E3S Web of Conferences **316**, 02024 (2021) https://doi.org/10.1051/e3sconf/202131602024
IConARD 2021

Smallholding farmers' resilience towards economic and ecological disruption of oil palm plantations

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Abstract. Indonesian smallholder oil palm plantations are facing both economic and ecological challenges, therefore the farmers struggle to be resilient. This study constructs two purposes, (1) to measure the resilience level of smallholder plantations, and (2) to assess the effect of economic and ecological disruption on smallholders' resilience. We interviewed a sample of 120 smallholders in South Bengkulu regency, Bengkulu Province, Indonesia. The methodology deploys a quantitative method (statistics and econometrics) to analyze the effect of disruptive incidents on smallholders' resilience. Resilience is indicated by farmers' ability to adapt to changes, to recover from downturn business conditions or catastrophes, to anticipate risk, and to innovate new designs of farming activities. Resilience is categorized as less or more resilient (binary). The economic disruption is triggered by production, market, and investment circumstances. Meanwhile, ecological disruption is resulted from natural disasters, climate change, farmer's treatment of the land, land fire, and government environmental policy. The result shows that more than 60% of smallholder oil palm plantations in Bengkulu Province are less resilient. Production uncertainty, bargaining position, climate change, and environmentally unfriendly farming behaviours increase the possibility of lowering smallholders' resilience level.

1 Introduction

In Indonesia, 38.26% of oil palm production is generated by smallholder plantations [1]. Smallholder agriculture is typically complex and heterogeneous in terms of economic-ecological system that is especially susceptible to perturbations. They are vital in ensuring food security in many developing countries [2]. The characteristics of this type of production system, such as small size farm ownership, low capital, labour's low productivity, traditional agriculture, price variation sensitivity [3], and limited access to

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information, market, and services [4], drive oil palm smallholders to be vulnerable to disruption and become less resilient. Oil palm plantation has unique features, which are seasonal, bulky, and high vulnerability to climate and market uncertainty [5]. There is also gap period between planting and harvesting time. In oil palm plantation, farmers need to wait about 4-5 years after planting to harvest first fresh fruit bunch (FFB). Smallholder agriculture is also often characterized by the incidence of poverty [6]. Under conditions, those characteristics, uncertainties, and disturbances can cause disruption and significantly degrade smallholder plantation resilience.

The concept of resilience was originally stated by Holling [7] in his research which focused on ecological systems. He tried to distinguish a condition other than stability that features a system's ability to absorb environmental changes. Farming systems are different from ecological systems in terms of production intention, environmental control and escaping environmentally induced disruptions. To build resilience in farming systems, including smallholder plantations, understanding geographical conditions, climate change, water, and other environmental circumstances is vital to note [8-10]. In previous research, resilience was measured partially. Smallholders' resilience was assessed by the adaptability capacities [11-13], the ability to recover [14-17], anticipation of risk and uncertainties [18-20], and farmer's innovation level [20, 21]. This study offers comprehensive multidimensional approach to measure smallholder resilience. Smallholder resilience is conceptualized as the dynamic capacities of plantation smallholders to adapt to changes, recover from business downturn and catastrophes, anticipate risks, and innovate new designs of farming system.

The resilience of small-scale agricultural businesses, including smallholder plantations, can be conceptualized as the ability of farming systems to cope with challenges, disturbances, or even disruptions [22]. At the farm scale, resilience may be conferred by diversifying crops and livestock, and by implementing adaptive approaches in response to perturbations [23]. Resilience also refers to business ability to recover in least possible time in the case of disruptive incidents [24]. Recent trend of agricultural resilience research has shifted to economic and ecological issues. Market challenges, investment, production and input problem, climate change, natural disasters, and the urge for eco-friendly farming are the biggest challenging circumstances for recent smallholders. Thus, the most relevant agricultural disturbances for this study are economic and ecological disruptions.

Economic disruptions on agriculture arise from agricultural uncertainties, agricultural financial problems, and disorderly market conditions, including consumer behaviour. Aditya highlights three main types of uncertainties in agriculture, (1) yield/production uncertainty, (2) price uncertainty, and (3) uncertainty regarding input price and quality [25]. Price volatility becomes a major disruption for smallholder agriculture. It drives farmers to conduct adaptation farming system [26], reduce labor and input usability [27], diverse farm activities and minimize household expenditures [28], change land usage and profession [29], and vent their land ownership [30]. Hu and Rahman explained that increasing input price and decreasing output price have exerted pressure on smallholders [31]. Moreover, price volatilities, distorted market conditions, and lack of financial resources potentially have direct implications to small farms' resilience [32]. The presence of financial support increases the productivity [33], and consequently it promotes farm resilience. Conversely, the absence of this resource can harm smallholder farm's resilience.

Ecological disruptions emerge from natural calamities and ecologically unfriendly human behaviours. Earthquakes and other natural disasters have been proven as disruptive and affect farm resilience [5, 34, 35]. Climate change has impacted crop production in regions of smallholder dominance [2, 36]. Smallholders' sensitivity to climate change is acknowledged by the United Nations Sustainable Development Goals (SDGs) [2], which implies that climate variabilities contribute negatively to smallholders' resilience. Beyond natural stressor, non-climatic but ecologically related destructive human behaviour in farming activities also have decreased smallholder resilience. Yang explained that common agricultural practices reduce soil productivity [37]. Soil degradation stimulates crop production decrease, which later reduces farmer's income. Land firing during land preparation for oil palm plantations is well known between farmers and companies to reduce time and cost. Unfortunately, this measure causes ecological and economic problems [38, 39]. Another non-climatic disruption is government's ecological policies. In Indonesian oil palm industry, there is RSPO, the recent policies for sustainable palm oil [40]. For modern and developed farmers, proper application of this standard can help them produce oil palm with minimum impact on environment. Conversely, RSPO is extremely costly for small scale farmer. It stimulates increasingly sharp disparity between farmers. The impact of climatic and non-climatic disruptions on agriculture systems' resilience has been widely estimated, but comprehensive assessment of smallholders' resilience with broader dimensions (adaptability, recovery, anticipation, and innovation level) is still lacking.

Therefore, this paper aims to: (i) measure the resilience level of smallholder plantations, and (ii) assess the effects of economic and ecological disruptions on smallholder plantations' resilience. In this research, resilience is defined as the ability of smallholder plantations to ensure the provision of agricultural system function in facing the increasingly complex and accumulating economic and ecological shocks and stresses, through capacities of adaptability, recovery, anticipation, and innovation.

2 Methods

2.1 Study area and data collection

The research was conducted in South Bengkulu regency, Bengkulu Province, Indonesia. Bengkulu is one of the poorest provinces in Indonesia. More than 60% of the population are farmers, and most of them are smallholding farmers [41]. Bengkulu's economic growth is sustained by agricultural sector. Plantation commodities, including oil palm, are recognized as the major contributor. In Bengkulu Province, oil palm plant was firstly introduced in South Bengkulu regency in 1984. Nevertheless, recently, the most productive region is Mukomuko, the youngest regency in Bengkulu Province [41]. More than half of the South Bengkulu area is low to moderate plains which is considered good for oil palm growth. The green colour in figure 1 shows the area of annual crops, including oil palm, that spreads in South Bengkulu regency.

Multistage sampling technique was used to select smallholding oil palm farmers for this study. In the first stage, South Bengkulu regency was purposively chosen. Then, Pino Raya district was selected based on the largest harvest land area. In this district, two villages producing the largest oil palm were determined. The two villages are Pasar Pino and Nanjungan. In the second stage, 60 farmers were randomly selected from each village. A total of 120 farmers were interviewed using structured questionnaire. During the survey, respondents were asked to rate the current conditions and actions in retaining and expanding their business to indicate their resilience level. They were also questioned to assess what they feel about the disruptions. In general, this research was originally obtained from farmers' perception.

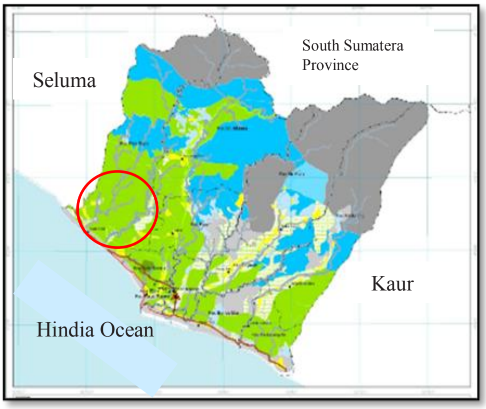

Fig. 1. Research location map

2.2 Empirical model

The objectives of this study are to (i) measure the resilience level of smallholder plantations, and (ii) assess the effect of economic and ecological disruption on smallholder plantations' resilience. A list of 41 items representing four dimensions of smallholder resilience (adaptability, recovery, anticipation, and innovation) was generated based on a comprehensive review of the literature [42-45]. Meanwhile, 68 items were stated in the questionnaire to represent the disruptions from economic and ecological incidents. Statements were written for each of these items (resilience or disruption) to which participants responded on a 5-point Likert-type-scale (1-strongly disagree; 2-disagree; 3-neutral; 4-agree; and 5-strongly agree).

By adopting resilience measurement from Levine [17], smallholder resilience is quantified by binary model. Levine expresses that resilience can be measured by probability approach, in which resilience is analysed by probit regression model. The various measured characteristics cannot be considered as constituent of resilience, but only as predictors of its likelihood, since it certainly makes sense to describe people being *more* or *less* resilient. To measure smallholder resilience, this study used original multidimensional approach, and the formula used to calculate is:

$$AR_n = \sum_{i=1}^{I} ACap_n \quad (1)$$

Where AR_n is the resilience of oil palm smallholder of respondent n, $ACap_n$ represents total average score of each capacity dimension of respondent n (min. 4 point, and max. 20 point), i indicates number of dimension capacity (4): capacity of adaptability, recovery, anticipation, and innovation. Then, smallholder resilience will be classified in binary, 1 for *more resilient* if the *AR* score of smallholders more than *mean*, and 0 for *less resilient* if the *AR* score of smallholders less than *mean*.

Based on Levine model approach of resilience analysis, and Sanchis & Poler disruption and resilience framework [46], the estimation formula to assess the effect of economic and ecological disruption on smallholder plantations' resilience can be represented as follows:

$$AR_n = Ed_{1n}\beta_1 + Ed_{2n}\beta_2 + \cdots + Eg_{1n}\beta_4 + Eg_{2n}\beta_5 + \cdots + \varepsilon_n \quad (2)$$

Table 1. Variables and indicators description

Variables	Measurement	Categories
Resilience	Binary response (1 = more resilient; 0 = less resilient)	≤ mean = less resilient > mean = more resilient
Adaptability	5-point Likert scale; represented by 3 indicators: Experience towards catastrophe, Diversification on farming activities, and Resource adaptability	1-1.8 = Not very adaptive; >1.8-2.6 = Less adaptive; >2.6-3.4 = Quite adaptive; >3.4-4.2 = Adaptive; >4.2-5 = Very adaptive
Recovery Capacity	5-point Likert scale; represented by 3 indicators: Willingness to recovery, Pressure management, and Resource maintenance	1-1.8 = Not very good; >1.8-2.6 = Not good; >2.6-3.4 = Quite good; >3.4-4.2 = Good; >4.2-5 = Very good
Anticipation	5-point Likert scale; represented by 4 indicators: Pre cultivation planning, Crisis planning, Farming protection effort, and Successor effort	1-1.8 = Not very anticipatory; >1.8-2.6 = Less anticipatory; >2.6-3.4 = Quite anticipatory; >3.4-4.2 = Anticipatory; >4.2-5 = Very anticipatory
Innovation	5-point Likert scale; represented by 3 indicators: Initiative, Creativity, and Entrepreneurship	1-1.8 = Not very innovative; >1.8-2.6 = Less innovative; >2.6-3.4 = Quite innovative; >3.4-4.2 = Innovative; >4.2-5 = Very innovative
Economic Disruption	5-point Likert scale; indicated by Production uncertainty (Ed_1), Input availability (Ed_2), Price volatility (Ed_3), Demand uncertainty (Ed_4), Bargaining position (Ed_5), Interest/Loan (Ed_6), Capital limitation (Ed_7), Consumer behaviour (Ed_8)	1-1.8 = Not very disruptive; >1.8-2.6 = Less disruptive; >2.6-3.4 = Quite disruptive; >3.4-4.2 = Disruptive; >4.2-5 = Very disruptive
Ecological Disruption	5-point Likert scale; indicated by Natural disaster incidents (Eg_1), Climate change (Eg_2), Ecologically unfriendly farming activities (Eg_3), Land fire (Eg_4), Ecological policies (Eg5)	1-1.8 = Not very disruptive; >1.8-2.6 = Less disruptive; >2.6-3.4 = Quite disruptive; >3.4-4.2 = Disruptive; >4.2-5 = Very disruptive
Since disruption is conceptualized as incidents causing damage and stimulating farmers to reduce the impact, disruptive incidents which will be formulated in the econometric model are in the category of more or as same as quite disruptive. The econometric model is solved by *Eviews7* software.		

3 Results and Discussion

3.1 The Oil Palm Smallholders' Resilience

Smallholders' resilience was indicated by dimensions of adaptability, recovery capacity, anticipation, and innovation level of farmers. These dimensions are reflected by a total of 13 indicators. Table 2 displays the indicator values of each resilience dimension. The results show that the largest score of resilience dimension is recovery capacity (4.16/5). It is represented by farmers' willingness to recovery, pressure management capacity, and resource maintenance ability. Willingness to recovery is the most valuable indicator in this dimension. It reflects farmers' faith in God's help (4.70), family support during harmful conditions (4.70), and their ability to carry out the business (4.20). It means that the influence of significant others around farmers is extremely important to their farm sustainability. FAO highlights that under threatening circumstances farmers must be able to shortly recover to prevent disaster and food crisis [43].

Further findings show that oil palm smallholders in South Bengkulu are categorized as innovative farmers. They have very good capacity of initiative and entrepreneurship, as well as decent creativity. Initiative capacity reflects farmers' ability to make decisions quickly. This indicator also represents how farmers execute their business independently. Entrepreneurship capacity is indicated by 5 statements related with (1) farm goal/target; (2) farmers' confidence level; (3) leadership capacity; (4) farm expansion plan; and (5) ability to manage risk. Futemma explains that farmers who have innovative and entrepreneurship capacity will be able to undertake problems [23]. It implies that they are able to increase the possibility of becoming more resilient.

Table 2. Resilience level of oil palm smallholder

Dimension of Capacity	Mean	Level
Adaptability Experience towards catastrophe Diversification on farming activities Resource adaptability	 2.58 1.70 3.10	2.46 Less adaptive
Recovery capacity Willingness to recovery Pressure management Resource maintenance	 4.50 4.10 3.90	4.16 Good
Anticipation Pre cultivation planning Crisis planning Farming protection effort Successor effort	 3.80 2.80 2.00 2.80	2.85 Quite anticipatory
Innovation Initiative Creativity Entrepreneurship	 4.20 3.50 4.50	4.07 Innovative
Resilience Level	13.75	
> 13.75 ≤ 13.75	38.33% 61.67%	More resilient Less resilient

In general, oil palm smallholders in South Bengkulu are quite anticipatory (2.85/5). 96% of farmers have pre-cultivation preparation and 85% of them arrange scheduled and structured planning (Table 3). Unfortunately, no oil palm farmers have farming protection scheme, like agricultural insurance. Agricultural insurance in Indonesia, as in most developing countries, is still rarely available. There are still various obstacles in the implementation of agricultural insurance in Indonesia [47]. Budhathoki et al claim that Nepal's farmers who have anticipation effort towards natural disasters have bought agricultural insurance [48]. In terms of succession of their plantations, farmers are in the category of quite anticipatory. 64% of farmers encourage their children to pursue the family's business, 60% of them provide their children with agricultural education, and 69% ask their children to be involved in farming activities. Meuwissen et all highlight that one of the social challenges that potentially affects farming systems is stress regarding the succession of farm [49].

The results in Table 2 also confirm that oil palm smallholders in research location are categorized as less adaptive farmers (2.46/5). 73% of farmers have experienced some natural disasters, such as earthquakes, floods, droughts, and plant pests and diseases, but only 25% of farmers perform preventive actions (Table 3). Furthermore, more than 90% of farmers have no diversification farming activities besides oil palm plantation. Previous research formulated that there are two possible positive impacts that can be generated by smallholders in Sumatera if they allocate space for diversification [50]. First, the productivity of oil palm per unit land can be improved through plot-level diversification. The second impact stated is that diversification could furthermore assist in enhancing or maintaining environmental performance. This low-level of adaptive capacity induced smallholding farmers in Bengkulu Province to become less resilient.

Table 3. Indicator statements of oil palm smallholders

Indicator statements	**Percentage (%)**	
	No	**Yes**
Pre cultivation preparation	4	96
Scheduled and structured planning	15	85
Encourage children to pursue the family's business	36	64
Provide agricultural education background for children	40	60
Involve children in farming activities	31	69
Experience to natural disasters	27	73
Perform preventive actions	75	25
Diversification farming activities	90	10
Prepare reserved fund	38	62
Input price increases	0	100
Scarcity of subsidized fertilizer	2	98
Difficulty in finding outsource labor	70	30
Price volatility	11	89
Capital limitation	56	44
Problem with interest and loan	84	16
Natural disaster incidents impact their plantations	35	65
Weather change	4	96
Extreme weather	5	95
Lack of knowledge of good agricultural practices	25	75
Lack of information about environmental policies	21	79
Land fire incident	96	4
Natural disaster incidents disturbed their farm	26	74
Need adjustment or changes duet to natural disasters	80	20

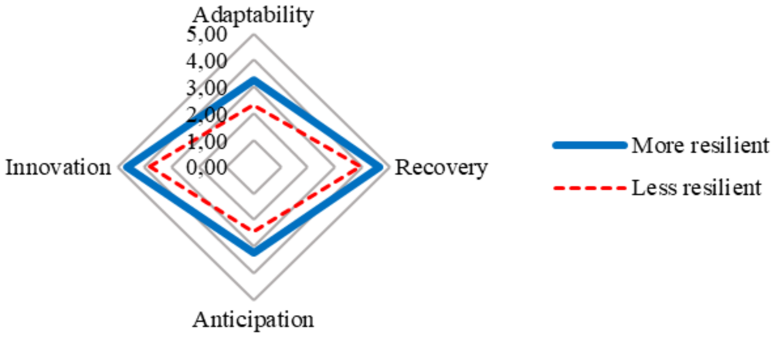

Fig. 2. Resilience's capacity of oil palm smallholders by dimension

More than 60% of farmers have under average score of resilience level and being less resilient smallholders. Figure 2 features four dimensions of smallholders' resilience between two farmers groups. More resilient smallholders have better adaptability capacity, capacity of recovery, level of anticipatory and innovation than less resilient smallholders. Resilient smallholders are categorized as quite adaptive, quite anticipatory, and innovative farmers. They also have good recovery capacity. Meanwhile, less resilient smallholders are les adaptive, less anticipatory, but quite innovative. However, they have good recovery capacity.

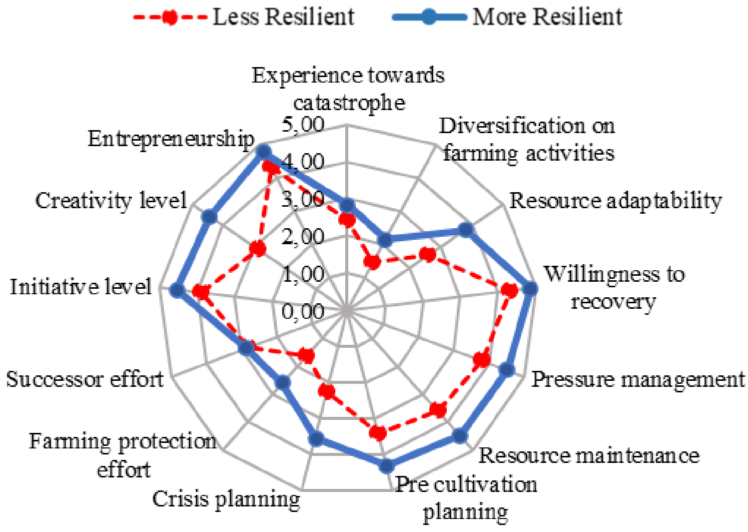

Fig. 3. Resilience of oil palm smallholders by indicators

Both groups of farmers have less capacity in handling natural disaster and diversification on farming activities (Figure 3). Resilient farmers are quite adaptive on resources adaptability, whereas less resilient farmers are not very adaptive. Only 4% of less resilient farmers have prepared organic fertilizer and seedling independently (Table 4). The most disruptive incidents related to input problems are scarcity and price increases. Conversely, there are 40% of more resilient farmers have executed those preparation independently.

Table 4. Indicator statements by less and more resilient smallholders

Indicator statements	**Percentage (%)**	
	Less resilient	**More resilient**
Prepare organic fertilizer and seedling independently	4	40
Execute risk planning and alternative planning	51	87
Agricultural insurance	0	0
Formulate new strategy or idea	52	100
Poor crops maintenance	98	97
Have no power to conduct price negotiation	100	48
Limited market information	78	57
Increasing land tenure by big estate	31	17
Less bargaining power disrupts smallholder	74	35
Discontinuity of FFB acceptance by CPO factory	65	22
FFB rejection by buyer during the transaction	65	22
Have no problem with capital limitation	38	82
Lack of knowledge of good agricultural practices	85	58

Further findings in Table 4 explore that there is a significant gap between more and less resilient farmer in crisis planning, farming protection scheme, and creativity level. 87% of more resilient farmers execute risk planning and alternative planning in anticipating crisis or disasters, but only 51% of less resilient farmers conduct these actions. There is no agricultural insurance implemented by both less and more resilient farmers, but 62% of farmers prepare reserved fund to anticipate emergency condition during cultivation. Creativity capacity reflects the ability of farmers to formulate new strategy or idea to undertake farming problem. 100% of more resilient farmers response that they have this ability. In contrast, only 52% of less resilient farmers agree that they have this creativity indicator.

3.2 The Impacts of Economic and Ecological Disruptions on Smallholders' Resilience

3.2.1 Economic Disruption

Overall, based on farmers' perspective, the economic disruptions level of oil palm plantations in Bengkulu Province are categorized as quite disruptive. From literature review, there are eight incidents that are identified as economic disruptions on oil palm plantations. Table 5 shows that the most disruptive incidents for smallholder plantations are price volatility and production uncertainty, both for less and more resilient smallholders (Figure 4). 89% of respondents claim that the price volatility disrupts farmers' plantations (Table 3). Farmers explain that the causes of price volatility are the Covid-19 pandemic, quality of fresh fruit bunch (FFB), buyer's attitude, factory price policy, and global market condition of crude palm oil (CPO). Moreover, farmers agree that production uncertainty is mainly caused by weather changes and poor crops maintenance.

The following finding shows that farmers classify input availability as a disruptive incident towards their oil palm plantations. Even more resilient smallholders claim input problems as disruptive incidents as same as less resilient smallholders (Figure 4). The input problems exposed by farmers are price increases of oil palm seed and fertilizer (100% of farmers), the scarcity of subsidized fertilizer (98%), and the difficulty in finding labour (30%). Less resilient smallholders (100%) confess that they have no power to conduct price negotiations with the buyer. The problems are limited market information (78%) and increasing land tenure by the big estate (31%) (Table 3). The farmers are also interrupted by demand uncertainty. 65% of less resilient smallholders explain that there is discontinuity of FFB acceptance by CPO factory and FFB rejection by the buyer during the transaction (Table 4). The farmers figured out that the rejection was caused by the low quality of FFB (raw and rotten fruit, small size, or no kernel inside the fruit).

The most minor economic disruptions are capital limitation, consumer behaviour, and interest/loans problem. 56% of farmers confess that they have no problem with capital limitation, and 82% of more resilient farmers confirm this circumstance. Since they have less information about consumer behaviour, they explain that consumer behaviour changes are less disruptive to their oil palm plantations. The field interview also uncovers that 84% of farmers (less and more resilient) have no problem with interest and loans. They claim that they are not involved in any loan scheme because of the difficulties of meeting the loan requirement from banks or other formal finance institutions.

Table 5. Economic disruption in oil palm plantations

Indicators	Mean	Level
Price Volatility	4.20	Quite disruptive (2.95)
Production Uncertainty	4.01	
Input Availability	3.67	
Bargaining Position	3.28	
Demand Uncertainty	2.75	
Capital Limitation	2.25	
Consumer Behaviour	1.86	
Interest/Loan	1.57	

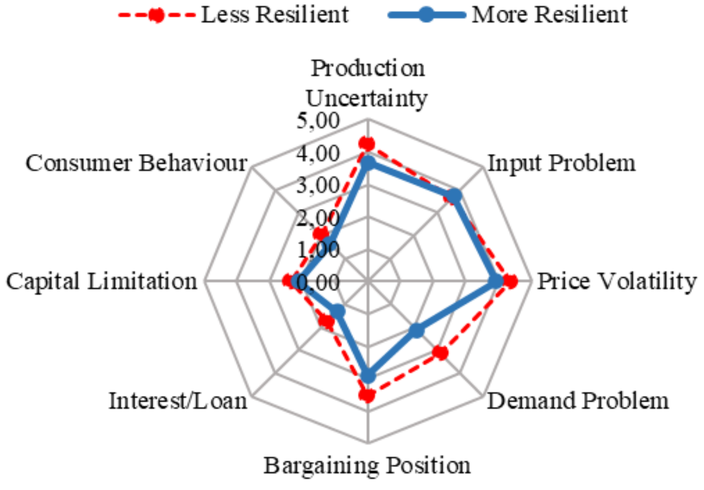

Fig. 4. Indicators of economic disruption

3.2.2 Ecological Disruption

Ecological disruption is considered as an incident of intense environmental stress occurring over some time and causing significant changes in the affected ecosystem. It can result from natural causes or human activities. Table 6 shows general ecological disruption incidents in oil palm plantations. The most disruptive incident, according to farmers' perception, is climate change and categorized as disruptive. This incident is indicated by weather change conditions, heat stress claim, and the impact of this circumstance on farmers' plantations. Climate change impacts more to less resilient smallholders than their counterparts (Figure 5).

The next ecological disruption, which is classified as a quite disruptive incident, is ecologically unfriendly farming activities. Farmers (less or more resilient farmers) confess that they are in a low level of knowledge about good agricultural practices. Thus, they conduct their plantations without giving attention to the environmental impact of their farm activities. Natural disaster incidents are also in the category of quite disruptive for both classes of farmers. There are three types of disasters that are recognized by farmers. Earthquake is the most frequent natural disaster that occurred in Bengkulu Province. However, this incident causes a medium impact on oil palm plantations. Then, there are flood and drought. 65% of farmers claim that natural disaster incidents in South Bengkulu impact their plantations. They agree that the effects include crop failure, facility damage, and input distribution problem. Meanwhile, ecological policies and land fire are categorized as less disruptive by oil palm smallholders. Both less resilient and more resilient farmers confess that they lack information about environmental policies related to oil palm cultivation (79%) and confirm that there is no land fire incident during their planting experience (96%) (Table 3).

Table 6. Ecological disruption in oil palm plantations

Indicators	Mean	Level
Climate Change	3.73	Quite disruptive (2.77)
Ecologically Unfriendly Farming Activities	3.02	
Natural Disaster Incidents	2.97	
Ecological Policies	2.09	
Land Fire	2.05	

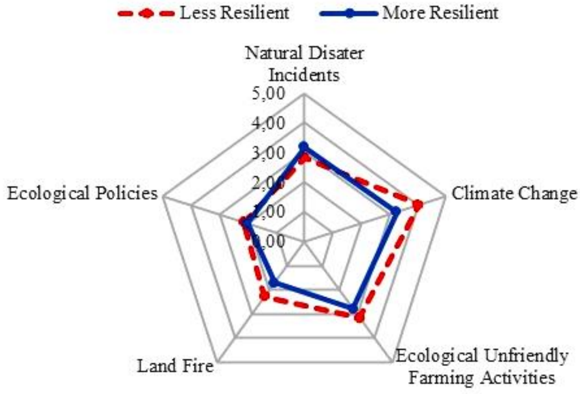

Fig. 5. Indicators of ecological disruption

3.2.3 How Farmers' Perspective towards Economic and Ecological Disruptions Affect Their Business' Resilience

Probit regression model results are presented in Table 7. The goodness-of-fit tests indicate that the selected disruption determinants provide a good estimation of the probability of smallholders' resilience. The explanatory variables are jointly statistically significant (LRx^2 test = 81.3318, p > 0.0000) [51]. Coefficient estimates of the binary probit model indicate that production uncertainty has a significant negative effect ($p < 0.1$) on smallholders' resilience. It explains that the increase in production uncertainty case 1% decreases the probability of oil palm smallholders' becoming more resilient about 34.74%. Since they have limited resources, less resilient smallholders are forced to run low quality of cultivation, and it triggers lower oil palm productivity. 98% of less resilient farmers agree that poor crops maintenance causes production uncertainty problem (Table 4). Meanwhile, 96% of farmers admit that unexpectedly changeable weather forces this matter (Table 3). Aditya uncovers that production uncertainty in agricultural business are uncontrollable [25].

Input availability shows an insignificant effect on smallholders' resilience. The case of oil palm smallholders, in research location, input availability problem is faced by almost whole farmers, such as price increasing (100%), subsidized fertilizer (98%), and limited labor (30%) (Table 3). These disturbances disrupt not only less resilient smallholders, but also resilient smallholders. Smallholding farmers in less developed and developing countries face those problems frequently [3]. Consequently, most of them feature resistance attitudes and stimulate better resources adaptability capacity and become innovative farmers (Table 2).

The further findings show that all farmers face price volatility problems. Thus, this disruption indicator has an insignificant effect on smallholders' resilience. Moreover, demand uncertainty also has an insignificant impact on oil palm smallholders' resilience. Resilient farmers generally have a vast area of plants and produce more oil palm than less resilient farmers. A large amount of production on one side generates more income. Still, unfortunately, on the other side, it can be a considerable disturbance when facing the distorted markets, such as price drops and a decrease in demand. The presence of these disruptions will be more disruptive for resilient farmers than less resilient farmers.

This study considered bargaining position as a disruptive incident for oil palm smallholders' resilience. Less power of bargaining increases the probability of farmers becoming less resilient. The result shows that bargaining position status has a significant negative influence on smallholders' resilience. This finding implies that farmers with the greater problems in bargaining positions will decrease their opportunities to become more resilient. 100% of less resilient farmers express that they always agree to the FFB price decided by the wholesaler or factory (Table 4). They state that this circumstance disrupts their farm, and they need to change. 78% of them confirm that this problem was triggered by limited market information. This finding is supported by Courtois and Subervie in their research result that this type of disruption is mainly caused by limited access of smallholding farmers to information and market [52].

The ecological disruptions in this research are directed by natural disasters, climate change, and ecologically unfriendly farming activities. Frequent natural disaster incident in Bengkulu Province is the earthquake. Drought and flood are not occurring very often. These natural disasters insignificantly affect oil palm smallholders' resilience. Widely, food farming or horticultural crops are disruptive by flood or drought. Earthquake, generally, contributes disturbance in the residential area. Plantation farming, especially oil palm, is more resistant to these types of disasters. 74% of farmers explain that natural disaster incidents disturbed their farm, but 80% of them confess that these incidents do not need adjustment or changes in their farm activities (Table 3).

Climate change has been the most popular research theme in the last decade. This environmental disruption causes various agricultural failures, such as unpredictable weather, production decreases, and health issues of farmers. As expected, the result shows that climate change has a significant adverse effect on smallholders' resilience. Climate change decreases the possibility of oil palm smallholders becoming more resilient. About 95% of farmers feel extreme weather change (Table 3). They describe that in the dry season they are stressed by heat. The farmers agree that this condition also causes crops damage. They further confirm that it forces them to adapt and execute adjustments in their oil palm plantations. Heat exposure also impacts smallholding farmers' resilience in Northern Ghana [53].

The last ecological disruption which has a significant negative influence on smallholders' resilience is ecologically unfriendly farming activities. FAO explicitly reported that smallholders use chemical fertilizer more intensively than their larger counterparts [4]. Conversely, FAO also uncovered that there was a decline soil fertility and yields lowering because of lack of inputs. In the research area, 75% of farmers confess that they lack knowledge about good agricultural practices (Table 3), and 85% of less resilient smallholders admit this problem (Table 4).

Table 7. Economic and ecological disruption impact to smallholding farmers' resilience

Variables	Coefficients	Standard error	Marginal effects
Production uncertainty	-1.0571*	0.5702	0.3472
Input availability	1.6546	0.5568	5.2364
Price volatility	1.3554	0.6590	3.8815
Demand uncertainty	0.0065	0.2431	1.0066
Bargaining position	-0.6126*	0.3513	0.5417
Natural disaster incidents	0.5746	0.2042	1.7770
Climate change	-1.2755***	0.4361	0.2791
Ecologically unfriendly farming activities	-0.9533***	0.3945	0.3852
Constanta	-0.0212	2.5506	
LRx^2	69.6326		
p-value	0.0000		
Number of observations	120		

***, **, and * confirm that it is statistically significant at 1%, 5%, and 10%, respectively.

4 Conclusions and Policy Implications

This study uses a multidimensional approach to resilience measurement based on a comprehensive review of literature. The resilience of smallholder oil palm farmers was measured by farmer's perception about how they adapt to environmental changes, recover from downturn business conditions or catastrophes, anticipate risk, and innovate new design of farming activities. The smallholding plantation farmers have a very good level of willingness to recovery, good pressure management, and resources maintenance in representing their recovery capacity level. They also feature innovative farmers by having a very good initiation and entrepreneurship character, and a good level of creativity. This research also uncovered that the smallholders have the quite anticipatory ability. This dimension was enlightened by pre cultivation planning, crisis planning, farming protection, and successor effort. Meanwhile, the adaptability capacity of smallholders was indicated as less adaptive. They are less adaptive on experience towards catastrophe, not very adaptive on farming activities diversification, and quite adaptive on resource adaptability. Estimation results confirmed that economic disruptions indicated by production uncertainty and bargaining position significantly weaken oil palm smallholders' resilience. Furthermore, the ecological disruptions represented by climate change and ecologically unfriendly farming activities also significantly negatively affect the resilience of smallholder oil palm plantations in Bengkulu Province.

The findings of this research have important policy implications. The production uncertainty could be the consequence of poor plant maintenance and climate problems existence. Whereas the bargaining position was more likely caused by limited access of farmers to information and market. The stable condition of the country on politics and economic environment and providing accessible market information from the government could help smallholder plantations reinforce their resilience. This study also highlights how climate change and farming habits contributed to weakening the smallholders' resilience. Thus, providing climate information and strengthening the adaptability of farmers to this disruption can assist farmers to enhance their resilience level. Moreover, to reduce the habit of ecological unfriendly farming activities, the government should intensively provide more extension and training programs about good agricultural practices.

Acknowledgment: Funding for this research was provided by The Ministry of Education, Culture, Research and Technology of The Republic of Indonesia, and supported by Indonesia Endowment Fund for Education (LPDP). The authors are immensely thankful to the farmers for providing valuable information needed during the field surveys.

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