

## Research Article

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# Mapping socio-economic vulnerability and conflict in oil palm cultivation: A case study from West Papua, Indonesia

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**Abstract:** The expansion of oil palm estates in West Papua, Indonesia, has had profound socio-economic and environmental impacts on local communities. This study aims to map and quantify the socio-economic vulnerable and conflict of these communities and actors in the face of increasing land use for oil palm cultivation. We used a mixed-method approach, combining socio-economic indicators to assess vulnerability and conflicts at the household level, involving 94 farmers, both Papua and non-Papua, as well as community actors. Key variables, including income diversification, access to land, social capital, and dependency on palm oil-related activities, were analysed to understand the adaptive capacities of local populations. The importance-performance analysis was conducted using Cartesian, multivariate, and stakeholder analyses, employing tools such as Excel, SmartPLS, and SocNetV software. The results indicate that land use has a positive and significant effect on both economic indicators and social variables. In contrast, perceptions negatively impact both economic participation and social variables. Social factors, while interconnected, appear to have a weaker direct effect on economic participation. Land use shows the strongest positive correlation with revenue generation, while perceptions tend to negatively affect revenue. Although social factors are related, they exert a lesser direct influence on revenue generation. The constructed model explains a considerable proportion of the variance in economic parameters, with a 36% explanatory power. Farmers have roles and functions in inducing vulnerability and conflict, including actors. This correlation matrix reveals the structural dynamics of relationships between actors in the network. Some actors

play pivotal roles in connecting multiple actors, while others are more peripheral or disconnected.

**Keywords:** Arfak community, conflict, land right owner, oil palm land, vulnerability, West Papua

## 1 Introduction

Over 25 million hectares of land in Indonesia are used for oil palm plantations, with a substantial portion located in Papua and Kalimantan [1–3]. The oil palm industry in Indonesia generated approximately \$35 billion in export revenue in 2023 [4,5]. While the sector employs millions, over 70% of these jobs are low-wage positions, often with limited protections and benefits. Approximately 60–70% of land for oil palm plantations in Indonesia, particularly in Papua [6–8], is controlled by corporations, with minimal land allocated for community or smallholder farming. This inequity exacerbates socio-economic vulnerability among local populations who rely on the land for traditional farming, hunting, and fishing. The absence of robust legal frameworks to protect indigenous rights leaves communities vulnerable. Indigenous land rights are often disregarded or inadequately enforced, which results in recurring land disputes and legal battles [9]. Therefore, many actors, communities, and individuals are involved.

Indigenous communities in regions like West Papua often have ancestral claims to land that lack formal legal documentation, making it easier for corporations to claim and convert these lands into plantations. This has led to significant displacement of local communities. In West Papua, oil palm plantations have become a major focus of economic development due to the lucrative global demand for palm oil [10,11]. Promoted as a means to drive economic growth and alleviate poverty, oil palm cultivation has attracted significant investment and interest from both private and public stakeholders [12–15]. However, the rapid expansion of oil palm has brought complex social and economic challenges, particularly for indigenous

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communities and local farmers. These populations often face issues related to land ownership, environmental degradation, and unequal distribution of benefits [16]. As a result, oil palm cultivation has led to social conflicts [17,18] and economic vulnerability [19,20], highlighting the need for more sustainable and equitable land management approaches in West Papua.

Oil palm expansion in West Papua poses both opportunities and challenges for local communities. While the industry promises employment, infrastructure development, and an increase in regional revenue, it has also created conflicts over land rights, as well as economic disparities between large corporations and local communities. Often, indigenous communities are pressured to give up ancestral lands, which are then converted into oil palm plantations. This displacement disrupts traditional livelihoods and places local farmers in economically vulnerable positions. Consequently, the socio-economic dynamics in oil palm cultivation areas highlight the pressing need for policies and practices that address both development goals and social welfare [21,22].

Socio-economic resilience has become an increasingly important concept in sustainable development, especially in areas undergoing rapid economic transformation. In West Papua, Indonesia, oil palm estates have played a significant role in reshaping local livelihoods and economic structures [23]. While these estates have contributed to economic growth and provided employment opportunities, concerns have emerged about their long-term impacts on local communities, ecosystems, and socio-economic stability [22]. The sustainability of these estates and the ability of local communities to adapt to changes and challenges brought about by oil palm cultivation have been insufficiently studied.

The reality on the ground reveals that oil palm development in West Papua does not uniformly benefit all stakeholders. Although the industry has generated employment opportunities, most jobs are low-wage and offer limited economic mobility for local workers. Additionally, the commodification of ancestral lands has created social tensions between indigenous communities and the corporations that operate plantations. Without clear and enforceable policies on land rights, indigenous communities remain vulnerable to exploitation. Furthermore, the environmental impacts, including deforestation, soil degradation, and reduced biodiversity, exacerbate these social and economic vulnerabilities. This reality illustrates a widening gap between promised economic benefits and the lived experiences of local communities in West Papua.

Land conflicts occur in West Papua. Indigenous communities often lack legal ownership documentation for

their ancestral lands, which facilitates their dispossession by corporations. Studies show that approximately 70% of indigenous land used for oil palm plantations lacks legal clarity [24,25], leading to increased conflicts between local communities and corporate entities. Economic inequality becomes the gap to prosperity [26–28]. The oil palm industry primarily benefits large corporations, with minimal economic gains reaching local communities. A significant percentage of revenue is retained by plantation companies, while local laborers receive low wages and limited job security. Environmental degradation cannot be hindered. Deforestation, soil degradation, and loss of biodiversity are common environmental consequences of oil palm plantations in West Papua. These environmental impacts undermine the natural resources that many indigenous communities depend on for traditional farming and hunting.

Local communities, particularly indigenous groups, often lack representation in decision-making processes. The absence of local voices in discussions around land use and development projects has contributed to feelings of disenfranchisement and resentment towards external stakeholders [29]. The expansion of oil palm in West Papua has intensified socio-economic vulnerabilities and land-based conflicts. Addressing these challenges requires a balanced approach that includes safeguarding indigenous land rights, ensuring fair economic opportunities for local communities, and implementing environmental protections to mitigate negative impacts on biodiversity and natural resources [30–32].

West Papua is a region rich in natural resources [33,34], with oil palm estates becoming one of the main drivers of economic activity over the last few decades [3]. Oil palm plantations, initially promoted as a means to enhance rural development and alleviate poverty [35–37], have brought mixed results. On one hand, the plantations generate income, provide jobs, and contribute to infrastructure development. On the other hand, concerns regarding environmental degradation, displacement of indigenous communities, and disruptions to traditional livelihoods have become pressing issues [38].

Socio-economic vulnerability refers to the ability of a community or system to withstand, adapt, and thrive in the face of economic, environmental, or social changes [39–41]. It involves multiple dimensions, including economic diversity, social networks, infrastructure stability, and access to resources. This framework is particularly relevant in analysing the complex dynamics in West Papua, where economic development through oil palm plantations intersects with traditional ways of life, environmental conservation, and social equity [42].

While numerous studies have explored the environmental impacts of oil palm plantations, less attention has been given to their socio-economic consequences, particularly in terms of community conflicts, vulnerability, and resilience. Existing research tends to focus on the economic benefits or ecological detriments in isolation without a comprehensive analysis of how oil palm estates affect the overall socio-economic resilience of local populations, including land right owners and their interlinked actors. Moreover, most of the studies are centred on regions such as Sumatra and Kalimantan [43,44], where oil palm plantations have been established for longer periods, leaving regions like West Papua underexplored. There is also a gap in the quantification of conflicts, vulnerable, and resilience, with much of the literature relying on qualitative assessments without providing measurable indicators of socio-economic vulnerability and conflicts including actors' involvement [45,46]. This study aims to fill these gaps by providing a robust, data-driven approach to mapping and quantifying socio-economic vulnerability and conflicts in West Papua, with the goal of offering insights that could guide future policy and development strategies in oil palm-producing regions.

## 2 Literature review

### 2.1 Introduction

The rapid expansion of oil palm cultivation in Indonesia has become a focal point for discussions on sustainable development, resource management, and social equity. In regions such as West Papua, this expansion is intertwined with complex socio-economic dynamics and emerging conflicts over land, resources, and cultural identity. This literature review synthesizes scholarly work on three interrelated areas: the socio-economic impacts of oil palm cultivation, the conceptual frameworks of vulnerability and conflict in resource-dependent regions, and the spatial mapping techniques employed to analyse these phenomena. The review aims to contextualize the case study of West Papua within broader debates in environmental and development studies.

### 2.2 Oil palm cultivation in Indonesia: Socio-economic and environmental impacts

A substantial body of literature has documented the dual-edged nature of oil palm expansion in Indonesia. On one

hand, palm oil is celebrated for its economic contributions, including increased export revenues, job creation, and rural development [2,47]. On the other hand, numerous studies highlight the environmental degradation and socio-economic disruptions associated with large-scale plantations. Deforestation, loss of biodiversity, and the conversion of traditional lands into commercial plantations have been linked to adverse outcomes for local communities [48]. Particularly in West Papua, researchers have pointed to the erosion of indigenous livelihoods and cultural practices, suggesting that economic benefits are often unevenly distributed while exacerbating social vulnerabilities [49].

### 2.3 Socio-economic vulnerability frameworks in agricultural systems

Understanding vulnerability in the context of oil palm cultivation requires a multi-dimensional framework. Scholars such as Turner [50] and Adger [51] have conceptualized vulnerability as the intersection of exposure, sensitivity, and adaptive capacity. In agrarian settings, these frameworks reveal that communities face increased risks not only from environmental hazards but also from socio-economic transformations induced by commercial agriculture. The transition from subsistence farming to plantation agriculture in Indonesia has led to significant disruptions in traditional economic practices, land tenure systems, and social networks. Such shifts leave local populations more susceptible to external shocks, including market volatility and policy changes, thereby deepening existing vulnerabilities.

### 2.4 Conflict in resource-dependent regions

The literature on resource-based conflicts provides critical insights into how the extraction and commercialization of natural resources can engender social and political unrest. The concept of the "resource curse" has been applied to explain paradoxical outcomes where resource abundance correlates with increased conflict and reduced governance quality [52,53]. In the context of oil palm cultivation, conflicts often emerge over issues such as land grabbing, unequal benefit sharing, and the displacement of indigenous communities. The reallocation of land for commercial purposes can lead to protracted disputes, as traditional land rights clash with state-led or corporate initiatives. This dynamic is particularly salient in West Papua, where historical grievances and contested land claims intensify the potential for conflict [54].

## 2.5 Mapping socio-economic vulnerability and conflict

Recent methodological advances have allowed researchers to spatially analyse vulnerability and conflict. Geographic information systems and other mapping techniques have been increasingly used to integrate socio-economic, environmental, and conflict-related data. Studies by Cutter et al. [55] and Birkmann [56] illustrate how spatial mapping can identify “hotspots” of vulnerability and conflict, providing policymakers with critical insights into where interventions may be most needed. However, while these techniques offer powerful visual and analytical tools, challenges remain. Data limitations, scale mismatches, and the need for participatory validation underscore the importance of coupling quantitative mapping with qualitative insights from local communities. In heterogeneous and often remote regions like West Papua, incorporating local knowledge is essential to accurately capture the nuances of socio-economic vulnerability and conflict dynamics.

## 2.6 The West Papua context: A case of intensified vulnerability and conflict

West Papua serves as a critical case study where the intersecting dynamics of oil palm cultivation, socio-economic vulnerability, and conflict are vividly manifested. Research specific to this region underscores how historical marginalization, combined with rapid economic transitions, has created a fertile ground for local conflicts. The influx of commercial interests in oil palm cultivation has led to the displacement of indigenous populations and the disruption of traditional livelihoods. Scholars argue that state policies favouring large-scale agricultural investments often neglect local socio-cultural contexts, thereby amplifying vulnerabilities and sparking localized conflicts [49,54]. Furthermore, the contested nature of land rights in West Papua – exacerbated by ambiguous tenure systems – intensifies these conflicts, making effective governance and conflict resolution particularly challenging.

## 2.7 Synthesis and research gaps

The literature reviewed reveals several critical themes. First, oil palm cultivation in Indonesia is a multifaceted phenomenon that simultaneously drives economic growth and exacerbates socio-economic and environmental vulnerabilities. Second, conceptual frameworks that integrate

exposure, sensitivity, and adaptive capacity offer valuable lenses through which to assess these vulnerabilities, yet they must be adapted to capture the unique dynamics of local contexts such as West Papua. Third, while spatial mapping techniques have advanced our understanding of vulnerability and conflict, the need for robust, high-resolution data and participatory approaches remains paramount. Finally, despite growing scholarly attention, there is a notable gap in longitudinal and context-specific studies that explore the long-term implications of oil palm-driven socio-economic transformations and conflict in West Papua. Addressing these gaps is crucial for designing policies that promote equitable and sustainable development.

# 3 Materials and methods

## 3.1 Research sites

The field research is located between 0°14' S and 130°31' E and was carried out in Manokwari Regency [57]. Research areas in the four districts, i.e. Warmare, Prafi, Masni, and Sidey, were selected from nine districts (districts). The four districts were selected by considering large areas of oil palm plantations, fertile land, and a centre for livestock development in Manokwari, West Papua Indonesia.

## 3.2 Research materials and implementation

The tools used for data collection included questionnaires and measuring instruments (Appendix). The field research was conducted in coordination with the District Heads, Village Heads, and Village Extension Officers. Data were gathered from households located in communities within oil palm plantation areas.

**Informed consent:** Informed consent was obtained from all participants.

**Ethical approval:** Consent has been obtained for this research from the Committee of Animal Ethics, The University of Papua (No. of Reference letter: SP-004/UN42.3/PP/2022).

## 3.3 Applied parameters

Parameters employed consisted of four groups of indicators (Table 1), i.e. Social (SocVar), Land use (LandVar),

Perception (PercepVar), and Economic variables (EconPar). In measuring vulnerability and conflict indicators, we designed indicators such as having customary land, social relationship amongst community, and lack of access to oil palm land, including market places. All these indicators were then mapped amongst grouped farmers, i.e. the first group for Arfak community (P0), the second group for Non Arfak Papuan (P1), and the third group for non-Papuan community (NP). The results were then entered into an Excel spreadsheet for further analysis and calculations.

Farmer income level [58,59] was computed using formulas of cost (Cost), consisting of fixed costs and variable costs (non-fixed costs). Total costs (TC) = fixed costs (FC) + variable costs (VC). Revenue (gross income) is all income obtained from crops and livestock farming during one period calculated from sales or reassessment (IDR/season). Income (revenue) is receipts minus costs. Income = Revenue (Py-Y) – Total Cost (TC), where Py is the production price (IDR/kg products) and Y is the amount of production (kg/product).

### 3.4 Data analysis

To calculate all parameters, descriptive statistical data analysis was used by calculating mean, median, minimum,

maximum, and standard deviations [60,61]. Data analysis using Cartesian graphs (often referred to as Quadrant Analysis or Importance-Performance Analysis) involves mapping data into four quadrants on the  $X$  and  $Y$  axes. Select two main variables to be analysed, for example, threat (importance of factors) as the  $Y$  axis and conflict (factor performance) as the  $X$  axis. The average of the  $X$  and  $Y$  variables will be the midpoint on the graph and serve as a boundary to divide the graph into four quadrants. Average  $X = \frac{\sum X_i}{n}$  and average  $Y = \frac{\sum Y_i}{n}$ , where the four quadrants on a Cartesian graph consist of quadrant I (high on  $X$  and  $Y$ ) then Maintain. Quadrant II (Low on  $X$  and High on  $Y$ ), then Priority to improve. Quadrant III (Low in  $X$  and  $Y$ ), then Less Priority. Quadrant IV (High on  $X$ , Low on  $Y$ ), then Potential for efficiency. In measuring relationship of all construct and latent variables, a SmartPLS software employed [59]. All inferential statistical data are presented in tables and figures. In knowing interlinked of involved actors, an SocNetV software was applied [62,63]. Value of Factor loadings (FL) computed in the context of a statistical model like CFA but there is no general standalone formula for it. FL are provided as output from SmartPLS [64]. FL for an observed variable  $X_i$  on latent factor  $\eta_j$  is often denoted by  $\lambda_{ij}$ . The value of average variance extracted

(AVE) computed as  $AVE = \frac{\sum_{i=1}^n \lambda_i^2}{n}$ , where  $\lambda_i$  is the standardized FL of item  $i$  and  $n$  is the total number of items

**Table 1:** Parameters, variables, and unit measurements

Parameters	Definition	Unit/shapes of data
<b>Sociology parameters (SocVar)</b>		
Soc1 = age	Age of farmers	Year
Soc2 = education	Education of farmers	0 = no education,..., 5 = University
Soc3 = number of people in the family	Household size	Head/households
Soc4 = land ownership	Land belongs to farmers	Number of land/family
<b>Land-use parameters (LandVar)</b>		
Lad1 = distance of land from house	Distances from farmers house (m)	Meter
Lad2 = allocation of working time on the land	Time spent during visits	Hours
Lad3 = impact of Covid-19 on land visits	Frequency of visits	0 = no impact,..., 5 = very impact
<b>Economic parameters (EconPar)</b>		
Rev1 = total assets	Total earned income	IDR
Rev2 = vegetable plants are profitable during a pandemic	Profitable vegetable	0 = no sold,..., 5 = very sold
Rev3 = cassava plants are profitable during a pandemic	Profitable cassava	0 = no sold,..., 5 = very sold
Rev4 = spice plants are profitable during a pandemic	Profitable spice	0 = no sold,..., 5 = very sold
Rev5 = grass fodder plants are profitable during a pandemic	Profitable grass	0 = no sold,..., 5 = very sold
<b>Perception parameters (PercVar)</b>		
Perc1 = perception of security disturbances on land	Perceive land security	0 = no impact,..., 5 = very impact
P2 = perceived feelings on the garden plot	Perceive on garden	0 = no impact,..., 5 = very impact
P3 = impact of Covid-19 on basic needs (eating and drinking)	Perceive on basic need	0 = no impact,..., 5 = very impact
P4 = perception of enjoying natural forests	Perceive on natural forest	0 = no impact,..., 5 = very impact
P5 = perception of enjoying palm oil	Perceive on palm oil	0 = no impact,..., 5 = very impact



(indicators) for the latent construct. Composite reliability (CR) is computed by  $CR = \frac{(\sum_{i=1}^n \lambda_i)^2}{(\sum_{i=1}^n \lambda_i)^2 + \sum_{i=1}^n \theta_i}$ , where  $\lambda_i$  is the standardized FL of item  $i$  and  $\theta_i$  is the error variance of item  $i$  (i.e.  $\theta_i = 1 - \lambda_i^2$ ). This provides a measure of the reliability of latent construct in terms of how well the observed variables represent it. The variance inflation factor (VIF) is computed by  $VIF(X_i) = \frac{1}{1 - R_i^2}$ , where  $R_i^2$  is the coefficient of determination (R-squared) obtained by regressing  $(X_i)$  on all the other predictor variables in the model [64].

### 3.5 Framework model

The study model framework is created as presented in Figure 1.

### 3.6 Hypothesis

The hypothesis according to this research is that economic (EconPar) are determined by SocVar, LadVar, and PercVar. In comparison, SocVar are affected by PercVar and LadVar.

## 4 Results and discussions

### 4.1 Descriptive characteristics of parameters

The descriptive statistics show varying levels of dispersion and central tendency across the different variables (Table 2). Sociology variables, particularly Soc1 and Soc3, show high variability, while Soc4 is relatively stable.

In the Economic variables, Rev2, Rev4, and Rev5 exhibit higher variability, indicating that responses are more spread out. The Land Use and Perception variables also demonstrate moderate variability, with some indicators showing a wider range of responses. These differences in the distribution of responses suggest that participants have diverse perspectives or experiences across these constructs.

### 4.2 Vulnerability vs conflicts

In Manokwari, West Papua, land use dynamics amongst Arfak Papuan farmers/breeders (P0), non-Arfak Papuans (P1), and NP people present various vulnerabilities and

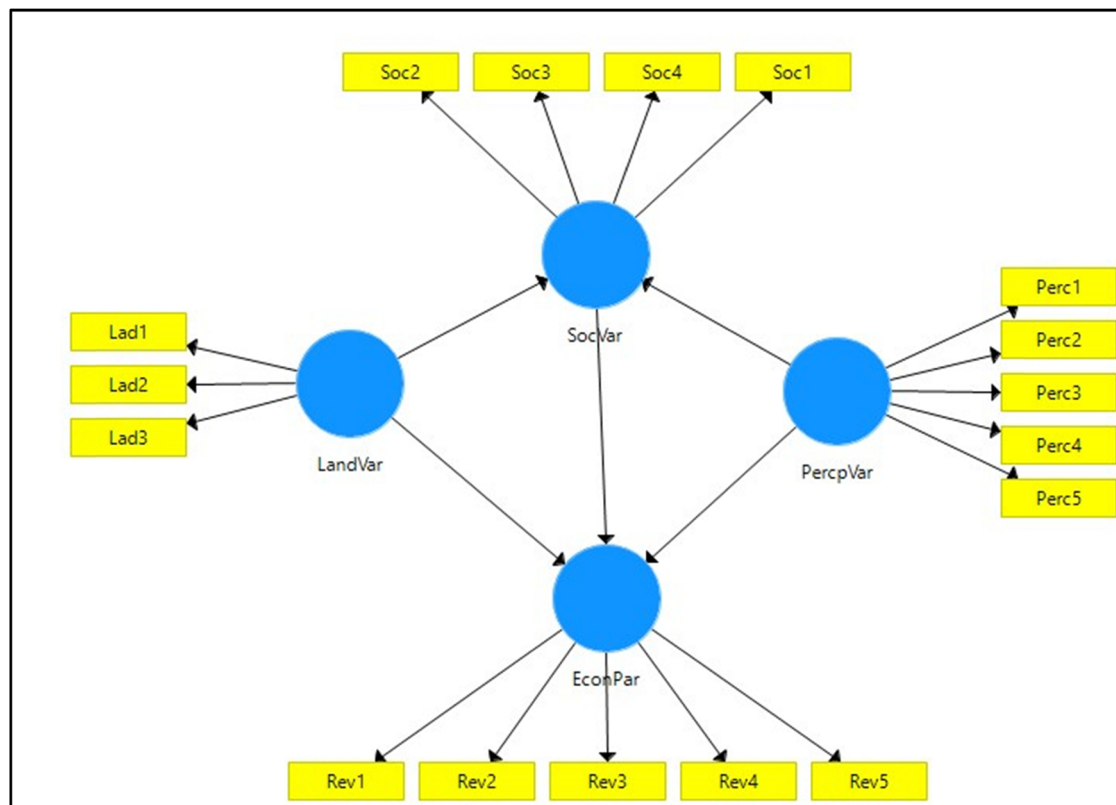


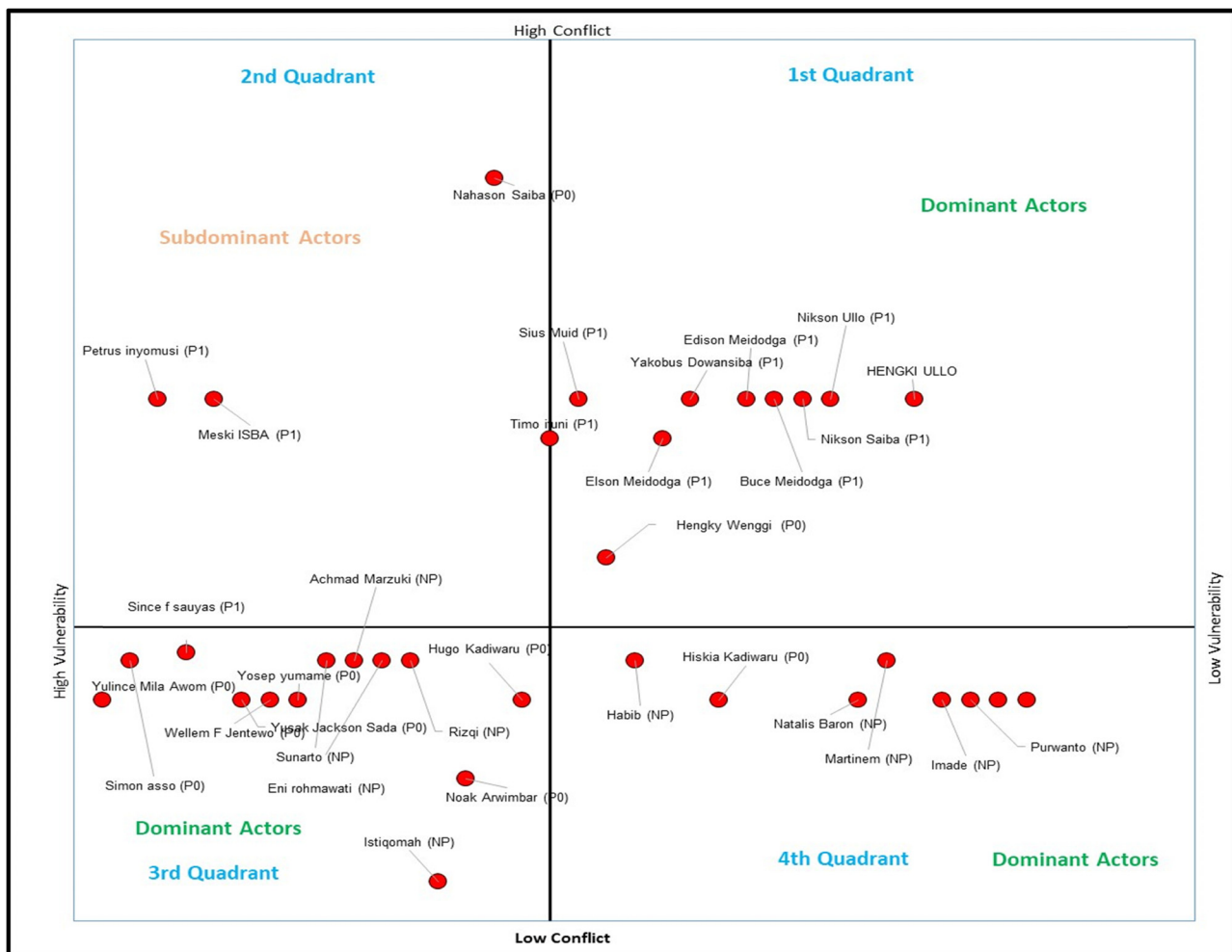
Figure 1: Model of SmartPLS constructed under this study.

**Table 2:** Descriptive statistics of the parameters used to measure indicators under this study

	Mean	Median	Min	Max	Standard deviation
Soc1	42.383	43.000	19.000	72.000	10.419
Soc2	2.649	3.000	0.000	5.000	1.218
Soc3	6.372	5.000	2.000	30.000	4.882
Soc4	1.500	1.000	1.000	3.000	0.782
Rev1	2.723	3.000	0.000	5.000	0.994
Rev2	2.234	3.000	0.000	4.000	1.462
Rev3	1.660	2.000	0.000	5.000	1.380
Rev4	1.330	1.000	0.000	5.000	1.454
Rev5	2.330	3.000	0.000	5.000	1.505
Lad1	2.989	4.000	0.000	4.000	1.259
Lad2	3.819	4.000	0.000	5.000	1.296
Lad3	2.777	3.000	0.000	5.000	1.230
Perc1	1.713	1.000	1.000	5.000	1.068
Perc2	2.649	3.000	0.000	5.000	1.302
Perc3	2.191	2.000	0.000	5.000	1.169
Perc4	3.149	3.000	0.000	5.000	1.810
Perc5	1.447	0.000	0.000	5.000	1.686

potential conflicts in oil palm plantation and agricultural activities (Figure 2). Several key factors cause them to experience varying levels of vulnerability and conflict, in terms of both socio-economic instability and disputes related to land use for livelihoods. Papuan Arfak (P0) farmers/breeders may experience low vulnerability (Not Vulnerable). This is because Arfak farmers have customary land rights. Arfak farmers also have mastery of local knowledge. High Vulnerability (Very Vulnerable) among Arfak farmers/breeders occurs when they are dependent on subsistence. Lack of Access to Markets and Modern Technology. Low Conflict (No Conflict) is caused by strong social relations within the community. Apart from that, customary land is protected by customs [65–67]. High Conflict (Very Conflict) is caused by the expansion of oil palm plantations. There is a factor of government or company intervention [68].

Non-Arfak Papuan Farmers/Ranchers (P1) experience low vulnerability (Not Vulnerable) due to access to



**Figure 2:** Mapping farmers from oil palm users in Manokwari. P0 = Papua farmers Non Arfak, P1 = Papua farmers (Arfak tribe, land right owners), and NP = Non Papua farmers.

customary networks and collectivities. In addition, adaptation to commercial farming. The High Vulnerability (Very Vulnerable) of Non-Arfak Papuan farmers/breeders occurs due to limited land rights [69]. There are obstacles due to lack of capital and technology [21,70,71]. Low Conflict (No Conflict) is possible due to partnerships with local communities. High Conflict (Very Conflict) can occur due to differences in land and economic access. Apart from that, external intervention in land governance exists.

NP can also experience low vulnerability (Not Vulnerable) through access to capital and business networks. Apart from that, they also have the ability to adapt to agricultural technology. High Vulnerability (Very Vulnerable) occurs when there is dependence on Government and Company support. Migrant farmers/ranchers also do not have customary land rights. Low Conflict (No Conflict) can occur when migrant farmers/breeders can partner with Companies and the Government. High Conflict (Very Conflict) usually occurs when there is tension with Local Communities over land control. There may be different economic interests.

Vulnerability and potential conflict in land use in Manokwari, West Papua, is influenced by various factors including customary land rights, access to capital, local

knowledge, and orientation towards commercial profits. Government and company intervention in the expansion of oil palm plantations and agricultural activities can lead to social conflict between indigenous communities and immigrants if resource management does not pay attention to local rights and traditions. Policies that respect local wisdom and accommodate economic interests in an inclusive manner can be a solution to minimize conflict and strengthen the economic and social resilience of the community in Manokwari.

### 4.3 Classic assumption and multicollinearity test

Figure 3 resulted from the running output of SemPLS. Calculated output of SemPLS consisted of classic assumption and multicollinearity test, validity and reliability test, path analysis, and  $R^2$ -Adj. Table 3 presents the VIF values for several indicators across different constructs. VIF is a diagnostic tool used to detect multicollinearity among independent variables in regression analysis. A high VIF indicates that an indicator is highly correlated with other

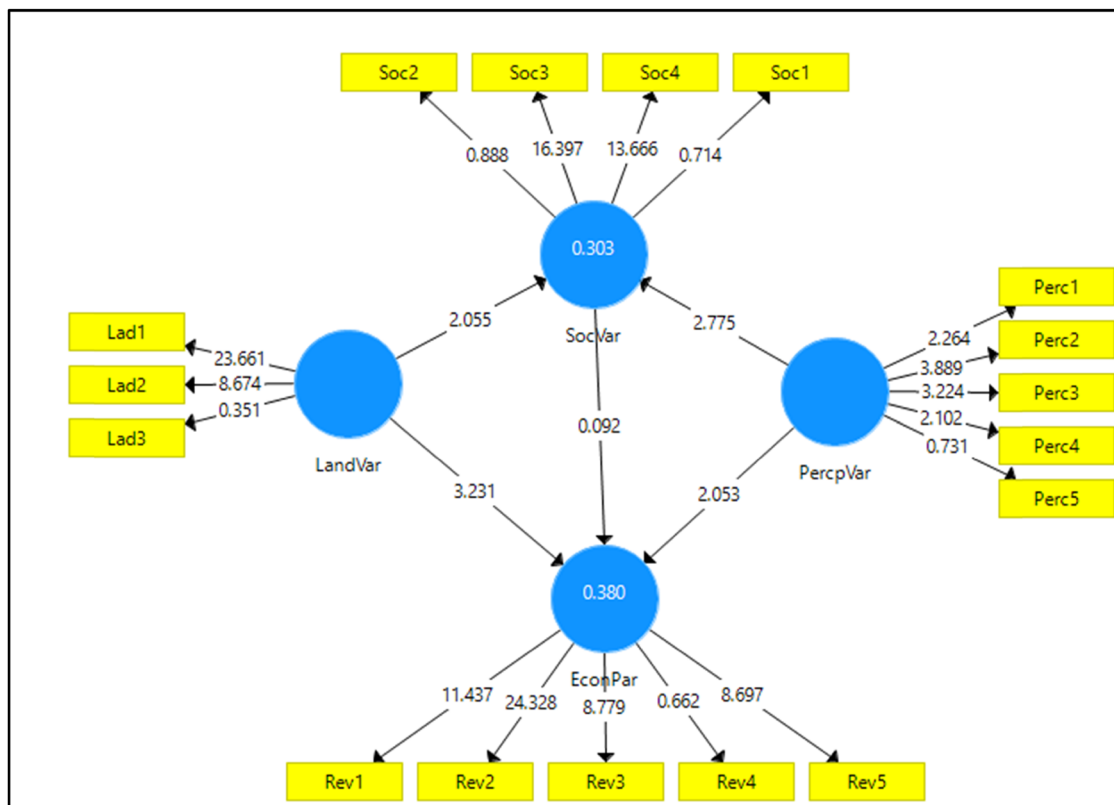


Figure 3: Output of SemPLS under this study.



indicators, potentially leading to instability in the regression coefficients. Generally, a VIF value above 5 is considered problematic, indicating strong multicollinearity, while values below 3 are acceptable and suggest low multicollinearity.

Lad1 (1.495) and Lad2 (1.514) have moderate VIF values, suggesting that these indicators do not have significant multicollinearity issues with other variables. Lad3 (1.072) shows a very low VIF, indicating minimal correlation with the other indicators. This suggests that Lad3 does not contribute to multicollinearity within the model, making it a relatively independent indicator of the Land Use construct [72].

The VIF values for Perc1 to Perc5 range between 1.093 and 1.418. Perc2 (1.095) and Perc5 (1.093) have the lowest VIF values, showing very low collinearity with other indicators. Perc3 (1.418) and Perc4 (1.385) are slightly higher but still well within the acceptable range. Overall, the Perception indicators exhibit low collinearity, meaning that the indicators for this construct are relatively independent of one another, reducing the risk of multicollinearity affecting the model's results.

The VIF values for the Economic variable range more widely, with Rev1 (1.367), Rev3 (1.326), and Rev4 (1.123) showing acceptable values. However, Rev2 (2.687) and Rev5 (2.177) have noticeably higher VIF values, although still below the threshold of 5. This suggests that while these two indicators have a stronger correlation with other variables, they do not present severe multicollinearity concerns. Rev2, in particular, approaches a higher range, which may warrant further investigation in terms of its

overlap with other economic indicators. The VIF values for the Sociology variable range from 1.244 to 1.571, all within acceptable limits. Soc3 (1.558) and Soc4 (1.571) are at the higher end but do not exceed the threshold, indicating that these variables are slightly more correlated but still manageable within the model. Soc1 (1.244) and Soc2 (1.257) show low VIF values, suggesting minimal collinearity with other indicators.

#### 4.4 Validity and reliability test

Table 4 presents the FL, AVE, and CR values for several variables: Economic, Land Use, Perception, and Sociology. These metrics help to evaluate the validity and reliability of the measurement model in a structural equation modeling framework.

The Economic variable is represented by five indicators (Rev1 to Rev5). The FL for these indicators range from 0.119 to 0.892. Rev2 (0.892) and Rev5 (0.751) have relatively high factor loadings, indicating that they strongly contribute to the construct. Rev4 (0.119) has a very low factor loading, suggesting it may not be a significant indicator of the Economic variable. The AVE for this construct is 0.466, which is below the recommended threshold of 0.50 for convergent validity. This indicates that the Economic variable explains less than half of the variance in its indicators. The CR for the Economic variable is 0.788, which is acceptable, indicating that the indicators have adequate internal consistency.

**Table 3:** VIF values for the collinearity test

Parameters	VIF
Lad1	1.495
Lad2	1.514
Lad3	1.072
Perc1	1.248
Perc2	1.095
Perc3	1.418
Perc4	1.385
Perc5	1.093
Rev1	1.367
Rev2	2.687
Rev3	1.326
Rev4	1.123
Rev5	2.177
Soc2	1.257
Soc3	1.558
Soc4	1.571
Soc1	1.244

**Table 4:** Loading factors, AVE values, and CR

Variable	Indicators	FL	AVE	CR
Economic	Rev1	0.686	0.466	0.788
	Rev2	0.892		
	Rev3	0.697		
	Rev4	0.119		
	Rev5	0.751		
Land Use	Lad1	0.927	0.508	0.693
	Lad2	0.810		
	Lad3	0.090		
Perception	Percp1	0.490	0.313	0.329
	Percp2	0.756		
	Percp3	0.703		
	Percp4	−0.475		
	Percp5	−0.176		
Sociology	Soc1	−0.219	0.416	0.569
	Soc2	0.887		
	Soc3	0.889		
	Soc4	0.199		

The Land Use variable is represented by three indicators (Lad1 to Lad3). The FL range from 0.090 to 0.927. Lad1 (0.927) and Lad2 (0.810) show strong contributions to the Land Use construct, while Lad3 (0.090) has a very low loading, suggesting that it does not meaningfully reflect the construct. The AVE for Land Use is 0.508, which is slightly above the threshold of 0.50, indicating adequate convergent validity. The CR is 0.693, which is marginal but still suggests moderate internal consistency among the indicators.

The Perception variable has five indicators (Percp1 to Percp5), with FL ranging from  $-0.475$  to  $0.756$ . Percp2 ( $0.756$ ) and Percp3 ( $0.703$ ) are the strongest contributors to the Perception construct, while Percp4 ( $-0.475$ ) and Percp5 ( $-0.176$ ) have negative or weak loadings, indicating poor contribution. The AVE for Perception is  $0.313$ , which is well below the acceptable threshold, indicating that the construct does not adequately explain the variance in its indicators. The CR is also very low at  $0.329$ , suggesting poor internal consistency, meaning that the Perception variable is not measured reliably by its indicators.

The Social variable is measured by four indicators (Soc1 to Soc4). The FL range from  $-0.219$  to  $0.889$ . Soc2 ( $0.887$ ) and Soc3 ( $0.889$ ) show strong contributions to the Sociology construct, while Soc1 ( $-0.219$ ) is negatively loaded, suggesting that it may not be a valid indicator for this variable. The AVE for Social is  $0.416$ , which is below the recommended value, indicating poor convergent validity. The CR for Sociology is  $0.569$ , which is also below the acceptable threshold of  $0.70$ , indicating weak internal consistency among the indicators.

The analysis of Table 5 indicates that some variables, such as Economic and Land Use, demonstrate moderate reliability and validity, with relatively higher factor loadings, AVE, and CR values. However, other variables like Perception and Sociology exhibit poor validity and reliability, with low AVE and CR values and negative or low factor loadings. This suggests that improvements in the measurement model are necessary, especially for the Perception and Sociology constructs, where certain indicators

may need to be revised or removed to enhance the model's overall fit and reliability.

Path Coefficient (O)  $0.375$  indicates a moderate positive relationship between LandVar (Land Use variables) and EconPar (economic parameters). *T*-statistic  $3.231$ , which exceeds the critical value of  $1.96$ , shows that this relationship is statistically significant. *p*-value  $0.001$  confirms strong statistical significance ( $p < 0.05$ ), indicating that variations in land use have a significant positive effect on economic parameters [7,73]. LandVar to SocVar is shown by Path Coefficient (O)  $0.199$ , indicating a weak positive relationship between LandVar and SocVar (social variables). *T*-statistic:  $2.055$  is above the threshold for statistical significance, and the *p*-value of  $0.040$  supports that the relationship is significant ( $p < 0.05$ ). This suggests that land use variation has a modest but significant effect on social variables.

PercpVar to EconPar is shown by Path Coefficient (O)  $-0.342$ , indicating a moderate negative relationship between PercpVar (perception variability) and EconPar. *T*-statistic:  $2.053$ , which meets the significance threshold, and the *p*-value of  $0.041$  indicates that this relationship is statistically significant. This implies that variability in perception negatively affects economic variables, meaning that unfavourable or inconsistent perceptions hinder economic parameters.

PercpVar to SocVar is shown by Path Coefficient (O)  $-0.431$ , showing a stronger negative relationship between PercpVar and SocVar. *T*-statistic  $2.775$ , which is well above the significance threshold, and the *p*-value of  $0.006$  confirms that this relationship is highly significant ( $p < 0.01$ ). This indicates that greater variability in perception is strongly associated with a decline in social variables, implying that inconsistent or negative perceptions adversely affect social dynamics. However, SocVar to EconPar shown by Path Coefficient (O)  $0.010$ , suggesting almost no relationship between SocVar and EconPar. *T*-statistic  $0.092$ , well below the critical value, and the *P*-value of  $0.927$  indicate that this relationship is not statistically significant. This suggests that social variables have

**Table 5:** Path analysis of this study

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	<i>T</i> -statistics ( O/STDEV )	<i>P</i> values
LandVar → EconPar	0.375	0.369	0.116	3.231	0.001
LandVar → SocVar	0.199	0.208	0.097	2.055	0.040
PercpVar → EconPar	$-0.342$	$-0.346$	0.166	2.053	0.041
PercpVar → SocVar	$-0.431$	$-0.420$	0.155	2.775	0.006
SocVar → EconPar	0.010	0.029	0.105	0.092	0.927

Table 6: Pearson correlation matrix (*r*)

	Soc1	Soc2	Soc3	Soc4	Rev1	Rev2	Rev3	Rev4	Rev5	Lad1	Lad2	Lad3	Perc1	Perc2	Perc3	Perc4	Perc5
Soc1	1.000																
Soc2	-0.432	1.000															
Soc3	0.128	-0.096	1.000														
Soc4	0.082	-0.162	0.592	1.000													
Rev1	0.017	0.078	0.151	0.219	1.000												
Rev2	-0.121	0.112	0.241	0.205	0.491	1.000											
Rev3	-0.080	-0.084	0.308	0.365	0.350	0.477	1.000										
Rev4	0.167	0.077	-0.173	-0.313	0.063	0.104	0.045	1.000									
Rev5	0.046	0.127	0.209	0.122	0.275	0.695	0.305	0.296	1.000								
Lad1	0.006	0.122	0.349	0.330	0.380	0.551	0.377	-0.056	0.451	1.000							
Lad2	0.220	-0.148	0.280	0.173	0.275	0.180	0.132	0.111	0.303	0.546	1.000						
Lad3	0.207	-0.201	0.221	0.138	-0.111	-0.148	0.206	-0.107	-0.075	-0.098	0.148	1.000					
Perc1	-0.229	0.151	-0.116	0.019	-0.125	-0.155	0.006	0.054	-0.093	0.014	-0.099	-0.049	1.000				
Perc2	0.051	0.043	-0.458	-0.486	-0.305	-0.443	-0.309	0.168	-0.256	-0.541	-0.359	0.157	0.149	1.000			
Perc3	-0.201	0.144	-0.275	-0.337	-0.220	-0.095	-0.348	-0.025	-0.193	-0.035	-0.153	-0.162	0.368	0.191	1.000		
Perc4	0.044	-0.179	0.114	0.180	0.106	0.075	0.195	-0.104	0.228	-0.004	0.238	0.345	-0.352	0.036	-0.421	1.000	
Perc5	-0.053	0.149	-0.175	-0.315	0.309	0.458	0.125	0.213	0.378	0.428	0.212	-0.239	-0.094	-0.103	0.086	0.166	1.000

no direct or significant impact on economic parameters in this model.

Table 6 provides the correlation matrix between various variables, including social factors (Soc1 to Soc4), revenue variables (Rev1 to Rev5), land use variables (Lad1 to Lad3), and perception variables (Perc1 to Perc5). The correlation coefficients range from -1 (perfect negative correlation) to 1 (perfect positive correlation), with 0 indicating no correlation. Soc1 shows weak positive correlations with Soc3 ( $r = 0.128$ ) and Soc4 (0.082) but a moderate negative correlation with Soc2 ( $r = -0.432$ ). This suggests that while some social factors are interconnected, Soc1 and Soc2 have opposing effects. Soc2 has a negative correlation with Soc3 ( $r = -0.096$ ) and Soc4 ( $r = -0.162$ ), indicating that Soc2 moves inversely with other social factors.

Revenue variables shown by Rev1 show moderate positive correlations with Rev2 ( $r = 0.491$ ) and Rev3 (0.350), suggesting that these revenue variables are inter-related. However, Rev4 and Rev5 have relatively weaker relationships with Rev1. Rev2 is strongly correlated with Rev5 ( $r = 0.695$ ), indicating a close relationship between these two revenue sources. This likely reflects a shared component in how revenue is generated or perceived. Rev4 has a relatively low correlation with other revenue variables but does show a weak correlation with Rev1 ( $r = 0.063$ ) and Rev5 ( $r = 0.296$ ).

Lad1 correlates moderately with several revenue variables, such as Rev1 ( $r = 0.380$ ) and Rev5 ( $r = 0.451$ ), suggesting that land use is closely related to revenue generation. Lad2 also shows positive correlations with Rev1 ( $r = 0.275$ ) and Lad1 ( $r = 0.546$ ), indicating a close relationship between land use variables and some revenue sources. Lad3, however, shows weaker and even some negative correlations with the revenue variables, suggesting that its relationship with revenue generation may not be as strong or straightforward.

Perception parameters shown by Perc1 show negative correlations with Rev1 ( $r = -0.125$ ) and Perc2 ( $r = -0.229$ ), indicating that unfavourable perceptions may negatively impact revenue. Perc2 has strong negative correlations with Rev1 ( $r = -0.305$ ) and Lad1 ( $r = -0.541$ ), suggesting that negative perceptions significantly affect both revenue and land use. Perc5 shows a moderate positive correlation with \*\*Rev5 ( $r = 0.378$ ), implying that more positive perceptions are associated with increased revenue generation in some cases.

In social factors and revenue, there are weak to moderate correlations between social factors and revenue, with Soc1 generally having weak relationships with revenue variables. This suggests that social aspects may play a minor role in determining revenue, except for specific cases like Soc4 showing some moderate correlations with revenue. Land use variables, especially Lad1 and Lad2, have strong

relationships with revenue variables, emphasizing the importance of land management in economic outcomes. Perception variables, especially Perc2 and Perc3, show strong negative correlations with revenue variables, indicating that negative perceptions may hinder economic success.

The *R*-squared adjusted value for EconPar is 0.360 (Table 7), indicating that the independent variables in the model explain 36% of the variance in economic parameters. This suggests a moderate level of explanatory power. The *T*-statistic of 4.250 and the *P*-value of 0.000 indicate that this model is statistically significant at the 1% significance level. Therefore, the independent variables have a strong and reliable influence on explaining variations in economic parameters. The *R*-squared adjusted value for SocVar is 0.287, indicating that the model explains 28.7% of the variance in social variables. This represents a somewhat lower level of explanatory power compared to economic participation, but it is still a meaningful result. The *T*-statistic of 2.738 and the *P*-value of 0.006 show that the model is statistically significant at the 1% significance level. This confirms that the independent variables have a statistically significant impact on the social variables.

The model explains a considerable proportion of the variance in economic parameters, with a 36% explanatory power. The strong statistical significance (*P*-value = 0.000) confirms that the model effectively captures the key factors influencing economic parameters. This suggests that the independent variables used in the model (likely land use, perceptions, etc.) are reliable predictors of economic outcomes. Although the explanatory power is slightly lower at 28.7%, the model Social Variables is still statistically significant (*P*-value = 0.006). This suggests that while the independent variables are moderately effective in explaining social outcomes, there may be other unexplored factors that could improve the model's explanatory power for social variables.

## 4.5 Actors' involvement

This correlation matrix presents the relationships between different actors in a network using social network analysis

(SNA). It measures the strength and direction of connections between each pair of actors, ranging from -1 (perfect negative correlation) to 1 (perfect positive correlation). These relationships help in understanding how actors are connected and influence each other within the network.

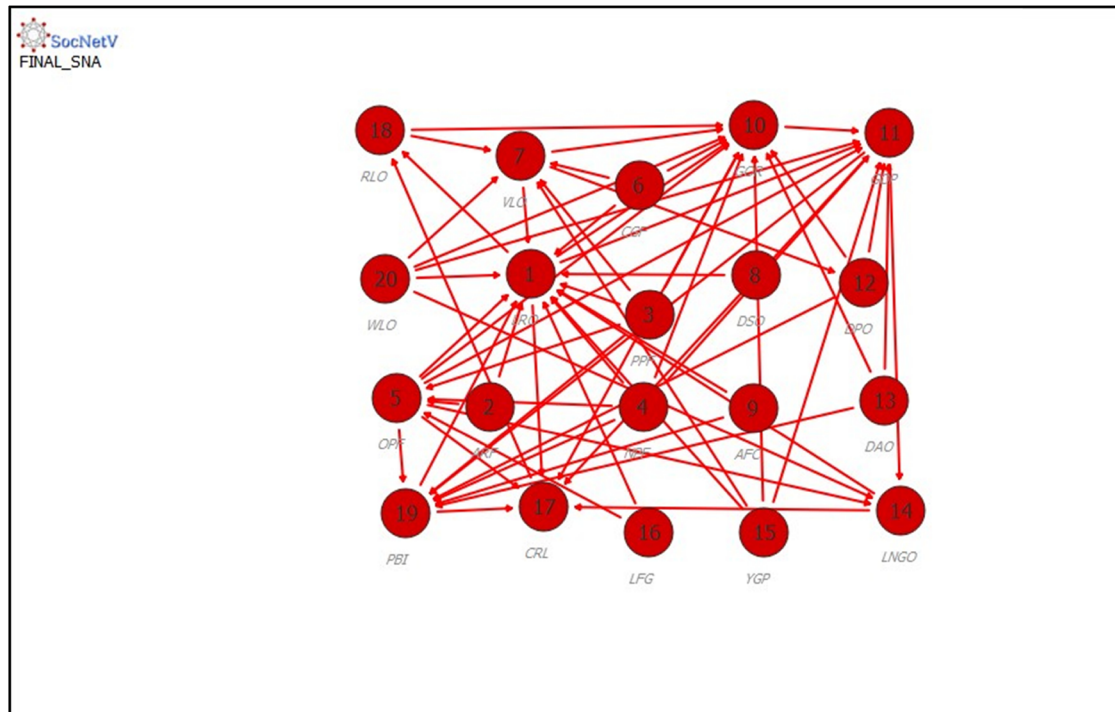
Strong positive correlations were seen in Actor 1 and Actor 10 ( $r = 0.667$ ). These two actors are highly correlated, indicating that their actions or positions in the network are aligned. They likely share similar roles, functions, or goals within the network. Actor 6 and Actor 15 ( $r = 0.840$ ) also show a strong positive correlation. This suggests a close working relationship or shared influence in the network. Actor 12 and Actor 13 ( $r = 1.000$ ) have the perfect positive correlation between these actors. It means they behave identically in the network. They could represent a pair of closely linked or even the same actors in terms of influence or activities. Actor 18 and Actor 6 ( $r = 0.793$ ) present a positive correlation, indicating that Actor 18 has a significant connection to Actor 6, perhaps relying on similar resources or strategies.

Negative correlations were seen in Actor 1 and Actor 2 ( $r = -0.167$ ). This slight negative correlation suggests a divergence between the roles or activities of these two actors. They might represent opposing or unrelated influences in the network. While Actor 17 and Actor 16 ( $r = -0.076$ ) look though weak, the negative correlation indicates a disconnection or potential conflict in goals or resources between these two actors. Actor 17 and Actor 19 ( $r = -0.076$ ) are similar to the case with Actor 16; Actor 17 seems to have little to no positive interaction with Actor 19.

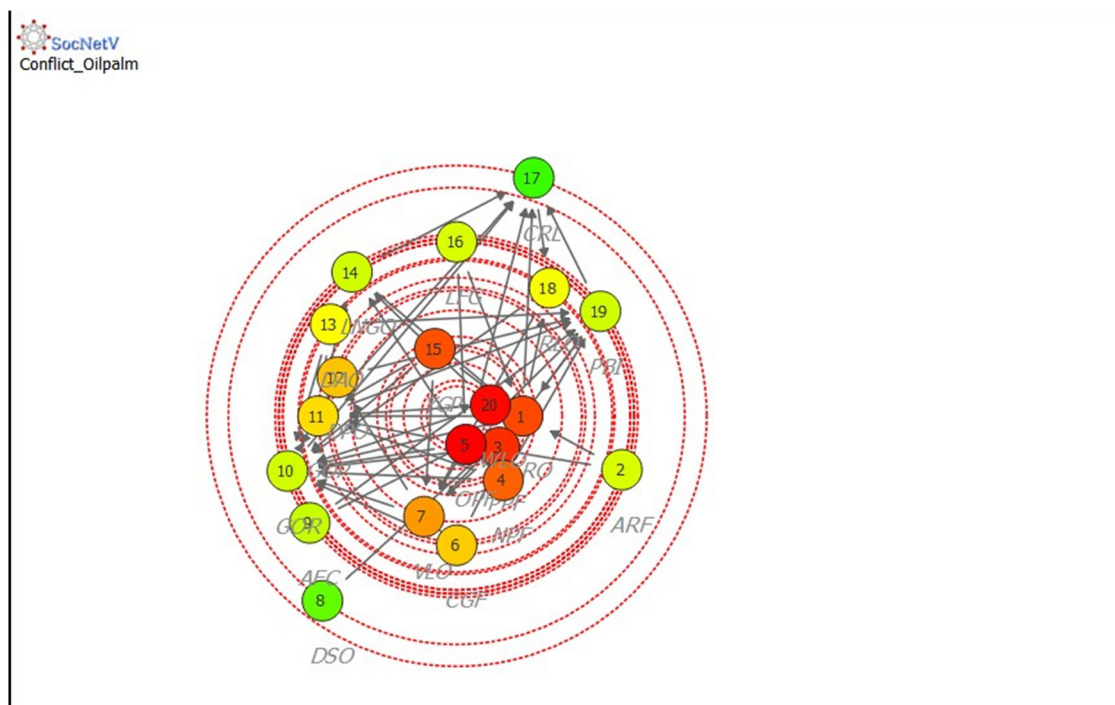
Identification of actors involved in the oil palm land use conflict in Manokwari district based on the analysis in Figure 2 can be ranked as many as 20 important and strategic actors or partners (Figure 4). The relationship between stakeholders in conflict and land use vulnerability is carried out using the Prominent Index method, namely Power Centrality, Radial Type, and the Force-Directed Model with the Reichterman-Reingold type. The results of the analysis on the Radial Diagram show that the centrality of power is indicated by the colour and size of the circle in the stakeholder number. The larger the circle size (Figure 5) in the stakeholder number and colour (stakeholder number 1–20) shows the level of power or bargaining position or

**Table 7:** *R*-squared adjusted

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	<i>T</i> -statistics ( O/STDEV )	<i>P</i> values
EconPar	0.360	0.420	0.085	4.250	0.000
SocVar	0.287	0.312	0.105	2.738	0.006



**Figure 4:** Model of SNA. 1 = LRO: Land right owners, 2 = ARF: Arfak farmers, 3 = PPF: Papuan farmers, 4 = NPF: Non-papuan farmers, 5 = OPF: Oil palm factory, 6 = CGF: Collective group of farmers, 7 = VLO: Village officers, 8 = DSO: District officers, 9 = AFC: Arfak community, 10 = GOR: Government of regency, 11 = GOP: Government of Provincial, 12 = DPO: District Police Officers, 13 = DAO: District army officers, 14 = LNGO: Local NGOs, 15 = YGP: Youth group, 16 = LFG: Livestock farmers group, 17 = CRL: Customary right leader, 18 = RLO: Religion leader officers, 19 = PBI: Private Bank Institutions, 20 = WLO = Women leader organization.



**Figure 5:** Output of model SNA analysis. 1 = LRO: Land right owners, 2 = ARF: Arfak farmers, 3 = PPF: Papuan farmers, 4 = NPF: Non-papuan farmers, 5 = OPF: Oil palm factory, 6 = CGF: Collective group of farmers, 7 = VLO: Village officers, 8 = DSO: District officers, 9 = AFC: Arfak community, 10 = GOR: Government of regency, 11 = GOP: Government of Provincial, 12 = DPO: District Police Officers, 13 = DAO: District army officers, 14 = LNGO: Local NGOs, 15 = YGP: Youth group, 16 = LFG: Livestock farmers group, 17 = CRL: Customary right leader, 18 = RLO: Religion leader officers, 19 = PBI: Private Bank Institutions, 20 = WLO = Women leader organization.



*bargaining position* from certain stakeholders. It can be said here that the actors who own customary rights (actor number 20 and actor number 5) have a red colour and a relatively large circle size.

From the picture above, it can also be said that most of the other actors have quite small roles and relationships. There are 14 actors in this Radial diagram who have low relationships and bargaining positions, including actors' numbers 17, 8, 2, 9, 10, 14, 16, 19, and followed by actors with numbers 13 and 18. Next are actors' numbers 6, 11, 12, and 7. Meanwhile, the actors who have power are actors' numbers 4, 15, 1, 3, 5, and 10. Quantitatively, this is shown by the results of the Pearson coefficient correlation (PCC) correlation analysis (Table 8).

Neutral or low connected/correlations actors present are represented by Actor 11 and many others (Actors 12, 13, 14). Actor 11 shows relatively low correlations ( $r = 0.216$ ) with many actors, indicating it might play a more peripheral role in the network, with fewer strong ties. However, Actor 5 and Actor 10 ( $r = 0.509$ ) have moderate correlation. It suggests that while there is a connection between these two actors, it is not particularly strong, possibly indicating some shared interests but limited cooperation.

Highly connected actors are shown by Actor 1. This actor shows positive correlations with several others, including Actor 4 ( $r = 0.289$ ) and Actor 5 ( $r = 0.491$ ). Actor 1 seems to play a central role in the network, maintaining multiple relationships. Actor 4 is showing strong correlations with several actors (e.g. Actor 3 at  $r = 0.733$  and Actor 5 at  $r = 0.630$ ), Actor 4 is likely influential in facilitating interactions across the network. Actor 15 with high positive correlations to Actor 6 ( $r = 0.840$ ) and Actor 1 ( $r = 0.375$ ). Actor 15 plays a key role in this network, bridging different actors together. Actors 12, 13, and 14 form a tightly connected group, with near-identical correlations across various pairs. This cluster suggests a subgroup within the network, where members are highly interconnected and possibly aligned in their activities or objectives. Actors 6, 7, and 8 show moderate positive correlations with one another, indicating a potential subgroup with shared goals or resources within the broader network.

## 5 Discussions

### 5.1 Land and resources in oil palm plantations

In Tables 1, 2, 5 and 7, it can be stated that there is a causal relationship between the parameters and indicators of the

model being built. Social aspects of farmers/breeders such as education level [34,74], age maturity [75], and land ownership [20,76,77] can influence the escalation of conflict and vulnerability, thereby reducing the ability and capacity to increase welfare through maximum income. This conflict and vulnerability can build negative perceptions and limit farmers/breeders' access to land resources and resources on oil palm plantations [78], as well as access to productive forests as a source of livelihood. This is characterized by a strong relationship between social aspects and economic impacts (Table 7). Farmers and breeders without access to land will be vulnerable, losing their ability to contribute significantly or at all to the development of agricultural and livestock activities, which serve as their primary source of income. This group of farmers/livestock will evolve to choose a more promising source of income that is free of conflict and vulnerability according to the skills and abilities they possess.

For this reason, the involvement of strategic actors or stakeholder partners [72] is necessary to immediately intervene such as increasing transparency and legal clarity on land ownership rights, building participatory mechanisms in decision-making, building a fair profit sharing or partnership system, capacity building and assistance for farmers, and application of sustainability principles [79–82].

### 5.2 Reduce conflict and address vulnerabilities

It can be indicated that in reducing conflict and overcoming vulnerabilities that occur in the dynamics of farmers/breeders, both as owners of customary land rights and various partners, independence and stable and strong economic strength are the main assets in maintaining harmony in the utilization and use of oil palm land [1,8,83–85]. Conflict and vulnerability in graphic image 2 can be grouped into four clusters, namely Low Vulnerable vs High Conflict (quadrant 1), High Vulnerable vs High Conflict (quadrant 2), High Vulnerable vs Low Conflict (quadrant 3), and Low Vulnerable vs Low Conflict (quadrant 4).

### 5.3 Maximizing the actor's role

Strategic steps are needed to maximize the role of weak/vulnerable and conflict actors, especially NP community groups and non-Arfak Papuan communities who do not have customary rights to land as a resource (Figure 2).

Table 8: Pearson correlation matrix (PCC,  $r$ )

Actor/Actor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.000	-0.167	-0.000	0.289	0.491	0.140	0.140	-0.115	-0.167	0.667	0.140	0.490	0.490	0.250	0.375	-0.167	0.459	0.250	0.250	0.289
2	-0.167	1.000	0.577	0.577	0.145	0.327	0.327	0.688	0.444	-0.111	-0.140	-0.140	-0.140	0.444	0.250	1.000	-0.076	-0.111	0.444	0.192
3	-0.000	0.577	1.000	0.733	0.378	0.728	0.404	0.397	0.577	-0.192	0.081	0.404	0.404	0.192	0.577	0.577	-0.132	0.577	0.192	0.467
4	0.289	0.577	0.733	1.000	0.630	0.404	0.404	0.397	0.577	0.192	0.081	0.728	0.728	0.192	0.577	0.577	-0.132	0.192	0.192	0.467
5	0.491	0.145	0.378	0.630	1.000	0.336	0.336	0.350	0.509	0.509	0.642	0.642	0.642	0.509	0.491	0.145	-0.150	0.145	0.509	0.630
6	0.140	0.327	0.728	0.404	0.336	1.000	0.608	0.546	0.327	-0.140	-0.176	0.216	0.216	0.327	0.840	0.327	-0.096	0.793	0.327	0.728
7	0.140	0.327	0.404	0.404	0.336	0.608	1.000	0.546	0.327	-0.140	-0.176	0.216	0.216	0.327	0.490	0.327	-0.096	0.327	0.327	0.404
8	-0.115	0.688	0.397	0.397	0.350	0.546	0.546	1.000	0.688	-0.076	-0.096	-0.096	-0.096	0.688	0.459	0.688	-0.053	-0.076	0.688	0.397
9	-0.167	0.444	0.577	0.577	0.509	0.327	0.327	0.688	1.000	-0.111	0.327	0.327	0.327	0.444	0.250	0.444	-0.076	-0.111	0.444	0.192
10	0.667	-0.111	-0.192	0.192	0.509	-0.140	-0.140	-0.076	-0.111	1.000	0.327	0.327	0.327	0.444	0.250	-0.111	-0.076	-0.111	0.444	0.192
11	0.140	-0.140	0.081	0.081	0.642	-0.176	-0.176	-0.096	0.327	0.327	1.000	0.216	0.216	0.327	-0.210	-0.140	-0.096	-0.140	0.327	0.081
12	0.490	-0.140	0.404	0.728	0.642	0.216	0.216	-0.096	0.327	0.327	0.216	1.000	1.000	-0.140	0.490	-0.140	-0.096	0.327	-0.140	0.404
13	0.490	-0.140	0.404	0.728	0.642	0.216	0.216	-0.096	0.327	0.327	0.216	1.000	1.000	-0.140	0.490	-0.140	-0.096	0.327	-0.140	0.404
14	0.250	0.444	0.192	0.192	0.509	0.327	0.327	0.688	0.444	0.444	0.327	-0.140	-0.140	1.000	0.250	0.444	-0.076	-0.111	1.000	0.192
15	0.375	0.250	0.577	0.577	0.491	0.840	0.490	0.459	0.250	0.250	-0.210	0.490	0.490	0.250	1.000	0.250	-0.115	0.667	0.250	0.866
16	-0.167	1.000	0.577	0.577	0.145	0.327	0.327	0.688	0.444	-0.111	-0.140	-0.140	-0.140	0.444	0.250	1.000	-0.076	-0.111	0.444	0.192
17	0.459	-0.076	-0.132	-0.132	-0.150	-0.096	-0.096	-0.053	-0.076	-0.076	-0.096	-0.096	-0.096	-0.076	-0.115	-0.076	1.000	-0.076	-0.076	-0.132
18	0.250	-0.111	0.577	0.192	0.145	0.793	0.327	-0.076	-0.111	-0.111	-0.140	0.327	0.327	-0.111	0.667	-0.111	-0.076	1.000	-0.111	0.577
19	0.250	0.444	0.192	0.192	0.509	0.327	0.327	0.688	0.444	0.444	0.327	-0.140	-0.140	1.000	0.250	0.444	-0.076	-0.111	1.000	0.192
20	0.289	0.192	0.467	0.467	0.630	0.728	0.404	0.397	0.192	0.192	0.081	0.404	0.404	0.192	0.866	0.192	-0.132	0.577	0.192	1.000

**Table 9:** Matrix conflict and vulnerability of farmers and community underutilization of oil palm land

		Conflict	
		Low	High
Vulnerability	Low	<ul style="list-style-type: none"> <li>– Have customary land rights</li> <li>– Understand the local ecosystem</li> <li>– Can farm/farm to move</li> <li>– Social relationships are strong within the community</li> </ul>	<ul style="list-style-type: none"> <li>– Do not have customary land rights</li> <li>– Does not understand the local ecosystem</li> <li>– Cannot farm/farm to move</li> <li>– Low social relations in the community</li> <li>– There is no protection of custom by custom</li> </ul>
	High	<ul style="list-style-type: none"> <li>– Protection of customary land by custom</li> <li>– Dependence on subsistence</li> <li>– Lack of access to markets</li> <li>– Lack of modern technology</li> </ul>	<ul style="list-style-type: none"> <li>– Not dependent on subsistence</li> <li>– Strong access to markets</li> <li>– Powerful modern technology</li> </ul>

Several key factors cause them to experience varying levels of vulnerability and conflict, in terms of both socio-economic instability and disputes related to land use for livelihoods. Sources of income as presented in Tables 2, 6 and 7 indicate the role of the social, land, and perception sectors in contributing to economic improvement. Land use conflicts in graphs 2 and 5 can be seen to have a relationship of conflict and vulnerability both individually to farmers/breeders and also together with stakeholder partners (Table 9). Therefore, actors who are strong and have a role, such as regional governments, both provincial and district, can act as a buffer in reducing and reducing conflict and escalation of vulnerabilities that easily occur in social life [86].

Vulnerability and potential conflict in land use in Manokwari, West Papua, is influenced by various factors including customary land rights [28,65,87–89], access to capital [90–92], local knowledge [93–95], and orientation towards commercial profits [96]. Government and company intervention in the expansion of oil palm plantations and agricultural activities can lead to social conflict between indigenous communities and immigrants if resource management does not pay attention to local rights and traditions. Policies that respect local wisdom and accommodate economic interests in an inclusive manner can be a solution to minimize conflict and strengthen the economic and social resilience of the community in Manokwari.

## 6 Conclusion

LandVar has a positive and significant effect on both EconPar and SocVar, indicating that effective land use management can enhance both economic and social outcomes. PercpVar negatively affects both economic participation and social variables, highlighting the detrimental

impact of inconsistent or negative perceptions on economic and social performance. SocVar do not appear to have a significant direct effect on EconPar, suggesting that social factors in this context might influence economic outcomes indirectly or through other mediating variables. Land use has the strongest positive correlation with revenue generation, while perception tends to negatively affect revenue, suggesting that improving perceptions and effective land management could lead to better economic outcomes. Social factors, although interrelated, have a weaker direct effect on revenue generation.

The model demonstrates good explanatory power for both economic and social variables, with particularly strong results for economic parameters. The statistically significant results reinforce the importance of the independent variables in shaping both economic and social outcomes in the context being studied.

This correlation matrix reveals the structural dynamics of relationships between actors in the network. Some actors play pivotal roles in connecting multiple actors, while others are more peripheral or disconnected. The presence of both positive and negative correlations illustrates the diversity of relationships – ranging from collaboration to opposition – within the network. Understanding these correlations can inform strategies for improving cooperation or managing conflicts between actors.

The constructed model explains a considerable proportion of the variance in economic parameters, with a 36% explanatory power. The model effectively captures the key factors influencing economic parameters. The independent variables used in the model (likely land use, perceptions, etc.) are reliable predictors of economic outcomes. The model of Social Variables is still statistically significant. This suggests that while the independent variables are moderately effective in explaining social outcomes, there may be other unexplored factors that could improve the model's explanatory power for social variables.

Limitations of the Research can be in terms of geographic scope, sample size and composition, temporal constraints, causality and complexity, and stakeholder representation. This study is limited to a specific region in West Papua, Indonesia, which may not fully represent the broader socio-economic conditions and conflicts related to oil palm cultivation across other regions of Indonesia. The findings may, therefore, have limited generalizability to other oil palm-growing areas. Data collection was conducted over a specific period, and any socio-economic changes or conflicts occurring after this time may not be reflected in the findings. Therefore, the results may not capture long-term trends or seasonal variations in vulnerability and conflict. While the research identifies correlations between socio-economic vulnerability and conflict, it may not fully establish causal relationships due to the complex nature of social, economic, and environmental factors that influence these issues. While the research includes farmers and community actors, it may not adequately represent all relevant stakeholders, such as government officials, corporate representatives, or environmental NGOs, whose perspectives may provide a more comprehensive understanding of the socio-economic issues surrounding oil palm cultivation.

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**Data availability statement:** The data that support the findings of this study are available from the Faculty of Agriculture, Papua University, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Faculty of Agriculture, Papua University.

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## Appendix

### QUESTIONNAIRE

*Research Title:*

#### **The impact of Covid-19 on farmers/breeders in utilizing oil palm land in Manokwari district, West Papua Province, Indonesia**

##### Introduction

We will conduct research related to land use for oil palm during the Covid-19 pandemic season. We will record the answers of Farmers/Ranchers and make them into reports in policy making for local governments in formulating policies during the face of the Covid-19 pandemic. We will keep the personal identities of Farmers/Ranchers and will not be published. For this reason, we thank you for your cooperation and assistance.

##### 1. Personal data

a. Surname:

b. Education:

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a. Not going to school, b. Completed elementary school, c. Finished junior high school, d. Graduated from high school, e. Graduated from college

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c. Number of dependents in the family:

##### 2. Social Data

a. Total land assets:

b. Relationship between Farmers and stakeholders:

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Regional/central government	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Owner of customary rights	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Bank	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Breeder group	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Village cooperative	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Village officials	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Security forces (Police/Army)	:	0: no relationship, 1: there is a relationship

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College	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive
Who else has made quite an impact?	:	0: no relationship, 1: there is a relationship - 0: Negative, 1: positive

---

### 3. Land use data

a. Distance of land from house:

b. Time allocation for working on the land:

c. Are there any impacts while working on your land:

---

a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

---

### 4. Economic data

Total financial assets owned:

Does the profit come from selling vegetables:

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a. No sales, b. few sales, c. enough to sell, d. there are sold, e. very sold

---

Do profits come from selling cassava:

---

a. No sales, b. few sales, c. enough to sell, d. there are sold, e. very sold

---

Does the profit come from selling spice plants:

---

a. No sales, b. few sales, c. enough to sell, d. there are sold, e. very sold

---

Does the profit come from selling animal feed grass:

---

a. No sales, b. few sales, c. enough to sell, d. there are sold, e. very sold

---

### 5. Perception data

Have you encountered any safety problems while gardening?

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a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

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What are your feelings about gardening:

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a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

---

Are your food and drink needs guaranteed during gardening during the Covid-19 pandemic:

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a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

---

Have you enjoyed the natural forest during this Covid-19 period?

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a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

---

Do you feel that during this Covid-19 period you enjoy farming on oil palm plantations:

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a. No impact, b. little impact, c. sufficient impact, d. there is an impact, e. very impactful

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Closing: This is how we collected this data. We would like to thank you for your cooperation and assistance in providing data. Greetings.

Manokwari, .....2022

Researcher