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Palm Oil Expansion and Subnational Food Security

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Abstract

This paper examines the impact of oil palm expansion on the food security status at the provincial level in Indonesia. The research utilized data from a food security vulnerability map that categorizes districts and provinces in Indonesia based on their vulnerability to food security using standard indicators across the four dimensions of food security. Additionally, the study considered the extent of oil palm cultivation at the provincial level, along with other control variables. The analysis results revealed a strong and negative influence of oil palm expansion on food security status. Furthermore, it was found that food expenditure has an unequivocally negative impact on food security status. However, food security status was identified as a significant predictor for a province to be classified as an oil palm grower. This suggests that provinces cultivating palm oil have a higher likelihood of achieving food security compared to those that do not engage in the cultivation of this commodity. Consequently, the conclusion drawn from this study has important policy implications. One such implication is that the expansion of oil palm should be undertaken while considering the social, cultural, and economic implications it may have on the target areas. This approach will ultimately influence the food security status.

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I. Introduction

Palm oil is one of Indonesia's leading commodities and plays a vital role in the country's non-oil and gas foreign exchange income. It ranks third, after coal and petroleum, in terms of its importance. The Indonesian government closely monitors the price of palm oil due to the contribution of edible oil (a product derived from crude palm oil) to regional and domestic inflation. Palm oil is a significant source of employment, providing jobs for approximately 6 million people on estates and even more in large privately and state-owned estates. It is widely used as a vegetable oil in Indonesian households, industrial processing, the food and confectionary industry, as well as the soap and cosmetics industry.

While the contribution of palm oil to the national and subnational economy is well-documented, its role in ensuring food security in producing provinces remains unclear. Although data on the status of food security at the provincial level is available, the extent to which oil palm cultivation and production contribute to food (in) security is not well-established.

In the 2018/2019 period, Indonesia produced 41.5 million tons of crude palm oil, with over three-quarters of it destined for foreign markets including China, India, Pakistan, Bangladesh, the European Union (EU), the Middle East, and Africa. Projections for 2019/2020 estimated crude palm oil production to exceed 43 million tons. The expansion of palm oil cultivation has led to a significant increase in production, extending beyond traditional regions such as Sumatra, Kalimantan, and Sulawesi to include Papua and West Papua, which represent the new frontier for palm oil growing. Indonesia has plans to increase the total area under oil palm cultivation to 40 million hectares by 2030, a target that seems attainable considering the current rate of expansion.

The expansion of palm oil cultivation has been incredibly rapid in the past decade. The target of reaching 23 million tons by 2020 was surpassed in 2014 when production reached 24.90 million tons. The primary reason behind this rapid increase is the expansion of the cultivation area for palm oil. Statistics on palm oil expansion strongly support this notion. The area dedicated to palm oil cultivation expanded at an average annual rate of 14,000 hectares in the 1970s, gained momentum in the 1980s with a growth rate of 71,000 hectares per year, and witnessed a phenomenal growth of 293,000 hectares in the 1990s. This growth rate was only surpassed by the expansion in the 2000s, which is projected to exceed 340,000 hectares per year. The significant expansion of palm oil cultivation has successfully achieved the objectives of successive Indonesian governments, including broadening the sources of the country's non-oil and gas foreign exchange earnings, increasing tax revenues, providing employment opportunities to combat unemployment and underemployment, and ensuring an adequate supply of crude palm oil (CPO) for domestic use and for supporting processing industries dependent on CPO as a raw material.

However, the rapid expansion of oil palm cultivation has had direct and unintended consequences on food security. The conversion of land for oil palm cultivation has reduced the availability of land for growing food crops both for local communities' own consumption and for generating additional income through sales. This research aims to examine the impact of oil palm expansion on the food security status at the provincial level.

Research on food security in Indonesia holds significant importance for several reasons. Firstly, Indonesia is the fourth most populous nation in the world, trailing behind China, India, and the United States. As a substantial importer of rice, wheat, soybeans, sugar, and other commodities, it becomes an interesting case to study in terms of food security-related issues. Additionally, since the transition from Suharto's authoritarian rule to a democratic system in May 1998, Indonesia has been striving to establish a functional democracy. This transition process implies that some of the key factors that contributed to temporary rice self-sufficiency, which was achieved in 1984 and garnered accolades from the FAO under Suharto's leadership, are no longer viable and can even be counterproductive. There is now a general consensus that achieving a country's food security requires a multi-sectoral, cross-regional, domestic, and globally interconnected approach.

The finding that oil palm expansion has a negative impact on food security contributes significantly to the ongoing debate surrounding the pros and cons of palm oil cultivation in countries still facing serious food security challenges. However, research results also emphasize the undeniable substantial contribution of oil palm cultivation to employment generation and as a source of livelihood for many Indonesians employed on plantations, as well as those involved in sectors that utilize crude palm oil as an input in the production process. Furthermore, it serves as a veritable source of tax revenues for local and national governments.

While the principles underlying food security policy under President Joko Widodo's administration have not changed, there have been fundamental shifts in strategies and programs aimed at realizing food security objectives. The Indonesian food security strategies outlined in President Widodo's nine priority programs (Nawa Cita) for the 2015-2019 medium-term development plan include efforts to increase food availability through enhanced domestic production of key crops such as rice, maize, wheat, sugar, chili, and onions. Additionally, there are initiatives to improve the quality of food distribution and accessibility, enhance the overall quality and nutritional value of the Indonesian diet, safeguard food security by preparing for natural disasters, mitigating the impact of climate change, and preventing pests and diseases in animals, as well as improving the livelihoods and welfare of farmers, fishermen, and other food producers.

The goals and targets set to achieve these strategies include, but are not limited to, increasing domestic production of key food commodities, with a particular emphasis on achieving self-sufficiency in rice. Other objectives involve improving food accessibility by monitoring food distribution and preventing price speculation, enhancing the overall quality of the diet by aiming for a national PPH score (Desirable Dietary Pattern) of 92.5 by 2019, developing and improving irrigation systems, and reducing land conversion by 600 thousand hectares. Additionally, the plan includes rehabilitating 1.75 million hectares of deteriorating irrigation infrastructure, effectively managing and maintaining the irrigation network spanning 2.95 million hectares, and establishing 132,000 hectares of swamp irrigation networks to address economic, environmental, and sustainability concerns (FSVA, 2015).

Undoubtedly, the rising prices of food crops, albeit at varying rates over time, have directly impacted domestic prices of rice, sugar, maize, palm oil, cassava, and shallots, thereby leading to soaring prices of farm inputs and food commodities in the domestic market. This price uncertainty has affected both producers and consumers, influencing their production and consumption decisions. In some cases, food crop producers, who are to some extent still influenced by government direction, have chosen to shift towards growing non-food crops due to better market prices. This shift has resulted in a reduction of land dedicated to staple crops like rice, as it has been allocated for growing vegetables and fruits, among other alternatives. The same trend applies to sugar production. The importation of foodstuffs, managed by the trade ministry, has become a source of frustration for producers, as it depresses the prices of their harvests. Compounding the issue is the lack of coordination between the ministry of agriculture, responsible for food security matters, and the ministry of trade, responsible for issuing trading and importing licenses.

In its strategic plan, Indonesia's Food Security Board, the agency responsible for guiding and directing national food security efforts, emphasizes several important objectives. These objectives include:

i) Ensuring the maintenance of the current minimum energy per capita of 2,200 kilocalories per day and a minimum availability of 57 grams per day. ii) Reducing the number of people vulnerable to food insecurity by at least 1 percent annually. iii) Achieving an increase in per capita food consumption to meet the energy needs of at least 2,000 kilocalories per day and 52 grams per day. iv) Reducing per capita rice consumption by 1.5 percent annually, accompanied by an increase in the consumption of tubers and other sources of animal and plant proteins. This shift should contribute to an improved quality of consumption, as measured by the expected food pattern (PPH) score of 93.3 in 2014. v) Achieving an improvement in food distribution to ensure stable and affordable food prices for the Indonesian population. vi) Enhancing the safety of fresh foodstuffs by increasing the involvement of producers and consumer awareness. vii) Enhancing the effectiveness of food security policy coordination through the Food Security Council.

Priority areas considered vital for implementing the above strategies include revitalizing land use and productivity, improving the quantity and quality of seedling nurseries, strengthening infrastructure and related facilities, enhancing human resource development, improving agricultural finance capabilities, expanding the scope and reach of agricultural institutions, revitalizing technology applications, and strengthening downstream industries.

Based on various indices of food security status, indications point to a persistently serious problem in Indonesia over the past few years. In 2014, the Food and Agricultural Organization (FAO) estimated that 8.7 percent of the Indonesian population was undernourished during the 2012-2014 period. This was corroborated by the Central Bureau of Statistics (BPS), based on their 2013 social and economic survey, which revealed that 52.52 percent of the Indonesian population did not meet the international minimum threshold of 2000 kilocalories per capita per day (BPS, 2014). In the same year, the International Food Policy Research Institute (IFPRI) ranked Indonesia 22nd out of 76 countries on the Global Hunger Index (GHI).

Five years later, in 2019, the food security situation had not significantly improved. Indonesia was ranked 62nd out of 113 countries on the Global Food Security Index released by the Economist Intelligence Unit (2019)[ii]. While the country performed well in terms of food affordability (score of 70.1) and moderately in food availability (score of 61.3), it fared poorly in the dimensions of food quality and safety (score of 47.1). The GHI index in 2019 reflected similar concerns, with Indonesia achieving a score of 20.1, ranking 70th out of 117 countries[iii]. The GHI score is aggregated from four dimensions, including undernourishment, child wasting, child stunting, and child mortality.

In terms of palm oil production, Indonesia produced over 30 million tons from 14.99 million hectares of land in 2022. This industry contributes approximately 4.5 percent to GDP, generates over $35 billion in exports, and provides direct employment to 8 million people, with a total of 21 million workers involved in various related sectors. The palm oil industry has also played a significant role in lifting 2.6 million people out of poverty, not only in the 18 provinces that are major palm oil producers but also in other parts of the country through transportation, logistics, oleochemical industries, cosmetics, soap, edible oil, and other sectors. Palm oil serves as a source of livelihood for 4 million smallholder households, both through Nucleus-Plasma partnerships and independent farming. Additionally, it contributes 17 percent of value-added through downstream agricultural processing and the logistics and transportation sector (FAO, 2021).

However, despite the positive contributions that palm oil growing and production have made to the population and economy, it is not surprising that any criticism towards efforts to expand the cultivation area, regardless of the social and environmental costs, is often met with opposition from parties heavily invested in the industry, both private and state institutions. Most notably, the Indonesian government views such criticism as contrary to the national interest. One of the ongoing challenges that Indonesia faces is the recurring issue of forest and land fires that regularly affect provinces.

During the period of 1997/1998, forest and land fires devastated 10 million hectares, resulting in a cost of $10 billion due to the adverse impacts on the affected provinces' economies, public health, ecology, transportation, and tourism. The fires also had ramifications beyond Indonesia's borders, impacting neighboring countries. In late 2015[iv] and early 2016, extensive forest and land fires in Sumatra and Kalimantan affected over 2.1 million hectares of land, displacing 12,000 people and incurring a cost of $30 billion (Tanoto, 2016). Multiple studies have demonstrated a strong association between the expansion of oil palm cultivation and the frequency and spread of forest fires. This is primarily because using fires to clear land for planting is a more cost-effective method, albeit with significant social, economic, health, and ecological consequences (Figure 1).

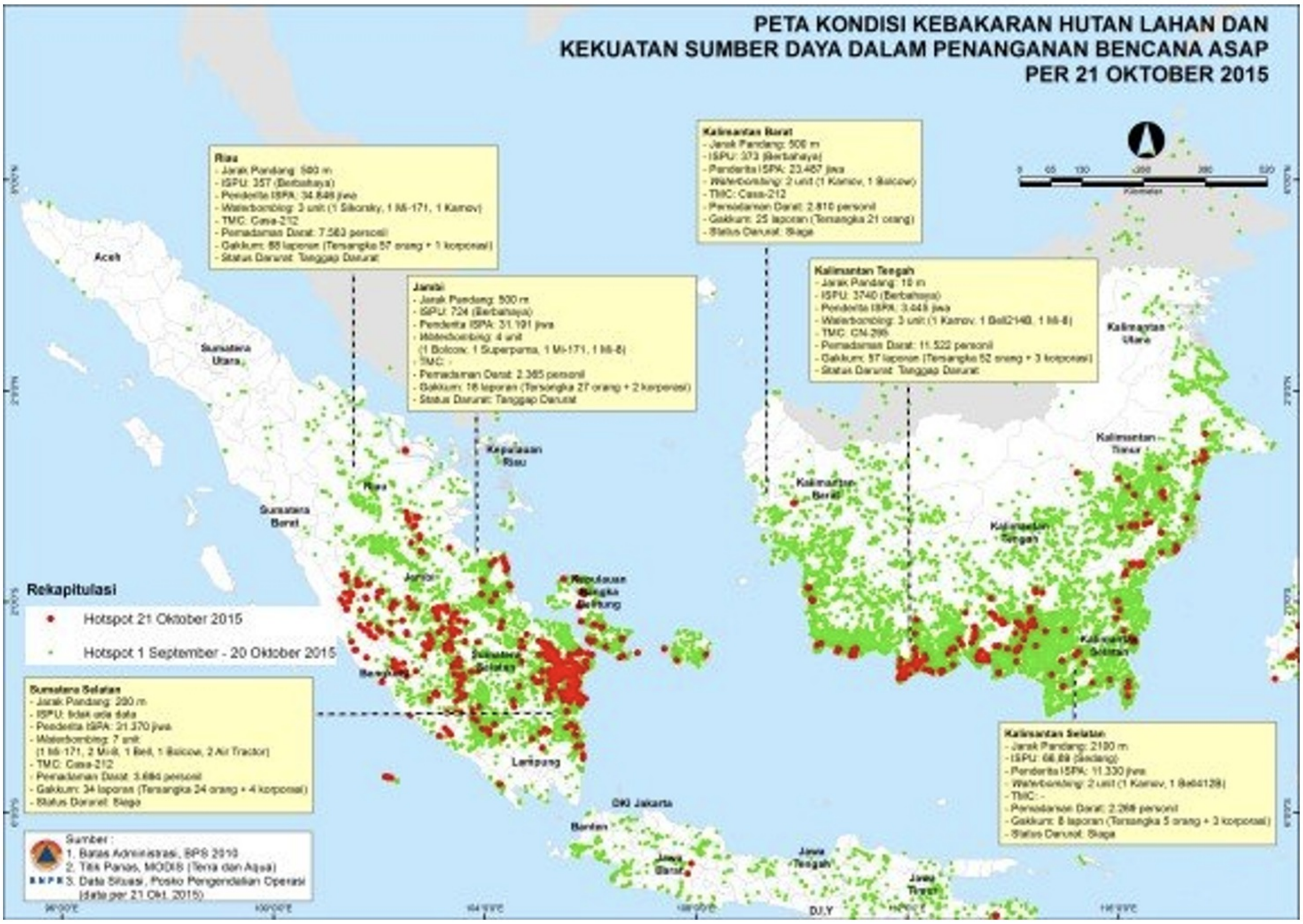

Figure 1. Location and spread of hotspots during late 2015 forest and land fires.

Source: National Disaster Mitigation Agency

Causes of forest and land fires include, but are not limited to, the age-old practice of slash and burn, which has been used by local communities to clear land prior to planting for more than 17,500 years (Goldammer and Seibert, 1989). The adoption of this practice on a larger scale by small and medium-sized concession companies is due to the relatively lower cost of clearing land compared to mechanical methods[v]. Moreover, the deliberate setting of forests on fire has been adopted through collusion between local government officials and concession companies as the easiest way to evict the local population with ancestral claims to the land. Higher levels of greenhouse gases and the resulting increase in atmospheric temperatures contribute to the likelihood of forest and land fires, particularly during El Niño Southern Oscillation (ENSO) events, as observed in 1997/1998 and 2015/2016 (Ainuddin et al., 2006). Areas of forest and grassland vegetation that have been previously affected by fires are more vulnerable to new fires due to the emergence of lighter vegetation cover, compared to the dense canopy that existed prior to the forest fires. Lastly, poor supervision of local and central government programs involving the allocation and use of forest and grasslands, such as concessions for timber logging, pulp and paper production, cash crop plantations, and transmigration resettlement, exacerbates the occurrence of forest and land fires.

However, despite the various factors contributing to forest and land fires, there is little doubt that the rapid expansion of palm oil cultivation has played a significant role in the spread and frequency of such fires in Indonesia. This is evident in the correlation between forest fires and high deforestation rates in key palm oil-producing regions, including Riau, North, South and West Sumatra, Jambi, as well as West, Central, East, and North Kalimantan. This suggests that the expansion of palm oil cultivation is not merely coincidental but rather a contributing factor to the persistent problem of forest fires.

Another challenging issue is that the rapid expansion of palm oil areas has not been accompanied by the necessary adherence to standard production and processing principles and practices for sustainable palm oil, as outlined by the Roundtable on Sustainable Palm Oil (RSPO[vi]). The RSPO brings together palm oil producers, buyers' organizations, and environmental and social groups. Its framework consists of principles and criteria based on internationally recognized standards, which undergo review every five years. These principles and criteria encompass legal and economic viability, adherence to environmentally friendly standards, and socially beneficial management and operations. National interpretations are considered, taking into account differences in legal and cultural frameworks. The credibility of sustainability claims is verified through the involvement and agreement of all stakeholders in the certifying country who have legal ownership of the entire palm oil supply chain.

The reality is that not all palm oil producers comply with sustainable palm oil principles and practices, as depicted in Figure 1. The figure illustrates that not all areas controlled by concessions adhere to recommended sustainable farm management practices, which are established based on the best production, processing, and distribution standards recognized by international development agencies, governments, financing institutions, and non-governmental organizations under the Roundtable on Sustainable Palm Oil (RSPO) framework. Consequently, the overlap between areas experiencing high deforestation rates, frequent forest and land fire hotspots, and palm oil concessions is not a mere coincidence but a reflection of cause and effect that cannot be easily disputed. In 2012, out of the total 78.6 million hectares of palm oil-growing land worldwide, only 13.7 million hectares (21 percent) had received certification under the RSPO framework. Indonesia accounted for 51 percent of certified palm oil production and processing based on research conducted by palm oil researchers and the RSPO in 2016.

Food security is defined in the existing literature as a status or state in which "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food for their dietary needs and food preferences for an active and healthy life" (The World Bank, 1986). The Community for Food Security Coalition (1995) further defines food security as "the state in which all persons obtain nutritionally adequate, culturally acceptable, safe foods regularly through local non-emergency sources. Food security encompasses a broader perspective on hunger, considering the systemic causes of hunger and poor nutrition within a community while identifying necessary changes to prevent their occurrence. Food security programs address hunger and poverty." According to the Food Insecurity Experience Scale (FIES) developed by the Food and Agriculture Organization (FAO, 2019), food insecurity refers to "limited access to food, at the level of individuals or households, due to lack of money or other resources."

In Food Law No. 18/2012, Indonesia adopted the definition of food security from the World Bank (1996) with some modifications that reflect social, religious, and cultural contextual factors. The adopted definition states that food security is "the fulfillment of conditions such that all people in all households at all times have sufficient food in both quantity and quality, that is safe, diverse, nutritious, equitably distributed, and affordable, and that does not conflict with religion, beliefs, or culture, to enable them to live healthy, active, productive, and sustainable lives." Additionally, the law outlines the principles expected to underpin the Indonesian food system, which include sovereignty, independence, resilience, safety, benefits, equity, sustainability, and justice (FSVA, 2015).

The concept of food security is associated with the stability of food availability and access at various levels, from individual households to regions and nations. Stability in food security, or the lack thereof, is often reflected in the concept of vulnerability (Brocca, 2002). Therefore, food security is comprised of four interrelated and interdependent dimensions: food availability, access, utilization, and vulnerability.

Regarding availability of food, it is important to note that it is just one necessary condition that influences food security but not sufficient on its own. The means and affordability to ensure access to food, the capacity to process food into a form that can be consumed and absorbed by the human body, and the stability of food sources are also crucial factors. This emphasizes the importance of both the quality and quantity of food, as well as the regularity of its availability. From this understanding, it becomes apparent that the propensity for a household, region, or nation to fall below or above a certain predetermined threshold of food security is just as influential as the factors of availability, access, and utilization.

At the household level, food security requires sufficient income or other entitlements (such as physical or financial assets) to purchase food (Bellu and Liberati 2005:6). Therefore, it is not surprising that food security status within a society is contextual, as it reflects the factors that influence and determine access, or lack thereof, to available resources for households, communities, and regions. In operationalizing the definition of food security, it is important to consider a predetermined threshold that takes into account the contextual factors (social, political, economic, and cultural). Thus, food security status is bound to vary across different times and locations. Lovendor (2004) explains that the desired outcome of food security status, which represents a socially acceptable standard of living, influences the determination of the minimum threshold and the level of income or expenditure categorized as falling below that threshold, which becomes the absolute poverty level.

At the macro level, food security is determined by availability, stability, and accessibility, with availability and stability being crucial for ensuring accessibility.

Food availability is dependent on the capacity to produce or import sufficient food, which includes considerations of production, importing, and storage capacities. The stability of food availability is essential, requiring a well-functioning and integrated market system and effective stock management. These aspects enable the organization and distribution of food to reach all households within a given setting, ensuring accessibility. Accessibility, in turn, relates to how people acquire food, taking into account their purchasing power and command over resources.

What is equally enlightening is the realization that the food security status of a society is influenced by a wide range of socioeconomic and political factors, which, in turn, impact and are impacted by the performance of the food economy, caregiving practices, and health and sanitation. In essence, the availability of food in a country must be complemented by the distribution of that food to the population in the right place and at the right price, and there must be mechanisms in place to ensure that the available food is of sufficient quantity and quality. Food access refers to individuals' capacity to obtain the necessary resources (entitlements) that enable them to acquire appropriate foods for a nutritious diet. These entitlements encompass both monetary and traditional rights and are influenced by the legal, political, economic, and social arrangements of the community in which individuals live.

The third variable is food utilization, which pertains to the extent to which available food is utilized through adequate diet, access to clean water, sanitation, and healthcare. Therefore, even if food availability and access are favorable, the conditions in which individuals live, such as access to clean water and sanitation, must be conducive to fully benefiting from the available food in meeting their energy requirements. Indicators of food utilization include factors such as having an adequate diet, access to clean water, sanitation, and healthcare.

Additionally, stability of access is the fourth variable that measures the extent to which the food security condition of a household remains unchanged, improves, or worsens over time. This variable leads to the concept of vulnerability. Food insecurity, or the absence of food security, can be assessed using various indicators, including but not limited to undernourishment, which refers to the condition of individuals whose food intake is insufficient to meet their basic energy requirements on an ongoing basis (Hadadd, 1999).

In terms of the determinants of food security, empirical research has identified various factors and practices that either support or undermine the food security status of households and regions. Rosegrant et al. (1998) identified per capita kilocalorie availability, the percentage of social expenditures as a share of total expenditures, the percentage of females with secondary education, the percentage of households with access to clean water, and a dummy variable for South Asia as determinants of global food insecurity (USAID, 2000). Policy interventions that are considered crucial for improving the food security status of a country or region include political stability, economic openness, democratization, reductions in food tariffs, the quality of rural roads, the level and quality of agricultural research, targeted food aid, household interventions, and access to safe water. Each policy intervention, except for political instability, influences food availability, female secondary education, and access to safe water.

Improving food security status requires changes and improvements in female educational attainment, access to safe water, political stability, public participation in the policy-making process, economic liberalization, trade openness to enhance competitiveness and resource use efficiency, investment in human capital, access to roads, agricultural infrastructure, effectiveness of agricultural research, targeted food aid (USAID, 2000), reduction of household dependency ratio (Rose et al., 1998; Ojogho, 2010; Omotesho et al., 2006), implementation of programs supporting food production, household electrification, access to immunization services, health facilities, and literacy education, all of which have been associated with improved food security (Khan & Gill, 2009). Other factors include increasing household expenditure, reducing household size, mitigating seasonality of household income, reducing the distance from food supply locations (both in urban and rural areas) (Garret and Ruel, 1999), promoting gender equality, ensuring the availability of affordable housing, and providing state food support (Mukherjee, undated). Creating a stable micro and macroeconomic environment that supports inclusive growth and decent work is also associated with a reduction in malnourishment, severe hunger incidence, and food insecurity, while protecting the domestic food sector from fluctuations in international food crop prices and promoting diversity of food crops available for households (Simler, 2010). Simler's findings were supported by Wardani & Muyanja-Ssenyonga's (2012) research, which found that economic liberalization is a key factor that exacerbates vulnerability to food insecurity.

Regarding the relationship between palm oil and food security, the existing literature provides mixed results. Shahputra & Zen (2018) associate oil palm cultivation with low poverty rates and high regional gross domestic product, while Azhar et al. (2017) argue that smallholder palm oil cultivation is biodiversity-friendly due to its multi-crop production approach, which also contributes to environmental conservation and poverty alleviation. However, large plantations, including certified ones, have a greater adverse impact on biodiversity and food security compared to smallholdings. As a result, recommendations have been made to adjust palm oil production policies to increase the cultivation on smallholder estates. On the other hand, palm oil cultivation, particularly on large plantations, has been criticized for exacerbating food insecurity among indigenous and local communities living in areas designated for palm oil expansion by national and state governments. This has led to conflicts between local communities, palm oil companies, and local/state governments (Nesadurai, 2013).

Despite efforts such as the certification of the palm oil value chain through RSPO, the small percentage of certified palm oil production, combined with the emergence of national certification schemes, has not significantly improved the harmonization of interests between palm oil cultivation, environmental conservation, and the sustainable livelihoods of local communities.

This research will approach the topic from the perspective that rapid growth in any economic activity, including palm oil cultivation, is likely to result in mistakes due to rushed planning and implementation, inadequate monitoring and supervision, and insufficient involvement of all stakeholders to ensure adherence to well-designed plans and environmental impact assessments. Taking this into consideration, the research will focus on the following entry point: the rapid expansion of palm oil cultivation has given rise to various issues. The remaining sections of this paper will be structured as follows: Section two will present the research methodology, followed by the presentation of results and discussion in section three. The final section will conclude the article.

II. Research Methodology

Assessing the extent to which a food and nutrition policy ensures the delivery of quality and sufficient food to the intended beneficiaries requires a comprehensive understanding of social organization. Social organization encompasses three levels: macro, meso, and micro. The macro level represents the world, regions, and nations, while the meso level refers to communities at various levels such as provinces, cities, districts, towns, sub-districts, and villages. On the other hand, the micro level pertains to households and individuals. Different levels of social organization necessitate different approaches and methods to assess and evaluate food and nutrition status. This is because although the determinants of food and nutrition status remain the same (food availability, access, utilization, and stability), the nature, causes, and effects of these determinants vary across different levels. Consequently, indicators of food and nutrition security also differ depending on the level of social organization.

At the macro level, indicators of food and nutrition security include fertility rate, food production, and population flows (availability), food prices, wages, and per capita food consumption (accessibility), stunting rate, wasting rate, and low birth weight (utilization), as well as regional disparities in food fluctuations (stability). Meanwhile, at the meso level, indicators encompass the stability of food production during harvest time (availability), market and retail food prices, latrine coverage, and dietary diversity rate (utilization), as well as pre/post-harvest food practices and women's body mass index (utilization). At the micro level, indicators of food and nutrition security include food storage, consumption of wild foods (availability), meal frequency, food diversity, and employment (accessibility), weight-for-age, goiter, and anemia prevalence (utilization), as well as pre-harvest food practices and migration (stability). The existence and relevance of these indicators, which vary depending on the level of social organization, imply that the assessment of food and nutrition security status also varies across macro, meso, and micro levels.

At the macro level, dimensions or categorical factors of food and nutrition security encompass precipitation levels and food balance (food availability), vulnerability mapping (accessibility), demographic and health services (utilization), and global information early warning systems. At the meso level, the assessment of food and nutrition security status involves conducting food market surveys (to gauge food availability), food-focused group discussions (accessibility), district health surveys (utilization), and anthropometric surveys in children (stability). At the micro level, food and nutrition security is assessed by evaluating the level of agricultural production (food availability), conducting inter-household food frequency questionnaires (accessibility), reviewing immunization charts (utilization), and weighing charts of pregnant women (Gross et al., 2000).

Changes in food prices serve as the primary channel through which shocks in food supply or demand, or both, translate and impact vulnerable food and nutrition security at the macro/meso level. Therefore, factors that cause shocks in food supply and demand become the focal point for assessing and identifying the causes of food and nutrition security issues and finding subsequent solutions. Factors attributing to shocks in food supply range from natural disasters to conflicts, food stock levels, balance of payments, agricultural production, and trade. Factors affecting the demand for food include conflicts and social protection policies. In the long term, food supply is influenced by agricultural production, research and technology, trade patterns, growth, exchange rates, natural resources, climate change, and environmental and biodiversity changes. Long-term food demand, on the other hand, is shaped by population growth, urbanization, and income growth (Peters et al., 2013).

The research focuses on the food security status of Indonesian provinces at the sub-national level. It employs a mixed research design, utilizing published secondary data on palm oil-related policies implemented by successive Indonesian governments, as well as data on national and regional food security status, with a particular emphasis on provinces that have extensive land areas dedicated to palm oil cultivation. The research also incorporates data on the expansion of palm oil cultivation in Indonesia over the past two decades, as well as data on the direct and indirect impacts of this expansion, including land and forest fires and their associated health, social, economic, and environmental costs.

Secondary data sources include the Central Bureau of Statistics in Indonesia, central government documents and reports, published research papers, and a report jointly produced by the World Food Program and the Indonesian Ministry of Agriculture on the vulnerability of food security. When examining the food security vulnerability status of Indonesian provinces based on the FSVA 2015, it was found that newly established districts exhibited higher food security vulnerability compared to pre-existing districts prior to the enactment of the Regional Autonomy law No. 22/1999 (amended to become Law No. 32/2004), which allowed for the creation of new districts. To prevent selection bias, new provinces will not be included in the analysis. This is because new provinces, which consist of newly established districts, are more likely to face higher levels of food insecurity compared to "old" districts within the established provinces. Therefore, provinces that were formed after the implementation of the decentralization policy in 2001 were excluded from the research.

The logit model was used to conduct the analysis. The model specification is based on logistic regression, which involves a binary dependent/response variable and independent variables. In logistic regression, the binary dependent variable ranges from zero (0) to one (1). In this case, the Y variable represents the food security status of a province, as indicated in the Food Security Vulnerability atlas. This atlas was developed through comprehensive research conducted in all districts of Indonesia by the World Food Program in collaboration with the Food Security Council and Ministry of Agriculture of the Republic of Indonesia in 2015. Provinces with a higher proportion of districts falling into priority categories 1 and 2 (indicating severe food security) were classified as 0 (zero), while those with most of their districts falling into categories 3 and 4 (relatively food secure to food secure) were classified as 1 (one). The independent variables are represented by X in $X_i'\beta$. These independent variables include regional gross domestic product, dependency ratio in the province, population in the province, total area under oil palm cultivation, total area in the province, total production of rice in the province, total consumption of protein in the province, expenditure on food in the province, and provincial government expenditure.

The model specification calculates the probability of observing a value of one for the dependent variable given the independent variables as:

$$\Pr\left(y_i = 1 \,\middle|\, x_i \,.\, \beta\right) = 1 - F(-x_i' \beta_i)$$

This means that F is a strictly and continuously increasing function that takes on real values ranging from zero at its minimum point to one at its maximum point. The F function is linear in parameters and takes the form $(x_i'\beta_i)$. The decision to use this model is based on the cumulative logistic distribution function. However, it is important to note that the dependent variable is skewed, with more provinces being food secure (having a value of one) and fewer provinces recording a value of zero. This suggests that an alternative specification, such as the extreme value specification, may be equally good or potentially better suited for the analysis.

III. Results and Discussion

Model specification. The logistic regression model used to analyze the data is specified as follows:

FOOD_SECURE = -100.461076576 - 0.00540886029573*OILPALM_ACREAGE

+ 1.84823548669*MOBILEOWNERSHIP

- 0.000113760388389*EXPFOOD - 0.000381636165261*ACCESS

Where OILPALM_ACREAGE represents the expansion of oil palm cultivation, MOBILEOWNERSHIP represents the percentage of mobile phone ownership, EXPFOOD represents expenditure on foodstuffs, and ACCESS represents road mileage. All variables represent values at the subnational (province) level.

Table 1. Logistic regression (ML.Logit Model Results)

Dependent Variable: FOOD_SECURE					
Method: ML - Binary Logit (Newton-Raphson)					
Date: 08/14/17 Time: 14:00					
Sample: 1 33					
Included observations: 31					
	Convergence achieved after 9 iterations				
	QML (Huber/White) standard errors & covariance				
Variable	**Coefficient**	**Odds Ratio**	**Std. Error**	**z-Statistic**	**Prob.**
C	-100.4611			-3.000198	0.0027
OILPALM_ACREAGE	-0.005409	**0.9946056**	33.48481	-3.197675	0.0014
MOBILEOWNERSHIP	1.848235	**6.3486043**	0.001691	2.778182	0.0055
EXPFOOD	-0.000114	**0.999886**	0.665268	-2.243450	0.0249
ACCESS	-0.000382	**0.9996181**	5.07E-05	-1.768887	0.0769
McFadden R-squared	0.661942		Mean dependent var		0.774194
S.D. dependent var	0.425024		S.E. of regression		0.269283
Akaike info criterion	0.683734		Sum squared resid		1.885340
Schwarz criterion	0.915022		Log likelihood		-5.597877
Hannan-Quinn criter.	0.759128		Deviance		11.19575
Restr. deviance	33.11788		Restr. log likelihood		-16.55894
LR statistic	21.92213		Avg. log likelihood		-0.180577
Prob(LR statistic)	0.000208				
Obs with Dep=0	7		Total obs		31
Obs with Dep=1	24				

*Significance error values: ***,1%; **5%, *10%*

The analysis results from logistic regression, after conversion into odds ratios, are presented in Table 1 and Table 2. Based on the results, it is evident that an increase in the ratio of the area dedicated to oil palm cultivation decreases the odds of achieving food security by a factor of 9 (almost 10), while keeping other explanatory factors constant. Additionally, a one-unit change in mobile phone ownership increases the odds of food security by a factor of 6.35, with other explanatory factors remaining constant. Furthermore, an increase of one unit in expenditure on food decreases the odds of food security by a factor of 9 (almost 10), holding other explanatory variables constant. Lastly, a unit increase in accessibility (infrastructure) decreases the odds of food security by a factor of 9 (almost 10), with other explanatory factors remaining constant.

Table 2. GLM Model results

Dependent Variable: FOOD_SECURE					
Method: Generalized Linear Model (Newton-Raphson)					
Date: 08/14/17 Time: 15:08					
Sample: 1 33					
Included observations: 31					
	Family: Binomial Count (n = 1)				
Link: Log-log					
Dispersion fixed at 1					
	Convergence achieved after 9 iterations				
	Coefficient covariance computed using the Huber-White method with				
observed Hessian					
Variable	**Coefficient**		**Std. Error**	**z-Statistic**	**Prob.**
C	-67.30798		18.77070	-3.585800	0.0003
OILPALM_ACREAGE	-0.003946	0.996062	0.001563	-2.524434	0.0116
MOBILEOWNERSHIP	1.246208	3.477133	0.361963	3.442911	0.0006
ACCESS	-0.000254	0.999746	0.000154	-1.647628	0.0994
EXPFOOD	-7.62E-05	0.999924	3.32E-05	-2.295376	0.0217
Mean dependent var	0.774194		S.D. dependent var		0.425024
Sum squared resid	1.809621		Log likelihood		-5.404722
Akaike info criterion	0.671272		Schwarz criterion		0.902561
Hannan-Quinn criter.	0.746667		Deviance		10.80944
Deviance statistic	0.415748		Restr. deviance		33.11788
LR statistic	22.30844		Prob(LR statistic)		0.000174
Dispersion	1.000000				

*Significance error values: ***,1%; **5%, *10%*

With the exception of the variable MOBILEOWNERSHIP, which has an odds ratio of 3.48, the results of the GLM model in Table 2 are virtually similar to the ML results in Table 1 in terms of the magnitude, signs, and significance level of the coefficients.

Table 3. Frequency of the dependent variable

Dependent Variable Frequencies				
Equation: MAKOMIKO_12				
Date: 08/14/17 Time: 13:26				
			Cumulative	
Dep. Value	**Count**	**Percent**	**Count**	**Percent**
0	7	21.88	7	21.88
1	25	78.13	32	100.00

From the frequency of the dependent variable (Table 3), it is apparent that 25 observations fall into the food secure category (Y = 1), while only 7 observations are classified as food insecure (Y = 0).

Testing for collinearity

To test for collinearity, confidence ellipses were used in E-views. The results showed that the joint confidence intervals form complete circles, indicating the independence of the explanatory variables and the absence of collinearity (Figure 2).

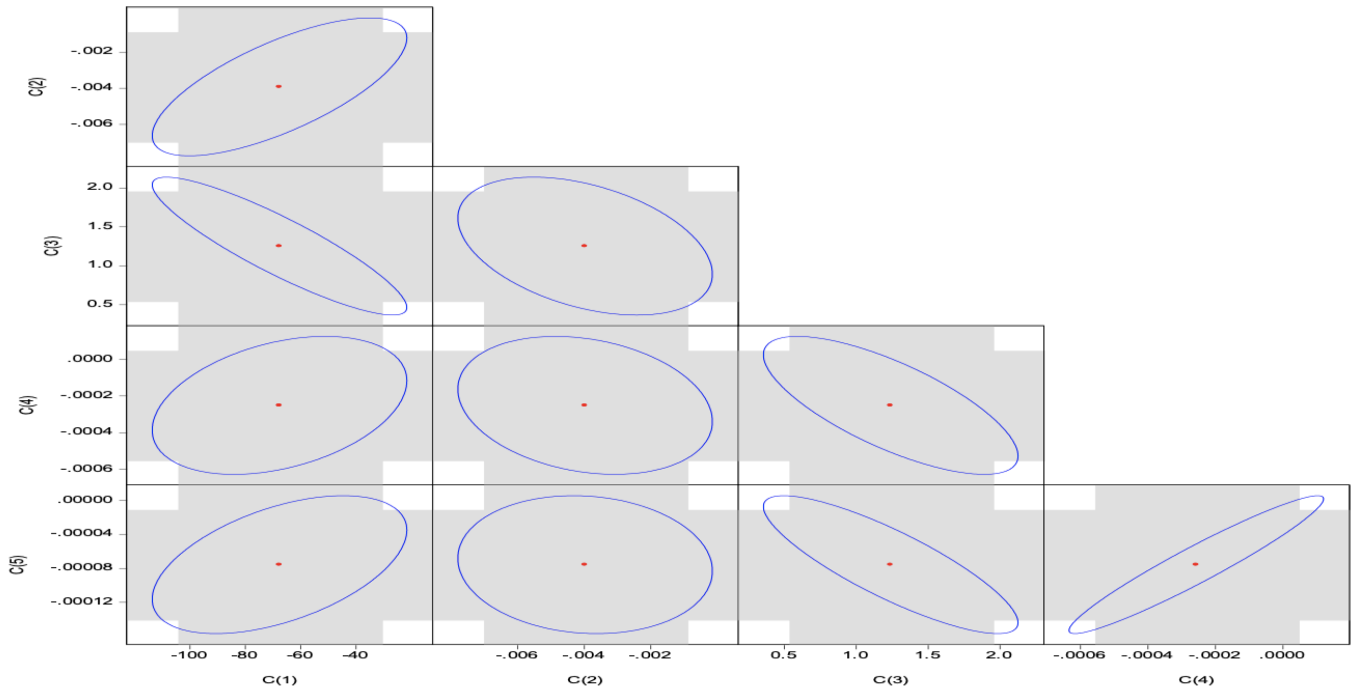

Figure 2. Confidence ellipse test for collinearity

Characteristics of explanatory variables

Based on the data used in the analysis, the average oil palm acreage in provinces categorized as food secure is lower (264.21 thousand Ha) compared to provinces categorized as food insecure (567.32 thousand Ha) (Table 4).

Table 4. Descriptive statistics of explanatory variables

Categorical Descriptive Statistics for Explanatory Variables			
Equation: MAKOMIKO_12			
Date: 08/14/17 Time: 14:20			
		Mean	
Variable	**Dep=0**	**Dep=1**	**All**
C	1.000000	1.000000	1.000000
OILPALM_ACREAGE	567.3200	264.2092	332.6535
MOBILEOWNERSHIP	82.61714	88.38042	87.07903
EXPFOOD	401708.6	400319.6	400633.2
ACCESS	18947.00	15041.75	15923.58
		Standard Deviation	
Variable	**Dep=0**	**Dep=1**	**All**
C	0.000000	0.000000	0.000000
OILPALM_ACREAGE	865.1883	361.4981	516.2323
MOBILEOWNERSHIP	8.546788	4.386681	5.946650
EXPFOOD	72187.27	79043.60	76371.45
ACCESS	11415.00	9775.758	10103.58
Observations	7	24	31

Mobile phone ownership is higher, on average, in provinces categorized as food secure (88.38 percent) compared to provinces categorized as food insecure (82.62 percent). Monthly per capita expenditure on food is also higher in provinces that are food secure (401,709 Rupiah) compared to provinces that are categorized as food insecure (401,709 Rupiah). Additionally, road mileage in provinces categorized as food secure is 11,415 Km, while it is 9,776 Km in provinces that are categorized as food insecure.

Model robustness evaluation results

To assess the robustness of the model, we conducted an Expectation-Prediction evaluation process, evaluated the goodness of fit, examined variable redundancy and missing variables, and performed the Ramset RESET Test. The results of the expectation-prediction evaluation are presented in Table 5.

Table 5. Expectation-Prediction Evaluation for the Model

Expectation-Prediction Evaluation for Binary Specification						
Equation: MAKOMIKO_12						
Date: 08/14/17 Time: 14:52						
Success cutoff: C = 0.5						
	Estimated Equation			**Constant Probability**		
	Dep=0	**Dep=1**	**Total**	**Dep=0**	**Dep=1**	**Total**
P(Dep=1)<=C	5	1	6	0	0	0
P(Dep=1)>C	2	23	25	7	24	31
Total	7	24	31	7	24	31
Correct	5	23	28	0	24	24
% Correct	71.43	95.83	90.32	0.00	100.00	77.42
% Incorrect	28.57	4.17	9.68	100.00	0.00	22.58
Total Gain*	71.43	-4.17	12.90			
Percent Gain**	71.43	NA	57.14			
	Estimated Equation			**Constant Probability**		
	Dep=0	**Dep=1**	**Total**	**Dep=0**	**Dep=1**	**Total**
E(# of Dep=0)	5.15	1.85	7.00	1.58	5.42	7.00
E(# of Dep=1)	1.85	22.15	24.00	5.42	18.58	24.00
Total	7.00	24.00	31.00	7.00	24.00	31.00
Correct	5.15	22.15	27.30	1.58	18.58	20.16
% Correct	73.54	92.28	88.05	22.58	77.42	65.04
% Incorrect	26.46	7.72	11.95	77.42	22.58	34.96
Total Gain*	50.96	14.86	23.02			
Percent Gain**	65.83	65.83	65.83			

**Change in "% Correct" from default (constant probability) specification*

***Percent of incorrect (default) prediction corrected by equation*

The estimated equation demonstrates an overall prediction accuracy of 88.05 percent, compared to the constant probability model with an accuracy of 65.04 percent. This indicates an improvement of 23.02 percent (88.05 - 65.04 percent) in prediction accuracy. Notably, the model performs better in classifying y = 0 observations (73.54 percent compared to 22.58 percent), while for y = 1 observations, it achieves a classification rate of 92.28 percent compared to 77.42 percent.

Evaluating model accuracy using precision, recall, and F-score values

Precision, recall, and F-score serve as indicators of the model's accuracy. Precision is calculated by dividing the total number of Y observations predicted as true positive (1) by the total number of observations that are actually true positive. Recall, on the other hand, is calculated by dividing the total number of observations predicted as true positive (1) by the total number of observations that are true positive (1).

Hence, precision is calculated as the number of correctly predicted positive instances divided by the total number of positive predictions, including true positives and false positives. Precision is represented by the formula TP/(TP+FP).

Based on the model results, *Precision = TP/(TP+FP): (23/(23+1)*100*≈ 96 percent

Meanwhile, recall is calculated as TP/(TP+FN), representing the predicted positive observations divided by all positive observations, which includes true positives and false negatives.

*Recall = TP/(TP+FN): (23/(23+2)*100*≈ 92 percent

The F-score measures the accuracy of the prediction model and is calculated using the formula:

=2(Precision * Recall)/(Precision + Recall)*

Based on the model results, the prediction model accuracy (F-score) is approximately 94 percent, calculated as

= 2(Precision * Recall)/(Precision + Recall) 2*(92%*96%)/(92%+96%)≈ 94 percent*

Thus, with precision, recall, and accuracy of 96 percent, 92 percent, and 94 percent, respectively, the model does a good job of predicting the dependent variable compared with a random prediction model.

Goodness of fit evaluation for the model

A goodness of fit evaluation for the binary specification was conducted. The test examines the extent to which fitted values are in line or diverge from actual values of the dependent variable by group (Table 6).

Table 6. Goodness of Fit Evaluation of the prediction model

Goodness-of-Fit Evaluation for Binary Specification
Andrews and Hosmer-Lemeshow Tests
Equation: MAKOMIKO_1217
Date: 08/15/17 Time: 16:00
Grouping based upon predicted risk (randomize ties)

	Quantile of Risk		Dep=0		Dep=1		Total	H-L
	Low	High	Actual	Expect	Actual	Expect	Obs	Value
1	3.E-07	0.6269	5	5.58905	2	1.41095	7	0.30800
2	0.6807	0.9981	2	1.41013	6	6.58987	8	0.29955
3	0.9997	1.0000	0	0.00082	8	7.99918	8	0.00082
4	1.0000	1.0000	0	2.2E-06	8	8.00000	8	2.2E-06
		Total	7	7.00000	24	24.0000	31	0.60837
H-L Statistic			0.6084		Prob. Chi-Sq(2)		0.7377	
Andrews Statistic			9.6396		Prob. Chi-Sq(4)		0.0470	

Based on the Hosmer-Lemeshow statistic (H) and the Andrew statistic, which measure the deviance between grouped observed and expected values (deciles in this case) of the Y = 1 observations in each group, an insignificant value of 0.0684 (with a probability value of 0.74) and a significant value of 9.64 (with a p-value of 0.047) were obtained, respectively. Thus, based on the expected and observed values of Y = 1, there is no significant difference between the predicted and observed values of the dependent variable. However, based on the observed and expected values of both Y = 1 and Y = 0, there is a significant difference in deviance. This is because the model performs better at predicting Y = 1 values than Y = 0 values.

Using RMSE to Indicate Goodness of Fit of the Model

The root mean squared error (RMSE) is used as a metric to indicate the goodness of fit of the model. It measures the fit based on residuals, which are the differences between observed and predicted values. The advantage of RMSE over mean absolute error (MAE) is that it amplifies and punishes large errors. The RMSE results are depicted in Figure 3. The goodness of fit of the model estimates compared with the observed values shows an RMSE of 0.33, indicating a small deviance between the predicted values and the actual observations of the dependent variable (Figure 3).

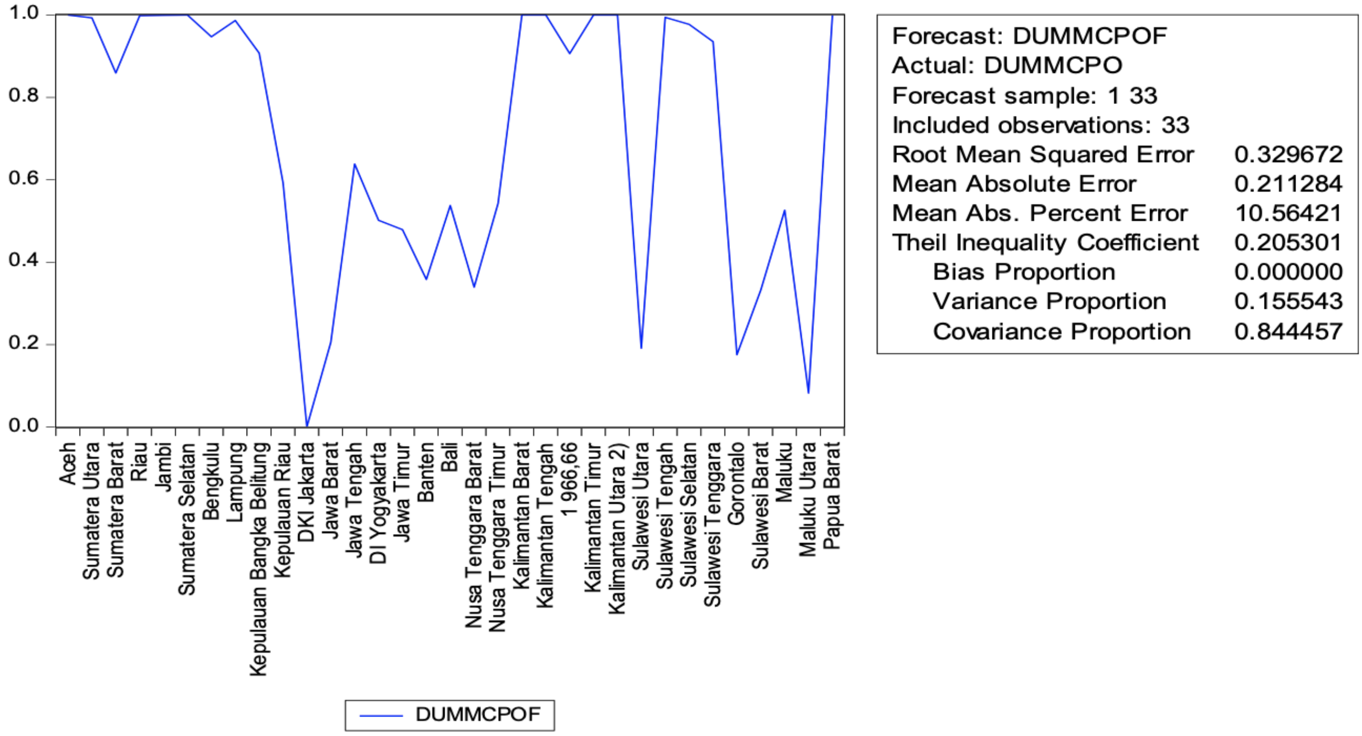

Figure 3. Forecasting food security

Oil palm cultivation and food security status

The authors also aimed to investigate the relationship between food security and oil palm cultivation from a different perspective. Specifically, they examined whether the food security status of a given province has any influence on the classification of the province as either engaged in oil palm cultivation or not (Table 7). The model specification aims to identify the key factors that influence oil palm cultivation and whether the food security status has any impact on the classification of a province as an oil palm-growing region (1) or not (0). The model specification is as follows:

$$\begin{aligned} DUMMCPO &= \beta_0 + \beta_1 \, GDRP^{2} + \beta_2 \, TOTAL\_AREA\_HA\_ \\ &+ \beta_3 \, FOOD\_SECURE + \beta_4 \, DUMMY\_E\_W + \mu_t \end{aligned}$$

Whereby DUMMCPO is the independent binary variable that takes a value of (1) when a province is engaged in oil palm cultivation and (0) otherwise. GDRP represents the value of the regional domestic product, LOG(TOTAL_AREA_HA) corresponds to the total area of the province in hectares. FOOD_SECURE is a dummy variable that classifies provinces as either food secure (1) or food insecure (0). DUMMY_E_W is a dummy variable that classifies provinces located in the Western region of Indonesia as (1) and provinces in Eastern Indonesia as (0). Lastly, CPI represents the level of inflation in the province.

Table 7. CPO production and food security

Dependent Variable: DUMMCPO					
Method: ML - Binary Logit (Newton-Raphson)					
Date: 08/16/17 Time: 18:41					
Sample: 1 33					
Included observations: 33					
Convergence achieved after 7 iterations					
QML (Huber/White) standard errors & covariance					
Variable	**Coefficient**	**Odds Ratio**	**Std. Error**	**z-Statistic**	**Prob.**
C	-7.134873	0.000797	2.321737	-3.073075	0.0021
TOTAL_AREA__HA_	0.000157	1.000157	4.67E-05	3.360833	0.0008
DUMMY_E_W	3.156205	23.481315	1.234194	2.557301	0.0105
FOOD_SECURE	3.957079	52.304322	1.590398	2.488106	0.0128
GDRP	-0.005467	0.9945479	0.002413	-2.265564	0.0235
McFadden R-squared	0.494772		Mean dependent var		0.696970
S.D. dependent var	0.466694		S.E. of regression		0.357899
Akaike info criterion	0.922854		Sum squared resid		3.586564
Schwarz criterion	1.149597		Log likelihood		-10.22709
Hannan-Quinn criter.	0.999146		Deviance		20.45417
Restr. deviance	40.48506		Restr. log likelihood		-20.24253
LR statistic	20.03089		Avg. log likelihood		-0.309912
Prob(LR statistic)	0.000492				
Obs with Dep=0	10		Total obs		33
Obs with Dep=1	23				

*Significance error values: ***,1%; **5%, *10%*

Based on the analysis results, an increase in the total area increases the odds of a province producing palm oil by a factor of 1 compared to a province that does not grow oil palm. The odds of a province located in Western Indonesia being a producer of palm oil is 23.5 times greater compared to a province in the Eastern part of Indonesia. The odds for a food-secure province to grow oil palm are 52 times greater than the odds for a non-food-secure province. Additionally, a unit increase in the gross regional domestic product decreases the odds of a province being an oil palm grower by a factor of nine (9). The GLM analysis results, while larger in terms of the magnitude of coefficients, exhibit similar signs and significance (Table 8).

Table 8. GLM model results

Dependent Variable: DUMMCPO					
Method: Generalized Linear Model (Newton-Raphson)					
Date: 08/16/17 Time: 18:37					
Sample: 1 33					
Included observations: 33					
Family: Binomial Proportion (trials = 1)					
Link: Log-log					
Dispersion fixed at 1					
Convergence achieved after 7 iterations					
Coefficient covariance computed using the Huber-White method with					
observed Hessian					
Variable	**Coefficient**	**Odds Ratio**	**Std. Error**	**z-Statistic**	**Prob.**
C	-4.890638	0.007517	1.633978	-2.993087	0.0028
TOTAL_AREA__HA_	0.000116	1.000116	3.50E-05	3.318262	0.0009
DUMMY_E_W	2.307488	10.04915	0.924586	2.495698	0.0126
FOOD_SECURE	2.936444	18.8487	1.192365	2.462707	0.0138
GDRP	-0.003696	0.996311	0.001180	-3.131378	0.0017
Mean dependent var	0.696970		S.D. dependent var		0.466694
Sum squared resid	3.696928		Log likelihood		-10.41155
Akaike info criterion	0.934034		Schwarz criterion		1.160777
Hannan-Quinn criter.	1.010326		Deviance		20.82311
Deviance statistic	0.743682		Restr. deviance		40.48506
LR statistic	19.66195		Prob(LR statistic)		0.000582
Pearson SSR	16.83769		Pearson statistic		0.601346
Dispersion	1.000000				

*Significance error values: ***,1%; **5%, *10%*

Meanwhile, the GLM results show that a change in total area increases the odds for a province to produce palm oil by a factor of 1 compared to a province that does not grow oil palm. The odds of a province located in Western Indonesia being a producer of palm oil is 10 times greater compared to a province in the Eastern part of Indonesia. The odds for a food-secure province to grow oil palm are 18.8 times greater than the odds for a non-food-secure province. Additionally, a unit increase in the gross regional domestic product decreases the odds of a province being an oil palm grower by a factor of nine (9). In terms of the GLM analysis results, the coefficients for the TOTAL_AREA_HA and GDRP explanatory variables have larger magnitudes compared to the ML model, while the rest of the variables have virtually the same magnitude as in the ML model. However, the signs of the coefficients and their significance remain more or less the same.

Tests for multicollinearity among explanatory variables

Confidence ellipse results indicate the independence of the explanatory variables (Figure 4).

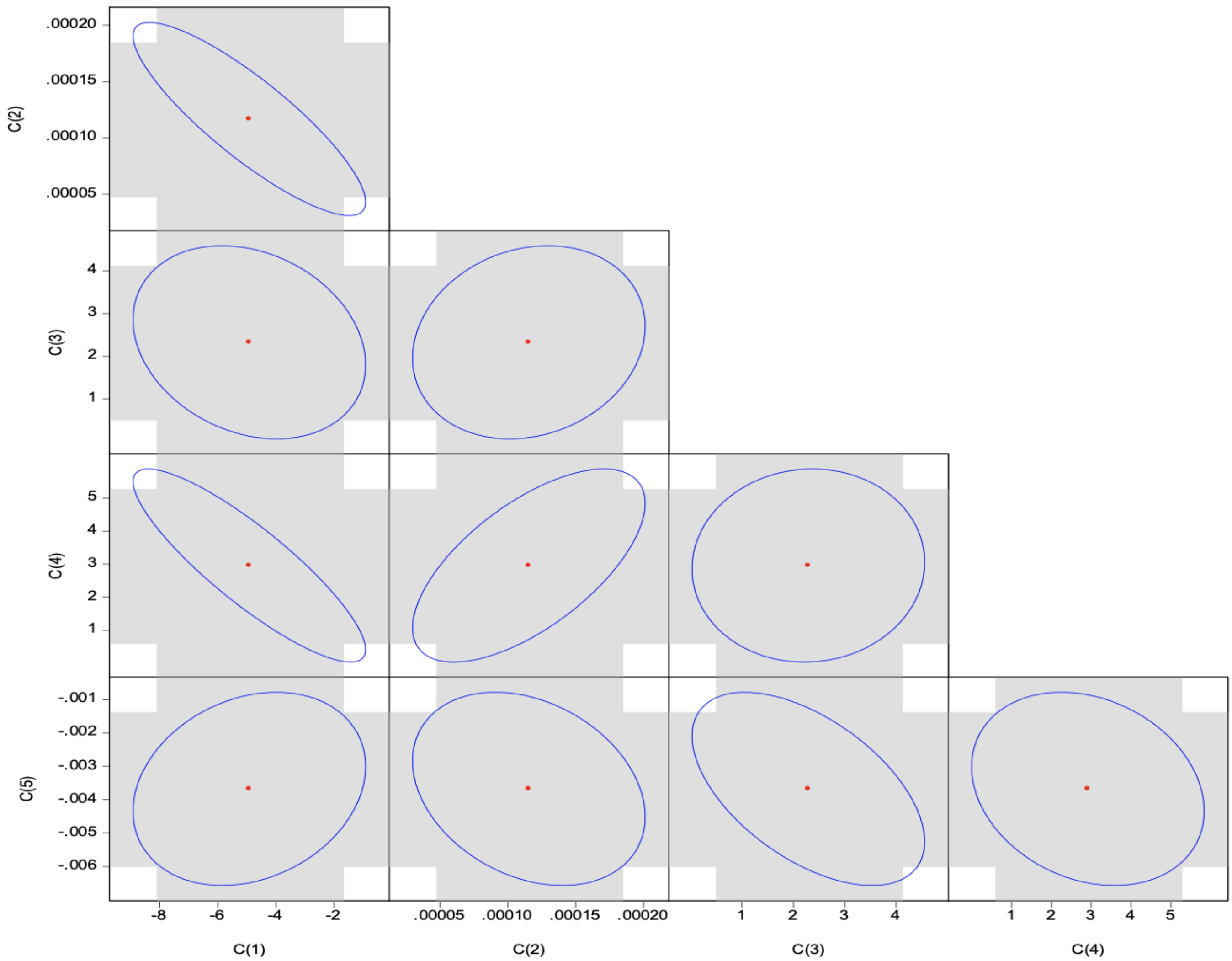

Figure 4. Confidence ellipse test

Model robustness evaluation

The robustness of the model is evaluated using the Expectation-Prediction Evaluation Test, precision, recall, and accuracy tests, as well as the Goodness of Fit Evaluation. Based on the results of the expectation-prediction evaluation tests, the model demonstrates an accuracy of 78.79 percent, whereas the constant probability model achieves an accuracy of 69.75 percent. This represents a gain of 9.09 percent (78.79 - 69.75 percent) (Table 8). However, the prediction model shows a higher recall gain of 40 percent compared to a lower precision gain of -13.04 percent, which significantly decreases its accuracy.

Evaluation of precision, recall, and accuracy in model specification

a. *Precision (Pre) = TP/(TP+FP): (20/(20+3)*100≈ 87* percent
b. *Recall (Re) = TP/(TP+FN): (20/(20+4)*100≈* 83 percent
c. *Accuracy (F-Score) = 2*(Pre * Re)/(Pre + Re) 2*(87%*83%)/(87%+83%)≈ 85 percent*

Thus, with precision, recall, and accuracy rates of 87 percent, 83 percent, and 85 percent, respectively, the model does a good job of predicting the dependent variable compared to a random prediction model.

The goodness-of-fit evaluation presents mixed results, with the H-L statistic not being significant, while the Andrews statistic is significant (Table 9).

Table 9. Expectation-prediction evaluation results

Expectation-Prediction Evaluation for Binary Specification						
Equation: MAGNANIMOUS						
Date: 08/16/17 Time: 18:43						
Success cutoff: C = 0.5						
	Estimated Equation			**Constant Probability**		
	Dep=0	**Dep=1**	**Total**	**Dep=0**	**Dep=1**	**Total**
P(Dep=1)<=C	**6**	**3**	**9**	0	0	0
P(Dep=1)>C	**4**	**20**	**24**	10	23	33
Total	10	23	33	10	23	33
Correct	6	20	26	0	23	23
% Correct	60.00	86.96	78.79	0.00	100.00	69.70
% Incorrect	40.00	13.04	21.21	100.00	0.00	30.30
Total Gain*	60.00	-13.04	9.09			
Percent Gain**	60.00	NA	30.00			
	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	6.51	3.49	10.00	3.03	6.97	10.00
E(# of Dep=1)	3.49	19.51	23.00	6.97	16.03	23.00
Total	10.00	23.00	33.00	10.00	23.00	33.00
Correct	6.51	19.51	26.03	3.03	16.03	19.06
% Correct	65.14	84.84	78.87	30.30	69.70	57.76
% Incorrect	34.86	15.16	21.13	69.70	30.30	42.24
Total Gain*	34.84	15.15	21.11			
Percent Gain**	49.98	49.98	49.98			

Change in "% Correct" from default (constant probability) specification

Percent of incorrect (default) prediction corrected by equation

Table 9. Goodness of fit test

Goodness-of-Fit Evaluation for Binary Specification								
Andrews and Hosmer-Lemeshow Tests								
Equation: MAGNANIMOUS								
Date: 08/16/17 Time: 18:45								
Grouping based upon predicted risk (randomize ties)								
	Quantile of Risk			**Dep=0**		**Dep=1**	**Total**	**H-L**
	Low	**High**	**Actual**	**Expect**	**Actual**	**Expect**	**Obs**	**Value**
1	0.0002	0.1750	3	2.74228	0	0.25772	3	0.28194
2	0.1912	0.3324	1	2.27162	2	0.72838	3	2.93183
3	0.3390	0.4790	2	1.82427	1	1.17573	3	0.04319
4	0.5014	0.5423	3	1.89277	1	2.10723	4	1.22949
5	0.5921	0.8589	1	0.91075	2	2.08925	3	0.01256
6	0.9059	0.9353	0	0.25180	3	2.74820	3	0.27487
7	0.9469	0.9926	0	0.09683	4	3.90317	4	0.09923
8	0.9940	0.9992	0	0.00860	3	2.99140	3	0.00862
9	0.9994	0.9998	0	0.00108	3	2.99892	3	0.00108
10	1.0000	1.0000	0	3.7E-06	4	4.00000	4	3.7E-06
		Total	10	10.0000	23	23.0000	33	4.88282
H-L Statistic			4.8828		Prob. Chi-Sq(8)		0.7700	
Andrews Statistic			22.0065		Prob. Chi-Sq(10)		0.0151	

The Andrews statistic test returns a significant value, while the H-L statistic, which examines only the deviance between predicted and actual values of true positive values (Y = 1), returns an insignificant value (4.88, p-value 0.77). However, the Andrews statistic returns a significant result (22.01, p-value 0.02). Consequently, in terms of precision, the model is a good fit for the data.

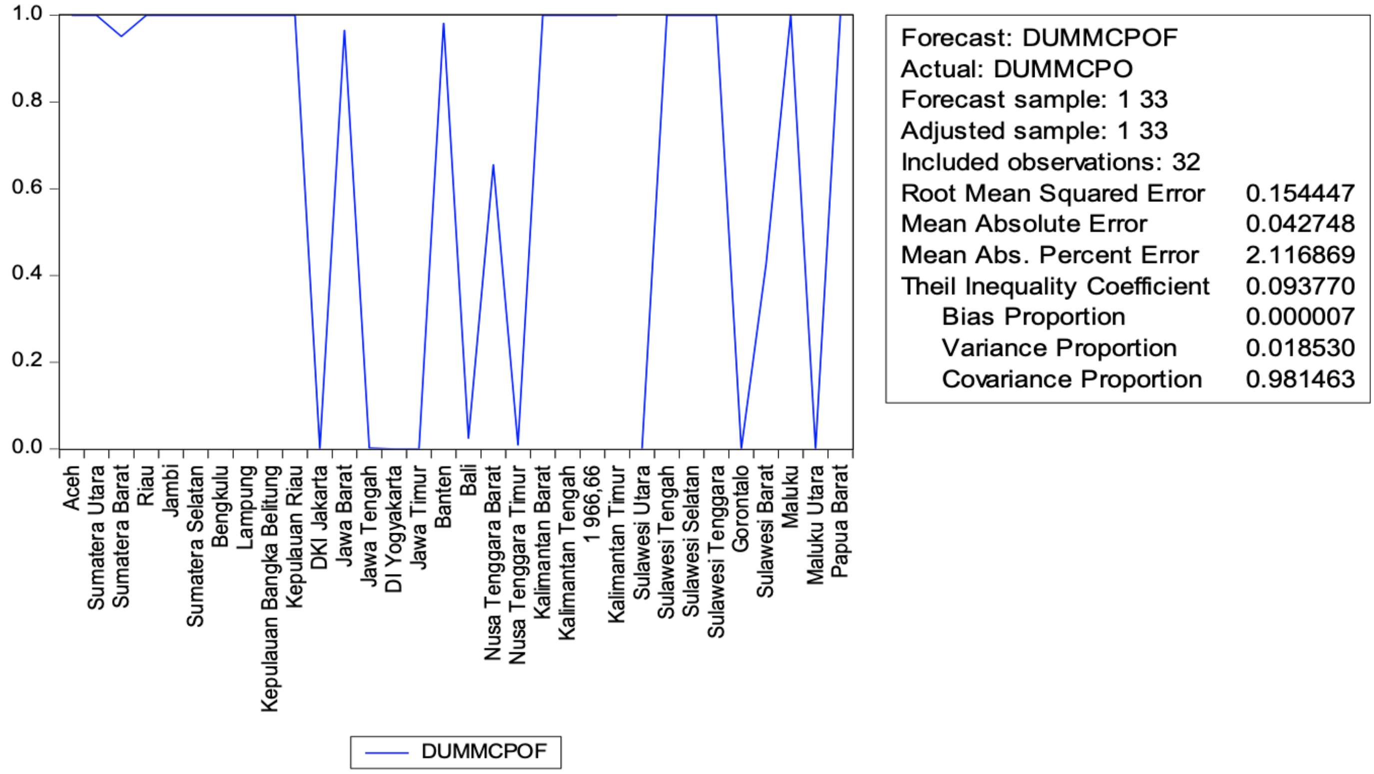

Figure 5. Goodness of Fit based on root mean squared errors (RMSE)

Analysis results reveal a very small RMSE value, indicating minimal deviation between the predicted and observed values of the dependent variable. The model's forecast shows an RMSE of 0.15, which is relatively low, indicating a strong goodness of fit between the fitted/predicted values of the dependent variable and the actual observations (Figure 5).

The analysis results demonstrate that an increase in the proportion of land dedicated to oil palm cultivation relative to the total area in the province results in a decrease in the odds of food security by a factor of 9 (almost 10). In other words, expanding the area for oil palm cultivation is estimated to exacerbate food insecurity. Additionally, an increase in monthly food expenditure in a province does not indicate an improvement in food security; rather, it suggests a deterioration in food security status. This could be attributed to the theory that the most vulnerable segments of society allocate a higher percentage of their disposable income to food, leaving little for other essential non-food expenses such as healthcare and education, among others.

Furthermore, another explanation for the negative sign of the food expenditure variable could be the influence of the rising cost of living on food insecurity. Higher food costs compel households to allocate a larger proportion of their income to food, which would not be the case if food prices were lower. However, the most surprising finding is the negative coefficient of access (road mileage), implying that an increase in mileage in a province reduces the odds of food security (increases the odds of food insecurity). This result can be attributed to the fact that food-insecure provinces are generally less populated and characterized by vast, sparsely populated areas, especially in the eastern part of Indonesia.

On the contrary, in the western part of Indonesia, road mileage per province may not be extensive but it is dense and well spread out, creating favorable conditions for effective accessibility. However, the variable that is of particular interest is mobile ownership. It turns out that mobile ownership is crucial for food security. This could be attributed to the increasing use of mobile phones, not only as a means of communication but more importantly as a medium that reduces distance barriers in accessing various services. These services include information on commodity availability, prices, financing options for both food and non-food expenses, as well as health, nutrition, and hygiene information.

Regarding the relationship between palm oil cultivation and food security, based on the dichotomous dummy variable of growing oil palm (value = 1) and non-palm growing (value = 0), the results indicate that being a food-secure province increases the odds of the province being a grower of oil palm. This finding is contradictory to the results obtained in the model where food security dummy is the response variable and the ratio of land dedicated to oil palm cultivation to the total area in the province in hectares is one of the explanatory variables. However, caution is needed here because the variables used in the two models are different. In the model on food security, oil palm cultivation was approximated by the ratio of area dedicated to growing oil palm to the total area in the province. In contrast, the model that estimated oil palm cultivation as the dependent variable used a dummy variable where oil palm cultivation is indicated by a value of one (1), and non-oil palm cultivation is indicated by a value of zero (0). The model also reveals that provinces located in Western Indonesia, which is generally more developed than Eastern Indonesia, are more likely to grow oil palm than those in Eastern Indonesia. Furthermore, the result regarding the variable of gross domestic product (GDP) is also surprising. A higher level of regional GDP is paradoxically associated with non-oil palm cultivation. This suggests that, in general, provinces with a high regional GDP do not engage in oil palm cultivation.

Based on the results, provinces that engage in oil palm cultivation are associated with lower levels of food security and regional gross domestic product. Although the findings do not establish a causal relationship, they raise concerns that oil palm cultivation may contribute to factors that undermine food security. However, it is important to note that the choice of variables used to represent oil palm cultivation can impact the obtained results, highlighting the need for caution when interpreting them.

It is undeniable that rice production remains a critical determinant of food security in Indonesia. This is due to the well-established food policies that support production, distribution, and pricing, making it a key factor in determining food security. What is novel in the context of research on food security in Indonesia is that this study approached the subject from a local government perspective, specifically examining the nexus between food security and oil palm cultivation. Additionally, the study analyzed the influence of expenditure on food and mobile phone ownership on food security status.

In particular, regarding mobile phone ownership (digital technology) and food security status, the findings of this study align with prior research that emphasizes the importance of financial inclusion in development. Previous studies (Karpowicz, 2014; Allen, Demirgüç-Kunt, Klapper & Martinez, 2012; Salazar-Cantú, Jaramillo-Garza, Álvarez-De la Rosa, 2015; Park & Mercado, 2015; Lundqvist & Erlandsson, 2014; García-Herrero & Turégano, 2015; Beck, T., Demirgüç-Kunt & Martinez-Peria, 2007; and Arora, 2012) have also highlighted the significance of mobile phone ownership and financial inclusion in promoting development.

Therefore, this study contributes to the understanding of food security in Indonesia by examining it at a local government level, investigating the relationship between food security and oil palm cultivation, and analyzing the impact of food expenditure and mobile phone ownership on food security status.

Research on the importance of mobile phone technology in promoting financial inclusion, particularly in the context of food security, is still a relatively new area that requires further investigation. In particular, more research is needed to understand the transmission mechanisms through which mobile communication and digital platforms influence development. Potential areas to explore in relation to food security include the role of mobile phone ownership as a proxy for accessibility and ease of accessing available food supplies, its indication of access to economic opportunities and purchasing power, and its potential as a medium for financial asset ownership and transactions (which is still developing in Indonesia).

This research aims to establish a link between food security, connectivity, and the political economy of plantation industries. It is important to note that the findings contribute to the ongoing debate surrounding the role of the palm oil industry in the Indonesian economy, as well as in the economies of other major producers and exporters of crude palm oil and palm kernel oil. By delving into the dynamics between palm oil cultivation and food security, this research addresses a contentious issue that continues to generate debate and raises a range of controversial topics.

Food security at the provincial level, influenced by the performance of lower administrative units such as districts, is essential for assessing the food status at the national level. Indonesia has over 511 district/city governments and 34 provinces as of April 2014. The performance of provinces offers a snapshot, though not always reliable, of the relative performance of lower-tier districts/cities. However, as demonstrated by FSVA (2015), evaluating food security performance is more effective at a lower level. Household-level status provides a better indication of food security at the neighborhood level, while the food status at the neighborhood level offers insight into the village level, and the village level status can gauge the sub-district level. However, practical constraints, including time limitations, made it difficult to employ such an approach. Consequently, the contribution of this research to the food security literature lies in providing a general overview of the food status at the provincial level and identifying the factors that play a significant role.

IV. Conclusion and Policy Recommendations

Based on the research findings, the expansion of oil palm cultivation has a negative impact on food security. Consequently, the rapid growth of oil palm cultivation in Indonesia raises significant concerns among various stakeholders, including academics, environmental conservationists, indigenous rights advocates, political economy analysts, and development agencies. These concerns primarily revolve around the long-term consequences of this policy on food security in provinces where oil palm cultivation is prevalent, such as Kalimantan, Sumatera, Sulawesi, as well as in new frontier provinces like West Papua and Papua.

The concerns stem from the apprehension that the expansion of palm oil production for biofuel purposes will lead to an increased demand for the commodity, both domestically and internationally. This demand poses a threat to the food security status of the provinces where palm oil has traditionally been grown. The potential impact on food security is particularly worrisome given that these provinces, including West Papua and Papua, are already identified as high-priority areas for addressing food security vulnerabilities, as indicated by the 14 districts categorized by FSVA (2015). These concerns highlight the need for careful consideration of the potential detrimental effects associated with the rapid expansion of the palm oil industry.

The cultivation of palm oil takes place on land that is highly suitable for growing food crops, resulting in the unavailability of such land for food crop cultivation. However, research findings highlight the importance of allowing palm oil cultivation, as it indirectly contributes to food security in several ways. Firstly, it provides employment opportunities for over 6 million people in palm oil plantations and smallholdings. Additionally, it serves as a vital source of income for individuals on both smallholdings and large plantations, whether privately or state-owned. Furthermore, palm oil cultivation contributes to improved accessibility through road construction and facilitates the availability of education and health services in the areas where palm oil estates are established. It also contributes to regional and national income through tax revenues and foreign exchange earnings, while serving as a source of edible oil for domestic use. Palm oil is widely utilized as a raw material in various food products such as margarine, confectionaries, and the manufacturing of personal care and cosmetic items.

To ensure that the expansion of palm oil cultivation does not exacerbate food security challenges in provinces where it is grown, as well as in newly introduced areas, it is crucial to consider the impact of land allocation for palm oil crops on food crops. This is particularly important for frontier provinces in the eastern part of Indonesia, which already face higher food security vulnerabilities due to cultural, social, economic, and political factors.

One significant finding of this research is the positive impact of connectivity on food security in Indonesia, an archipelago nation. The widespread ownership of mobile phones, both in rural and urban areas, has a significant and positive influence on food security. Therefore, the use of mobile phones should be prioritized in future efforts to maintain food security stability where it is already assured, and more importantly, to create conditions that foster favorable food security conditions in areas where it has been intermittent or entirely elusive thus far. The rising cost of food budgets is a concerning issue that poses a serious threat to food security.

This issue has gained significance due to recent government efforts to reduce public expenditure by gradually reducing and eventually eliminating subsidies on essential public services such as gasoline, electricity, and liquefied natural gas. While the phased removal of government subsidies is a commendable step towards reducing the budget deficit, it is important to exercise caution. Such an achievement may come at the expense of undermining food security in areas where it is already established, while exacerbating food insecurity in regions where it is already a problem.

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Footnotes

[i] Department of Management and Public Policy, Gadjah Mada University, Yogyakarta, Indonesia

[ii] https://foodsecurityindex.eiu.com/Index

[iii] https://www.globalhungerindex.org

[iv] According to the World Resource Institute, the carbon emissions resulting from the 2015 forest fires alone caused Indonesia's emissions levels to match those of Brazil. This led to a rapid increase in Indonesia's annual CO2 emissions, reaching approximately 750Mt CO2 as of October 26, 2015. On 38 out of the 56 days during that period, Indonesia's greenhouse emissions surpassed those of the United States (Harris, et al., 2015).)

[v] Large estates often do not consider the higher cost of US$250 per hectare for land clearance using mechanical methods compared to slash and burn practices. This is why the issue is more common in areas controlled by small and medium-sized concession holders who are often situated between large estates and communities (Tanoto, 2016)

[vi] RSPO principles and criteria are based on the management and operational standards established by the "iseal" organization (https://www.isealalliance.org/)

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