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Sumatra Farmers' Welfare Analysis: A *Modified Geographic Weight Regression (Gwr)* Model Application

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ABSTRACT

This study aims to analyze the level of welfare of farmer households on the island of Sumatra and examine the determinants of their factors. The study employs a multidimensional poverty index (MPI) comprising three dimensions: health, education, and standard of living. This poverty data and the determinant factors used in this study were obtained from data from the 2023 National Socio-Economic Survey (Susenas) involving 154 city districts on Sumatra Island. The data was analyzed using Modified Geographically Weighted Regression (GWR) where commodity prices and the Geographic Difficulty Index (IKG) were used as weights instead of latitude and longitude. The findings indicate that farmers' welfare is quite good on the island of Sumatra, where the results of calculating the district/city MPI are at a value of 0 to 0,2726 which is included in the Low MPI criteria. The Modified GWR model performs better with an R-square of 0,49 and an adjusted R-square of 0,47. This study also found that the variables of average length of schooling, number of household members, per capita expenditure, government assistance, life expectancy, and land ownership had a very significant effect on the farmers' welfare. Therefore, it is im-

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portant for the government to ensure equitable access to education, health and other public facilities, enhancing farmers' skills through mentoring programs, especially for people in rural areas.

Keywords: Farmers Welfare; Multidimensional Poverty Index; Geographically Weight Regression(GWR); Modified GWR; Sumatra Island

1. Introduction

Farmers' welfare is the main indicator in assessing the success of economic and social development in an agrarian country such as Indonesia. The percentage of the population working in the agriculture, forestry and fisheries sectors reached 45,25 percent in August 2023—the highest among all 16 other sectors based on the publication of the Indonesian Labor Market Indicator of the Central Statistics Agency^[1].

One of the indicators to see the current welfare of farmers is the Farmer Exchange Rate (NTP) figure. NTP provides an overview of the welfare of farmers in various provinces. NTP shows the ratio between the price index received by farmers and the price index paid by farmers. The highest NTP figure in 2023 from the six largest islands in Indonesia is Sumatra Island, which is 126,7. The highest NTP is found in Riau Province and Bengkulu Province^[2]. According to BPS data in the 2023 Regency/City Poverty Data and Information Publication, Bengkulu Province is the second poorest province on the island of Sumatra^[3]. This reflects that the NTP has a weakness in measuring the welfare of farmers because it only looks at the Index received and the Index paid by the farmer. If you look at the distribution share of the Gross Regional Domestic Product (GDP) on the basis of applicable prices, sector A, namely Agriculture, Horticulture and Forestry. The share of the island of Sumatra has the highest value compared to the share of the other five islands, which is 22,32 percent^[4]. The value of the NTP and GDP of the agriculture, horticulture and forestry sectors of Sumatra Island has the highest value among the other five islands. The island of Sumatra is the island with the second fastest economic development after the island of Java. The economic activity on this island is supported by its abundant natural resource potential and strategic geographic location.

Each province has different geographical and so-

cioeconomic characteristics. The poverty rate in Sumatra is one of the important indicators that shows the various challenges faced by agricultural households on this island. A more comprehensive measure of well-being should consider a variety of other dimensions, such as education, health, and the standard of living of agricultural households. One approach that can be used to understand welfare more comprehensively is the Multidimensional Poverty Index (MPI), which provides a holistic view of welfare conditions. MPI is able to provide a more complete picture of welfare conditions. This is evidenced by many researchers, including Alkire et al (2023), Chakravarty et al (2008), and Deyshappriya and Feeny (2013)^[5-7], which uses this index as a measure of household well-being.

If you look at some of the studies that have been conducted, the factors that affect the welfare of farmers still vary. However, the existing research is still mostly limited to the welfare of farmers from an economic perspective, even though welfare is not limited only to the economic side but also to other aspects such as health, education, access to facilities and a decent standard of living. Some of the studies that analyze the welfare of farmers from an economic perspective include: Nirmala et al (2016), Hamjaya et al (2022), Sinaga et al (2022), Syifa et al (2021), and Marsudi et al (2020)^[8-12]. This study will analyze the welfare of farmers in 2023 on the island of Sumatra using MPI as the main measuring tool. Data analysis also involves the prices of major commodities and the IKG as the weigh-in. Measuring farmers' welfare with MPI by involving commodities and geographical difficulty index differentiated this study from previous research.

Departing from the discussion above, this study aims to analyze the level of welfare of farmer households on the island of Sumatra. The second goal is to identify the factors that affect the welfare of farmers. This goal is answered by modifying the GWR using the price

weighter of the leading commodity and the Geographical Difficulty Index (IKG).

2. Brief Literature Review

Welfare

According to Sen (2014)^[13], the origin of individual welfare is from the ability to function properly in a society. The concept of welfare can be seen from various dimensions, such as economic, socio-cultural, and so on. The essence of the concept of welfare is the condition of fulfilling every aspect of human life, both moral and material.

Amartya Sen (1980) has long criticized the approach to poverty using monetary analysis. According to Amartya Sen, this approach only captures a small part of the magnitude of the poverty problem. The problem of poverty is not only about the ability to buy power, income or consumption but there is a broader dimension of poverty conditions. When there are some people who cannot access basic education or health services due to inability in the economy, it can be said to be poor. Likewise, the quality of living standards such as houses with dirt floors, no good sanitation, energy sources for lighting and cooking that are not feasible, is part of poverty in MPI: Concepts and Measurements in Indonesia^[14]. According to Pindyck & Rubinfeld in their research, poverty is the antithesis of a person's well-being^[15].

The concept of multidimensional poverty was first initiated by Amartya Sen through his various writings, namely around the mid-1980s. One of Sen's writings is outlined in his book *Development as Freedom* (1999) which states that income is not the only instrument for determining the ability of someone. Poverty and household welfare have a close relationship, where poverty can have a negative impact on household welfare. Sen's thought was then applied through the research of Alkire and Foster from OPHI (2011) which later gave birth to the Multidimensional Poverty Index (MPI). The capability approach is used in various fields, namely economic welfare, social policy, political philosophy, and most prominently in development thinking. According to John Rawls 1971 in the book *A Theory of Justice*, there are three aspects of poverty. The first is multi-dimensional

poverty, the second is the relationship between aspects of poverty, and the third is that poverty is closely related to rural areas. Research using MPI has been extensively conducted and implemented in several countries such as China, Colombia, Malaysia, India, Brazil, Ecuador, and Africa^[16–22]. Each researcher and country uses slightly different dimensions and indicators from the initial MPI concept promoted by Alkire-Foster (AF). This is to adjust to various conditions in their respective countries or regions. This is one of the advantages of multidimensional poverty measurement with the AF method, where each region/country can modify the dimensions and indicators of MPI according to the conditions of their respective regions/countries and in accordance with the Sustainable Development Goals or SDGs. There are five indicators that are often used in measuring well-being. Indicators to measure welfare include the Farmer Exchange Rate, the Multidimensional Poverty Index, the Human Development Index, the Happiness Index and the criteria for a prosperous family based on the National Family Planning Coordinating Board. First is the **Farmer's Exchange Rate**. The Farmer Exchange Rate is an indicator that can measure the purchasing power of farmers as one of the main actors in the agricultural sector. NTP is calculated from the ratio of the price received by farmers (it) to the price paid by farmers (ib). Several studies used NTP as a farmers' welfare indicator including Kurniawan (2023), and Syifa et al (2021)^[11, 23]. Second is the **Multidimensional Poverty Index (MPI)**. The Multidimensional Poverty Index (MPI) was first developed by the Oxford Poverty and Human Development Initiative (OPHI) and the United Nations Development Programme's Human Development Report Office (UNDP HDRO) in 2010. For UNDP, MPI is an integrated part of the Sustainable Development Goals (SDGs) framework. MPI can monitor the progress of efforts to achieve Goal 1 of Sustainable Development, which is to end poverty in all its forms. Third is the **Human Development Index (HDI)**. The Human Development Index (HDI) is one of the measurement indicators set by all countries in the world, which classifies a country as a developed, developing or underdeveloped country. HDI is based on three main dimensions: longevity and health, a decent standard of living, and knowledge^[24]. Fourth is the **Hap-**

piness Index. Based on the Happiness Index Publication (BPS, 2021), the assessment of the level of happiness is covered in 3 (three) dimensions of life, namely: The dimension of life satisfaction, the Dimension of feelings and the Dimension of the meaning of life^[25]. Finally, the **Size of the National Family Planning Coordinating Board (BKKBN)**. BKKBN measures based on two criteria, namely: Pre-Prosperous Family and Prosperous Family^[26].

Research on farmers' welfare must consider various factors that affect their lives in a multidimensional way. The average length of school shows the importance of investing in education to improve skills and economic opportunities. Per capita expenditure describes the level of the economy that can support or hinder welfare. Government assistance reflects the important role of policy interventions in supporting vulnerable groups. Life expectancy indicates health conditions that affect work ability and productivity. Land ownership is a crucial asset that determines the production capacity and economic security of farmers.

Agricultural commodities have an important role in increasing farmers' income regardless of geographical location. This is because farmers will definitely choose commodities that are suitable for planting based on the geographical location of their area. Highland areas are suitable for growing vegetables such as carrots, potatoes,

cabbage and lettuce as well as fruits such as strawberries, apples and pears and Plantation crops such as tea and coffee. In contrast to lowland areas, farmers usually choose crops that can adapt to warm climatic conditions such as rice, coconut, rambutan, oranges, bananas and various other vegetables. Commodity prices also often fluctuate due to several factors, one of which is related to the smooth distribution of marketing^[27].

This study uses a modification of the Geographically Weighted Regression (GWR) model by changing the latitude and longitude spatial weights to commodity prices and the geographic distress index (IKG).

3. Methodology

This type of research is quantitative research that uses descriptive analysis methods and inferential analysis. MPI calculation is carried out to obtain the value of welfare variables. In this study, the dimensions and indicators of MPI and their weights are formulated as shown in **Table 1**.

Furthermore, the analysis uses Modified GWR with the weighting of superior commodity prices in July 2023 from the results of the 2023 Agricultural Census and the 2023 Rural Price Survey and IKG from the results of the 2021 Village Potential data collection in 154 districts/cities located on the island of Sumatra.

Table 1. Dimensional Weights and MPI Indicators.

Dimension	Weight Dimensions	Indicators	Weight Indicator
Health	1/3	Health Complaints	1/9
		Skip 1 meal	1/9
		Skipping 1 meal day	1/9
Education	1/3	Literacy skills	1/6
		Length of school	1/6
Quality of life standards	1/3	Roof, floor and walls of the house	1/18
		Sanitation	1/18
		Access to the main water source for drinking	1/18
		Primary sources of description	1/18
		Types of cooking fuel	1/18
		Home assets	1/18

According to the National Development Planning Agency (Bappenas), Indonesia is divided into four main development areas, namely A, B, C and D. Sumatra Island consists of 2 development areas, namely:

1. The main development area of Sumatra A. The Sumatra A region consists of five provinces, namely: Aceh consists of 23 districts/cities, North Sumatra consists of 33 districts/cities, West Sumatra consists of

19 districts/cities, Riau consists of 12 districts/cities, and Riau Islands consists of 7 districts/cities.

2. The main development area of Sumatra B. Region of Sumatra B consists of 5 provinces, namely: Jambi consists of 11 districts/cities, South Sumatra consists of 17 districts/cities, Bengkulu consists of 10 districts/cities, Bangka Belitung Islands consists of 7 districts/cities and Lampung consists of 15 districts/cities.

3.1. Framework of Analysis

The conceptual framework of this study is built on a background and supported by several theories of well-being, according to Amartya Sen, Alkire Foster and John Rawls. Susenas data is sorted based on the business fields of heads of households who work in the agriculture, food crops and crops, horticulture, plantations, fisheries, livestock and forestry or other agriculture. Furthermore, indicators of the average length of school, the head of household, the number of household members, per capita expenditure, government assistance, life expectancy and land ownership which will be independent variables are calculated and welfare is calculated using the MPI method to be used as a dependent variable.

Based on **Figure 1**, this study uses modifications to the weights, namely commodity prices and IKG, as new weights to replace the latitude and longitude commonly used in GWR analysis. This is done based on the theory that the plants planted by farmers must have adjusted to the geography of the area, so that there are other weights that can be used as a substitute for spatial points in the

GWR. Furthermore, data processing was carried out using the welfare dependent variable (Y) from the MPI calculation to see the influence of the independent variable X on the dependent variable (Y).

3.2. MPI Indicator and Measurement

The operational definitions of the variables used in this study are as follows:

3.2.1. The Dependent Variable (Y) Is Welfare

Welfare is assessed using three dimensions: Education, Health, and Living Standards which are explained by each indicator sourced from the 2023 National Socio-Economic Survey (**Table 2**).

3.2.2. Independent Variables

To obtain the value of independent variables, Susenas data was processed in 2023 by selecting the business field code of heads of households working in the Agriculture Sector of rice and palawija, Horticulture, Plantations, Fisheries, Animal Husbandry, as well as forestry and other agriculture. Operational Definition of Independent Variables is shown by **Table 3**.

3.3. Analysis Method

Inferential analysis is used as a hypothesis test tool in research. testing based on data processing using MPI calculation and modified GWR. The socio-economic conditions of an area are very closely related to welfare so that the selection of weights in the farmer welfare model is based on commodity prices and IKG.

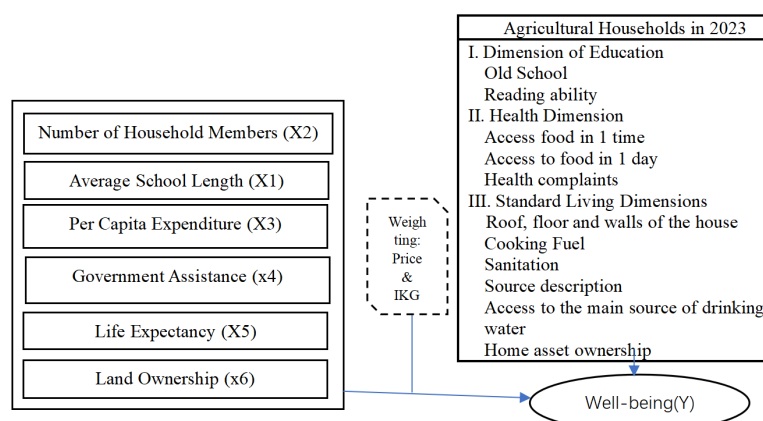


Figure 1. Research Conceptual Framework.

Table 2. Operational Definition of Dependent Variables.

Dimension	Indicators	Operational Definition
Education	Reading & Writing Skills	If one can read and write simple sentences and Latin, Arabic and other letters
	The highest level of education was terminated.	Which was once occupied by someone who no longer went to school, both formal and equitable.
Health	Health or psychiatric complaints	Due to disease disorders that are often experienced or due to acute, chronic illnesses, due to accidents, criminality, or other health complaints
	Skipping one meal on a given day	Skip heavy meals such as breakfast, lunch or dinner. because they do not have enough money or other resources to get food
	Is ART not eating all day due to lack of money/resources	Asking not to eat all day, which is done when you don't have food. does not include not eating all day for weight loss, fasting for health or religious reasons, etc.
Standard of living	Main building materials floors, walls, roof of the house	meet at least two of the following three conditions: i) the roof of the house is made of palm oil / rambia / leaves and others, ii) the floor of the house is of soil type and others, iii) the walls of the house are made of bamboo and others, so it is said to be deprived of this indicator. This depravity criterion is based on one of the criteria for a livable house from the Ministry of PUPR
	Defecation Facility	Using a joint toilet facility or no latrines, as well as households that even though they use their own or joint latrines but do not use a gooseneck toilet or do not use a SPAL as a final disposal place,
	The main source of water for drinking	from unprotected wells/springs, rivers and others, as well as those that access drilled wells/pumps and protected wells/springs but the distance to the sewage/feces storage area is less than 10 meters
	Source of house lighting	The most frequently used source of information by households in their daily lives
	The main fuel of cooking	The most commonly used fuel of the household for daily cooking purposes

Source: Book 4 Concept and Definition of the March 2023 Socio-Economic Survey^[28].

Table 3. Operational Definition of Independent Variables.

Variable	Operational Definition
Average length of head school	The average number of years of study of the population aged 15 years and above that have been completed in formal education. This indicator is very important because it can show the quality of human resources.
Number of Household Members	The number of household members owned by a household
Life Expectancy	The estimated age expected to be achieved by household members based on health and environmental conditions
Per Capita Expenditure	Total household expenditure for a month divided by the number of household members.
Government Assistance	Assistance received by farmer households from the government,
Land Ownership	The percentage of households that own land is the ratio of the number of households that own land to the number of all households.
	FORMULA: $\frac{\text{Number of households that own land} \times 100\%}{\text{Number of households}}$

Source: Book 4 Concept and Definition of the March 2023 Socio-Economic Survey.

3.4. MPI Measurement

The Multidimensional Poverty Index (MPI) assessment for each district/city evaluates specific poverty indicators using a 0-1 scale. A score of 1 is assigned when a district/city meets the poverty criteria according to MPI standards. Assessments will continue to be carried out on each indicator. After getting an assessment of all indicators, it will be calculated based on the formula as follows:

$$C_i = W_1I_1 + W_2I_2 + \dots + W_dI_d$$

Where $I_i=1$ if deprived in indicator i and $I_i=0$ if not deprived.

W_i = weight of indicator i

With

$$\sum_{i=1}^d W_i = 1$$

All indicators and dimensions are added together, and the average value is obtained. It is said to be poor if the total average judgment is large than 1/3. MPI is the multiplication between Multidimensional headcount ratio (H) and intensity poverty (A).

3.5. Modified Geographically Weight Regression (GWR)

Geographically Weight Regression (GWR) is a statistical analysis method that allows for spatial variation in relationships between dependent and independent variables. GWR is a local form of linear regression that pays attention to spatial aspects or geographic location in the form of point coordinates.

Modified GWR is a GWR model with weights that are modified from the coordinates of the latitude and longitude location points to other weights, which in the research on farmers' welfare are agricultural commodity prices and the geographical difficulty index (IKG).

Weighted regression is a statistical technique in which observations in a dataset are given different weights based on their importance or reliability. In weighted regression, the weight given to each observation may reflect the accuracy of the measurement, the importance of the observations in the sample, or the level of confidence in the observed relationship^[29]. The equation

of the modified GWR model is as follows:

$$Y_i = \beta_{0(u_i, v_i)} + \beta_{1(u_i, v_i)}X_1 + \beta_{2(u_i, v_i)}X_2 + \beta_{3(u_i, v_i)}X_3 + \beta_{4(u_i, v_i)}X_4 + \beta_{5(u_i, v_i)}X_5 + \beta_{6(u_i, v_i)}X_6 + \varepsilon_i$$

Information:

U_i = Prices of Superior Commodity of districts/cities

V_i = District/city geographical difficulty index

Y_i = Household welfare of MPI farmers

X_1 = Average School Length

X_2 = Number of household members

X_3 = Per capita expenditure

X_4 = Government assistance

X_5 = Life Expectancy Number

X_6 = Land ownership

4. Results and Discussion

The island of Sumatra is the third largest island in Indonesia and is an island rich in agricultural products. The leading commodities on the island of Sumatra are oil palm, hybrid paddy rice, rubber, coffee, hybrid corn, free-range chicken, cassava, coconut, cloves, pork, areca nut, cocoa, avocado, cinnamon, banana, and paddy rice^[30].

The island of Sumatra is the island with the second largest economy in the country. Based on the vision of a golden Indonesia 2045, the targets of several indicators of economic and social transformation include: Equitable education with one of the indicators being the average length of school and health for all with one of the indicators being life expectancy and social protection that is adaptive to the poverty level indicator.

The largest sectors that dominate the economy on the island of Sumatra are agriculture, forestry and fisheries, especially plantation commodities with a contribution of 22,78 percent and the highest compared to other sectors based on the distribution of GDP in the Sumatra region in the 1st semester of 2024.

4.1. Descriptive Statistical Analysis

4.1.1. Dimensions of Education

The Education Dimension is one of the dimensions in assessing welfare. Indicators in this dimension are: literacy and the highest education completed. Based on data, 97 percent of farmer households can read and

write letters. Reading and writing are interrelated and have benefits, namely they can improve language skills and expand insights. The indicator of the highest level of education that was terminated, in the Education dimension is shown in **Figure 2**.

4.1.2. Health Dimension

Good health can affect aspects of life. Health can cause activities to be smooth and productive, immunity is better, and improves quality of life. In the Health Complaint Indicator in Sumatra Region A, 30,2 percent of households have health complaints. Health complaints in Region B are less at 29,9 percent. Common health com-

plaints include: heat, cough, runny nose, diarrhea, and dizziness. Indicators of the health dimension are shown in **Table 4**.

4.1.3. Standard Living Dimensions

The standard dimensions of life have six indicators. The six indicators of living standards are the type of building materials, sanitation, access to drinking water, lighting, cooking fuel and asset ownership. In terms of the main building materials of residences, the majority of households use zinc roofs, walls, and cement floors. Indicators of building material types are presented in **Table 5**.

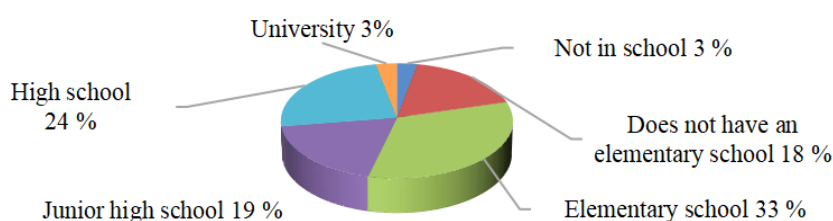


Figure 2. Highest Levels of Education Completed.

Table 4. Health Dimension Indicators.

Health Dimension	Sumatra A				Sumatra B			
	Yes		Not		Yes		Not	
	Total KRT	Percent	Total KRT	Percent	Total KRT	Percent	Total KRT	Percent
Have Health Complaints	7.631	30,2%	17.633	69,8%	5.851	29,9%	13.693	70,1%
Skip a meal one time	752	3%	24.512	97%	315	1,6%	19.229	98,4%
Skip a meal for a day	272	1,1%	24.992	98,9%	152	0,8%	19.392	99,2%

Source: Susenas Sumatra 2023 data processed.

Table 5. Building Materials for Farmer Households on the Island of Sumatra.

Building Type	Building Materials	Sumatra A		Sumatra B	
		Number of Households	Percent	Number of Households	Percent
Roof	Zinc	23.195	91,8	8.931	45,7
	Tile/concrete	773	3,1	8.833	45,2
	Asbestos	766	3,0	1.592	8,1
	Other	530	2,1	188	1,0
Wall	Wall	13.438	53,2	13.020	66,6
	Wood/ board	11.279	44,6	5.917	30,3
	Stucco/wire/bamboo weaving	355	1,4	412	2,1
	Wood/Bamboo Trunk	118	0,5	93	0,5
	Other	74	0,3	102	0,5
Floor	Cement/ red brick	14.940	59,1	9.690	49,6
	Ceramics	5.598	22,2	5.871	30,0
	Wood/board	3.729	14,8	3.015	15,4
	Other	997	3,9	968	5,0

Source: Susenas Sumatra 2023 data, processed.

In the second indicator, as many as 85 percent of farmers have their own defecation facilities. The ownership and use of healthy latrines is one of the indicators of

clean and healthy living behavior in the household order.

Regarding the indicators of water sources, lighting and cooking fuels are shown in **Table 6**.

Table 6. Water Sources, Lighting Sources, and Cooking Fuels.

Types of facilities	Information	Sumatra A		Sumatra B	
		Number of Households	Percent	Number of Households	Percent
Source of Drinking Water	Well/Protected springs	7.839	31,0	8.255	42,2
	Branded Bottled Water/Refill/Plumbing	8.510	49,6	3.967	20,3
	Borewell/Pump	3.954	30,0	2.576	13,2
	Other	4.961	15,4	4.764	24,3
Source Description	PLN Electricity with Meter	23.157	91,7	17.665	90,4
	PLN Electricity without Meter	1.107	4,4	1.236	6,3
	Non-PLN electricity	623	2,5	538	2,8
	Other	377	1,4	105	0,5
Cooking Fuel	LPG 3 kg	20.423	80,8	17.483	89,5
	Charcoal/ Firewood	3.446	13,7	1.451	7,4
	LPG other than 3 kg	467	1,8	304	1,6
	Kerosene	798	3,2	65	0,3
	Other	130	0,5	241	1,2

Source: Sumatra 2023 susenas data processed.

According to the World Health Organization (WHO), safe drinking water, sanitation and hygiene are essential for health and well-being^[31]. Sanitation is not only a prerequisite for health. Sanitation contributes to livelihoods, school participation, self-esteem and helps create resilient communities in a healthy environment. In the sixth indicator, when viewed from the status of home ownership, the status of self-ownership is 86 percent.

4.2. Inferential Statistical Analysis

4.2.1. Modified Geographically Weighted Regression (GWR) Estimation Results

Data processing in modified GWR is carried out by modifying the coordinates of the *Latitude* and *Longitude* regions into commodity prices and IKG. From the processing results, it was found that there was no multicollinearity between independent variables and there was a violation of the assumption of homogeneity, so the processing was carried out with the Modified GWR Model. The best model chosen is the *Adaptive bisquare Kernel* model. This is because *the Adaptive bisquare Kernel* has an *RSquare* value of 0,49 and an *adjusted RSquare*

of 0,47 and the AICc value of *the adaptive bisquare kernel* is smaller than the adaptive gaussian kernel which is -774, so it can be concluded that to describe the welfare of farmers on the island of Sumatra in 2023 is *the Adaptive Bisquare Kernel*.

4.2.2. Farmers' Welfare in the Sumatra Region A

Of the 5 provinces in the Sumatra A Region, there are significant similarities in the four provinces, namely Aceh, West Sumatra, Riau and Riau Islands Provinces. The variables of Average School Age, Number of Household Members, Government Assistance, Life Expectancy and Land Ownership significantly affect welfare in the four regions. The variable per capita expenditure does not significantly affect the welfare of farmers in the four provinces. This reflects that the per capita expenditure of farmer households is almost the same or homogeneous in one household so that the variable of per capita expenditure is not significant in the four provinces on the island of Sumatra A.

Variables that are not significant in the Province A area are the number of household members and the Per Capita Expenditure of the Population in Riau Province. The life expectancy variable is significant in all regions in

West Sumatra and Riau Provinces, which indicates that the health dimension greatly affects the welfare of the community, especially farmers in the two provinces. The variable the average length of school is significant in all regions in Riau Islands Province, which indicates that the Education Dimension greatly affects the welfare of the community, especially farmers.

Of the 6 independent variables that affect the welfare of farmers in 5 provinces in the Sumatra A region, North Sumatra Province is the only province with all independent variables that significantly affect the welfare of farmer households on the island of Sumatra.

4.2.3. Farmers' Welfare in Sumatra Region B

Of the 5 provinces in the Sumatra B Region, there are significant similarities between Jambi Province and the Bangka Belitung Islands Province, namely: the variables of Average School Length, Government Assistance, Life Expectancy and Land Ownership. A significant variable in all regions of Jambi Province and Bangka Belitung Islands Province is the life expectancy variable, which indicates that the health dimension greatly affects the welfare of the community, especially farmers.

South Sumatra Province, Bengkulu Province and Lampung Province have similarities in the welfare model, namely of the six independent variables, only the per capita expenditure variable does not significantly affect the welfare of farmers' households. This reflects that the per capita expenditure of farmer households is almost the same or homogeneous in one household so that the variable of per capita expenditure is not significant in the district/city area on Sumatra Island B.

Of the 6 independent variables that affect the welfare of farmers in 5 provinces in the Sumatra B region, significant variables that affect the welfare of farmers in the Sumatra B region include: Average length of schooling, Number of Household Members, Government Assistance, Life Expectancy and Land Ownership. Variable Per capita expenditure is not significant in all areas in the province, which is in the Sumatra part B region.

Of the ten provinces on the island of Sumatra, all the Independent variables are significant only in the northern Sumatra Province. For the variable number of household members, it is not significant only in two

provinces, namely Jambi Province and Bangka Belitung Islands Province. In the variables that affect the welfare of farmers based on the results of MPI calculation, it is found that the average value of districts/cities located in five provinces in Sumatra A is higher than that of districts/cities located in Provinces in Sumatra B which indicates that the Sumatra B region is more prosperous based on the dimensions of education, health and living standards.

4.2.4. Farmers' Welfare Based on MPI Calculation Results

Agriculture plays an important role in economic development, food security and welfare. The welfare value is calculated using the Alkire Foster method. Scores are obtained based on the Indicators in the SDGs or Sustainable Development Goals. MPI is used to describe the level of welfare of farmers on the island of Sumatra.

MPI is a measure of poverty that is not only based on income, but also takes into account various indicators of well-being. A high MPI value indicates a more severe level of multidimensional poverty. A low MPI score indicates better or more prosperous conditions. This approach provides a more holistic picture compared to income-based poverty measurement alone.

Areas with high MPI are likely to have a reliance on the traditional agricultural sector, which is vulnerable to climate change and price fluctuations. If you look at the results of the MPI calculation shown in **Table 7** of the development areas of Sumatra A and Sumatra B, the Sumatra B region is more prosperous.

The maximum MPI is in region B and the average MPI is lower, which is 0,0789 and 0,0373. MPI in region A has a higher maximum value of 0,2726 with an average MPI value of 0,0502 in Regency/city.

4.2.5. Independent Variables Affecting Farmers' Welfare

The independent variables in this study are: average length of school (RLS) in years, number of household members (JART) in people, per capita expenditure (PP) in million rupiah, government assistance (BP) in percent, life expectancy (AHH) in years, and land ownership (KL) in percent. The comparison of the six variables in the two regions is shown in **Table 8**.

Table 7. Comparison of Welfare Between Regions.

Variable	Sumatra A				Sumatra B			
	At least	Maximum	Mean	Std dev	At least	Maximum	Mean	Std dev
Welfare	0,000	0,273	0,050	0,047	0,003	0,079	0,037	0,017

Table 8. Comparison of Independent Variable Values Between Regions.

Variable	Sumatra A				Sumatra B			
	At least	Maximum	Mean	Std dev	At least	Maximum	Mean	Std dev
RLS (year)	6,06	11,76	8,73	1,09	6,72	11,72	8,10	0,87
JART (person)	2,82	4,74	3,79	0,32	3,16	4,15	3,53	0,23
PP (million)	0,618	3,066	1,243	0,32	0,837	2,994	1,263	0,42
BP (percent)	12,50	91,18	49,12	20,74	12,50	76,74	38,71	14,70
AHH (year)	69,57	75,55	73,15	1,37	70,81	75,37	73,67	0,85
KL (percent)	20,73	97,02	70,08	16,76	69,67	96,18	86,09	6,27

Source: Susenas Sumatra 2023 data, processed.

Of the 94 districts/cities in the Sumatra A region, the average RLS of heads of households is 8,73. The Sumatra B region consists of 60 districts/cities, and the average RLS of the Head of Household is 8,10 years. In comparison, the average level of education in the Sumatra A region is higher than in the Sumatra B region. For the JART variable, the Sumatra A and B regions have an average number of members in each household of 4 people. This condition can be caused by cultural or social factors. These factors include still holding the tradition of a large family and the need for labor that supports agricultural activities.

When viewed from the value of per capita expenditure, the average value of per capita expenditure in the Sumatra A region is lower than that of the Sumatra B region. For the variable, more government assistance is given to districts/cities in the Sumatra A region with an average of 49,12 percent. This can be caused by the fact that in the region there is a province that has the highest poverty rate, namely Aceh Province. Based on BPS data, the percentage of poor people in Aceh Province was 14,45 percent in March 2023.

Life expectancy (AHH) represents the average age that a population can reach measured in years. When viewed from the average AHH, the Sumatra B region has a higher average value of 73,67 years. Life expectancy in an area reflects the health level as one of the indicators to see the level of well-being.

For the variable land ownership (KL), judging from

the average land ownership figure, the Sumatra B area is larger, which is 86,09 percent. When viewed from the maximum and minimum values, the percentage of regency/city land ownership in the Sumatra B region is more even.

From the six variables, it can be seen that per capita expenditure, life expectancy and land ownership in Sumatra Part B are higher than in Sumatra A. Government assistance variables and average length of schooling are lower in districts/cities in the Sumatra B region. The standard deviation in Sumatra Region A is higher than in Sumatra B. From the data, it can be concluded that farmers in Sumatra B are more prosperous than those in Sumatra A.

Based on the H_0 hypothesis: There is no influence of the independent variable on the local model. Partial parameter testing on the modified GWR model with *Adaptive Bisquare Kernel* weights was carried out using t-test statistics. When the value $|t_{Count}| > |Table|$ then the conclusion of minus H_0 is obtained. Based on the value in the t table, a t value of 1,976 was obtained.

Of the six independent variables in this study, based on the results of data processing, 4 variables were obtained that had an effect in more than 69 districts/cities on the island of Sumatra, namely: average length of schooling, government assistance, life expectancy and land ownership, while the variables of the number of household members and per capita expenditure were significant only in 17 districts/cities and 2 districts/cities on

the island of Sumatra. From the output results of modified GWR processing, it can be seen that the six independent variables significantly affect the welfare of farmers.

The Independent variables that have a significant influence on the farmer welfare model in regions A and B on the island of Sumatra are shown in the following **Table 9**:

Table 9. Number of Significant Variables in 154 Regencies/Cities on the Island of Sumatra.

Variable	Significant Kariables (Kab/Kot)	Percent
Average length of school	99	64,29
Number of Household Members	17	11,04
Per capita expenditure	2	1,30
Government Assistance	69	44,81
Life Expectancy Figures	136	88,31
Land Ownership	113	73,38

4.2.6. The Effect of RLS on Farmers' Welfare

Based on the output of the Modified GWR model, in **Table 9**, the RLS variable shows a significant influence on the welfare of farmers in 99 districts/cities on the island of Sumatra, by 64,29%. The results of the study showed that 52 percent of the heads of households in farming households on the island of Sumatra were poorly educated (< high school), and only 27 percent of the heads of households in farming households on the island of Sumatra were highly educated (> high school). The head of the household is a very influential figure in decision-making in a family so education will influence the mindset in decision-making. Higher education can also improve the quality of human resources for the better so that it can increase productivity. Increasing productivity can increase income so that it can improve welfare. The level of education has a significant effect on well-being^[32]. Education has an influence on the level of farmers' welfare^[33]. Better education allows for higher incomes, which will affect well-being^[34]. Education levels have a positive influence on people's welfare^[35].

Farmers with higher levels of education are better able to understand and adopt modern farming techniques which allow farmers to access better information. Information related to agricultural techniques, market opportunities, and government policies, can ultimately improve crop yields and farmers' welfare. Education of the head of household is the dominant factor influencing the choice of strategy^[36].

Overall, the Average School Length (RLS) has a significant influence on the welfare of farmers through various mechanisms, both economic and social. Higher ed-

ucation improves farmers' ability to access agricultural technology, understand market and policy information, and manage finances and resources. In addition, better education also has an impact on improving the health and quality of life of farmer families, as well as opening up better educational opportunities for future generations. All of these factors contribute to the overall improvement of farmers' welfare.

4.2.7. The Influence of JART on Farmers' Welfare

The results of the Modified GWR showed that there was a significant influence of the variable number of household members on the welfare of farmers in 17 districts/cities on the island of Sumatra (11,04%). Data shows that the average number of farmer household members on the island of Sumatra is 4 people and tends to be homogeneous in the district/city area on the island of Sumatra. The number of family members can act as a driver as well as an obstacle to development^[37]. As a driver, this can increase the number of workers and expand the market for goods and services. However, on the other hand, population growth can also be an obstacle to development because it can reduce productivity and increase the unemployment rate.

Households with a larger number of children tend to be less prosperous because a certain level of income has to be used to support more household members. A greater number of household members can lead to greater economic needs and a higher burden on households, potentially lowering well-being. The number of household members is a factor that affects the strategy chosen^[38]. Other factors such as education, health, land ownership,

access to markets, access to financing, or local socio-economic conditions are more dominant than the number of household members in influencing farmers' welfare.

4.2.8. The Effect of Per Capita Expenditure on Farmers' Welfare

The per capita expenditure variable shows a significant influence on the welfare of farmers in only 2 districts/cities on the island of Sumatra, namely Nias and South Nias. Data shows that the average per capita expenditure of farmer households on the island of Sumatra in 2023 is one million two hundred thousand rupiah. This value varies in each household with a per capita expenditure of at least six hundred and eighteen thousand rupiah and a maximum of three million rupiah.

Although low per capita expenditure often indicates economic constraints, its impact on farmers' well-being is felt only in a small part of the region. Only 1,30% of the total area on the island of Sumatra shows a strong relationship between per capita expenditure and farmers' welfare.

In many agricultural areas on the island of Sumatra, farmers often rely on subsistence farming (producing their own basic necessities). Therefore, low per capita expenditure does not mean that they cannot meet basic needs or live in poverty, as most of their needs can be met through their own agricultural output. Subsistence farming can reduce dependence on per capita expenditure, as farmers can obtain most of their basic needs from agricultural produce^[39].

In some areas with low per capita expenditure conditions, farmers may generate high income from the agricultural sector thanks to fertile land conditions, abundant yields, or good market prices. In this case, their expenses may be lower because they only spend a small portion of their income on basic needs. If farming businesses can survive in the long term with stable incomes, low household spending may not have an impact on well-being, as income from farming is sufficient for their needs. In areas with high agricultural yields and favorable market prices, household spending can be lower without affecting farmers' welfare levels^[40].

In some areas on the island of Sumatra, social and cultural structures can reduce the impact of low per capita expenditure. For example, in some rural com-

munities, extended families and mutual cooperation in the agricultural sector can support the economic sustainability of households despite their limited expenditure. Farmers in communities that have strong, mutually supportive social networks may not experience a decline in well-being even though their expenditures are low, as they help each other in meeting needs. In many rural communities, co-working or social cooperation can reduce the negative impact of low spending and improve collective well-being. Household income is a general measure of household welfare^[41]. Poverty alleviation can be done by increasing economic output to increase per capita income^[42]. Per capita expenditure can also measure the social welfare of a region^[43].

4.2.9. The Influence of Government Assistance Variables on Farmers' Welfare

The variable of government assistance has a significant effect on welfare in 69 out of 154 districts/cities on the island of Sumatra (44,81%). This shows that in almost half of the areas studied, government assistance has a clear impact on farmers' welfare. Based on data, government assistance is more provided in the Sumatra A region with an average of 49,12 percent of 94 districts/cities indicating that this region is a priority.

The PKH program is effective in reducing poverty^[44]. The PKH program is designed to reduce the burden of expenditure on poor families and improve the standard of living of beneficiary families through access to education, health and social welfare services. Government assistance can help increase household income and consumption, as well as reduce poverty rates^[45].

Several factors may explain why government assistance shows limited effectiveness in most studied regions. The first cause of government aid may not be evenly or effectively distributed in certain regions. There may be limited access or a lack of knowledge about existing assistance programs. Farmers in more remote or underdeveloped areas do not have sufficient access to take advantage of the assistance. One of the challenges in the distribution of government aid is often abuse or inaccuracy in the determination of aid recipients, which leads to inequality in its distribution.

In March 2025, the Government through the Ministry of Social Affairs and Social Services in Regen-

cies/Cities is carrying out ground checks of Aid Recipients to update the DTSEN database throughout Indonesia. This aims to reach people in need and reduce *inclusion errors*, namely removing people from the list of aid recipients because they do not meet the criteria as households receiving assistance.

Access to good markets, more advanced infrastructure, or access to more advanced agricultural technologies can further improve farmers' well-being compared to direct assistance. In areas with strong market infrastructure, farmers have an easier time accessing information and selling their produce, which has a direct impact on their income and well-being without relying on government assistance. The Family Hope Program (PKH) has a negative effect on poverty and has a positive impact on welfare^[46]. Aid can make a positive contribution to poverty reduction and its impact is greater in countries with lower human development indicators^[47]. Regions that do not feel the significant impact of government assistance may face risks that cannot be fully resolved with government assistance alone. For example, natural disasters or a decrease in the price of agricultural commodities can have a greater effect on the welfare of farmers than the assistance provided.

Therefore, it is important to design aid programs that are more targeted, sustainable, and reach the areas that really need them in order to have a broader positive impact. Larger, more targeted assistance programs can have a significant impact on farmers' well-being, especially in areas with higher levels of vulnerability.

4.2.10. The Effect of Life Expectancy Variables on Farmers' Welfare

The variable life expectancy has a significant effect in 136 districts/cities on the island of Sumatra (88,31%). This means that more than 80% of regions show that better health can affect farmers' well-being, but the effect is not true in all regions. Life expectancy figures show health conditions that affect the ability to work and productivity at work. Life expectancy is one of the indicators in the health dimension. Higher life expectancy figures reflect better health levels, which allow farmers to work more productively and have a better quality of life, which ultimately improves their well-being. Life expectancy in Latin American and Caribbean countries has

contributed to improved welfare^[48]. Increasing life expectancy has a positive effect on welfare^[49-51].

A higher Life Expectancy (AHH) does have a significant effect on the welfare of farmers, especially in increasing work productivity, reducing the burden of health costs, and improving the overall quality of life. Better health allows farmers to work more productively, reduce medical costs, and better manage economic risks. Socially, better health improves the social mobility, access to education, and social resilience of farming families. However, this impact does not always apply in all regions, especially if there are other external factors that are more dominant in influencing the welfare of farmers.

4.2.11. The Influence of Land Ownership Variables on Farmers' Welfare

The land ownership variable has a significant effect in 113 districts/cities or 73,38 percent of the area on the island of Sumatra. This shows that land ownership has a strong impact on the welfare of farmers. The results of the study show that not all farmer households on the island of Sumatra have their own land. Access to wider land and security of land tenure can significantly improve farmers' productivity and welfare^[52]. Extensive land ownership also provides farmers with economic stability and reduces their vulnerability to changes in prices or market conditions. Farmers who have more land can make more optimal use of natural resources and reduce dependence on other sectors. Farmers who own more land tend to have greater economic advantages and social resilience than farmers with limited land. Policymakers should focus on improving access to land, which is critical to improving well-being^[53-55].

4.3. Strategic Implications

The welfare of the community, especially farmers, is a goal that the Government wants to achieve and has been the focus of research to date, because the majority of the Indonesian population works in the agricultural sector. Welfare is part of the sustainable development goals (SDGs) of the social, economic and environmental pillars, including: SDGs goal 2 to improve community welfare, goal 3 to increase food sovereignty, goal 4 to implement the smart Indonesia and healthy Indonesia pro-

gram, goal 6 water security, goal 7 energy sovereignty and goal 11 to build housing and residential areas.

Based on the results of the research, RLS has an effect on the welfare of farmers in 64,29 percent of areas on the island of Sumatra. This implies that RLS has not affected the welfare of farmers in all regions on the island of Sumatra. Based on the results of the processing, it can be seen that most of the education of heads of households in the agricultural sector on the island of Sumatra is still below high school, so it is hoped that the local government can provide educational facilities and easy access to education for the community, especially in rural areas where most of the population is engaged in the agricultural sector. Various policy programs such as free education, scholarship programs, foster parent programs and others. This is also done to increase the average number of school years which can increase the human development index that reflects the welfare of the community.

The results of the study also show that the number of household members has a significant effect in 11,04 percent of regencies/cities on the island of Sumatra. This result implies that the variable number of household members only has a significant effect in a small number of districts/cities in Sumatra because the data tends to be homogeneous. The role of driving cadres at the village level is still needed in various programs to improve family welfare, including through the Family Welfare Driver (PKK) and Posyandu programs. Various priority programs that include improving health services, providing nutritious food, and family economic empowerment can be implemented through this activity.

Based on the results of the study, per capita expenditure has a significant effect in 1,30 percent of districts/cities on the island of Sumatra. This result implies that the per capita expenditure of the population with business fields in the agricultural sector tends to be homogeneous, so the role of the government is needed to increase people's income, especially in the agricultural sector. Various policy programs such as: assistance of agricultural extension workers to continuously improve knowledge and skills in the agricultural sector regarding agricultural technology and innovation, such as agricultural tools, efficient irrigation systems and superior crop varieties. The current challenges are limited access

to technology in remote areas and the need for ongoing training for farmers in Indonesia, especially on the island of Sumatra. The development of adequate infrastructure such as roads, irrigation, and storage facilities can reduce production costs, facilitate the distribution of agricultural products and reduce farmers' losses after harvest. The current government's challenge is related to the maintenance of existing infrastructure and planning for the development of agricultural infrastructure for areas that have limited infrastructure at this time. In addition, the government's role is needed in terms of access to credit for farmers and the marketing of agricultural products so that an increase in farmers' income can be achieved. The government can launch various programs to provide access to affordable financing for farmers such as the People's Business Credit (KUR) and other agricultural financing programs. The government can also set up agricultural microfinance institutions to provide small credit on more accessible terms.

The results of the study showed that the variable of government assistance had a significant effect in 44,81 percent of districts/cities on the island of Sumatra. This reflects that the program has been felt and has an effect on the welfare of farmers in several areas on the island of Sumatra. The empowerment of the Family Hope Program (PKH) needs to be improved in terms of monitoring and evaluating the implementation of the program so that it can be more effective. PKH assistance personnel can monitor the use of assistance according to the purpose and can evaluate the accuracy of the target of program recipients. In March 2025, PKH Assistance Officers have been trained to update the database of program recipients. Supervision from the government and the community is needed regarding the database of aid recipients which is integrated into one DTSEN database managed by the Ministry of Social Affairs and the Social Service in the local government. Supervision is needed to ensure that government assistance is given to households that are entitled to receive it according to the criteria set by the government.

Based on the results of the study, the Life Expectancy Rate has a significant effect on the welfare of farmers in 88,30 percent of areas on the island of Sumatra. This reflects that the Life Expectancy variable has

a significant effect in almost all districts/cities on the island of Sumatra. Life expectancy is a reflection of the health dimension. Health facilities and access to health services are important factors in increasing life expectancy. Various programs in the health sector are needed by the community such as free health facility services, provision and access to adequate health facility infrastructure, especially in rural areas. The provision of access to health facilities for the community carried out by the current government needs to continue to be improved so that it will increase the human development index which will ultimately improve welfare.

Based on the results of the study, the variable of land ownership has a significant effect on the welfare of farmers in 73,38 percent of districts/cities on the island of Sumatra. This implies that the variable land ownership has a significant effect in most districts/cities on the island of Sumatra. Farmers who have their own land tend to be more prosperous than farmers who do not have their own land. For this reason, the role of the government is needed in facilitating the land ownership process for farmers, especially in rural areas. Land ownership can be obtained through access to credit provided by the government through financial institutions in rural areas, most of which are engaged in the agricultural sector. The ease of administrative management related to agricultural land owned by the community is also needed by the community through government programs that support the improvement of farmers' welfare.

5. Conclusions and Suggestions

The conclusions obtained from this study are:

- 1). The welfare of farmers can be seen from the MPI value produced based on the Education Dimension, Health Dimension, and Standard of Living Dimension. The MPI value of Regencies/Cities on the island of Sumatra is in the range of 0 to 0,33 which is at a low criterion which reflects the level of welfare of farmers on the island of Sumatra.
- 2). The variables of average length of schooling, number of household members, per capita expenditure, government assistance, life expectancy, and land ownership together affect the welfare of

farmers on the island of Sumatra in 2023. In the equation model, commodity price and IKG weighers can be used to address the problem of heteroscedasticity, this can be seen from the *larger adjusted R square* GWR model compared to the multiple linear regression model. The adjusted R-square value is 0,47 which means that the six Independent Variables affect the Welfare variable by 47 percent, the remaining 53 percent is influenced by other variables. Of the 6 independent variables that affect the welfare of farmers, North Sumatra Province is the only province with all six independent variables that significantly affect welfare. Meanwhile, the six independent variables did not significantly affect the welfare variables of farmers in two districts/cities, namely Gunung Sitoli City and West Lampung Regency.

- 3). Welfare is part of the sustainable development goals (SDGs) of social, economic and environmental pillars, from the results of the research, it is hoped that the Government can provide educational facilities and ease of access to education for the community, health facilities, and increase income with various programs such as free education, scholarships, foster parents, Improvement of free health facilities, provision and access to adequate health facility infrastructure, provision of nutritious food, as well as family economic empowerment, increasing knowledge and skills in the agricultural sector related to agricultural technology and innovation, such as agricultural tools, efficient irrigation systems and superior crop varieties. Programs developing adequate infrastructure such as roads, irrigation and storage facilities can reduce production costs, streamline the distribution of agricultural products and reduce farmers' losses after harvest. In addition, the government's role is needed in terms of access to credit for farmers and the marketing of agricultural products such as People's Business Credit (KUR) and other agricultural financing programs through agricultural microfinance institutions. As well as a program to increase farmer productivity to help farmers who have limited agricultural land

that they are currently cultivating.

Author Contributions

Conceptualization, I.I., K.S., Methodology, I.I., K.S., Software, I.I., validation, I.I., K.S., R.A.E., P.N., formal analysis, I.I., K.S., R.A.E., P.N., Investigation, I.I., K.S., resources, I.I., data curation, I.I., writing-original draft preparation, I.I., K.S., writing-review and editing, I.I., K.S., R.A.E., P.N., visualization, I.I., K.S., R.A.E., P.N., Supervision, K.S., Project administration, I.I., K.S., funding acquisition, I.I. All authors have read and agreed to the published version of the manuscript.

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Data used in this study are available from the corresponding author at reasonable request. The data micro Susenas can be assessed at Available online: <https://silastik.bps.go.id/v3/index.php/site/login/> (accessed on 2024)

Conflicts of Interest

The authors declare no conflict of interest.

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