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Analysis of Sustainable Food Sector Development in the Sumatra Island

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Abstract: The research aims to analyze the development of food security through indicators of the sustainable food sector on the island of Sumatra in 2018-2022. Food sector indicators include the number of poor people, food inflation, rice consumption per capita, insufficient food consumption, and food insecurity. Food security indicators use the food security index. The research method is quantitative through secondary data collection with panel data analysis from cross section results of 10 provinces on the island of Sumatra and time series data for 2018-2022. The approach used, namely CEM, FEM, REM. The research findings show that the food inflation variable has a positive and significant effect on the food security index, the poor population variable, rice consumption per capita, insufficient food consumption has a positive and insignificant effect on the food security index. Population with food insecurity has a negative and insignificant effect on the food security index.

Keywords: Sustainable Food Sector, Food Security

Introduction

Food security as mentioned in Law Number 18 of 2012, is the condition of food fulfillment for the state and individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, evenly distributed, and affordable and not conflicting. with the religion, beliefs and culture of the community, to be able to live a healthy, active and productive life in a sustainable manner**.** Food security has milestones in its development over time which are seen in four periods based on the development of world awareness of the importance of food security, years 1930-1945 (marked by the post-First World War situation and the role of the League of Nations), 1945-1970 (marked by the emergence of the World Food Organization (FAO), a food surplus situation and food aid), the years 1970-1990 (marked by awareness of the importance of world food security), and the years 1990-now (marked by the golden age of world food security) (Syaparuddin & Nuzul, 2021).

The World Food Summit in 1996 defined food security as a situation where all people can have access to sufficient, safe and nutritious food to meet their daily needs. Increasing concerns about food security in food insecure areas of the world show the inadequacy of sectoral approaches in dealing with agricultural problems (Bhaduri et al., 2018). Based on the Food Insecurity Experience Scale, in 2014-2016 Asia was a food insecure region, especially in the Southeast Asia Region (Cafiero et al., 2018). The 2018 Global Hunger Index (GHI) shows that the level of hunger and malnutrition in the world is in the serious category; including Indonesia with a GHI score of 21.9, there is a serious level of hunger (Hadi et al., 2019).

The development of food security policies has an impact on the development of food security measures. Therefore, food security measures then cover various levels, ranging from global, national, regional, community, household to individual coverage. At the regional level which includes global, national and regional, measuring food security can use various indicators, including: (1) level of food production, availability, consumption and trade, (2) ratio of food stock and consumption, (3) level score availability and consumption, (4) food security conditions, (5) institutional conditions of community food reserves, and (6) ability to carry out food stocks (Syaparuddin & Nuzul, 2021).

The agricultural development strategy during the 2015-2019 period will focus on 7 (seven) Main Strategies for Strengthening Agricultural Development for Food Sovereignty (SADFS), namely (1) increasing land availability and utilization; (2) improving agricultural infrastructure and facilities; (3) development and expansion of seed/seedling logistics; (4) strengthening farmer institutions; (5) development and strengthening of agricultural financing; (6) development and strengthening of bioindustry and bioenergy; (7) strengthening agricultural product market networks. Apart from the seven main strategies, there are 9 (nine) supporting strategies, namely: (1) strengthening and increasing the capacity of agricultural human resources; (2) increasing quarantine support; (3) increasing innovation and technology support; (4) public information services; (5) regulatory management; (6) management of information and communication technology; (7) planning management; (8) structuring and strengthening the organization; and (9) management of the supervision system (Sulaiman et al., 2018).

Efforts to achieve sustainable food security in Indonesia by 2025, based on challenges and their handling, over the last five years, at a macro level, Indonesia has been able to provide sufficient food to meet the needs of its citizens, but the quality of food consumption has decreased. On average, Indonesian people are still below the recommendations of nutrition experts. The challenge of sustainable food security includes the supply side and the needs fulfillment side. To overcome these challenges, it is necessary to adjust the direction of food security development policies, especially in setting goals, choosing how to achieve goals, and determining national food security targets (Achmad, 2014).

Integrated Smart Food Safety System Platform concluded that the problems that are often encountered in the food supply chain are uncertainty in demand and supply because data discrepancies often occur from both the producer and consumer side, crop failure due to lack of product quality monitoring which results in consumers returning the product to the producer. ISFSSP (Integrated Smart Food Security System Platform) is a problem-solving solution for managing the risk of food supply chain insecurity. Factors that influence the

food supply chain are extreme climate change, pandemics, macroeconomics, trade disputes and geographical conditions (Sumarni et al., 2023).

The challenges in achieving food self-sufficiency in Indonesia are the decline in land production and the reduction in labor in the agricultural sector. Special efforts in developing food agriculture, especially within the framework of the national food security program, namely efforts to increase food crop productivity, efforts to increase the expansion of new agricultural land (Chaireni et al., 2020). Furthermore, the impact of population on sustainable food security is that to achieve food security, approaches to food availability and ownership need to be considered and for sustainable food security a new paradigm is needed). The challenge towards sustainable Indonesian food security in 2025 will be increasingly difficult (Khairi et al., 2020).

The island of Sumatra is divided into ten (10) provinces with different regional characteristics in terms of area, population and regional potential. Jambi Province is the largest province with an area of 89,935.90 km^2 with the largest population center in North Sumatra Province at 15,115.2 thousand people. Viewed from the economic aspect, the highest economic growth was in South Sumatra Province at 5.23 percent which was supported by the mining and quarrying sector; and the agriculture, forestry and fisheries sectors (Central Bureau of Statistics, 2023).

The role of the agricultural sector on the island of Sumatra is considered quite significant in supporting economic performance. Apart from that, this sector has an important role in meeting the food needs of the population on the island of Sumatra, which amounts to 59,977.3 thousand people in 2022 and continues to increase every year (Central Bureau of Statistics, 2023). Even though it is supported by an adequate agricultural sector, this does not mean that Sumatra Island has strong food security. (Food Security Agency, 2023) noted that the food security index for Sumatra Island in 2018 reached 67.84 percent to 70.97 percent in 2022. Meanwhile, the food insecurity rate for Sumatra Island was at the moderate food insecurity level, which was 7.06 percent lower than Indonesia's food insecurity rate of 8.23 percent in 2018 and 2022 of 4.65 percent. The movement in food insecurity figures was also followed by the percentage of population according to Food Consumption Inadequacy (PoU) status which was in the medium category at 9.65 percent in 2018 increasing to 11.42 percent in 2022.

Malthus' concept which states that food growth is like an arithmetic series and population growth is like a geometric series, seems to be gaining momentum at the moment. The island of Sumatra, which has positive population growth, if not accompanied by an increase in food production, will most likely face obstacles in meeting the food needs of its population in the future. (Chaireni et al., 2020) stated that the general problem regarding food security is a large population with positive population growth. So food needs continue to increase along with the increase in population. In terms of fulfillment, not all food needs can be met, because food production and distribution capacity is increasingly limited. This causes food instability between national needs and fulfillment. Data on rice consumption per capita for 2018-2022 in various provinces on the island of Sumatra shows a downward trend from 95.46 kg/capita/year to 92.27 kg/capita/year. (Rachman et al., 2019) stated that farmers are generally rice consumers because most farmers sell their crops and buy rice to meet basic food needs. An increase in rice prices can also have a negative impact on the stability of prices of goods in general. (Tessalonica et al., 2023) and (Wehantouw et al.,

2021) stated that rice consumption has a positive and significant effect on food security. Apart from that, (Joseph, 2017) saying that part of people's consumption habits is generally grains which reaches 1,166.9 kcal/capita/day, the total energy supply (AKG) of society is 2,021 kcal/capita/day, so rice is the staple food. The more rice consumed, the better the level of food security (Ali et al., 2017). (Erokhin & Gao, 2020) suggests that food insecurity is influenced by food prices or inflation. Research shows (Prabayanti et al., 2022) that the price of rice has a negative and significant effect on food security.

The concept of sustainable food sector development is related to the issue of food security. At the beginning of the New Order era, food security policy in Indonesia was based on a food supply approach known as the FAA (Food Availability Approach). This approach does not pay attention to aspects of distribution and access to food. The assumption underlying this approach is that if food supplies are available, traders will distribute food throughout the region efficiently. In addition, food prices will remain stable at a reasonable level so that the whole family can afford it. Even though food availability is sufficient, some people still experience hunger because they do not have enough access to food. This phenomenon is called the "hunger paradox". This is what causes the food availability approach to fail to achieve sustainable food security in several countries (Rahayu et al., 2019). Furthermore, in 2015 the United Nations (UN) in the 2030 Sustainable Development Goals (SDGs) through goal number two, namely Zero Hunger which aims to end hunger, achieve food security, improve nutrition and encourage sustainable agriculture (Hatmanto & Setyono, 2018). The UN SDGs give top priority to food and energy security (Kline et al., 2017). The concepts of the hunger paradox and zero hunger are closely related to poverty. The number of poor people on the island of Sumatra in 2018 was 10.00 percent and continued to decline until 2022 to 9.22 percent. In line with what was stated (Wehantouw et al., 2021), poverty has an insignificant negative effect on food security. (Rahmanto et al., 2021) stated that in Indonesia, the food diversification program was correlated with a decrease in the number of rural poor by 4.7% (from 16.31 people to 15.54 people).

The picture of food security is seen from the aspects of food availability, food affordability and food utilization. Thus, strengthening food security is proxied by the food security index. Meanwhile, to see the sustainable food sector, it is proxied by the percentage of poor people, food inflation, rice consumption per capita, inadequate food consumption (PoU), and food insecurity. These five variables are the challenges for the future of Sumatra Island in achieving a sustainable food sector. This means that when there is an increase in the number of poor people, food inflation, insufficient food consumption, then food insecurity will increase so that the government's efforts to achieve superior and strategic food security are not achieved. This means that these four variables have a negative relationship with food security. Meanwhile, to increase per capita rice consumption, it is necessary to increase the availability of food production so that food security increases, meaning that this variable has a positive relationship with food security. This research aims to analyze the development of food security through sustainable food sector indicators on the island of Sumatra.

Based on previous research that has been presented, researchers tried to examine food sector indicators in strengthening food security on the island of Sumatra, by using several indicator variables for food security. This research combines several variables, percentage of poor people, food inflation, rice consumption per capita, inadequate food consumption,

and food insecurity. So the novelty of this research is the use of four main indicators of the food sector on Sumatra Island which include food inflation, rice consumption per capita, insufficient food consumption, and food insecurity, as well as their impact on food security on Sumatra Island.

This research contributes in three parts: first, adding facts about strong food security on the island of Sumatra, through strengthening the sustainable food sector. Second, different from the national scale, Sumatra Island considers the percentage of poor people, food inflation, rice consumption per capita, inadequate food consumption, and food insecurity as factors that strengthen Sumatra Island's food security. Third, the variables percentage of poor people, food inflation, rice consumption per capita, inadequate food consumption, and food insecurity have an influence on food security.

Literature Review

Food Security Theory

Food security is a condition where food is met for the country and individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable and affordable and does not conflict with the religion, beliefs and culture of the community, to be able to live a healthy, active and productive life in a sustainable manner. Food and nutrition security development is carried out systemically by involving cross-sectors. This approach is directed at realizing adequate food availability through domestic food production and trade; achieving stability in food availability and access at macro-meso and micro levels; adequate quality (food diversity and safety) and quantity of food consumption supported by infrastructure improvements. To realize these conditions, macroeconomic policy support is needed that is able to achieve economic stability, guaranteeing stability in food supplies and prices (Food Security Agency, 2022).

In 1996, the World Food Summit adopted the definition of food security, i.e. all people, at all times, achieve food security when they have physical and economic access to sufficient, safe and nutritious food to meet the food needs and food preferences of their active lives. and healthy (Vos et al., 2022). Furthermore, a study conducted by Amartya Sen (Mahmood, 2022) identified a new emphasis on consumption, the demand side, and the issue of vulnerable communities' access to food. Avoiding the concept of food security, it focuses on the rights of individuals and households. The problem of food security has several aspects. Therefore, the provision of safe, nutrient-dense and quantitatively adequate food, as well as universal access to food, is necessary for food security. These are the three aspects of food security.

The level of food security in a region and its supporting factors has developed an assessment system in the form of the Food Security Index (FSI) which refers to the definition of food security and the subsystems that make up the food security system. The nine indicators used in preparing the FSI are derivatives of three aspects of food security, namely availability, affordability and utilization of food (Food Security Agency, 2022). Referring to the concept developed by the Indonesian Food Security Agency, the Food Security Pillar is viewed from the Food Availability Aspect, including indicators of domestic food production, food stocks/reserves, exports and imports. Aspects of Food Affordability include distribution indicators, supply and price stability, logistics systems,

stock management, people's purchasing power, access to markets and information. The Food Utilization aspect includes indicators of improving consumption patterns, diversifying consumption, improving nutrition, food safety and quality (Food Security Agency, 2022).

Meanwhile, apart from the food security pillar concept, there are 9 indicators developed by the Indonesian Food Security Agency which are used to measure the Food Security Index, including the indicators of the ratio of normative consumption per capita to net production; Percentage of population living below the poverty line; Percentage of households with the proportion of expenditure on food more than 65 percent of total expenditure; Percentage of households without access to electricity; The average length of schooling for women is over 15 years; Percentage of households without access to clean water; The ratio of population per health worker to population density level; Percentage of toddlers with height below standard (stunting); Life expectancy at birth (Food Security Agency, 2022).

The Declining Food Availability Theory claims that a sharp decline in the amount of food available causes food insecurity. This theory treats the issue of food availability as the same as the issue of food security. As long as a decrease in the amount of available food resources is recognized as a cause of food insecurity, this ignores any causes or circumstances that might lead to a lack of food supply (Mahmood, 2022). The core hypothesis of this theory is that food insecurity is caused by a sharp decline in available food supplies. In other words, this theory equates the problem of food security with the problem of food availability. This ignores any reasons or conditions that could explain the lack of food supply and remains reasonable as long as food insecurity is accepted to result from a reduction in available food resources (Mahmood, 2022). Sen's Rights Theory First published in 1981, Amartya Sen's property rights theory offers an alternative framework for analyzing hunger by redefining the issue of food security as an issue of demand specifically, the inability of individuals to obtain basic foods rather than the decline and scarcity of food supplies. Sen observed famines in Asia and Africa, and concluded that food shortages not only put a person at risk of starvation and starvation, but also reduced their privileges in trade (Kungu & Iraya, 2017).

The Relationship between Poor Population and Food Security

Poverty is a condition of a person's inability to fulfill basic needs, both food and non-food, as measured in terms of expenditure. Efforts made by the government to maintain stable food security for the survival of the existing community and to reduce the existing poverty rate (Central Bureau of Statistics, 2023). (Food Security Agency, 2022) stated that the indicator of the population living below the poverty line shows the rupiah value of per capita expenditure every month to meet the minimum standards of food and non-food consumption needs needed by an individual to live a decent life. People living below the poverty line do not have sufficient purchasing power to meet their basic living needs, which will affect food security. In line with what was stated (Wehantouw et al., 2021), poverty has an insignificant negative effect on food security, meaning that an increase in food security will be followed by a reduction in poverty. (Rahmanto et al., 2021)stated that food security through food diversification programs can reduce the number of rural poor people.

H_1: The poor population has a negative relationship with the food security index.

The Relationship between Food Inflation and Food Security

Food inflation is an increase in food prices caused by limited stocks of food commodities in many regions. According to (Erokhin & Gao, 2020) him, food inflation is the percentage change in the price of a basket of standard food from month to month which is calculated from the national Consumer Price Index. Food inflation is used to determine the effect of changes in access to food and agricultural products on food security. This choice correlates well with recommendations (Huseynov, 2019) that use exchange rates, inflation rates, and food trade as variables to identify short- and long-term impacts on food security. Furthermore, (Erokhin & Gao, 2020) he stated that the risk of food security arises because economic access to food availability and access to basic commodities in food insecure communities is influenced by food prices or inflation. The increase in food inflation worsens food access in African Group 1 countries because it is closely related to the increase in the number of people whose food consumption is insufficient. This correlates with FAO estimates that the cost of a healthy diet in 2020 has exceeded the international poverty line, making it unaffordable for the poor and thereby triggering food insecurity in most developing countries, especially in Sub-Saharan Africa and South Asia.

Research shows (Prabayanti et al., 2022)that the price of rice has a negative and significant effect on food security. The research results (Shilwatso et al., 2024) show that food inflation has a significant negative effect on food security, which shows that an increase in food inflation of 1 percentage reduces Kenya's food security performance by 15.31 percent, if all other factors are considered constant.
H_2: Food inflation has a negative relationship with the food security index.

The Relationship between Per Capita Rice Consumption and Food Security

Average Consumption per Capita a Week is the average consumption of several types of food that are commonly consumed. Presentation of per capita consumption per year by multiplying per capita consumption per week multiplied by 365/7. Food consumption is the type and amount of food (both original and processed) consumed by a person/resident within a certain period of time (as well as normative consumption) for a healthy and productive life (Food Security Agency, 2023). Various literature shows that per capita food consumption, especially rice, has an influence on food security. (Ali et al., 2017) stated that rice consumption that is too high could be a threat if rice production decreases due to extreme weather changes and natural disasters hitting various rice producing areas. This can ultimately affect food security, especially food security in areas that produce these commodities. The community must pay attention to the availability of rice and also access to food in an area so that the area can be called a food secure area. This is in accordance with the statement (Tessalonica et al., 2023) and (Wehantouw et al., 2021) suggests that rice consumption has a positive and significant effect on food security. This means that if rice consumption increases, food security will also increase. (Joseph, 2017) in his research results, he said that generally people have the habit of consuming rice as a staple food. So the results of this research are strengthened by (Ali et al., 2017) the fact that the more rice consumed by the community, the better the level of food security in a region, which means that if rice consumption increases, food security will also increase
H_3: Per capita rice consumption has a positive relationship with the food security index.

The Relationship between Inadequate Food Consumption (Pou) and Food Security

Inadequate food consumption or what is called PoU (Prevalence of Undernourishment), or Prevalence of Inadequate Food Consumption, is a condition where a person regularly consumes food that is less than their energy needs or does not provide enough energy needed to live a normal, active and healthy life. There are 5 (five) PoU status classifications, namely < 2.5% very low, 2.5% - 4% low, 5% - 19% medium, 20% - 34% high and > 35% very high (Food Security Agency, 2023). The PoU indicator is often used to calculate food insecurity rates based on calorie intake limits calculated by considering gender, age, height and weight. However, in the research the PoU variable is used with the aim of seeing whether the movement of the PoU indicator influences the food security index on the island of Sumatra. This means that when PoU increases, the food security index decreases in the sense that PoU is negatively related to the food security index. In some of the literature examined, the PoU indicator is more widely used to see the reduction in stunting rates. As research (Istiqomah, 2022) suggests, the prevalence of inadequate food consumption has a negative influence on the prevalence of stunting. Furthermore, the Food Security Agency, 2023) stated that toddlers who experience stunting generally have inadequate nutritional status due to lack of access to food. (Istiqomah, 2022) states that the prevalence of inadequate food consumption is an estimate of the proportion of a certain population, where the usual daily energy consumption from food is insufficient to meet the energy levels needed for a normal, active and healthy life. So this indicator describes changes in food availability and the ability of households to access that food, at different socio-economic levels, as well as at national and sub-national levels. The PoU concept makes it possible to estimate conditions of severe food shortages in large populations, so this indicator is used to measure targets for eliminating hunger globally.
H_4: Insufficient food consumption has a negative relationship with the food security index.

The Relationship between Food Insecurity and Food Security

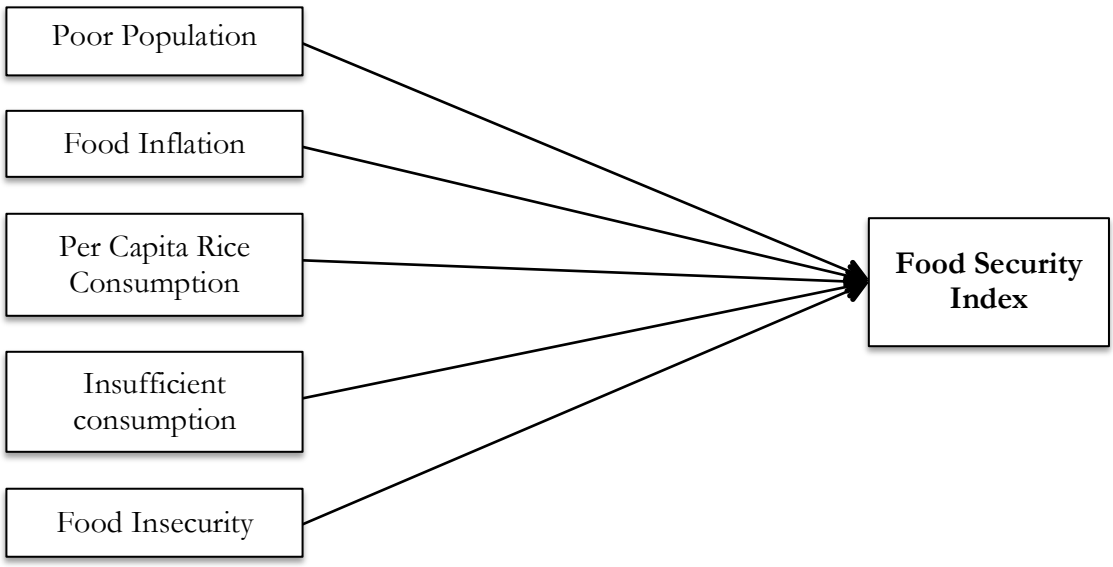
Food Insecurity or FIES (Food Insecurity Experianced Scale), which is a food insecurity rate based on a food insecurity experience scale. The FIES score consists of (1) mild food insecurity or worry with a score of <4, (2) moderate, namely compromise with the quality and type of food or compromise with the quantity of food with a score of 4-6 and (3) severe, namely not eating or being hungry because lack of money or other resources with a score of 7-8 (Food Security Agency, 2023). In the research, the FIES variable is used with the aim of seeing whether the movement of the FIES indicator influences the food security index on the island of Sumatra. This means that when FIES increases, the food security index decreases in the sense that FIES is negatively related to the food security index. Research shows (Istiqomah, 2022)that the FIES indicator is used to see a reduction in stunting rates, with the research results that the prevalence of food insecurity (FIES) has a negative influence on the prevalence of stunting. The prevalence of food insecurity measures the percentage of individuals in the population nationwide who have experienced or experienced moderate or severe levels of food insecurity at least once in the past 12 months. A person's inability to access food can be seen from different experiences and socio-economic and cultural levels. The research (Nikmah & Ratnasari, 2017)used variables of food availability, food access, food absorption on food insecurity which showed positive and significant results. This means that the better the factors of food availability, food

access, and food absorption in a region, the better the influence on increasing food insecurity in that region.
H_5: Food insecurity has a negative relationship with the food security index.

Referring to the conceptual framework, the hypotheses proposed in this research are:

1. Poor communities are thought to have a negative relationship with the food security index. This means that if the number of poor people increases, the food security index decreases.
2. Food inflation is thought to be negatively related to the food security index. This means that if food inflation increases, the food security index decreases.
3. Per capita rice consumption is estimated to be positively related to the food security index. This means that if per capita rice consumption increases, the food security index will increase.
4. Insufficient food consumption is estimated to be negatively related to the food security index. This means that if insufficient food consumption increases, the food security index decreases.
5. Food insecurity is thought to be negatively related to the food security index. This means that if food insecurity increases, the food security index decreases.

Figure 1. **Conceptual Framework**



Method

This research uses a quantitative research approach method that is designed descriptively and externally. The data presentation method is dominated by numbers and the data analysis used is statistical in nature with the aim of testing hypotheses (Subagyo, 2020). Descriptive design is used to provide an overview of the development of food security variables. Meanwhile, explanatory design is used to present data statistically through econometric testing. The description of strengthening food security is proxied by the food security index. Meanwhile, to see the sustainable food sector, it is proxied by the

percentage of poor people, food inflation, rice consumption per capita, inadequate food consumption (PoU), and food insecurity.

The type of data used is secondary data with data sources obtained from the Central Statistics Agency and the Food Security Agency. The secondary data used is panel data from cross sections from 10 provinces on the island of Sumatra and time series data for 2018-2022.

Table 1. **Operational Definition of Variables**

Variable	Draft	Unit	Source
Food Security (Y)	Meeting the food needs of the community both in terms of availability, affordability and utilization of food	Index	(Food Security Agency, 2023)
Poor Population (X_1)	Population living below the poverty line based on monthly per capita expenditure	Soul	(Food Security Agency, 2023)
Food Inflation (X_2)	The percentage change in the price of a standard food basket from month to month calculated from the national Consumer Price Index	Percent	(Food Security Agency, 2023)
Rice Consumption Per Capita (X_3)	Average consumption of rice is based on per person per year	Kg/Capita/Year	(Food Security Agency, 2023)
Insufficient Food Consumption (X_4)	Consumption of food that is less than energy requirements in the categories very low, low, medium, high, very high	Percent	(Food Security Agency, 2023)
Food Insecurity (X_5)	The food insecurity score is based on the food insecurity experience scale with mild, moderate and severe food insecurity scores	Number Scale	(Food Security Agency, 2023)

This research data analysis uses panel data analysis (Widarjono, 2018). Panel data is a combination of time series data and cross section data . In other words, panel data is the same units observed over a certain period of time. In general, panel data is characterized by a small time period T (t=1, 2, …, T) and a large number N individuals (i=1, 2, …, N). However, this does not rule out the opposite possibility, namely that panel data consists of a large time period and a small number of individuals. Three approaches to using this panel data, namely:

1. Common Effects Model
   Common effect combines time series data and cross section data in pool form, and the estimation technique uses the pooled less squares approach. The regression equation in the common effect model can be written as follows:

$$yit = \alpha + \beta Xit + \varepsilon it, \text{ for } i = 1,\dots ,N \text{ and } t = 1,\dots,T \quad (1)$$

2. Fixed Effects Model
   Fixed Effect assumes that differences between individuals can be accommodated through differences in intercepts. This model is based on differences in intercepts between individuals, but the intercepts are the same over time (time invariant). The FEM model can be formulated as follows.
   $$yit = \alpha i + \beta 1X1it + \beta nXnit + \varepsilon it \quad (2)$$
   Where
   $$\alpha i = \alpha + \mu i;\ i = 1,2, \dots ,N \quad (3)$$

3. Random Effects Model
   Random Effect assumes that each individual has a different intercept which is a random or stochastic variable. The regression equation can be written as follows:
   $$yit = \alpha i + \beta' Xit + wit \quad (4)$$
   With
   $$wit = \mu i + \varepsilon it \quad (5)$$

Panel The panel data regression model selection is used to determine the most appropriate panel data regression estimation technique, therefore three types of tests are carried out, namely the first, the F statistical test is used to choose between an OLS model without dummy variables (Common Effects) or Fixed Effects. Second, the Lagrange Multiplier (LM) test is used to select a model between Common Effect and Random Effect. Third, to choose a model between the Fixed Effect or Random Effect model, the Hausman test is used. Equality Which obtained from A estimate Can operated in one sense statistics If fulfil presumption classic It is fulfil free multicollinearity, heteroscedasticity, autocorrelation, as good as distributed in one sense normal.

Hypothesis testing for significance testing uses the F statistical test (simultaneous test) and the t statistical test (partial test). Meanwhile, the coefficient of determination (goodness of fit) test is carried out to determine how large a percentage of the independent variable is able to explain variations in the dependent variable. Panel data testing in this research uses the Eviews 10 software application.

Findings

Descriptive Analysis Results

To measure the level of food security in a region and its supporting factors, an assessment system was developed in the form of IKP which refers to the definition of food security and the subsystems that make up the food security system. The ninth indicator used in preparing the IKP is a derivative of three aspects of food security, namely availability, affordability and utilization of food. In relation to this research, the three aspects of food security are proxied by the food security index. Meanwhile, to see the sustainable food sector, it is proxied by the percentage of poor people, food inflation, rice consumption per capita, food consumption for the poor (PoU), and food insecurity. Judging from the development of the Food Security Index, it reflects 4 provinces with IKP >70 percent, namely Lampung Province, West Sumatra, North Sumatra and Jambi.

Table 2. **Descriptive Statistics**

Province	Variable					
	PP	**FI**	**RCP**	**PoU**	**FIES**	**FSI**
Aceh	15.25 (0.4923)	1.89 (1.3964)	101.34 (1.7763)	8.91 (1.4787)	5.58 (1.3126)	69.22 (2.3909)
North Sumatra	8.85 (0.2990)	1.82 (2.2473)	100.30 (1.8927)	6.47 (1.4374)	6.98 (0.9811)	70.51 (1.9464)
West Sumatra	6.40 (0.2994)	1.10 (1.1325)	100.60 (2.0701)	5.90 (0.8953)	6.00 (0.8095)	77.50 (2.3386)
Riau	7.04 (0.2482)	0.86 (1.4851)	88.06 (1.3456)	10.57 (2.6757)	6.07 (1.5225)	64.68 (2.4279)
Jambi	7.76 (0.2303)	1.39 (1.2320)	89.87 (1.4472)	9.90 (1.3201)	4.79 (0.9196)	70.90 (2.4228)
South Sumatra	12.58 (0.3878)	1.09 (0.9457)	93.52 (1.2984)	8.77 (1.6674)	6.27 (1.5489)	69.07 (0.6281)
Bengkulu	15.11 (0.3063)	0.44 (0.3485)	100.45 (1.8420)	8.88 (1.6319)	5.49 (1.7479)	68.23 (3.7644)
Lampung	12.46 (0.5745)	1.86 (1.7374)	89.58 (1.1008)	11.94 (1.7482)	6.82 (0.8503)	75.89 (3.0733)
Kep. Bangka Belitung	4.75 (0.3270)	1.66 (1.5707)	86.97 (1.6756)	10.70 (2.7675)	3.12 (0.6341)	66.90 (7.4310)
Kep. Riau	6.08 (0.1577)	1.41 (1.7672)	83.57 (4.2771)	6.68 (2.8827)	5.96 (1.3094)	61.57 (2.3585)

Source: Processed data

Based on the table above, during the 2018-2022 period, the provincial poverty rate on Sumatra Island, the highest percentage of poor people was in Aceh Province with an average value of 15.25 percent with a standard deviation of 1.3964. This means that the poverty rate refers to the number 15.25 and spreads between 15.25 ± 1.3964 , Bengkulu Province is ranked second highest on the island of Sumatra, the percentage of poor people in Bengkulu Province_also higher than the percentage of poor people nationally (Indonesia). Meanwhile, the lowest poor population is in the Bangka Belitung Islands Province at 4.75 percent, while the highest standard deviation is in Lampung Province. To reduce poverty in rural areas, efforts are needed to create jobs and increase the income of the poor.

The average food inflation value for Aceh Province was 1.89 percent and the lowest for Bengkulu Province was 0.44 percent. Food inflation is dominated by consumption of grains. The increase in food inflation is influenced by harvest conditions, natural disturbances, or developments in food commodity prices at home and abroad. Judging from the highest per capita rice consumption is Aceh Province and the lowest is Riau Islands Province. Per capita rice consumption on the island of Sumatra is higher than consumption of tubers, corn and soybeans. Considering that rice is one of the staple foods of the population on the island of Sumatra, rice is the main consumption compared to tubers, corn and soybeans. Fluctuations in rice consumption on the island of Sumatra show that the price of rice in each province on the island of Sumatra experiences price differences and fluctuates so that people's ability or purchasing power is also low and fluctuates.

The minimum standards used for PoU calculations are adjusted to individual calorie needs based on gender, age at certain height and weight and activities undertaken. The

categorization of the PoU percentage is divided into 5 statuses, namely very low if the PoU is 35 percent. the PoU on Sumatra Island appears to be increasing, namely the provinces of Aceh, North Sumatra, West Sumatra, Riau, Jambi, Bengkulu, Bangka Belitung Islands, Riau Islands have medium status. Meanwhile, the provinces of South Sumatra and Lampung experienced winter with moderate status. If we look at the percentage of population according to insufficient food consumption (PoU) status, it can be seen that Lampung Province has the highest average PoU value, namely 11.94 percent with a standard deviation of 1.7482 and the lowest is West Sumatra Province at 5.90. percent. The higher the PoU figure, the higher the population experiencing food shortages.

Furthermore, moderate and severe levels of food insecurity can be measured using the FIES (Food Insecurity Experianced Scale), namely the level of food insecurity based on the food insecurity experience scale. The FIES score consists of (1) mild food insecurity or worry with a score <4, (2) moderate, namely compromise on the quality and type of food or compromise on food quantity with a score of 4-6 and (3) severe, namely not eating or being hungry due to lack of money or other resources with a score of 7-8. Based on data, Sumatra saw a downward trend, which means that the percentage of the population that is unable to meet its daily energy needs is decreasing, namely in the provinces of Aceh, West Sumatra, Jambi, South Sumatra, Bengkulu, Bangka Belitung Islands. Meanwhile, the provinces of North Sumatra, Riau, Lampung, Riau Islands experienced fluctuating FIES numbers. The highest average FIES figure is West Sumatra Province at 6.98 percent with a scale score close to severe. Meanwhile, the lowest average FIES score was in the Bangka Belitung Islands province at 3.12 percent with a score on the food insecurity scale of light or concern.

Panel Data Regression Results

Selection of the appropriate model

1. Chow Test (CEM or FEM Model Selection)

Table 3. **Chow Test Results**

Effects Test	Statistic	d.f.	Prob.
Cross-section F	8.232746	(9,35)	0.0000
Cross-section Chi-square	56.843420	9	0.0000

Source: Processed data

Cross-section F is 0.0000, which means the p-value is smaller than □ =5% (0.05), so the conclusion from the Chow Test is that the Fixed Effect Model approach is better than the Common Effect Model.

2. Hausman Test (FEM or REM Model Selection)

Table 4. **Hausman Test Results**

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	3.670190	5	0.5978

Source: Processed data

The Hausman test results obtained a value of Prob. The Random Cross Section of 0.5978 is greater than □ =5% (0.05) so the best model for sorting is the Fixed Effect Model.

Classic Assumption Test Results

Based on the results of the suitability test, namely the Fixed Effect Model, the results of the classical assumption test are as follows.

1) Multicollinearity Test Results

Table 5. **Multicollinearity Test Results**

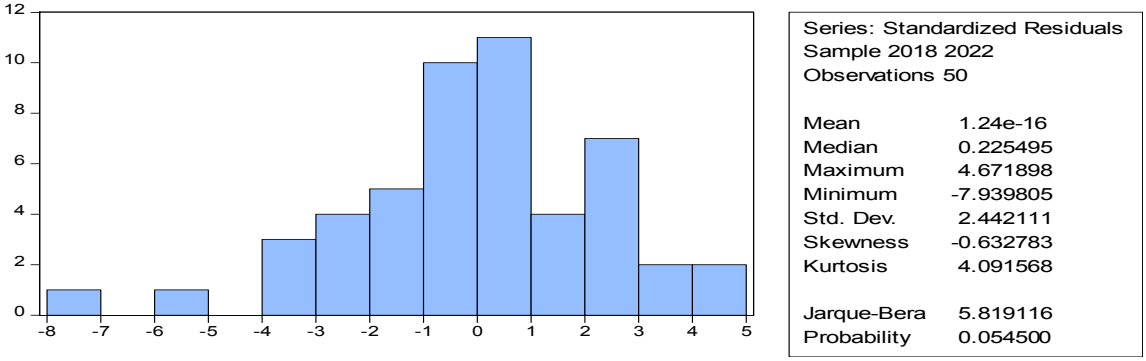
	FSI	PP	FI	RCP	POU	FIES
FSI	1,000,000	0.149436	0.323993	0.356230	0.155371	0.016891
PP	0.149436	1,000,000	-0.069286	0.540587	0.115094	0.269961
FI	0.323993	-0.069286	1,000,000	-0.138186	0.269437	-0.331960
RCP	0.356230	0.540587	-0.138186	1,000,000	-0.405112	0.258477
POU	0.155371	0.115094	0.269437	-0.405112	1,000,000	-0.265460
FIES	0.016891	0.269961	-0.331960	0.258477	-0.265460	1,000,000

Source: Processed data

The value between independent variables is below 0.85 so that the data in this study does not have multicollinearity problems.

2) Normality Test Results

Figure 2. **Normality Test Results**



Source: Processed data

Number of observations (n = 50 and k = 5), obtained degrees of freedom (df) = 45, and used □ = 5%. The Jarque Bera value is 5.819116 with a probability of 0.054500. It can be concluded that the data is normally distributed.

3) Autocorrelation Test Results

Table 6. **Autocorrelation Test Results**

Model	Durbin-Watson Statistics	N	K	d_L	d_u	4-d_L	4-d_u	Conclusion
IKP	2.472521	50	5	1,335	1,771	2,665	2,229	No Positive Autocorrelation

Source: Processed data

Models that are more than d_u or symbolized by $d > d_U$. Thus, it is concluded that the food security index model does not contain positive autocorrelation.

4) Heteroscedasticity Test Results

Table 7. **Heteroscedasticity Test Results**

Variable	Coefficient	Prob.
C	11.65647	0.3779
PP	0.246156	0.7234
FI	0.064072	0.7249
RCP	-0.033976	0.7740
POU	0.032187	0.7980
FIES	-0.054937	0.7831

Source: Processed data

Based on the results of the heteroscedasticity test, it can be seen that all independent variables have an insignificant influence on the quadratic residual variable of the model. So it can be concluded that the food security index model is free from heteroscedasticity problems.

Interpretation of Estimation Models

The model used to estimate the food security index model on Sumatra Island is the Fixed Effect Model.

Table 8. **Final Estimation Model (FEM)**

Variable	Coefficient	Std. Error	t-Statistics	Prob.
C	52.99213	29.46336	1.798577	0.0807
PP	1.209411	1.615126	0.748803	0.4590
FI	0.877904	0.399537	2.197301	0.0347
RCP	0.019876	0.277060	0.071738	0.9432
POU	0.490093	0.282658	1.733874	0.0917
FIES	-0.451416	0.461060	-0.979082	0.3343
Securities Specifications				
Fixed cross section (dummy variable)				
R-squared	0.800126	Means var depends		69.45000
Adjusted R-squared	0.720176	SD-dependent var		5.462448
SE regression	2.889545	Akaike info criteria		5.203400
The sum of the squares is located	292.2314	Schwarz criteria		5.777007
Note the possibilities	-115.0850	Hannan-Quinn criteria.		5.421833
F-statistics	10.00788	Durbin-Watson Statistics		2.472521
Problem (F-statistics)	0.000000			

Source: Processed data

Based on a series of model significance tests that have been carried out, the regression equation estimation model based on the Fixed Effect Model in this research is:

$$FSI_{it} = 52.99213 + 1.209411PP_{it} + 0.877904FI_{it} + 0.019876RCP_{it} + 0.490093PoU_{it} - 0.451416FIES_{it}$$

The conclusion is that at the 95% level, the IBM variable (food inflation) has a significant effect on the FSI (food security index), while the PP variable (poor population), RCP (rice consumption per capita), PoU (population according to insufficient food consumption status), FIES (population with moderate or severe food insecurity, food insecurity experience scale) does not have a significant effect on FSI (food security index).

The results of the F test obtained an F-statistic value of 10.00788 with a probability value (F-statistic) of 0.000000 < □ = 5%, then the variables PP (poor population), FI (food inflation), RCP (rice consumption per capita), PoU (population according to insufficient food consumption status), FIES (population with moderate or severe food insecurity, food insecurity experience scale) together have a significant effect on the FSI (food security index).

The test results obtained an R-squared value of 0.800126, which means the variables PP (poor population), FI (food inflation), RCP (rice consumption per capita), PoU (population according to insufficient food consumption status), FIES (population with insecurity experience scale medium or heavy food) was able to explain changes in the FSI (food security index) of 80.01 percent, while the remainder (19.99 percent) was explained by other variables outside the model.

The Influence of the Number of Poor Population on the Food Security Index of Sumatra Island

The regression coefficient for the poor population is 1.209411 with a unidirectional (positive) relationship, which shows that under ceteris paribus conditions, if the poor population increases by 1 percent, the average food security index will increase by 1,209 percent. The poor population variable shows a positive sign and is not significant on the food security index on the island of Sumatra. The results of this research are different from several previous studies which analyzed the influence of poverty on the food security index. Research (Wehantouw et al., 2021) using the percentage of poverty using multiple regression shows that poverty has a negative and insignificant effect on food security, meaning that an increase in food security will be followed by a reduction in poverty. This research actually found that the results of the poor population variable showed a positive and insignificant relationship with the food security index. Referring to the data used in this research, the number of poor people on Sumatra Island shows a decreasing trend, but not in the same direction as the food security index which shows an increase from 2018-2022. Thus, the poor population in 10 provinces on the island of Sumatra has decreased but food security has increased.

The Effect of Food Inflation on the Sumatra Island Food Security Index

The food inflation regression coefficient is 0.8779041 with a unidirectional (positive) relationship, which shows that under ceteris paribus conditions, if food inflation increases by 1 percent, the average food security index will increase by 0.877 percent. The food inflation variable shows a positive and significant sign on the food security index on the island of Sumatra. If food inflation increases, the average food security index will increase. The results of this research are in line with research results (Erokhin & Gao, 2020) that food inflation has a positive and significant effect on food security. This means that the increase in food prices actually causes people's access to basic commodities to experience food insecurity because food availability is difficult to reach, causing risks to food security. This is different from research (Prabayanti et al., 2022) that shows the price of rice has a negative and significant effect on food security.

The Influence of Per Capita Rice Consumption on the Food Security Index of Sumatra Island

The regression coefficient for per capita rice consumption is 0.019876 with a unidirectional (positive) relationship, which shows that under ceteris paribus conditions, if per capita rice consumption increases by 1 percent, the average food security index increases by 0.019 percent. The per capita rice consumption variable shows a positive sign and does not have a significant effect on the food security index on Sumatra Island. If per capita rice consumption increases, the average food security index will increase. The research results are supported by research (Tessalonica et al., 2023) and (Wehantouw et al., 2021) suggest that rice consumption has a positive and significant effect on food security. Apart from that, (Mahdalena et al., 2015) he said that the availability of rice in North Sumatra Province is partially influenced by domestic rice prices and rice consumption. Apart from that, Joseph (2017) said that part of people's consumption habits in general are grains. The more rice consumed, the better the level of food security. Rice consumption that is too high

could be a threat if rice production decreases due to extreme weather changes and natural disasters hitting various rice producing areas.

The Influence of PoU on the Sumatra Island Food Security Index

The PoU regression coefficient is 0.490093 with a positive relationship indicating that under ceteris paribus conditions, if PoU increases by 1 percent, the average food security index will increase by 0.490 percent. The PoU variable shows a positive sign and has no significant effect on the food security index on Sumatra Island. If PoU increases, the average food security index will increase. (Food Security Agency, 2023) stated that the percentage of population according to the status of food consumption insufficiency (PoU) on the island of Sumatra has increased but is still in the medium category, ranging between 5%-19%. PoU calculates food insecurity rates based on calorie intake limits which are calculated by considering gender, age, height and weight. A condition where a person regularly consumes food that is less than their energy needs or does not provide enough energy needed to live a normal, active and healthy life.

The Influence of Food Insecurity on the Sumatra Island Food Security Index

The FIES regression coefficient is 0.451416 with a unidirectional (negative) relationship which shows that under ceteris paribus conditions, if FIES increases by 1 percent, the average food security index will decrease by 0.451 percent. The FIES variable shows a negative sign and has no significant effect on the food security index on Sumatra Island. If FIES increases, the average food security index will decrease. Sufficient food is a prerequisite for achieving food security. (Food Security Agency, 2023) stated that an area said to be food insecure can be measured by the relative large number of poor households due to economic reasons, the nutritional status of the community as indicated by the nutritional status of children under five, regional food availability, and food vulnerability. Conditions of food insecurity can be caused by: (a) lack of economic access for individuals/households to obtain sufficient food, (b) lack of physical access for individuals/households to obtain sufficient food, (c) insufficient food for a productive life for individuals /household and, (d) food supply that is insufficient in terms of quality, variety, safety and affordability. Food insecurity occurs when each individual is only able to meet 80% of their daily food and nutritional needs. Furthermore, according to Suryana (2014), the imbalance in food production between regions causes almost all commodities, the proportion of food production on the island of Java to be more than 50 percent of national food production. This inequality will increase the problem of food distribution efforts and food distribution costs, making it difficult to provide food evenly spatially in all regions in Indonesia. If infrastructure and food logistics systems between regions are not built, production disparities between regions will be difficult to overcome.

The implication of this research is that the research has theoretical implications for the food security index, namely the variable poor population and per capita rice consumption which are the indicators used in calculating the food security index. Practically, this research can provide input as a reference in making policies related to food security on the island of Sumatra.

Conclusion

Based on the research results, food sector indicators have a positive and negative effect on food security on the island of Sumatra. The decline in the number of poor people on the island of Sumatra is an opportunity to increase food security, but you need to be careful because several provinces are still above 10 percent. Likewise, food inflation needs to be watched out for because food prices tend to increase every year. If there is an increase in food prices, the food security index will decrease. However, on the contrary, food inflation on the island of Sumatra is relatively stable, which can influence the increase in the food security index. Per capita rice consumption is still the main consumption of the population of Sumatra Island, because rice is still a basic need so rice food stocks need to be increased. Insufficient food consumption and food insecurity greatly influence the decline in the food security index. If these two indicators increase, the food security index will decrease.

These five food sector variables are the challenges for the future of Sumatra Island in achieving a sustainable food sector. This means that when there is an increase in the number of poor people, food inflation, insufficient food consumption, then food insecurity will increase so that the government's efforts to achieve superior and strategic food security are not achieved.

Suggestions that can be proposed and implemented by policy makers to strengthen food security through a sustainable food sector are as follows: (i) The Ministry of Agriculture, in collaboration with the Food Security Agency, needs to encourage the development of food security both in terms of food availability, food affordability and food utilization. (ii) The regional government of each province needs to design appropriate food policies and management in accordance with empirical conditions in the field. (iii) Other efforts made by local governments to realize strong food security are through aspects of climate suitability, suitability of regional topography, development of farmers human resources (HR), use of technology, existing food maps, on-farm and off-farm expansion plans in the future. Future, as well as regional policy support for self-sufficiency. The limitations of this research are that it does not cover food security index variables such as food imports, food exports, food reserves and other variables that are relevant to the food security index. So it is hoped that future researchers will consider these variables as factors that influence the food security index and add broader research observations.

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