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RESEARCH ARTICLE   OPEN ACCESS

Assessing household vulnerability of smallholder farmers during oil palm replanting: a case study in West Sumatra, Indonesia☆

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Abstract – Oil palm replanting is a capital-intensive process that often disrupts household income, leading to increased livelihood vulnerability among farming communities. This study assesses the level of household vulnerability experienced by smallholder oil palm farmers in Dharmasraya Regency, West Sumatra Province, Indonesia, both before and during the replanting phase. A mixed-methods approach was used, with a census-based sample of 180 households selected from four Village Unit Cooperatives (VUCs), Associations of Farmer Groups (AFGs), and Farmer Groups (FGs) that received replanting assistance in 2018 through Indonesia's Palm Oil Plantation Fund Management Agency (POFMA). Vulnerability was measured using the Livelihood Vulnerability Index (LVI), which captures changes across five livelihood asset categories: human, physical, social, natural, and financial. The findings reveal a significant increase in vulnerability during the replanting period, primarily due to reduced income and shifts in household assets. These results highlight the need for targeted government interventions to strengthen household resilience and mitigate the socio-economic impacts of oil palm replanting. Policy recommendations are provided to improve the effectiveness of replanting programs in supporting rural livelihoods.

Keywords: farmers households / livelihood / oil palm / replanting / smallholders / vulnerability

Résumé – Évaluation de la vulnérabilité des ménages d'agriculteurs familiaux pendant la replantation du palmier à huile : étude de cas dans le Sumatra occidental, Indonésie. La replantation du palmier à huile est un processus nécessitant des investissements importants, qui perturbe souvent les revenus des ménages et accroît la vulnérabilité des moyens de subsistance au sein des communautés agricoles. Cette étude évalue le niveau de vulnérabilité des ménages d'agriculteurs familiaux producteurs de palmier à huile dans le district de Dharmasraya, province du Sumatra occidental (Indonésie), à la fois avant et pendant la phase de replantation. Une approche mixte a été utilisée, avec un échantillon de 180 ménages basé sur un recensement, sélectionnés au sein de quatre coopératives villageoises (VUC), associations de groupes d'agriculteurs (AFG) et groupes d'agriculteurs (FG) ayant bénéficié d'une aide au remplacement des palmiers en 2018 *via* l'Agence de gestion du fonds pour les plantations de palmier à huile (POFMA) d'Indonésie. La vulnérabilité a été mesurée à l'aide de l'indice de vulnérabilité des moyens de subsistance (Livelihood Vulnerability Index − LVI), qui prend en compte les changements dans cinq catégories d'actifs : humains, physiques, sociaux, naturels et financiers. Les résultats montrent une augmentation significative de la vulnérabilité pendant la période de replantation, principalement en raison de la baisse des revenus et de la modification des actifs des ménages. Ces résultats soulignent la nécessité d'interventions ciblées de la part du gouvernement pour renforcer la résilience des ménages et atténuer les impacts socio-économiques du renouvellement des palmiers à huile. Des recommandations politiques sont proposées pour améliorer l'efficacité des programmes de replantation afin d'améliorer les moyens de subsistance en milieu rural.

Mots-clés : ménages agricoles / moyens de subsistance / palmier à huile / replantation / petits exploitants / vulnérabilité

☆ Contribution to the Topical Issue: "Palm and palm oil / Palmier et huile de palme".
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Highlights

- Smallholder households engaged in oil palm replanting in Dharmasraya Regency, West Sumatra, Indonesia were more vulnerable than non-participants, with an LVI of 0.91.
- Vulnerability varied across households due to differences in livelihood assets and replanting strategies.
- Limited adaptive capacity constrained households' ability to meet daily needs, reducing welfare and increasing poverty risk.

1 Introduction

Indonesia is the world's largest exporter of palm oil, with exports reaching USD 4.2 billion in 2014 (Vitaliano, 2016). The country's oil palm plantation area reached 12,307,677 hectares by 2017, producing 35,359,384 tons of fresh fruit bunches (FFB). In 2016 alone, the production volume and value were 1,126,194 tons and USD 1,276,098,000, respectively (Directorate General of Plantation, 2015). The land potential has not been optimally utilized in the implementation of an integrated farming system, thereby limiting its capacity to enhance productivity, sustainability, and resource efficiency (Hidayati *et al.*, 2019). These figures highlight the strategic importance and immense potential of oil palm as a key plantation commodity in Indonesia's agricultural economy.

However, sustaining high levels of productivity in oil palm plantations largely depends on the age of the plants. The economic life span of oil palm trees is typically around 25 yr, after which productivity declines to below 13 tons per hectare per year (Tarmisol, 2012; Tamura, 2008). Many of Indonesia's oil palm plantations, originally planted in the 1980s, have now exceeded this economic age, resulting in significantly reduced yields. To address this, replanting is recognized as a critical strategy to restore productivity (Andriani, 2016).

Replanting involves replacing old, unproductive palms with new, high-yielding seedlings in the same area to ensure the sustainability and continuity of oil palm cultivation (Irwanto, 2021). The main objective of replanting is to increase both the quantity and quality of production. In line with this, the Indonesian government has issued Guidelines for the Replanting of Oil Palm Plantations, serving as a national reference for supporting and developing efficient, sustainable oil palm cultivation (Regulation of the Minister of Agriculture of Indonesia, 2016).

Given the costs and potential income loss during the replanting period, careful and phased planning is essential. Replanting activities typically involve felling old trees, chopping and mulching, planting cover crops, staking, implementing soil conservation measures, digging planting holes, and planting new seedlings. To minimize disruptions, replanting is implemented gradually, covering around 4% of the total plantation area annually, so that immature plants do not exceed 12% of the total cultivated area.

To support this process, the Indonesian government, through the POFMA, offers financial and technical assistance, particularly to smallholders. POFMA, established by the government, is responsible for managing oil palm plantation funds, including collecting, allocating, and distributing them. The agency provides financial support amounting to IDR 25,000,000 (1,530 USD) per hectare. Beyond funding, POFMA also contributes to enhancing farmers' human and physical capital by offering human resource development (HRD) programs and infrastructure support. These efforts aim to ensure that replanting is carried out effectively, efficiently, and in a targeted, timely, and cost-conscious manner.

Dharmasraya Regency, with its capital Pulau Punjung, is a prominent agricultural area in West Sumatra Province, Indonesia. Among its agricultural commodities, plantation crops, particularly oil palm, which have the highest production levels (Tab. 1). Dharmasraya ranks as the second-largest oil palm-producing regency in the province, after West Pasaman Regency. In 2015, the oil palm plantation area in Dharmasraya reached 72,934 hectares, producing over 1.29 million tons of oil palm fresh fruit bunches. By 2016, the area slightly increased to 73,106 hectares (Statistics Indonesia-Dharmasraya Regency, 2018).

Much of the oil palm cultivation in Dharmasraya began in the 1980s as part of a government transmigration program designed to utilize idle land in Sumatra. Today, many of these community-managed plantations have surpassed their economic age, making replanting not only necessary but urgent. With government support and funding mechanisms like POFMA, replanting programs in Dharmasraya are expected to restore productivity, support farmer livelihoods, and strengthen the long-term sustainability of the oil palm sector.

West Sumatra is one of the provinces in Indonesia with a relatively large area of smallholder oil palm plantations, totaling 11,415 ha. At present, replanting is necessary, as most of these plantations have reached an unproductive age. Dharmasraya Regency represents the largest replanting area in West Sumatra, covering about 3,000 ha. Like other oil palm-producing regions that have undergone replanting, smallholder farmers in Dharmasraya Regency experience economic shocks due to the temporary loss of income from their plantations. This replanting process significantly affects farmers' livelihood assets and strategies, as they must cope with income reduction during the transition period.

Farmers will experience a loss of income while they await the first harvest of their crop. Studying the vulnerability of farming households is crucial. According to Dow (1992), Adger (2006) and Shah *et al.* (2013), vulnerability indicators are useful tools for monitoring vulnerability in spatial and temporal contexts, identifying vulnerability processes, prioritizing strategies to reduce fragility, and evaluating the effectiveness of strategies in different social and ecological settings.

Several previous studies have examined livelihood vulnerability in various contexts. Madhuri *et al.* (2015) and Shah *et al.* (2013) developed the Livelihood Vulnerability Index (LVI) for wetland communities in Trinidad and Tobago, while Irwansyah (2015) assessed tidal flood-prone subdistricts in Jakarta. However, until to date, household vulnerability during oil palm replanting in West Sumatra remains unexplored, and findings from other settings are not directly transferable due to differing socio-demographic, crop, and economic conditions.

Table 1. Plantation crops production of Dharmasraya Regency 2011–2015 (Tons).

No	Commodity	2012	2013	2014	2015
1	Palm oil	400,822.76	360,079.27	355,457.16	347,985.31
2	Rubber	39,974.58	34,160.26	34,376.85	34,739.35
3	Cocoa	716.85	894.76	1,124.52	1,184.30
4	Coffee	363.62	394.62	352.32	283.51
5	Coconut	808.26	891.68	722.11	779.91

Source: Statistics Indonesia-Dharmasraya Regency (2018).

Table 2. The VUC, AFG and FG received financial assistance from the government for the replanting program under POFMA in 2018.

No	Name of VUC, AFG and FG	Land area (ha)
1	*Kebun Tani Makmur*	89.84
2	*Kamang Masam*	115.5364
3	*Keluarga Saiyo Sakato*	54.101
4	*Bukit Sayak*	82.1228
	Total	341.6002

Therefore, this study aims to measure the level of vulnerability to the impacts of replanting before replanting and during replanting in Dharmasraya Regency by applying the LVI that was developed by Hahn *et al.* (2009). Recommended alternative policies to reduce the impacts of replanting oil palm plantations owned by smallholders in Dharmasraya Regency were also suggested. The findings could be beneficial to improving policy and the effectiveness of replanting programs in supporting rural livelihoods.

2 Materials and methods

This study was conducted using mixed methods; a mixed research method is a method used in research using qualitative research and quantitative research. Qualitative research is intended to understand what phenomena are experienced by research subjects and provide a deeper understanding of various cultural aspects of society. It also produces descriptive data in the form of written or spoken words from people and observed behavior. The quantitative approach is intended to obtain information on the welfare index, needs, ownership of livelihood assets, and the level of sustainability of the livelihoods of smallholder oil palm plantation households during replanting in Dharmasraya Regency.

According to data from Statistics Indonesia-Dharmasraya Regency (2018), several VUCs, AFGs, and FGs received government financial assistance through POFMA to implement replanting programs. As shown in Table 2, the groups undertaking replanting were situated in Sungai Dareh Village, Pulau Punjung Subdistrict, Dharmasraya Regency.

The samples were collected using a census approach, which involved including all available VUCs, AFGs, and FGs engaged in smallholder plantations in Dharmasraya Regency in 2018. These groups were selected based on eligibility criteria for grant funds managed by POFMA for replanting initiatives. The sampled VUCs, AFGs, and FGs were "*Kebun Tani Makmur*" (48 respondents), "*Kamang Masam*" (59 respondents), "*Keluarga Saiyo Sakato*" (28 respondents), and "*Bukit Sayak*" (45 respondents). In total, 180 households participated, covering a replanted area of 341.6002 hectares.

Vulnerability refers to the susceptibility of farming households to income loss during the replanting of oil palm plantations. This vulnerability is assessed at the local (sub-district) level by comparing the degree of income decline among households. Population vulnerability is analyzed based on socio-economic conditions, while physical vulnerability is assessed through assets such as home ownership and vehicles. These aspects are evaluated for both before and during replanting periods. The extent of damage is represented using a vulnerability curve, which is then applied to classify damage levels as high, medium, or low.

The Livelihood Vulnerability Index (LVI) was calculated using the approach of Hahn *et al.* (2009). Shah *et al.* (2013), Azzahra *et al.* (2017), with components comprising socio-demographic profiles, livelihood strategies, social networks, health, food, water, housing, and land ownership. The index was adapted to local conditions and data availability and estimated through a weighted average approach, where all subcomponents contribute equally despite variation in the number of subcomponents across components.

LVI uses a simple approach that applies the same value weight to all main components as in equation (1):

$$IndexSd = \frac{Sd - Smin}{Smax - Smin},\qquad(1)$$

where *Index Sd* is subcomponent index, *Sd* is subcomponent value, *Smin* is minimum value and *Smax* is maximum value

After determining the value of the subcomponent, the next stage is to determine the value of the main component using the equation (2):

$$M_d = \frac{\sum_{i=1}^{9} IndexS_d}{9},\qquad(2)$$

where *Md* is standardized ratios of the main components (socio-demographic profile, livelihood strategies, social networks, health, food, water, housing and land tenure, and flooding), *Index Sd* is subcomponent index and *i* is subcomponents (1, 2, 3, ..., 9).

The next step is to determine the LVI value of each respondent in Pulau Punjung subdistrict using the equation (3):

Table 3. Livelihood vulnerability index (LVI) interval class.

LVI value	Classification
0.00 − 0.10	Not vulnerable
0.11 − 0.20	Less vulnerable
0.21 − 0.30	Moderately vulnerable
0.31 − 0.40	Highly vulnerable
0.41 − 0.50	Very vulnerable

Source: Adapted from Hahn *et al.* (2009).

$$LVI_d = \frac{\sum_{i=1}^{9} Wmi.Mdi}{\sum_{i=1}^{9} Wmi}, \qquad (3)$$

where *LVId* is LVI for subdistricts affected by replanting, *Wmi* is main component, *Mdi* is principal component, and *i* is subcomponents (1, 2, 3, ..., 9).

According to Hahn *et al.* (2009), the LVI scale ranges from −1 (least vulnerable) to +1 (most vulnerable). For the purposes of this study, the LVI values were further classified into five categories, adapted from Hahn *et al.* (2009), as shown in Table 3.

The final step involves determining the LVI value for each location, as defined in equations (4) and (5):

$$LVI_d = \frac{\sum_{i=1}^{5} Wmi.Mdi}{\sum_{i=1}^{5} Wmi}, \qquad (4)$$

where LVI_d *is* LVI for villages in subdistricts (1,2, 3..., etc.), *Wmi* is main component, and *Md*i is principal component.

$$LVI - IPCCd = (ed - ad) * Sd, \qquad (5)$$

where is $LVI - IPCCd$ is LVI for communities expressed using the (Intergovernmental Panel on Climate Change (IPCC), 2022; Turner et al., 2003), *ed* is exposure score calculation (changes due to replanting), *ad* is adaptive capacity score calculation (weighted average of socio-demographic, social network, and formal institutional values) and *Sd* is calculation of sensitivity scores (health, food, and water).

$LVI - IPCCd$ is scaled from −1 (lowest vulnerability) to +1 (highest vulnerability) (Shah *et al.*, 2013). Once the LVI value is known, the data obtained will be explained in the LVI asset pentagonal diagram.

Three primary components of vulnerability were indicated by exposure, sensitivity, and adaptive capacity (Tab. 4). In this study, exposure refers to the number of oil palm plantations that underwent replanting, representing a long-term change in land use. Household income is also categorized under exposure, as it reflects the most significant stress experienced by farmer households during the replanting period. Sensitivity is assessed through several factors: the lack of alternative land to replace the replanted areas, the absence of household savings at the time of replanting, the unavailability of post-replanting support from the government (such as fertilizers and horticultural seeds), and the lack of alternative income sources from other businesses. Adaptive capacity is evaluated through

the farmers' financial ability, their level of knowledge and understanding of replanting practices, their livelihood strategies, the strength of their social networks, and the influence of environmental, social, economic, political, political, infrastructure, and technological factors.

Following this, pentagonal mapping diagrams of household assets among oil palm farmers were developed. These diagrams present a comparative assessment of livelihood assets before and during the replanting period in Dharmasraya Regency. Livelihood strategies among farming households are shaped by access to the five key capital, namely natural, physical, human, financial, and social. Asset indices were derived from farmer household evaluations using a 0–5 scale, where lower values indicate limited asset ownership and higher values represent greater asset endowments.

3 Results and discussion

3.1 Exposure

The Exposure Index calculation aims to further determine the impact of replanting experienced by farming households. This calculation is based on the method of Hahn *et al.* (2009). The calculation of the Exposure Index or the impact of replanting smallholder oil palm plantations felt by farming households is shown in Table 5.

The level of exposure in replanting activity in Dharmasraya Regency will be analyzed through the amount of land that is replanted and the income received by farmer households that carry out replanting. The more land that is replanted, the greater the negative impact on the economy of farmer households that carry out replanting. The area of replanting land with an index of −0.07 means that the area of land is very impacted or vulnerable to the replanting process of smallholder oil palm plantations that occurs, while the income value with an index of 1.53 has no impact or is not vulnerable to the replanting of smallholder oil palm plantations that occurs. While the exposure index value is 0.46 with a moderate level of vulnerability, meaning that the exposure variable has a moderate effect on the replanting process of smallholder oil palm plantations that occurs.

3.2 Sensitivity

Sensitivity Index refers to the extent to which humans and nature are affected or potentially affected by environmental exposure. In this study, the exposure considered is the replanting of smallholder oil palm plantations. The Sensitivity Index was calculated to assess the degree of farming households' sensitivity to this replanting process, as presented in Table 6.

The average land ownership and income sources have indices of 0.46 and 0.50, respectively, indicating that the sensitivity index of these two components falls within the moderate vulnerability category. In contrast, the component of seed assistance received by farming households has an index of 0.01, reflecting low vulnerability sensitivity, while the alternative business component has a sensitivity index of 0.30, also indicating low vulnerability. The overall sensitivity level in Dharmasraya Regency is generally dominated by the medium to low category, as reflected in the sensitivity of

Table 4. Vulnerability indicator groups and key components in farmer households engaged in smallholders oil palm replanting in Dharmasraya Regency.

Indicator group	Main components
Exposure	• Amount of land replanted • Income value
Sensitivity	• There is no alternative land to replace the land that is being replanted. • There are no savings when replanting is carried out • Lack of additional assistance from the government after replanting occurs (fertilizer and horticultural seeds) • There is no alternative source of income from other businesses.
Adaptive Capacity	• Farmers' financial capability Level • Level of understanding (knowledge) of farmers regarding replanting • Level of education • Livelihood strategy • The level of functioning of the social network owned by farmers. • The role of the natural, social, economic, political and infrastructure environment and the technology owned by farmers.

Table 5. Exposure index of farmer households involved in smallholders oil palm replanting in Dharmasraya Regency.

No.	Exposure components	Component value	Min	Max	Index	Vulnerability (0–1)
1.	Replanting land area	1.80	2	5	−0.07	Low
2.	Income value	3.80	0.9	2.8	1.53	High
	Exposure	**2.80**			**0.46**	**Medium**

Table 6. Sensitivity index for farmer households involved in smallholders oil palm replanting in Dharmasraya Regency.

No.	Sensitivity components	Component value	Min	Max	Index	Vulnerability (0–1)
1	Average Land Area	3.39	2	5	0.46	Medium
2	Source of Income	3.01	1	5	0.50	Medium
3	Seed Assistance	1.01	1	2	0.01	Low
4	Business Alternatives	2.20	1	5	0.30	Low
	Sensitivity	**2.40**			**0.35**	**Medium**

average land ownership, income sources, seed assistance, and business alternatives. Thus, when averaged, the sensitivity level in Dharmasraya Regency tends to fall within the medium to low category. This suggests that the potential for the system across all sensitivity factors to be adversely affected or damaged by replanting exposure is relatively low.

3.3 Adaptive capacity

The Adaptive Capacity Index was calculated to assess how smallholder oil palm farmer households in Dharmasraya Regency respond to the challenges of replanting. The assessment considered factors consisting of household income, farming experience, level of understanding of replanting, sources of replanting information, and farmers' educational level. These components are presented in detail in Table 7.

Five adaptive capacity variables, namely average income, farming experience, understanding, sources of information, and level of education, the average value was found out to determine the level of adaptive capacity in the research area. The average income had an index value of 0.60, and farming

experience had an index of 0.37, both of which were classified as indicating moderate vulnerability. In contrast, farmer understanding and access to information sources both had index values of 0.00, indicating low adaptive capacity. This suggests that households involved in replanting had very limited knowledge and access to relevant information. The overall adaptability index for these households was 0.10, reflecting a low ability to adapt to the replanting process. Additionally, community interaction was found to significantly influence the adaptability of farmer households engaged in replanting.

The identification of livelihood vulnerability was carried out to assess the extent to which farming households are affected during oil palm replanting in Dharmasraya Regency. Vulnerability was measured using the LVI, and the results are presented in Table 8.

Based on the calculated values of the main components; exposure (index: 0.46), sensitivity (index: 0.35), and adaptive capacity (index: 0.10, the Livelihood Vulnerability Index (LVI) was determined to be −0.019. This LVI falls within the medium vulnerability category, as it lies within the interval of

Table 7. Adaptive capacity index of farmer households involved in smallholders oil palm replanting in Dharmasraya Regency.

No.	Adaptive capacity components	Component value	Min	Max	Index	Vulnerability (0–1)
1.	Average Income	3.81	2	5	0.60	Medium
2.	Farming Experience	15.21	2	38	0.37	Medium
3.	Understanding	1.00	1	2	0.00	Low
4.	Resources	1.00	1	3	0.00	Low
5.	Level of education	1.99	1	4	0.33	Medium
	Adaptive Capacity	**4.60**			**0.10**	**Low**

Table 8. Livelihood vulnerability index (LVI) of farmer households involved in smallholders oil palm replanting in Dharmasraya Regency.

No.	Main components	Component values	Index	Vulnerability
1.	Exposure	2.80	0.46	Medium
2.	Sensitivity	2.40	0.35	Medium
3.	Adaptive Capacity	4.60	0.10	Low
	LVI		**0.91**	**High**

$-1 \leq \text{LVI} \leq +1$. However, when normalized, the LVI value of 0.91 indicates that smallholder oil palm farmer households undergoing replanting experience a relatively high level of livelihood vulnerability. This contrasts with households that are not involved in replanting, which typically have an LVI ranging between 0 and 0.5. These results indicate that households involved in replanting are more vulnerable than those not participating in such activity.

The results show that smallholder oil palm farmer households in Dharmasraya Regency who undergo replanting are more vulnerable than those who do not. This conclusion is based on measurements of the three main vulnerability components: exposure, sensitivity, and adaptive capacity. These components are influenced by various factors, namely human, physical, economic, social, and environmental change significantly during the replanting process. Replanting disrupts livelihoods and increases the vulnerability of affected households, making them less resilient in the face of such changes.

According to Macchi (2008), vulnerability is a function of both the magnitude of change and the system's ability to cope with its impacts. A vulnerable system is one that cannot manage or adapt effectively to change. In the context of this study, replanting serves as the stressor, and the ability, or lack thereof, of farmer households to adapt to this process determines their level of vulnerability. The findings suggest that households involved in replanting are particularly at risk due to limited adaptive capacity.

Households not engaged in replanting tend to exhibit lower vulnerability, as their livelihood systems remain stable. In contrast, replanting directly affects multiple livelihood assets including natural, human, financial, social, and physical capital, which collectively reduce the ability of households to maintain or improve their standard of living. This disruption can have long-term effects on food security, income generation, and social well-being.

Communities in Dharmasraya Regency have long relied on strong social institutions and adaptive strategies to manage risks and sustain their livelihoods. However, the high

Livelihood Vulnerability Index (LVI) score of 0.91 among replanting households indicates that their current coping mechanisms are insufficient. This high level of vulnerability suggests that many of these households struggle to meet basic needs, leading to declining welfare and increased risk of poverty. The score observed among smallholder households during the replanting period reflects the severe economic shock caused by the loss of income from oil palm, their primary livelihood source.

This finding is supported by broader evidence of livelihood vulnerability among farming households, particularly in the context of agricultural transitions and climate-related stressors revealed from past studies. For example, Bacon *et al.* (2008) reported that smallholder coffee farmers in Nicaragua experienced increased livelihood insecurity during the implementation of sustainable certification programs. Similarly, Azine *et al.* (2025) found that livestock farmers in the lowland zones of South Kivu Province, Democratic Republic of Congo, were highly vulnerable due to exposure to extreme climatic events and sensitivity to disease outbreaks and declining pasture productivity. In Ghana, Dompeh *et al.* (2021) reported that certification programs for cocoa and oil palm smallholders contributed to food insecurity, with 65% and 68% of certified farmers, respectively, classified as vulnerable based on the Food Consumption Score (FCS). Collectively, these studies underscore the persistent fragility of smallholder livelihoods in the face of economic transitions, institutional interventions, and environmental pressures.

Given this vulnerability, it is critical that oil palm smallholder households in Dharmasraya undertaking replanting programs adopt deliberate adaptation strategies to protect their livelihoods. Key measures include strengthening financial resources, improving access to knowledge and information, and reinforcing social and community networks. Without such interventions, replanting may exacerbate socio-economic challenges rather than promote long-term agricultural sustainability and resilience. This finding is consistent with Petri *et al.* (2024), who identified limited knowledge and training,
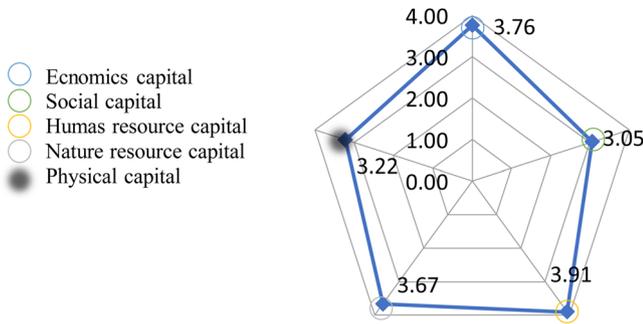
Fig. 1. Pentagon of household assets of oil palm farmers before the replanting of smallholder oil palm plantations in Dharmasraya Regency.

Table 9. Value of livelihood assets among farmer households before replanting the replanting of smallholder oil palm plantations in Dharmasraya Regency.

Capital/Assets	Scale value before replanting
Economic Capital	3.76
Social Capital	3.05
Human Resource Capital	3.91
Natural Resource Capital	3.67
Physical Capital	3.22
Amount	**17.61**
Average	**3.52**

3.4 Pentagonal mapping of household assets among oil palm farmers before the replanting period

Figure 1 shows the pentagonal assets of farmer households in Dharmasraya Regency before replanting, measured through human capital variables such as education, health, experience, knowledge or skills, labor, and self-character including motivation and innovation. Human quality needs to be continuously improved so that asset management is efficient and sustainable (Tab. 9).

The assets in farmer households before replanting on smallholder oil palm plantations that have the highest value are human resource capital, namely 3.91, while the capital that has the lowest value is social capital, namely 3.05, due to the variable always invited and involved in making decisions at meetings that have the lowest value because in the research area before the replanting process, smallholder oil palm farmer households admitted that they were not invited and involved in making decisions at meetings, whether program meetings, extension meetings or decision-making meetings (Fig. 1).

3.5 Pentagonal mapping of household assets among oil palm farmers during the replanting period

Figure 2 shows the pentagonal mapping of household assets and the values of livelihood assets of farmer households during the replanting phase. In Dharmasraya Regency, replanting was associated with increases in economic capital, social capital, human capital, and physical capital. However, natural capital remained unchanged before and during the replanting period (Tab. 10).

The natural resource capital variables that remained unchanged include a well-preserved surrounding environment and a rich diversity of biological resources in the area. Coastal waters are in very good condition, with no signs of pollution, and access to natural resources within the village remains consistently easy. However, despite the abundance of natural resources, there has been excessive exploitation in some areas.

3.6 Comparison before and during replanting

Pentagonal mapping of household assets comparisons of before and during replanting is presented in Figure 3. The value of farmer household livelihood assets in smallholder oil palm plantations in Dharmasraya Regency increased from 3.52 before replanting to 3.81 during replanting, indicating an improvement in asset value associated with the replanting process (Tab. 11).

The values of economic, social, human, and physical capital changed during the replanting period, whereas natural capital remained constant at 3.67 both before and during replanting in Dharmasraya Regency.

Ownership of assets and livelihoods can affect the strategies used by farming households. Livelihood strategies are closely related to assets owned and accessible to carry out livelihoods. Assets are capital to carry out activities so that livelihood goals can be achieved. The five capitals include natural capital, physical capital, human capital, financial capital, and social capital. These capitals are the main assets for the population in their lives, as sources of livelihood for the population, because the availability of these assets greatly supports diverse livelihood strategies. The analysis reveals variation in both access to, and the relative importance of, livelihood assets across households, underscoring the heterogeneous nature of asset distribution and utilization within the study population.

Overall, the livelihood asset values of oil palm smallholder households in Dharmasraya Regency, covering natural, physical, human, financial, and social capital, ranged from 3.22 to 3.76 before replanting and 3.47 to 3.78 during replanting. When compared with findings from other studies in Indonesia, these values were substantially higher than those reported for farmer households in Mulyoarjo Village (0.34 to 0.79) and Sumber Ngepoh Village (0.34 to 0.46), in Esta Java where farmers engaged in conventional and organic paddy cultivation (Sibarani & Somboonsuke, 2024). Similarly, the values in Dharmasraya were also higher than those of potato-farming households in Probolinggo Regency, East Java (0.83 to 0.96) as reported by Noor *et al.* (2025).

On top of that, the values observed in Dharmasraya were higher than the LVI of 0.42 reported by Ratnasari *et al.* (2023) for the conversion of agricultural land into shrimp
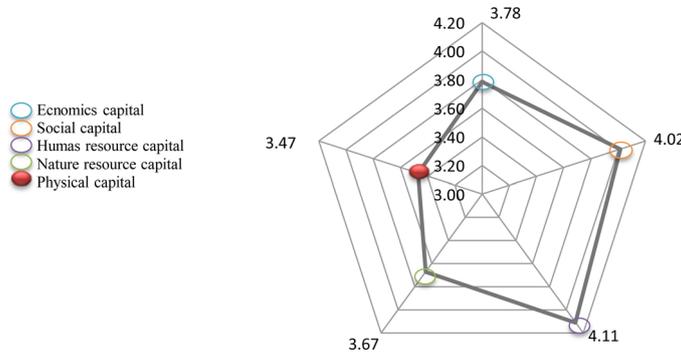
Fig. 2. Pentagon of household assets of oil palm farmers during the replanting of smallholders oil palm plantations in Dharmasraya Regency.

Table 10. Value livelihood assets among farmer household during the replanting of smallholders oil palm plantations in Dharmasraya Regency.

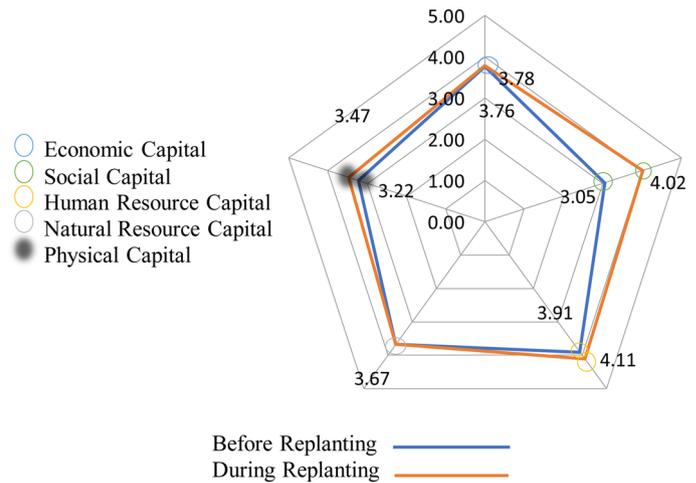| Capital/Assets	During replanting
Economic Capital	3.78
Social Capital	4.02
Human Resource Capital	4.11
Natural Resource Capital	3.67
Physical Capital	3.47
Amount	**19.05**
Average	**3.81**

Fig. 3. Comparison of pentagonal values of farmer household livelihood assets before and during the replanting of smallholders oil palm plantations in Dharmasraya Regency.

ponds in the coastal area of Kebumen Regency, Central Java of Indonesia. That value was derived from exposure (0.48), sensitivity (0.36), and adaptive capacity (0.32). Likewise, the values in Dharmasraya also exceeded the LVI of 0.42 reported by Thao *et al.* (2019) for Krong No District, Dak Nong Central Highlands of Vietnam, where drought had caused crop damage, yield reductions, and severe water shortages. In this case, the index was determined by exposure (0.38), sensitivity (0.52), and adaptive capacity (0.57).

Taken together, these comparisons may indicate that oil palm smallholder households in Dharmasraya Regency possess relatively stronger livelihood assets and experience lower vulnerability compared with farming communities in other contexts.

4 Conclusion

This study successfully assed household vulnerability of oil palm smallholder farmers during replanting through a case study in West Sumatra, Indonesia. The smallholder oil palm households participating in replanting in Dharmasraya Regency are more vulnerable compared to those who are not engaged in the process. This is reflected in the three key components of vulnerability *e.g.*, exposure, sensitivity, and adaptive capacity. The Livelihood Vulnerability Index (LVI) for these households was 0.91, indicating a high level of vulnerability.

The finding underscores that, within the replanting context, households have limited adaptive capacity, which constrains their ability to meet daily needs, reduces household welfare, and increases the risk of poverty. Smallholder palm farmer households in Dharmasraya Regency showed livelihood asset values of 3.22 to 3.76 prior to replanting, which rose modestly from 3.47 to 3.78 during replanting, indicating a potential improvement in household resilience across natural, physical, human, financial, and social capital.

This study also found that household livelihood strategies vary according to farmers' knowledge and experience in managing replanting. Although households are exposed to similar levels of natural disaster risk, differences in the assets they possess shape the degree of vulnerability experienced. Consequently, the impacts of vulnerability are uneven across households. Overall, the asset conditions of farming households can be considered relatively strong.

To safeguard livelihoods and prevent further welfare decline, farmer households undergoing replanting must adopt deliberate adaptation strategies. Such strategies are critical for maintaining stability and avoiding poverty during the transition period.

Based on the LVI analysis, several policy recommendations were formulated to mitigate the negative impacts of oil

Table 11. Value of livelihood assets of farmer households before and during the replanting of smallholder oil palm plantations in Dharmasraya Regency.

Capital	Scale value	
	Before replanting	During replanting
Economic Capital	3.76	3.78
Social Capital	3.05	4.02
Human Resource Capital	3.91	4.11
Natural Resource Capital	3.67	3.67
Physical Capital	3.22	3.47
Amount	**17.61**	**19.05**
Average	**3.52**	**3.81**

palm replanting. Strengthening economic capacity is crucial, as it underpins households' ability to mobilize the financial resources required for adaptation. Regional governments should therefore assess the development potential of each locality and promote initiatives that enhance local economic capacity. At the same time, existing agricultural development programs should be sustained, while future policies should consider leveraging locally based, non-mainstream commodities as alternative livelihood options for rural households.

Acknowledgments

Conflicts of interest

The authors have no conflict of interest in relation to this article.

Author contribution statement

Filya Hidayati contributed to the conceptualization, investigation, methodology, data curation, formal analysis and writing original draft of the present article, Darius El Pebrian contributed to review and editing of the present article, while Afdhi Gusril contributed to data curation.

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