Cluster Development of Plantation-Based Industries in Penajam Sub-District as an Economic Growth Center Supporting the Nusantara Capital

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Abstract. Regional development is a strategic program aimed at enhancing growth and reducing welfare disparities among regions by optimizing resource utilization through a comprehensive approach that includes physical, social, economic, cultural, and environmental aspects. Industrial clustering plays a crucial role in driving regional growth, improving competitiveness, fostering innovation, and creating synergy among various economic sectors. However, the effective implementation of clustering often encounters challenges, particularly in identifying and optimally leveraging specific regional potentials. This study aims to address this gap by focusing on the formation of plantation-based industrial clusters in Penajam District at the sub-district and village levels. Data on plantation industry production in Penajam District for 2023, including Crude Palm Oil (CPO), Palm Kernel Oil (PKO), and kernels, demonstrates significant potential in this sector, with CPO production reaching 99,199 tons per hour. Penajam District, located near the new capital city of Nusantara (IKN), has a comparative advantage in agriculture, particularly in palm oil and coconut plantations. The industrial clustering based on plantations in this area is expected to enhance product value, attract investment, and strengthen local industry competitiveness. The study findings indicate that plantation-based industrial clusters with indicators of raw material proximity are located in Sotek and Riko villages, market accessibility is found in Sepan, Jenebora, Gersik, and Bukit Subur villages, and labor availability is present in Petung and Buluminung villages.

Keywords: Industry Cluster, Plantation, Regional Development

1   Introduction

Regional development is a strategic program designed to accelerate growth and reduce disparities in welfare among regions by optimizing resource utilization through a comprehensive approach that encompasses physical, social, economic, cultural, and environmental aspects [1]. The strategic sectors that can expedite regional development include basic and industrial sectors [2]. In the context of regional development, industrial zones are defined as growth centers capable of stimulating the development of other economic sectors. Consequently, regional development is closely linked to the industrial sector and the formation of industrial clusters.

Industrial clusters play a crucial role in regional growth by enhancing competitiveness, fostering innovation, and promoting economic expansion [3,4]. By leveraging clustering approaches, regions can maximize their competitive advantages, attract investment, and promote sustainable development strategies.

Industrial clustering is vital not only for effective resource management but also for creating synergy among various economic sectors, which can enhance overall productivity and regional competitiveness. However, numerous studies indicate gaps in the effective implementation of clustering, particularly in identifying and optimally utilizing specific regional potentials [5,6]. This research aims to address these gaps by focusing on the establishment of plantation-based industrial clusters in Penajam District at a more micro level, specifically at the sub-district and village levels.

Data from the North Penajam Paser Regency Agriculture Office for 2023 shows significant figures in plantation commodity production, with Crude Palm Oil (CPO) reaching 99,199 tons per hour, Palm Kernel Oil (PKO) at 4,338 tons per hour, and kernels at 21,296 tons per hour. This production data highlights the substantial potential of the plantation sector, particularly palm oil, in Penajam District. The high CPO production indicates significant capacity in palm oil processing, while the production of PKO and kernels also demonstrates substantial processing activities and further development potential. These production figures suggest that Penajam District has a strong comparative advantage in the palm oil industry, which can be optimized through the development of plantation-based industrial clusters. By leveraging this substantial production capacity, the region can attract more investment, increase product value, and strengthen local industry competitiveness.

Penajam District, located near the new capital city of Nusantara (IKN), possesses considerable potential for regional development. The district has a comparative advantage in agriculture, especially in the plantation subsector, with extensive land available for coconut and palm oil production, presenting a significant opportunity for economic advancement [5]. As seen in other regions, industrial clusters have demonstrated the ability to enhance regional competency and economic growth [6]. By focusing on the development of plantation-based growth centers and identifying core capabilities in potential industries such as coconut and palm oil, Penajam District can become a key player in the economic landscape and harness agglomeration for the economic advancement of North Penajam Paser Regency [7]. Growth centers based on plantations in Penajam District, such as Petung, Buluminung, Sotek, Sepan, Riko, Gersik, Jenebora, and Bukit Subur villages, exhibit high levels of accessibility, effective service hierarchies, and a range of plantation-based commodities [8,9].

Conversely, the relocation of IKN to Sepaku District, East Kalimantan, has the potential to impact surrounding areas. One possible impact is the increased regional disparity in nearby areas [10]. To address this disparity, it is essential to continue promoting development and growth centers within the region [11]. Therefore, Penajam District, as an area directly adjacent to the IKN region, plays a crucial role in preventing increased disparity through the development of sector-based and industrial regions. The IKN development opportunity could drive accelerated economic transformation and serve as a momentum for developing new economic clusters, such as the planned sustainable agricultural industrial zone in Buluminung, North Penajam Paser Regency [12]. This underscores the relevance of plantation-based industrial development in Penajam District for creating added value to the regional economy. Therefore, this study focuses on how the clustering of regions driven by plantation industry potential can enhance economic competitiveness and reduce regional disparities in Penajam District. Defining these development clusters is crucial for strengthening regional growth centers and addressing potential disparities.

2   Literature Review

2.1   Regional Development

Regional development is a broad concept that encompasses various efforts to improve the welfare of communities and reduce disparities among regions. Generally, theories of regional development focus on how factors such as investment, government policies, and economic interventions can drive regional growth and development. Endogenous growth theory, for instance, emphasizes the importance of innovation and knowledge in driving economic growth [13]. Meanwhile, central place theory discusses the hierarchy where higher-level central places offer a broader range of goods and services and influence the economic viability of lower-level places [14]. This is analogous to how service and industrial centers are formed and impact the economic distribution in their surrounding areas. On the other hand, the sector model developed by Homer Hoyt provides further guidance on how urban and regional development patterns form radially from economic centers. This theory explains that urban areas develop in sectors radiating from a central point, influenced by transportation and economic activities [15]. The sector model is relevant for understanding how plantation-based industrial clusters can develop around existing growth centers in Penajam District.

2.2   Industry Cluster

Strategic sectors that can accelerate regional development include focusing on the primary and industrial sectors [2]. Therefore, efforts to enhance economic and regional growth are needed through the development of industries based on key commodities [16]. With changes in the global environment, there has been a crisis affecting economies, particularly industries relying on imported raw materials, necessitating the development of strategies through an industrial cluster approach [17]. This is expected to improve competitiveness and create synergies among industries that support each other and are based on competitive advantages.

Industrial development requires an interconnected industrial cluster system. This relates to the indicators that form these industrial clusters. The concept of industrial clusters is formed from the presence of core industries that are interconnected, supplier industries that provide raw materials, supporting industries, and industries that connect with stakeholders [18]. The development of industrial clusters is closely related to aspects such as company agglomeration, value addition and value chains, cooperative networks, and economic infrastructure [19]. As part of regional development, cluster theory provides a more specific framework for how the concentration of firms in the same sector in particular locations can enhance efficiency and competitiveness. Industrial clusters act as a crucial source of regional competitiveness, as evidenced by economic impact modeling in underdeveloped areas, such as Jiangxi Province [20]. Industrial clusters serve as an important mechanism for driving local and regional economies, particularly in strategic sectors such as plantation-based industries.

To promote regional growth, the development of industries based on key commodities should be prioritized. The formation of such industries is based on indicators of industrial development adjusted to the potential of the region [16]. In this regard, some indicators that shape industrial development clusters, particularly in areas with plantation potential, should focus on proximity to raw material sources, availability of labor, and ease of market access.

3   Methods

3.1   Data Collection

The data collection method was conducted through secondary survey techniques. This secondary survey is divided into institutional surveys and literature surveys. The secondary survey data in this study includes administrative data of the region, demographic data, and data on the production of leading plantation commodities in Penajam District.

3.2   Analytical Technique

The analysis stages used to achieve the research objectives are divided into two: determining industrial development area clusters through quartile analysis and determining industrial development area clusters through hierarchical cluster analysis. The formation of these regional clusters is determined by referring to industrial development indicators within the region [8]. These indicators include proximity to raw material sources, availability of labor, and ease of market access. The steps in this research analysis are as follows:

Stage 1. Determining plantation-based industrial development areas oriented towards raw material proximity. At this stage, data input is performed using production data from plantation commodities in growth center villages. This data is then processed using SPSS software to examine the distribution of production data. Production figures that fall within the third quartile are interpreted as the highest contribution to commodity production. Thus, villages with production figures that fall within or above the third quartile are classified into the industrial development cluster oriented towards proximity to raw material sources. Quartile analysis is used in this determination as it can identify groups as well as statistical outliers, and can enhance the efficiency and quality of cluster formation [21,22]. Additionally, this quartile analysis can add meaning to each cluster by providing clear and easily understandable semantic clusters, thereby improving data interpretation, particularly concerning raw material commodities in plantation industries [23].

Stage 2. Determining plantation-based industrial development areas oriented towards labor availability and ease of market access. This stage involves data input from labor force data and market access distance data in growth center villages that are not included in the raw material proximity-based industrial development cluster. Then, the data is processed using SPSS software with hierarchical cluster tools. The output is a dendrogram, which is interpreted into two clusters: those oriented towards ease of market access and those oriented towards labor availability.
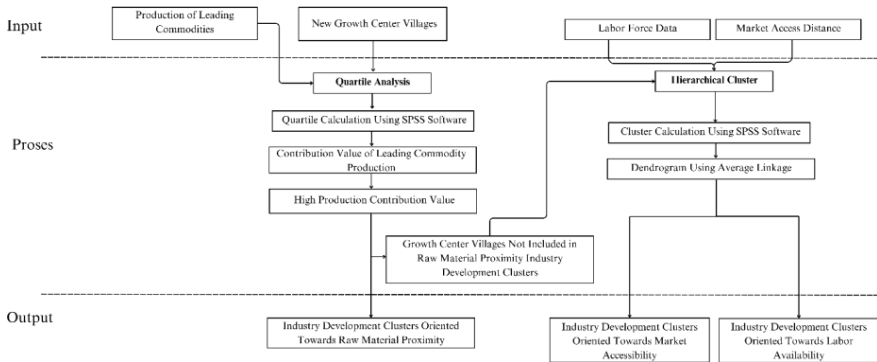

Fig. 1. The analysis process that combines quartile analysis and hierarchical cluster

Figure 1 illustrates the general steps of the research analytical method which focused on the grouping the leading commodities in the new growth center based on the raw material proximity. The following step was combining the market access and the labor force data to support the formation of industry development clusters. Both technique required SPSS software and data interpretation to create the desire outputs.

4   Results and Discussion

The development of regions, particularly on the island of Kalimantan, is directed towards accelerating regional growth and solidifying its role as a national energy hub and one of the world's lungs. One of the strategies implemented by the government includes the development of superior commodities such as plantation crops, as well as the construction of major growth centers prioritized for industrial area development. The following outlines the direction of regional development on the island of Kalimantan:
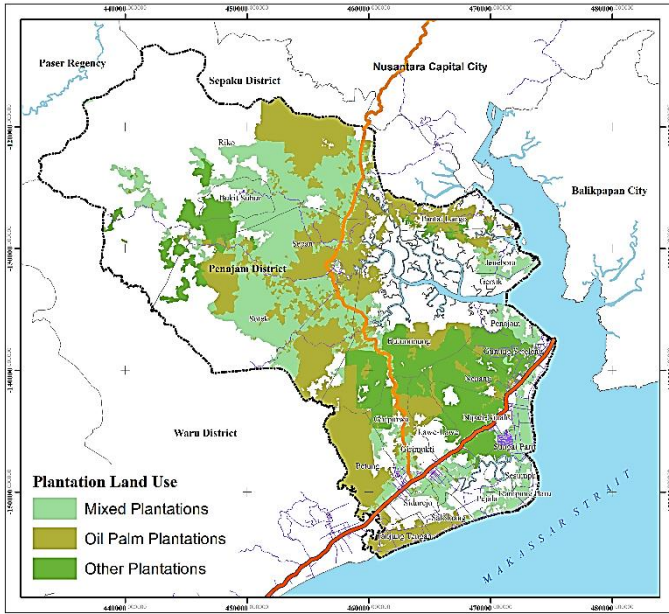
Fig. 2. National Planning of Technocratic in Kalimantan Island from 2020 to 2024

One of the Regional Activity Centers (PKW) in North Penajam Paser Regency (PPU) is the Buluminung Industrial Area located in Penajam District. This area serves as a regional growth center that, in the Technocratic Draft of the RPJMN 2020-2024 (**Fig. 2**), is directed within the corridor of equitable distribution. Within this corridor, the strategy for regional equity includes the development of local economic growth

centers, such as the provision of economic infrastructure and the enhancement of key sectors and supporting sectors to increase economic value-added, thereby creating regional equity.

Penajam District is the capital region of PPU Regency. This district consists of 19 sub-districts and 4 villages with a total area of 883.71 km². Penajam District has sub- stantial potential in the agricultural sector, particularly in the plantation subsector. Fig-ure 3 depicts the plantation subsector in Penajam District that encompasses 19,311.3 hectares of oil palm plantations, 17,458.09 hectares of mixed gardens, and 11,024.61 hectares of other plantations. The following is a map of land use for plantations in Penajam District.

Fig. 3. The mapping of plantation commodities in PPU Regency, Indonesia

In terms of population, Penajam District has the largest population in PPU Regency, with 86,040 inhabitants, or 48.15% of the total population residing in this district [9]. Among this population, the number of individuals of productive age reaches 47,683. The distribution of the productive-age population in Penajam District is illustrated by Figure 4.
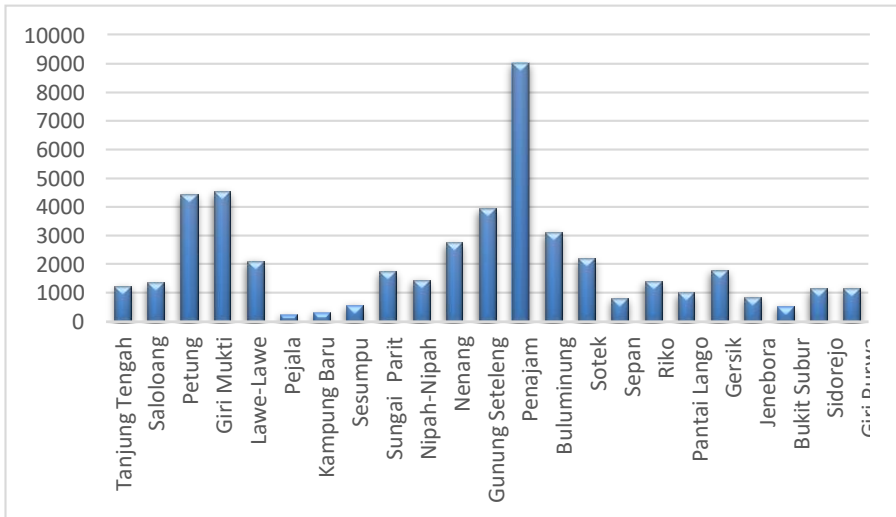

Fig. 4. The demographic data of PPU Regency productive population

Out of the total productive-age population, the number of people employed in the agricultural sector reached 40.08% in 2020 [9]. Penajam District has notable plantation commodities with significant production, specifically in oil palm and coconut [5]. The following figure (**Fig. 5**) is the production of palm oil and coconut commodities in each sub-district/village in Penajam District.
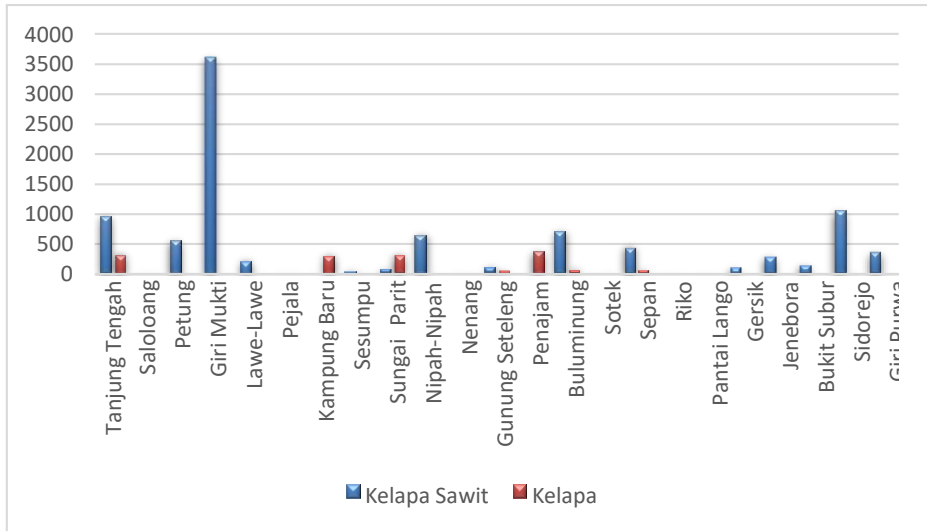
Fig. 5. The statistic palm and coconut oil production in Penajam District

Penajam District falls within the typology of regions that are potential for the development of plantation industry areas [16]. To support this, this study identifies alternative locations for the development of the plantation industry using a clustering approach focused on growth center villages. This identification is carried out in plantation-based growth center villages in Penajam District, namely Kelurahan Petung, Buluminung, Sotek, Sepan, Riko, Gersik, Jenebora, and Bukit Subur. These villages were selected due to their strong potential in terms of high accessibility, high service hierarchy, and a diverse range of base commodities. This determination involves two stages: quartile analysis to obtain clusters for raw material-based industrial development and hierarchical cluster analysis to obtain clusters for market and labor-based industrial development.

4.1   Quartile Analysis

Quartile analysis is used to determine plantation industry development areas oriented towards the proximity of raw material sources. This analysis assesses the percentage contribution of production for each commodity, namely oil palm and coconut, to the overall plantation commodity production in Penajam District. The following are the quartile analysis results of the production contribution values for each plantation commodity in Penajam District.
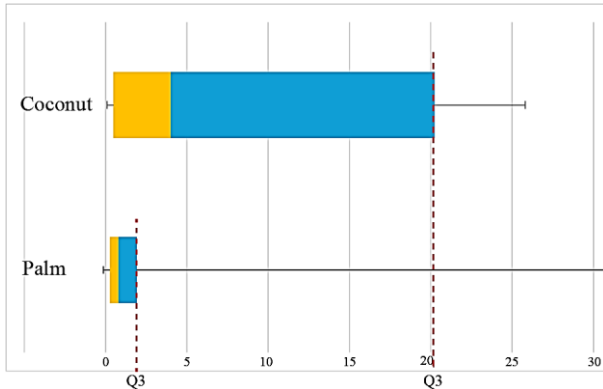
Fig. 6. Quartile distribution of plantation commodities

Table 1. The production contribution value of palm and coconut in Penajam District

Commodities	Production Contribution Value (%)	
	Low	High
Palm	≤ 0,78	2,16 – 43,39
Coconut	≤ 4	21,55 – 25,81

Referring to the table and graphs above, it is observed that the highest production contribution values for palm oil commodities range from 2.16% to 43.39%, while for coconut commodities, the range is from 21.55% to 25.81%. In terms of production percentage, the coconut commodities within the third quartile have a production volume of 50.45 tons. Meanwhile, palm oil commodities within the third quartile have a production volume of up to 90.74 tons.

The areas identified as potential for plantation industry development oriented to- wards raw material proximity are obtained by combining the results of the quartile anal- ysis of production contribution values. Table 2 shows the regions that are the largest producers of leading commodities or those that form clusters for industry developmentoriented towards the proximity of raw material sources.

Table 2. The production contribution value of palm and coconut in Penajam District

New Growth Center Villages	High Contribution Quartile		Raw Material Cluster
	Oil Palm	Coconut	
Petung	-	-	-
Buluminung	-	-	-
Sotek	43,39%		√
Sepan	-	-	-
Riko	38,35%	-	√
Gersik	-	-	-
Jenebora	-	-	-
Bukit Subur	-	-	-

The determination of plantation industry development areas oriented towards raw material proximity is made by considering the high quartile contribution values. The consideration is that each sub-district/village that becomes a new growth center must have at least one high quartile contribution value for plantation commodities. Based on the table above, it is identified that the clusters for plantation-based industry development oriented towards raw material proximity are Sotek village and Riko village.

4.2 Hierarchical Cluster

The formation of plantation-based industry development clusters oriented towards market accessibility and labor availability is conducted using hierarchical cluster analysis techniques. In this analysis process, sub-districts/villages that are already included in the raw material proximity-oriented industry development clusters are excluded from the data input for this analysis. Thus, only six sub-districts/villages remain to be ana- lyzed using hierarchical cluster analysis. The following are the results of the hierar- chical clustering of plantation-based industry development clusters.
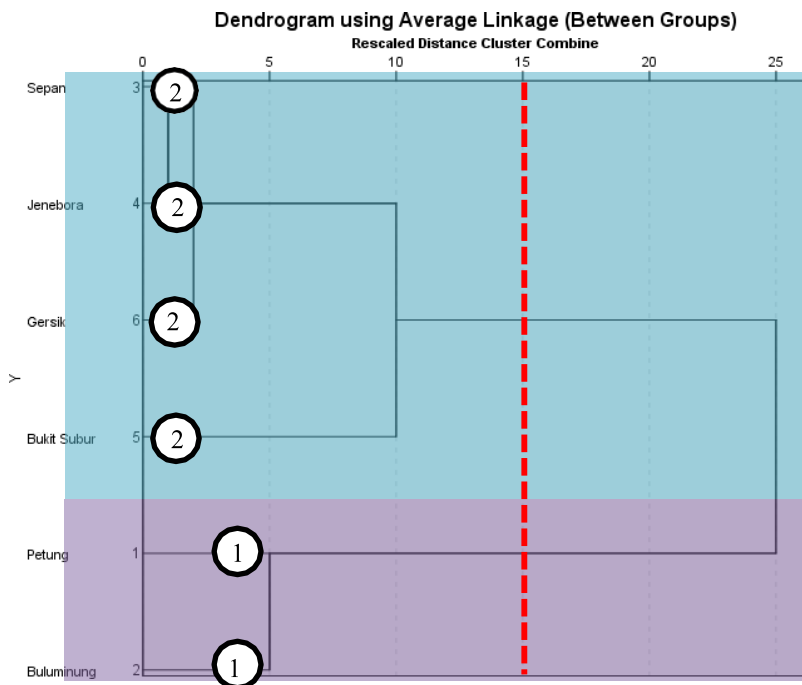

Fig. 7. The statistic palm and coconut oil production in Penajam District

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Based on the dendrogram (**Fig 7**), Sepan and Jenebora villages form a single cluster with a lifetime value of 1. Subsequently, Sepan and Jenebora merge into a cluster with Gersik at a lifetime value of 2 and then further merge with Bukit Subur at a lifetime value of 10. Meanwhile, Petung and Buluminung form a single cluster with a lifetime value of 5. Eventually, all these villages merge into one group at a lifetime value of 25. Cluster determination is obtained by calculating the farthest distance (lifetime) from each village. The Petung and Buluminung cluster has a lifetime value of 5, and the Sepan, Jenebora, Gersik, and Bukit Subur cluster has a lifetime value of 10. When the dendrogram is divided into two groups, the cluster lifetime value is 15 (represented by the red line on the dendrogram), which is the largest and farthest value for cluster for-mation, indicating that the two clusters are truly separate. Therefore, it is determined that Petung and Buluminung are in one cluster because they share similarities in labor-related variables, indicated by the number 1. In contrast, Sepan, Jenebora, Gersik, and Bukit Subur fall into the same cluster due to their similarities in market-related varia-bles, indicated by the number 2 on the diagram.

Plantation Industry Development Cluster Areas in Penajam District. Based on the classification results through quartile analysis and hierarchical clustering analysis, which consider the development clusters for raw materials, marketing, and labor, the interpretation can be seen in Table 3.

Table 3. The production contribution value of palm and coconut in Penajam District

Cluster Type	Villages	Variables
Raw Material Proximity	Sotek and Riko	High quartile contribu-tion
Labor Availability	Sepan, Jenebora, Bukit Subur, and Gersik	Labor-related variables
Market Accessibility	Petung and Buluminung	Market-related variables

It is observed that based on the results of quartile analysis and hierarchical cluster analysis, the sub-districts/villages classified as clusters for industry development oriented towards proximity to raw material sources are Sotek and Riko. This cluster of development concerning proximity to raw materials refers to how close the industrial locations are to the primary raw material sources required for production, measured by geographic distance. Sotek and Riko have a significant volume of raw material production, reaching 95.3%. The cluster for industry development oriented towards ease of market access includes Sepan, Jenebora, Gersik, and Bukit Subur. This cluster, based on market accessibility, refers to the ease and speed of access to target markets for products produced by the industrial cluster, measured by geographic distance. These sub-districts have an average distance to market of 39.75 km. The cluster for industry development oriented towards high labor availability consists of Petung and Buluminung. This cluster refers to the number of available workers in the vicinity of the industrial cluster. The workforce includes both skilled and unskilled labor necessary for industrial operations. These sub-districts have a total workforce of 7,570 individuals. The results of the mapping of industrial clusters based on plantation commodities for new growth centers in the Penajam District are shown in **Fig. 8.**
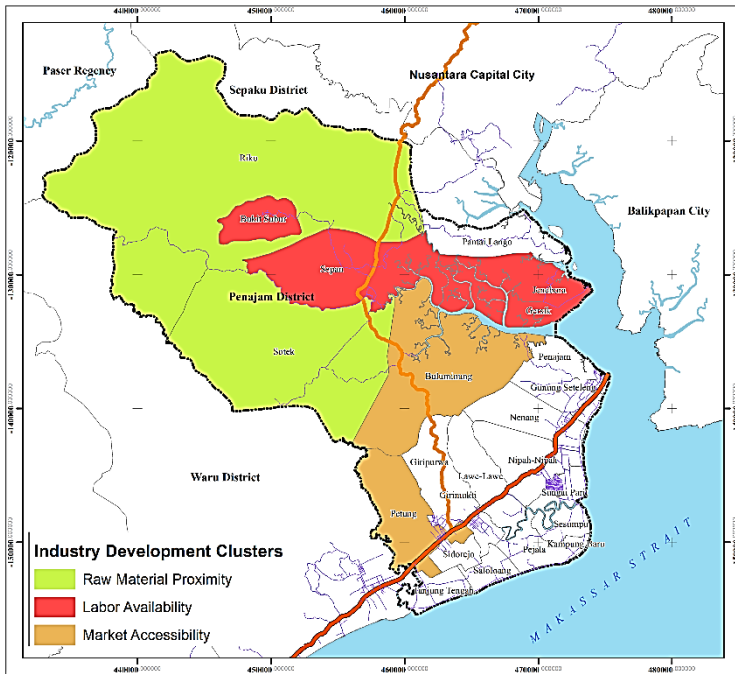
Fig. 8. The mapping of industry development clusters of Penajam District

Based on the image above, it is evident that the new plantation-based growth centersin Penajam Sub-District have significant potential for regional economic improvementand food security for the needs of the National Capital (IKN). By combining the indus-trial sector and the base sector, these new growth centers are expected to drive massive development in the hinterland or its supporting areas.

An example of industry development for alternative plantation industry locations close to raw material availability indicates that these areas are suitable for plantation industries. Such proximity can strengthen supply chains, reduce logistics costs, and allow for the development of processing facilities to increase value-added and competitiveness. On the other hand, alternative plantation industry locations close to market access can be utilized to develop efficient distribution networks, such as good access to seaports for easy export. Meanwhile, alternative plantation industry locations close to labor availability can help create new jobs and improve the welfare of the local community. Thus, the plantation industry development clusters are expected to impact land development positively, particularly for investors in these new growth centers when determining alternative plantation industry development locations, especially for oil palm and coconut commodities.

5   Conclusion

Based on the results and discussion, it can be concluded in line with the problem formulation and objectives, which involve determining the clusters for plantation-based industrial development. The findings indicate that the sub-districts/villages classified as clusters for industry development oriented towards proximity to raw material sources are Sotek and Riko. These sub-districts have a significant volume of raw material production, reaching 95.3%. The sub-districts classified under the cluster for industry development oriented towards ease of market access are Sepan, Jenebora, Gersik, and Bukit Subur. These areas have an average distance to the market of 39.75 km. Meanwhile, the sub-districts classified as clusters for industry development oriented towards high labor availability are Petung and Buluminung. These sub-districts have a total workforce of 7,570 individuals.

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