The Potential Impact of Peri-Urbanisation to the Continuity of Agricultural Practices Surrounding Malang City, Indonesia: A Spatial Autocorrelation Analysis

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Abstract. Urbanisation has caused a significant increase in the sprawl of urban settlement. Some researchers introduced the phenomena of peri-urbanisation where the peri-urban areas have become an extension of urban system. Consequently, the existence of peri-urban agriculture is under the threat of land conversion, particularly into housing and other settlement-related services. This study is among the research that provides empirical evidence of the contestation between urban housing expansion and the presence of agricultural land. By using the case of Malang Regency in East Java Province where the peri-urbanisation of Malang City has taken place, this research utilises the spatial autocorrelation analysis to explain the spatial pattern of peri-urbanisation. We found that all variables describing the agricultural sector in Malang Regency exhibit positive spatial autocorrelation with clustering patterns. The distribution of areas with High-High, Low-Low, Low-High, and High-Low agricultural conditions facilitates a more equitable distribution of agricultural resources in Malang Regency as a hinterland and Malang City as the centre of activities. Distance to the city area (Malang City) is one factor that causes clusters to form in the southern or northern areas of Malang Regency.

1 Introduction

The increasing necessity of urban settlement triggers urbanisation in peri-urban areas [1]. This is due to the expansion of urban built-up areas in the districts surrounding the urban administrative area. It is observed by the change of land use in previously unbuilt areas dominated by agricultural areas to built-up land [2]. This phenomenon is caused by the increasing necessity of land in urban areas, while the land available within the city boundary is extremely costly, hence the expansion of the urban system to the surrounding administrative areas [3, 4]. Additionally, the process of gentrification indicated by massive urban regeneration that is followed by land-grabbing by investors decreases the affordability of intra-city settlements [5].

The peri-urban areas act as a buffer zone for urban activities, providing resources such as water, food, and labour. As an area dominated by agricultural areas, peri-urban plays a pivotal role in providing food for urban communities. It further establishes a pattern of interconnection between urban and its surrounding peri-urban regions. [6]. The urban and peri-urban interaction is primarily hence the conversion of peri-urban agriculture that potentially impacts the established urban-rural food system [7].

By considering the inevitable peri-urbanisation of the constantly growing urban areas, this research is keen to observe the spatial pattern of peri-urbanisation in Malang Regency, in which food and labour of Malang city primarily originate [8]. By using spatial regression analysis, this research is expected to provide empirical evidence of the peri-urbanisation phenomena following the increasingly intense urban activities in Malang City.

2 Methods

This study uses the sub-district-level agricultural statistical data published by the Indonesia Statistical Agency (BPS) in 2013 and 2023. The Central Bureau of Statistics of Indonesia conducts the agricultural census every ten years. Over this period, the census data is hoped to show how urbanization will impact changes in the agricultural sector in the surrounding area. The map used is a topographic map published by the Geospatial Information Agency, which has an

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administrative unit that matches the agricultural census unit. In total there are 33 sub-districts in Malang Regency are selected to examine the potential impact of peri-urbanisation of Malang City. Figure 1 shows the research areas where Malang City is excluded from the analysis.

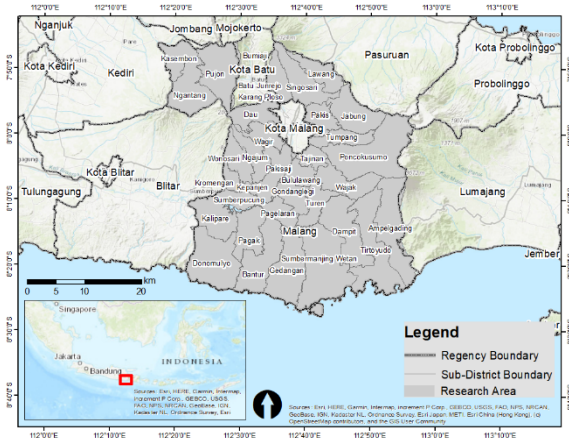

Fig. 1. Map of Malang Regency Research Area

Specifically, this study attempts to see the impact of Malang City urbanisation on the potential continuity of agricultural practices in Malang Regency. In doing so, several variables are selected as presented in Table 1. In general, the variables can be categorised into two, firstly related to the continuity of the farming practices which is represented by the number of farmers and farming household. The second category related to the continuity of farm itself in which the availability of rice fields is examined along with non-rice field land use., rice production, and harvest areas. This study was conducted by comparing data from two farmer census periods, i.e., 2013 and 2023, in order to capture the dynamics of agricultural practices. Choropleth map was used to describe the conditions of changes in variables that represent agricultural conditions in a time series. Spatially, the analysis was carried out using a geographic information system. The spatial relationship of agricultural sector conditions in sub-districts of Malang Regency was analysed using the spatial autocorrelation of Moran's I Index. This analysis will show whether the occurring phenomena will be distributed either in a clustered or a random pattern [9]. Spatial distribution analysis using Geoda 1.22 software was used to determine the relationship between sub-districts in Malang Regency, which consists of 33 sub-districts.

Table 1. Variables and Secondary Data Used in the Research

No.	Variable	Reference	Source
1	Total of populations	[10, 11]	Malang Regency in Number
2	Number of farmers		Agricultural Census Data
3	Number of farming households		Agricultural Census Data
4	The average area of rice fields	[12, 13, 14, 15, 16]	Agricultural Census Data
5	The average area of non-rice fields		Agricultural Census Data
6	Rice harvest area		Malang Regency in Number
7	Rice production		Malang Regency in Number

3 Result and Discussion

The development of the peri-urban areas is described from several variables related to the agricultural sector. The peri-urbanisation as an impact of urban expansion of Malang City is observed through the impact of changes in agricultural sector data in the surrounding area. The sub-districts that are located on the borderline of Malang City are potentially becoming transitioning areas where urban and rural functions meet [17, 18]. Relatedly, the combination of built-up land use and agriculture is one of the characteristics shown by the peri-urban area, while agricultural areas should dominate the hinterland area.

3.1 Population, Farmers, and Farming Households in Malang Regency

Peri-urbanisation is characterised by a shift in the agricultural sector due to the expansion of urban systems. By analysing the potential continuity in both agricultural practices (human dimension) and agricultural land, this research is expected to show how sub-districts transform into peri-urban areas. Growing population and increasingly dense areas will potentially lead to the conversion of agricultural land into settlements or other built-up functions. The rise in population from 2013 to 2023 is not significantly observed in sub-districts bordering Malang City (Figure 2). This finding indicates, from the population growth perspective, there is limited expansion of

Malang urban system to its surrounding areas. While the most significant population growth is observed in Dampit sub-district (the darkest colour).

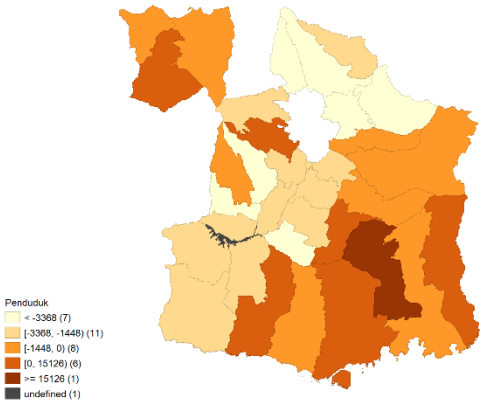

Fig. 2. Choropleth map of total population change 2013 - 2023

In terms of livelihood, peri-urbanisation is characterised by the shift of the dominant livelihood sector of the community, primarily from agriculture-related, such as farmers, to service-oriented livelihood. Addressing this aspect, we consider the number of farmers and farming households in Malang Regency. Figure 3 shows a relatively low number of farmers in the bordering sub-district of Malang City, indicating the potential shift of livelihood into non-agricultural sectors. Moreover, the distribution of changes in the number of farming households can be seen in Figure 4, which shows how the number of farmers in Malang Regency changed in each sub-district in 2013 and 2023. A reduction in farming households mostly occurred in sub-districts near Malang City

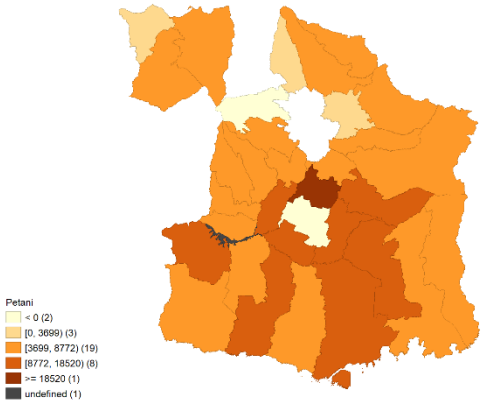

Fig. 3. Choropleth map in changes of number of farmers 2013 - 2023

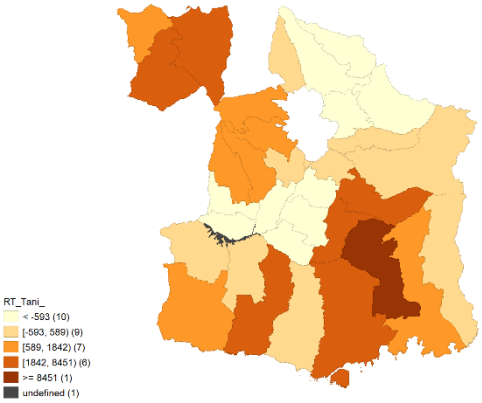

Fig. 4. Choropleth map in changes of number of farming households 2013 - 2023

The distribution of changes in the average area of rice fields can be seen in Figure 5. A reduction in the rice field areas mostly occurred in sub-districts nearby the urban centre of Malang City. Meanwhile, the rise of non-rice fields areas is observed in the Singosari sub-district, on the north border of Malang City (see Figure 6)

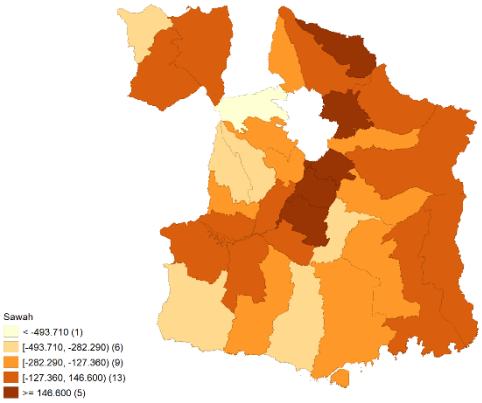

Fig. 5. Choropleth map in changes of the average area of rice fields 2013 - 2023

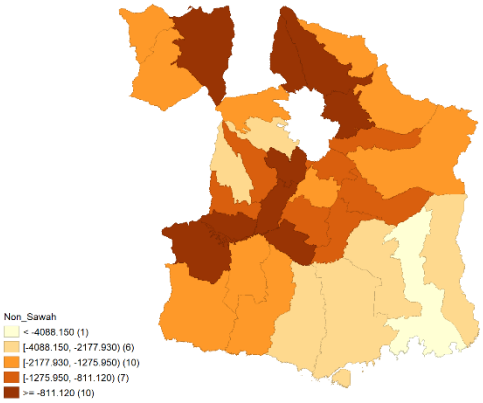

Fig. 6. Choropleth map in changes of the average area of non-rice fields 2013 - 2023

The changes in harvested area can be seen in Figure 7. The distribution is relatively random, with significant increases in sub-districts near Malang City. Furthermore, the changes in rice production, as shown in Figure 8, show a reduction in rice production mostly occurred in sub-districts near Malang City, while increases were mostly seen in distant sub-districts (see Figure 8).

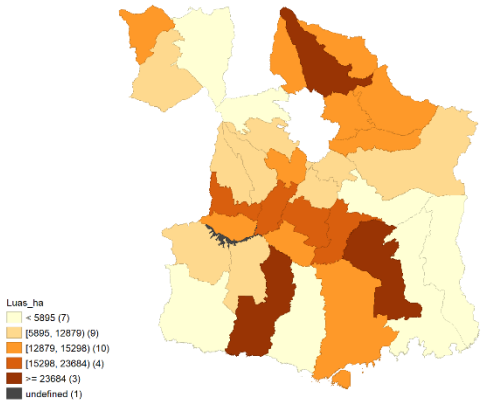

Fig. 7. Choropleth map in changes of rice harvest area 2013 - 2023

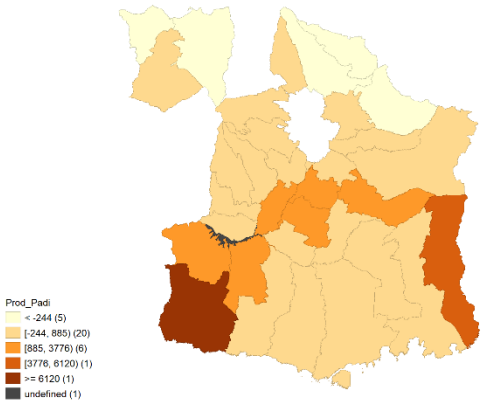

Fig. 8. Choropleth map in changes of rice production 2013 - 2023

3.2 Spatial Autocorrelation of Agricultural Sector in Malang Regency

Table 2 shows the Morans Index of each variable in two different timeframes. In general, all values are positive which indicates the spatial autocorrelation among those variables with its surrounding sub-districts. In other words, such variables mutually influence the same variables in the surrounding sub-districts.

Table 2. Global Morans'I Value

Variable	Data 2013	Data 2023
Total of populations	0,323	0,292
Number of farmers	0,391	0,456
Number of farming households	0,426	0,471
The average area of rice fields	0,309	0,366
The average area of non-rice fields	0,195	0,108
Rice harvest area	0,027	0,283
Rice production	0,095	0,198

The spatial autocorrelation with a value >0 also indicates that each variable has a clustered distribution. This clustering can occur due to various factors, including the regional development conditions in Malang Regency that need to adapt to the city's growth, particularly in fulfilling food necessities in Malang City.

3.3 Typology Cluster Map

Apart from the Morans Index, the spatial correlation analysis also results in a quadrant of scatterplot which represents four regional typologies:

- High-High (H-H) is when the high-value sub-district is surrounded by high-value sub-districts.
- Low-Low (L-L) is when the low-value sub-district is surrounded by low-value sub-districts.
- Low-High (L-H) is when the low-value sub-district is surrounded by high-value sub-districts.
- High-Low (H-L) is when the high-value sub-district is surrounded by low-value sub-districts.

Based on the previous Morans Index values, the number of farmers in Malang Regency in both 2013 and 2023 exhibited spatial autocorrelation. One of the clusters formed by these values includes districts with high population numbers (H-H). In 2013, the H-H

cluster was present in the districts of Singosari, Lawang, Karang Ploso, and Pakis. By 2023, the H-H cluster had decreased, and it was now only present in the districts of Lawang and Singosari. Additionally, the L-L cluster in 2013 was spread across the districts of Pujon, Wonosari, and Kalipare. There was also a region with the L-H typology in the district of Jabung, which maintained a low population and was surrounded by other low-population districts in both 2013 and 2023. In 2023, the H-H cluster was limited to the districts of Lawang and Singosari, while the L-L cluster was distributed across the districts of Pujon, Ngantang, and Wonosari.

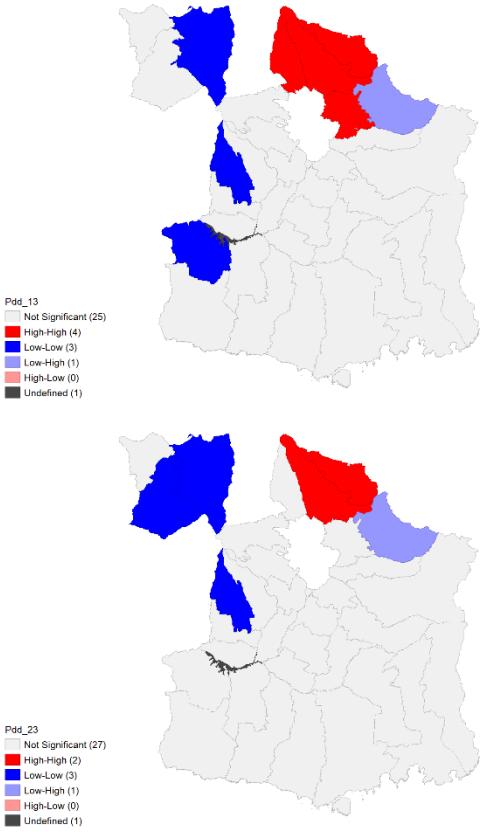

Fig. 9. Distribution pattern of populations in 2013 (top) dan 2023 (down)

In 2013, the H-H cluster was present in the districts of Ampelgading, Tirtoyudo, Dampit, and Sumbermanjing Wetan (Figure 10.). By 2023, the H-H cluster experienced a slight shift, now spread across the districts of Tirtoyudo, Dampit, Sumbermanjing Wetan, Wajak, and Turen. Additionally, in 2013, there was an H-L cluster where Ngajum was a district with a high number of farmers, surrounded by districts with a low number of farmers such as Pakisaji and Kepanjen (L-L). However, by 2023, Ngajum had joined Pakisaji and Kepanjen in the L-L cluster.

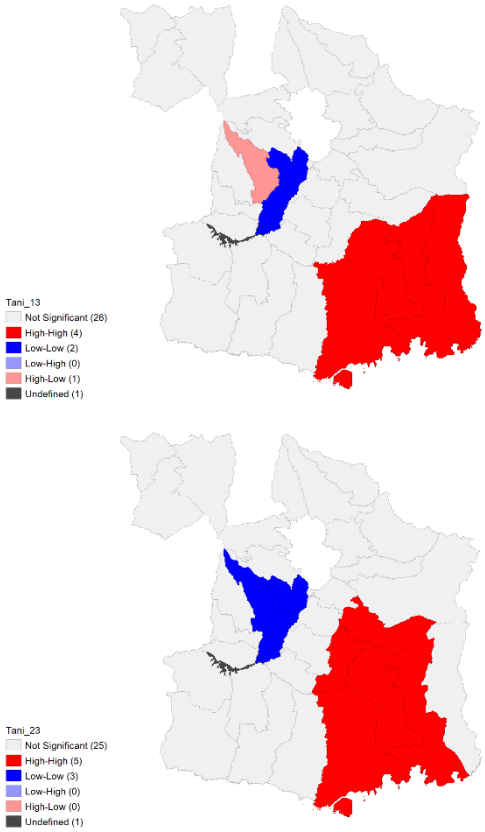

Fig. 10. Distribution pattern of farmers in 2013 (top) dan 2023 (down)

The H-H cluster, in terms of the number of farming households, was present in the districts of Ampelgading, Tirtoyudo, Dampit, Sumbermanjing Wetan, and Turen in 2013 (Figure 11). By 2023, the H-H cluster expanded to include the district of Wajak. Additionally, in 2013, the L-L cluster included the districts of Pakisaji, Wagir, Ngajum, Kromengan, and Kepanjen. By 2023, the L-L cluster comprised the districts of Pakisaji, Ngajum, Kepanjen, and Singosari.

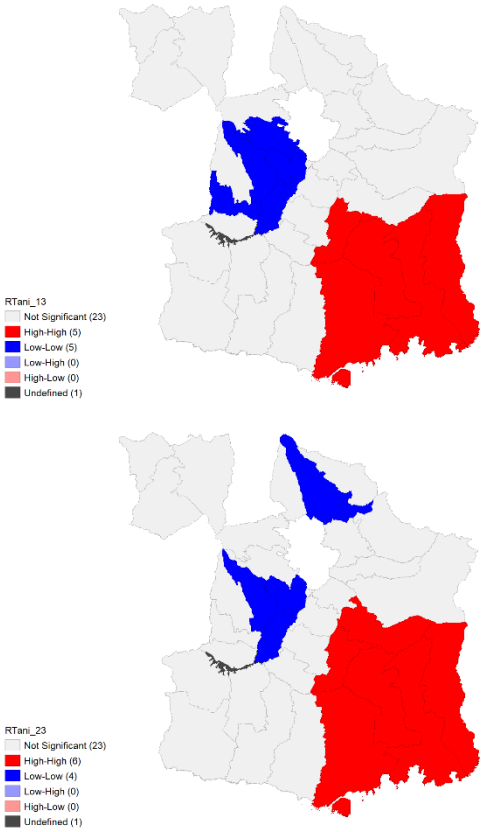

Fig. 11. Distribution pattern of farming households in 2013 (top) dan 2023 (down)

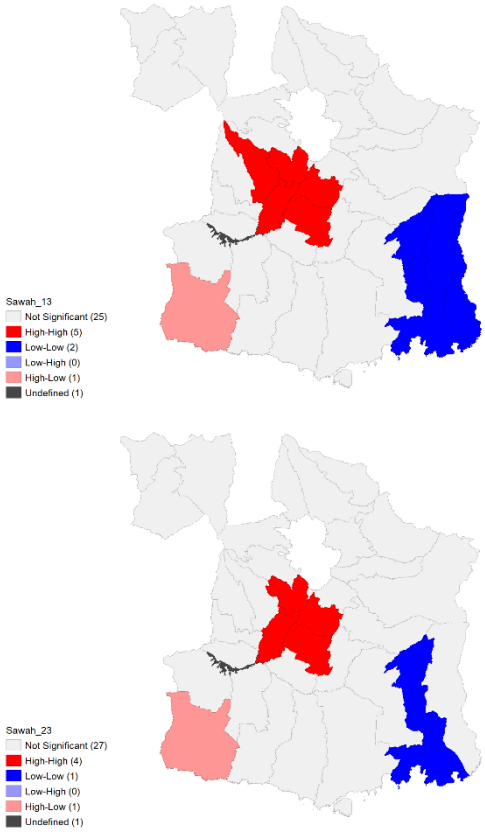

Fig. 12. Distribution pattern of the average rice fields area in 2013 (top) dan 2023 (down)

There were three clusters based on the average area of rice fields in 2013 (Figure 12). The H-H cluster was present in Ngajum, Pakisaji, Kepanjen, Bululawang, and Gondanglegi districts. The L-L cluster was found in the districts of Ampelgading and Tirtoyudo. The district of Donomulyo was classified as an H-L cluster in both 2013 and 2023. By 2023, the H-H cluster had decreased, including only the Pakisaji, Kepanjen, Bululawang, and Gondanglegi districts. Similarly, the L-L cluster was now present only in the district of Tirtoyudo.

There were three clusters based on the average area of non-rice fields in 2013 (Figure 13). The H-H cluster was present in the districts of Tirtoyudo and Sumbermanjing Wetan. The L-L cluster was identified in the district of Gondanglegi. The H-L cluster was found in the district of Bululawang. By 2023, the H-H cluster had shifted significantly to the districts of Donomulyo and Bantur. The L-L cluster was spread across Kromengan, Wajak, and Dampit districts. The district of Ngajum was characterized by the H-L typology.

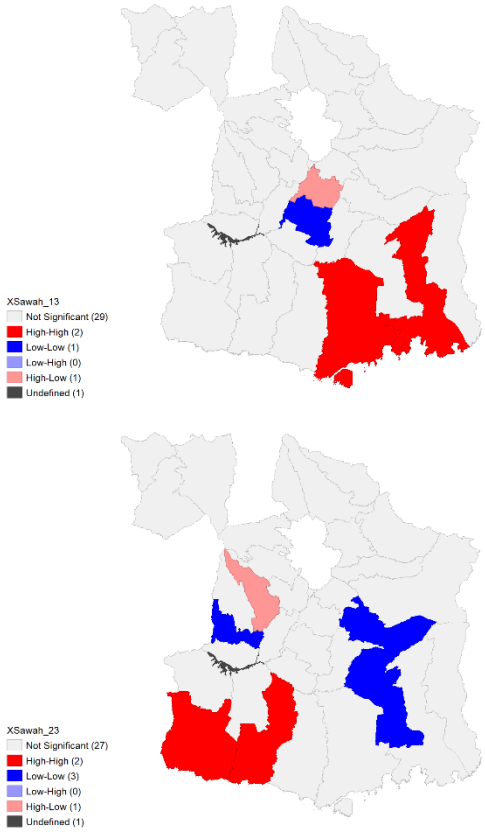

Fig. 13. Distribution pattern of the average non-rice fields area in 2013 (top) dan 2023 (down)

The H-H cluster for rice harvest area was present only in the district of Lawang, with no other clusters identified in 2013 (Figure 14). This is supported by the Moran's Index value for this variable, which was only 0.027, indicating a distribution closer to random spatial distribution. By 2023, the H-H cluster had shifted significantly to the districts of Kalipare and Sumberpucung. The L-L cluster was distributed across the districts of Ngantang, Pujon, and Kasembon. In 2023, a new L-H typology emerged in the district of Pagak.

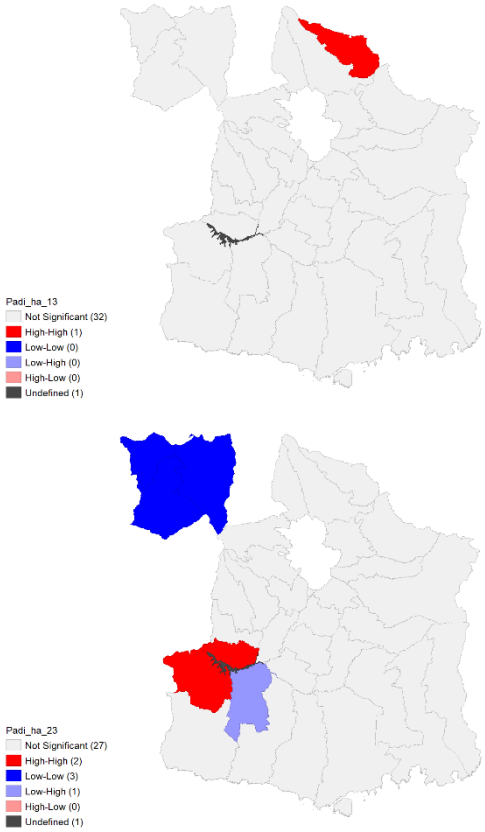

Fig. 14. Distribution pattern of rice harvest area in 2013 (top) and 2023 (down)

In 2013, the H-H typology for the variable of rice production was present only in the district of Lawang, with no other clusters identified (Figure 15). Similarly, the L-L typology was found only in the district of Ampelgading. The L-H typology was present only in the district of Gedangan. By 2023, the H-H cluster had shifted significantly to the districts of Kalipare and Gondanglegi. The L-L cluster was distributed across the districts of Pujon and Kasembon. In 2023, a new L-H typology emerged in the district of Pagak.

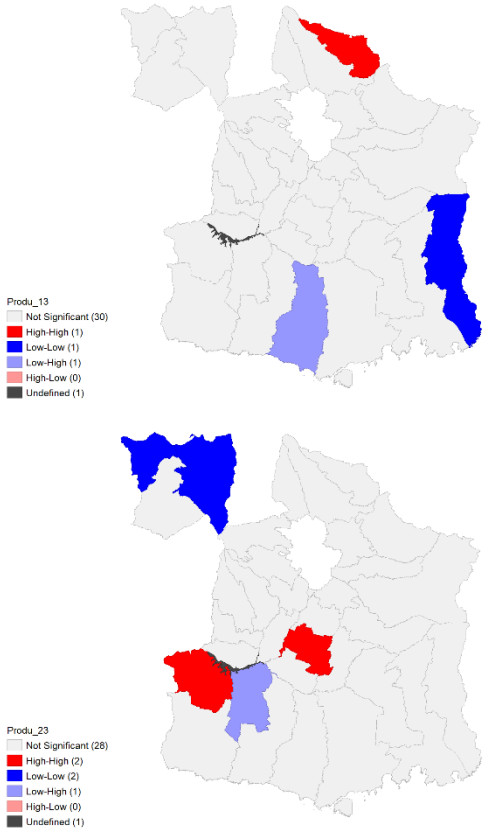

Fig. 15. Distribution pattern of rice production in 2013 (top) and 2023 (down)

4 Conclusion

The spatial distribution of variables such as population, number of farmers, number of farming households, average rice field area, average non-rice field area, rice harvest area, and rice production in Malang Regency reveals differing agricultural conditions in the peri-urban areas between 2013 and 2023. According to Moran's Index values, all variables describing the agricultural sector in Malang Regency exhibit positive spatial autocorrelation with clustering patterns. This information assists policymakers in understanding the distribution of areas with H-H, L-L, L-H, and H-L agricultural conditions, thereby facilitating a more equitable distribution of agricultural resources in Malang Regency as a hinterland and Malang City as the centre of activities. Distance to the city area (Malang City) is one factor that causes clusters to form in the southern or northern areas of Malang Regency.

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