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Livelihood Sustainability Assessment of Payment for Ecosystem Services Providers in Cidanau Watershed, Banten Province

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Abstract

The payment for ecosystem services (*PES*) *scheme in the Cidanau Watershed, Banten Province, Indonesia has yet quantified and reviewed its livelihood impacts to its providers after two decades of implementation. Therefore, this study maps the livelihood sustainability of PES farmers and non-PES farmers in the Cidanau Watershed using capital indexes based on the five livelihood capital assets of the DFID's sustainable livelihood framework. The research uses a quantitative method to formulate the livelihood capital indexes* (*LCI*) *as approximates to the subjects' livelihood sustainability based on their livelihood information and drawing implications from the results thereof. A total of 168 agroforestry farmers both from PES and non-PES group were interviewed across 12 villages in the upstream area. The results show that both PES and non-PES groups share the same pattern of capital assets sustainability with the PES group having a slightly higher human capital asset. The overall LCI calculated for the PES and non-PES groups are 0.445 and 0.48, respectively. The livelihood of both groups is deemed as not yet sustainable. The farmers would have to develop their financial and human assets to attain more sustainable livelihoods and prepare themselves towards adopting new types of PES in the future.*

Keywords: *livelihood, sustainability, resilience, socio-economy, agroforestry, PES*

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Introduction

Along with dozens of other countries in the world, Indonesia has committed to mitigating the impact of climate change through the targets set in their nationally determined contribution (NDC), which plans to reduce their carbon emissions by 29% without international support or 41% with international support in 2030 (Ditjen PPI KLHK, 2021). To reduce such emissions, payment for ecosystem services (PES) schemes are conducted in various sites throughout Indonesia, which involves conserving a certain amount of forest land to sequestrate carbon as one of the GHG emissions and maintain their ecosystem services for the surrounding living beings (Nugroho et al., 2022).

The PES scheme itself is one of the instruments that is upheld to encourage the efforts to manage environmental resources and managing the surrounding community's economy in a sustainable manner, in which parties who preserve an ecosystem or environmental service are given incentives by those who benefit from the preservation of these services (Grima et al., 2016). However, PES contribution does not always have a significant impact on the economy of the farmers or their ecosystem service providers, especially in developing and low-income countries (Zbinden & Lee, 2005; Benjamin & Sauer, 2018). It is vital that while PES schemes seek to ensure the preservation of environmental services, they do not impoverish the communities within as environmental degradation increases with poverty and vice versa (Duraiappah, 1998; Le Velly & Dutilly, 2016). In practice, PES schemes in Indonesia haven't had an official guideline, so the process of designing, implementing, and managing watershed management programs were carried out by conducting trials and errors (Amaruzaman et al., 2022).

Among these schemes, the oldest ongoing PES scheme, Cidanau Watershed in Banten Province which has been running since 2004, mainly aims to preserve the water ecosystem services along with the newly added fragment of land used for preserving biodiversity protection (Suich et al., 2017). The PES scheme in the Cidanau Watershed consists of three main stakeholders, namely: the community of farmer groups in the upstream area of Cidanau Watershed as service providers or sellers; an intermediary, *forum komunikasi DAS* Cidanau (FKDC), which is a forum whose members consist of government, non-government, NGOs, and the farmer groups themselves, and was established in 1998 to implement integrated water resources management (IWRM) at Cidanau Watershed; and the buyers, with PT Krakatau Tirta Industri (KTI), a water company who extracts water

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from the watershed directly, as the main buyer since 2004 (Amaruzaman et al., 2017; Rahadian, 2018). Until today, numerous farmer groups in the upstream area of Cidanau Watershed are still interested to join the scheme (Sunaedi et al., 2022). The majority of these farmers are smallholders or small-scale land owners with an agroforestry system (Amaruzaman et al., 2017).

Based on the previous qualitative livelihood impact research of Cidanau Watershed PES to the service providers in 2010 (Leimona et al., 2010), the scheme has increased awareness of the farmers about the existence of PES schemes and general environmental issues, such as erosion prevention, prevention of illegal logging, waste management, and the role of forests in preserving water and land services, as well as increasing the participation of farmer groups and land owners to contribute their efforts to conservation. The farmers also reported that their capacity and ability to manage their agricultural organization had increased, despite the average education level of 5 years among them (Lapeyre et al., 2015). The existence of the scheme has also expanded the network of farmer groups with the local government agencies, PES buyers, and other supporting organizations such as Rekonvasi Bhumi as the prominent local NGO, research institutions such as ICRAF, and others. This has an impact on improving the local community's economy because of the support received from the NGOs and government agencies who are involved (Leimona et al., 2010; Amaruzaman et al., 2017). PES in Cidanau initially had no impact on the economic livelihoods of its service providers. This is because the people's source of livelihood mainly depends on their forest land as their main source of income before the scheme emerged (Harbi et al., 2018). PES actually limits land clearing and logging owned by the participants, so they need alternative livelihoods (Leimona et al., 2010). Meanwhile, in the scheme, the value that the buyer (KTI) pays to the intermediary increases by IDR25 million for each 5 year period contract since 2004, starting from IDR175 million in 2004 until IDR275 million in the 2015 to 2019 contract, which were approved by representatives of the farmers themselves through an agreement (Rahadian, 2018). According to (Sunaedi et al., 2019a), the incentive received by the farmer groups is used by the members to buy livestock, for business capital, for their children's schooling fees, and for public amenities in the form of water shelters in mosques that function as restrooms. This was also noted in (Leimona et al., 2010), where in Citaman Village, one of the villages that provide the services in the upstream area of Cidanau Watershed, used the incentives to build a pipeline to serve clean water for 50 households. However, other villages who participated in the scheme did not report any kind of investments. Supposedly, the increases of incentive per contract could further provide more opportunities in terms of investments for the farmers, which increases livelihood resilience if utilized properly. This begs the question on whether there has been an actual impact and progress in the development of the PES participants' livelihood from the scheme's incentive. Moreover, there hasn't been any quantitative livelihood impact research conducted.

Therefore, this study is expected to provide new insights to Leimona's research in 2010 quantitatively regarding the PES participants livelihood conditions and issues based on the quantification of each livelihood capital asset, which consists of financial, social, physical, human, and natural capital asset as approximates to their livelihood sustainability using the recognized sustainable livelihood framework (SLF) (DFID, 1999; Carloni & Crowley, 2005). The results then could be utilized as an evaluation on how the scheme has contributed to the livelihood of its participants after 20 years of implementation and also to provide new possible recommendations inside and outside the scheme.

Methods

The main goal of this research is to examine the livelihood of farmer communities, including both participants and non-participants of the PES scheme in the upstream area of Cidanau Watershed by using the capital assets from the SLF. The indicators for each capital asset are modified accordingly to the livelihood context of the communities.

The research uses a quantitative approach. The quantitative method is used to collect the subject households' information regarding their livelihood capital assets, formulating the livelihood capital indexes as approximates to the subjects' livelihood sustainability, and drawing implications from the results thereof. Figure 1 presents the thought process of this research starting from the background research until formulating the conclusion and recommendations drawn from the results.

The research was conducted from March to April 2023. The research is conducted in Cidanau Watershed, Serang Regency, Banten Province, Indonesia, specifically in villages located at the upstream area where the service providers reside. The 12 villages are located in the Padarincang and Ciomas District, which consists of Panyaungan Jaya, Padarincang, Citasuk, Cibojong, Kadubeureum, Kadukempong, Batukuwung, Ramea, Cikumbueun, Ujung Tebu, Cisitu, and Citaman Village as depicted in Figure 2. Administratively, the total area of Cidanau Watershed is 22,620 ha (Khairiah et al., 2016; Rahadian, 2018). The land use in Cidanau Watershed is mainly used for farming, which mainly consists of farmlands at 59% such as for rice field and mixed dryland farming, followed by plantation forest at 15%, and secondary dryland forest at 13% as depicted in Figure 3. In this land cover classification, dryland farms are open pasture farmlands while mixed dryland farms consist of a mixture of open farmlands and mixed plantation forest (KLHK, 2020). Most farmers own a farmland with sizes below 1 ha, ranging from 0.2 to 0.5 ha and are used for rice fields and followed by mixed plantation (Rahadian, 2018).

Data collection and analysis The method of data collection uses a cross-sectional survey, which is a one-time data collection. The estimation for the number of sample uses the Slovin formula as shown in Equation *[1]* (Yamane, 1967) for the total population of the farmer groups who participate in the scheme with an error margin of 10%.

$$n = N/(1+Ne^2) \quad [1]$$

note: n = the number of sample, N = the total population of

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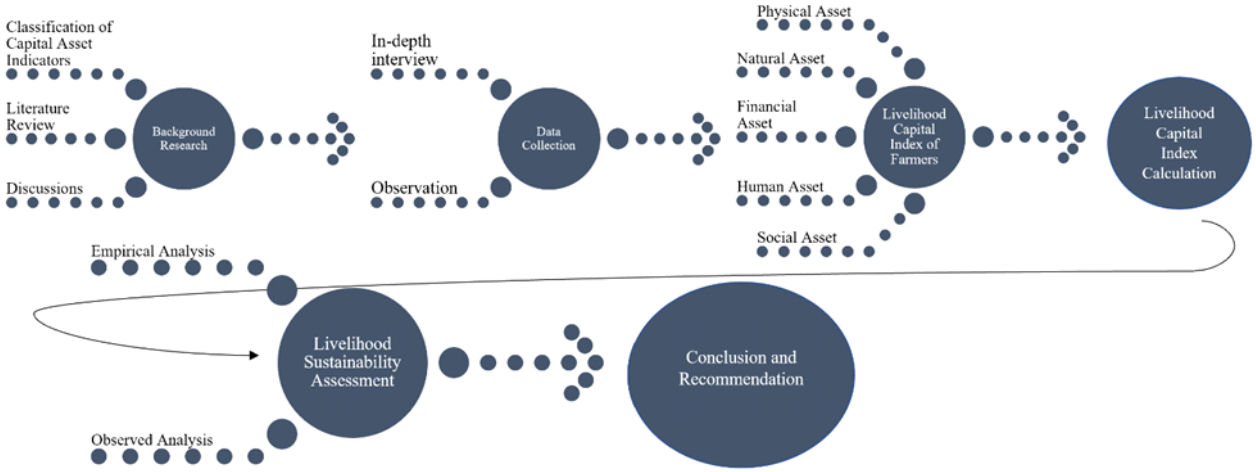

Figure 1 Research stages.

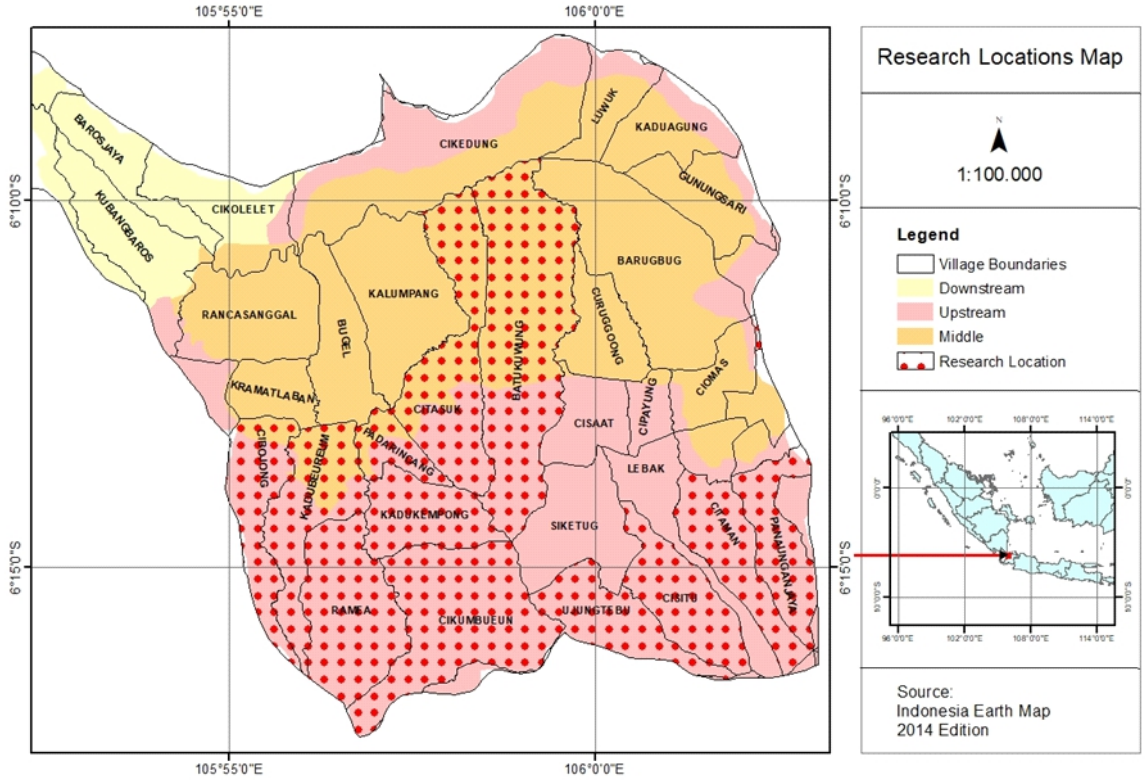

Figure 2 Research locations in Cidanau Watershed.

farmers who participate in the PES scheme, and *e* = the margin of error.

The resulted number from that population is also used for the non-participants, as there is no recent data regarding the total number of the non-participants and to give the same proportion of comparison between the two groups. The sample of farmers are stipulated using a purposive sampling technique which includes the criteria as follows: landowners or agroforestry farmers in the upstream area of Cidanau Watershed; have a household or contribute to their household's income; belong in a farmer group, and reaches the minimum working age. The instrument of the data collection is a questionnaire, which is used through interviews conducted in the villages.

Accordingly, the total population of the existing farmer groups who are PES participants reaches a number of 520 farmers. Using the Slovin formula, a total of 168 farmer households data was stipulated and collected, which originates from the resulting number of 84 from the total number of farmers who are PES participants and multiplied by two as the number is also for the non-PES farmer groups to give a fair comparison.

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Sustainable livelihood framework Assets owned between families in a community or between individuals in a family can vary, because the outcome of each of their activities may differ due to different influences by the transforming structures and processes that encompass them. The key point is that it creates a trend of how their jobs and their surrounding amenities contribute to their well-being and self-sufficiency (DFID, 1999; Carloni & Crowley, 2005). The results would then be analyzed along with the previous and relevant research data. The SLF framework along with the five capital assets pentagon are depicted in Figure 4.

The pentagon is used to show and describe the differences in people's access to the livelihood capital assets depending on how large or small the percentage of the asset's availability within the shape from the lowest (center) to the highest score (edge). These capital assets are related to one another, as one's availability may enhance the other through productive activities. The assets consist of natural capital, financial capital, human capital, physical capital, and social capital. Natural capital is the natural resources that are available to access, such as size of land and useful resources for the fulfilment of livelihood which are determined. Financial capital is namely people's income and savings, which encourages the capability of pursuing the goals in livelihood strategies. Social capital is namely the scope of a community's social network and potential reach to the outside world which could be drawn upon pursuing livelihood strategies that require collaboration and coordination.

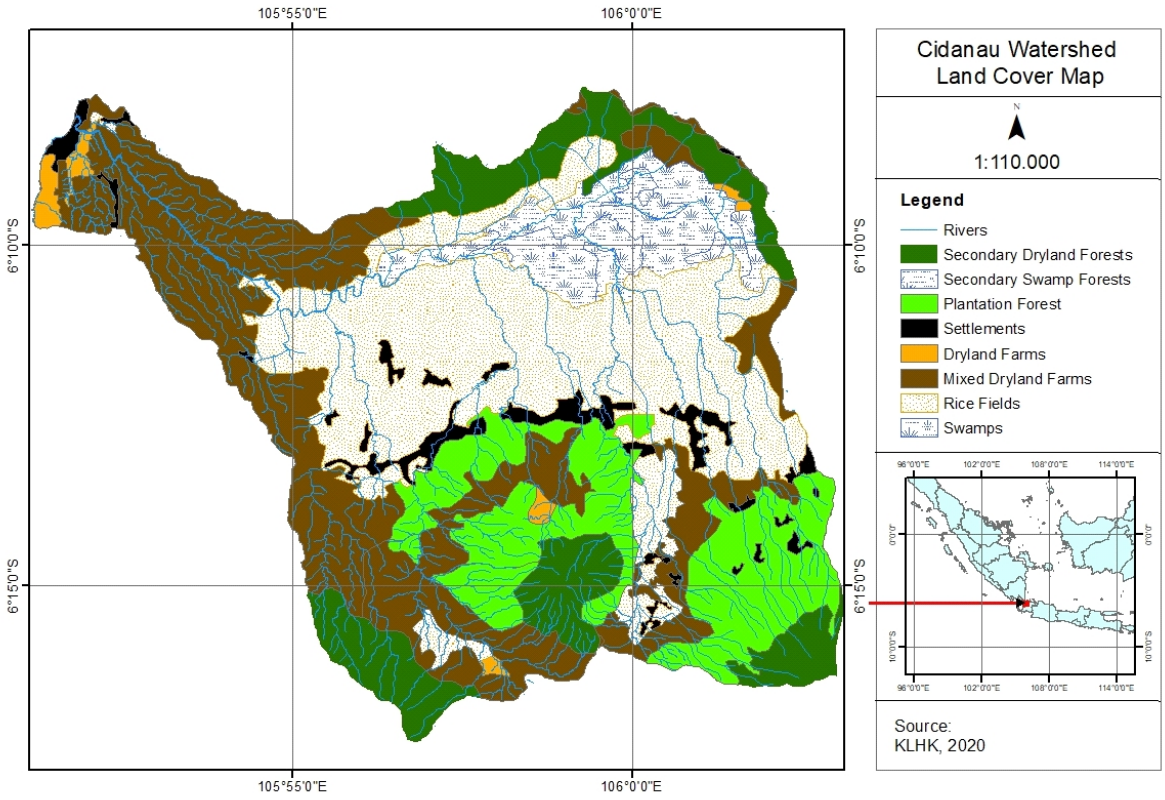

Figure 3 Cidanau Watershed land cover map.

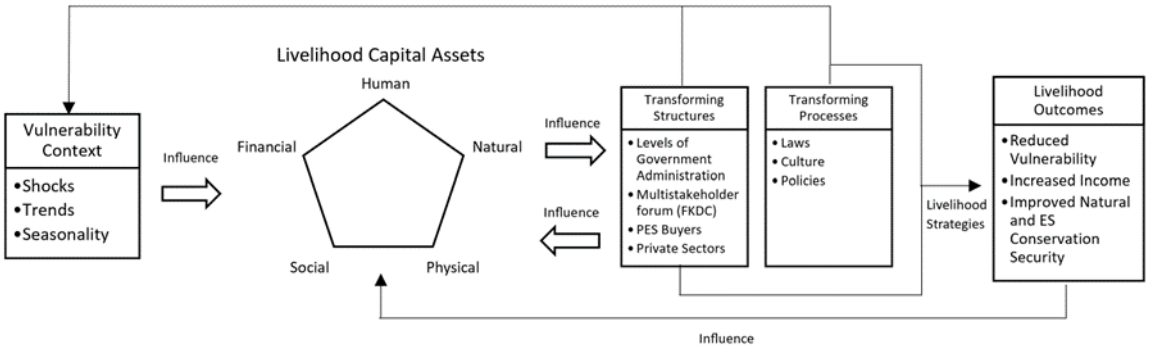

Figure 4 Sustainable livelihood framework. Source: DFID (1999), redrawn according to context.

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Physical capital is namely a community's access towards infrastructure, healthcare, public amenities, and transportation, which in general support the fulfilment of people's needs and productivity. Lastly, human capital is namely the skills, knowledge, ability to labour and fitness for people to achieve their daily goals, (DFID, 1999). These assets are able to be associated with influences from policies, institutions, and other bodies which may enable or disable a community's access towards their assets, measure an approximate towards a community's vulnerability to shocks before falling into poverty, and accordingly, draw up the strategies to meet the lack of livelihoods in the future through appropriate development program interventions (DFID, 1999; Carloni & Crowley, 2005).

Livelihood capital index (LCI) To analyze the five livelihood capital assets, the calculation of LCI was applied to identify the sustainability of each livelihood capital assets for both participants and non-participants. The calculation of LCI is based on the indicators that are stipulated under each of the five livelihood capital assets that represent the farmers' livelihood under the context of the PES scheme's impacts (Hahn et al., 2009; Tran et al., 2021) with the stipulation of indicators reflecting from previous agricultural and livelihood studies (Gayen et al., 2019; Awazi & Quandt, 2021; Nasrnia & Ashktorab, 2021; Tran et al., 2021; Guo et al., 2022; Pham et al., 2022). The stipulation of sub-components and their indicators for the five livelihood capital assets along with their references for this research are listed in Table 1. Along with the capital assets, the survey also includes answers from the farmers regarding their livelihood, community, and environmental issues that are deemed necessary and relevant with their assets.

Initially, the data that are collected for the sub-components will have different units according to the context of indicators that they are in such as income, education, area, etc. Therefore, these units are needed to be standardized in order to become indexes. The calculation of the index is stipulated as shown in Equation *[2]*.

$$Index_{sd} = \frac{Sd - Smin}{Smax - Smin} \qquad [2]$$

note: *Sd* is the sub-component data under the indicators that comprise a capital asset, which is collected in area *d*, for example in group *d*. Meanwhile, *Smax* and *Smin* are the maximum and minimum value respectively. Then, after the unit of the sub-components are standardized, the standardized values are averaged using the calculation as shown in Equation *[3]*.

$$M_d = \frac{\sum_{i=1}^{n} Index_{Sdi}}{n} \qquad [3]$$

note: *Md* is the average value of one indicator, which then will be added into the calculation of the overall livelihood capital index. $Index_{Sdi}$ shows that the number of indicators is *n* in a capital asset with indicator *i*. Once the indicators have been averaged, the calculation of the livelihood capital index (LCI) as shown in Equation *[4]*.

$$LCI_d = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{Mi}} \qquad [4]$$

LCI_d shows the overall livelihood capital index of a capital asset in group *d*, which is the result of the calculation of the averaged indicators from Equation *[2]*. W_{Mi} in this case is the weighted indicators which is determined by the number of sub-components contributing to the calculation of the indicators. LCI_d is valued from 0 to 1, which ranges accordingly from minimum to maximum (highest) possible sustainability.

Results and Discussion

Characteristics of the farmers Table 2 presents the general household data of PES and non-PES farmer households which consists of 84 farmers in each group. The data was gathered from the survey using the pre-defined questionnaires and then calculated using Microsoft Excel. This data also accounts for the LCI calculation. Generally, out of all the farmers that were able to be interviewed, only 11% are female. The data shows that 76% of the farmers from both groups only graduated from primary school. Only a few of those attain a higher level of education and still take up farming. It is found that regarding the farmers' awareness or knowledge of the PES scheme, 76% of farmers in the non-PES group does not know or is not aware about the ongoing PES scheme in Cidanau, even after 20 years of implementation. Reflecting on the index value of additional jobs, the majority of farmers rely on their land for their main source of livelihood which accounts for the 61% of farmers. Most of the farmers have only 1 variant of land, which is a mixture of crops and trees (agroforestry). Some farmers have 2 variants, which the other is utilized for the conventional agricultural land, such as a rice field or other crops. In general, most farmers also have 4 to 5 family members in their household with the average income of PES group slightly higher than the non-PES group. The detailed data of the income range comparison between the groups in Rupiah can be seen in Figure 5.

To account for the percentage of poor households, this research uses the poverty line according to (BPS Serang Regency, 2023), which is stipulated at IDR385,864 or around USD25 (XE Currency, 2023). The resulting data shows that the non-PES group has a higher percentage of poor household compared to the PES group. However, both groups have around the same amount of household who receive livelihood supports from the government at around 17%. The support varies in each household, which ranges from family hope program (PKH), non-cash food assistance (BPNT), united Banten People's social security (Jamsosratu), and village fund direct cash assistance (BLT DD). This data reveals that households who are not poor (have an income above the poverty line) still receive monthly government aid programs, with 17% of households receiving the aid, even though there is only 4% who are found to be poor in total. This finding is in line with the research conducted by (Nugroho et al., 2021), where the intended target of poor and nearly-poor households (bottom four of income decile) in most poverty eradication programs are poorly targeted.

Livelihood sustainability analysis based on the LCI The livelihood sustainability diagram of the farmers in PES and non-PES group is represented in Figure 6, with the details of each sub-component index value presented in Table 3 and the details of the statistics in Table 4. It can be derived from

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Table 1 Assets indicators and their sub-components

Capital	Sub-components	Sub-components definition	Reference
Financial	Channel of sales	The number of channels that the farmer is able to reach to sell their land products.	Modified from (Tran et al., 2021)
	Savings per period	The value that the farmer is able to save per month from their income	Guo et al. (2022)
	Active bank account	Whether the farmer has an active bank account at their disposal	Awazi and Quandt (2021); Nasrnia and Ashktorab, (2021)
	Income per period	The farmer's approximate income per month (the value is uncertain due to unpredictable harvesting seasons)	Tran et al. (2021); Guo et al. (2022)
	Additional jobs	The number of additional livelihoods that the farmer has	Hahn et al. (2009; Nasrnia and Ashktorab, (2021); Tran et al. (2021); Pham et al. (2022)
Natural	Size	The amount of land that the farmer possesses	Awazi and Quandt (2021) ; Nasrnia and Ashktorab (2021); Guo et al. (2022)
	Amount used	The amount of land that is used from the total amount that the farmer possesses	Modified from (Guo et al., 2022)
	Variants	The number of different types of productive land that the farmer has	Modified from (Awazi & Quandt, 2021; Nasrnia & Ashktorab, 2021)
	Slope	The degree of slope on the farmer's land	Gayen et al. (2019)
	Individual or collective	Whether the ownership of the farmer's land is fully for his/her or with another person/group	Modified from (Awazi & Quandt, 2021; Nasrnia & Ashktorab, 2021)
Physical	Cooking	Whether the farmer uses wood and/or LPG (liquid petroleum gas) for their stove	Modified from (Tran et al., 2021)
	Washing facility	Whether the farmer has a toilet in his/her residence	Modified from (Tran et al., 2021)
	Vehicle	The number of transportation that the farmer possesses in his/her household	Modified from (Tran et al., 2021)
	Farming	Whether the farmer's farming tools and materials is adequate for their farming needs	Nasrnia and Ashktorab (2021)
	Farm water resource	The quality of the farmer's water resource on their land	Awazi and Quandt (2021); Nasrnia and Ashktorab (2021)
	Road quality	The quality of the road paving and infrastructure that the farmer goes by daily	Modified from (Nasrnia & Ashktorab, 2021; Tran et al., 2021)
	Health access	The farmer's convenience to access healthcare from his/her household	Modified from (Hahn et al., 2009)
	Health service	The quality of service of the nearest healthcare that the farmer can access	Modified from (Hahn et al., 2009)
Human	Level	The education level that the farmer was able to graduate, from preschool to diploma and above	Awazi and Quandt (2021); Nasrnia and Ashktorab (2021); Tran et al. (2021); Guo et al. (2022)
	Training	The approximate number of relevant training that the farmer has attended until now	Modified from (Guo et al., 2022; Pham et al., 2022; Tran et al., 2021)
	Organization skills	The farmer's experience and ability to manage an organization	Modified from (Nasrnia & Ashktorab, 2021)
	Machinery skills	The farmer's ability to operate and comprehend farming tools and machines, and whether he or she uses them daily	Modified from (Guo et al., 2022)
	Able-bodiedness	Whether all of the farmer's household members are able to work or contribute to their livelihood	Guo et al. (2022); Hahn et al. (2009); Nasrnia and Ashktorab (2021)
Social	Active Organizations	The number of active organizations that the farmer currently participates in	Awazi and Quandt (2021); Tran et al. (2021); Guo et al. (2022)
	Participation in social events	The number of social events that the farmer attends regularly in a month	Modified from (Tran et al., 2021)
	Friends	The number of friends that the farmer thinks he/she has	Guo et al. (2022)
	Trust	The number of friends or relatives that the farmer can rely on when he/she needs help	Guo et al. (2022)

Figure 6 that generally, both groups have relatively low livelihood sustainability at below 0.5, where specifically financial and human asset of the farmers are in the least sustainable condition, ranging from 0.26 to 0.31. On the other hand, natural asset is the most sustainable among the other capital assets for both groups valuing at around 0.65, followed by social asset and physical asset above 0.55. Both PES and non-PES group share the same pattern of their livelihood capital assets sustainability, with the PES group having a slightly higher human capital index compared to the non-PES group with a margin of 0.038. However, the overall LCI calculated for the PES and non-PES group are 0.445 and 0.48, respectively, which shows that both groups have almost the same value of overall LCI. This higher overall LCI of the non-PES group is due to the slightly higher capital index in financial, natural, physical, and social than the PES group.

Overall, the results of the livelihood sustainability index assessment are in line with the results of the analysis

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Table 2 Characteristics of farmer households

Characteristics	Average	
	PES (n = 84)	Non-PES (n = 84)
Gender (person)		
Male	72	80
Female	12	4
Education (%)		
No education	4	5
Primary school	64	63
Middle school	17	13
High school	13	18
Diploma and above	2	1
Hous eholds		
Poor households (%)	1	7
Households who receive government support (%)	18	17
Household members (avg)	4. 62	4.7
Income (avg, IDR)	1,663,462	1,548,611
Attended training courses (%)	79	46
Knowledge of PES (%)	99	24
Additional jobs (avg)	0.39	0.4
Land		
Size <1 ha (%)	37	52
Size 1–2 ha (%)	49	43
Size >2 ha (%)	14	5
Slope (avg, 1 = flat, 0.5 = sloped)	0.96	0.97
Variants (avg)	1.11	1.25

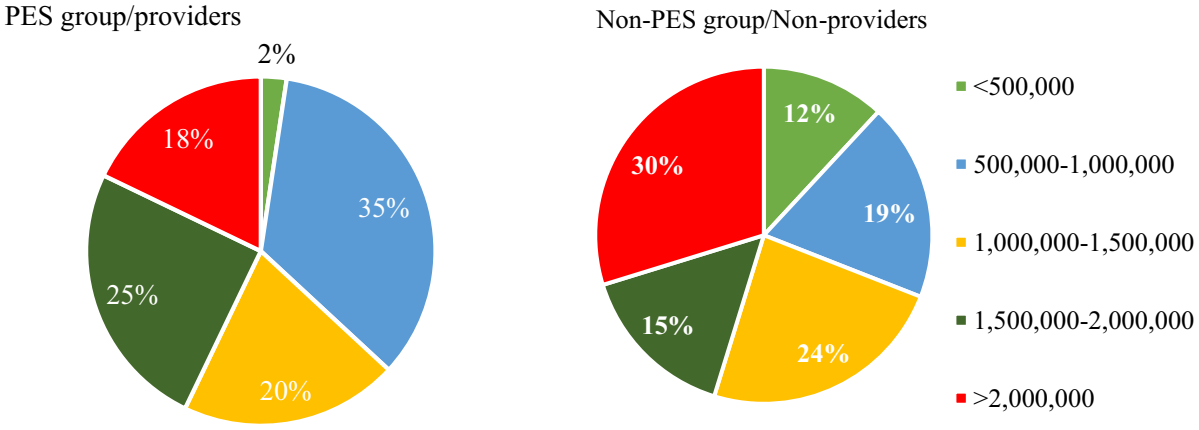

Figure 5 Total income per month of respondents per group in IDR.

conducted by (Rahadian, 2018) regarding the Cidanau Watershed service providers, which are: the farmers are dependent on their farms to meet their livelihood needs; the average education level of the farmers is that they have not completed their elementary school; and the farmers lack the desire, knowledge, and ability in developing innovations and utilizing agricultural technology to optimize their land use. Additionally, these results also appear to be similar with (Blundo-Canto et al., 2018; Z. Liu & Kontoleon, 2018), which showed that PES schemes in average provided more positive than negative impacts to the livelihood of its providers, albeit insignificantly.

Natural capital The diagram in Figure 6 shows that the natural capital index for both PES and non-PES group are quite similar, which are 0.652 and 0.667, respectively. The detail for each sub-component is broken down in Table 3 and the comparison between the two groups are presented in Figure 7, where the index value calculation for the land size that the farmers in PES group is significantly higher than the non-PES group while the non-PES group is notably higher in having the variants of land use. Other values such as the amount of land used, slope, and individual or collective type of use are quite similar in each group. The finding shows that most of the farmers own their land which is entirely used for

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Table 3 Index value of each sub-component

Capital	Sub -components	Index value		Mean value	
		PES	Non -PES	PES	Non -PES
Financial	Channel of sales	0.67	0.68	0.26	0.27
	Savings per period	0.05	0.02		
	Active bank account	0.27	0.32		
	Income per period	0.12	0.11		
	Additional jobs	0.20	0.20		
Natural	Size	0.26	0.19	0.65	0.67
	Amount used	0.98	0.98		
	Variants	0.11	0.25		
	Slope	0.92	0.93		
	Individual or collective	1.00	0.99		
Physical	Cooking	0.57	0.54	0.55	0.56
	Washing facility	0.49	0.48		
	Vehicle	0.21	0.22		
	Farming	0.48	0.44		
	Farm water resource	0.73	0.65		
	Road quality	0.69	0.82		
	Health access	0.61	0.69		
	Health service	0.62	0.67		
Human	Level	0.49	0.49	0.31	0.27
	Training	0.30	0.18		
	Organization skills	0.26	0.19		
	Machinery skills	0.06	0.11		
	Able-bodiedness	0.45	0.41		
Social	Active organization	0.26	0.27	0.58	0.61
	Participation in social events	0.76	0.68		
	Friends	0.69	0.83		
	Trust	0.61	0.64		

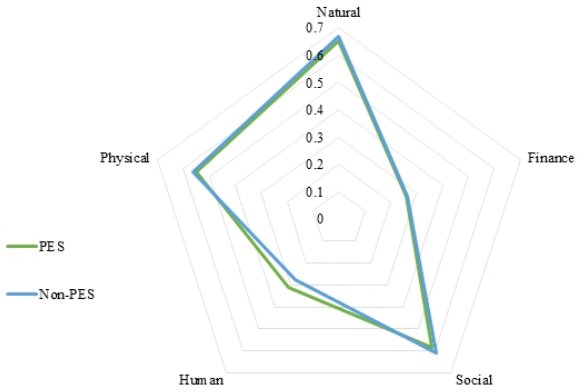

Figure 6 Livelihood sustainability diagram of PES and non-PES farmers.

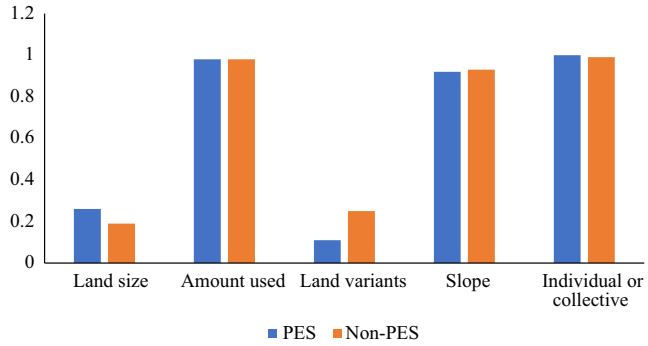

Figure 7 Comparison of natural asset index values between PES and non-PES groups.

their own disposal, which they could utilize for their daily consumption. Most farmers acquired in this research has a farming land size of 1 ha and slightly above, with more ownership in the Non-PES group. Usually, farmers whose land size are above 2 ha, pay cultivators (*penggarap)* who usually do not own a land to manage and tend their land. The cultivators will get a share of profit from the total harvesting revenue. On the other hand, there are farmers who work an additional job as farm labors (*buruh tani*), which are paid daily to plant or manage another farmer's land (Roy, 2021). Based on the index value calculations in Table 3, most of the farming lands are safe from erosion because of the latosol soil type commonly found in Padarincang, Ciomas, and Mandalawangi Sub-districts. Latosol soils are generally not prone to erosion and have a relatively small chance of eroding due to water runoff (Olivetti et al., 2015). This is also

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Table 4 Sub-component units, average, and standard deviation

Capital	Sub-components	Indicator of sub-components	Average		Standard deviation	
			PES	Non-PES	PES	Non-PES
Financial	Channel of sales	Number of channels	1.33	1.36	0.50	0.51
	Savings per period	IDR per month	108,353.17	45,833.73	336,225.83	163,107.06
	Active bank account	Number (0 = none, 1 = have)	0.27	0.32	0.45	0.47
	Income per period	IDR per month	1,663,462.30	1,548,611.11	1,845,679.19	1,536,247.40
	Additional jobs	Number of additional jobs	0.39	0.40	0.49	0.52
Natural	Size	Hectares	1.37	1.03	0.96	0.76
	Amount used	Percentage	0.99	0.99	0.05	0.06
	Variants	Number of different type of farmland use (forest, farm)	1.11	1.25	0.31	0.44
	Slope	(1 = flat to slightly inclined, 0.5 = inclined, 0 = very steep)	0.96	0.97	0.13	0.12
	Individual or collective	(individual = 1, collective = 0)	1.00	0.99	0.03	0.11
Physical	Cooking	(LPG = 1, wood & LPG = 0.5, wood = 0)	0.57	0.54	0.31	0.31
	Washing facility	(flush toilet = 2, squat toilet and dipper = 1, None = 0)	0.98	0.95	0.22	0.21
	Vehicle	Number of vehicles	1.07	1.08	0.71	0.70
	Farming equipment	(1 = satisfied, 0 = not satisfied)	0.48	0.44	0.50	0.50
	Farm water resource	(Likert scale, 1 = very poor, 5 = very good)	0.73	0.65	0.26	0.28
	Road quality		0.69	0.82	0.21	0.21
	Health access		0.61	0.69	0.28	0.22
	Health service		0.62	0.67	0.18	0.21
Human	Level	(0 = not schooled, 1 = elementary, 2 = primary school, 3 = middle school, 4 = high school, 5 = diploma and above)	2.43	2.43	0.94	0.99
	Training	Number of participated training activities	3.35	1.98	2.06	2.27
	Organization skills	(0 = no experience, 0.5 = has experience somewhat, 1 = confident)	0.26	0.19	0.28	0.33
	Machinery skills		0.03	0.05	0.12	0.16
	Able-bodiedness	Number of productive working members in the household divided by total number of household members	0.55	0.51	0.18	0.20
Social	Active organizations	Number of active organizations currently in	2.05	2.10	0.31	0.57
	Participation in social events	Number of social events participated per month	3.82	3.39	0.87	1.46
	Friends	Number of friends claimed to have	4.77	5.33	1.37	1.31
	Trust	Number of people outside of the household that can be relied on	4.45	4.56	1.29	1.28

supported by the statements from the farmers that the most common occurring disaster is flooding.

As an additional information, when asked about the environmental issues on their farm, 65% of farmers mentioned pests to be the problem, followed by drought during dry seasons at 8%, soil contamination due to chemicals at 4%, and the inability to harvest some commodities for years due to the weather at 3%. This data is depicted in Figure 8. Some farmers commented that the pest problem persists due to the farmers lack of knowledge and equipment on how to treat them, which as stated in the physical capital section, the lack of equipment such as grass cutters and sprayers is evident. This is also supported by the low human capital index, specifically regarding the low index value of training and machinery skills.

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However, this finding of natural capital does not accommodate the land productivity as it is assumed that they are based on the human and physical asset which represents the farmer's ability and facilities in managing their land, where higher human and physical asset would result in a higher financial revenue (Ma et al., 2018; Liu et al., 2021). Furthermore, (Lan et al., 2021) found that physical, natural, and financial asset are mutually dependent among agriculture-based livelihood. This finding only signifies the available natural capital assets at the farmer's disposal and their susceptibility to natural disasters such as erosion based on its sloping (Gayen et al., 2019; Lan et al., 2021).

Financial capital Among the five capital assets, financial capital in both groups is the lowest and least sustainable. The financial capital index of the non-PES group is slightly higher than the PES group with the value of 0.27 and 0.26, respectively. The comparison of financial capital index values between the two groups is shown in Figure 9. There is very low number of farmers that are able to create savings from their income. This small number shows that most of the farmers barely have enough to spend for their household needs. It is found that more farmers in the PES group are able to save a portion of their income than the non-PES group as stated in Table 3 and Table 4. Statistically, based on Table 4, the standard deviations of savings and income per period are higher than their average, which shows that there is high difference compared to the mean regarding the value of income and savings per month among farmers. A high standard deviation value indicates a high variation in income values among farmers, where some farmers have very high incomes, while some have very low incomes despite the average income of IDR1,500,000. On the other hand, more farmers in the non-PES group have an active bank account than in the PES group. The bank account herein signifies the farmer's access to a savings account and knowledge of banking, which contributes to the increase of his or her overall livelihood resilience, as a study in Cameroon found that farmers who are more educated are more likely to have access to a bank account, own more farm plots and land holdings, and also plant more trees on their farms (Awazi & Quandt, 2021).

Both groups have a similar value in having the number of channels to sell their land products, where specifically most farmers use middlemen only (48%), followed by middlemen and local market (36%), local market only (14%), and others, which is through social media or by selling manually (2%). The visualization of this data is depicted in Figure 10. The difference in market channel choice influence the farmer's welfare through the selling price of agricultural products that they receive (Mmbando et al., 2017). It was found that most farmers choose a middleman due to their friendship with the middleman and the convenience of selling the product, saving their time and energy, which is in line with the results in (Imaniar & Brata, 2020). As an additional information, there are about 26% of farmers in the PES group and 24% in the non-PES group that reported to have debts with varying reasons, such as for daily needs, schooling fees, medical bills, house construction, vehicle credit, farming equipment, loans, and business capital. From the interviews, it was known that farmers usually pay in installments for their vehicles and house constructions, while for daily needs or farming capital, some farmers informally indebt themselves to their neighbors or relatives, owing money or other forms of repayment.

Even though the PES group receives incentive from their contract twice per year, the reason why the non-PES group has almost the same income index value as the PES group could stem from several factors, such as due to the small

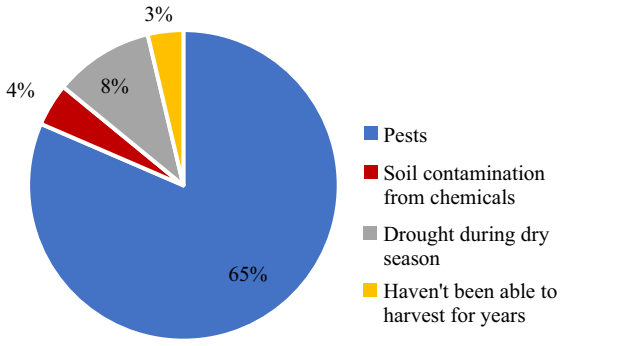

Figure 8 Overall issues on farming land.

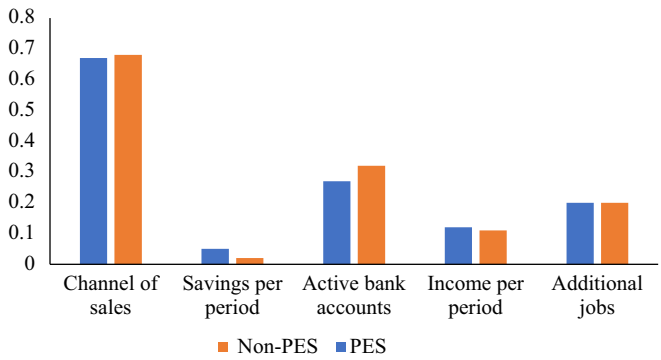

Figure 9 Comparison of financial asset index values between PES and non-PES groups.

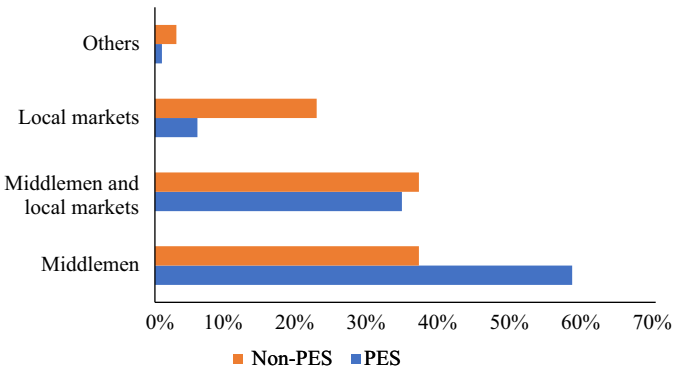

Figure 10 Comparison of the channel of sales between PES and non-PES groups.

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incentive from PES given per year to each household is not significant and more apparent to the amount able to be saved. The non-PES groups could also have a quicker access to cash by felling trees (Melvani et al., 2022) or through more farmers receiving government support programs, which supported their income numbers as stated in Table 3 and Table 4. As noted in the interviews, the incentive received twice per year varies to PES farmers, as it is based on the size of land that the farmer owns. Farmers whose land are smaller will receive a smaller value of incentive. Thus, it will create a smaller amount to save and most likely spend the incentive for household needs rather than saving or investing for long-term and collective needs such as farming tools to increase livelihood resilience. This is in line with the results in (Sunaedi et al., 2022) as the incentives are actually used to pay for monthly electricity bills.

As most farmers rely on their farms for their main source of livelihood, most have only one channel and a limited amount of input for their income. This is also shown with the low value of income per period in both groups. This finding is in line with (Leimona et al., 2010; Sunaedi et al., 2022) which found that most farmers in Cidanau Watershed rely on their farms as their main source of income and have a below average income. After 20 years of the scheme's implementation, there seems to be no difference of alternative livelihoods between both groups.

There are also a number of reasons that contribute to why the financial capital asset index is low in both groups. Additional information in the interviews showed that the farmers income has reduced since some fruits such as durian in the area weren't able to be harvested for 3–4 years due to the lack of sunlight from the weather. According to the farmers, durian itself could contribute a substantial amount of income from around IDR8 to 12 million year^{-1} if harvested and considered as a high value commodity, in line with the results from (Sunaedi et al., 2022). Pests and drought during dry season on the land also contributed to the loss of income due to the reduced quantity and quality of harvest.

It was also found that for their business capital, farmers don't know where to access and search for, and who to contact for possible investors and networking. Aside from that, the farmers' businesses are not optimally guided by the local government. According to the research that was conducted by (Atmaja, 2019) in Padarincang District, the village government's role in developing the village's entrepreneurship is limited to only proposing the participants who will take part in training activities. There has not been any extensive field guidance implemented to the prospective farmers to develop their business. Therefore, most of the farmers have to develop their business by relying on themselves and their network.

However, this capital doesn't account for the economic valuation of the natural assets that they have on their farmlands, such as crops for consumption noted in (Sunaedi et al., 2022), as this merely signifies the amount of money that they receive from their periodical sources of income and the amount that they able to spend to fulfill their daily needs.

Social capital The social capital index for PES and non-PES group are 0.583 and 0.606, respectively. The comparison of their index values is shown in Figure 11. This shows that both group's social capital is relatively similar. The PES group has a higher index value when it comes to participating in social events compared to the non-PES group. According to previous PES impact studies (Pham et al., 2022), PES may increase a community's social connectivity. This higher value in the PES group originates from attendance of the scheme's training activities which the participants are given and more group gatherings. Therefore, PES has indeed increased the frequency of social event participation among its farmers. Meanwhile, the non-PES group reportedly have more friends and people that they could trust compared to the PES group, which contributes to their higher social capital. The social capital in this research are in line with the results in (Leimona et al., 2010; McGrath et al., 2018) where social connections and interactions in the area are found to be high between neighbors and farmers. All in all, both groups signify that frequent interaction and mutual help are common occurrences among them.

In relation with other capital assets, social capital is affected by financial and human asset (Liu et al., 2021). However, despite both financial and human asset being considerably low, the social capital index is quite high. Furthermore, in this research, the social capital sub-components do not account for possible connections with the financial and human asset. The index only signify how close and frequent interactions are between the farmers.

Physical capital The diagram shows that the physical capital index for PES and non-PES group are 0.550 and 0.562, respectively. The comparison of the index values is shown in Figure 12. This indicates that both groups physical capital is quite similar with each other. The non-PES group has a higher physical capital index due to the higher index values of the farmers' perception towards their road quality, health access, and health service in their area. Otherwise, the PES group has slightly higher index values for their amenities, which include the type of cooking stove, toilet in their houses, farming equipment, and farm water resource compared to the non-PES group as described in Table 3.

For the amenities, it was found that 61% of the farmers in total cook with a mix of using LPG and wood, followed by LPG only at 25%, and wood only at 14%. Specifically, 62% farmers in the non-PES group use a mixture of wood and LPG for their stove while the PES group is 60%. Around 13% of farmers in the PES group and 15% in the non-PES group use wood only, while there are 27% farmers in the PES group and 23% farmers in the non-PES group who can use only LPG as their daily appliance. These numbers are sensible, as farmers in the PES group are prohibited to use wood from their tree stands (Sunaedi et al., 2019b) and more able to afford an LPG with the incentive from the scheme. The PES farmers who use wood only claim that they use the available wood litters that they could gather from their land. For washing facility or toilet, most of the farmers use a squat toilet and dipper (*toilet jongkok dan gayung*) which is common in village areas. One farmer from the PES group has a flush toilet. However, 5% of the farmers have no toilet in their residence and this number applies for both groups. This results in people defecating in the forest land. For farming equipment, 50% of the farmers in total stated that they need grass cutters for weeding, 35% stated that they

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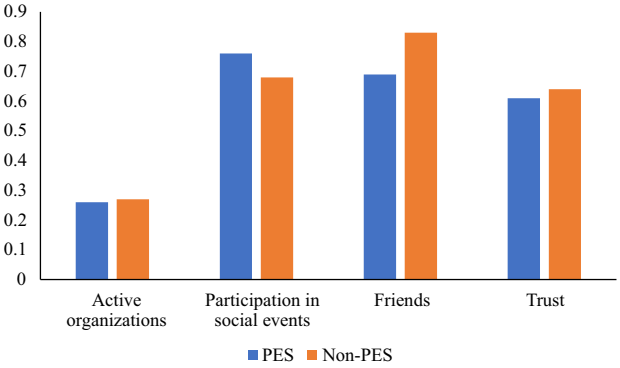

Figure 11 Comparison of social asset index values between PES and non-PES groups.

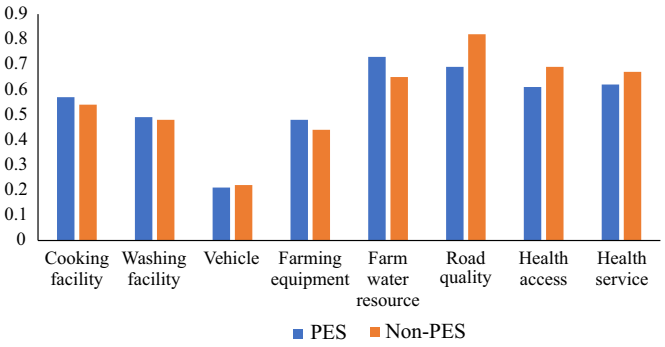

Figure 12 Comparison of physical asset index values between PES and non-PES groups.

need sprayers for applying pesticides, watering, or liquid fertilization, 20% stated that they need fertilizers, and 16% stated that they need cultivators for plowing. However, this research only accounts the statement from the farmers and does not account for the actual equipment that they have, as some farmers don't have the knowledge of the items and that preliminary research regarding the tools was not conducted. Overall, this shows that most farmers do not have the mechanical farming equipment to tend to their farms. For vehicles, 68% of farmers in total have only one motorcycle, while 18% have more than one and may have a car, and the other 14% have no transportation. This shows that most farmers have access to private transportation. For farm water, 79% of farmers in total reported to have an irrigation system of pipes connected to the water spring on their land while 19% have no irrigation at all, and 2% collects from the river. Those who don't have irrigation may have difficulties to fetch water, by using a sprayer or other means to water their plants. The figures for these amenities are presented in Figure 13.

However, 31% of those who do not have access to water piping system on their farms complained that they suffered drought on their land during dry seasons. Meanwhile, 5% of those who have water piping stated that the pipes are too far to access, 3% complained that the pipe infrastructure are still insufficient, and 12% complained that they still experience drought on their land despite having the water pipes.

The sub-components for farm water, road quality, health access, and health service were assessed based on Likert scale scoring from 1 to 5, and may produce inaccuracies due to subjectivities. Despite the high index values, it was found that some areas have low scores in road quality such as due to unrepaired roads in Kadukempong Village and unbuilt roads in Cikumbueun Village. Many farmers across the villages complained about the distant access to health services despite giving a score of 3 and above. There are also many complaints regarding the unoccupied local healthcares and their poor services.

Human capital The human capital index shows an overall of 0.313 and 0.275 for the PES and non-PES groups, respectively. Along with the financial capital index, the human capital index of the farmers in DAS Cidanau is considered one of the least sustainable. The comparison of index values between the groups is shown in Figure 14. Most of the index values are similar with each other. However, the PES group excels at both training and organization skills with a significantly higher value than the non-PES group at 0.30 to 0.18 and 0.26 to 0.19, respectively. It was stated from the interviews that the training activities held by the PES network can increase the farmers' understanding on how to manage their farmlands which is in line with the previous research (Leimona et al., 2010; Amaruzaman et al., 2017; Sunaedi et al., 2019b). Accordingly, the PES scheme has expanded the networking and facilitated numerous capacity-building sessions for the farmer groups who participate through training activities, new information channels, insights, and organization in the framework of conservation, which contributed to the higher index values for training and organization skills of the farmers in the PES group. However, the training activities do not seem to affect the livelihoods of the PES farmers compared to the non-PES farmers based on their other livelihood capital index values. It is assumed that the capacity-building sessions has not contributed to the increase of financial support that can be utilized by the PES farmers in general. As found in (Rahadian, 2018), this could stem from the lack of desire, knowledge, and ability to change from the farmers and that they should be actively guided and properly prepared for their business investments and networking.

The low education level of farmers who mostly graduated from primary school, makes for the low value of human capital index and lower still is the training and organization skills. As observed in the interviews, most farmers struggle to read, comprehend, and learn new concepts. In addition, most farmers seem to be unfamiliar with mechanized farming tools or other technologies based on their machinery skills index scores. This indicates that they rarely use automated tools in their work, including automated farming tools. Overall, this hinders their ability to acquire an alternative livelihood and renders them more vulnerable to shocks. Those who have higher assets in general may have a higher chance to withstand shocks to protect their livelihood from economic, ecological, and/or social disturbances (DFID, 1999; Carloni & Crowley, 2005), as human asset signifies the farmer's knowledge and makes them more aware of their livelihood risks while also improving their ability to access and utilize information to deal with livelihood risks (Kuang

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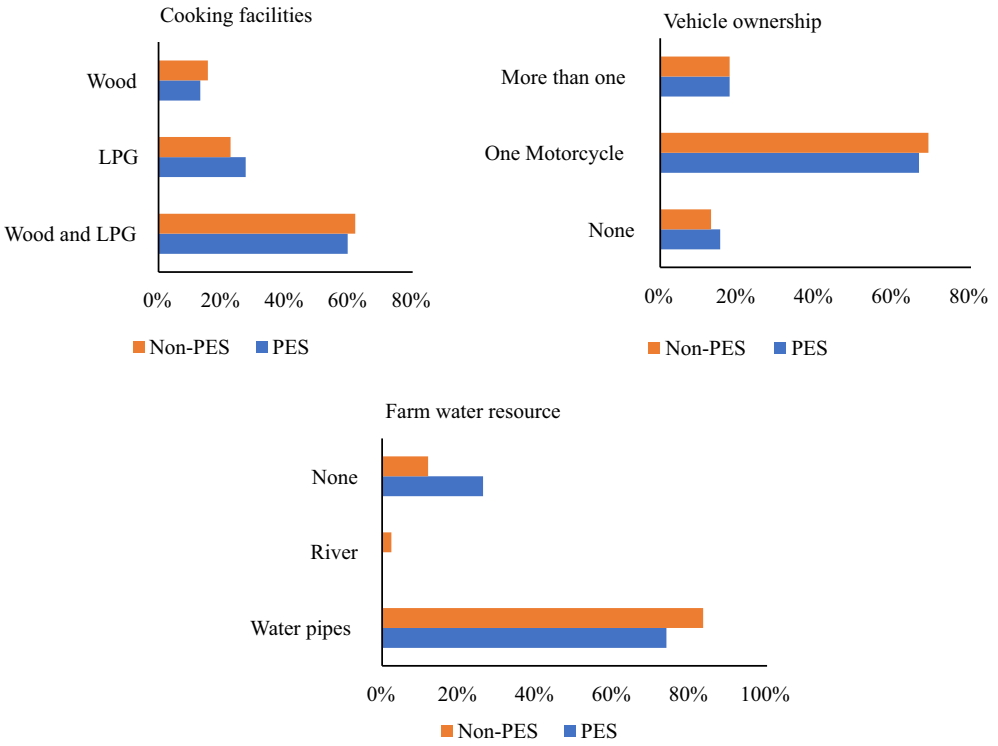

Figure 13 Comparison of cooking facilities, vehicle ownership, and farm water resources between PES and non-PES groups.

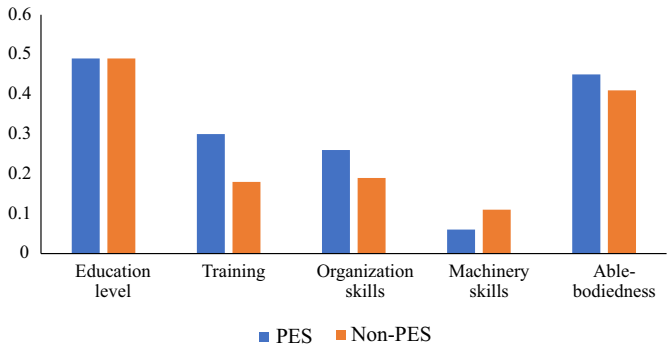

Figure 14 Comparison of human asset index values between PES and non-PES groups.

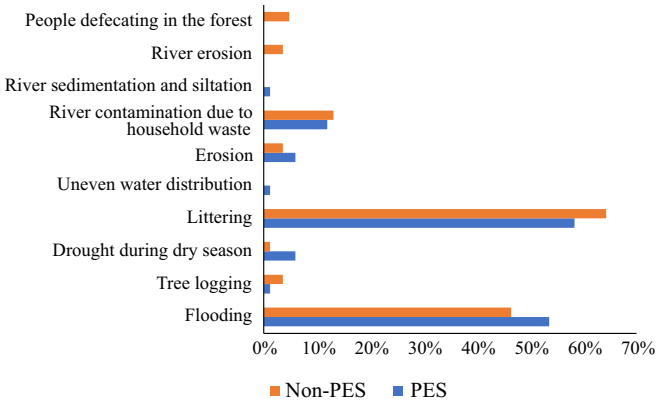

Figure 15 Environmental issues in the research locations.

et al., 2020; Li et al., 2017).

In relation with other capital assets, the human capital index influences the financial asset and vice versa (Liu et al., 2021). Specifically, human asset is the key factor affecting the income of the farmers. Ideally, a higher human asset can increase a rural household income effectively (Ma et al., 2018). In this case, the low human capital index can be implicated towards the low financial capital index of the farmers, which includes income. However, the finding in this research contradicts the said statement as the data shows a correlation coefficient of 0.32 between the farmers' education level and income variable. This shows that in reality, there is no correlation between a higher education resulting in higher incomes.

Additional findings Aside from the results of the LCI calculation, the interviews also gathered information regarding environmental issues that the farmers deem as pressing in general, including in their household. From all the farmers interviewed in both groups, people littering is the most mentioned issue by 61% of farmers, followed by flooding during rainy seasons at 46%, river contamination from household waste and littering at 13%, and other issues brought up by the minority. This data is presented in Figure 15. Some farmers thought that the littering is due to the people's lack of awareness and the lack of land to waste the dump onto, which can be implied towards the low education level and human capital index. Although this research has no proof regarding the said issues, the littering possibly

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contributes to the environment being prone to flooding during rainy seasons due to the lack of waste management and scattering of waste dumps, as both issues are raised by most of the farmers.

Another issue was a female PES farmer who stated that she felt excluded from the training activities. Although this finding is a minority, gender equality and social inclusion may prove to be a necessity when it comes to due diligence in the future, such as for carbon projects standards (Plan Vivo Foundation, 2022).

Conclusion

Based on the findings above, it could be determined that the livelihood sustainability of both PES farmers and non-PES farmers in Cidanau Watershed is not sustainable as noted by the overall LCI of below 0.48 due to the significantly low values of human and financial capital index, which is shown by the low indices ranging from 0.26 to 0.31. Other capital indexes are all above 0.55 with natural asset being the highest among them from 0.65 to 0.67. Further, it could be derived that the PES scheme in Cidanau Watershed has not given a significant difference compared to the Non-PES group after two decades of implementation in terms of livelihood to its participants, even with the increase of incentives in each 5-year contract. Merely an impact in terms of human capital, awareness of environmental issues, and the climate change. These results appear to be similar to previous reviews on multiple PES livelihood impact studies, as a significant number of PES schemes around the world were found to cause net losses to its service providers in spite of giving more positive livelihood impacts than negative ones but insignificant on average, specifically on the financial capital. Reflecting on the livelihood assets, financial and human assets are the area that the agroforestry farmers would have to develop in to further sustain their livelihood and to prepare for a more livelihood benefiting ecosystem services conservation in the future, such as enlisting in a potential voluntary carbon market. Future research should incorporate more in-depth analysis of the existing conditions of both the PES and non-PES farmers' farm commodities, their current market values, business opportunities, and technology utilization such as internet applications and modern farming tools to attain better livelihood strategies between the two groups.

Recommendation

PES schemes in general have a better livelihood impact by increasing the payment rate (in cash or in-kind payments that address local needs such as technical assistances, training and extension services relevant to livelihood, farming equipment, renovation of physical infrastructures, roads, healthcare, telecommunications, etc.) (Liu & Kontoleon, 2018; Ola et al., 2019), whereas in this research, the amount of cash from the scheme was found to be modest and dependent on the size of the farmland that the farmers own, which is shown from the results that the scheme does not create an advantage of financial capital in the PES group compared to non-PES group. Aside from that, other important factors to consider in terms of improving the livelihoods are to increase the degree of voluntary participation, incur lower transaction costs, and provide alternative livelihoods sources (Meijaard et al., 2011; Bremer et al., 2014; Liu & Kontoleon, 2018).

There are some possible recommendations based on the findings in this research, which are: The increase of incentives from the PES scheme have not been utilized optimally to increase the farmers' livelihood resilience, as from the interviews show that it has not been used for appropriate investment of tools, business assets, or for other long-term livelihood needs; Additionally, as most of the farmers depend on their farms for their main source of livelihood, the watering infrastructure, knowledge of pest management, lack of machinery skills and supporting farming equipment, are issues that should be addressed with the ever-increasing impacts of climate change. Therefore, a significant effort must be implemented by institutions such as FKDC and the village governments in complementing the farmers' farming needs, actively guiding and educating them to increase their livelihood resilience, and create the supporting policies to attaining livelihood sustainability; the piping infrastructure on the farmlands must be managed properly to supply water more evenly to the farmers to increase land productivity and prevent drought. This includes detail mapping of the pipes, its expansion according to needs, and regular maintenance; and due to high number of complaints regarding littering, the community in general must be able to manage their own waste and not dump them carelessly on a river or land. Therefore, the village government must coordinate with the Sanitation Office (*Dinas Kebersihan*) or other relevant offices in order to manage their waste or there has to be an appropriate policy implemented in these villages where the community collect their own waste and transfer them to the authorized personnels.

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