

Spatial Autocorrelation Analysis of Agricultural Commodity Regionalization in Buru Regency

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Abstract

The agropolitan concept is expected to boost farmers' welfare and increase the share of the agricultural sector in the regional gross domestic product (RGDP). The purpose of this study is to examine the distribution pattern of agricultural commodities in Buru Regency based on spatial autocorrelation and to determine agropolitan districts that can be developed based on the results of cluster and outlier analysis. This study uses secondary data and analyzes it using spatial autocorrelation and LQ analysis techniques. The results show that the LQ (Location Quotient) value for rice is relatively uniform in Buru Regency, with only three subdistricts statistically included in the high cluster. The LQ values for tubers are relatively concentrated in Buru Regency, and the High High cluster values for several areas indicate that there are areas with LQ values > 1 in two other subdistricts that function as buffers. Clove LQ values > 1 are found in eight subdistricts in Buru Regency, with only two subdistricts statistically included in the high clove production cluster, while other areas function as buffers. Coconut LQ values > 1 are found in ten subdistricts in Buru Regency, with only five subdistricts statistically included in the high coconut production cluster, while other areas serve as buffers.

Keywords: Location quotient, cluster, Buru Regency, spatial autocorrelation

INTRODUCTION

The concept of regional development planning that has been quite popular in recent decades developing and agrarian countries such as Indonesia is the concept of agropolitan development. Agropolitan area development aims to increase community income and welfare through accelerated regional development and increased connectivity between villages and cities (Bahasoan, 2021). Agropolitan areas consist of agricultural towns and villages that are centers of agricultural production. These areas are not limited by administrative boundaries (villages/subdistricts, districts, and regencies/cities). Instead,

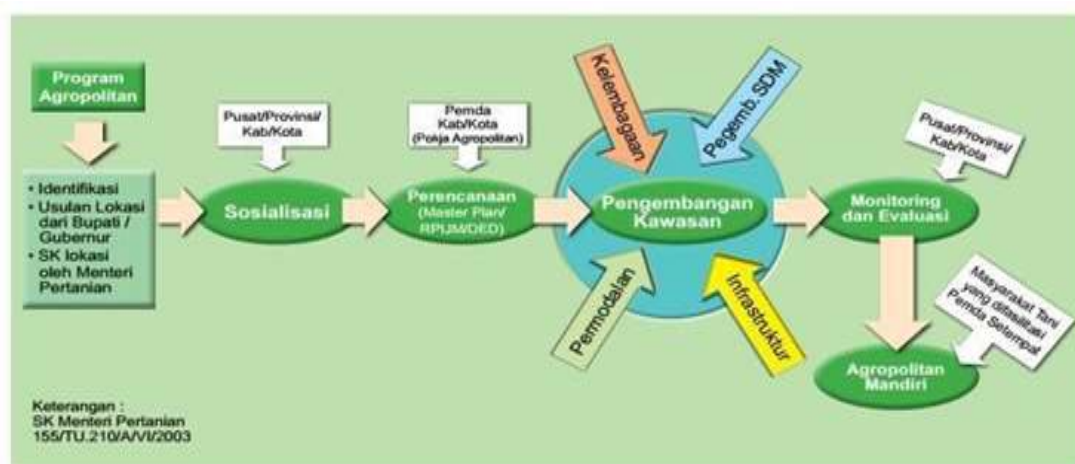
804



they are adjusted according to the economic scale of the area, making them more flexible. Thus, the shape and area of an agropolitan area can cover one village/subdistrict, one subdistrict, or several subdistricts within a regency/city. This area can also cover areas that cross into other neighboring regencies/cities.

According to Friedman and Whitby, the main process of rural development is the agriculture-based economic sector. Friedman adds that the concept of agropolitan is an effort to develop rural areas through spatial planning as the basis for development. Friedman and Aloson theorize that agropolitan is an approach to basic needs and focuses more on rural development through the concept of agricultural growth. However, ongoing development has led to a gap between urban and rural areas and urban bias. Urban bias is a deviation caused by the tendency to prioritize development at the ends of economic growth. The gap between urban and rural areas has encouraged efforts to develop rural areas, grow, serve, and encourage agricultural activities in the surrounding areas.

According to Widhaswara & Sardjito (2017), there are five criteria for agropolitan characteristics: (1) Agropolitan areas include small to medium-sized cities; (2) Agropolitan areas have rural areas that produce leading commodities; (3) Agropolitan areas have main urban areas where agro-industries are built in accordance with natural conditions; (4) Agropolitan areas have growth centers for companies and for the development of agro-industries; (5) Agropolitan areas are able to develop and promote rural areas optimally. The implementation of the agropolitan program has been quite successful, as evidenced by several programs that have been carried out, such as agricultural machinery assistance, guidance, and counseling for farmers. Farmer groups are provided with various activities in an effort to empower the farming community. However, intensive monitoring is still needed for the sustainability of the program (Mubarokah et al. 2024).



METHOD

This research was conducted in Buru Regency. The data collection stage was carried out by taking secondary data from the Buru Regency Central Statistics Agency (BPS). The data collected was from Buru in Figures 2024, which contains agricultural production data for several commodities in each sub-district in Buru Regency. The commodity data used was for paddy, tubers, cloves, and coconuts, as well as administrative area data in Buru Regency.

Analysis Method

In general, this study used several features in ArcGIS software that support the expected output of the analysis results. Some of the functions used include:

1. The join function, to combine rice production attribute data and LQ (Location Quotient) data with administrative map attribute data that only contains subdistrict name information
2. LQ and LI (Localitazion Index) values were calculated using Microsoft Excel software.
3. Spatial autocorrelation function.
4. Cluster and outlier analysis function.
5. The query function was used to display the final map combining the results of the cluster and LQ analyses.
6. Map layout process.

Spatial autocorrelation and cluster analysis

The next step is to analyze the data that has been obtained. In data analysis, there are steps that must be taken. The first step in analyzing the data is to calculate the Moran Index from the available data. The Moran Index can be calculated using ArcGIS software. The file type used in processing the data is SHP (Shape File), which is a base map from the Central Statistics Agency with administrative boundaries. The attribute data on the base map is then supplemented (joined) with attribute data on agricultural commodity production in each subdistrict. The data used for spatial autocorrelation analysis here is production data, not productivity data. Lembo (2006) argues that spatial autocorrelation analysis shows the form of interrelationships in a region with only one indicator. Spatial autocorrelation measurement using the global Moran Index was formulated by Patrick Moran as follows (Kosfeld, 2006; Kosfeld, 2011):

$$I = \frac{N}{\sum_i \sum_i w_{ij}} \frac{\sum_i \sum_j \sum_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2}$$

Where:

y_i : agricultural production value of subdistrict i

806



- $\bar{y}$: average agricultural production value
 y_j : agricultural production value of subdistrict j
 N : number of samples
 $\sum_i \sum_j w_{ij}$: spatial adjacency matrix

Where is the average observation and weighting of the relationship between regions i and j. In testing the Moran's I Index output, the following hypotheses can be used:

H_0 = No Spatial Autocorrelation

H_a = Spatial Autocorrelation Exists

If the value of $Z(I) > Z\alpha/2$ or $-Z(I) < -Z\alpha/2$, it can be concluded that there is a significant spatial correlation at the significance level α . The range of values for the Moran Index in the case of a standardized spatial weight matrix is $-1 \leq I \leq 1$. A value of $-1 \leq I < 0$ indicates negative spatial autocorrelation, while a value of $0 < I \leq 1$ indicates positive spatial autocorrelation. A Moran Index value of zero indicates no clustering. The magnitude of spatial autocorrelation can be used to identify spatial relationships (Anselin and Rey, 2010). Often, neighboring subdistricts have similar characteristics or indicators. Thus, there is correlation in space or place, not correlation between data at different points in time.

The next step is to determine whether there is spatial autocorrelation in the production of paddy, sweet potatoes, cloves, and coconuts by conducting a significance test. If the significance test shows spatial autocorrelation, the next step is to determine whether the spatial autocorrelation is positive or negative. This spatial autocorrelation serves as the basis for the formation of districts producing leading commodities in Kuningan Regency. Next, mapping is carried out using cluster analysis to show the spatial distribution of these commodity productions. In cluster and autocorrelation analysis, in addition to conceptualizing spatial relationships, it is also necessary to select the distance used for calculation. The distance concepts found in autocorrelation and cluster analysis are Euclidean distance and Manhattan distance. The selected neighborhood concept affects the type of distance calculation. This study uses the concept of neighborhood based on polygon contiguity, using the Euclidean distance concept.

Basic Sector Analysis and Activity Concentration

The LQ (Location Quotient) and LI (Localization Index) calculations complement and justify the results of spatial autocorrelation analysis and cluster analysis. The clustered regions are then combined with their attribute data using LQ and LI values. After that, a final mapping process is carried out to produce a map of LQ value distribution, which includes statistical and spatial clustering of specific commodities that can be used as agropolitan districts. LQ analysis is used to determine food crop sub-sector commodities that have a comparative advantage, with the criterion of $LQ > 1$. Operationally, the LQ formulation can be formulated as follows (Hendayana, 2003):

807



$$LQ = \frac{p_i/p_t}{P_i/P_t}$$

where:

p_i = harvested area of commodity i at the subdistrict level

p_t = total harvested area of all commodities at the subdistrict level

P_i = total harvested area of commodity i at the district level

P_t = total harvested area of commodities at the district level

The Localization Index is an index that describes the relative concentration of an activity compared to the total trend within a region. This index is generally used to determine the percentage distribution of a particular activity within a region (Rustiadi et al, 2011). In general, this analysis is used to determine regions that have the potential to develop certain activities. The LI equation can be said to be part of the LQ equation.

$$LI = \frac{1}{2} \sum_{j=1}^n \left\{ \frac{X_{ij}}{X_j} - \frac{X_i}{X} \right\}$$

To interpret the results of the Localization Index analysis, the following is generally used

1. If the value is close to 0, it means that the development of an activity tends to have the same level as the development of the region in a broader scope. The level of activity development will be relatively indifferent in all locations. This means that the activity has a relatively equal chance of development in all locations.
2. If the value is close to 1, the observed activity will tend to develop centrally in a location. This means that the observed activity will develop better if carried out in certain locations.

Cluster and outlier analysis identifies patterns from existing values in attributes to find hot spots, cold spots, and spatial outliers using Anselin Local Moran's I . The results of this analysis generate new features with attributes used as feature inputs. Local Moran's I Index values, z-scores, p-values, and cluster/outlier types. Payung et al. (2016) state that the z-values and p-values are interpreted in the same way as spatial autocorrelation analysis, which serves to reject the null hypothesis. The interpretation for rejecting and accepting the null hypothesis in this analysis is described as follows:

1. A large and positive z-value indicates that the features included in the analysis have the same value (high or low). Clustering for each region is HH for regions with high value characteristics and LL for regions with low value characteristics.
2. A small and negative z value indicates that the features included in the analysis are identified as spatial outliers. HL indicates that the region has a high value and



is surrounded by regions with low values. Meanwhile, LH indicates that the region has a low value and is surrounded by regions with high values.

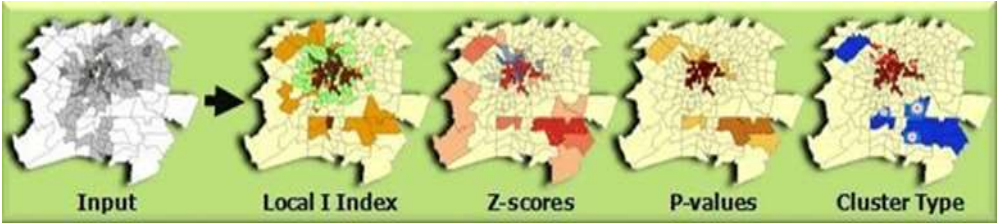
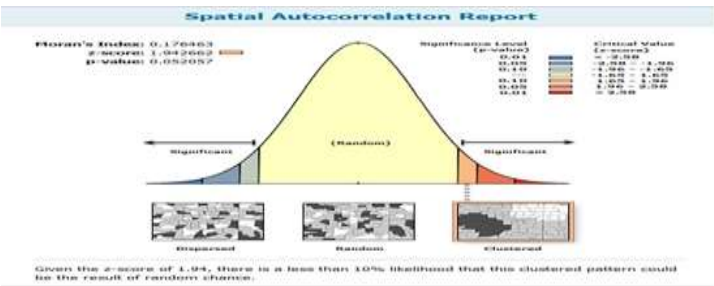


Figure 2. Illustration of cluster and outlier analysis

RESULTS AND DISCUSSION

Paddy Commodity Analysis

From the statistical calculations for spatial autocorrelation of paddy commodities, it can be seen that paddy commodities have a weak clustering tendency with an error rate of 10%. The Moran's index value (0.176) is closer to zero than one, therefore the clustering pattern that occurs can be said to be quite weak even though it is statistically significant.



Moran's Index:	0.176463
Expected Index:	-0.023285
Variance:	0.015134
z-score:	1.942662
p-value:	0.050275

The clustering pattern that was formed was then analyzed further using the cluster and outlier analysis function to obtain a spatial overview of which areas have the potential to become paddy commodity development districts in supporting the implementation of the agropolitan concept in Buru Regency. Based on the cluster analysis results (Figure 3), areas included in the High High (HH) cluster were obtained, consisting of 3 subdistricts. This indicates that these areas are areas with high paddy production. Administratively, these three subdistricts are located in the Waeapo Plain, namely Waeapo, Waelata, and Lolong Guba subdistricts. The results of the cluster analysis for paddy commodities were combined with economic-based data (LQ calculation) for comparison. It was found that the level of paddy commodity development in Buru Regency is not uniform when viewed from the LQ value. Of the 10 subdistricts in Buru Regency, only 3 subdistricts have an LQ value for paddy of more than 1, the majority of which are located in the Waeapo Plain. In other words, there are indications of a concentration of paddy production activities in sub-regions



(subdistricts). It can also be interpreted that subdistricts with an LQ value > 1 have the potential to export paddy production to other regions because their production is relatively above the average production in the entire analysis area. The LQ calculation results for food crops show that paddy is a leading or base commodity in the region with a value of 1.13, while the other two commodities, corn and tubers, are supporting commodities and not leading commodities with LQ values of 0.09 and 0.03, respectively (Hidayat et al., 2021). When supplemented with the LI value, the LI value for paddy is 0.11, so it can be said that the development of paddy production activities tends to have the same level as the development of the wider region. Thus, the High High cluster in the Waeapo Plain can be the main driver of paddy production in Buru Regency, while other areas can function as supporting areas.

Tubers Commodity Analysis

The relative position of Buru Regency in tubers production in Maluku Province is quite good. With this potential, developing tuber commodities through the agropolitan concept is a good option. First, it is necessary to look at the spatial statistics of areas with the potential to become tubers production clusters in order to facilitate the development of agropolitan districts. From the statistical calculations for the spatial autocorrelation of tuber commodities, it can be seen that tuber commodities have a fairly good clustering tendency with an error rate of 1%. The Moran's index value (0.454), although between zero and one, indicates a fairly strong and statistically significant clustering pattern.

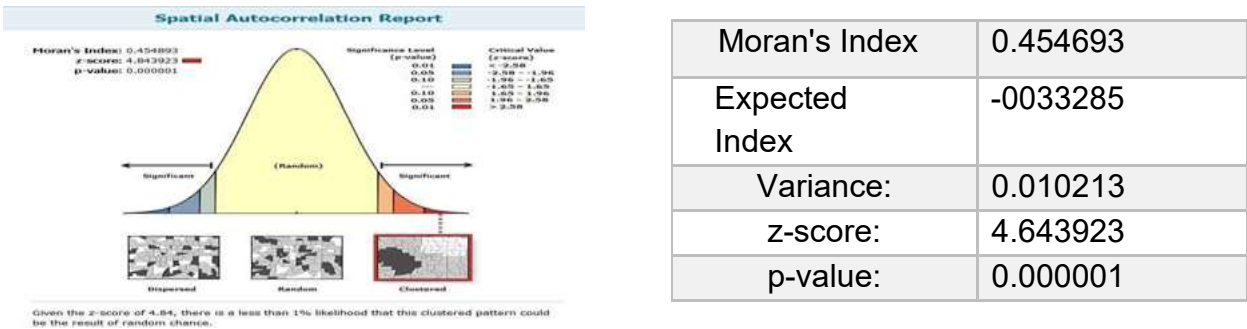


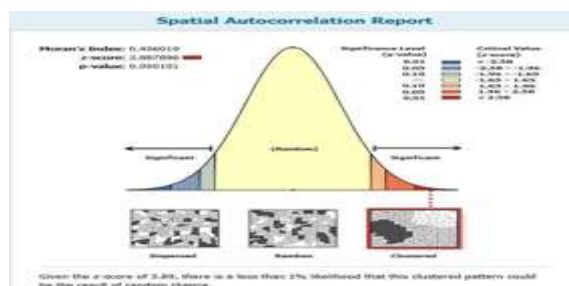
Figure 4. Results of spatial autocorrelation analysis of tuber commodities

Based on the cluster analysis results (Figure 4), areas included in the High High (HH) cluster consisting of 2 subdistricts were obtained. This indicates that these areas are areas with tubers production and the surrounding areas (neighbors among the 2 subdistricts) also have high values. The cluster analysis results confirm that tubers are one of the commodities that are suitable for development in Buru Regency, because spatially,

the distribution of tubers production is positively correlated. The level of development of tuber commodities in Buru Regency is relatively concentrated when viewed from the LQ value. Of the 10 subdistricts in Buru Regency, only 2 subdistricts, namely Airbuaya Subdistrict and Waplau Subdistrict, have an LQ value for tubers of more than 1. An LQ value > 1 indicates a concentration of tubers production activities in the sub-region (sub-district), or it can also be interpreted that sub-districts with an LQ value > 1 have the potential to export tubers production to other regions because their production is relatively above the average production in the entire analysis area. When supplemented with the LI value, the LI value for tubers is 0.54, which is between 0 and 1, so it can be said that the development of tubers production observed will tend to be concentrated in one location. This means that the observed activity will develop better if carried out in certain locations. With the LQ value for tubers relatively concentrated in Buru Regency and a High High cluster value for several areas, it is appropriate to designate the Airbuaya Subdistrict as a tuber production center. Although there are still areas with an LQ value > 1 in other subdistricts, development efforts should be prioritized in the Waplau Subdistrict, with subdistricts outside the Airbuaya Subdistrict serving as support areas.

Clove Commodity Analysis

Clove is one of the plantation commodities that has a fairly high price despite its nature as an annual crop. In terms of its relative position to other regions, Buru Regency is not a major center of clove production. However, to assist in the analysis process, clove plantation commodities were selected to illustrate the potential distribution of production in Buru Regency.



Moran's Index:	0.406019
Expected Index:	-0.023358
Variance:	0.013718
z-score:	3.687896
p-value:	0.000101

Figure 5. Results of spatial autocorrelation analysis of clove commodities

From the statistical calculation results for the spatial autocorrelation of clove commodities, it can be seen that clove commodities have a fairly good clustering tendency with an error rate of 1%. The Moran's index value (0.406), although between zero and one, indicates a fairly strong and statistically significant clustering pattern. Based on the cluster analysis results, areas included in the High High (HH) cluster were obtained, consisting of

two subdistricts. This indicates that these areas are areas with high clove production and surrounding areas. Administratively, these two subdistricts are located in the Buru Regency, namely Batabual Subdistrict and Airbuaya Subdistrict. Geographically, cloves are ideally grown in highland areas, as is typical for plantation crops. The western part of Buru Regency is located in a highland area, resulting in relatively good clove production. Local regulations stipulate that Batabual Subdistrict has a leading plantation crop, one of which is cloves.

The level of clove commodity development in Buru Regency is relatively concentrated in the Batabual area when viewed from the LQ value. Of the 10 subdistricts in Buru Regency, two subdistricts have an LQ value for cloves of more than 1, the majority of which are in Batabual Subdistrict and Airbuaya Subdistrict. An LQ value > 1 indicates a concentration of clove production activities in a sub-region (subdistrict), or it can also be interpreted that subdistricts with an LQ value > 1 have the potential to export clove production to other regions because their production is relatively above the average production in the entire analysis area. When supplemented with the LI value, the LI value for cloves is 0.483, which is close to 0.5, so it can be said that the development of clove production activities will tend to be concentrated in one location. This means that the observed activities will develop better if carried out in certain locations. Although clove LQ values > 1 are found in two subdistricts in Buru Regency, based on cluster analysis, only two subdistricts are statistically included in the high clove production cluster. Thus, the High High clusters in Batabual and Airbuaya subdistricts can be the main drivers of clove production in Buru Regency, while other areas function as buffers because the production focus is on other commodities.

Coconut Commodity Analysis

Coconut is one of the most promising plantation commodities, as every part of the tree can be utilized, from the fiber, leaves, and trunk. Economically, coconut trees can generate significant profits if managed properly. However, most coconut trees grown in Buru Regency are still naturally grown and have not been developed on a large scale. To complement the plantation commodities in the analysis, another plantation commodity, namely coconut, was selected to illustrate the potential distribution of its production in Buru Regency. The development of the Agropolitan area seeks to identify specific commodities that have the potential to become leading commodities. With the characteristics of the mountainous and coastal areas and the vast potential of agricultural land, it is possible to obtain an overview of the clustering of coconut commodity production.



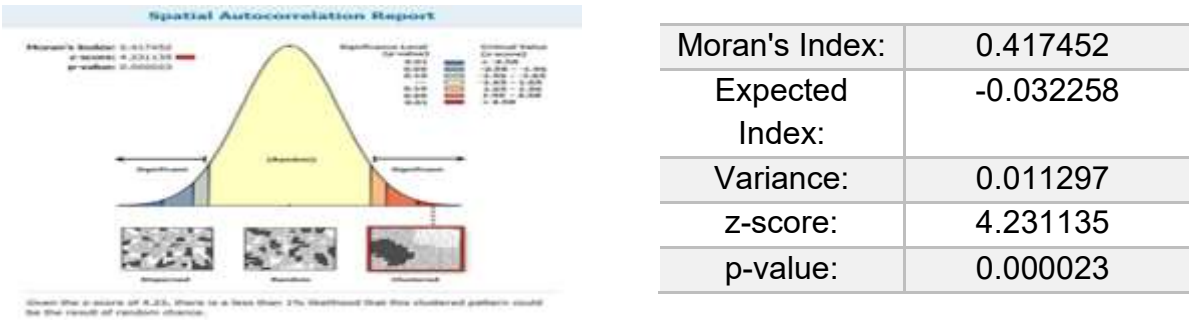


Figure 12. Results of spatial autocorrelation analysis of coconut commodities

From the statistical calculation results for spatial autocorrelation of coconut commodities, it can be seen that coconut commodities have a fairly good clustering tendency with an error rate of 1%. The Moran's index value (0.417), although between zero and one, indicates a fairly strong and statistically significant clustering pattern. The cluster analysis results obtained areas included in the High High (HH) cluster consisting of 5 sub-districts. These five sub-districts are Waplau Sub-district, Airbuaya Sub-district, Fena Leisela Sub-district, Batabual Sub-district, and Namlea Sub-district. The level of coconut commodity development in Buru Regency is relatively concentrated in the northern part and partly in the western region, as seen from the LQ value. Of the 10 subdistricts in Buru Regency, there are 5 subdistricts with an LQ value for coconuts of more than 1, the majority of which are located in the northern part. An LQ value > 1 indicates a concentration of coconut production activities in the subdistrict, or it can also be interpreted that subdistricts with an LQ value > 1 have the potential to export coconut products to other regions because their production is relatively above the average production in the entire analysis area. When supplemented with the LI value, the LI value for coconuts is 0.857, which is close to 1, so it can be said that the development of coconut production activities tends to be concentrated in one location. This means that these activities will develop better if carried out in certain locations. Although coconut LQ values > 1 are found in 5 subdistricts in Buru Regency, based on cluster analysis, only three subdistricts are statistically included in the high coconut production cluster. Thus, the coconut production cluster (High High) in the northern region can be the main driver of coconut production in Buru Regency, while other areas with an LQ > 1 serve only as buffers, because based on the analysis, they are more suitable for other commodity activities.

CONCLUSION

The distribution pattern of rice commodities is found in 3 subdistricts, namely Waeapo, Waelata, and Lolong Guba. The distribution pattern of tuber commodities is found in 2 subdistricts, namely Airbuaya and Waplau. The distribution pattern of clove

commodities is found in 2 subdistricts, namely Batabual and Airbuaya. Meanwhile, the distribution pattern of coconut commodities is found in 5 subdistricts, namely Waplau, Airbuaya, Fena Leisela, Batabual, and Namlea.

There are three agropolitan areas in Buru Regency, namely the Waeapo Plain area with paddy as its leading commodity, the Batabual Plain area with cloves as its leading commodity, and the North Buru Plain area with coconut and tuber as its leading commodities.

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