Addressing ..... Yonariza et al 2019

by Mahdi Mahdi

Ecosystem Services 39 (2019) 100995

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

Addressing knowledge gaps between stakeholders in payments for watershed services: Case of Koto Panjang hydropower plant catchment area, Sumatra, Indonesia

Yonariza[a,*], Bevi Astika Andini[a], Mahdi[a], Simone Maynard[b]

[a] Universitas Andalas, Padang, West Sumatra, Indonesia
[b] Australian Rivers Institute, Griffith University, Queensland, Australia

A R T I C L E I N F O

Keywords:
Payment for watershed services
Watershed management
Hydropower
Water supply

A B S T R A C T

This study assesses the knowledge and perceptions of potential participants in a payment for watershed services (PWS) scheme in a watershed containing a reservoir and hydropower plant in Indonesia. Information was collected by interviewing watershed service providers such as upland farmers and downstream beneficiaries of services i.e. fishers, rest area operators, tourists, and the power plant manager. The study found some challenges if relying on stated preference values as a basis for a workable PWS scheme, specifically asymmetric information among stakeholders. Upland farmers did not realize their location within the upland of a watershed whose activities affect the quality of watershed services. Watershed users similarly do not know what activities their counterparts do in the upland. The study reveals market forces are a driver of livelihoods in the watershed. It concludes that prior to introducing a PWS scheme it is: 1/important to address any asymmetric information across stakeholders (e.g. through farmer extension services); and 2/consideration should be given to fluctuating commodity price subsidies so to sustain farmers' livelihoods and ensure they maintain sustainable management practices for the uninterrupted and long term supply of watershed services. This study provides important lessons for other regions struggling with the same issues.

1. Introduction

Indonesia is in one of the four sub-regions of the Asia Pacific region, the Southeast Asia sub region (see Maynard et al. and Sayre et al., this issue, for more information on Asia Pacific and its sub regions). Indonesia's characteristics of being a developing country, having a tropical climate, high rainfall, volcanic mountainous islands, an agricultural economy and a large indigenous population are shared with many of the Oceania sub-region's island nations, specifically those of Melanesia (i.e. Vanuatu, Solomon Islands, Fiji, Papua New Guinea, New Caledonia (France) and Western New Guinea). The mountain ranges and high rainfall have carved extensive watersheds and the ecosystem services provided by these have had a profound effect on the human settlements in these areas. People both upland and lowland (downstream) take advantage of the natural resources and ecosystem services available to them to support their livelihoods (for example subsistence or cash-based agriculture).

A common problem shared by these nations is the lack of sustainable and equitable energy supplies available to households, businesses and industry. Access to and distribution of energy from city centers to rural upland poor is challenged not only by terrain but also a lack of infrastructure and financing (Chaurey et al., 2004; Raturi and Nand, 2017). For example, the distribution of energy in Oceania's small island nations is uneven and access is sporadic, with approximately 70% of people without electricity, and 85% having limited access to clean cooking technologies (Dornan, 2015; Surroop et al., 2018). Hence, lessons learnt from our study have the potential to inform other developing nations with similar socio-ecological-economic characteristics around the world.

Indonesia and other nations with similar characteristics have a high potential to utilize energy derived from hydropower. For example, the potential of hydropower in Indonesia is estimated about 75,000 MW which makes it the fourth ranking nation in Asia after China, the former Russian Federation and India (Hasan et al., 2012) At present the contribution of hydroelectric power in Indonesia is only 9% of the installed electric capacity in the country, or 39,257.53 MW (PT PLN (Persero), 2014). Unfortunately, many hydropower plants in Indonesia are short lived due to unprotected watersheds (Siciliano et al., 2015). Siltation

* Corresponding author at: Department of Agricultural Socioeconomic, Faculty of Agriculture, Universitas Andalas, Limau Manis, Padang 25163, Indonesia.
E-mail address: yonariza@agr.unand.ac.id (Yonariza).

https://doi.org/10.1016/j.ecoser.2019.100995
Received 7 April 2019; Received in revised form 21 July 2019; Accepted 12 August 2019

accumulation at reservoir would reduce the dam capacity to retain water and will eventually reduce power production (Urquiza and Billi, 2018). Sediment accumulation near the dam strongly influence the operation of the hydro power plant (Harb et al., 2015) and in long term reduce power production especially in lower head dam (Musa et al., 2019).

Payments for Ecosystem Service (PES) as a market-based mechanism for nature conservation and natural resource management is becoming more widely accepted and implemented (Bösch et al., 2019; Ezzine-De-Blas et al., 2016), PES involves a connection (contract) between an ecosystem service provider who agrees to apply good land management practices to ensure the flow of services (Willingness to Accept – WTA), and an ecosystem service user (beneficiary) who agrees to pay the provider to perform these actions (Willingness to Pay – WTP) (Engel et al., 2008; Fripp, 2014; Pagiola, 2008). PES, specifically Payments for Watershed Services, is increasingly becoming adopted across nations in Asia particularly in China (Sheng and Webber, 2017; Xu et al., 2017), Vietnam (Suhardiman et al., 2013; The et al., 2004), India (Hayes et al., 2017) and Indonesia (Huang et al., 2009; Pirard, 2012; Ranjan, 2019).

Payments for Watershed Services (PWS) is an example of the many types of innovative PES schemes applied throughout the world (Pagiola, 2008; Rist and Dahdouh-Guebas, 2006), including in Asia (Huang et al., 2009; The et al., 2004) and Oceania (Friedlander, 2018; Woinarski, 2010; Donato et al., 2012). The uninterrupted and long term provision of watershed services such as water regulation and supply (FAO, 2007; Huang et al., 2009; Pirard, 2011)), soil retention (Brand and Pfund, 1998), aesthetics (van Riper et al., 2012), recreation and tourism opportunities (Arifin, 2005), productive soils (Adhikari and Hartemink, 2016), carbon storage and sequestration (Montagnini and Nair, 2004), and biodiversity maintenance (Di Minin et al., 2017) (to name a few) is influenced by the land use type and natural resource management practices in the uplands. Vegetation cover, in particular forest structure, plays an important role as it is highly correlated to rainfall (Dietz et al., 2006, 2019), soil infiltration capacity and moisture retention (Jindal et al., 2013; Peña-Arancibia et al., 2019), which are important ecological processes underpinning these services.

Research confirms that PWS is positively associated with reduced deforestation, although to improve the design and implementation of PWS a better understanding is required of the complex socio-economic and ecological interactions between the environment and stakeholders within a watershed (Seymour and Busch, 2016). There is a clear link between landholders in the upland of a watershed as 'ecosystem service providers' (providers) and those on the lowland of watersheds as 'ecosystem service beneficiaries' (beneficiaries) (Fripp, 2014). In a perfect setting, people in the upland and lowland would know each other's activities and how their activities impact on both private and public watershed services, thereby adjusting their practices accordingly. In PWS, people in the upland and in the lowland are assumed to be connected in a social and economic network or socio-economic system. However, watershed boundaries may not coincide directly with administrative units, cultures or other socio-economic boundaries of local people: people in the upland and lowland may be connected to each other only via hydrology. Hence, a PWS scheme may be the only mechanism to connect people in the uplands and lowlands.

In a large watershed (i.e. across administrative boundaries), the knowledge across watershed service providers and beneficiaries of the services being provided and the costs and benefits of sustainably managing natural resources for their provision may not be equal (i.e. asymmetric). Any form of hypothetical market valuation, however, must assume that the involved parties are well informed. Contracts with landowners, managing organizations and enforcement agencies must be negotiated and penalties can be applied, or payments withheld, for breaching agreed to terms (Corbera et al., 2017). Asymmetric information between service providers and the users have shown to cause inefficiencies in PWS schemes and reduce their effectiveness (Ferraro, 2008; Hackett et al., 1994) - consequences of breaching agreements can be social, economic and environmental.

Problems associated with asymmetric information are more common and likely to be greater when the service providers and users are poor (Leimona et al., 2015; Pagiola et al., 2005). Remoteness and lack of infrastructure in poor areas limits access to information and transportation, and hence can make PWS expensive to implement as often extension services are required to address knowledge gaps (Sheng and Webber, 2017). Asymmetric information can also lead to 'information rent', defined as "the possibility that service providers are paid more than necessary to cover their PES provision costs, since the latter are unknown to program implementers" (Ferraro, 2008). Based on four case studies in Indonesia, Leimona et al. (2015) found that local communities and policymakers have a diverse range of knowledge regarding watershed processes and services.

Whilst some studies of PWS in Asia and Oceania have been conducted from a socio-economic perspective (Beilin et al., 2014; Huang et al., 2009; Leimona et al 2015; Takasaki, 2011), much research is still required at the micro household level, as in Asia and Oceania households are most likely to make and receive watershed service payments. Studies are required that investigate people's knowledge and perceptions of PWS and the interconnections among socio-economic groups that may be relevant to PWS transactions e.g. upland and lowland people understanding the impacts of their activities on adjacent lands. Applying PWS requires individuals (landholders) to think beyond their own interests (how to maximize economic benefits from their own land) to land management and water production at the watershed scale including any negative economic or ecological externalities they may create). As PWS aims to change behavior among these parties to more sustainable natural resource management (Jack et al., 2008), addressing asymmetric information is important to implementing a successful PWS program.

The watershed area supporting the Koto Panjang Hydro Electric Power Plant (HEPP) in Sumatra, Indonesia, provides a good case study for PWS, as energy production by the plant has declined greatly in the last 5 years and there has been a sharp fluctuation in water flow. The water table was high during periods of high rainfall causing flooding and water was released through the spillway without generating power. A report by the Government of Indonesia says HEPP will exhibit a lower internal economic rate of return than it estimated in its original plan (Anon, 2003). Three years after HEPP began operations, an independent review strongly recommended that the national electric company should establish community socio-economic empowerment for the purpose of improving soil and water resource conservation in upstream areas (i.e. in the Koto Panjang basin) (Anon, 2003). Until now, no mechanism has been developed to reverse watershed degradation, and there has been no specific study to design a PWS program.

This study is part of a multiyear program titled "Market, land use change, and ecosystem services in Koto Panjang HEPP Watershed area". In this first year of research on which this article is based, we used interviews focusing on understanding the dynamics of land use change in upland areas and the willingness to accept (WTA) compensation for changes in land-use practices by farmers. The study also investigated the willingness to pay (WTP) of beneficiaries downstream such as fishers, tourists and rest area operators, and the hydropower company. In this paper we: 1) identify gaps in knowledge between watershed service providers and watershed service beneficiaries that if left unaddressed will influence the effectiveness of a PWS program, 2) present an example of non-market environmental valuation, and 3) provide suggestions to addressing asymmetric information challenges to implementing a PWS scheme relating to hydropower production and improved watershed management in high rainfall mountainous areas.

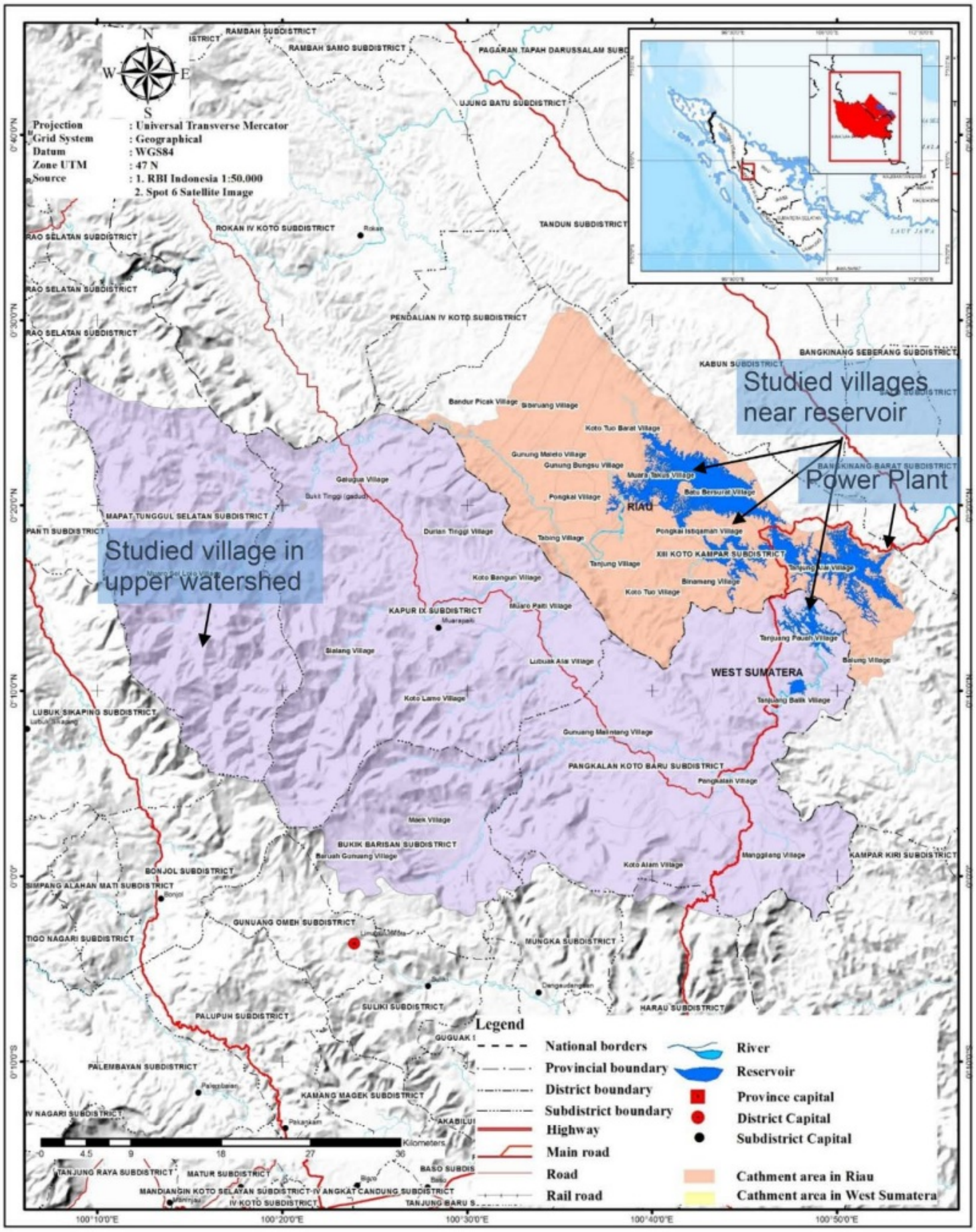

Fig. 1. Map showing the study site, including the 2 provinces of Koto Panjang HEPP watershed, Muaro Sungai Lolo in the upper watershed, the reservoir, the power plant location, the 3 downstream villages, and the rest area location near the main road crossing the reservoir.

2. Method

This study in the Koto Panjang Hydro Electric Power Plant (HEPP) watershed area was motivated by fluctuating water supplies to generate hydropower and more frequent flooding in the reservoir. Documents (grey and peer reviewed) were reviewed to assess the current knowledge about watershed service in the site and other similar settings. This section first describes the study area then provides a description of the data collection techniques.

2.1. Study area

The Koto Panjang Hydro Electric Power Plant (HEPP) was built from 1992 to 1998. It is a gravity dam and hydroelectric power plant (38 MW × 3 units). The watershed supporting the plant covers an area of 323,900 ha in two provinces of Indonesia: Riau (23% of area) and

West Sumatra (77% of area), see Fig. 1. The reservoir itself covers 12,400 ha or almost 4% of the basin and is located mainly in Riau province. The reservoir provides benefits not only to the national power corporation (PLN) as the main water user, but also to the people living in areas surrounding the reservoir where they engage in fish aquaculture and ecotourism.

As Fig. 1 shows, the catchment area is administratively located in three districts across the two provinces. District Limapuluh Kota and Pasaman are part of West Sumatra Province, whilst District Kampar is in Riau Province. We selected a village named Muaro Sungai Lolo (MSL) in the Mapat Tunggul Selatan sub-district, Pasaman District, West Sumatra Province. MSL is located in the upper most part of the Koto Panjang HEPP watershed and it covers a large percentage of the HEPP watershed area (55,429.50 ha or 17%). This is a remote area typically characterized by agriculture, inadequate infrastructure and transportation.

There are 10 villages surrounding the downstream reservoir. Some of these villages are involuntary resettlement sites of people whose former villages were inundated.

We selected three villages: *Tanjung Pauh* village in West Sumatra Province, and *Muara Takus* village and *Pongkai Istiqomah Village* in Riau Province. In these villages, we interviewed fishers focusing on their knowledge about the watershed and their willingness to pay for watershed protection. We also interviewed tourists and operators of rest areas who are benefitting from the reservoir as ecotourism destinations.

MSL village in the upper most part of the watershed and the reservoir downstream are located more than 100 kms apart and in different provinces. In MSL the village is also not connected to the national power network (i.e. not receiving energy from the hydropower). The dominant land use in MSL village is shifting cultivation, a farming system where plot rotation is more important than crop rotation using slash and burn technology to grow rice as staple food (Dressler et al., 2017; Tinker et al., 1996). Unfortunately, the harvest of rice in shifting cultivation is no longer enough to support household consumption due to low productivity.

Table 1 shows land use change in the Koto Panjang HEPP watershed area from 1988 to 2016. It reveals a decrease in forest cover, but an increase in dry land farming, open land and oil palm production over the last two decades. This change in land cover and unsustainable land use is thought to have caused a decline in water retention capacity and other watershed services. A lack of protection of forested areas combined with increased agriculture has reduced the reliability of water supply affecting electric power production.

2.2. Data collection techniques

Data collection via a series of interviews of upland service providers and lowland services beneficiaries was carried out from May to November 2016 during the dry season. Primary data was collected from providers and beneficiaries of watershed services using semi-structured interviews (see Questionnaire in Appendix). Respondents consisted of four groups; farmers upland in the watershed, fishers around the reservoir, rest area operators, tourists, and the electricity company management. The number of respondents from each group, the location of interviews and sampling technique is presented in Table 2.

Table 1
Land cover change in Koto Panjang HEPP watershed before and after dam construction. The dam was constructed from 1992 to 1998.

Land cover type	1988 (ha)	2016 (ha)	Change (ha)	Change (%)
Forest	188,196.77	154,928.22	(33,268.65)	−17.68
Dry land farming	128,012.76	135,975.67	7962.91	6.22
Open land	5100.41	10,562.52	5462.11	107.09
Oil Palm	2680.38	11,558.52	8878.14	331.23
Water body	–	10,965.39	10,965.39	100.00
Total	**323,990.32**	**323,990.32**		

For farmers and fishers (who are local residents) the samples were selected randomly from the list of households found at the village head office. Interviews in the upland (i.e. farmers) were made between April and May 2016, while in the reservoir (i.e. all other stakeholders) were made from September to October 2016. The following are descriptions of each group of respondents.

2.2.1. Upland farmers

In the upland of MSL village, 59 farmers were interviewed equating to ten percent of the total households. Questions focused on their socioeconomic position, their knowledge of the watershed and watershed services, as well as their WTA payments if they had to change their existing environmentally unfriendly farming systems.

2.2.2. Fishers

The 10,965 ha reservoir for HEPP is surrounded by resettlement areas. Some of these households engage in fish aquaculture in the reservoir. The future of their fish aquaculture activity depends on water quality and the sustainability of the reservoir. The total number of fishers in this population is unknown. During this research we interviewed 61 fishers in three villages.

2.2.3. Tourist and rest area operator

Koto Panjang HEPP Dam is passed by an interprovincial connecting road, the Padang - Pekanbaru highway. This reservoir attracts passersby to take a break at rest area sites. The sites offer reservoir views from the hillside where food and drink are served. Here we identified two kinds of beneficiaries: the passerby or tourist, and the rest-area operator. The length of time tourists spent in the rest area was not recorded, but most were short, less than half an hour. We recorded respondents' socioeconomic background, knowledge of watershed services, as well as their WTP for them. We interviewed 16 rest area operators and 22 tourists. We treated these types of respondents differently to the other groups since they do not live in the area and their livelihoods indirectly depend on watershed services. Before we began interviewing them, we showed them a map of the watershed to familiarize them with the watershed situation.

2.2.4. Hydropower plant representative

The National Electric Company (or PLN) is the main user of watershed services in the area. The generator produces between 490 and 767 GWh per year supplying power to three provinces in Sumatra Island: West Sumatra, Riau and Jambi interconnection. Four turbines were installed, but only three of them are in full operation. The fourth is only occasionally operated due to fluctuating water supply. The manager of Koto Panjang HEPP in Pakanbaru city, Riau province, was interviewed.

3. Results and discussion

We present our results in the following order: the socioeconomic characteristics of respondents; knowledge of watershed services of people in the upland and people near the reservoir; and the economic value of watershed services in terms of WTA and WTP.

3.1. Socioeconomic characteristics of respondents

To better understand responses to questions asked, the socioeconomic characteristics of respondents in upland areas and those downstream near the reservoir were identified. The following five socioeconomic characteristics were collected: gender, age, educational level, number of dependents at home and housing condition.

3.1.1. Social characteristics

3.1.1.1. Gender. As in many countries, some societal roles in Indonesia

Table 2
Sample distribution by group and sampling technique.

Respondent Group	Location/Village	Sampling Technique	Number of Respondents
Upland farmers	Nagari MSL	Cluster random sampling by sub-village (*kampung*)	59
Fishers in the reservoir	1. Tanjung Pauh 2. Muara Takus 3. Pongkai Istiqomah	Cluster random sampling by sub-village (*kampung*)	61
Rest area operator	Along highway near reservoir	Random sampling	16
Tourists	Along highway near reservoir	Accidental sampling	22
National Power Company Representative	Pekanbaru	Key informants	1

favor one gender more than another (e.g. traditionally fishers are male), hence it was thought the gender of respondents may influence their knowledge on watershed services. Fig. 2 presents the gender of respondents. It shows that all respondent groups were male dominated except for rest area operators who were mostly female.

3.1.1.2. Age and education level. Age may influence respondents' perception and knowledge of watershed services and the local area, and their willingness to make a change. Education can also influence one's openness to new information and adoption of innovation. As shown in Table 3, farmer respondents in the upland dominated the higher age bracket (> 57 years) whilst tourist respondents dominated the lower age bracket (18–27 years). Fishers tend to be concentrated in the middle age group.

Unequal educational attainment among respondents is evident. Farmers and rest area operators in the upland had less 'formal' education than other respondent groups. Upland farmers had less education in all age ranges. Fishers were concentrated mostly in elementary and junior high school, whilst tourists of all age groups tended to have attained a higher level of education. Fishers and rest area operators of all age groups had attained only elementary school level education.

3.1.1.3. Number of dependents. The number of dependents per household is an important economic indicator as it represents unproductive members of the household who are also receiving benefits of watershed services. Fig. 3 presents data on the number of dependents living among respondents. It reveals fishers and farmers having a relatively higher number of dependents compared to rest area operators.

3.1.1.4. Housing. Housing condition (i.e. type of house), in part, explains the socioeconomic status of people both in upland and downstream areas of the watershed. The type of house may be permanent, semi-permanent, or non-permanent. Fig. 4 presents the housing conditions of respondents. It shows the housing condition of fishers near the reservoir is better than those of the farmers in the upland, as fewer have non-permanent housing. Fishers mostly have permanent or semi-permanent housing indicating that watershed services are enjoyed consistently throughout the year by people downstream.

3.1.2. Economic characteristics

3.1.2.1. Upland farmers. People upland depend on agriculture for their livelihood. They grow rice in the uplands using a shifting cultivation technique. Shifting cultivation refers to a technique of rotational farming in which land is cleared for cultivation (normally by fire) and then left to regenerate after a few years. When the forest is cleared, they grow rubber as a long-term investment.

Rubber used to be the main income in MSL village, but with a declining rubber price from IDR 20,000 (USD 1.3) per kg in year 2010 to only IDR 5000 per kg in year 2015, farmers were pushed to revitalize rice and their shifting cultivation systems. Fig. 5 and Table 4 shows the number of households engaged in shifting cultivation has increased over the last 5 years (Mahdi and Yonariza, 2017), even though rubber price has declined. Many have diversified their rubber production with gambier[1] as a cash crop, but farmers keep expanding their small holder rubber plantations as they still expect the rubber price to improve. To support rubber plantations more forest was cleared thus reducing the quality of watershed services. However, those with enough gambier plantation could rely on it for their livelihood.

Table 4 indicates that rice production has been deficient every year. As rice is a staple food in Indonesia, those who do not practice shifting cultivation solely depend on rice from outside their land. The rice produced from the shifting cultivation system, on average, is enough for only half a year's consumption per household. This puts high pressure on forest and other natural resources and pushes farmers to choose unfriendly farming practices that threaten watershed services.

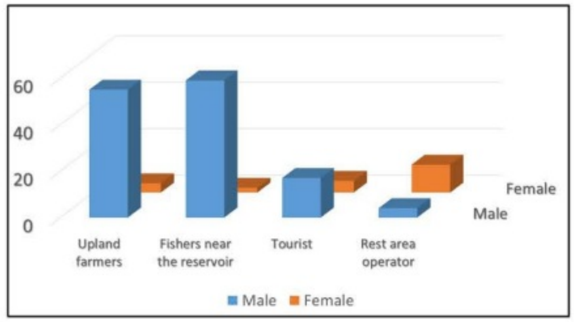

Fig. 2. Distribution of respondents gender by group.

3.1.2.2. Fishers. Koto Panjang Reservoir provides the main source of income for fishers around the reservoir. Fish aquaculture in floating nets, growing Tilapia and Carp, fishing in the reservoir using fish nets, and using hazardous chemical are all practiced by fishers in Koto Panjang Reservoir. The catch is mainly for sale in nearby markets or to local collectors. Fishers main source of the fishers is fishing.

[1] *Uncaria gambier* Roxb is a bush type crop of the family Rubiceae which grows at altitudes between 2–500 m above sea level. It is not an environmentally friendly crop due to its nature as a bush crop (Yeni et al., 2014).

Table 3
Distribution of respondents by education level and age group.

Respondent Group	Education Level	Age Group (years)					Total
		18–27	28–37	38–47	48–57	58–67	
Upland farmers	No formal education or not finish elementary school	0	4	13	15	9	41
	Elementary school	1	3	4	3	1	12
	Junior High School	1	1	1	1	0	4
	College	0	1	0	0	0	1
	university	0	0	1	0	0	1
	Total	**2**	**9**	**19**	**19**	**10**	**59**
Fishers near the reservoir	No formal education or not finish elementary school		0	3	4	0	7
	Elementary school		6	11	9	2	28
	Junior High School		6	10	1	0	17
	Senior high school		6	2	0	1	9
	Total		**18**	**26**	**14**	**3**	**61**
Tourist	No formal education or not finish elementary school	0	0	0	1		1
	Elementary school	0	0	0	1		1
	Junior High School	0	1	0	0		1
	Senior high school	10	2	0	2		14
	College	2	2	1	0		5
	Total	**12**	**5**	**1**	**4**		**22**
Rest area operator	No formal education or not finish elementary school	0	0	1	0		1
	Elementary school	0	1	1	3		5
	Junior High School	1	3	1	0		5
	Senior high school	1	1	1	1		4
	College	0	1	0	0		1
	Total	**2**	**6**	**4**	**4**		**16**

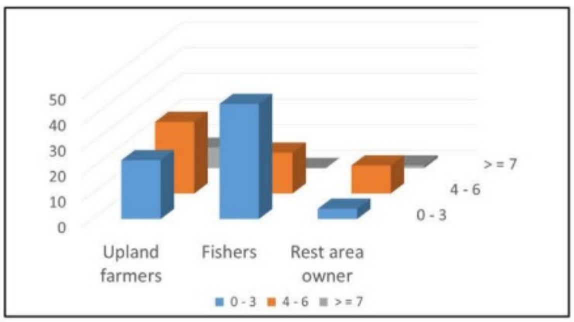

Fig. 3. Number of dependents by respondent group.

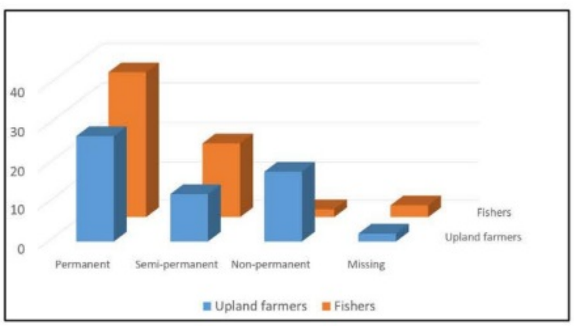

Fig. 4. Housing condition of upland farmer and fisher respondents.

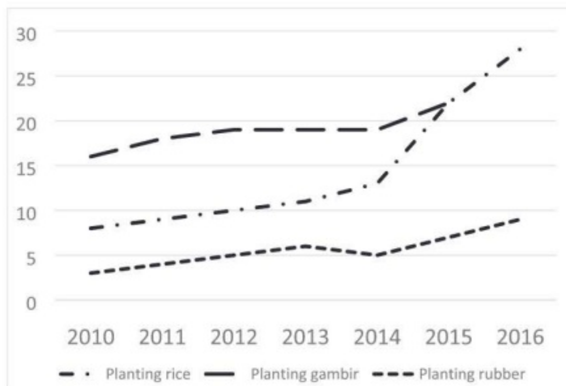

Fig. 5. Number of respondents (N = 59) involved in planting rice, rubber and gambier 2010–2016.

Table 4
Trend in shifting cultivation among famer respondents 2010–2016 (N = 59).

Year	2010	2011	2012	2013	2014	2015	2016
# of households involved in shifting cultivation	8	9	10	11	13	22	28
average land size (ha)	1.8	1.87	1.97	1.82	1.82	1.59	1.38
average length of rice consumption (months) in a year	6.83	6.33	7.43	7.71	7.22	8.21	6.2

3.2. Knowledge on watershed services

3.2.1. Upland farmers

The two watershed services of most interest to upland farmers are water supply and reduction in siltation. In the uplands, hillside forests are cleared for cultivation by farmers, which triggers erosion. Once the land is cleared, farmers practice shifting cultivation which often triggers further erosion. Some also practice agroforestry, known as rubber jungle, where perennial crops such as rubber and other fruit trees are grown and these can reduce siltation and erosion. We investigated farmers' knowledge of upland watershed services, their perceived location of their village within the watershed, the effect of farming on ecosystem services, and their willingness to maintain forest cover. The questions asked and farmers responses are presented in Table 5.

Responses from the interviews revealed most upland farmers (61%) were unaware their forests were in the Koto Panjang HEPP watershed, or that their village was upstream in the watershed (75%). Mostly

Table 5
Upland farmers knowledge of watershed services.

Question	Response	N = 59	%
Do you know if these forests are part of Koto Panjang HEPP watershed?	Yes	19	32
	No	36	61
	Do not know	4	6
Do you know if the cultivation activities at your location effect KP HEPP?	Yes	13	22
	No	23	39
	Do not know	23	39
Are you willing to maintain forests upstream through agroforestry?	Yes	19	32
	No	3	5
	Do not know	37	65
Do you know if your village is upstream Koto Panjang, HEPP watershed?	Yes	15	25
	No	44	75

farmers denied their activities affected the lower watershed (39%), or they were unsure if they had any impact at all (39%). When farmers were asked if they would be willing to maintain forests upstream through agroforestry 65% of respondents said they were unsure, whereas 32% said they would.

3.2.2. Lowland fishers

Koto Panjang dam serves multiple purposes aside from electric power generation, such as: fisheries, ecotourism, irrigation, domestic water supply, sediment and flood control. Villagers surrounding the reservoir capitalized on its construction and turned their livelihoods from agriculture to fisheries. Table 6 presents the questions asked of fishers and their knowledge about reservoir water condition, watershed services, and the effects of land use on siltation and on their aquaculture.

All fishers agree there has been a decline in water condition at the reservoir. The 'main possible reason for declining water condition' was said to be the long dry season (80%). Oil palm production was identified as the main land-use underpinning declining water quality in the reservoir (66%). Oil palm is practiced in the Kampar District near the dam site. Some fishers also say shifting cultivation in the upland effects the water quality (13%). There is a disconnect however between perceptions of upland and downstream point sources, as when asked if reservoir condition was affected by people in the 'upland' Pasaman's watershed area, 46% of respondents said "no" indicating their limited knowledge about farming practices in the upland. Nevertheless, reforestation of the watershed was said to be the appropriate way to improve water condition.

3.2.3. Tourists and rest area operators

Construction of the dam created an artificial lake landscape. The view from the hill road offers passersby an opportunity to stop at several rest areas. This economic opportunity for local people opened since the operation of Koto Panjang HEPP Dam. As beneficiaries also of watershed services, it is important to know the tourists' and rest area operators' knowledge about the watershed and their willingness to pay (WTP) for watershed services. Table 7 presents the questions asked, and the tourists' and rest area operators' knowledge and perceptions of water shed services.

Over a third of the tourists and operators said the reservoir was silted (34%), and 21% of respondents said they were unsure. Although siltation perceptions were similar across beneficiaries, across all questions, tourists said they were 'unsure' or 'do not know' about watershed shed services more times than local operators.

Tourists and operators had very different perceptions on the type of farming systems in the watershed that were affecting watershed services. Tourists identified small holder rubber plantations as the primary farming activity affecting the watershed, but operators did not (6/0 responses). This was the reverse for oil palm plantations (0/7 responses). Both groups of respondents identified shifting cultivation and irrigated rice farming as affecting the watershed. Shifting cultivation

Table 6
Fishers knowledge on watershed services.

Question	Response	Frequency	%
Do you observe declining water condition at the reservoir?	Yes	61	100
	No	0	0
What is the main possible reason for declining water condition?	Environmental unfriendly farming practices	2	3
	Long dry season	49	80
	Rainy season caused mudy water	2	3
	Other	7	12
	Do not know	1	2
	Total	61	100
What is the effect of declining water level at the reservoir on your fish aquaculture?	Dizzy fish	1	2
	Drown fish	3	5
	Fish disappeared	1	2
	Fish lost	55	90
	Total	60	99
	Missing system	1	2
Do you observe the possibility of reservoir silted?	No	6	10
	Yes	43	71
	Not sure	8	13
	Other	4	7
	Total	61	100
What type of land use is affecting water condition at the reservoir?	Oil palm plantation	40	66
	Fish pond	1	2
	Shifting cultivation	8	13
	Oil palm and shifting cultivation	1	2
	Do not know	7	12
	Total	57	93
	Missing system	4	7
Is reservoir condition effected by people in the upland Pasaman's watershed area?	No	28	46
	Yes	33	55
	Total	61	100
Do we need to improve the condition of forests in the watershed area?	No	3	5
	Yes	58	95
	Total	61	100
What is an appropriate effort to maintain water condition?	Reforestation	56	92
	Extension service for shifting cultivator	1	2
	Other	2	3
	Total	59	97
	System	2	3

was the primary activity identified by the rest area operators.

The same number of tourists and operators (12/12) said reservoir condition in the upper part of the watershed (i.e. at MSL) affects the condition of the reservoir. However, different from operators, nearly as many tourists (10) also said it was not affected. Both groups agree that farming practices in the watershed should be environmentally friendly (79%) and as presented in Fig. 6, forest rehabilitation is needed to improve watershed health (76%).

3.3. Payments for watershed service

Having acquired respondents' knowledge on ecosystem services, including their perceived location in the watershed and the influence of their land use on the quality of watershed services, as evidence of asymmetric information, we further tested economic valuation in term of willingness to accept (WTA) for people in the upland and willingness to pay (WTP) for people downstream. Our aim was to determine if economic valuation could help solve the problem of watershed degradation.

3.3.1. Willingness to accept by farmers upstream

Farming practices in the watershed area in MSL village are not environmentally friendly. Shifting cultivation technology is practiced on steep slopes, threatening soil erosion and reducing the water retention capacity of the forest. The same holds true for gambier farming

Table 7
Tourists' and rest area operators' knowledge on watershed services.

Question	Response	Respondent Group		Total
		Tourist	Rest area operator	
Is there any possibility of the reservoir being silted?	Yes	7	6	13
	No	4	6	10
	Not sure	6	2	8
	No response	5	2	7
	Total	**22**	**16**	**38**
Which farming activities affect the watershed the most?	Irrigated rice farming	3	1	4
	Small holder rubber plantation	6	0	6
	Shifting cultivation	4	8	12
	Oil Palm plantation	0	7	7
	Total	**13**	**16**	**29**
Is reservoir condition affected by the upper watershed area?	Yes	12	12	24
	No	10	4	14
	Total	**22**	**16**	**38**
Is there a need for environmentally friendly land uses?	No	1	1	2
	Yes	16	14	30
	Not sure	5	0	5
	Other	0	1	1
	Total	**22**	**16**	**38**
How to improve the watershed area?	Forest rehabilitation	15	14	29
	Protect forest from encroacher	5	0	5
	Other	0	2	2
	Do not know	2	0	2
	Total	**22**	**16**	**38**

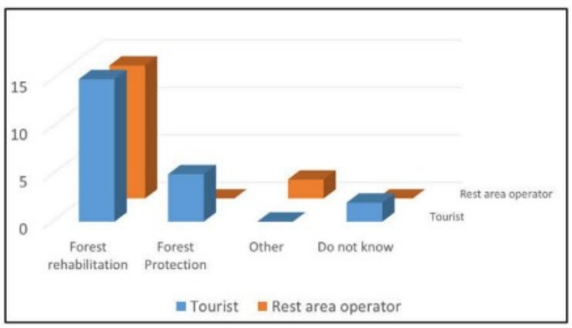

Fig. 6. Tourist and Rest Area Operator perceptions on how to improve watershed quality.

as it typically begins with forest clearing in hilly land and as a shrub type of crop its water retention is low. An alternative to this is an agroforestry system. We asked farmers whether they would agree to change their current farming system and what compensation they would ask in return as an indicator for WTA.

Farmer responses are presented in Table 8, including farmer WTA compensation for farming practice change. Most farmers agreed with changing farming practices toward more environmentally friendly ones (76%). In exchange for this practice, compensation by way of goods and materials and subsidies for rubber price as cash crops were requested. Other types of compensation were also identified such as rehabilitation of paddy fields, cash money and agricultural extension service provision. Those who disagreed mentioned that it's hard to see other economic alternatives in their locality due to their socio-economic condition.

Table 8
Farmer willingness to accept compensation for farming practice change.

Item	Response	Frequency	%
Willingness to change farming practices	Agree	45	76
	Disagree, hard to see other economic alternative in their locality due to their socio economic condition	14	24
Type of compensation	Disagree to change	14	24
	Subsidies in price commodity	13	22
	Compensation of goods	15	25
	Other compensation such as; rehabilitation of paddy field, cash money, agricultural extension service provision	17	29

3.3.2. *Willingness to pay by downstream beneficiaries*

Beneficiaries of the reservoir include the national electric company (PLN), fishers, tourists and operators of the rest areas. Given their partial knowledge on watershed services, we aimed to determine their willingness to pay (WTP) for watershed services, including how much they would be WTP, or if not willing then why. We were also interested in who beneficiaries perceived were responsible for watershed maintenance and what an indicator of a good watershed maintenance might look like.

Table 9 presents the questions asked to 99 downstream beneficiaries. They included fishers (61 respondents), tourists (22 respondents) and rest area operators (16 respondents). More than half of all beneficiaries interviewed disagreed with PWS or their WTP was IDR 0 (53%). Of this 53%, respondents included most fishers (38 respondents) and rest area operators (9 respondents). More tourists agreed to a PWS (17) than disagreed (5).

Most beneficiaries of watershed services did not respond when questioned why they disagreed with PWS (46%). A hypothetical market or PWS scenario is difficult for them to understand given their low level of education or experience with PWS schemes. Others perceived watershed management as the government's responsibility (41%) and a few stated they did not have money to pay for services (7%). The price for watershed services range from 21% of respondents suggesting less than IDR 10,000; 16% suggesting IDR 25,000; and 10% suggesting more than IDR 25,000 per year. Seventy-one percent of respondents identified stable water level at the reservoir as an indicator for good watershed management. Less popular indicators included reduced siltation, increased forest cover and cleaner water.

4. Discussion and implications

Debates on economic valuation techniques continue today (Fanning, 2016). The use of contingent valuation, although widely used, has advantages and limitations for example it may not accurately estimate real economic values (Murphy and Stevens, 2004). However, others are sure the limitations of contingent valuation can be resolved by carefully designing the study and its implementation so that biases are minimized (Carson et al., 2001). Cummings and Taylor (1999) proposed unbiased value estimates for environmental goods using calibration techniques to estimate differences in response. Our study explored another aspect of contingent valuation, namely knowledge of watershed services by both providers and users.

Payments for ecosystem services (PES) is a well-accepted concept for multipurpose natural resources management (Gaworecki, 2017). The results, however, vary considerably at policy and implementation level and the same holds true for stages of application (Gaworecki, 2017). In the Asia and Oceania regions there is a move towards PES application because it is relevant to responding to various sustainability issues affecting these regions (Rist and Dahdouh-Guebas, 2006), such as deforestation (Yurike et al., 2018), poverty alleviation (Arifin, 2005),

Table 9
Willingness to pay of beneficiaries around the reservoir.

Payment for Watershed Services Component	Response	Type of Beneficiaries			Total
		Fishers	Tourist	Rest area operator	
Willingess to Pay for PES	Disagree	38	5	9	52
	Agree	23	17	7	47
PES Range (1 USD is equal with IDR 13,500)	IDR 0	38	5	9	52
	< IDR 10,000	10	8	3	21
	IDR 10,000–25,000	9	6	1	16
	> IDR 25,000	4	3	3	10
Main reason for disagreeing with PES	No response	21	18	7	46
	I don't have money	6	1	0	7
	Declining water supply condition is not a priority problem	0	0	1	1
	Not interested in the problem	0	0	2	2
	It's the government's responsibility	34	2	5	41
	Unable to pay and it is government responsibility	0	1	1	2
Indicator of good watershed management	No response	2	7	2	11
	Stable water level at reservoir	51	7	12	70
	Reduced siltation	3	0	0	3
	Increased forest cover	2	3	1	6
	Other	3	5	1	9

climate change (Ranjan, 2019), energy demand and its distribution (Suhardiman et al., 2013), agricultural market risk (Mahdi and Yonariza, 2017) as well as biodiversity conservation (Villamor et al., 2014). This study has lessons to be learnt in other regions of the world, particularly around asymmetric information, and especially in high mountainous regions with high rainfall challenged with energy production and distribution such as in many areas of Asia and the Melanesian islands in Oceania.

Payments for watershed services (PWS) essentially are about establishing a long lasting socio-economic and ecological connection (contract) between people in the upland as service provider and people in the lowland as the user. In economic terms, it is conceptualized as upstream landholders' WTA to provide watershed services by changing their land use behavior, and WTP by downstream beneficiaries who receive the resulting watershed services. In the context of this study, WTA depends on farmers' knowledge of the benefits accruing to others if they change their land use from environmentally unfriendly practices such as shifting cultivation and other intensive cash cropping into agroforestry, and the cost of them doing so; and WTP depends on beneficiaries' knowledge of the benefits accruing to them from this change in practice, and the value of these benefits to them.

Asymmetric information can be problematic in establishing connections and designing contracts between service providers and users and it can be a factor constraining the achievement of PWS goals (Jindal et al., 2013). Previous research in Asia and Oceania has shown these knowledge gaps can reduce the effective of PWS schemes as it increase costs of implementation and inflict information rent (Ferraro, 2008). Our findings confirm this problem and show where knowledge among stakeholders in the HEPP watershed area is asymmetric. Examples of asymmetric information in our study are:

- Upland farmers did not know their farming affects watershed service production through siltation, water excess during wet season, and therefore the livelihoods of downstream beneficiaries;
- Although beneficiaries' perceptions of siltation in the reservoir were similar, across all questions, tourists were most 'unsure' or 'do not know' about this issue, most likely as they are not from the local area;
- Service providers in the upland of the HEPP watershed and beneficiaries in the lowland as the service users have different socio-economic backgrounds in terms of their access and dependencies on ecosystem services for their livelihoods, their level of education, and the infrastructure available to them (e.g. energy, transportation). These socio-economic factors have produced asymmetric information among these stakehoders. The downstream beneficiaries whose livelihood affected did not know why they received degraded watershed service and it is external to them, Externality is a strong indication of asymmetric information.

In the upland, the ecosystem perspective by farmers are narrow as they focus more on how to maximize individual benefits at the farm scale (i.e. earn a living) than the public benefits derived from their land. Knowledge on the location of their farming and ecological processes (e.g. soil erosion, water filtration) underpinning watershed services within a larger watershed area limits the potential of their focus. A similar perspective is shared by downstream beneficiaries who are limited in their knowledge of the watershed services they are receiving, and of activities delivering or impacting on these services within the broader watershed area. Hence, the providers of services do not know what the benefit of activity change is to beneficiaries; and beneficiaries of watershed services within the HEPP area do not know who to pay or what they should be paying for. These knowledge gaps are further exacerbated by the fact that watershed services are perceived mainly as a public good and there is an expectation that government should guarantee service provision.

These knowledge gaps among parties to a potential PWS scheme can produce bias in environmental economic valuations (Murphy and Stevens, 2004). Therefore, the amount of payment beneficiaries said they were willing to pay (e.g. for water and aesthetics) should only be considered an estimate until further action is taken to address asymmetric information and further enquiries about payments can be undertaken. As an example, whilst Ferraro (2008) says asymmetric information can lead to 'information rent', the phenomena on service providers being paid more than necessary to cover their PES provision costs, most evidence extracted from the Gaworecki (2017) review of 38 PES schemes from developing countries (in the Asia, Africa and South America regions) suggested that 'payments were often too low to cover the opportunity costs of agricultural development or other profitable activities that the land could have been used for'.

This study shows the importance of identifying and addressing asymmetric information in the 'predesign' of a PWS scheme (i.e. prior to any design or agreement among parties). The type of compensation farmers said they were most willing to accept was agricultural extension services (including assistance to rehabilitate paddy fields and cash money), so there is a good opportunity to address asymmetric information among stakeholders in the HEPP area. Compensation for goods purchased to apply the required change to more environmentally friendly forms of farming was the next most acceptable type of compensation identified. Hence opportunities also exist to address broader natural resource management issues through influencing markets in sustainable agricultural products and farmer knowledge on the use of pesticides and fertilizers that add nutrients to waterways and affect biodiversity.

Market forces (e.g. for rubber) have and continue to play an important role in land-use change in the HEPP watershed, often encouraging the uptake of livelihoods (i.e. fisheries and tourism) or deforestation to make way for more profitable agricultural activities. Hence, extension services alone are unlikely to address the issues of unsustainable farming practices and deforestation. Subsidies when commodity price declines for produce were also considered acceptable payments to farmers during these times. Without subsidies farmers are most likely to grow crops that provide the most return, particularly as the livelihood of the majority of farmers interviewed supported 4–6 dependents as well.

5. Conclusion

This research shows market forces are a driver of livelihoods for upland poor in the HEPP watershed. Unless watershed services enjoyed by people downstream are paid for, watershed services will continue to be undersupplied as people in the upland continue to practice environmentally unfriendly farming systems. Payments for watershed services are fairest when both parties have equal knowledge of the services being provided, the cost of delivery and their value to beneficiaries. But this knowledge is not always equal across upland providers and downstream beneficiaries especially in large watersheds where there may be a large distance between them and infrastructure is limited.

As it is likely that differences in knowledge about watershed services will create serious bias in the estimation of the willingness to pay and accept through a PES program, these asymmetric gaps must be addressed in the predesign of any PWS scheme. This information can be addressed through appropriate extension services, and this is a real possibility for the area within this study as the most farmers identified this as their preferred payment. A commodity price subsidy that responds to changing markets will ensure upland farmers maintain sustainable management practices for the uninterrupted and long-term supply of watershed services. Given the close inter-connections in natural resources, the planning and management of forestry and agricultural practices, biodiversity conservation, energy production, hazard risk reduction and freshwater use (and climate variability and change) through a PWS scheme will be best achieved through integrated and coordinated efforts across stakeholders. Clearly, further research into this problem of asymmetric information is warranted.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was funded by *Hibah Penelitian Guru Besar* or Professorship Research Grant from Andalas University contract number 524/XIV/A/UNAND, Date 9 May 2016 and contract number 52/UN.16.17/PP.RGB/LPPM/2018. We also thank two anonymous reviewers for their constructive comments to improve this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2019.100995.

References

Adhikari, K., Hartemink, A.E., 2016. Linking soils to ecosystem services – a global review. Geoderma. https://doi.org/10.1016/j.geoderma.2015.08.009.

Anon, 2003. Republic of Indonesia Kotapanjang Hydroelectric Power and Associated Transmission Line Project (1) (2) Third Party Ex-Post Evaluation Report.

Arifin, B., 2005. Opportunities in Developing Environmental Service Markets: Lessons from Institutional Studies on RUPES in Indonesia. RUPES World Agroforestry Centre, Bogor.

Beilin, R., Lindborg, R., Stenseke, M., Pereira, H.M., Llausàs, A., Slätmo, E., Cerqueira, Y., Navarro, L., Rodrigues, P., Reichelt, N., Munro, N., Queiroz, C., 2014. Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Scandinavia, Iberia and Oceania. Land Use Policy 36, 60–72. https://doi.org/10.1016/j.landusepol.2013.07.003.

Bösch, M., Elsasser, P., Wunder, S., 2019. Why do payments for watershed services emerge? A cross-country analysis of adoption contexts. World Dev. 119, 111–119. https://doi.org/10.1016/j.worlddev.2019.03.010.

Brand, J., Pfund, J.L., 1998. Site-and watershed-level assessment of nutrient dynamics under shifting cultivation in eastern Madagascar. Agric. Ecosyst. Environ. 71, 169–183. https://doi.org/10.1016/S0167-8809(98)00139-X.

Carson, R.T., Flores, N.E., Meade, N.F., 2001. Contingent valuation: controversies and evidence. Environ. Resour. Econ. 19, 173–210. https://doi.org/10.1023/A.

Chaurey, A., Ranganathan, M., Mohanty, P., 2004. Electricity access for geographically disadvantaged rural communities-technology and policy insights. Energy Policy 32, 1693–1705.

Corbera, E., Persson, U.M., Wunder, S., Baylis, K., Ezzine-de-Blas, D., Honey-Rosés, J., Börner, J., 2017. The effectiveness of payments for environmental services. World Dev. https://doi.org/10.1016/j.worlddev.2017.03.020.

Cummings, R.G., Taylor, L.O., 1999. Unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method. Am. Econ. Rev. 89, 649–665. https://doi.org/10.1257/aer.89.3.649.

Di Minin, E., Soutullo, A., Bartesaghi, L., Rios, M., Szephegyi, M.N., Moilanen, A., 2017. Integrating biodiversity, ecosystem services and socio-economic data to identify priority areas and landowners for conservation actions at the national scale. Biol. Conserv. 206, 56–64. https://doi.org/10.1016/j.biocon.2016.11.037.

Dietz, J., Hölscher, D., Leuschner, C., Hendrayanto, 2006. Rainfall partitioning in relation to forest structure in differently managed montane forest stands in Central Sulawesi, Indonesia. For. Ecol. Manage. 237, 170–178. https://doi.org/10.1016/j.foreco.2006.09.044.

Dietze, V., Hagemann, N., Jürges, N., Bartke, S., Fürst, C., 2019. Farmers consideration of soil ecosystem services in agricultural management – a case study from Saxony, Germany. Land Use Policy 81, 813–824. https://doi.org/10.1016/j.landusepol.2018.11.003.

Donato, D.C., Kauffman, J.B., Mackenzie, R.A., Ainsworth, A., Pfleeger, A.Z., 2012. Whole-island carbon stocks in the tropical Pacific: implications for mangrove conservation and upland restoration. J. Environ. Manage. 97, 89–96. https://doi.org/10.1016/j.jenvman.2011.12.004.

Dornan, M., 2015. Renewable energy development in small island developing states of the pacific. Resources 4, 490–506. https://doi.org/10.3390/resources4030490.

Dressler, W.H., Wilson, D., Clendenning, J., Cramb, R., Keenan, R., Mahanty, S., Bruun, T.B., Mertz, O., Lasco, R.D., 2017. The impact of swidden decline on livelihoods and ecosystem services in Southeast Asia: a review of the evidence from 1990 to 2015. Ambio. https://doi.org/10.1007/s13280-016-0836-z.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: an overview of the issues. Ecol. Econ. 65, 663–674. https://doi.org/10.1016/j.ecolecon.2008.03.011.

Ezzine-De-Blas, D., Wunder, S., Ruiz-Pérez, M., Del Pilar Moreno-Sanchez, R., 2016. Global patterns in the implementation of payments for environmental services. PLoS One 11. https://doi.org/10.1371/journal.pone.0149847.

Fanning, A.L., 2016. Contrasting values in the sustainability debate: limitations of economic valuations and their role in decision-making. Int. J. Sustain. Dev. 19, 185–200. https://doi.org/10.1504/ijsd.2016.077205.

FAO, 2007. Paying Farmers for Environmental Services. Rome.

Ferraro, P.J., 2008. Asymmetric information and contract design for payments for environmental services. Ecol. Econ. 65, 810–821. https://doi.org/10.1016/j.ecolecon.2007.07.029.

Friedlander, A.M., 2018. Marine conservation in Oceania: past, present, and future. Mar. Pollut. Bull. 135, 139–149. https://doi.org/10.1016/j.marpolbul.2018.05.064.

Fripp, E., 2014. Payments for Ecosystem Services (PES): A practical guide to assessing the feasibility of PES projects. Bogor.

Gaworecki, M., 2017. Cash for conservation: Do payments for ecosystem services work? [WWW Document]. URL https://news.mongabay.com/2017/10/cash-for-conservation-do-payments-for-ecosystem-services-work/ (accessed 7.19.19).

Hackett, S., Schlager, E., Walker, J., 1994. The role of communication in resolving commons dilemmas: experimental evidence with heterogeneous appropriators. J. Environ. Econ. Manage. 27, 99–126. https://doi.org/10.1006/jeem.1994.1029.

Harb, G., Badura, H., Schneider, J., Zenz, G., 2015. Silting problems in hydropower plants with low hydraulic head. Osterr. Wasser- und Abfallwirtschaft 67, 315–324. https://doi.org/10.1007/s00506-015-0246-7.

Hasan, M.H., Mahlia, T.M.I., Nur, H., 2012. A review on energy scenario and sustainable energy in Indonesia. Renew. Sustain. Energy Rev. 16, 2316–2328. https://doi.org/10.1016/j.rser.2011.12.007.

Hayes, T., Murtinho, F., Wolff, H., 2017. The impact of payments for environmental services on communal lands: an analysis of the factors driving household land-use behavior in Ecuador. World Dev. 93, 427–446. https://doi.org/10.1016/j.worlddev.

Addressing ..... Yonariza et al 2019

ORIGINALITY REPORT

7%	3%	5%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Oxford Student Paper	4%
2	zenodo.org Internet Source	2%
3	www.healthytipsadvice.com Internet Source	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		