversion of timbers to other forest products had also led to deforestation in some patches of areas in the upstream, which have 7.52% cases from the respondents. Similarly, 7.52% of cases also confirm that solid wastes disposed in the river by the communities upstream clog some parts of the tributary leading to flooding in the downstream areas. With these issues regarding deforestation and environmental degradation, all of the respondents agreed that there is an urgent need to protect and conserve the forest and agroforest ecosystems in their area. As such, there were 99.5%

that consider the importance of the appropriate management of the subwatershed for both lowlands and uplands, especially knowing that this will result to the improved provision of ecosystem services.

Table 15. Activities in the upstream area that causes flooding in the downstream area

Variable	n	% of cases
Logging	115	86.47
Improper waste disposal	10	7.52
Land conversion to subdivision	13	9.77
Quarrying	4	3.01
Timbers converted to forest products/ charcoal	10	7.52
Increase in population (Encroachment)	2	1.50
Upland community's mismanagement of the forest	4	3.01

*multiple response

Meanwhile, there were such factors in the lowland areas mentioned by the respondents as these can also induce such flooding incidents (Table 16). 123 of the respondents stated that wastes that are improperly disposed on the river, drainage and lake impede the flow of storm drains (1.528 mean votes). And as people encroach near the river, more wastes are dumped into the waterways resulting to clogging and further into flooding. It was also noticed by 78 of the respondents that the drainage systems in their area do not have the capacity to drain such high volume of floodwaters and runoff discharges (1.769 mean votes). However, despite of its higher number of observations, the absence of forest cover in the lowland has more negatively affected the infiltration and percolation capacity of the soil, having average votes of 1.622. While in connection with the deforestation occurring in the upstream area, some of the logs that were carried by the river to the downstream areas cause clogging of the tributaries (1.926 mean votes) and results to river overflow (2.088 mean votes).

Table 16. Ranking on the causes of flooding in the downstream area

Variable	Obs	Mean	Std. Dev.	Min	Max
Lack of forest cover	74	1.622	0.887	1	4
Heavy rainfall	56	1.946	1.034	1	5
Land conversion	22	2.682	1.427	1	5
Poor drainage systems	78	1.769	0.805	1	4
Improper waste disposal	123	1.528	0.669	1	4
Logs that clogged the river	27	1.926	1.035	1	5
Geothermal	2	2.500	0.707	2	3
River overflow	34	2.088	1.026	1	4
Landslide	2	2.500	0.707	2	3
Quarrying**	1	2.000	.	2	2
Not aware**	3	1.000	0.000	1	1

**cannot be ranked

3.3 Attitude and behaviour of the respondent to Cambantoc Subwatershed and its flood damage mitigation benefits

Deforestation and degradation impacts results to complex environmental issues that affects both the upstream and downstream communities inside the subwatershed. It was evidently proved above by the responses of the downstream households that human activities are the primary cause of the destruction of forest that led to consequences such as flooding. Being that humans contribute a large impact on forest and its services, it is thus crucial to analyse the attitude and behaviour of the downstream households towards the subwatershed and its provision of flood regulation service.

Responses showed that nearly all of the respondents value the need to protect the trees in forest and agroforest ecosystem. Most of them (60.7%) agreed that this was indeed very important, while 38.81% values the protection of trees as important only. In terms of the participation of communities in the protection and rehabilitation activities of the forests and agroforests, the level of importance that was portrayed by the respondents decreased, as only 46.77% considered it as very important and 50.25% rated it as important. Only small fraction (3.98%) of respondents did not considered flood regulation service as an important function of the forest and agroforest ecosystem. However, 51.74% expressed that it is very important for the benefit of the communities, and 44.28% evaluated it as important only. While the establishment of Small Water Impounding System (SWIS), a compact dam that is used for water harvesting and storage and flood control structure, was considered by majority (56.72%) as of medium importance and 27.86% as very important. 15.42% of the respondents differs in opinion on the structure's importance, since they believe that it would not be applicable in their municipality due to its high initial and establishment cost and the damages it may charge to the affected farmers and communities.

3.4 Willingness to Pay of Downstream Households for Flood Damage Mitigation Benefits as Forest Ecosystem Service in Silang-Santa Rosa Subwatershed

The survey questionnaire used in this study was pre-tested so as to determine the bid levels to be used in the elicitation. Such amounts were shown in Table 17. Distribution of bid ranges from 19.4% to 20.4% of the total population sampled.

Table 17. Bid amounts used in the survey for 20% flood reduction

Variable	n	%
100	39	19.4
200	40	19.9
300	40	19.9
400	41	20.4
600	41	20.4
Total	201	100

Hypothetical scenario on flooding was demonstrated to the respondents, in relation to the background information on the current unsustainable land practices on Cambantoc Subwatershed that was also given. The respondents were asked on their willingness to pay assuming that there was a 20% flood reduction in their area as the result of the flood mitigation activities done. As there can be some respondents who will try to insist that no flooding had happened and will occur in their area, they were informed that severe flooding can still happen due to the changing climate happening globally. Given the premise, responses revealed that 43.78% of the respondents were willing to support the said program while 56.22% of them were not favour for the payment (Table 18). The latter's primary reason being not favour for the payment was that they do not have enough money to contribute for the proposed project (81.21% of cases) (Table 20). According to some of the respondents, as there's a price increase of commodities nowadays in the country, they preferred more to lessen their expenditures, in which this includes the possible contribution for the proposed project. While second to the most popular reason of the respondents was *the government should fund the project*. As 9.70% cases of the respondents believe that the government should be the one in charge in funding the program since they have enough funds for it. Moreover, they pointed it out that they were already a tax payer and there was a current increase in taxes, in which they percept that it is also tantamount to an increase also in budget for addressing such environmental concerns. While 7.88% of cases do not believe that sustainable and appropriate land use management in the uplands will not be effective in mitigating flood problems in the downstream area. Some of them indicated that they will only pay after they have seen the results once the program was implemented. Whereas, 62.16% cases of the respondents were willing to pay due to the protection from flooding the forest and agroforest can provide through the improved provision of ecosystem services (Table 19). And some (54.05%) of them stated that as they support the funding for the restoration and rehabilitation of the deforested and degraded forest and agroforest areas uplands, they get benefits from it aside from flood mitigation services. Moreover, the payment for ecosystem program can also be means for conserving forest and agroforest in their area, as answered by 36.04% cases of the household respondents.

Table 18. Willingness to pay for the 20% flood reduction

Bid Amount (20%)	YES		NO		Total
Php	**n**	**%**	**n**	**%**	
100	24	61.54	15	38.46	39
200	15	37.50	25	62.50	40
300	19	47.50	21	52.50	40
400	17	41.46	24	58.54	41
600	13	31.71	28	68.29	41
	88	43.78	113	56.22	201

Table 19. Reasons why the household respondents are favour for the payment

Variable	n	% of cases
I get protection from the ecosystem services provided by the watershed.	69	62.16
I benefit from the ecosystem services provided by the watershed.	60	54.05
I get satisfaction in knowing that I am contributing to the conservation of forests and agroforests.	40	36.04
I want to help the future generation and the other people who are also flooded.	1	0.9
If it is really needed and the majority is required to pay, I will pay too.	1	0.9

*multiple response

Table 20. Reasons why the households are not in favour for the payment

Variable	n	% of cases
I do not know about the benefits from ecosystem services provided by the watershed.	3	1.82
I do not think the measure of conserving forest and agroforest will be effective.	13	7.88
I do not experience any benefits from the ecosystem services.	2	1.21
I do not trust the people who will manage the payment funds.	9	5.45
I do not have enough money to contribute.	134	81.21
The government should fund the project.	16	9.7
I will pay only if the majority will also pay.	2	1.21
People in the upstream should be the one to pay the communities in downstream areas.	2	1.21
I am not affected from flood.	8	4.85
I want a higher percent of flood reduction.	4	2.42
I am not concerned with the ecosystem.	1	0.61
People should have the freedom to choose how much they will pay.	1	0.61

*multiple response

As the positive bidders realized the current situation of their subwatershed and the effects of deforestation and forest degradation in the downstream areas, 63.96% of cases chose *reforestation* as the activity that can be implemented using the collected funds (Table 21). It is in coherent with the previous statements of the respondents that logging is the underlying activity in the upstream area that leads to flooding in the downstream. It is followed by downstream activities, such as *river rehabilitation (58.56%)* and repairing and cleaning of drainage (54.05%), for the households also wanted to address other environmental problems in their area (Table 21). While 29.73% of cases also chose *expenditure for forest conservation and green area protection* as they consider that it is also important to maintain the reforested areas through conservation and protection for the sustainable provision of ecosystem services (Table 21).

Positive bidders were also inquired on their chosen payment vehicle. 59.46% of them preferred to pay directly over adding the payment through their electric bill (22.52%) and water bill (18.02%), as the respondents wanted to be sure that their payment will directly proceed for the program. In terms of the organization that will manage the payment, local government units garnered the highest number of votes (56.76%), and followed by private company (30.63%) and non-government organizations (7.21%). The most cited reason of the positive bidders for choosing the local government unit was their trust to the organization (63.49%). They believe that as the government is already organized, and has done numerous projects before, it will be able to manage the payment rightly and transparently.

Table 21. Activities that can be done using the payments from the households

Variable	n	% of cases
Reforestation	71	63.96
Expenditure for forest conservation, green area protection	33	29.73
Water Impounding System	31	27.93
River Rehabilitation	65	58.56
Drainage System	60	54.05
Early Warning System	15	13.51
Monitoring of the Project	1	0.9
Waste Management	2	1.8
River Clean-Up Drive	1	0.9

*multiple response

3.5 Flood Damage Assessment

The respondents' experiences on such flooding event were also analysed, as these can influence the willingness of an individual to support the funding stream that targets the mitigation of flooding in their area. Among the typhoons that occurred for the past 10-11 years and had caused extreme flooding in their area were recorded in Table 22. Based on the responses, Typhoon Milenyo (*International code: Xangsane*) caused severe flooding which had also eventuated to damages on most of the respondents' assets. Moreover, it was shown that extreme flooding events during typhoons usually appeared at an average of every three years, as these were evidenced in popularly cited typhoons by the respondents which include: Ondoy (*Ketsana*) in 2009, Glenda (*Rammasun*) and Yolanda (*Haiyan*) both in 2013, and such typhoon in 2017 (Table 22-23). Whereas, only 6 of the respondents indicated that no flooding occurred in their barangay during the past 10-11 years.

Table 22. Typhoon that has caused extreme flooding

Typhoon	n	%
Milenyo (2007)	77	38.31
Ondoy (2009)	55	27.36
Southwest monsoon or Habagat (2012)	4	1.99
Glenda (2013)	20	9.95
Yolanda (2013)	14	6.97
Year 2011	1	0.50
Year 2015	2	1.00
Year 2016	2	1.00
Year 2017	13	6.47
Cannot remember	7	3.48
None	6	2.99
Total	201	100

Flooding instances commonly recede after 6 days and a maximum of 90 days, with a minimum of almost 1 meter flood up to the yard or road and inside their house (Table 24). Households who experienced longer days and higher depths of flooding, were mostly those who resides near and between the lower downstream part of the tributary and Laguna Lake, wherein they become sandwiched by excess water due to river overflow (or large volume of water coming from the uplands) and flash flood from the lake. However, respondents indicated that river overflow is the main cause of flooding, having 65.17% of cases (Table 25). For large volume of rainfall cannot be held entirely by the river and with that, excess water from the upstream directly falls in the downstream barangays through the Maitim river. While inundation of Laguna Lake only aggravates the flooding situation, as it was mentioned by 12.94% cases of the respondents (Table 25). According to them, inundation of the lake is common during heavy rains and typhoons; however, river overflow results to more flooding in their area. It is also interesting to know that one of the reasons for the river to overflow was due to logs from the upstream that had clogged the river (12.44%) (Table 25). This cause was ranked as 5th among popularly cited reasons of flooding. Whereas, flooding causes mentioned such as *Heavy rainfall (39.30%)* and *Typhoon (36.82%)*, though were ranked as 2nd and 3rd respectively, were of natural events and cannot be considered as major causes of flooding (Table 25).

Table 23. Experiences of the downstream households during flooding events

Variable	Mean	Std. Dev.	Min	Max
How often do they experience flooding in the area	3.181	2.628	0	20
Number of days the flood stayed	5.668	17.302	0	90

Table 24. Actual depth of flood (in meter)

Variable	Mean	Std. Dev.	Min	Max
Up to the yard/road	0.971	0.655	0.070	3.100
Inside the house	0.911	0.629	0.070	2.500

Table 25. Specified causes of flooding during typhoon

Variable	n	% of cases
Heavy rainfall	79	39.30
Flashflood	26	12.94
Typhoon	74	36.82
River overflow	131	65.17
Lake water level rise	16	7.96
Drainage problem	17	8.46
Improper solid waste disposal	20	9.95
Deforestation	13	6.47
Low elevation	5	2.49
Urbanization	1	0.50
Not aware	8	3.98
Logs that clogged the river	25	12.44
Quarrying	1	0.50
Landslide	6	2.99
Water coming from the upstream areas	3	1.49
Siltation of river	13	6.47
Underpreparation of the government regarding flooding	2	1.00

*multiple response

The respondents were also inquired on their suggested adaptation/mitigation measures that could combat severe flooding in their area. Chosen measures based on the per cent of cases were *Widening and Dredging of river (45.77%), Waste Management and Community Endeavour and Discipline*

(27.86%), *Reforestation and Forest Protection (24.38)*, *Repair or Cleaning of Drainage (22.89)* and *Water Impoundment System (21.39%)* (Table 26). However, rankings on these measures show that *Waste Management and Community Endeavour and Discipline* garnered the highest number of votes (1.571) followed by *Repair/Cleaning of Drainage (1.196)*, *Widening and Dredging of river (1.620)*, *Water Impoundment System (1.860)*, and *Reforestation and Forest Protection (1.959)*, respectively (Table 27). According to the respondents, it is of more prioritized that the government should discipline first the community in order to educate and prepare them to properly comply with the project in order for it to continue successfully. Among other activities that were included in the first-prioritized choice include waste management, community endeavour such as river-clean-up and etc. It is also very noticeable that most of the respondents chose to prioritize more the activities that are mostly done in the downstream areas despite that the commonly cause of flooding is due to the river overflow that was caused by large volume of water coming from the upstream. This only explains that they want to solve first the problems in their vicinity before fixing the upland area's problem. Despite the fact that reforestation and forest protection is also of great importance in order to minimize the surface run-off from the uplands that will result to flooding in downstream areas, it became as lesser priority for the respondents.

Table 26. Respondents' choice on the adaptation/mitigation measures that should be prioritized by the government

Adaptation/Mitigation Measures	n	% of cases
Early Warning System	29	14.43
Water Impoundment System	43	21.39
Reforestation and Forest Protection	49	24.38
Widening and Dredging of river	92	45.77
Dike construction	39	19.40
Repair/Cleaning of Drainage	46	22.89
Waste Management & Community Endeavour and Discipline (e.g. community management, river clean-up)	56	27.86
Riprap	11	5.47
No idea	9	4.48
Rehabilitation of Laguna Lake	3	1.49

*multiple response

Table 27. Ranking on the choice on the adaptation/mitigation measures that should be prioritized by the government

Adaptation/Mitigation Measures	Obs	Mean	Std. Dev.	Min	Max
Early Warning System	29	3.103	1.448	1	5
Water Impoundment System	43	1.860	0.804	1	4
Reforestation and Forest Protection	49	1.959	1.060	1	4
Widening and Dredging of river	92	1.620	0.810	1	5
Dike construction	39	2.308	1.490	1	5
Repair/Cleaning of Drainage	46	1.196	0.401	1	2
Community discipline/ management of the people / Community Endeavour / River Clean-Up/ waste management	56	1.571	0.892	1	6
Riprap**	11	1.182	0.405	1	2
Rehabilitation of Laguna Lake**	3	1.333	0.577	1	2
No idea**	8	1.000	0.000	1	1

**cannot be ranked

Extreme flooding events had caused damages and loss to such community's assets and health. These incurred damages and loss due to a specified extreme flooding were inquired in detailed to the respondents. It was shown in Table 28 that most of the households incurred loss of income or wages during the severe flood incident. Among occupations that was heavily affected due to flooding in which they cannot work for 55-70 days was the tricycle drivers. As the flood has not receded yet, flood waters can cause damage to their vehicle's machine. Household appliances that were too big and heavy enough to be lifted were also damaged. These include washing machine, television set and refrigerator. Moreover, businesses of some of the household respondents, such as fish farm, rice farm and horticulture and gardening acquired great loss with the maximum of Php 309,250.00. Meanwhile, there were some households that got injured while evacuating and assisting others to evacuate also. Some of the household members got sick with flu, colds, cough and fever that were treated as well using herbal medications as these were not too costly. Household appliances that were too big and heavy enough to be lifted were also damaged.

Table 28. Damage/loss incurred by the respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
House	87	15,878.16	41,887.77	300	300,000.00
Appliance/ Vehicle/ Amenities	63	9,931.43	13,831.49	200	80,000.00
Loss of income/wage	119	3,171.61	5,692.18	50	35,000.00
Loss of business	32	23,711.25	56,339.09	200	309,250.00

Dead or missing	0				
Injured	7	435.7143	710.8178	0	2,000.00
Disease/Illness	16	925.9375	1558.685	0	6,500.00
Total Damage Cost Due to Extreme Flooding	165	19,886.76	48,430.44	20	380,000.00

3.6 Descriptive Statistics of the Variables and the Results of the Parametric and Nonparametric Models

As there were distributional assumptions that were considered in which it affects the willingness of an individual in supporting the program, parametric approach through the logistic regression was used to model the said dichotomous outcome of variables and estimate the WTP values. Table 29 showed the different variables that influenced the WTP, and were used in the multivariate logit model. One of the variables—flood damage cost (*lnfloodcost*) was converted to its natural logarithm for it to be refined and the model to be statistically significant.

Meanwhile, another way of estimating the WTP was also implemented, namely the turnbull estimator. Unlike the previous model, this non-parametric model does not consider any distributional assumptions as factors affecting WTP. With that, there was no refining done in the needed data, as mean WTP values were generated directly.

Table 29. Descriptive Statistics of the Variables used in the Multivariate Logi

Variable	Mean	Std. Dev.	Min	Max
wtp20yn	0.438	0.497	0	1
bid20	322.886	172.550	100	600
age	45.697	15.227	16	91
sexmf	0.254	0.436	0	1
civstat	0.637	0.482	0	1
numhh	4.935	2.189	1	12
occup	0.577	0.495	0	1
dwellnrr	0.070	0.255	0	1
educyears	9.522	3.358	1	20
affectprov	0.841	0.367	0	1
impprot_rec	0.960	0.196	0	1
flood_often	3.181	2.628	0	20
lnfloodcost	7.068	3.633	0	12.84793
monthly_ex~l	17518.370	17151.860	1000	137500

Results of the two logit models of the parametric approach revealed to be both significant at 0.05 levels, having p-values of 0.024 (Bid only model) and 0.038 (Multivariate model) (Table 30). The bid variable in the bid only model is significant also at 0.05 levels with a p-value of 0.026. While in the multivariate model, four of the variables used are significant, which are bid (*bid20 at 0.061)* gender (*sexmf at 0.016)*, dummy variable for employed and unemployed respondents (*occup at 0.044)* and the awareness of the respondents on the effect of forest and agroforest vegetation on the provision of ecosystem services (*affectprov at 0.110)* (Table 30). Other variables that appeared to be insignificant can be explained with the small sample size used that cause for the variables to appear as imprecise. Multicollinearity problem was also checked through the variance inflation factors and no detection of problem has found. Meanwhile, the result of the multivariate model denotes that it is almost precise for the data but not too accurate for only four of its variables are significant. While the signs of the coefficients of the variables in the multivariate and bid only model depicted the expected directions of the probability of yes answers, except for *occup*, *dwellnrr*, and *educyears*.

Whereas, as there were no variables needed to be considered, the Turnbull Estimator of non-parametric approach has given straightforwardly the mean WTP values as shown in the lower bound and upper bound of the model which are Php250 and Php710, respectively (Table 31). On the other hand, mean WTP values of the bid only model (Equation1) and multivariate model (Equation 2) of parametric approach were computed using the equations stated:

$$E(WTP) = -(a + b_1 * bid20\ )/\ b_1 \tag{1}$$

$$E(WTP) = -(a + b_2 * age + b_3 * sexmf + b_4 * civstat + b_5 * numhh + b_6 * occup + b_7 * dwellnrr + b_8 * educyears + b_9 * affectprov + b_{10} * impprot\,rec + b_{11} * flood\,often + b_{12} * lnfloodcost + b_{13} * monthly\,exptotal\ )/\ b_1 \tag{2}$$

Table 30. Logit regression results on two different models

Bid only model					Multivariate model			
Variable	**Coef.**	**Std. Err.**	**z**	**P>z**	**Variable**	**Coef.**	**Std. Err.**	**P>z**
bid20	-0.002	0.001	-2.220	0.026**	bid20	-0.002	0.001	0.061 *
_cons	0.355	0.305	1.170	0.244	age	-0.011	0.011	0.351
					sexmf	0.874	0.361	0.016 **
					civstat	-0.490	0.321	0.127
					numhh	-0.025	0.077	0.740
					occup	-0.643	0.320	0.044 **

Log likelihood	-135.217				dwellnrr	0.693	0.638	0.277
LR chi2(1)	5.090				educyears	-0.005	0.051	0.926
Prob > chi2	0.024**				affectprov	0.724	0.453	0.110 *
Pseudo R2	0.019				impprot_rec	0.956	0.922	0.300
					flood_often	0.040	0.062	0.522
					lnfloodcost	0.026	0.046	0.580
					monthly_exp_total	0.000	0.000	0.209
					_cons	-0.713	1.416	0.615
					Log likelihood	-126.120		
					LR chi2(13)	23.290		
					Prob > chi2	0.038**		
					Pseudo R2	0.085		

***, **, *significant at 1%, 5% and 15% level, respectively

Table 31. Turnbull estimates result

Bid	Nj	Tj	Fj	Nj*	Tj*	Fj*	fj*	Elb	V(Elb)	Eub
0			0.000			0.000		0		38.462
100	15	39	0.385	15	39.000	0.385	0.385	19.038	60.689	38.077
200p	25	40	0.625	46	80.000	0.575	0.190	2.073	30.547	4.146
300p	21	40	0.525							
400	24	41	0.585	24	41.000	0.585	0.010	39.024	236.793	58.537
600	28	41	0.683	28	41.000	0.683	0.098	190.244	211.256	570.732
1800			1.000			1.000	0.317			
Total	113	201		113	201.000		201.000	250.38	539.285	709.953

Table 32 shows the computed estimates of willingness to pay from the different models used. Using the mean WTP of each model, such values for the year 2018 were acquired by multiplying it to the current household population of the municipality of Bay. Computations on the WTP values were based on two parameters: *%Yes only* and *All respondents*. Through the *%Yes only*, positive bidders only were included and protest bids were removed. Results revealed that Turnbull Estimates gained the highest WTP values, compared to the two parametric models. This can be attributed that unlike the non-parametric model, parametric models considers the qualitative data obtained in which it affects the utility of the ecosystem services. While according to Bateman, 2002 and Carandang, Calderon, Camacho & Dizon, 2008, Turnbull Estimator basically use the yes or no sequence of proportions for each bid to provide an algorithm in computing the WTP.

Table 32. Mean and Total WTP of downstream households for the year 2018

Model	E(WTP) per month (Php)		E(WTP) per year (Php)		Total (Php)	
					2018	
Parametric	%Yes only	All resp	%Yes only	All resp	%Yes only	All resp
Logit (bid only)	59	136	713	1,629	12,068,908	27,567,173
Logit (multivariate)	71	162	852	1,946	14,418,526	32,934,047
Non parametric (Turnbull)						
Lower bound	250	3005	50,855,085			
Upper bound	710	8519	144,199,696			

Total WTP of the three models were also computed through the present value terms for 5-year period, using the 10% discount rate (Table 33). Flood damage costs were projected as well through the mean, minimum and maximum values acquired from the data (Table 34). Values acquired from the flood damage costs projection were: Php 1,549,051,785 (mean), Php 1,557,872 (min) and Php 29,599,576,709 (max), assuming that no mitigation efforts were done. However, with the occurrence of climate change, such flooding disasters can continue to happen.

Table 33. Total WTP of downstream households in present value terms for 5-year period

Model	Total (Php)	
Parametric	PV (2018-2023)	
	%Yes only	All resp
Logit (bid only)	55,541,345	126,864,654
Logit (multivariate)	66,354,329	151,563,108
Non parametric (Turnbull)		
Lower bound	234,036,064	
Upper bound	663,609,735	

Table 34. Projected flood damage cost of the downstream households

No.	Year	Household population	Mean	Min	Max
0	2018	16,926	336,602,651	338,519	6,431,867,598
1	2019	17,344	344,916,736	346,881	6,590,734,728
2	2020	17,772	353,436,180	355,449	6,753,525,876
3	2021	18,211	362,166,053	364,228	6,920,337,965
4	2022	18,661	371,111,555	373,225	7,091,270,313

5	2023	19,122	380,278,010	382,443	7,266,424,690
Present Value			**1,549,051,785**	**1,557,872**	**29,599,576,709**

3.7 Socio-Demographic, Economic and Location Profile of the Upstream Farmer Respondents

Total number of respondents per study site was determined based on the secondary data and information acquired from the respective barangays. Proportion of farmer respondents in the two study sites was computed using Proportionate sampling and was shown in Tables 35 and 36.

Due to urban development in the upland area of Silang-Santa Rosa Subwatershed, most of the farm lands are being bought by the developers, and thus only 30 respondents were interviewed. Out of the 30 farmers, 20 of them are practicing agroforestry as their land use. It is followed by monoculture of pineapple with 8 respondents. While in the upstream of Cambantoc Subwatershed, most of the farmers' current land use is mixed perennial (40%). Mixed perennials land use system is adopted by the farmers near the foot of Mt. Makiling, since they are prohibited in the area to cut trees and to plant monoculture of agricultural crops. While as some of the areas in Tranca and Masaya are flat, 19 of the interviewed farmers adopt monoculture of rice.

Table 35. Numbers of farmers surveyed in upstream of Cambantoc Subwatershed relative to barangay and farming systems

	Farming Systems					
Barangay	***Mixed agricultural crops***	***Agroforestry***	***Mixed perennials***	***Monoculture perennials***	***Monoculture (Rice)***	**Total**
Bagong Silang	0	2	3	0	0	5
Bitin	0	1	2	2	0	5
Masaya	1	0	0	0	9	10
Paciano Rizal	0	2	6	1	1	10
Sta. Cruz	0	2	8	0	0	10
Tranca	1	0	1	2	6	10
Total	2	7	20	5	16	50

Table 36. Numbers of farmers surveyed in upstream of Silang-Santa Rosa Subwatershed relative to barangay and farming systems

	Farming Systems			
Barangay	***Agroforestry***	***Mixed perennials***	***Monoculture (Pineapple)***	**Total**
Bucal	2	0	1	3
Hukay	2	0	2	4
Munting Ilog	3	0	2	5
Pook 2	3	1	1	5

Pulong Bunga	2	1	0	3
Puting kahoy	0	0	1	1
Tartaria	4	0	1	5
Tibig	4	0	0	4
Total	20	2	8	30

The mean age of all farmer respondents interviewed was about 58 years (Table 37). While in comparison between the two subwatersheds, farmers in the Cambantoc Subwatershed were older than the farmers in Silang-Santa Rosa Subwatershed (Table 37). It was also evident in Cambantoc Subwatershed that tree-based system adopters were older than the non-adopters, having the mean ages of 59.772 and 57.750, correspondingly. Moreover, average years of farming of the adopters were much longer than the non-adopters (35.138 and 24.844). On the other hand, non-adopters of tree-based system in the uplands of Silang were much older than the adopters (59.5 and 53.5, respectively). Likewise, that was shown also in the average years of farming of adopters and non-adopters of tree-based system in Silang (28.2 and 33).

Table 37. Age of the upstream farmer-respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
Age of all respondents	80	58.6380	11.8035	28	81
Age of farmers from Cambantoc Subwatershed	50	60.3400	11.7084	28	80
Age of farmers from Silang-Santa Rosa Subwatershed	30	55.8000	11.6008	33	81

Most of the tree-based system adopters in Cambantoc have also higher average years of education (8 in agroforestry and 7.95 in mixed perennials) than the non-adopters (6.5 in mixed agriculture farming system and 7.125 in rice monoculture). Values imply that they had reached secondary education. However, farmers who practice monoculture of perennials have only reached primary education, with an average of 5.6 years. Similarly in Silang, tree-based system adopters have higher mean years of education (10 in agroforestry and 12.5 in mixed perennials system) than those who practice monoculture of pineapple (9.125). While in comparison between the two subwatersheds, farmers in Silang have higher years of education than the farmers in the upstream of Cambantoc (Tables 40-41). Survey results also revealed that majority (62.50%) of the decision-makers regarding farming activities were predominantly male. Likewise was shown in the two subwatersheds (Table 38). Adopters of tree-based system in the uplands of Cambantoc was mostly female, as land operations for rice monoculture and mixed agriculture system requires heavy labor. Whereas, in Silang, those who practice tree-based systems were 16 out of 22 males and 6 out of 8 females. A majority (86.25%) of the farmer respondents were married (Table 38). And the household size of all respondents ranged from 1 to 9 people and has an average of 4 people per household (Tables 40-41). While only small difference was observed between the two subwatersheds (Tables 40-41). The average household monthly income and expenditure of all respondents are Php 9,966.575 and Php 10,658.25 (Table 39). Farmers in Silang have higher household monthly income and expenses (Php 14,768.33 and Php 16,189.06) than the farmers from Cambantoc (Php 7,085.52 and Php7,339.76) (Tables 40-41).

Table 38. Socio-demographic characteristics of the upstream farmer respondents

Gender (all resp)	n	%	Civil Status of farmers in Silang- Santa Rosa SW	n	%
Male	50	62.50	Single	2	6.67
Female	30	37.50	Married	27	90.00
Total	80	100	Common-law	1	3.33
			Widow/Widower		
Gender of farmers in Cambantoc SW			Separated		
Male	28	56.00	Total	30	100.00
Female	22	44.00			
Total	50	100	Educational Attainment of all respondents		
			Elementary	35	43.75
Gender of farmers in Silang-Santa Rosa SW			High School	28	35.00
Male	22	73.33	College	14	17.50
Female	8	26.67	Vocational	3	3.75
Total	30	100	Total	80	100.00
Civil Status of all respondents			Educational Attainment of farmers in Cambantoc Subwatershed		
Single	4	5.00	Elementary	26	52.00
Married	69	86.25	High School	16	32.00
Common-law	6	7.50	College	7	14.00
Widow/Widower	1	1.25	Vocational	1	2.00
Separated			Total	50	100.00
Total	80	100.00			
Civil Status of farmers in Cambantoc SW			Educational Attainment of farmers in Silang-Santa Rosa Subwatershed		
Single	2	4.00	Elementary	9	30.00
Married	42	84.00	High School	12	40.00
Common-law	5	10.00	College	7	23.33
Widow/Widower	1	2.00	Vocational	2	6.67
Separated			Total	30	100.00
Total	50	100.00			

Table 39. Other socio-economic characteristics of all respondents in the upstream

Variables	Mean	Std	Min	Max
Age	58.6375	11.8035	28	81
Household size	4.1000	1.6505	1	9
Number of years of education	8.3500	3.7386	1	15
Years of farming	34.2375	17.0882	3	63
Monthly Income (Php)	9,966.5750	10,504.9700	1,000	50,000
Monthly Expenditure (Php)	10,658.2500	10,548.9500	1,462	51,500

Table 40. Other socio-economic characteristics of farmer respondents in upstream of Cambantoc Subwatershed

Variables	Mean	Std	Min	Max
Age	60.3400	11.7084	28	80
Household size	3.6800	1.4769	1	7
Number of years of education	7.4000	3.6533	1	15
Years of farming	35.2200	18.3173	4	63
Monthly Income (Php)	7,085.5200	5,242.3740	1,000	29,000
Monthly Expenditure (Php)	7,339.7600	5,523.8690	1,462	28,750

Table 41. Other socio-economic characteristics of all respondents in upstream of Silang-Santa Rosa Subwatershed

Variables	Mean	Std	Min	Max
Age	55.8000	11.6008	33	81
Household size	4.8000	1.7100	1	9
Number of years of education	9.9333	3.3726	4	15
Years of farming	32.6000	14.9703	3	60
Monthly Income (Php)	14,768.3300	14,697.6800	2,000	50,000
Monthly Expenditure (Php)	16,189.0600	14,175.8500	2,280	51,500

Table 42. Monthly Income and Expenses Range

Monthly expenses range of all respondents	Freq.	Percent	Monthly income range of all respondents	Freq.	Percent
1000-5000	26	32.50	1000-5000	30	37.50
5001-10000	26	32.50	5001-10000	24	30.00
10001-20000	19	23.75	10001-20000	19	23.75
>20001	9	11.25	>20001	7	8.75
Total	80	100	Total	80	100

Monthly expenses range of farmers in Cambantoc SW			**Monthly income range of farmers in Cambantoc SW**		
1000-5000	22	44.00	1000-5000	22	44.00
5001-10000	17	34.00	5001-10000	18	36.00
10001-20000	9	18.00	10001-20000	8	16.00
>20001	2	4.00	>20001	2	4.00
Total	50	100	Total	50	100
Monthly expenses range of farmers in Silang-Santa Rosa SW			**Monthly income range of farmers in Silang-Santa Rosa SW**		
1000-5000	4	13.33	1000-5000	8	26.67
5001-10000	9	30.00	5001-10000	6	20.00
10001-20000	10	33.33	10001-20000	11	36.67
>20001	7	23.33	>20001	5	16.67
Total	30	100	Total	30	100

3.8 Farm characteristics of parcel of farmer respondents in the upstream

Though some farmers can have more than one parcel, only one parcel per farmer was analysed in the study. Such parcel was chosen among other parcel owned by a farmer if it is the largest among other parcels. While if the parcels have the same area, but with different farming system and crop species, both of the parcels will be encoded and analysed. In the case of this study, there was no encountered such similar circumstance mentioned in the latter. However, there were cases in which a farmer has two parcels but with the same farming system used and crops planted. With such case, only one parcel was selected to be analysed. Area of parcel of the farmer respondents ranges from .0048 ha to 4.5 ha. On the average, farmer respondents in Silang has larger parcel area (1.079 ha) than the farmers in Cambantoc (1.051 ha). While two of the three tree-based farming systems in Cambantoc have larger parcel area (1.369 in agroforestry system adopters and 1.223 mixed perennial system adopters) compared with the two non-tree based farming systems (0.7 ha in mixed agricultural crops system adopters and 0.925 in non-tree based monocrop system adopters) (Table 43-45). Likewise also in Silang, those who engage in tree-based farming systems have larger parcel areas—having an average of 1.2081 ha in agroforestry system adopters and 1.625 ha in mixed perennial system adopters—compared with those who are engaged in monoculture of agricultural crops in which their parcel has an average of 0.61875 ha.

Table 43. Area of parcel of the farmer respondents in the upstream

Variables	Mean	Std	Min	Max
Area of parcel of all respondents	1.0637	0.8742	0.0048	4.5000
Area of parcel of farmers in Cambantoc SW	1.0507	0.8732	0.0048	4.5000
Area of parcel of farmers in Silang-Santa Rosa SW	1.0787	0.8976	0.0120	3.0000

Table 44. Area of parcel of the farmer respondents per farming system in upstream of Cambantoc Subwatershed

Variables	Mean	Std	Min	Max
Area of parcel of agroforestry system adopters (tree-based)	1.3690	1.5080	0.0200	4.5000
Area of parcel of mixed perennial system adopters (tree-based)	1.2230	0.9340	0.1000	4.0000
Area of parcel of monocrop system adopters (tree-based)	0.4610	0.4970	0.0048	1.0000
Area of parcel of mixed agricultural crops system adopters (non-tree based)	0.7000	0.2830	0.5000	0.9000
Area of parcel of monocrop system adopters (non-tree based)	0.9250	0.4107	0.3000	2.0000

Table 45. Area of parcel of the farmer respondents per farming system in upstream of Silang-Santa Rosa Subwatershed

Variables	Mean	Std	Min	Max
Area of parcel of agroforestry system adopters (tree-based)	1.2081	0.8771	0.0120	3.0000
Area of parcel of mixed perennial system adopters (tree-based)	1.6250	1.9445	0.2500	3.0000
Area of parcel of monocrop system adopters (non-tree based)	0.6188	0.5781	0.1000	1.5000

Crops planted per farming system in the two subwatersheds were shown in Tables 46-52. Banana integrated in the agroforestry system in Cambantoc SW has the highest percentage of cases (71.43%). It is followed by lanzones (57.14%) and papaya, rambutan, taro and cassava (42.86%) (Table 46). While for mixed perennial system, most common crop species planted were lanzones (85% cases), banana (80% cases), rambutan (60% cases) and coconut (55% cases) (Table 47). In monocrop perennial farming system, only two crops were planted by the farmers, in which these include banana (80%) and coffee (20%). For the non-adopters of tree-based system, rice is the most common crop planted in the two farming systems (mixed agriculture and monocrop agriculture). Gabi and pechay were integrated in the mixed agricultural farming system, in which both have percentage of cases of 50%. In the other subwatershed in the upstream in Silang, 90% of the agroforestry system based-adopters plant pineapple. It was integrated with banana (65% cases), papaya (45% cases), coffee (40% cases) and guyabano (35% cases) (Table 51). While in mixed perennial system, all of its adopters integrated coffee with banana, and 50% added guyabano to the system (Table 52).

Table 46. Crop species planted by the agroforestry system based-adopters in upstream of Cambantoc Subwatershed

Crop species	Frequency	% of cases
Coconut	2	28.57
Papaya	3	42.86
Lanzones	4	57.14
Rambutan	3	42.86
Avocado	1	14.29
Coffee	1	14.29
Banana	5	71.43
Taro	3	42.86
Cassava	3	42.86
Rice	2	28.57
Guyabano	1	14.29

*multiple response

Table 47. Crop species planted by the mixed perennial system based-adopters in upstream of Cambantoc Subwatershed

Variable	Frequency	of cases
Coconut	11	55
Lanzones	17	85
Rambutan	12	60
Mango	1	5
Avocado	1	5
Coffee	1	5
Banana	16	80
Dalandan/Calamansi	6	30
Custard apple	1	5
Guyabano	2	10

*multiple response

Table 48. Crop species planted by the monocrop perennial system based-adopters in upstream of Cambantoc Subwatershed

Crop	Freq.	Percent
Coffee	1	20
Banana	4	80
Total	5	100

Table 49. Crop species planted by the mixed agricultural system based-adopters in upstream of Cambantoc Subwatershed

Crop species	Frequency	% of cases
Gabi	1	50
Rice	2	100
Pechay	1	50

*multiple response

Table 50. Crop species planted by the monoculture agricultural system based-adopters in upstream of Cambantoc Subwatershed

Crop	Freq.	Percent
Rice	16	100
Total	16	100

Table 51. Crop species planted by the agroforestry system based-adopters in upstream of Silang-Santa Rosa Subwatershed

Crop	Frequency	of cases
Pineapple	18	90
Coconut	1	5
Papaya	9	45
Avocado	1	5
Coffee	8	40
Pepper	5	25
Banana	13	65
Taro	1	5
Cassava	3	15
Eggplant	1	5
Guyabano	7	35

*multiple response

Table 52. Crop species planted by the mixed perennial system based-adopters in upstream of Silang-Santa Rosa Subwatershed

Crop	Frequency	of cases
Coffee	2	100
Banana	2	100
Guyabano	1	50

*multiple response

Table 53. Crop species planted by the monocrop agricultural system based-adopters in upstream of Silang-Santa Rosa Subwatershed

Crop	Freq.	Percent
Pineapple	8	100
Total	8	100

Survey results revealed that 58.75% of the total respondents owned the farm parcel they are cultivating. In the upstream of Cambantoc, farmers who adopt tree-based system, and at the same time are owners of such parcel have higher proportion (57.14% in agroforestry, 75% in mixed perennials, and 60% in monoculture perennials) than those who are only tenants (42.86% in agroforestry, 25% in mixed perennials, 40% in monoculture perennials). However, those who are engaged in monoculture of agricultural crops have slightly higher proportion of tenants (43.75%) than owners (37.5%) and renters (18.75%). Same was also observed in the tree-based system adopters in Silang wherein those who owned such parcel were slightly higher (55% in agroforestry and 100% in mixed perennials) than the tenants (45% in agroforestry). On the contrast to Cambantoc, those who are owners of parcel and adopters of pineapple monoculture have higher proportion than those who are only tenants.

In terms of topography, higher proportion of farmers indicated that their parcel was flat (46% in Cambantoc Subwatershed and 50% in Silang-Santa Rosa Subwatershed). It was also observed by 38% of farmers that there was an average nutrient degradation in Cambantoc, while both average and high were observed by 36.67% of the farmers in Silang. Low soil erosion was also observed by most farmers in the two subwatersheds (58% in Cambantoc and 63.33% in Silang) in Table 54.

Table 54. Other farm characteristics of the farmer respondents in the upstream

Ownership status of parcel of all respondents	n	%	Topography of parcel of farmers in Silang- Santa Rosa Subwatershed	n	%
Owned	47	58.75	Undulating	5	16.67
Renter	3	3.75	Rolling	10	33.33

Tenant/Rights	30	37.5	Flat	15	50
Total	80	100	Total	30	100
Ownership status of parcel of farmers in Cambantoc SW			Levels of soil erosion in the parcel of all respondents		
Owned	29	58	High	12	15
Renter	3	6	Average	20	25
Tenant/Rights	18	36	Low	48	60
Total	50	100	Total	80	100
Ownership status of parcel of farmers in Silang- Santa Rosa SW			Levels of soil erosion in the parcel of farmers in Cambantoc SW		
Owned	18	60	High	8	16
Renter	0	0	Average	13	26
Tenant/Rights	12	40	Low	29	58
Total	30	100	Total	50	100
Topography of parcel of all respondents			Levels of soil erosion in the parcel of farmers in Silang- Santa Rosa SW		
Undulating	16	20	High	4	13.33
Rolling	26	32.5	Average	7	23.33
Flat	38	47.5	Low	19	63.33
Total	80	100	Total	30	100
Topography of parcel of farmers in Cambantoc SW			Levels of nutrient degradation in the parcel of all respondents		
Undulating	11	22	High	26	32.5
Rolling	16	32	Average	30	37.5
Flat	23	46	Low	24	30
Total	50	100	Total	80	100
Levels of nutrient degradation in the parcel of of farmers in Cambantoc SW			Levels of nutrient degradation in the parcel of farmers in Silang-Santa Rosa SW		
High	15	30	High	11	36.67
Average	19	38	Average	11	36.67
Low	16	32	Low	8	26.67
Total	50	100	Total	30	100

Perceived causes of soil problems in such parcel were also identified in Table 55. The most common cause for the farmers in Cambantoc SW was topography (44% of cases), as there were 22-32% of the respondents who indicated that their parcel's topography is rolling to undulating. Soil erosion is connected with topography. Though most of the farmers rated that soil erosion in their parcel is mostly low to average, they believed that soil erosion will be higher through time due to other factors. Among these are: *too much use of chemicals in farm (32% of cases), trees in the parcel are not enough in improving soil quality (30%), lack of knowledge in sustainable farming practices (22%)* and *climate change (16%).* While in the upstream of Silang, 60% of cases suggest that too much use of chemicals is the major cause of soil problems, being pineapples are planted as major crop, however requires high intensive inputs in which leads to the increase of soil acidity in the soil. Other farmers also indicated that their farming practices can be unsustainable (36.67%) and the trees in the parcel are also not enough in improving the soil quality (30%), as some of them may prefer crops with high marketability than crops that can help in achieving sustainability. Whereas, 23.33% of the farmers perceived that soil problems occur in their parcel due to their lack of knowledge on farming practices that promotes sustainability.

Table 55. Causes of soil problems in the upstream areas

Causes	All respondents		Cambantoc Subwatershed		Silang-Santa Rosa Subwatershed	
	n	of cases	n	of cases	n	of cases
Topography	23	28.75	22	44	1	3.33
Too much use of chemicals in farm	34	42.5	16	32	18	60
unsustainable farming practices	25	31.25	14	28	11	36.67
Trees in the parcel are not enough in improving soil quality	24	30	15	30	9	30
Lack of knowledge on sustainable farming practices	18	22.5	11	22	7	23.33
High soil erosion	2	2.5	2	4	5	16.67
Climate change	13	16.25	8	16	3	10
No idea	9	11.25	6	12	1	3.33

*multiple response

Among the measures done by the farmers to mitigate soil problems are determined and ranked. According to the farmers, identified causes mentioned lead to the impairment of quality of soil and eventually to leaching of nutrients. With that, 76% of the farmers in Cambantoc and 63.33% of the farmers in Silang mentioned that they are planting such species that aids in nutrient cycling, such as kakauate (*Gliricidia sepium*). While 50% of the farmers in Cambantoc Subwatershed indicated that they are planting trees on areas that have high probability of soil erosion. Fallowing is also one among the most common practices done by the farmers in Cambantoc with 30% of cases. In Silang, half of the farmer respondents indicated that they are practicing crop rotation for some time (planting peanuts after pineapple), and indeed was effective in restoring the lost nutrients of the soil. However, such measure is no longer applied as planting pineapple is more preferred due to high net income. While in areas that are rolling to undulating, trees are planted by 40% of farmers to reduce the risk of soil erosion. This measure was ranked as the highest by the farmers in Cambantoc (1.64). While planting species that aids in nutrient cycling was ranked as the most practiced measure in Silang (1.578947) in Table 57-58.

Table 56. Measures done to mitigate soil problems

Causes	All respondents		Cambantoc Subwatershed		Silang-Santa Rosa Subwatershed	
	n	of cases	n	of cases	n	of cases
Crop rotation	26	32.5	11	22	15	50
Plowing/ Soil tillage	17	21.25	10	20	7	23.33
Planting certain species on areas with high probability of soil erosion	37	46.25	25	50	12	40
Planting species that aids in nutrient cycling	57	71.25	38	76	19	63.33
Fallowing	26	32.5	15	30	11	36.67
no idea	1	1.25	1	2	15	50

*multiple response

Table 57. Rank on the measures done to mitigate soil problems in Cambantoc Subwatershed

Measures	Obs	Mean	Std. Dev.	Min	Max
Crop rotation	11	1.8182	1.0787	1	4
Plowing/ Soil tillage	10	1.6000*	0.6992	1	3
Planting certain species on areas with high probability of soil erosion	25	1.6400	0.8602	1	4
Planting species that aids in nutrient cycling	38	1.7368	0.7947	1	4
Fallowing	15	2.3333	1.4960	1	5

*cannot be ranked

Table 58. Rank on the measures done to mitigate soil problems in Silang-Santa Rosa Subwatershed

Measures	Obs	Mean	Std. Dev.	Min	Max
Crop rotation	15	1.9333	0.8837	1	3
Plowing/ Soil tillage	7	2.4286	1.5119	1	5
Planting certain species on areas with high probability of soil erosion	12	1.9167	0.9962	1	4
Planting species that aids in nutrient cycling	19	1.5789	0.8377	1	4
Fallowing	11	2.2727	1.6787	1	5

3.9 Financial Profitability of Farming Systems

Parameters involved in the study such as labour cost, yield, and price of a particular product were sourced based on the survey interviews with the farmers. Values of family labour and *bayanihan* labour of the farmers on the other hand, were converted based on the average of current labour rate on their respective areas. These calculated values also served as input on rate on unit in each day work (*man-day*, *man-animal day* and *animal day*) per farming operations that involves family labour and *bayanihan* labour. While it was also noted if there are contract basis for such operation in which different operations are clumped into one payment for the labourers. Likewise it is also noted that in harvest labour that involves contract between the middleman and farmer in which the farmer will not bear costs for harvesting since the middleman will be the one in-charge in harvesting the crops and will just provide payment to the farmer for the harvested products. Each of the costs and returns are based on cropping cycle per year and computed in hectare basis. Summarized cost and return of different farming systems were shown in Tables 59-60. Such values were used in the cash flow in time horizon of 10 years to generate results for NPV, BCR and EAB. Cash flow and in-detailed farming operations per crop were shown in appendices section (Appendix 1.1-1.16). Meanwhile, annuity factor was based on the author's calculation.

Table 59. Summary of cost of production, return and net return of various farming systems for one year in Cambantoc SW (PhP ha^{-1})

Item	Rice Monoculture	Mixed Agriculture	Mixed Perennials	Monoculture of Perennials	Agroforestry
	Value/Amount (Php)	Value/Amount (Php)	Value/Amount (Php)	Value/Amount (Php)	Value/Amount (Php)
Return (Php/ha)	242,564.50	312,205.6	33,191.8	17,750	54,736.6
Cost of Production (Php/ha)					
Material inputs	26,806	28,828	7,957	1,393	21,645
Labor cost	139,927	145,283	21,092	16,850	28,897
Establishment	66,278.43	83,311.11	3,090	1,775	12,476
Maintenance	26,300.45	16,022.22	3,037	3,000	3,867
Harvest	47,348.49	45,950	14,964	12,075	12,554
Fixed cost	25,522	-	-	-	-
Total Cost	192,255	174,111	29,049	18,243	50,542
Net Return (PhP/ha)	50,310	138,095	4,143	(493)	4,195

Table 60. Summary of cost of production, return and net return of various farming systems for one year in Silang-Santa Rosa SW (PhP ha^{-1})

Item	Pineapple Monoculture	Mixed Perennials	Agroforestry
	Value/Amount	Value/ Amount	Value/Amount
Return (PhP/ha)	587,750.00	25,450	333,323.30
Cost of Production (PhP/ha)			
Material inputs	59,969.753	9,766.667	36,575.14
Labor cost	34,092.259	22,300	41,259.93
Establishment	15,043.75	10,100	11,133.38
Maintenance	13,077.08	4,400	18,292.54
Harvest	5,971.429	7,800	11,834.01

Fixed cost	316.557	0	-
Total Cost	94,379	32,066.667	77,835.07
Net Return (PhP/ha)	493,371.431	-6,616.667	**255,488.24**

Generated values of economic indicators imply that all land use systems are profitable at this cost of capital, having there are no negative NPV. Other economic indicators (BCR and EAB) likewise suggest that all of the farming systems in both of the subwatersheds are also profitable. Among the five farming systems in Cambantoc SW, mixed agriculture is considered as the most profitable farming system. It was then followed by rice monoculture with an NPV of 465,949.82 and EAB of 51,254.48 (Table 61). Same trend was also shown in the Silang-Santa Rosa Subwatershed wherein monoculture of agricultural crops has the highest profitability among other farming systems (Table 62).

Table 61. Values of economic indicators relative to various farming systems in Cambantoc Subwatershed

Economic indicators	Farming Systems				
	Rice Monoculture	Mixed Agriculture	Mixed Perennials	Monoculture of Perennials	Agroforestry
NPV (PhP)	465,949.82	848,532.53	57,627.47	16,934.86	81,420.61
BCR	1.45	1.79	1.65	1.28	1.36
EAB (PhP/year)	51,254.48	93,338.58	6,339.02	1,862.83	8,956.27

Table 62. Values of economic indicators relative to various farming systems in Silang-Santa Rosa Subwatershed

Economic indicators	Farming Systems		
	Pineapple Monoculture	Mixed Perennials	Agroforestry
NPV (PhP)	1,178,468.79	32,722.68	499,616.17
BCR	3.18	1.41	2.41
EAB (PhP/year)	129,631.57	3,599.49	54,957.78

3.10 Opportunity Cost (Forgone Income) for Adopting Tree-based Systems

As mentioned above, monoculture of agricultural crops and mixed agricultural crops are among with the highest profitability. However, incorporating trees into the system will result to loss of income for the farmers, for such part of the parcel that was before attributed for agricultural crops were converted for perennial crops. Perennial crops are seasonal, which also means that longer time is needed before the harvesting period. Intersections on Tables 63-64 show the values of the probable loss of income of farmers for adopting tree-based systems respectively expressed in Net Present Values (NPV) and Equivalent Annualized Benefit (EAB) with a time horizon of ten years. In the Cambantoc Subwatershed, results revealed that among the alternative land use of rice monoculture, monoculture of perennials has the highest value of opportunity cost, and likewise were also shown in the alternative land use from mixed agriculture. While agroforestry gained the lowest opportunity cost respective to the monoculture and mixed cropping farming systems, including also the in the subwatershed of Silang-Santa Rosa.

Table 63. Opportunity cost or forgone income for adopting Tree-Based systems in Cambantoc Subwatershed

Tree-Based Farming Systems	**Non-Tree Based Farming Systems**			
	Rice Monoculture		Mixed Agriculture	
	NPV (PhP)	EAB (PhP/year)	NPV (PhP)	EAB (PhP/year)
Mixed Perennials	408,322.35	44,915.46	790,905.06	86,999.56
Monoculture of Perennials	449,014.96	49,391.65	831,597.67	91,475.74
Agroforestry	384,529.21	42,298.21	767,111.92	84,382.31

Table 64. Opportunity cost or forgone income for adopting Tree-Based systems in Silang-Santa Rosa Subwatershed

Tree-Based Farming Systems	**Non-Tree Based Farming System**	
	Pineapple Monoculture	
	NPV	EAB
Mixed Perennials	1,145,746.11	126,032.07
Agroforestry	678,852.62	74,673.79

3.11 Farmers' WTA for Conserving Forest and Adoption of Tree-based System

From 2019 survey of upstream households, the estimated mean amounts of WTA were 337 PhP/month/household (Table 65). The expected amounts of WTA from upstream household (service sellers) were higher than the expected WTP (PhP 59, PhP 71, PhP 250 in Table 32) offered by the service buyers. The results of expected amounts of WTP&WTA must be presented to downstrem and upsteram households of the subwatershed and local government and to discuss the proper the payment levels to be used. Table 66 presents statistics of variables used in WTA estimation, and Table 67 summarized results from the logit regression model used to estimate WTA amounts.

Table 65. Mean and total WTA of upstream households for the 2019

Calculation	
Mean WTA	$= -(a+b_2*age+b_3*gen+b_4*educyears+b_5*yrsfarming+b_6*parcel1\_area+b_7*topog+ b_8*soilerosion+ b_9*monthly\_exp\_total+b_{10}*own\_fl+b_{11}*numhh+b_{12}*aware6+b_{13}*aware7)/ b_1$ = -(3.08411+-0.04318*55.85+-0.32385*0.497+-0.04897 *1.90+-0.00601*31.98+ 0.29505*1.08+ 0.04164*0.57+ 0.66705*0.43+ 0.000014 *11,016.57+ -0.11233*1.98+ -0.01766*4.23+-0.91876*1.03+0.01775*0.82)/ 0.00065 = -(-0.21912)/ 0.00065 =337 PhP / month/ household = 4,045 PhP / year/ household

Table 66 Descriptive statistics of variables used in WTP estimation.

Variables	Mean	Std.Dev.	Min	Max
Wta	0.68	0.47	0	1
bid20	361.41	215.72	100	700
age	55.85	13.14	23	84
gen	0.497	0.50	0	1
educyears	1.90	0.96	1	5
yrsfarming	31.98	18.40	1	70
parcel1_area	1.08	0.91	0.0048	4.5
Topog	0.57	0.50	0	1
Soilersion	0.43	0.50	0	1
monthly_exp_total	11,016.57	11,434.80	200	100,000
own_fl	1.98	1.48	1	8
numhh	4.23	1.93	1	10
aware6	1.03	0.31	1	4
aware7	0.82	0.38	0	1

Table 67 Results from the logit regression model for WTA estimate.

(1) Bid only model				(2) Multivariate model			
Variables	Coefficient	Std. Error	P>z	Variables	Coefficient	Std. Error	P>z
constant	0. 42326	0.30271	0.162	constant	3.08411	1.36299	0.024**
Bid20	0. 00095	0. 00075	0.204	bid20	0.00065	0.00083	0.435
				age	-0.04318	0.01647	0.009 ***
				gen	-0.32385	0.35941	0.368
				educyears	-0.04897	0.19822	0.805
				yrsfarming	-0.00601	0.01052	0.568
				parcel1_area	0.29505	0.20292	0.146*
				Topog	0.04164	0.40826	0.919
				Soilersion	0.66705	0.43922	0.129*
				monthly_exp_total	0.000014	0.000017	0.508
				own_fl	-0.11233	0.11197	0.316
				numhh	-0.01766	0.090488	0.845
				aware6	-0.91876	0.82487	0.265
				aware7	0.01775	0.45627	0.969
Log likelihood		-114.99691		Log likelihood		-100.90145	
LR $chi^2(1)$		1.65		LR $chi^2(8)$		19.04	
Prob > chi^2		0.1996		Prob > chi^2		0.0875**	
Pseudo R^2		0.0071		Pseudo R^2		0.0862	

***, **, *significant at 1%, 5% and 15% level, respectively

3.12 Factors affecting adoption of Nature-based approach (Tree-based systems)

Result from logit regression analysis on the factors affecting adoption of tree-based system for the two subwatersheds was significant at 1% level (Table 68). Logit regression analysis for each of the sites was not possible due to small sample size. The independent variables that are significant include area of parcel (parcel1_area), topography of parcel (topog), soil erosion levels (soilerosion) and perception of the farmers on the higher long run returns of agroforestry and timber-based systems than the traditional continuous annual (aware7). The model was checked also for multicollinearity problem and revealed no such problem has found.

Table 68. Variables affecting adoption of tree-based systems and its marginal effects

Variable	Coef.	Std. Err.	P>z	dy/dx
age	-0.04840	0.0428	0.258	0.0082
gen	0.5004	0.8226	0.543	0.0873

educyears	0.0405	0.1315	0.758	0.0068
yrsfarming	0.0086	0.0273	0.754	0.0014
parcel1_area	0.9567	0.4939	0.053*	0.1612
topog	2.7432	0.8658	0.002**	0.4665
soilerosion	1.4254	0.9016	0.114*	0.2217
monthly_exp_total	6.59E-06	0.00004	0.881	1.11E-06
own_fl	0.9341	0.7616	0.22	0.1644
numhh	-0.2571	0.2271	0.258	0.0433
aware6	-2.4818	1.9078	0.193	0.2110
aware7	1.8090	0.9740	0.063*	0.3800
_cons	1.4872	3.7607	0.693	
Log likelihood	-29.7760			
LR chi2(13)	41.34			
Prob > chi^2	0.0000***			
Pseudo R^2	0.4097			

***, **, *significant at 1%, 5% and 15% level, respectively

4. Conclusions

Payments for Forest Ecosystem Services (PFES) can be a viable tool to improve the provision of goods and services of the forest and agroforest areas. Through the conservation and sustainable management of forest and agroforest in the subwatershed, this institutional mechanism would be effective and efficient in addressing socio-economic and environmental concerns, which are the goals of integrated watershed management. An approach used to properly value the forest ecosystem services in the subwatershed was Willingness to Pay (WTP). With this, such information on crafting sound payments for ecosystem services were revealed. These include the preferred payment vehicle (*direct payment*), authorities that will manage their payment (*local government units*) and the activity (*reforestation*) that should be prioritized using the generated funds. Moreover, as the respondents' awareness, attitudes and perceptions on forest and agroforest ecosystem services and severe flooding experiences were inquired, these had served to properly analyse such factors that affected their WTP. These factors were used in the estimation of WTP through the multivariate model of parametric approach. While amounts obtained for the mean WTP estimates of % Yes only of bid only logit model, multivariate logit model and turnbull estimates (lower bound and upper bound) were as follows: Php59, Php71, Php250 and Php710. Turnbull estimates got the highest WTP values as in the non-parametric approach, no factors were needed to be considered that can affect the WTP. The values acquired using the three models were computed to their present value terms (5 years, 10% discount rate) and the severe flood damage cost as well using the mean, minimum and maximum values of incurred flood damages. Results generated evidently indicate that present value terms of flood damage costs for five years were higher than the Total WTP in all of its models. Seeing that the damage cost is larger than the WTP for all the estimates of the models, it is more acceptable to support for the flood mitigation program through the improvement of flood regulating services of the forest and agroforest area than to incur a greater damage due to flooding disasters. However, the expected amounts of WTA from the upstream households were higher than the expected amounts of WTP from the downstream households. There is need to have negotiation of an ecosystem service's value between the upstream and downstream households in order for the mitigation program to continue successfully.

Through the adoption of Nature-based Approaches such as agroforestry and tree-based systems in the scheme, this can restore the ecosystem services of the forest and agroforest in the uplands while providing incentives to the producers of it. However, for a traditional farming system to be changed, it requires to be profitable enough for the farmers. Through forgone income, probable estimated losses of farmers for adopting tree-based system were identified. The model for adopting tree-based systems by the farmers reflects that the model used in the study is statistically correct (with a p-value of 0.0000), however is not accurate for the whole data as some of the variables in the model are not significant. Among these factors that influence the decision of the adoption of tree-based farming systems are: parcel area (parcel1_area at 0.053), parcel topography (topog at 0.002), soil erosion levels (soilerosion at 0.114) and perception on the long run returns provided by the tree-based farming systems (aware7 at 0.063).

5. Future Directions

The results of the Forgone Income of the upstream households in the two subwatersheds could serve as a basis in crafting the Payments for Ecosystem Services scheme. Adoption of nature based approaches such as timber-based farming systems can eventually lead to the improved provision of flood mitigating service. However, there is a need to have a better understanding on the tree species that will be incorporated in the program. Suitability of such tree species on a certain area, profitability and high capability to infiltrate surface run-off were among the factors that can motivate a farmer to adopt the tree-based farming system. Moreover, it is also important for the local government units, barangay staffs and the community to have a better understanding on the mechanics of the PES scheme and the benefits of the Nature Based Approaches. Awareness of the farmers on sustainable farming should also be increased through the information and education campaign, in order for them to be more responsible with their actions that could result to externalities on the other parts of the subwatershed. Researches on other stakeholders of the upstream of the subwatershed, as well as the institutional and legal aspects of both the upstream and downstream areas, are also needed to be considered for sustainably managing a subwatershed requires the cooperation of different stakeholders within the subwatershed.

With the current market failure, deforestation and forest degradation and flooding problem in the Philippines, the implementation guideline was written drawing from the experiences, lessons and results of the project (see in Appendix 2). This document serves as a reference for interested organizations in setting up PFES scheme in a watershed setting within the Philippines and in other countries of Southeast Asia, in order to address the existing forest degradation and climate change impacts.

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7. Appendix

Appendix 1: Cash flow and in-detailed farming operations per crop in the upstream watershed

1.1 Summary of the cost and return of rice monoculture in Cambantoc Subwatershed (ha^{-1})

Item	Value/ Amount
Return (Php/ha)	242,564.50
Cost of Production (Php/ha)	
Material inputs	26,806
Labor cost	139,927
Fixed cost	25,522
Total Cost	192,255
Net Return	**50,310**

1.2 Summary of the mixed agriculture farming system in Cambantoc Subwatershed (ha^{-1})

Item	Value/ Amount
Return (Php/ha)	312205.6
Cost of Production (Php/ha)	
Material inputs	28,828
Labor cost	145,283
Fixed cost	-
Total Cost	174,111

Net Return	**138,095**

1.3 Summary of the mixed perennial farming system in Cambantoc Subwatershed (ha^{-1})

Item	Value/Amount
Return (Php/ha)	33191.8
Cost of Production (Php/ha)	
Material inputs	7,957
Labor cost	21,092
Establishment	3,090
Maintenance	3,037
Harvest	14,964
Fixed cost	-
Total Cost	29,049
Net Return	**4,143**

1.4 Summary of the monoculture perennial farming system in Cambantoc Subwatershed (ha^{-1})

Item	Value/Amount
Return (Php/ha)	17750
Cost of Production (Php/ha)	
Material inputs	1,393
Labor cost	16,850
Establishment	1,775
Maintenance	3,000
Harvest	12,075
Fixed cost	-
Total Cost	18,243
Net Return	**(493)**

1.5 Summary of the agroforestry system in Cambantoc Subwatershed (ha^{-1})

	Value/ Amount		
Item	Combined	Agri	Per
Return (Php/ha)	54736.6	36581.94	23380.64
Cost of Production (Php/ha)			
Material inputs	21,645	13515.574	8603.254
Labor cost	28,897	12,882	24,053

Appendix 1e. Summary of the agroforestry system in Cambantoc Subwatershed (ha-1) cont.

Establishment	12,476	9449.444	4376.19
Maintenance	3,867	600	5500
Harvest	12,554	2832.778	14176.67
Fixed cost	-	-	-
Total Cost	50,542	26,398	32,656
Net Return	**4,195**	**22,332**	**28,429**

1.6 Summary of the pineapple monoculture in Silang-Santa Rosa Subwatershed (ha^{-1})

Item	Value/Amount
Return (Php/ha)	587,750.00
Cost of Production (Php/ha)	
Material inputs	59969.753
Labor cost	34092.259
Establishment	15043.75
Maintenance	13077.08
Harvest	5971.429
Fixed cost	316.557
Total Cost	94,379
Net Return	493371.431

1.7 Summary of the mixed perennial farming system in Silang-Santa Rosa Subwatershed (ha^{-1})

Item	Value/Amount
Return (Php/ha)	25450
Cost of Production (Php/ha)	
Material inputs	9766.667
Labor cost	22300
Establishment	10100
Maintenance	4400
Harvest	7800
Fixed cost	0
Total Cost	32066.667
Net Return	-6616.667

1.8 Summary of the agroforestry system in Silang-Santa Rosa Subwatershed (ha^{-1})

	Value/ Amount				
Item	Combined	Agri	Per	Pineap only	Agri w/o pineap
Return (Php/ha)	333,323.30	328908.2	21726.02	346152	5109.286
Cost of Production (Php/ha)					
Material inputs	36,575.14	34597.905	3145.014	34181.089	2219.429
Labor cost	41,259.93	33,863	12,726	33,249	1,791
Establishment	11,133.38	10783.27	917.6566	11046.69	900.7143
Maintenance	18,292.54	17717.86	4008.878	17535.5	620
Harvest	11,834.01	5361.444	7799.44	4667.157	270
Fixed cost	-	3,255	-		
Total Cost	77,835.07	68,460	15,871	67,430	4,010
Net Return	**255,488.24**	**260,448**	**5,855**	**278,722**	**1,099**

1.9 Cash flow for rice monoculture in Cambantoc Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	242564.5	139927.37	26805.942	166733.312	75831.188	220,513.18	151,575.74	68937.44
2	242564.5	139927.37	26805.942	166733.312	75831.188	200,466.53	137,796.13	62670.40
3	242564.5	139927.37	26805.942	166733.312	75831.188	182,242.30	125,269.21	56973.09
4	242564.5	139927.37	26805.942	166733.312	75831.188	165,674.82	113,881.10	51793.72
5	242564.5	139927.37	26805.942	166733.312	75831.188	150,613.47	103,528.27	47085.20
6	242564.5	139927.37	26805.942	166733.312	75831.188	136,921.34	94,116.61	42804.73
7	242564.5	139927.37	26805.942	166733.312	75831.188	124,473.94	85,560.55	38913.39
8	242564.5	139927.37	26805.942	166733.312	75831.188	113,158.13	77,782.32	35375.81
9	242564.5	139927.37	26805.942	166733.312	75831.188	102,871.03	70,711.20	32159.83
10	242564.5	139927.37	26805.942	166733.312	75831.188	93,519.12	64,282.91	29236.21
					Sum	1,490,453.85	1,024,504.02	

1.10 Cash flow for mixed agriculture farming system in Cambantoc Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	312205.6	145283.33	28827.508	174110.838	138094.762	283,823.27	158,282.58	125540.69
2	312205.6	145283.33	28827.508	174110.838	138094.762	258,021.16	143,893.25	114127.90
3	312205.6	145283.33	28827.508	174110.838	138094.762	234,564.69	130,812.05	103752.64
4	312205.6	145283.33	28827.508	174110.838	138094.762	213,240.63	118,920.05	94320.58
5	312205.6	145283.33	28827.508	174110.838	138094.762	193,855.11	108,109.13	85745.98
6	312205.6	145283.33	28827.508	174110.838	138094.762	176,231.92	98,281.03	77950.89
7	312205.6	145283.33	28827.508	174110.838	138094.762	160,210.84	89,346.39	70864.45
8	312205.6	145283.33	28827.508	174110.838	138094.762	145,646.22	81,223.99	64422.23
9	312205.6	145283.33	28827.508	174110.838	138094.762	132,405.65	73,839.99	58565.66
10	312205.6	145283.33	28827.508	174110.838	138094.762	120,368.77	67,127.27	53241.51
					Sum	1,918,368.26	1,069,835.73	

1.11 Cash flow for mixed perennial farming system in Cambantoc Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	0	6127.36	1392.75	7520.11	-7520.11	-	6,836.46	-6836.46
2	0	3037.281	0	3037.281	-3037.281	-	2,510.15	-2510.15
3	33191.8	18001.591	0	18001.591	15190.209	24,937.49	13,524.86	11412.63
4	33191.8	18001.591	0	18001.591	15190.209	22,670.45	12,295.33	10375.12
5	33191.8	18001.591	0	18001.591	15190.209	20,609.50	11,177.57	9431.92
6	33191.8	18001.591	0	18001.591	15190.209	18,735.91	10,161.43	8574.48
7	33191.8	18001.591	0	18001.591	15190.209	17,032.64	9,237.66	7794.98
8	33191.8	18001.591	0	18001.591	15190.209	15,484.22	8,397.88	7086.34
9	33191.8	18001.591	0	18001.591	15190.209	14,076.56	7,634.43	6442.13
10	33191.8	18001.591	0	18001.591	15190.209	12,796.88	6,940.39	5856.48
					Sum	146,343.64	88,716.17	

1.12 Cash flow for monocrop perennial farming system in Cambantoc Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	0	4775	1392.75	6167.75	-6167.75	-	5,607.05	-5607.05
2	0	3000	0	3000	-3000	-	2,479.34	-2479.34
3	17750	12075	0	12075	5675	13,335.84	9,072.13	4263.71
4	17750	12075	0	12075	5675	12,123.49	8,247.39	3876.10
5	17750	12075	0	12075	5675	11,021.35	7,497.62	3523.73
6	17750	12075	0	12075	5675	10,019.41	6,816.02	3203.39
7	17750	12075	0	12075	5675	9,108.56	6,196.38	2912.17
8	17750	12075	0	12075	5675	8,280.51	5,633.08	2647.43
9	17750	12075	0	12075	5675	7,527.73	5,120.98	2406.75
10	17750	12075	0	12075	5675	6,843.39	4,655.44	2187.96
					Sum	78,260.28	61,325.42	

1.13 Cash flow for agroforestry system in Cambantoc Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	36581.94	19175.155	21644.869	40820.024	-4238.084	33,256.31	37,109.11	-3852.80
2	36581.94	18382.222	13515.574	31897.796	4684.144	30,233.01	26,361.81	3871.19
3	54736.6	22758.412	13515.574	36273.986	18462.614	41,124.42	27,253.18	13871.24
4	54736.6	22758.412	13515.574	36273.986	18462.614	37,385.83	24,775.62	12610.21
5	54736.6	22758.412	13515.574	36273.986	18462.614	33,987.12	22,523.29	11463.83
6	54736.6	22758.412	13515.574	36273.986	18462.614	30,897.38	20,475.72	10421.66
7	54736.6	22758.412	13515.574	36273.986	18462.614	28,088.53	18,614.29	9474.24
8	54736.6	22758.412	13515.574	36273.986	18462.614	25,535.03	16,922.08	8612.95
9	54736.6	22758.412	13515.574	36273.986	18462.614	23,213.66	15,383.71	7829.95
10	54736.6	22758.412	13515.574	36273.986	18462.614	21,103.33	13,985.19	7118.14
					Sum	304,824.62	223,404.02	

1.14 Cash flow for pineapple monoculture in Silang-Santa Rosa Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	0	28120.83	59969.753	88090.583	-88,090.58	-	80,082.35	-80082.35
2	587750	19048.509		88090.583	499,659.42	485,743.80	72,802.13	412941.67
3	0	28120.83	59969.753	88090.583	-88,090.58	-	66,183.76	-66183.76
4	587750	19048.509		88090.583	499,659.42	401,441.16	60,167.05	341274.10
5	0	28120.83	59969.753	88090.583	-88,090.58	-	54,697.32	-54697.32
6	587750	19048.509		88090.583	499,659.42	331,769.55	49,724.84	282044.71
7	0	28120.83	59969.753	88090.583	-88,090.58	-	45,204.40	-45204.40
8	587750	19048.509		88090.583	499,659.42	274,189.71	41,094.91	233094.81
9	0	28120.83	59969.753	88090.583	-88,090.58	-	37,359.01	-37359.01
10	587750	19048.509		88090.583	499,659.42	226,603.07	33,962.73	192640.34
					Sum	1,719,747.29	541,278.50	

1.15 Cash flow for mixed perennial farming system in Silang-Santa Rosa Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1		14500	9766.667	24266.667	-24266.667	-	22,060.61	-22060.61
2		4400		4400	-4400	-	3,636.36	-3636.36
3	25450	12200		12200	13250	19,120.96	9,166.04	9954.92
4	25450	12200		12200	13250	17,382.69	8,332.76	9049.93
5	25450	12200		12200	13250	15,802.45	7,575.24	8227.21
6	25450	12200		12200	13250	14,365.86	6,886.58	7479.28
7	25450	12200		12200	13250	13,059.87	6,260.53	6799.35
8	25450	12200		12200	13250	11,872.61	5,691.39	6181.22
9	25450	12200		12200	13250	10,793.28	5,173.99	5619.29
10	25450	12200		12200	13250	9,812.08	4,703.63	5108.45
					Sum	112,209.81	79,487.13	

1.16 Cash flow for agroforestry system in Silang-Santa Rosa Subwatershed

Year	Benefit	Labor	Inputs	Total	Net Benefits	PVB	PVC	PV NB
1	5,109.29	35,299.44	39,545.53	74844.9709	-69735.6849	4,644.81	68,040.88	-63396.08
2	5,109.29	28,002.25	2,219.43	30221.6783	-25112.3923	4,222.55	24,976.59	-20754.04
3	26,835.31	42,181.22	36,400.52	78581.7403	-51746.4343	20,161.76	59,039.62	-38877.86
4	372,987.31	35,801.69	2,219.43	38021.1183	334966.1877	254,755.35	25,968.94	228786.41
5	26,835.31	42,181.22	36,400.52	78581.7403	-51746.4343	16,662.61	48,793.08	-32130.46
6	372,987.31	35,801.69	2,219.43	38021.1183	334966.1877	210,541.61	21,461.93	189079.68
7	26,835.31	42,181.22	36,400.52	78581.7403	-51746.4343	13,770.76	40,324.86	-26554.10
8	372,987.31	35,801.69	2,219.43	38021.1183	334966.1877	174,001.33	17,737.13	156264.20
9	26,835.31	42,181.22	36,400.52	78581.7403	-51746.4343	11,380.79	33,326.33	-21945.54
10	372,987.31	35,801.69	2,219.43	38021.1183	334966.1877	143,802.75	14,658.79	129143.97
					Sum	853,944.32	354,328.15	

Appendix 2: Guidelines for Establishing Payment for Forest Ecosystem Services: The Case of Silang-Sta. Rosa and Cambantoc-Bay Subwatersheds Experience

C.D. Predo, J. Kawasaki, R. Legaspi, D.B. Macandog, J. Brian, and I. Endo

Introduction

Forest degradation is one of the major threats in the developing countries of the Southeast Asian region. And among the common determinants on forest degradation is human impact. It has been reported by the United Nations that the human population had currently reached 7.6 billion and is projected to reach 9.8 billion in 2050 and 11.2 billion in 2100 (United Nations, 2017). But even if some countries have slower population growth and lower fertility rates, it is still expected for the upward trend of the global population growth to continue, having 83 million people are being added every year. This increasing population rate puts significant threat to the environment and considerable challenges for the resource and environmental management, as the level of consumption of the growing population is higher than the recovery of the resources to be provided (Sterner, 2003).

In the Philippines, there is a "relatively high" population growth rate of the poor in which this accounts for 20 million people that resides in the upland areas or public forestlands (Fortenbacher & Alave, 2014). Meanwhile, the continued increase of the upland population in the public forestlands of the country has been one of the elements that resulted to the decreasing forest resources (Fortenbacher and Alave 2014; Rebugio, et al. 2007). As it is positively correlated to increased demand for food, and in turn will cause for more forested areas to be cleared for subsistence farming or agricultural expansion (Grainger 1993; Carandang, et al. 2013). Other than that, as population increases, more lands are needed for the establishment of residential areas. Notwithstanding that outsiders are buying lands in the upstream areas and converting them into other land uses. These further results to forest degradation as capacity of the forest to supply goods and services are reduced due to the negative changes within the forest.

One of the areas in the Philippines that experiences rapid land use conversion and forest degradation problem is the Silang- Santa Rosa Subwatershed. Based on the study of Magcale-Macandog, et al. 2015, the subwatershed has been experiencing rapid land conversion since 1990s. Projections in their study showed that based on the increasing rates of land use change in the area, the mix scrub and broadleaf forest in the upland area of the subwatershed will decrease by 80.89% from 2014 to 2025 if current trends continue, as it will be soon converted to built-up areas. Mismanagement in the uplands brought about by rapid land use change and high forest degradation leads to the deforestation, as a permanent environmental problem. Instances of these activities include: shifting land cultivation, land use conversion, unsustainable upland farming, and etc. These in turn impair the ecosystem services, and eventually leading to externalities as the real cost—which is high flooding risk in the case of the Silang-Santa Rosa Subwatershed. Based on the vulnerability assessment of the subwatershed by Magcale-Macandog, Gunay, & Bragais, 2017, there are high volumes of surface flow in the downstream and midstream areas along the riverine system during medium to heavy rains and typhoons. Increase in affected barangays due to flooding since year 2008-2012 are also observed (Magcale-Macandog, et al., 2015). Aside from the voluminous run-off coming from the upstream areas, flooding in the downstream areas is aggravated by lake water level rise affecting households near the coastal areas.

As established, increased risk of flooding in the downstream areas of the subwatershed is the side effect of the high occurrence of deforestation, forest degradation and land conversion in the upstream areas. This is primarily due to the underappreciated market value of the forest ecosystem services as the forest is often seen primarily as free public good. According to Sterner 2003, these services tend to be undersupplied by the market for it is difficult to exclude who do not pay. With that, such policy instrument is needed in order to establish a stable market for the flood mitigation service in the subwatershed, which in turn will result to appropriate conservation measures for the sustainable provision of the ecosystem service. Payment for Forest Ecosystem Services (PFES) is among the appropriate tools in conservation and environmental management that realigns the private and social benefits. This is based on a concept that those who benefits from the ecosystem service should make payments to the providers of it (Fripp, 2014). In the case of the Silang-Santa Rosa Subwatershed, the downstream households are the beneficiaries of the ecosystem service and they should compensate the farmers for adopting a sustainable forest/land measures that will result to improved provision of flood mitigation service. As the farmers' adoption of sustainable measures will incur them some loss of income, it is important that the payments from the downstream are higher than the costs of providing the ecosystem service; while the downstream households' payment for the ecosystem service received should be lower than the damage cost that will be incurred without such environmental intervention. Meanwhile, funds generated from the downstream areas will be used in the development and management of the forest and agroforest in the uplands to sustain the ecosystem service provision and the integrity of the subwatershed.

With the current market failure, deforestation and forest degradation and flooding problem in the Philippines, the project entitled, "Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand" aimed to strategically generate scientific knowledge in the process of designing effective payment for forest ecosystem services (PFES) based on its detailed contexts. This is a collaborative project between the Institute of Global Environmental Strategies (IGES) and the University of the Philippines Los Baños (UPLB) aiming to target conservation and to mitigate the high flooding scenarios on selected areas in the country's component. As one of the outputs of the project, this implementation guideline was written drawing from the experiences, lessons and results of the project.

Objectives

This document is written to serve as a reference for interested organizations in setting up PFES scheme in a watershed setting within the Philippines and in other countries of Southeast Asia, in order to address the existing forest degradation and climate change impacts. More specifically, the following objectives are to:

- assess the potential of PFES within the selected area of study;
- explore the detailed contexts and arrangements in setting up the PFES scheme within the subwatershed level;
- draw important lessons learned in developing PFES scheme based on the experiences from the study.

Conceptual Framework

Related literatures suggest the connection of land management in the uplands that affects the provision of ecosystem services in the downstream areas (Arunyawat and Shrestha, 2016; Rebugio, et. al. 2007). However, with the increase in encroachment in the uplands and land use change, these promote shifts from forested area to agriculture, residential areas and eventually to urban development (Fortenbacher and Alave 2014). With that, deforestation and forest degradation result to decrease in soil infiltration, and eventually, excess water from the upland area of the subwatershed directly fall through the downstream areas leading to flooding.

Farmers, as one of the land owners in the upstream areas of the subwatersheds, can be agents for sustainable land management by adopting nature-based solutions such as tree-based systems or agroforestry. It is viewed that through the adoption of nature-based approaches of the farmers, this will result to sustainable and improved provision of ecosystem service—flood mitigation service. Such current land-use of farmer is affected by socio-economic, behavioural and farm characteristics. Moreover, institutional and policy factors such as land tenure and market are among the underlying factors that also affect the land use systems applied by the farmers. Opportunity cost in shifting from current farming system to nature-based approach was determined. The forgone income of the producers of ecosystem services will then be used as a baseline on the application of nature-based approach as a farming system. This will result to sustainable land management of the forest and agroforest ecosystem, through the Payment for Ecosystem scheme, and this eventually lead to the improved flood mitigation service of the forest and agroforest ecosystem in the long run.

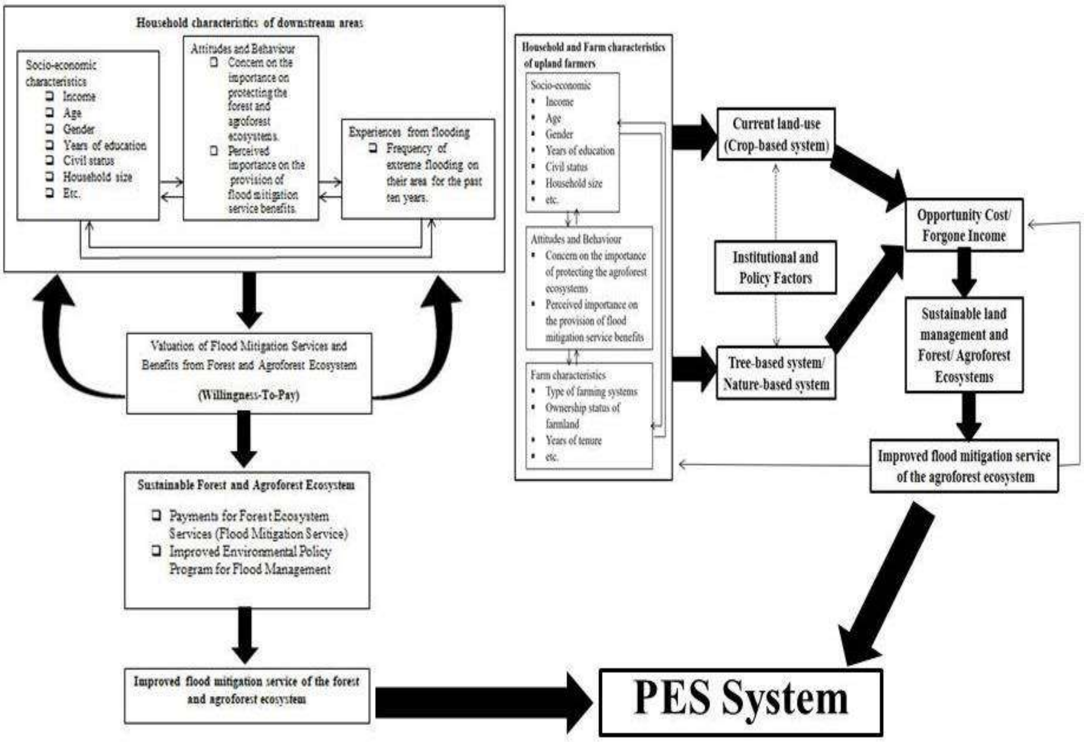

Figure 1. Conceptual Framework of the PES System

Methodology

According to Lawton (2013), identifying the potential of PES in an area should be a prioritized activity in setting up a fully operational PES scheme. Researches involved in the project correspond to determine the feasibility of implementation. This guide summarizes the five portions incorporating the steps involved in the identification of the feasibility of PFES, which some are also based on the study of Fripp (2014) and drawing from the lessons in the project. Among these are as follows:

A. Ecosystem Service

Step 1. Determine the ecosystem service

Objectives:

- To specifically identify and define the ecosystem service that should be bought and sold

- To acquire an overview of the current environmental problem and causes of environmental threats

Key Actors:

- IGES Project Leader
- UPLB Research Team
- City/Municipal Environment and Natural Resources Office staff (CENRO/MENRO)

Process:

- Courtesy call and Gathering secondary data

LGUs must be informed first regarding the activities that will be done in the area, as they will be involved in the data gathering process and establishment of the PES scheme. While one of the vital requirements in designing the PFES scheme is clearly identifying the ecosystem service that should be bought or sold, the service should be specific as different ecosystem service requires a specific valuation method that will be crucial in performing the future tasks related in the PFES design. Related researches and studies can provide information that can be useful in identifying the ecosystem service. However, it is also apparent in most cases that an ecosystem service to be chosen should be the emergence of the current environmental problem is (Fripp, 2014). Mostly, the defined threat to the ecosystem service is the specific cause that links to the degradation of the ecosystem service.

- Conducting ocular visits and primary interview with City/Municipal Environment and Natural Resources Office (CENRO/MENRO)

This activity serves as a cross-reference to the identified ecosystem service and its related environmental problem, by visiting the area and interviewing the municipal staffs who are knowledgeable in terms of the problem occurrence and its drivers and pressures.

In the case of the Silang-Santa Rosa Subwatershed, high flooding occurrences is the identified problem in the downstream areas of the subwatershed (Santa Rosa), in which it is linked with forest degradation and deforestation and land use conversion in the uplands of Silang, as mentioned in the study of Magcale-Macandog 2015 and Magcale-Macandog, Gunay and Bragais 2017. The link of forest degradation and deforestation to impairment of flood mitigation service was further strengthened as the CENRO of Santa Rosa was interviewed regarding the cause of flooding in their area.

Expected Results:

- Research problem will be well-defined and clear, and the research team will be confident that such environmental problem exists and really affects the provision of a specified ecosystem service.
- The specified ecosystem service can be assessed for its potential for the inclusion in the PFES scheme, or whether the PFES scheme is really suitable measure for the situation in the area.
- The research can have a direction in identifying possible measures that can be incorporated for the PFES scheme in order to address the environmental problem.

Step 2. Boundaries should be clearly set

Objectives:

- To acquire a well-defined direct link between the cause and effect of the provision of the ecosystem service
- To assess and determine the geographic boundaries and the market ecosystem and its actors that should be covered by the PFES scheme

Key Actors:

- IGES Project Leader
- IGES Research Team (with expertise in GIS)
- UPLB Research Team

Process:

- Evaluation of the geographic boundary, the market ecosystem and its actors

The geographic boundaries for the scheme should be clearly identified, as to prevent the mechanism for having the risk of leakage wherein it can benefit a certain area, however can damage the other areas. This also includes the identification of the possible sellers and buyers of the ecosystem service covered in the market ecosystem.

- Conduct or research a study on whether the environmental problem can be really addressed using the mechanism that will be employed in the market scheme of PFES

In PFES, the buyers will pay for the improved ecosystem service they receive while the sellers of the ecosystem service will adapt sustainable land management for the continuous production of the resources. As there is a clear evaluation on the cause and effect of the measure that will be applied for the improvement of the ecosystem service, the buyers of the ecosystem service will participate knowing that the changes in the environment through the mechanism will really provide the desired benefit. The scientific basis for the measure should be realistic so as to attract the buyers. The study of Johnson *et al (personal communication)* provides the researchers of the project a basis that if the forest cover will increase through forest rehabilitation or adoption of agroforestry system will yield to a maximum of 20% flood reduction downstream.

Expected Results:

- Scientific basis on the linkage between the environmental problem and the ecosystem service
- Credible mechanism that can have high probability of being effective, and be a reference in the sustainable methods that will be used in the PFES.
- Delineated Topographical Map of the Area of Study

B. Access on the market and its actors

Step 3a. Determine the economic value of the ecosystem service through valuation in the downstream area (buyers), and generate other relevant information

Objectives:

- To estimate the willingness-to-pay values of the downstream households for the improved provision of flood mitigating service of forest and agroforest ecosystem
- To assess the factors that affect the willingness-to-pay of the downstream households for the improved flood mitigation service
- To determine the awareness and perceptions of the downstream households (buyers) about forest and agroforest ecosystem services provided by the subwatershed
- To draw policy implications related to development of PFES in the sub-watershed

Key Actors:

- IGES Project Leader
- UPLB Research Team

- Downstream households of Santa Rosa City

Process:

- Designing of Survey Instrument
- Courtesy Call
- Pre-Testing of Survey Instrument
- Data collection
- Data Encoding, Analysis and Research Writing

Expected Results:

- Baseline information regarding the current state of the environmental problem in the downstream part of the subwatershed and the factors that determine their willingness to pay.
- Willingness to pay estimates and other specifications of the downstream households that will serve as a reference in the payment scheme of the ecosystem service

Step 3b. Determine the forgone income of the sellers on adopting Nature-based Solutions for the improvement of ecosystem service in the upstream

Objectives:

- To estimate the forgone income values of the farmers in the upstream for Nature-based Solutions that will result to the improved provision of flood mitigating service of forest and agroforest ecosystem
- Assess the factors influencing the decision of farmers in adopting nature-based approach for sustainable farming
- To analyse the ownership status and use rights of the ecosystem service or land where the ecosystem service is produced
- To acquire an overview of the land use systems where the ecosystem service is produced
- To draw policy and implications for the enhancement of the PFES scheme related to improvement and application of sustainable farming system in the degraded uplands in order to achieve sustainability

Key Actors:

- IGES Project Leader

- UPLB Research Team
- Upstream households of Silang, Cavite

Process:

- Designing of Survey Instrument
- Courtesy Call
- Pre-Testing of Survey Instrument
- Data collection
- Data Encoding, Analysis and Research Writing

Expected Results:

- Baseline information regarding the current state of the upstream part of the subwatershed.
- Forgone income of the farmers that will serve as a baseline information in substitute of the willingness to accept value of the ecosystem service

Step 4a. Identify the market access and conditionality

Objectives:

- To determine the appropriate market mechanisms and transaction infrastructure for the PES scheme. (Includes payment vehicles, organization that will manage the funds, etc.)
- To determine and assess the rules needed to be adhered by the buyers and sellers of the ecosystem service for the sustainable provision of ecosystem service.
- To identify a mechanism that will be able to achieve the monitoring, reporting and verification (MRV) requirements.

Key Actors:

- IGES Project Leader
- UPLB Research Team
- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Conduct workshop and forums with the LGUs of the upstream and downstream areas of the subwatershed.

Information from the researches regarding market actors (buyers and sellers of the ecosystem service) must be presented to the LGUs. As the research study has provided the information regarding the suggested payment vehicle and organizations that will manage the funds, it is also crucial for the LGUs to assess and decide if these will be acceptable, efficient and effective on their part of implementation.

- Identifying the conditionality and the MRV process that should be adhered.

The conditionality refers to the rules of land use management and provision of ecosystem service within the involved actors. This can also involve such rules on transaction costs, which must be cleared by both of the parties. Monitoring Reporting and Verification (MRV) mechanism must also be crafted through the arrangements between the LGUs of the upstream and downstream areas, including also if transaction costs will be necessary. This should determine if the sellers are meeting the desired scenario on the environment for the improvement of the ecosystem service provision. Moreover, MRV is also done to determine if the payment can cover all the cost incurred by the sellers. In the implementation through time, MRV will be crucial in identifying if the goals and objectives of the PES are achieved and whether there is a need for additionality of the ecosystem service.

Expected Results:

- Specifications on the PES scheme are identified in-detailed including its possible pros and cons.
- The LGUs will become knowledgeable in terms of PES implementation.
- Assessed MRV requirements and process

C. Governance and institutional systems

Step 5. Identify and assess the governance arrangement of the ecosystem service

Objectives:

- To determine the implications on the governance of the resource in the household level to municipality level, and the market itself
- To assess the possible risks on the governance arrangement
- To draw recommendations on possible governance arrangement on the PES system

Key Actors:

- Third party knowledge providers
- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Conduct workshop and forums with the LGUs and other relevant agencies of the upstream and downstream areas of the subwatershed for the arrangement of the governance of the PES system.

It is indeed important to identify the intricacies in managing the PES system. This includes first on identifying the governance relationships of the actors within the boundary of the PES setting. Though the barangays included within the boundary has been identified in the two studies, it should be set clearly among the LGUs from the barangay to municipal levels and the organization on their roles, duties and responsibilities in the PES system. Moreover, to avoid conflict, existing laws that govern the natural resources must be compatible with the PES system also. Coordination between the organizations of the sellers and buyers is also crucial in the systematic, efficient and effective way of managing the system. While it must be also ensured that the shifting of the governance will not affect the management of the resource.

The organization that will administrate the sellers should have a sufficient capacity to manage and sell the environmental service. In this step, such capacity building is needed to intricately identify the procedures in administration and management of the PES. Instances of this include: the involvement of staff and responsibilities in managing the funds. Some more detailed queries needed to be addressed in managing the funds are: (1) the organization who will manage; (2) ways of managing the funds (Is bank account needed? How do the payments will be disbursed?).

Expected Results:

- Specifications on the governance arrangements of PES system are identified in-detailed including its possible pros and cons.
- People's organization or co-management between stakeholders in the PES system is crafted to promote the sustainability of the system and the active social movement of the actors
- The LGUs will become knowledgeable in terms of the management in PES.
- Assessed governance framework on PES implementation

D. Baseline Data

Step 6. Conceptualization of business-as-usual and with project scenarios

Objectives:

- To provide factual basis on the different scenarios that will serve as an outline in the track of MRV process
- To strengthen the capacity of the governance of PES with regards to awareness on the PES system and the involvement of decision making

Key Actors:

- Third party knowledge providers (research group or NGOs)
- People's organization of the PES system
- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Conceptualization and preparation for data collection for baseline data

Baseline is referred to the current scenario without the intervention of the PES scheme. This step is crucial as it is a prerequisite of all PES projects (Fripp, 2014). Studies on this will serve as a factual basis on comparing the scenarios on the projections in the absence of the scheme (business-as-usual) and on the forecast outcome of the PES scheme. With the baseline projection, the PES managers will have an idea on the extent of seriousness of the ecosystem degradation without the interventions from the PES. Moreover, this can also serve as an outline in tracking whether the scheme really increases or decreases the ecosystem service provision.

Meanwhile, in terms of preparation for the data collection, indicators that are needed to be estimated must be identified. Indicators should also base on the MRV requirements. Among the variables should include attributes from social, economic and environmental components as these are the pillars of sustainable development being one of the targets of the project.

Expected Results:

- Knowledge on the baseline and its indicators needed to be measured
- The POs and other relevant agencies will have the capacity in managing the PES system by acquiring knowledge on the intricacies of PES system and its processes
- Detailed MRV requirements

Step 7. Establishment and modelling of business-as-usual and with project scenarios

Objectives:

- To determine the baseline by data collection on the indicators required in the MRV
- To assess the risks, pros and cons of the projections on the different scenario (business as usual and with project scenario)
- To strengthen the capacity of the governance of PES with regards to awareness on the PES system and the involvement of decision making

Key Actors:

- Third party knowledge providers
- People's organization of the PES system
- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Conduct studies on measuring the baseline data

This will require the expertise from the knowledge providers. They should be able to identify the primary evidence and project it to different scenarios (with and without intervention). Moreover, the data needed should also be based on the MRV process.

- Design monitoring and verification methods

The result of the baseline study must be presented to the POs, relevant agencies and LGUs of the upstream and downstream areas of the subwatershed.

Expected Results:

- Factual basis on the different scenarios which serves as crucial information for decision-making process with regards to the PES system and MRV process in the area
- The POs and other relevant agencies will have the increased capacity in managing the PES system
- Strengthened involvement and commitment of the local community and other relevant agencies in the long-term provision of the ecosystem service

E. Credibility, assurance and sustainability

Step 8. Facilitate MRV and requirements for the communities and other relevant agencies of the PES system

Objectives:

- To analyse whether the ecosystem services are being delivered and enhanced through the PES system intervention
- To assess if there are externalities in the PES system
- To evaluate if the requirements, goals and objectives of the PES system are being achieved
- To strengthen the capacity of the governance of PES with regards to awareness on the PES system and the involvement of decision making

Key Actors:

- Third party knowledge providers (research group or NGOs)
- People's organization of the PES system
- Upstream and Downstream communities

- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Monitoring

Regular measurements should be done based on the agreed indicators. As the baseline has been established, trends on the provision of the ecosystem service in the implementation can be compared to the baseline (Lawton, 2013). This is to monitor the deviations from the changes anticipated on the provision of ecosystem service and to the promised benefits to the communities.

- Reporting

The reporting should also be done in a regular basis so as to provide insights on the experiences on implementation. With this, it can provide useful information on the decision making process in solving the drawbacks and enhancing the parts where the PES system is good at. Moreover, this could also serve as a reference or process documentation on the implementation of PES in other areas, in order for the technology to be developed through time. If the communities involved are under the management paradigm of *Community Based Natural Resources Management* in the PES system, it is crucial that they are also involved in the reporting process, with the aid of the knowledge providers and relevant organizations. This is to ensure the active participation and empowerment of the communities and the long-term sustainability of the PES system in their area.

- Verification

The verification involves assessment of the ecosystem services delivery mechanisms to ensure credibility of the PES system. This requires third party verifier for transparency purposes.

Expected Results:

- Detailed MRV documentation and processes
- The POs and other relevant agencies will have the capacity and be empowered in managing the PES system by acquiring knowledge on the intricacies of PES system and its processes
- Active participation of different actors in the PES system

- Ensured temporal relationships among the actors of the PES system for the sustainability of the provision and appropriate land use management

Step 9. Develop pro-poor benefit-sharing mechanisms

Objectives:

- To assess whether equitable sharing of the environmental, social and financial gains of the provision of ecosystem service is ensured
- To assess whether the PES system can consider multiple benefits

Key Actors:

- Third party knowledge providers (research group or NGOs)
- People's organization of the PES system
- Upstream and Downstream communities
- LGUs of the upstream subwatershed
- LGUs of the downstream subwatershed

Process:

- Courtesy call
- Monitoring
- Reporting
- Verification
- Assess the prospect for multiple-benefit of PES

It is the quantification of other environmental benefits if it is feasible to be bundled or layered. This can be done and assessed by the knowledge providers, with the help of various actors in the PES system.

Expected Results:

- Knowledge on the baseline and its indicators needed to be measured
- The POs and other relevant agencies will have the capacity in managing the PES system by acquiring knowledge on the intricacies of PES system and its processes

- Detailed MRV requirements

Lessons Learnt from the Case Study

There are already existing guidebooks in the literature describing the requirements and processes involved in setting up the scheme for payment for forest ecosystem services as one innovative financing mechanism in addressing failures in environmental management and to achieve sustainable forest management. The practical guidelines developed by Fripp (2014) aims to facilitate the identification and implementation of PES at any level from community to district to national up to international level. It takes the user through 10 practical steps to identify and assess the feasibility of establishing PES projects. Alternative guides are available for full implementation of a PES scheme. An example is the practice guide developed by Smith *et al*. (2013), which covers the design and implementation of PES schemes.

Keeping the existing guidebooks in mind, the guidelines provided here are based on actual experience in conducting the valuation study in support of designing and implementing PES scheme in the area. This study was not intended for designing and implementing the actual PES. Therefore, the following lessons are put forward in the context of the requirements and processes in the economic valuation part of the entire PES design.

- It is important to inform the key decision makers at the local government units and other stakeholders in the community about the study to establish rapport and cooperation in all aspects of the study. A short presentation on the objectives and expected outputs needs to be discussed in a local forum to solicit suggestions and active engagement of various stakeholders.
- At the outset, avoid false hopes and expectations what the project or study could bring. For example, it should be clear to the different stakeholders that the project is a research understanding, and not a development project, to generate knowledge and information about the benefits of flood mitigation t the beneficiaries side and the opportunity cost or foregone income for the ecosystem service providers. This means that design and implementation of PES will come later using the results of the study.
- When sufficient research budget is available, it is important to share the final findings of the study to the different stakeholders, particularly the local government units within the watershed covered in the study.

Based on the lessons learned cited above, a sequel study on the processes and activities during the design and implementation of PES scheme be implemented using the results of the current study as basis for initial discussion. The second phase of the study should also document and assess the transaction costs associated in setting up the entire PES scheme.

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Effective Models for Payment Mechanisms for Forest Ecosystem Services in Madang Province in PNG

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1. Introduction

Papua New Guinea (PNG) is blessed with a large expanse of natural forest rich in biodiversity that provides a wide array of ecosystem services of global, national and local significance. Despite their environmental values, in many areas PNG's forests have not been managed well and the total area of forest is declining. Successive governments have focused their policies on acquiring the rights to natural resource development from local communities (the customary landowners) and making these available to corporate interests for development. Concessions have become the main instrument of forest management by which forests are exploited for their timber. While the forest regulatory framework has been strengthened to incorporate the concept of sustainability, weak enforcement has resulted in widespread forest degradation. In recent years, large areas of forest have also been converted for agricultural developments, especially for oil palm, and the area exposed to shifting agriculture has increased as a result of rapid population growth. Given that the drivers underlying deforestation and forest degradation in the coming years are unlikely to wane, without incentive mechanisms for forest conservation and sustainable forest management PNG will continue to lose its forests.

The APN research project "Effective Models for Payment Mechanisms for Forest Ecosystem Services in Papua New Guinea, Philippines and Thailand" aimed to generate knowledge on how payments for forest ecosystem services (PFES) could contribute to forest conservation in areas where forests are facing increasing pressures. The objectives of the APN research project were 1. Identify a cost-effective and scientifically robust method to assess ecosystem services; 2. Identify the steps necessary to establish the institutional framework and activity for generating the ecosystem services; 3. Compare and contrast pricing and payment options, both voluntary and compulsory, based on the scientific quantification and valuation of forest ecosystem services; and 4. Strengthen capacity of the stakeholders for the identification, assessment and delivery of forest ecosystem services.

Payment for carbon storage and certified sustainable timber in community-managed forest in PNG was identified as one of three project case studies. To develop the case study, a team of researchers from the Institute for Global Environmental Strategies (IGES), the Foundation for People and Community Development (FPCD) and Papua New Guinea Forest Research Institute (PNG-FRI) was formed. With agreement from the customary landowners, the research team selected Ugalingu forest in Madang Province as the case study site

The activities set for the APN research project were 1. Assess the selected forest ecosystem services and its economic values; 2. Assess policies, laws, strategies and institutions for generating ecosystem services; and 3. Analyze transaction costs and options payment for PFES. The research project in PNG focused mostly on Activity 1, which proved to be especially complex, but also made progress on Activities 2 and 3.

To assess the selected forest ecosystem services and its economic values, the research project developed a case study with one clan, Ugalingu, who reside in Koromosarik next to the Sogeram River in Madang province. Ugalingu are a relatively small clan of just over 100 people and are the customary owners of 1,400 ha of mostly pristine low hill rainforest. This report explains the methodology applied, presents the results, provides a conclusion and presents recommendations for PFES in PNG, including for further analysis and development at the case study site.

2. Methodology

2.1) Activity 1 Assess the selected forest ecosystem services and its economic values

The research estimated net greenhouse gas emissions, measured in tonnes (t) (megagrams) carbon dioxide equivalent (CO2e), that could be avoided by protecting Ugalingu forest from a large-scale logging operation. The research did not analyze ecosystem services associated with certified community forestry as initially proposed, as FPCD's Certified Community Forestry program was inactive at the time of the research. In addition to its own primary data, the research project utilized data and information generated from previous support projects to Ugalingu on forest management implemented by FPCD and IGES.

A robust carbon accounting methodology is needed to generate tradeable emission offsets for PFES. Different carbon schemes have different methodological requirements, so the first step in developing a methodology for the case study site was to identify forest carbon schemes appropriate to the site. Two carbon schemes were assessed – the Verified Carbon Standard (VCS) and Plan Vivo. VCS is the world's largest voluntary carbon scheme and is well-recognized by the market. Under the VCS, methodologies are approved separately from project design and undergo an expert review process. The VCS has approved methodologies that can be applied to new projects, so long as these projects meet the eligibility criteria set by the methodologies. In contrast, Plan Vivo was developed especially for community-managed forest carbon projects. It requires project developers to develop their own methodologies following good practice, such as that set by the Intergovernmental Panel on Climate Change (IPCC), VCS and the Clean Development Mechanism (CDM). As Plan Vivo does not have approved methodologies that new projects can apply, the research team decided to use existing VCS approved methodologies as a basic reference for the analysis.

VCS methodologies and their criteria were assessed in terms of the eligibility of the case study site. The case study site was found to be eligible to apply three methodologies –VM0010 and VM0011, which are improved forest management (IFM) methodologies, and VM0007, which is a reducing emissions from deforestation and forest degradation (REDD) methodology (Table 1). VM0010 was selected to estimate net emissions from all aspects of the anticipated logging operation bar the deforestation resulting from road construction. VM0010 was preferred over VM0011, as it has been applied to more projects and is less restrictive. VM0007 was selected to estimate emissions from deforestation associated with the construction of logging roads.

Table 1. Assessment of case study site against VCS methodology criteria

VCS methodology	Criteria	Evaluation
VM007 REDD methodology framework	Either converted to non-forest or tree plantation, or not converted but degraded by fuelwood or charcoal production extraction	Eligible, but only for deforested areas
VM0009 Avoided deforestation	For conversion to non-forest. End land use is non-forest	Eligible, but only for deforested areas

VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest	Logging was planned: legal right to harvest and intent to harvest must be demonstrated. The legal right to harvest must pre-exist the implementation of the project. In project scenario, forest use must be limited to activities that do not result in commercial timber harvesting or forest degradation.	Eligible
VM0011 Methodology for Improved Forest Management - Logged to Protected Forest: Calculating GHG Benefits from Preventing Planned Degradation	Provides a procedure to determine the net greenhouse gas (GHG) emission reductions associated with an Improved Forest Management - Logged to Protected Forest (IFM-LtPF) activity where selective logging is the most likely baseline activity above all other possible land use alternatives	Eligible
VM0015 Avoided unplanned deforestation	Project activity involves avoiding unplanned deforestation with mosaic or frontier configuration. Baseline activities that may be displaced by the project activity include logging, fuel-wood collection and charcoal production, agriculture and grazing	Not eligible

VM0010 provides a detailed procedure to estimate the net GHG emission reductions/removals resulting from the implementation of projects aimed at the protection of forests that would be logged in the absence of a carbon project. The core methodological components of VM0010 are presented in (Box 1).

Box 1. Core methodological components of VM0010

• **Determine Eligibility**: Sets the criteria for eligibility of projects under the methodology

• **Set Project Boundaries and Scope**: Provides guidelines for defining the geographical and temporal boundaries of the project and lists the GHG emissions sources and carbon pools to be included in the project

• Assess **Baseline Scenario**, **Additionality** and **Baseline Modelling**: Provides guidelines to select the most conservative baseline scenario and to determine the additionality of the project

• **Quantify Baseline Emissions**: Provides procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks as a result of planned timber harvest in the baseline scenario

• **Quantify Project Emissions**: Provides the detailed procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks in the project scenario

• **Quantify Leakage**: Describes the approach to account for leakage arising from the implementation of project activities

• **Quantify Net Emission Reductions**: Provides the approach to determine the amount of net greenhouse gas emission reductions/removals at the end of each year for both the baseline and project scenarios

• **Quantify Verified Carbon Units**: Provides the approach to determine, on the basis of the amount of net greenhouse gas emission reductions/removals, and deductions to account for risk and uncertainty, the amount of Verified Carbon Units (VCUs) that should be credited to the project each year over the project crediting period

• **Perform Ongoing Monitoring**: Provides guidelines for the implementation of a monitoring plan and identifies monitored parameters to assess carbon stock change and disturbance in the project scenario.

The research project applied these methodological components as well as the methodological components of VM0007 only as a general guide, rather than strictly implementing them, because of time constraints. The estimation of net avoided emissions is thus tentative and further work would be required for a validated offset project.

- **Project boundaries**

The VCS methodologies provide guidelines for defining the geographical and temporal boundaries of the project and lists the GHG emissions sources and carbon pools to be included in the project. The geographical boundaries were established through a ground-based survey. Under an earlier support project, an FPCD forester accompanied by clan members had delineated the outer boundaries of the research project area and the boundary between the two land-use zones within this area using a handheld Garmin GPS. This exercise took several days due to the rough terrain. In this initial mapping, straight lines were drawn between waypoints, which did not correctly reflect the boundaries that followed river and stream courses. Under the APN PFES project these boundaries were corrected using GIS and a Landsat image.

- **Stratification**

VM0010 requires stratification to improve the accuracy and precision of carbon stock estimates, if the proposed project area contains different forest types or forests with different carbon density. Stratification was not conducted as Ugalingu forest represents one forest class and there are no large areas of disturbance.

- **Baseline Scenario, Additionality and Baseline Modelling**

Under VM0010, once the baseline scenario of planned timber harvest is demonstrated, the project proponent must determine how to model the baseline management scenario. A historical baseline scenario must be used where data is available, otherwise a common practice baseline scenario must be used. The research selected the common practice baseline approach, as historical records of forest management could not be secured. It developed a basic harvest plan using data from an inventory conducted by FPCD. Following guidance in VM0007, the area of forest that would be cleared to construct roads was estimated using an area near Ugalingu that had been recently logged as a proxy.

- **Merchantable timber volume**

VM0010 requires calculation of merchantable volume of timber per unit area that is potentially available for harvest based on data from field measurements in sample plots. Merchantable trees are defined in the PNG Logging Code of Practice as trees greater than 50 cm diameter at breast height (DBH) or above fluting, and excluding reserved and special trees as prescribed in the Timber Permits and Environmental Plans.

As part of its Certified Community Forestry program FPCD conducted a forestry inventory (hereafter referred to as the "timber inventory") in Ugalingu forest. The inventory followed the requirement set out in s. 47(1,2) of the Forestry Act 1991 for a 1% (by area) systematic sample to determine allowable cuts. In this approach the timber trees assessment is continuous along a stripline. On either side and within 10 m from the stripline all pulpwood size trees (>20 cm DBH) are measured and within 20 m from the stripline, all saw log size trees (>20 cm DBH) are measured.[9]

[9] Dr. Cossey Yosi, pers. comm.s, 04-03-2019

The total area sampled for the timber inventory was 10.1 ha, providing a sampling intensity of 1.16%. Within this area, commercially viable timber species of high value and other forest values of significance were assessed. A total of 315 stems were measured.

This 1% inventory approach differs from that set out in VM0010. VM0010 advocates a sampling approach in which the number of sample plots is not determined by area but by required precision and accuracy of volume estimates. These are set at 15% and 95%, respectively. Brack (2011, p. 71) considers the stripline approach to be inefficient, as the 1% inventory using striplines results in more plots "by orders of magnitude" than required for accurate estimates of overall mean volume. This implies that while the sampling approach used by FPCD differs from that set out in VM0010, it can be expected to generate an estimate of mean timber volume that satisfies VM0010 requirements for precision and accuracy.

The FPCD inventory assessed commercially viable timber species of high value, other forest values of significance and site characteristics. The variables assessed were DBH at above buttress, height at merchantable length, species identification, geology and soil type, forest type, non-timber forest products, topography, hydrology and other attributes. The original data was lost, but summary tables are found in the forest management plan that FPCD prepared for Ugalingu.

Merchantable volume was converted to biomass using data from Eddowes (1977) and the IPCC compilation for Asian rain forest (IPCC, 2006) (see Fox (2010)). When species could not be identified the average value of 0.477 g/cm3 was used as a default, following Fox et al. (2010). The IPCC default of 0.5 (t C (t d.m.)-1) (IPCC, 2006, 3.25) for the carbon fraction of dry matter was used. All C estimates were converted to CO2 using the fraction 44/12.

- **Total carbon stock**

A second inventory (hereafter referred to as the "biomass inventory") was conducted under the APN PFES project to provide a more precise estimate of total carbon stock in forest biomass. Eight 35 X 35 m nested biomass sample plots were established and measured to estimate forest carbon stocks in aboveground living biomass for trees with a diameter at breast height greater than 5 cm. These were in addition to four plots established under an earlier project, bringing the total to twelve 35 X 35 m plots.

In the 35 X 35 m sample plots, all live trees with DBH >5.0 cm were sampled. The research employed a participatory approach to forest sampling (Photo 1). The methods used for organizing and managing survey teams, plot sitting and layout, tree measurement, field sheet design, data recording, quality control and safety are those set out in *Forest Monitoring Manual: FPCD Indigenous Community Forestry Group Certification Scheme Members*, Ver. 1.0, Nov. 2012. This manual was prepared by IGES and FPCD for guiding community forest carbon accounting in Papua New Guinea. Clan members participated in all of the field-based sampling work, including establishing plots and taking and recording measurements.

Photo 1. Biomass sampling with clan members, Ugalingu forest

Aboveground biomass in each tree was estimated as a function of tree parameters using the following allometric developed by Chave et al. (2005) for wet tropical forests and valid for trees with 5-156 cm diameter at breast height:

$$AGLB_i = 0.776\left[p_i D_i{}^2 TH_i\right]^{0.940}$$

Where:

$ABLB_i$ *T*otal above ground living biomass in each tree, kg

p_i Specific gravity of tree *i*, g/cm^3

D_i Diameter at breast height of tree *i*, cm

THi Total height of tree *i*, m

This allometric was developed from a review of 27 published and unpublished data sets covering America, Oceania and Asia, and applies to trees ≥5cm DBH.

For carbon stock estimations, the species values were totaled and expanded to 1 hectare. When expanding plot values to 1 ha values, an adjustment for slope was made in the spreadsheet, as plots on sloping group appear larger when projected on a flat plane.

With information from the first four plots, the total number of plots required to assess forest biomass with an acceptable error was estimated using the following standard formula (Phillip, 1994) for a non-stratified sampling design:

$$n = \frac{CV^2 t^2}{E^2}$$

Where:

N Number of samples

CV Coefficient of variation

T Student's *t* value for a 95% confidence interval at the specified degrees of freedom

E The required precision (15%)

Applying this formula, a total of 12 plots is required (Table 2).

Table 2. Estimation of sample plot number from pilot survey

Plot 1	116.0 t C/ha
Plot 2	97.9 t C/ha
Plot 3	144.2 t C/ha
Plot 4	134.3 t C/ha
No. of plots	4
Mean	123.1 t C/ha
SD	20.5 t C/ha
CV	0.2
DF	3
t-value	3.182
Total no. of sample plots needed (95% CI, 15% E)	**12.4**

Note: Sampling of trees >5 cm DBH using field measurements to estimate total height

To ensure the remaining plots were located without bias and provide good geographical coverage, plot locations were predetermined using a GIS software package (QGIS ver. 3.2.1). Plots were located at set intervals using a grid pattern with a random start (Figure 1). Geographic coordinates from the GIS were entered into handheld Garmin GPS, which were used by the field survey teams to identify the start point of each plot.

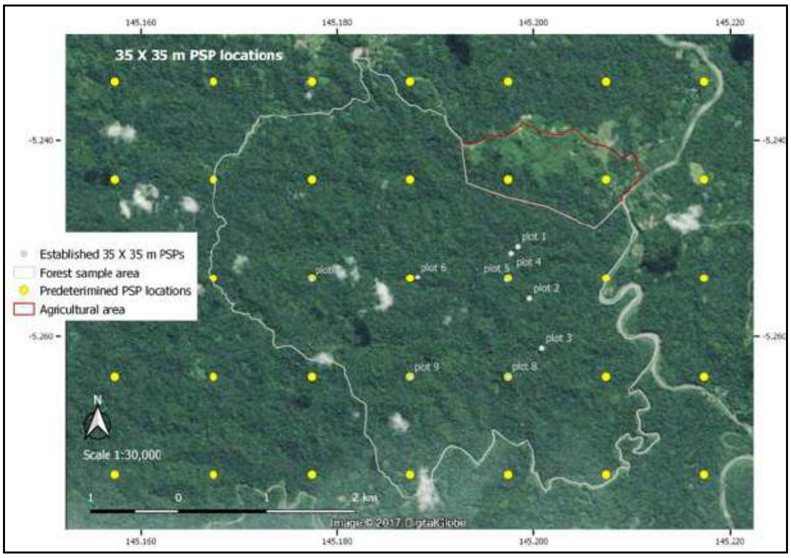

Figure 1. Biomass plot locations

Survey teams were organized in accordance with the guidance in the Forest Monitoring Manual. Plot information was recorded on a set of prepared field sheets by either foresters/researchers or literate clan members. In addition to tree measurements, site data on plot location, altitude, slope, aspect, slope position and disturbance were recorded. The contents of each field sheet were checked at the closing of each plot survey. The data was later entered into a spreadsheet and checked for anomalies by IGES researchers. The original spreadsheet is from Winrock International and is their intellectual property. Adjustments were made to this spreadsheet, including the addition of species-specific look-up tables for wood density and merchantable height.[10]

A nested sample plot design was used to increase cost efficiency (Figure 2). As the natural diameter class distribution in a natural forest has an inverse J shaped curve, and as most of the stand basal area is contained in the few large trees, the nested sample design has a wider sampling area to cover the few large trees with decreasing sample areas for the lower diameter class ranges.

[10] The elaborated spreadsheet was kindly provided by Dr. Julian Fox.

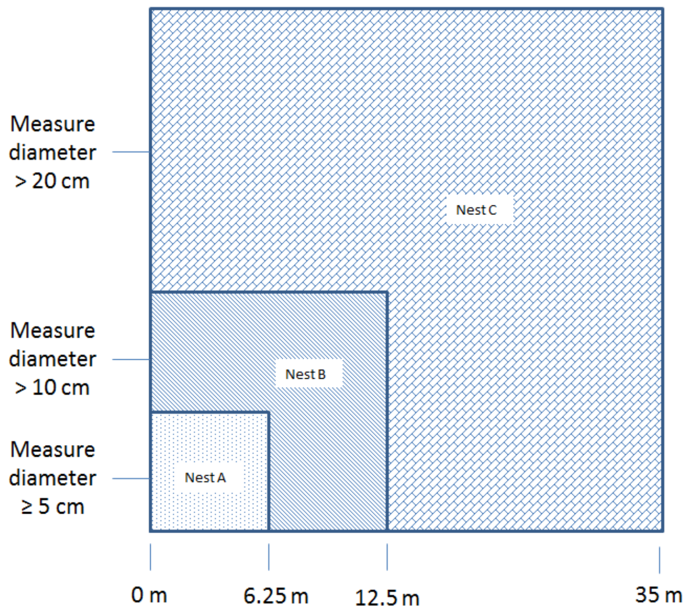

Figure 2. Biomass plot dimensions

The measurement of tree parameters follows standard practice in PNG (PNGFRI, 1994). Tree diameter (*D*) was measured at breast height (1.3 m) or above using diameter tape following prescribed protocols. Tree species were identified using botanical names by FPCD foresters and clan members. Tree height was estimated using a clinometer and measurement tape. For height estimation using a clinometer, adjustment of the trigonometry is required when distance measurements are made on sloping ground. A function to adjust for slope in height calculations was built into the spreadsheet.

Tree biomass was estimated for each tree using both field measurements and heights modelled from species-specific height-diameter relationships developed from the Forest Research Institute's 1 ha permanent sample plots (J.C. Fox et al., 2010). The master spreadsheet includes species look-up tables for wood density and tree height.

- **Harvesting plan**

VM0010 guides the development of a mock harvesting plan, which is used to estimate avoided emissions by protecting a forest from logging. It requires that the relative number of trees per hectare potentially available for harvest by species be identified from a timber inventory. In reality, however, it is common practice that not all trees eligible for harvesting, i.e. above 50 cm DBH, are harvested. Therefore, to provide a more realistic estimation of harvest intensity the approach used deviated from VM0010. Rather than producing a harvest intensity based on the timber inventory, a harvesting intensity was estimated from actual logging set-ups in PNG. This produced a much more conservative estimate than would have been generated from the VM0010 method.

As Ugalingu forest covers just over 1,400 ha, it was assumed that harvesting, including the construction of infrastructure, would be completed in one year and that the operator would not target specific species.

- **Emissions from forest degradation**

Under VM0010, the net C stock change to be converted to emissions is equal to the C stock change as a result of timber harvest plus the C stock change resulting from conversion and retirement of wood products minus C sequestration from forest regrowth after harvest. VM0010 identifies eight sources of emissions in the baseline scenario (Table 3). All of these were included in the calculations, except for emissions from the creation of skid trails, which were conservatively omitted. For the conversion of wood products, the methodology calculates emissions from the combustion of fossil fuels in forestry and wood processing machinery. These were also conservatively excluded.

Table 3. Emission sources

1. Emission from wood product conversion
2. Decomposition of deadwood from harvested trees
3. Emissions from wood product retirement
4. Stock change due to regrowth following timber harvest
5. Decomposition of trees incidentally killed during tree felling
Where project proponent accounts for forestry infrastructure:
6. Decomposition of trees killed through skid trail creation (conservatively excluded)
7. Decomposition of trees killed through road construction

- *Emission from wood product conversion and 3. Emissions from wood product retirement*

It was assumed that all timber removed from the forest would be exported as logs, which account for about 90% of all PNG forestry exports. VM0010 assumes that C in wood waste from wood product conversion is emitted at the time of harvest. For the proportion of extracted biomass that is oxidized from the production of commodities, the value of 24% for developing countries was applied from Winjum et al. (1998).

A simplifying assumption was made that all of the wood would be used in products that would be retired between 3-100 years following harvest. To determine the rate of decay of wood products manufactured from harvested timber, VM0010 requires selection of the anticipated end use of the extracted timber. The four wood product classes it provides are sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other. Winjum et al. (1998) provide default values for the fraction of biomass carbon that is assumed to be emitted to the atmosphere, i.e. the oxidizing fraction, for these four wood classes. According to the default values for tropical forests, all carbon in wood products, regardless of class, will be emitted into the atmosphere within 100 years. As the wood products have a service life of between 3 and 100 years, following section 4.5.3 of the VCS AFOLU Requirements a 20-year decay function was applied.

- *2. Decomposition of deadwood from harvested trees and 5. Decomposition of trees incidentally killed during tree felling*

Deadwood arising from the logging operations includes deadwood left on the forest floor after timber harvest and deadwood from residual stand damage. C in deadwood left on the forest floor was calculated as the difference in biomass between C in total tree biomass and C in merchantable volume. To estimate total tree biomass data from both inventories were used. The biomass inventory was used to develop biomass expansion factors for the main species, which were then applied to merchantable volume estimates from the timber inventory.

Following VM0010, emissions from residual stand damage are calculated by applying a residual stand damage factor to the C stock of timber extracted from the forest. The area of roads was excluded from the calculation as VM0007 is used to calculate the loss of C stock from biomass excluding merchantable volume in this area.

The residual stand damage factor used is 0.53 t C m^3, which is the default value for broadleaf and mixed forests given in VCS Module VMD0011 REDD Methodological Module: Estimation of emissions from market effects (LK-ME) Ver. 1. This default value is from the slope of the regression equation between carbon damaged and volume extracted based on 774 logging gaps measured by Winrock International in Bolivia, Belize, the Republic of Congo, Brazil and Indonesia. Following VM0010, it is assumed that dead wood left on the forest floor following timber harvest follows a ten-year linear decay function.

- *Stock change due to regrowth following timber harvest*

The forest regrowth rate after harvest that was applied was derived from a forest growth model developed from more than 15 years of data from 1 ha permanent sample plots in selectively logged forests across (Julian C. Fox, Vieilledent, Yosi, Pokana, & Keenan, 2011). The sequestration rate assumed from this model is 1.12 t C/ha/yr, which is the average for PNG.

- *Decomposition of trees killed through road construction*

See section "Emissions from deforestation."

- **Emissions from deforestation**

VM0007 was used as a general guide to estimate emissions from deforestation as a result of road construction for the logging operation. As there is no pre-existing logging plan, the rate of road construction must be established by examining proxy areas. To provide a preliminary estimate of net emissions from road construction, one proxy area located close to Ugalingu forest was used. This proxy area meets the conditions for proxy areas stated in VCS Module VMD0006 REDD Methodological Module: Estimation of Baseline Carbon Stock Changes and Greenhouse Gas Emissions from Planned Deforestation and Planned Degradation (Bl-Pl) Ver. 1.2. These conditions include biophysical, tenure and management characteristics.

In forest areas converted to logging roads it was assumed that there is no replacement vegetation cover that would sequester carbon. Across PNG it can be seen that logging roads are not readily vegetated. The soil is heavily compacted, so vegetation does not readily colonize logging roads even if they are abandoned.

The carbon pools included were above- and belowground biomass in living trees with DBH greater than 5 cm. To estimate belowground biomass, a root:shoot ratio of 0.37 t root dm/t AGB was assumed, based on the value for tropical rainforest reported in Table 4.4 of the IPCC Guidelines for Agriculture, Forestry and Other Land Use (IPCC, 2006). Trees above 50 cm were assumed to be removed from the forest along with other harvested timber and were thus accounted for using VM0010. The simplifying assumption was made that all other vegetation would be left on the forest floor and would follow a ten-year linear decay function. It was assumed that stumps would be removed during the construction of roads, so the root:shoot ratio was applied to the total biomass estimate from the sampling.

- **Project emissions**

Under VM0010, project emissions include the change in carbon stocks of ongoing forest growth, forest disturbances and illegal logging. A simplifying assumption is made that project emissions are zero. As the composition of Ugalingu forest is considered to represent climax vegetation, forest biomass is assumed not to be expanding. "Disturbance" refers to natural disturbance and is divided into fire and non-fire disturbances. Fires and damage from fire have not been observed in Ugalingu forest or surrounding forests, so were excluded from the calculations. Also, fire is considered a greater risk after logging, because of increased access and the forest drying that can occur. Wind damage can be observed in some areas, but could be worse if the forest was logged because of the canopy gaps that would be created.

According to discussions with the Ugalingu clan, there has been no illegal logging in Ugalingu forest. Based on experiences elsewhere in PNG, illegal logging, i.e. harvesting without a permit, is in fact a greater problem after legal logging has taken place (the non-project scenario) than before logging (the project scenario). This is because logging roads open up the forest, increasing their accessibility to harvesting by local people using portable sawmills.

- *Leakage*

A simplifying assumption that leakage would be zero was applied. Because Ugalingu forest is small, it is unlikely that excluding if from the logging operation in the forest management area where Ugalingu is located would result in either activity shifting or market leakage.

2.2) Activity 2 Assess policies, laws, strategies and institutions for generating ecosystem services

The review of policies, laws, strategies and institutions was based on existing literature.

2.3) Activity 3 Analyze transaction costs and options payment for PFES

Transaction costs were identified at a project workshop and quantified based on experience with other projects supporting community-based forest management and cost estimates provided on the Plan Vivo website. Revenue for emissions offsets by protecting Ugalingu forest from logging was estimated from recent global prices for voluntary market offsets delivered by improved management projects.

3. Results and Discussion

Natural forests in PNG deliver a wide range of ecosystem services. There is no general consensus on which of these has the greatest potential for market development. In a review of ecosystem services in New Britain, Crane (2015) concluded that ecotourism is the ecosystem service with the greatest potential for development on the island. An earlier policy paper on developing a PES system for PNG implied that reducing emissions from deforestation and forest degradation may have the greatest development potential (Expert Consultation Group of the Community Carbon Forestry PNG project, 2008).

The project team decided that the research should focus on the protection of forest carbon stocks as the ecosystem service at the case study site. The team noted that the government has developed a national strategy for reducing emissions from deforestation and forest degradation and enhancing forest carbon stocks (REDD+), and felt that the research could help provide ideas for how this strategy could be implemented. Also, earlier work at the case study site had produced data that could be used to assess the potential for PES for forest carbon stock protection.

The results and discussion on the research into PES for forest carbon stock protection at the case study site are presented below under each of the three project Activities. Before this, a description of the research project area is provided.

3.1) Description of the project area

The project area is located in a remote part of the Sogeram Valley, adjacent to Koromorasik (also spelt Karamarsik) Village in Usino Bundi District, Madang Province, Papua New Guinea (Figure 3). The project area is linked by roads to the port at Madang, which serves as the port of export for logs harvested within the province. The total distance to Madang is about 70 km. The road from the project area is the all-weather (gravelled) Trans-Gogol Road, which runs from the Trans-Gogol Bridge on the Ramu Highway as far as Koromorasik. The sealed Ramu Highway provides the remaining connection with Madang town. The Sogeram River runs between the project area and the road end and is unbridged.

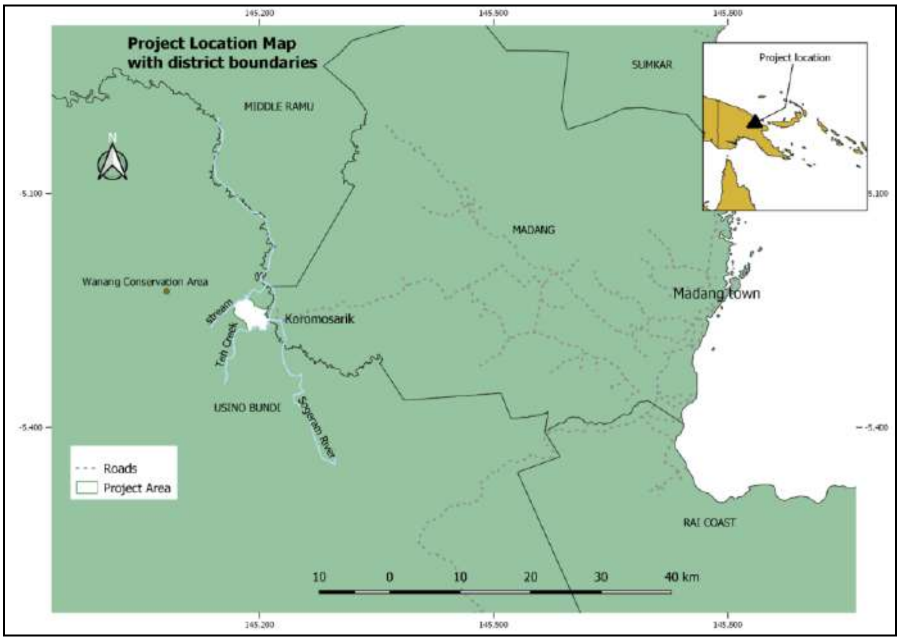

Figure 3. Research project location map

With support from FPCD, Ugalingu demarcated the boundaries of their land and informally divided it into two zones for managing their land use. The largest of these zones is the forest that Ugalingu have set aside for conservation. In this report this area is referred to as Ugalingu forest and for a PFES research project is the carbon accounting area. The smaller area is an area that Ugalingu have set aside for rotational agriculture and comprises land under cultivation and land in fallow. These two areas are collectively referred to as the project area. The boundaries of the project area and two major land-use zones are overlaid on a Landsat image from 2017 in Figure 4. The Landsat image shows that the accounting area is completely forested. The estimated sizes of the project area, Ugalingu forest (accounting area) and the agricultural area are given in Table 4.

Figure 4. Customary land of Ugalingu clan zoned according to their major land-use categories, projected on 2017 Landsat image.

Table 4. Size of the project area and the two primary land-use zones

Zone	Area (ha)
Agricultural area	148.4
Conservation area	1,463.3
Total (project area)	1,611.7

- **Physical characteristics**

The geological history of the Madang-Ramu area is one of uplift and faulting with marine deposition in the central depression during the Miocene and Pliocene (Robbins, 1976). The project area lies in a geographical zone known as the Central Hills, which is part of a wider area classified as the hill zone (Robbins 1976). This zone is heavily dissected as a result of renewed uplift. The Central Hills comprise about 3,400 sq km inland of the Adelbert Range and the hills forming the divide between the Ramu and Sogeram Rivers, where the project area is located.

A 10 m contour map of the project area and surrounds with watercourses was generated from an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) tile using QGIS (Figure 5).[11] The contours were generated using the GDAL contour algorithm in QGIS. River and stream channels were generated using the r.watershed module in GRASS.[12] The channels were "thinned" to one pixel width using r.thin and were then "extracted" from the raster file using r.to.vect. Smaller channels were manually removed to leave the main channels.

Figure 5 shows that the project area is characterized by closely dissected steep-sided hills and ridges. The range in elevation is 90 to 261 m and slopes generally lie between 15 and 30°. Three main ridges run through Ugalingu forest from the Southwest and are separated by two small watercourses – Abul

[11] ASTER GDEM is a product of METI and NASA. ASTER GDEM has a pixel size of one arc-second. GDEM 2 has an overall accuracy of around 17 m at the 95% confidence level, and a horizontal resolution on the order of 75 m. The ASTER tile used was s06_e145_1arc_v3.

[12] GRASS is the Geographic Resources Analysis Support System, which is a is a free and open source GIS software suite.

creek and Sigi creek. Sogeram River forms the eastern boundary, Teh Creek forms part of the southern boundary and Wanang Creek forms part of the western boundary of the forest.

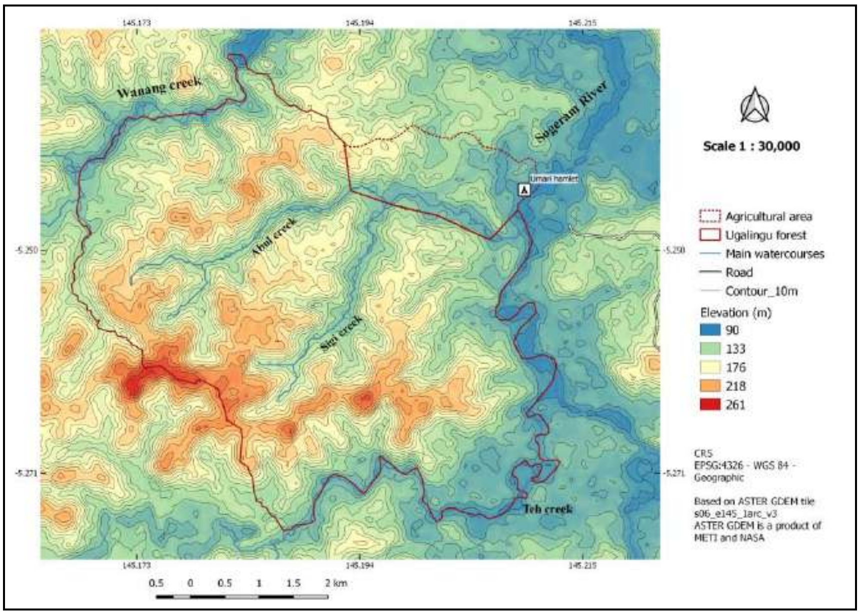

Figure 5. 10 m contour map of the project area and surrounds

The creeks within the project area run clean and the water is potable as the catchments are under natural forest and are uninhabited, and as there is little slope erosion. There is no significant water logging in the project area, which is well drained due to the good drainage conditions provided by the soil and geological composition.

Climate in the project area is characterized by hot and humid conditions with annual rainfall of 1,000-4,000 mm, reaching up to as much as 6,000 mm. The highest rainfall is recorded between December to March, whereas the driest season is between the months of July and September. The temperature ranges from a minimum 21 to a maximum 33°C (FPCD, 2011).

The soils in the project area are part of a grouping of soil families described as immature brown residual soils. These soils are immature because of the similarity between soil and parent material textures, the dullness of the soil colours, the low degree of leaching and the shallowness of the soil profile (Haantjens, 1976). According to Dow (1974) the major soil composition and classification for the FMA is inceptisols, i.e. freely draining soils yet to develop distinct horizons. Casts are present in certain parts of the project area.

The project area holds a remnant of largely untouched and pristine tropical rainforest that lies within the Northern New Guinea lowland rain and freshwater swamp forests ecoregion. Ugalingu forest is classified as "Low Altitude Forest in Uplands Below 1,000 m" according to PNG's Forest Inventory Mapping System (FIMS). This forest class has been described by Robbins, Saunders and Pullen (1976); their terminology is Lowland Hill Forest. It structurally consists of three strata above a shrub and ground layer. The upper canopy trees may average about 35 m with emergent up to 45 m. The sub-canopy is about 25 m. Below this is a more spaced lower tree layer ranging from 5 to 20 m.

There is no recent anthropogenic disturbance of Ugalingu forest. There are no settlements or agricultural plots in the forest. The direct family of Umari Bagusa, the clan leader, is the only family from Ugalingu to have established a hamlet within the project area, but this lies in the agricultural zone, not the forest zone. All other hamlets are located on the opposite side of the Sogeram River. Permanent and shifting agriculture is located in the agricultural zone and on the Koromosarik side of the Sogeram River, away from Ugalingu forest.

- **Socio-economic characteristics**

A socio-economic survey conducted by FPCD found that the Ugalingu clan comprises about 114 people in 2011. Many clan members do not have birth certificates, so the figures on population are based on the recall of clan members. There are 40 adult (18+ years) males, 38 adult females and 36 children. The clan appears to have a high birth rate and to be growing rapidly.

The home base of the Ugalingu clan is Koromosarik Village, which has a population of about 1,000 people. The village setting is linear and centralized, but people live in separate hamlets in their family units to protect their land from trespass and illegal land use. The neighboring villages are Wagusarik, Galisakang, Wanang, Musak and Kamambu.

Immigrants have established settlements in Madang Province but not adjacent to the project area. Simbai people established a settlement in the Ugalingu area during the period of road construction, but have since left. No other new settlements have been established.

Land chieftainship is patriarchal, i.e. land is passed on from father to son. Both men and women play leadership roles in religious and other social groups. Women have a say in decisions on family matters, while clan matters are dealt with by clan elders and community matters by the clan chiefs. Customs that are upheld include the husband and wife living in separate huts, and a separate hut being made available for visitors. Girls are expected to marry men with land.

Catholic and Lutheran are the major religious denominations in Koromosarik. Religious and social affiliations are important in providing free or cheap labor for communal and other activities. They contribute to community development and to meeting spiritual needs, which helps to reduce law and order problems. Sorcery is still practiced in the Gogol area. Ugalingu forest holds sites of forest dwelling spirits. These culturally significant sites include Kudupnge, Karukatamda, Kuvingkakme, Uyangikatam and Yambagesala.[13]

The livelihoods of Ugalingu are largely subsistence based, though a small amount of cash flows into the community through wage labor and the sale of agricultural produce. Shifting agriculture (Photo 2), hunting, fishing and gathering from the wild provide families with most of their subsidence needs. Agriculture provides food on the table and the forest provides supplementary food, materials for buildings and tools, medicines and cultural practices. Fish are caught in Sogeram River. The clan usually eats twice a day. Meals are unbalanced, often lacking protein. The staples are starches such as banana, taro, yam, cassava, sago, and sweet potato, and a few greens.

Photo 2. Land under shifting cultivation in project area zoned for agriculture

The main agricultural cash crop is cocoa, with most households having a cocoa plot. There is no value-added processing. Growers sell the fermented wet beans to traders. Most households also raise a few pigs. About 13 people from Ugalingu are in paid employment. Their occupations include Catholic Bishop, teacher, driver, mechanic, lecturer, secretary, surveyor, and machine operator. Sources of cash within the wider community of Koromosarik Village include employment with RD Tuna Canners Ltd, royalties from large-scale logging operations, small-scale sawmilling and providing transportation services.

[13] This information was gathered by FPCD forester Mark Winai during his study on the role of customs in protecting Ugalingu forest.

The amount of cash flowing into the community is small. As the community is relatively-cash poor, Ugalingu households hold few physical assets. The assets of the clan leader were estimated to be worth about K1,000.[14] As an indicator of general living standards and the amount of cash in the clan, most (35) of the houses are constructed of bush materials, only three houses are semi-permanent and there are no permanent houses. Wood is still the main source of energy for cooking and heating.

Like most rural areas in PNG, delivery of government services in Sogeram is lax. Koromosarik has its own primary and elementary school, but the literacy level in Ugalingu is very low. Most of the older clan members received no formal education. Access to education is hindered by remoteness and lack of income to pay school fees. However, the situation is improving because of the road link with Madang town. One person was attending high school and 13 children were attending Koromosarik primary school.

The most common illnesses experienced by Ugalingu include flue, skin diseases such as grille, malaria, arthritis and asthma. For health services, Ugalingu mostly rely on Utu, Mawan and Danben health centers. Utu and Mawan are both located about 35 km from Koromosarik.

The major needs perceived by Ugalingu include transportation, proper housing and electricity. Rapid population growth is another concern, as it will lead to land scarcity. The clan's vision is that the next generation of children will live in a community that has a high literacy level, a nearby and easily accessible school and health facilities, good road access, and secure food and income sources.

3.2) Activity 1. Assess the selected forest ecosystem services and its economic values

- *Baseline scenario*

Two land-use scenarios for Ugalingu forest over the next 30 or so years can be foreseen. The first is that the forest remains intact and undisturbed, as at present. The second and most likely scenario is commercial logging of the project area by an outside logging company using heavy machinery and in weak compliance with the logging code of practice, followed by the penetration of shifting agriculture in some parts of the project area.

There is some possibility of the first scenario, though it is considered unlikely. The sons of Ugalingu clan leader, Umari Bagusa, will be responsible for the forest after his passing and may decide to resist any activities that would degrade or destroy the forest. Two of the son's have been employed by New

[14] One PNG kina (k) = 0.29 US dollars on 01 12 2019 (https://www.xe.com/currencyconverter/).

Guinea Binatang Research Center and have developed an interest in research on biodiversity and conservation. However, this scenario is considered improbable due to the large “benefits” that would flow to the community from commercial logging of the forest and the pressure being placed on the forest by the rapidly growing local population.

The second scenario is considered most probable and therefore is the baseline scenario for Ugalingu forest in the situation of no additional incentive to conserve the forest. There are three elements of this scenario that require further explanation: (1) logging by an outside logging company and benefits anticipate by the community; (2) damage to forest as a result of logging; and (3) agricultural encroachment.

(1) Logging by an outside logging company and anticipated benefits

The project area lies within the Ramu Block 1 Forest Management Area (FMA). A forest management area is an area demarcated by the PNG Forest Authority for a selective logging project under the Forest Act 1991. The concession was purchased on 24 June 2004 and runs for 50 years through to 2054. The total area is 158,000 ha and the area suitable for logging is 112,328 ha (PNGFA, n.d.). As customary groups such as clans own almost all of PNG’s forest estate, the state must first acquire the timber rights from these groups before it can issue a timber permit. Before the customary landowners pass on the timber rights to the state, they must incorporate themselves as land groups, following the Lands Act 1975. A review of the concession’s development in 2001 found that of 117 incorporated land groups (ILGs) within Ramu Block 1, 81 had signed the FMA (PNG Forestry Review Team, 2001). Ugalingu opposed the logging of its forest and did not sign the FMA. Umari, the clan leader, recalls that Ugalingu forest was initially mapped for logging, but that he insisted the map be redrawn to exclude the forest.

Ugalingu clan members recall government foresters coming to the area and organising public meetings to establish ILGs for logging purposes. The forestry officers were accompanied by lands officers, who displayed satellite images using a projector and then requested the landowners to indicate their customary boundaries on these images. They then had the landowners fill in forms to request birth certificates, which are necessary for land group incorporation. An independent review of the logging operation found that ILGs were incomplete and flawed as they were based on families rather than clans and lacked property lists (PNG Forestry Review Team, 2001). This did not stop the logging from proceeding.

Photo 3. Logs being transported along the Trans-Gogol Road out of the FMA, 2017

While the clan leader has resisted approaches from the logging company, this resistance could easily dissipate at some time in the future because of the benefits from logging. These benefits far exceed current cash flows in the community and they require no effort from the clan.

The main benefits that local people anticipate from logging are cash payments, infrastructure and community development projects. Cash payments come in the form of royalties, which are paid per cubic metre of timber harvested, as well as a "project development benefit" (PDB), which is paid for every shipment of logs. The rates are given in Table 5. Under the Project Agreement for Madang Timbers, the PDB is to be allocated on the basis of 60% to the Middle Ramu Block 1 Project Area Trust Fund for the purpose of providing infrastructure and community development projects, and 40% as a cash premium to be distributed on an equitable basis to all ILGs in the project area.

Table 5. Royalty and PDB rates

Royalties		**Project Development Benefit**	
Species	Rate	Export log price (per m^3)	PDB payment (per m^3)
Kwila	K35	K91-K110	K2
Rosewood	K35	K111-K130	K5
Ebony	K100	K131-K150	K8
Group 1 species	K27	K151-K200	K13
Group 2 species	K22	>K200	K13+7.5% FOB prices over K200
Other species	K12		

Source: Schedule 3; Middle Ramu Block 1 Facebook page.

In terms of infrastructure benefits, for many remote communities the construction of a road by the logging company can be especially attractive. Under the Project Agreement, the company is required to construct and maintain main roads, bridges and crossings over a distance of 97 km to Department of Works standards for permanent roads and bridges. It is also required to construct village access roads over a distance of 140 km. The logging company has constructed an unsealed road that links with the sealed road to Madang town, but the final section of this before Koromosarik is in very poor condition. Over this section, the road is deeply rutted and covered in high grasses. The bridges are not maintained and must be inspected before each crossing. If the logging was to cease, the entire road is likely to fall into disrepair. Conversely, if Ugalingu were to allow logging of its forest, the road to Koromosarik would be much improved, giving it better access to markets and services.

Other infrastructure benefits the community would receive are the construction, upgrading and maintenance of schools, which are obligations the permit holder must comply with as per the Project Agreement for Madang Timbers for Middle Ramu Block 1. These include the upgrading of classrooms and teachers' houses using permanent materials and providing them with water tanks; construction of health facilities and staff houses, and providing them with water tanks and solar lamps; construction and upgrading of police facilities; provision of communication facilities; construction of buildings and sports fields for recreation; construction of community buildings; provision of water supply systems; and establishment of guest houses and market facilities at district centers and local level governments. [15]

(2) Anticipated harm to the forest from logging

Commercial logging of Ugalingu forest at current standards will cause considerable harm to flora and fauna, degrade ecosystem services and reduce biomass. Under the Forest Act 1991, logging of natural forest involves selective harvesting of commercially saleable species with a diameter at breast height greater than 50 cm. This form of logging causes immense damage because of the construction of roads and skid trails, the practice of skidding logs through the forest, and the use of heavy machinery. Further degradation occurs as a result of repeated logging cycles (Shearman & Bryan, 2015).

The intention of the Forest Act 1991 and the PNG Logging Code of Practice is to make logging sustainable, i.e. to allow production in perpetuity, by limiting the harvest volume, setting out practices to reduce the impact of logging, and setting a logging cycle of 35 years. In practice, however, forest regulations are weakly enforced, resulting in logging operations failing to implement the required

[15] Source: Schedule 4; from Middle Ramu Block 1 facebook page

sustainability measures (NEPCon, 2017). Also, repeat harvests within the 35-year cycle are common and there are doubts that 35 years is sufficient for forests to recover for a repeat harvest (Shearman & Bryan, 2015).

(3) Agricultural encroachment

If commercial logging under the FMA was to take place in the project area, there is a risk that shifting agriculture, and possibly permanent agriculture, would encroach into the forest. The logging roads and skill trails would make the forest much more accessible to the rapidly growing local population, which will increasingly experience land scarcity.

Figure 6 shows small patches of deforestation that occurred between 2001 and 2013 to the north and east of the project area. This deforestation has taken place within the FMA and is likely mostly associated with shifting agriculture and settlements. By contrast, as Ugalingu forest has not been penetrated by logging roads, it remains undisturbed.

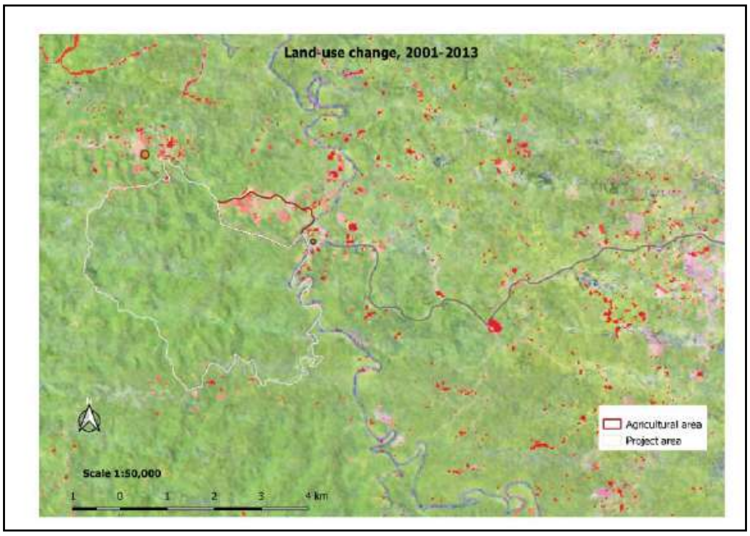

Figure 6. Forest loss in project area vicinity, 2001-2013

Source: PNG REDD portal. Note: Forest loss is shown by shades of red.

A true color Landsat image from 23 July 2018 reveals that Ugalingu forest is part of a narrow area of undisturbed forest that runs to the west of the Sogeram River (Figure 7). The area immediately to the north and south of Ugalingu forest is forest that appears to have been more disturbed by gardening. Areas where recent tracks have been constructed can be seen further to the north and upstream (south) on the west side of Sogeram River, where there is clear evidence of recent logging. In Figure 8, a false color composite from the Landsat 23 July 2018 tile, land without vegetation appears as cyan. Logging roads constructed within the last five years can be seen to the southwest of Sogeram River.

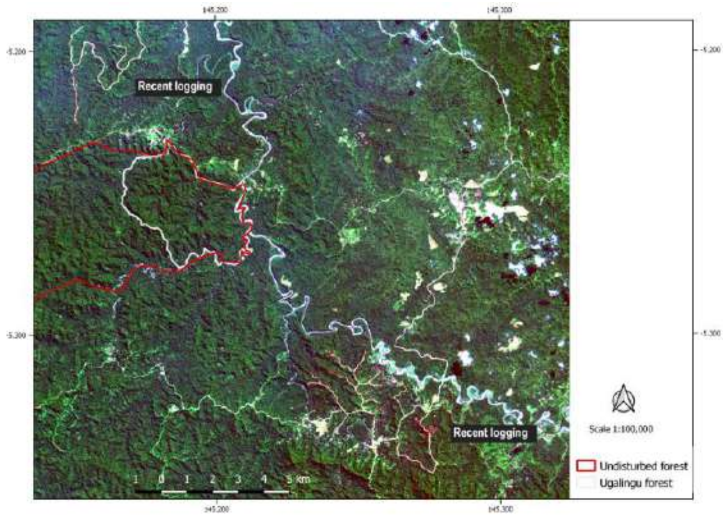

Figure 7. Ugalingu forest and surrounds

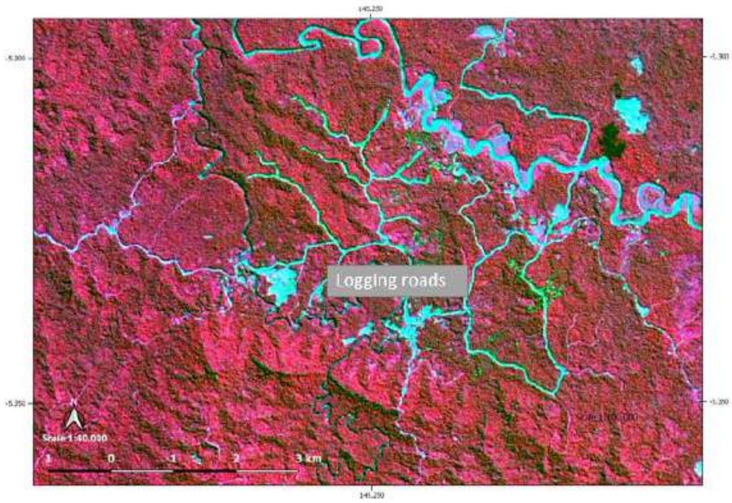

Figure 8. Logging tracks to the south of Ugalingu forest

The Ugalingu clan has restricted agriculture to outside the project area, but without strong controls in place may not be able to maintain this restriction. New families are likely to be established through intermarriage with other groups and they may wish to establish gardens in the project area. Logging tracks in the project area would accelerate this process and enable people to establish gardens in areas previously not attractive to them for gardening. It is also possible that without Ugalingu cementing its control over the project area, other clans will dispute Ugalingu's customary land boundaries as their populations grow.

Additionality

The VCS tool VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and other Land Use (AFOLU) Project Activities was used as a general guide to assess additionality. The tool has four steps: 1. Identification of alternative land-use scenarios to the AFOLU project activity; 2. Investment analysis to determine that the proposed project activity is not the most economically or financially attractive of the identified land use scenarios; 3. Barriers analysis; and 4. Common practice analysis. Based on the Tool, a FPES project to conserve Ugalingu forest is considered additional.

Step 1 on alternative land-use scenarios is addressed above under “Baseline scenario.” The most likely land-use scenario for Ugalingu forest over the next 30 years is considered to be commercial logging with weak compliance to sustainability standards followed by encroachment in the more accessible areas. The baseline scenario is more conservative as it excludes encroachment.

For Step 2 investment analysis, it can be seen from the earlier discussion on the large benefits of logging perceived by communities and the small amount of cash flowing into the community that the proposed project activity is clearly not the most economically or financially attractive of the identified land use scenarios.

Step 3 barrier analysis is optional and aims to complement Step 2. It requires the determination of any barriers that would prevent the conservation of Ugalingu forest without the revenue from the sale of GHG credits, and absence of barriers to the alternative land-use scenarios. In the former case, there are no other likely sources of revenue that could be generated from the forest to ensure its continued conservation. While ecotourism or certified community forestry might be suggested, the community has insufficient human and financial resources to implement such enterprises without considerable external assistance. In the latter case, as Ugalingu is within an active FMA, there are no legal or other conceivable barriers to it being commercially logged in the near future.

Step 4 common practice analysis is concerned with whether there are similar projects in the vicinity to that proposed. If so, the Tool assumes that without the PES project under VCS, a similar project could be implemented in the accounting area. There are no similar projects in the FMA.

Quantification of the ecosystem service

- *Activity data*
- **Harvestable area**

The PNG Logging Code of Practice was applied to estimate the harvestable area within the total area of Ugalingu forest of 1444.1 ha. The areas ineligible for logging found in Ugalingu forest are slopes greater than 30 degrees and buffer zones around watercourses. Other ineligible areas under the PNG

Logging Code of Practice, i.e. areas of high relief with slopes above 25 degrees, permanently inundated land, limestone country and mangrove areas, are not found in the project area.

The GDAL slope plugin in QGIS was applied to an ASTER GDEM image (s06_e145_1arc_v3) to generate slopes. 0.2% of Ugalingu forest was found to be above 30 degrees slope, which reduces the harvestable area by 2.9 ha (Figure 9).

The Logging Code of Practice sets minimum buffer zone widths around watercourses. To set these buffers, river and stream channels were generated from the ASTER GDEM using the r.watershed module in GRASS. The channels were "thinned" to one pixel width using r.thin and were then "extracted" from the raster file using r.to.vect. Smaller channels were manually removed to leave the main channels. Buffers were applied to Teh Stream and Wanang River (class 2 streams – bed width less than 5 m and greater than 1 m; buffer 10 m either side) and Sogeram River (class 1 stream – bed width more than 5 m; buffer 50 m either side) in accordance with the Logging Code of Practice. Sigi Creek and Abul Creek within Ugalingu Forest are considered to be on average less than one meter width and not used regularly by the community, so no buffer was applied to them. The buffers were applied using a buffer algorithim in QGIS. Where Sogeram River, Wanang River and Teh Stream form boundaries of Ugalingu Forest, the buffer was applied to the mapped boundaries, rather than the channels generated from the ASTER DEM. There are some small differences between the generated channels and mapped boundaries, and, as the mapped boundaries were manually traced from a Landsat image, they were considered more accurate. Applying the watercourse buffers reduced the harvestable area by 23.0 ha to 1,418.2 ha (Table 6).

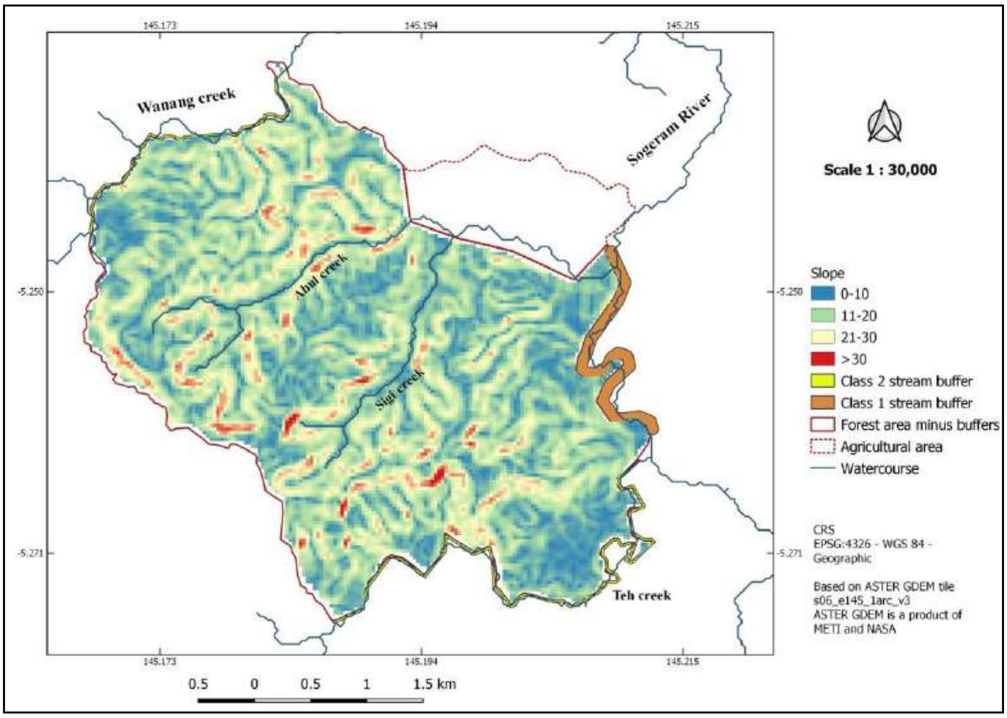

Figure 9. Slope map with stream buffers

Table 6. Estimation of total harvestable area

Total area (ha)	1444.1
Area > 30° slope (ha)	2.9
Watercourse buffers (ha)	23.0
Total harvestable area (ha)	1418.2

- **Deforested area**

To predict the area of deforestation, the construction of log ponds was conservatively excluded and the area of roads was estimated using a proxy area. A larger proxy area (proxy area 1) was used to estimate the length of roads and a smaller proxy area (proxy area 2) located within this was used to estimate the width of roads. Proxy area 1 is in close proximity to Ugalingu forest, lying 3.3 km directly south of the southernmost point of Ugalingu forest. The proxy area has recently been exposed to logging under the same FMA that Ugalingu is located in.

Logging in the proxy area was detected in two points in time from two Landsat 8 images, one from 01 Nov. 2014 and the other from 31 July 2018. The images were pan-sharpened with band 8 (panchromatic) of the image sets to 15 m optical resolution using the semi-automatic classification plugin in QGIS. In the true color composite from the 31 July 2018 Landsat tile, the roads appear as white and recent logging as red areas within the forest (Figure 10).

A vector of the roads was created by physically tracing them using GIS and their total length was calculated. An approximate boundary was drawn around the roads to demarcate the boundaries of proxy area 1 and the density of roads (km/ha) was calculated. This figure was then applied to the area of Ugalingu forest to estimate the length of roads that would be built for the forest to be logged. Applying this method, it was estimated that 9.78 km of roads would be constructed inside Ugalingu forest (Table 7). As Ugalingu forest comprises just one land cover class, spatially explicit modelling of the road locations was considered unnecessary.

To estimate the total area that would be deforested for roading in Ugalingu forest, the likely average width of forest clearance for roads was estimated from a small subset (proxy area 2) of proxy area 1 where recent logging had occurred (Figure 10). Proxy area 2 was classified into two land cover classes – forest and roads – using the spectral area mapping algorithim in the semi-automatic classification plugin in QGIS. A small number of pixels were incorrectly classified as road, so the total of these was manually subtracted from the road class and added to the forest class. The average width of forest clearance for roads in proxy area 2 was estimated to be 53.2 m. Applying this estimate, the likely area to be cleared for roading in Ugalingu forest is 52.0 ha (Table 7).

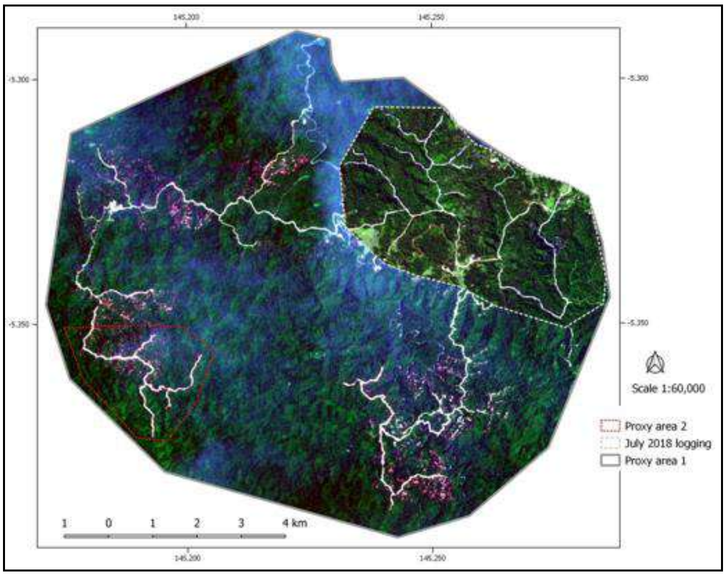

Figure 10. Proxy area for estimating deforestation for roading in Ugalingu forest
Note: A high thin cloud cover appears over some areas.

Table 7. Values to calculate deforestation for roading

Proxy area 1 – estimate values	
Total road length (km)	68.981
Total area (ha)	10,323
Road density (km/ha)	0.006682
Proxy area 2 – estimated values	
Average road width (m)	53.2
Ugalingu forest	
Total area (ha)	1,463.3
Road density estimate (km/ha)	0.006682
Estimated road length (km)	9.78
Average road width (m)	53.2
Estimated area deforested for roading (ha)	52.0

- *Emission factors*
- **Deforestation**

The results of the sampling from the 12 35 X 35 m biomass plots are given in Table 8. As is common in natural tropical forest with large variation in topography, the C stocks exhibit wide spatial variation, with a range from 65.9 to 213.7 t C/ha across the 12 sample plots. The mean C stock estimate from modelled tree heights (149.1 ± 55.3 (SD) t C/ha) was larger than that from tree heights estimated using clinometers (135.8 ± 45.4 (SD) t C/ha). The latter is conservatively used in all calculations. The total biomass and stem counts for species are presented in Figure 11 .

Table 8. Results of biomass sampling from 12 35X35 m sample plots

Plot Code	Carbon stock (t C/ha DBH$_{>5\ cm}$, estimated heights)	Carbon stock (t C/ha DBH$_{>5\ cm}$, calculated heights)	Basal area (m^2/ha)	Merchantable volume (m^3/ha)
Sogeram1	116.0	145.6	31.7	128.1
Sogeram2	97.9	114.4	25.3	74.0
Sogeram3	144.2	168.3	46.1	237.6
Sogeram4	134.3	134.0	35.4	130.4
Sogeram5	97.4	101.4	28.5	98.0

Sogeram6	121.9	155.0	39.9	143.7
Sogeram7	65.9	80.7	25.7	0.0
Sogeram8	213.7	292.3	55.1	350.7
Sogeram9	113.4	106.6	31.9	66.6
Sogeram10	176.0	161.8	44.6	138.6
Sogeram11	213.7	195.2	52.6	145.7
Sogeram12	135.2	134.4	38.1	154.8
Mean	135.8	149.1	37.9	139.0
SD	45.4	55.3	10.0	88.2
SE	13.1	16.0	2.9	25.5
Approx CI	26.2	31.9	5.8	50.9
CI%	19%	21%	15%	37%

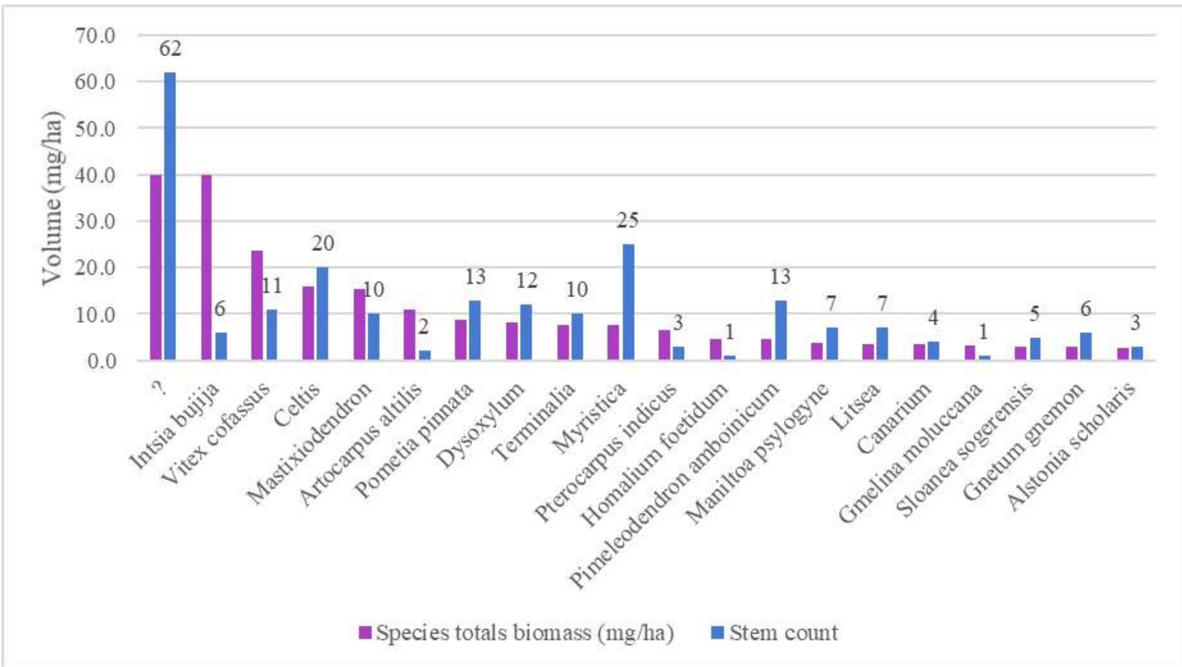

Figure 11. Species total biomass $DBH_{>5cm}$ and stem count per species from 12 35X35m sample plots
Note: "?" represents unidentified species

Table 9 presents biomass assessment results of other studies. As is to be expected, these studies suggest high variation in C stocks in PNG tropical forests and elsewhere. Of these studies, Fox (2010) is especially relevant, as his 10 sample plots were located in the broad same forest class as Ugalingu forest. His estimate of mean C stock in aboveground forest biomass (106.3± 50.6 t C/ha) is lower than that of the project area (135.8 t C/ha). This would partly be accounted by his exclusion of trees between 5 and 10 cm DBH. His results also exhibit a high co-efficient of variation (48%). In contrast, the IPPC default for lowland tropical forest (180 t C/ha) is much higher than the research project estimate. With these points in mind, the results from the project area are judged as reasonable.

Table 9. C stock estimates in forest biomass from various studies

Source	Details	t C/ha
Abe (2007)	Limestone forest in Mongi-Busiga FMA, east of the Huon Peninsula; 2 1 ha plots 111 - 146 m above sea level sampled; Litter + understory + lianas$_{>5cm}$ + standing dead wood + trees$_{>5cm}$	251.8±62.6
Fox et al. (2010)	10 1 ha PSPs, undisturbed lowland forest, AGLB DBH$_{>10cm}$, located across PNG	106.3± 50.6
IPCC (2006)	Default for lowland tropical forest	180

- **Degradation**

The summary results from the FPCD inventory of merchantable stock are presented in Table 10.

Table 10. Summary results of inventory of merchantable stock

Summary of merchantable stock (> 50 cm DBH)							
Plot size (m)			20 X 50				
Sample area (ha)			10.1				
Sample intensity for forest management area (869 ha) (%)			1.16				
Species	Av. DBH (cm)	Total stems	Stems/ha (approx.)	Total Volume (m3)/species	Total basal area (BA) (m2)	Vol./ha (m3/ha)	BA/ha (m2/ha)
Celtis sp.	60	11	1.1	92.91	7.56	9.19	0.749
Dysoxyllum spp.	60	5	0.5	14.98	1.32	1.48	0.131
Cryptocarya sp.	60	12	1.2	47.89	3.39	4.74	0.336
Instia spp.	80	42	4.2	155.76	12.14	15.42	1.202
Mastixiodenderon sp	70	31	3.1	144.33	10.7	14.29	1.059
Pometia spp.	65	14	1.4	124.58	10.11	12.33	1.001
Pterocarpus sp.	70	8	0.8	16.66	2.1	1.65	0.208
Terminalia sp.	65	17	1.7	85.86	6.7	8.5	0.663
Vitex spp.	67	6	0.6	16.1	2	1.59	0.198
Miscellaneous spp.	69	87	8.6	398.17	28.48	39.42	2.820

Total	233	1097.2	84.5	108.6	8.37

The estimated merchantable volume is 108.6 m^3/ha. However, logging operations do not extract all trees of commercial size. Current logging operations in PNG were examined to estimate the percentage of commercial volume likely to be harvested. Data from three set ups in the Vailala logging project in Gulf Province were used (Table 11).[16]

Table 11. Harvesting intensity in 3 logging set-ups in Vailala

Set up	Area (ha)	Total stems harvested	Average stems harvested per ha
CK-1	150	826	5.5
CK-2	128	475	3.7
CK-3	98	418	4.3
		Mean	4.5

The mean of 4.5 stems extracted per ha coincides with explanations from two national forestry experts that on average 4 to 6 stems are harvested per ha.[17] Using this extraction rate, and the average merchantable volume per stem, estimated from the timber inventory at 3.5 m^3/stem, the estimated merchantable volume extracted per ha is 15.8 m^3/ha.

- **Net avoided emissions**

Estimated annual emissions for each emissions source for the first 10 years of a PFES project to protect carbon stocks in Ugalingu forest are presented in Table 12. The estimate of total avoided emissions over the first 10 years is 80,670 tCO2e.

Table 12. Net annual avoided emissions for PFES project in Ugalingu forest (Unit: t CO2e)

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[16] This data was provided by Mr. Javen Evera (PNGFA).

[17] Pers. Comm.s Dr. Yosi K. Cossey (PNG University of Technology) and Mr. Javen Evera (PNGFA)

Year	Wood production conversion and retirement		Decomposition of deadwood from harvested trees	Stock change due to regrowth following timber harvest	Decomposition of trees incidentally killed during tree felling	Decomposition of biomass excluding merchantable volume in road areas
	Emissions from wood products	Emissions from wood waste				
1	3,068	19,606	2,184	- 5,611	4,158	2,307
2	3,068		2,184	- 5,611	4,158	2,307
3	3,068		2,184	-5,611	4,158	2,307
4	3,068		2,184	-5,611	4,158	2,307
5	3,068		2,184	-5,611	4,158	2,307
6	3,068		2,184	-5,611	4,158	2,307
7	3,068		2,184	-5,611	4,158	2,307
8	3,068		2,184	-5,611	4,158	2,307
9	3,068		2,184	-5,611	4,158	2,307
10	3,068		2,184	-5,611	4,158	2,307
Source totals	30,680	19,606	21,840	-56,105	41,578	23,071
Total net avoided emissions						80,670

3.3) Activity 2. Assess policies, laws, strategies and institutions for generating ecosystem services

In terms of national policies and institutions, there is no direct support for a community-based PFES scheme in PNG. PNG's land development policies don't disallow community-based PFES, but they don't favor it either. The dominant land development policies have centered on transferring forest and land rights from local communities to outside developers with the necessary resources to implement large-scale forestry, agricultural and mining projects (Scheyvens et al., 2019). Also, there is no single government agency responsible for overseeing a PES exchange and if a PES market was to develop under current legislation it would be completely unregulated (Crane, 2015). An analysis of PNG's readiness to implement a PES scheme identified the following significant policy gaps: no polices regulating the exchange of money for environmental services; inadequate regulations for representation of sellers; no internationally accepted procedure for determining the value of ecosystem service; no policy to regulate the exchange of environmental services for payments; root causes of environmental degradation are not being addressed (ibid.).

PNG has no law on carbon rights, but it can be assumed that as long as the customary landowners have held on to their resource rights as laid out in the Constitution, they hold the rights to carbon in their forests. Customary rights recognized by the Constitution include rights to all natural resources, with the exception of minerals, petroleum, water, and genetic resources.

Ugalingu have the rights over carbon, but do they have the right to trade carbon offsets generated from activities to protect the carbon stocks in Ugalingu forest? A review of national policy suggests they do. The protection of carbon stocks in Ugalingu forest from logging would be understood under national policy as a REDD+ activity. PNG's National REDD+ Strategy allows project proposals from landholders, private sector actors and NGOs; however, they must be able to demonstrate clear competencies within the areas of project development and a strong commitment to the ongoing support and development of communities within the project location, as well as secure long-term financial investment. Projects are also required to ensure that methodologies used for calculating their project-scale forest reference level (baseline) are in line with those used at the national level and that data can support national systems. In addition, projects must have clear national reporting on the application of safeguards (in line with the United Nations Framework Convention on Climate Change (UNFCCC) Cancun Safeguards), the accounting and reporting of emissions and payments, and financial management systems (Climate Change and Development Authority PNG, 2017).

The policy gaps identified above do not preclude the development of a PFES scheme centering on community-based forest management. However, they do mean that protections to ensure community interests are met are lacking in the law and that initiative for community-based PFES may have to initially come from outside government. The National REDD+ Strategy allows for such a scheme at project scale, but it would have to be designed to comply with the requirements of the Strategy. The National REDD+ Strategy requires adherence to the Cancun Safeguards, which include community well-being. Therefore, it the National REDD+ Strategy is properly implemented, safeguards for communities would be in place for any REDD+ initiative.

3.4) Activity 3. Analyze transaction costs and payment options.

Transaction costs for a PFES scheme to support the protection of forest carbon stocks by the customary landowners from the logging of their forest were discussed at a project workshop. Table 13 provides a list of transaction costs and a very rough estimate of each. Reference was made to information on project costs provided by Plan Vivo (https://www.planvivo.org/develop-a-project/costs/). In estimating costs, it was assumed that the PFES project would be managed by an NGO in PNG that has expertise in forestry and community development.

Table 13. Estimates of setting up PFES for Ugalingu forest protection

Cost item	Rough estimate (US $)
Further community consultation and awareness raising	10,000
Assessment of capacity and institutional gaps (e.g. land group incorporation) within communities to implement PFES projects and filling of these gaps	50,000
Workshops with provincial and national stakeholders, especially government, to ensure buy in	5,000
Capacity building of a local organization within PNG to be the PFES scheme manager	10,000
Scheme operating activities	100,000
Technical expertise to provide a final emissions baseline, draft project description and provide guidance on emissions monitoring and reporting	30,000
Project validation	8,000
Certificate issuance fees (at US $0.35/certificate)	28,000
Total	241,000

Funding and revenues would ideally be generated from two sources. The first is technical assistance for up-front costs, which could possibly be sourced from local government budgets and international funds. Financing is now available from various sources to support REDD+ initiatives, such as the Green Climate Fund, bilateral schemes such as Japan's Joint Crediting Mechanism and Germany's Early Movers Programme, the World Bank's Carbon Fund, and voluntary markets.

The second source of financing is payments for carbon offsets. As there is no domestic emissions trading scheme in PNG, the main option for selling carbon offsets would be the voluntary market. The outlook for the trade in voluntary carbon offsets has improved in recent years. Forest Trends' Ecosystem Marketplace (2019) reported a 52.6% increase in volume and a 48.5% increase in value for transactions of voluntary carbon offsets in 2017 over 2016. There was a significant increase in the traded volume of forestry and land use offsets, which appears to be driven by buyer preferences for natural climate solutions. The average price of forestry and land use offsets traded in 2017 was US $3.2. However, the average price for improved forest management projects, which is more relevant to an avoided logging project, was US $9.32 (ibid.).

This latter figure applied to the estimated net avoided emissions by protecting Ugalingu forest from logging generates gross revenue for a PFES project with Ugalingu of above US$ 700,000. This would be sufficient to cover the costs listed in Table 13 and provide an income stream to Ugalingu. However, the costs listed should be understood as minimum estimates, so actual costs could exceed these and additional costs could arise. Additional sources of income would thus be desirable. One option could be to develop payment for other ecosystem services together with carbon stock protection. Ugalingu forest would be attractive to nature lovers, including bird watchers, so has potential for ecotourism. However, this would require considerable investment to develop services at international standards.

To increase net revenue, another option would be to include other communities within the Ramu Block 1 FMA that have resisted attempts to log their forests. This could reduce transaction costs per unit of carbon offset generated, but would require a thorough feasibility analysis.

In terms of payments, benefit sharing and the form of payments to the community also need to be considered. For any community-based PFES in PNG, the communities and the scheme manager should agree on benefit-sharing prior to launching the scheme. A benefit sharing and distribution system (BSDS) should be designed to reflect local customs as well as international principles including transparency, accountability, inclusiveness, gender sensitivity and equity (Crane, 2015). Payments received by communities could be direct payments of cash as well as payments in kind, e.g. the construction of infrastructure for the community, investments in alternative livelihood activities, etc. A trust fund could be established and mandated to provide support to the community to ensure that any payments are spent wisely.

4. Conclusions

While there are significant policy gaps that would need to be filled for PNG to implement a national PES scheme, current policies and laws do not preclude the development of PES initiatives by non-governmental actors. PFES is supported by PNG's National REDD+ Strategy, which lays out a set of requirements that aim to ensure that private PFES initiatives do not act against national interests and undermine community well-being.

The research project supports the notion that there is potential to develop PFES schemes in PNG that protect forest carbon stocks from "development." The research findings suggest that the scale of implementation does not have to be so large to generate a stream of revenue for communities protecting their forests from logging. Still larger payments could be expected for communities protecting their forests from agricultural development, which involves clear-felling.

There is a risk that the costs of establishing a PFES initiative could be very high if expertise from outside the country is primarily relied upon for technical inputs and project management. Costs can be kept to a reasonable level by building the capacity of a local institution with expertise in forestry and community development to contribute to technical inputs and manage the PFES initiative.

In the case of an avoided logging project, the methodology to estimate net avoided emissions is complex. As a result, considerable investment is needed to apply the methodology. Given the size of this investment, it would make more financial sense to bundle several communities under a FPES initiative than limit the initiative to just one community.

5. Future Directions

The following recommendations have been derived from the research project:

For the research project community and surrounding area

1. Further refine and implement the methodology to provide a final estimate of net avoided emissions and tradeable carbon offsets;
2. Assess the potential for other communities within the FMA to be brought under a PFES imitative.

For a national level PFES scheme

1. Assess policy gaps that have been identified by earlier studies and fill these gaps;
2. Develop a national program, including piloting, to support community-based PFES, with a view to environmental protection and building resilient and vibrant communities. Focus the piloting on communities interested in conservation and with community leaders who are committed to working towards community interests. Maximize opportunities for community participation by utilizing and building their capacities to play key roles in PFES, and to use any income they receive wisely, including in technical activities such as carbon accounting.

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