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SPATIAL AUTOCORRELATION OF FOOD SECURITY OF PAPUA ISLAND DISTRICTS & CITIES 2023

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Abstract.

This research analyzes the relationship between global and regional food security on Papua Island in 2023. This type of research is quantitative causality research. The data used is the 2023 Regency/City food security index data on Papua Island and SHP data for Papua Island with Regency/City administrative areas. This type of research data is secondary data obtained from BPS for each province on Papua Island. The total population and sample are 42 districts/cities, and the sampling technique is a census. The analysis tools used are Moran's I and LISA, which use GeoDa software. The Moran's I test result of 0.150 indicates positive spatial autocorrelation. This means the food security index tends to be clustered or collected geographically. LISA (Local Indicators of Spatial Association) analysis for the Food Security Index, there are eight regencies/cities that have significant values between 0.01 to 0.05, namely Tolikara Regency, Jayapura City, Puncak Regency, Puncak Jaya Regency, Mimika Regency, Lanny Jaya, Jayawijaya Regency, and Keerom Regency. This significant value indicates a meaningful spatial correlation, where the food security condition in these areas is related to the surrounding area.

Keywords: Food Security Index, Papua Island, Moran's I, LISA

INTRODUCTION

According to the definition of the Food and Agriculture Organization (FAO) of the United Nations (UN), food security consists of four main dimensions, namely availability, accessibility, usability, and sustainability or stability. Food availability is the availability of sufficient quantities to meet the population's needs in an area. At the same time, accessibility refers to the ability of individuals or communities to access food without facing excessive physical or economic obstacles (CFS, 2014). Thus, food security is not only related to adequate food availability but also involves accessibility at the regional level, people's purchasing power, food quality, political and socio-economic stability, and various other factors (Xie et al., 2021).

Food is a basic need that is important for human survival. Therefore, every individual has the right to obtain sufficient food whenever needed Rumawas et al., (2021). This topic is of concern at both international and national levels.

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Globally, this is stated in **the Sustainable Development Goals** (SDGs), especially the second goal, namely "**zero hunger**," which focuses on eliminating hunger through food security, improving nutrition, and sustainable agriculture (Fadila. M.A & Putri, 2023). Especially since the COVID-19 pandemic, food production has experienced a significant impact, which has encouraged global awareness of the importance of maintaining food security (Gebeyehu et al., 2023). As productivity and living standards increase, understanding of the concept and dimensions of food security is increasingly developing and deepening, reflecting the characteristics and challenges of the contemporary era.

At the national level, the 2020-2024 National Medium Term Development Plan (RPJMN) targets increasing food security and the competitiveness of the agricultural sector to create a more advanced, independent, and modern agriculture in Indonesia (Ministry of Agriculture, 2022). Indonesia, even though it is known as an agricultural country with abundant natural resources, still faces difficulties in ensuring accessible and affordable access to food for its people. Instead of being self-sufficient, in the last few decades, Indonesia has become one of the leading importers of food commodities such as rice, sugar, soybeans, and wheat (Salasa, 2021). This reflects the gap between domestic production potential and national food needs and emphasizes the importance of improving agricultural and distribution policies to achieve sustainable food security.

The 2023 Food Security Index (IKP) calculation results show the district/city food security ranking based on nine indicators for districts and eight for cities. These regions are grouped into six categories: group 1 shows the highest food vulnerability, and group 6 has the best food security. Of the 416 districts, 67 districts (16.11%) have low IKP scores, including 21 districts in Priority 1 (very vulnerable), most of which are in Papua and West Papua. Of the 98 cities, only Subulussalam City in Aceh Province is in Priority 2. The five districts with the highest IKP scores are Gianyar and Badung in Bali, Sukoharjo in Central Java, Tabanan in Bali, and Gresik in East Java. In contrast, the five districts with the lowest scores are all in Papua: Intan Jaya, Nduga, Central Mamberamo, Puncak, and Paniai (National Food Agency, 2023).

Papua Island, which consists of two central provinces, namely Papua and West Papua, has unique challenges in terms of food security. Even though this region is rich in natural resources, difficult geographical conditions, limited infrastructure, and low accessibility are significant obstacles to equitable food distribution. Most of Papua is a mountainous area with steep terrain, making it difficult to transport food and creating dependence on air routes or sea transportation, which are often unstable. The fertile geographical conditions of

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West Papua support the growth of agriculture, especially food crops, which can meet the needs of the community. However, geographical differences between districts, such as highlands, lowlands, coasts, and islands, cause variations in agricultural commodities. This has an impact on the food availability and consumption patterns of different communities in each region (Widati, 2016).

In addition, relatively high levels of poverty and economic instability in several regions are increasingly worsening people's purchasing power (Amanda & Fathoni, 2023). This makes food access, both in terms of availability and affordability, a critical issue. The low Food Security Index (IKP) in several districts in Papua, especially in remote areas such as Intan Jaya, Nduga, and Puncak, reflects the high level of food vulnerability in these areas (National Food Agency, 2023). On the other hand, food security in the Papua Islands is not only influenced by physical and economic factors but also by socio-political conditions, which are sometimes volatile, affecting the stability of food distribution. The central and regional governments have made efforts to increase food security through various agricultural and infrastructure development programs. However, existing challenges still require further attention, especially in ensuring continued equitable access to food for all Papuan people.

The findings of Nurhasan et al. (2021) show that in Papua, food supply is highly dependent on certain provinces. When a province experiences crop failure, the impact will be felt on food supplies for other provinces, potentially disrupting overall food security. This becomes more critical for districts and cities with low levels of food production, as they are more vulnerable to food crises due to high dependence on suppliers from other provinces.

Overall, the food security situation on Papua Island illustrates the significant imbalance between the potential of abundant natural resources and the community's ability to utilize and access them, demanding comprehensive and sustainable solutions. Spatial autocorrelation analysis of the food security index on Papua Island is very important to understand distribution patterns and interrelationships between regions, as well as identifying factors that influence food security in more depth so that it can support the formulation of more effective and data-based policies to improve food security in that region..

LITERATURE REVIEW

Food security

Law no. 18 of 2012 concerning food in article one defines food security as "*conditions for the fulfillment of food for the state and individuals, which is reflected in the availability of food that is sufficient in quantity and quality, safe,*

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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. Sustainable". Food security is a condition where food is met, from the country to the individual level, characterized by the availability of sufficient food in terms of quantity and quality. The food must be safe, diverse, nutritious, equitable, affordable, and by the community's religion, beliefs, and culture. Food security aims to enable people to sustainably live healthy, active, and productive lives. Food and nutrition security development is carried out systemically by involving various cross-sectors (National Food Agency, 2023).
The food security index indicators used in Indonesia are:

1. The ratio of normative consumption per capita to net production.
2. The percentage of the population living below the poverty line.
3. The percentage of households with a proportion of expenditure on food is more than 65 percent of total expenditure.
4. Percentage of households without access to electricity.
5. The average length of school for women is over 15 years.
6. Percentage of households without access to clean water.
7. The ratio of population per health worker to population density level.

And 8) the percentage of children with height below standard (*stunting)* (National Food Agency, 2023). Efforts to evaluate food and nutrition security continue to be carried out by developing various indices, such as the FAO Index, Global Hunger Index (GHI), Global Food Security Index (GFSI), Food Security and Vulnerability Atlas (FSVA), Rice Bowl Index, and Hunger and Nutrition Security Index (HANCI). Each of these indices has different characteristics. The FAO Index and GHI are used to measure the level of world hunger, FSVA maps food insecurity in Indonesia at a rural scale, GFSI measures general food and nutrition security, while HANCI assesses each country's commitment to food and nutrition issues (Dedy Sutrisno, 2022).

Spatial Association Theory

Spatial association refers to the extent to which the value or pattern of a variable is related to the spatial distribution of other variables (Haining, 2003). This analysis measures the extent to which the same or different values of two variables tend to appear together or separately in geographic space. Spatial association analysis is an essential tool in geographic research and helps to understand the relationships and patterns between different phenomena across space (Goodchild & Janelle, 2004). There are several methods and measures used to assess spatial association, including:

1. Spatial Autocorrelation: This method measures the similarity of values between adjacent locations. This shows whether similar values tend to

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cluster together (positive spatial autocorrelation) or whether different values are close to each other (negative spatial autocorrelation). Standard measures of spatial autocorrelation include Moran's I and Geary's C (Li et al., 2012).

2. Spatial Cross-Correlation: This correlation examines the relationship between two variables at each location. This method measures how one variable's value is related to other variables' value throughout space (Chen, 2015). Methods such as spatial regression, geographically weighted regression (GWR), and spatial econometrics are commonly used for spatial cross-correlation analysis.
3. Cluster analysis identifies spatial clusters or groupings of similar values or patterns. It helps identify areas with high or low values of variables and assess their statistical significance. Methods such as k-means clustering, hierarchical clustering, and spatial scanning statistics are commonly used for cluster analysis (Sinharay, 2010).
4. Hotspot Analysis: This analysis identifies areas with statistically significant high or low values of a variable (Ord & Getis, 2010). It helps identify spatial groups with high or low values and determine whether the observed patterns are statistically significant. Hotspot analysis methods include Getis-Ord Gi and Anselin Local Moran's I.

Hotspot And Coldspot

Draft hotspot And coldspot relates to spatial autocorrelation, which measures the degree of similarity or dissimilarity between neighboring locations in terms of certain attributes or phenomena (Link et al., 2013). Hotspot And coldspothelps identify areas of high and low value, and provides insight into spatial patterns and clustering.

A hotspot refers to an area where the value of a particular variable is significantly higher or lower than the average value in the surrounding area. Hotspots represent spatial groups with a high value or concentration of certain phenomena. Hot spots can indicate areas of intense activity, high risk, or strong positive spatial autocorrelation. Identifying hotspots can be useful in areas such as public health, crime analysis, and environmental studies to target interventions, allocate resources, or understand underlying processes.

Coldspot Cold spots, on the other hand, refer to areas where the value of a particular variable is significantly lower than the average value in the surrounding area. These points represent spatial groups of low value or areas with a lack or absence of certain phenomena. Cold spots can indicate areas of low activity, low risk, or strong negative spatial autocorrelation. Identifying cold spots can be useful in understanding areas of particular challenge, underperforming areas, or areas where intervention may be needed.

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There are several methods available for the identification of hotspots and coldspots in spatial autocorrelation analysis. Some commonly used approaches include:

1. Getis-Ord Gi* statistic: This measure identifies statistically significant hot spots and cold spots by evaluating the spatial clustering of high or low attribute values. This statistic calculates a z-score for each location, which indicates the degree of clustering relative to the surrounding area (Getis & Ord, 1992).
2. Moran's I statistic: This measure evaluates the global spatial autocorrelation of attribute values. This statistic assesses whether similar or different values cluster across the study area, indicating the presence of hot spots or cold spots (Getis & Ord, 1992).
3. Local Indicators of Spatial Association (LISA): LISA statistics, such as Local Moran's I, provide information regarding the significance and location of hot spots and cold spots at the local level. This method assesses whether a particular location is surrounded by the same or different values, identifying spatial groups with high or low values (Ord & Getis, 2010).

These methods help quantify the degree of spatial autocorrelation and identify areas with significant clustering patterns. These methods provide valuable insights into spatial patterns, enabling targeted interventions, resource allocation, and informed decision-making.

METHODS

This quantitative research, using a causality approach, aims to analyze the influence of various factors on food security in the Papua region. The data used in this research includes the food security index for 42 Regencies/Cities on Papua Island in 2023 and SHP (Shapefile) data for the Regency/City administrative areas, which will be used in spatial analysis. The data type used is secondary data obtained from the Central Statistics Agency (BPS) in each province on Papua Island, thus providing accurate and relevant information to support this research. The population and sample in this research are all regencies/cities on Papua Island, with 42 units. The sampling technique uses the census method, which involves the entire population in the analysis.

Data analysis was done using a spatial approach to see geographical food security patterns, using Moran's I method and Local Indicators of Spatial Association (LISA). Moran's I is used to identify whether or not there is a global spatial correlation, namely whether food security in one region is correlated with food security in neighboring areas. Meanwhile, LISA is used to detect local spatial patterns, namely to see areas with a high or low concentration of food security. These two techniques were analyzed using GeoDa software.

RESULTS AND DISCUSSION

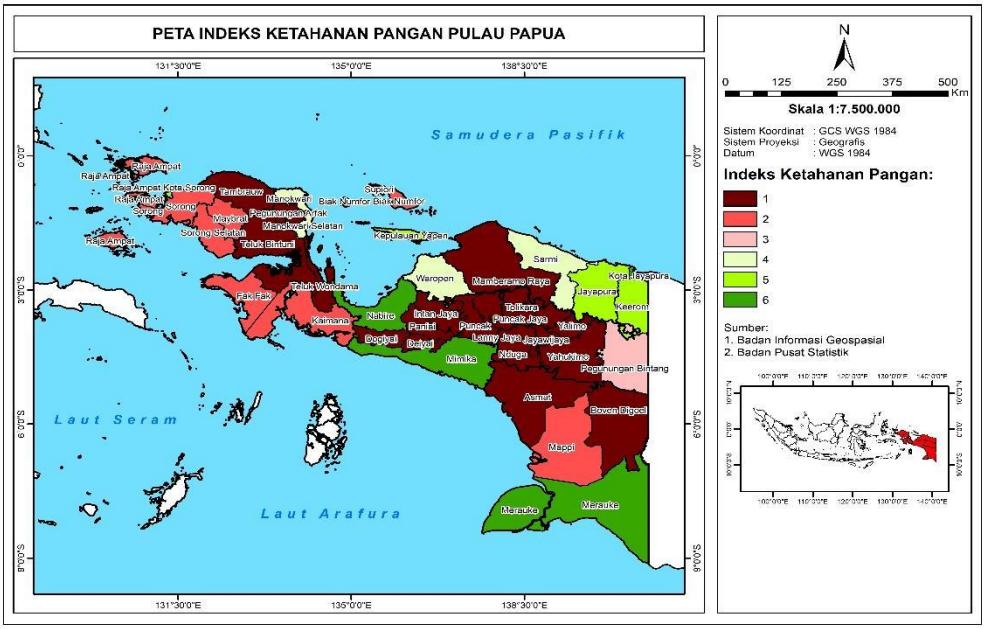

Figure 1. Food Security Index Map for Papua Island in 2023

Figure 1 displays the Food Security Index Map for Papua Island in 2023, which illustrates the condition of food security in various districts/cities in the region. On this map, districts/cities marked in dark color or denoted by the number 1 indicate areas with a very vulnerable level of food security. This means that districts/cities that fall into this category face severe challenges in meeting the food needs of their population, both in terms of availability, access, and food stability.

Districts/cities categorized as very vulnerable to food security on Papua Island include Jayawijaya, Paniai, Puncak Jaya, Boven Digoel, Asmat, Yahukimo, Tolikara, Supiori, Mamberamo Raya, Nduga, Lanny Jaya, Central Mamberamo, Yalimo, Puncak. , Dogiyai, Intan Jaya, Deiyai, Wondama Bay, Bintuni Bay, Tambrauw, Arfak Mountains, as well as several other areas such as Penial, Deiyai, Dogiyai, and Jayawijaya. These areas experience very high food insecurity and need special attention from the government and related parties to increase food security through various programs and interventions.

Factors contributing to food insecurity in this region can vary, ranging from geographical conditions that are difficult to reach and limited infrastructure to dependence on limited local food sources. According to (Purwaningsih, 2014), the topography is hills/mountains, with an uncertain climate making Papua Island more vulnerable to poor food security. Most farmers in Papua carry out

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agricultural activities to meet the family's food needs, with only a tiny amount of the produce sold for other purposes (Widati, 2016). This has an impact on food security, especially in areas that are categorized as very vulnerable. Reliance on subsistence farming makes the area vulnerable to food shortages, especially if production is disrupted. Commodities such as rice, sweet potatoes, cassava, corn, sago, nuts, and vegetables, as well as livestock and fish products, although abundant, are not enough to overcome food vulnerability in districts/cities on Papua Island. There are various root causes of chronic food and nutrition insecurity at the regional and household levels. In Jayawijaya Regency, this problem is exacerbated by the lack of commitment from the local government to improving community welfare. Apart from that, the low purchasing power of the people, which is caused by limited employment opportunities in both the agricultural and non-agricultural sectors, is also a factor that worsens the situation (Central Java Government, 2023).

Analisis Moran's I

Moran's I analysis is a statistical method used to measure the level of spatial autocorrelation in data. Spatial autocorrelation is a concept that describes how similar or related data values are in geographically close locations. Moran's I is a statistical measure that ranges from -1 to +1. Values close to +1 indicate positive autocorrelation, where similar values tend to be close together. Values close to -1 indicate negative autocorrelation, where different values tend to be close together. Values close to 0 indicate a random pattern or absence of autocorrelation.

Moran's I provide an index that reflects the extent to which spatial patterns are present in the data. This index ranges from -1 to 1, with the following interpretation:

1. **Moran's I Positive (can range from 0 to 1)**

   This index shows that there is a positive spatial pattern or a collection of high values tends to be close to high values, while low values tend to be close to low values. Values close to 1 indicate the presence of strong positive autocorrelation.

2. **Negative Moran's I (can range from -1 to 0)**

   This index shows that there is a negative spatial pattern or groups of high values tend to be close to low values, and vice versa. Values close to -1 indicate the presence of strong negative autocorrelation.

3. **Moran's I ≈ 0**

   An index close to zero indicates that spatial patterns in the data are random or not spatially significant. The following are the results of the Morans'I analysis: the following are the results of the Moran's I test

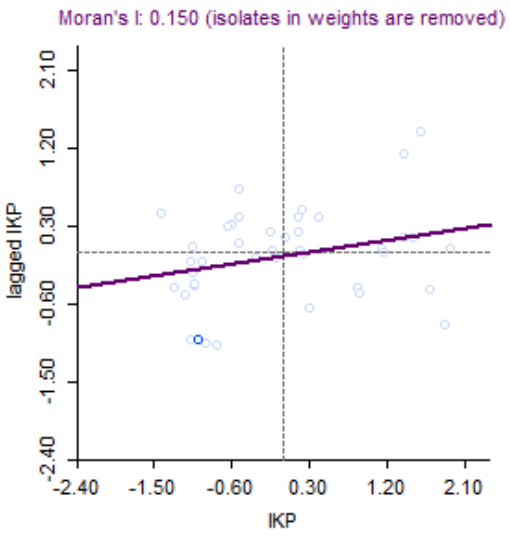

Figure 2. Moran's I Food Security Index Test Results for Papua Island Regencies and Cities 2023

A Moran's I value of 0.150 indicates positive spatial autocorrelation. This means that the food security index tends to be clustered or collected geographically. Areas with similar levels of food security tend to be close to each other on Papua Island. A positive Moran's I value, in this case, 0.150, indicates that there is a tendency for similar values in the data to cluster together at close locations. This means that there are patterns or clusterings in the data that are not completely random.

Figure 2. is the Morans'I Scatter Plot. Morans'I Scatter Plot is used to identify similarities and anomalies in food security index data across districts and cities on Papua Island. Based on the results of this mapping, the data is divided into four main categories, namely Quadrant I (*High-High*), Quadrant II (*High-Low*), Quadrant III (*Low-Low*), and Quadrant IV (*Low-High*). Quadrant I includes districts and cities with high levels of food security that are located around other districts and cities with also high levels of resilience index. Quadrant II depicts districts and cities with high levels of food security, which are surrounded by districts and cities with low food security index levels. Quadrant III consists of districts with low levels of food security that are close to other districts that also have low levels of food security. Finally, Quadrant IV marks districts with low levels of food security that are surrounded by districts with high levels of food security.

Quadrant I (*High-High*) consists of the districts of Fak Fak, Jaya Pura, Kaimana, Keerom, Jayapura City, Sorong City, Manokwari, South Manokwari, Merauke, Mount Bintang, Sorong, Sorong Sekat. Quadrant II (*High-Low*) consists of Biak Numfor, South Manokwari, Mimika, Nabire, Sarmi, and

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Waropen districts. Quadrant III (*Low-Low*) consists of the districts of Asmat, Jayawijaya, Lanny Jaya, Mamberamo Raya, Mamberomo Tengah, Maybrat, Nduga, Paniai, Puncak, Pucak Jaya, Teluk Bintuni, Tolikara, Yahukimo, and Yalimo. Quadrant IV (*Low-High*) consists of the districts of Boven Digoel, Deiyai, Dogiyai, Intan Jaya, Mount Arfak, Raja Ampat, Supiori, Tambrauw, Teluk Bintuni, Teluk Wondama.

Analisis Local Indicators Of Spatial Association (LISA)

LISA (Local Indicators of Spatial Association) analysis is a statistical method used to identify spatial correlation patterns in geographic data. On this map, the spatial correlation for the 2022 food security index in a region is illustrated. The following is an explanation for LISA analysis based on the elements contained in the map:

1. Green Color with Various Levels of Brightness: Represents areas that have food security indices with different statistical significance. Darker colors indicate higher significance.
    a. Dark Green (p = 0.001): Areas in dark green (1 area) have a highly statistically significant spatial correlation. This means that there is strong evidence that the food security index in these areas does not occur randomly but is related to the food security index in the surrounding areas.
    b. Medium Green (p = 0.01): Areas in medium green (4 regions) also show significant spatial correlation but with a slightly lower level of confidence compared to p = 0.001.
    c. Light Green (p = 0.05): Areas in light green (3 areas) indicate that there is statistical significance in the spatial correlation, but the level of confidence is even lower.
2. Gray Color (Not Significant): Areas that are not colored or colored gray (33 areas) do not show statistical significance in terms of spatially related food security index. This means there is not enough evidence to state that the food security index in this area is correlated with the food security index in the surrounding area.

The following are the results of the LISA analysis regarding the food security index in the region.

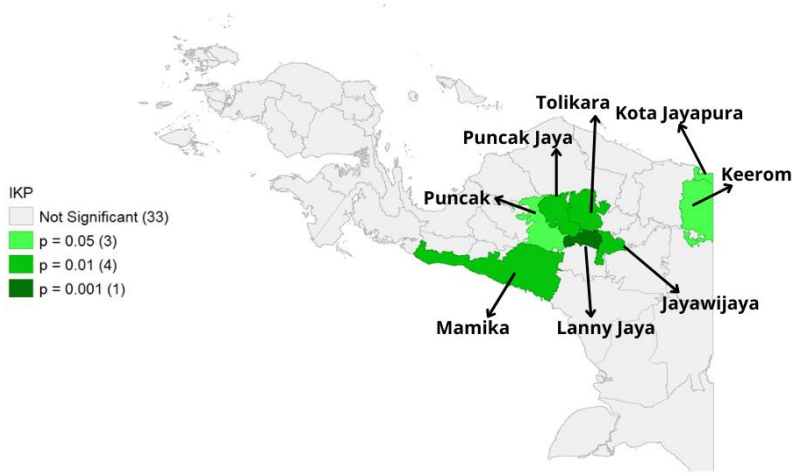

Figure 3. LISA Test Results for the Food Security Index for Districts and Cities of Papua Island 2023

Based on the results of the LISA (Local Indicators of Spatial Association) analysis for the Food Security Index, there are eight regencies/cities that have significant values between 0.01 to 0.05, namely Tolikara Regency, Jayapura City, Puncak Regency, Puncak Jaya Regency, Mimika Regency, Lanny Jaya Regency, Jayawijaya Regency, and Keerom Regency. This significant value indicates the existence of a meaningful spatial correlation, where the condition of food security in these areas is related to the surrounding area. This indicates that food security in this district/city does not occur randomly but is influenced by geographical, social, and economic factors that are interconnected with the surrounding areas. Mountain districts such as Lanny Jaya, Tolikara, Pucak, and Puncak Jaya, for example, often face infrastructure and accessibility challenges that affect food distribution and availability, while urban areas such as Jayapura City may face pressure on food resources due to high population. Dependence between regions in food distribution or limited infrastructure also influences this pattern, where food security problems in one region can have an impact on neighboring regions.

According to Nugraha & Wibowo (2023), the deforestation of natural forests has resulted in the reduction of two of the Papuan people's life sources. Research on the role of forests in supporting food security reveals that forests provide wild plant food sources, including fruit, mushrooms, leaves, and tubers. In addition, forests are also a habitat for insects that can be consumed, wild animals that are hunted for their meat, and fish in tropical regions, all of which have an important role in maintaining food security (Rowland et al., 2017).

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Forests support food security by providing food sources such as wild plants and game products. Agroforestry combines trees and food crops to increase production and provide environmental benefits. Secondary forests, plantations, and trees outside forests also contribute to food security by providing food products for rural and urban communities (Chamberlain et al., 2020).

Tolikara Regency, Jayapura City, Puncak Regency, Puncak Jaya Regency, Mimika Regency, and Lanny Jaya Regency have significant geographical proximity, which influences their food security index. The altitude of Puncak Regency, which is between 1,500 and 4,000 meters above sea level (BPS Puncak Regency, 2024), makes it one of the areas with a very vulnerable food security index. These extreme geographical conditions cause difficulties in access to transportation and food distribution (Yustiawan, 2024), which has an impact on the availability and stability of food supplies. In addition, agricultural land in the highlands is often less fertile (Turasih et al., 2016) and vulnerable to climate change (Sharratt et al., 2015), adding to the challenges in meeting people's food needs. Other regencies, such as Tolikara Regency and Lanny Jaya Regency, although they have more diverse altitudes, also experience similar impacts due to interconnected geographical and climatic conditions. The close proximity of these districts means that challenges faced by one district can affect others, especially in terms of food supply and distribution. For example, food production difficulties in Puncak Regency could worsen the situation in Tolikara Regency and Lanny Jaya Regency, which may depend on supplies from these areas.

Jayawijaya Regency is a Regency that has a food security index linkage with a nearby region, namely Keeromm Regency. According to research results, Wijaya (2023) said that on Papua Island, there are often tribal wars, and wars between tribes have become a tradition to survive. Furthermore, Wijaya (2023) said that Jayawijaya Regency experienced conflicts more often. Inter-tribal conflict in Papua, especially in Jayawijaya City, can have a significant impact on food security in other districts. Disruption of food distribution due to disruption of road access and tight security can hamper the supply of staple foods to other areas. In addition, population migration from conflict areas to safer areas has the potential to increase food demand in districts receiving migrants, thereby exacerbating strains on food supplies. Disruptions to food production in agricultural areas affected by conflict can also occur, resulting in reduced production output that affects districts that depend on food supplies from these areas. This could then trigger an increase in food prices, which would have a negative impact on food security, especially in areas that are already vulnerable. In addition, prolonged conflict can hamper infrastructure development and

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investment in the agricultural sector, which ultimately worsens food security conditions in other areas that are economically and socially linked to the conflict area.

CONCLUSION

This research concludes that there is positive spatial autocorrelation in food security on Papua Island, where areas with similar food security indices tend to be close together. Several districts, such as Fak Fak and Jayapura City, are in the high food security category (High-High). In contrast, mountainous areas such as Jayawijaya and Yahukimo experience food insecurity (Low-Low) due to geographical factors and inadequate infrastructure. Inter-tribal conflicts, especially in Jayawijaya, have also worsened food security conditions by disrupting food distribution and production. Recommended implementation includes strengthening infrastructure, managing disputes, and developing local agriculture to increase food security in vulnerable areas. Diversifying food sources through forest use is essential to support long-term food security.

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