

Research Article**Spatial-Temporal Study of Stunting Risk in East Java 2021 - 2023**Sofiyulloh^{1*} | Martya Rahmaniati¹ | Fajar Nugraha¹

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ABSTRACT

Stunting remains a significant global health issue affecting children, and Indonesia is still one of the countries with a high prevalence of stunting. Over the past three years, the prevalence of stunting in Indonesia was reached 24.4% in 2021, 21.6% in 2022, and 21.5% in 2023. East Java is one of the provinces still experiencing high stunting rates, although the figures are slightly below the national average. From 2021 to 2023, a decrease occurred, though not significantly. Several factors such as age at marriage and low birth weight are associated with the risk of stunting in East Java. This study employs a spatial-temporal approach through the visualization of stunting risk mapping using geographic information systems (GIS). Secondary aggregate data were obtained from the Indonesian Ministry of Health, BPS East Java, and digital maps sources. The h three-year autocorrelation analysis showed greater changes in the Moran's I value from 2021-2023, indicating changes in special pattern. In mapping the risk of stunting, there is a change in distribution of t high and low risk areas, although some areas remained in the same category. The results from the analysis and visualization in this study are expected to serve as valuable input for stakeholders to overcome stunting in East Java.

Keywords: stunting, East Java, spatial, GIS, autocorrelation

INTRODUCTION

Stunting is one of critical health issue affecting children globally, including Indonesia, and continues to be a major concern and priority. Recent data show that stunting persist, with more than 149 million children under the age of five worldwide affected, resulting in a global stunting prevalence of 22.0% in 2020. The highest incidence is estimated to occur in Asia and Africa (Prendergast & Humphrey, 2014; Raiten & Bremer, 2020). Stunting is a complex problem, because it is caused by direct and indirect factors.. Some of these factors found from several regions highlight that poor nutritional status, both in children and mothers during pregnancy (de Onis & Branca, 2016; Vaivada et al., 2020). Malnutrition in pregnant women can result to low birth weight (LBW), which is one of the contributing factors for stunting (Halli et al., 2022; Ode et al., 2022). Additionally, limited access to health services and inadequate sanitation, such as lack of clean drinking water, which is related to the causes of infection (Budiyatri et al., 2024; de Onis & Branca, 2016). Socioeconomic factors, such as poverty and low levels of maternal and family education,



also play a significant role (Banhae et al., 2023; Vaivada et al., 2020). Moreover, teenage motherhood increases risk of stunting in children (Haque et al., 2022; Simbolon et al., 2021).

The prevalence of stunting in Indonesia has shown a declining in recent years, decrease, although it remain quite high compared to several other Southeast Asian countries. As of 2022, it was estimated that more than six million children in Indonesia were affected stunting (Helmyati, 2022; Prafianti, 2024; Suparji et al., 2024). In 2021, the stunting prevalence in Indonesia was 24.4%, decreasing to 21.6% in 2022, and slightly dropping to 21.5% in 2023.. Although this show a decrease trend, the reduction has not met the expectations set by the Indonesian Government (BPPK & Kemenkes, 2024; BPPK Kemenkes, 2023; Kemenkes, 2021). The incidence of stunting in several Southeast Asian countries, including Indonesia, is influenced by several factors such as parenting practices, health status, socioeconomic background, maternal factors, educational, as and government policies (UNICEF, 2021, 2022). In Indonesia, stunting hotspot areas have been identified on several islands, namely Sumatra, Java, Sulawesi, Bali, East Nusa Tenggara (NTT), and West Nusa Tenggara (NTB). Significant contributing factors include maternal characteristics, socioeconomic condition, and sanitation factors (Murad et al., 2022; Sipahutar, Eryando, & Budhiharsana, 2022). Maternal factors linked to stunting include antenatal care (ANC) attendance, labor and delivery condition (such as the duration of labor), education level, maternal age, marital age, and economic status. Infant-related factors, such as circumstances at birth, prematurity, LBW, and a history of exclusive breastfeeding, are also associated with stunting in Indonesia (Apriluana & Fikawati, 2018; Budiastutik & Nugraheni, 2018; Holimombo, 2023; Mustajab & Indriani, 2023; Sofiyulloh & Rahmaniati, 2024).

Similar to the national trend, East Java has experienced a downward trend in stunting prevalence over the past three years. In 2021, the prevalence reached 23.5%, decreased to 19.2% in 2022, and further dropped to 17.7% in 2023, (BPPK & Kemenkes, 2024; BPPK Kemenkes, 2023; Kemenkes, 2021). East Java, as part of Java Island, is one of the hotspot areas for stunting incidence (Sipahutar, Eryando, & Budhiharsana, 2022). Despite the decline, some areas in East Java still report quite high rates. For instance, in 2022, Jember, Bondowoso, and Situbondo each had stunting prevalence rates of more than 30%. These high rate are related with multiple factors, such as maternal and adolescent health status, as well as the incidence of child marriage (Sekneg RI, 2023). Marriage at a relatively young age can negatively affect maternal health, which in turn to increases the risk of LBW and stunting in children. So, sustained and targeted efforts are needed to reduce stunting in East Java and meet the national targets set by the central government (BKKBN, 2023; Mukodi et al., 2023). In addition, based on a spatial analysis of the incidence of stunting in Indonesia, 21 out of a total of 38 districts/cities in East Java are considered vulnerable (Sipahutar, Eryando, & Budiharsana, 2022), which means that more than 75% of areas in East Java remains at high risk for stunting.

Based on the literature review presented earlier, several contributing factors have been identified as determinants of stunting in the East Java region. These include maternal factors, such as age at marriage, and infant-related condition, most notably the incidence of LBW. From this findings, an intervention approach that focuses areas with a high risk of stunting prevalence is very important. Areas with significant risk levels require special attention. Therefore, this study aims to map the risk of stunting incidence in East Java, using time series data from the past three years (2021 – 2023). With this stunting risk mapping, it is hoped that targeted interventions can be implemented in high risk areas, while medium-risk areas can receive preventive measures and monitoring. Meanwhile, low-risk areas can serves as models or learning center for other areas. Data

from the Indonesian Ministry of Health and the East Java Central Bureau of Statistics serve as the primary sources for determining stunting risk areas in East Java.

MATERIAL AND METHODS

This section explains the research type, location and timeframe, population and sample, sampling technique, data collection method, data analysis, and data presentation. For studies utilizing tools and materials, it is essential to clearly specify the tools and materials used. Qualitative studies, such as case studies, phenomenology, ethnography, and others, must include an additional explanation of how the validity of the research findings is verified.

This research is an ecological study employing a spatial approach. The ecological aspect in this study involves the use of aggregate data, specifically secondary data obtained from the Ministry of Health of the Republic of Indonesia and the Central Bureau of Statistics (BPS) of East Java for the years 2021, 2022, and 2023. These data have been officially published and are accessible through their website <https://jatim.bps.go.id/id> and <https://www.badankebijakan.kemkes.go.id/>. The variables used in this study include are the prevalence of stunting (sourced from Ministry of Health), the number of babies born weighing less than 2.5kg (low birth weight), and the percentage of women whose first marriage before the age of 19 (age of marriage), with both of the latter variables sourced from BPS East Java. For the spatial analysis, shapefile data were obtained from <https://www.indonesia-geospasial.com/2020/05/download-data-peta.html>, consisting of district / city level maps of East Java and provincial level maps of Indonesia. The unit of analysis is at the district/city level in East Java, totalling 38 administrative areas for each year analysed (2021, 2022, and 2023). Data processing and analysis were conducted using a spatial approach, including stunting risk mapping. Additionally, statistical analysis was carried out using multiple linear regression to examine contributing factors to stunting incidence in East Java during 2021 - 2023.

After data collection, we conducted autocorrelation analysis using Moran's I, both globally and locally, to obtain the Moran's I value and identify distribution pattern (Sipahutar et al., 2024). Next, we used Quantum GIS (QGIS) to visualize the data in the form of digital maps. In this study, researchers mapped the prevalence of stunting in East Java for each year, 2021, 2022, and 2023. For each year, the prevalence of stunting was classified into three categories: low, medium, and high. These classifications were determined based on the distribution of stunting prevalence across East Java, with category intervals established after reviewing the three-year series of prevalence data. In addition to the stunting variable, the variables of age at first marriage and low birth weight were also grouped into three groups following a similar approach.

For the variables of low birth weight and age at marriage, the researchers conducted categorization and scoring. Score weighting was applied after assigning a category to each variable. The scoring range was 1 to 3, a score 1 was given to the low category, 2 to the medium category, and 3 to the high category. So, the maximum score for each variable in a single year was 3, and the maximum cumulative score over three years was 9. Based on the scoring results, a new classification was conducted, dividing the scores into three categories, low, medium and high.

The next step was the overlay process for stunting risk mapping, derived from the combined results of the three variables. Researchers mapped the stunting risk for each year, 2021, 2022, and 2023, and also mapped the overall risk of stunting by analysing all three years and variables. For this cumulative mapping, classification was again divided into three categories, low, medium, and high based on the total score obtained from the sum of three variables. The maximum possible score in this case was 27. The categories are low, medium, and high.

RESULTS AND DISCUSSION

Overview of Stunting in East Java

The first spatial analysis carried out was autocorrelation using Moran's Index, which included both global and local tests. In the global test, the Moran's I stunting values were obtained for each year (2021 - 2023), while the local test produced stunting clustering map for each year, according to the respective quadrant. The following are the results of the autocorrelation analysis of stunting in East Java for the years 2021 to 2023:

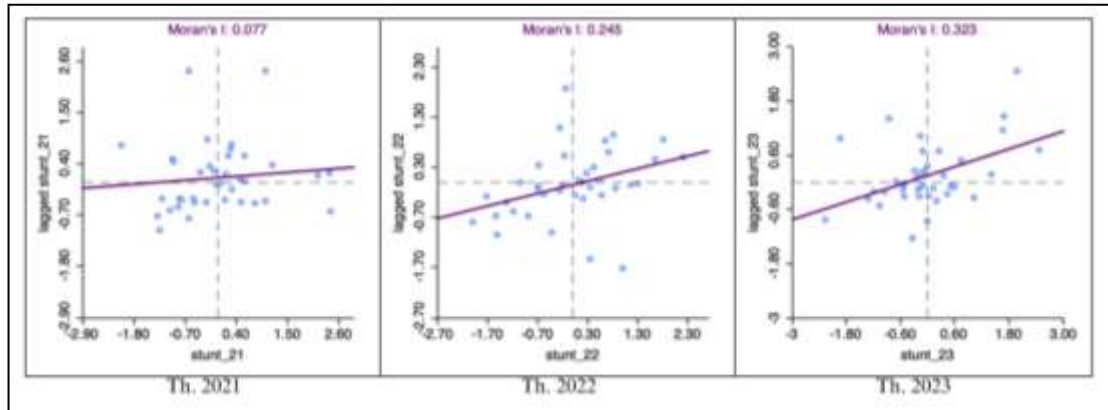


Figure 1. Moran's Index Calculation Results

Based on the results of the Moran's I calculation in Figure 1, there are observable changes and increases in the Moran's I value from 2021 to 2023. In 2021, the Moran's I value was 0.077 which means the correlation is very weak. In 2022, the Moran's I value increased to 0.245 and indicated a more significant correlation than in the previous year. By 2023, the Moran's I value had reached 0.323, indicating a moderate correlation, greater than in the previous two years. These results suggest that the distribution of stunting cases in East Java tends to be increasingly clustered in certain locations.

Further details regarding the clustering distribution of stunting are presented below:

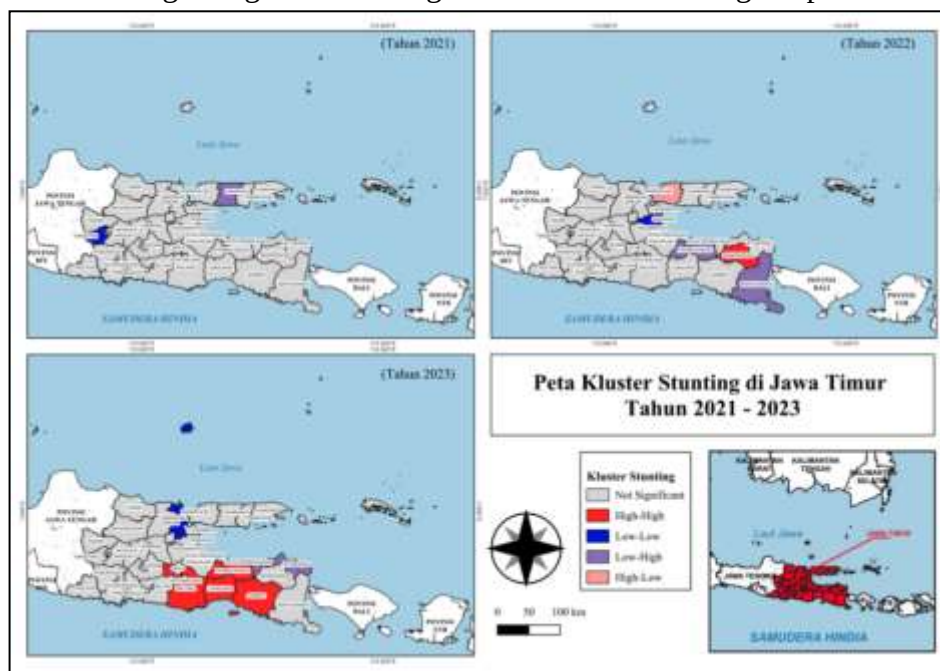


Figure 2. Stunting Clustering Map in East Java in 2021, 2022, and 2023 Using Moran's Local Index

Based on the results of the local autocorrelation analysis, the clustering pattern of stunting cases in East Java from 2021 to 2023 are shown in Figure 2. The results indicate changes in the clustering distribution pattern over the years, including the number of districts / cities that are significant areas in quadrant I (high-high), quadrant II (low-low), quadrant (low-high), or quadrant IV (high-low). Of the three years, 2023 shows the highest number of high-high areas, which also appears to be clustered. In contrast, in 2022, only one district, Situbondo was not included in this category. In 2021, no high-high areas we identified, and only two districts showed significant clustering, Magetan (low-low) and Sampang (low-high).

In mapping the prevalence of stunting in East Java from 2021 to 2023, classification were made based on the existing prevalence values. The classification is divided into three categories: low (<16.5%), medium (16.5% - 21.97%), and high (>21.97%). The following presents the stunting prevalence maps in East Java for each year, 2021, 2022, and 2023:

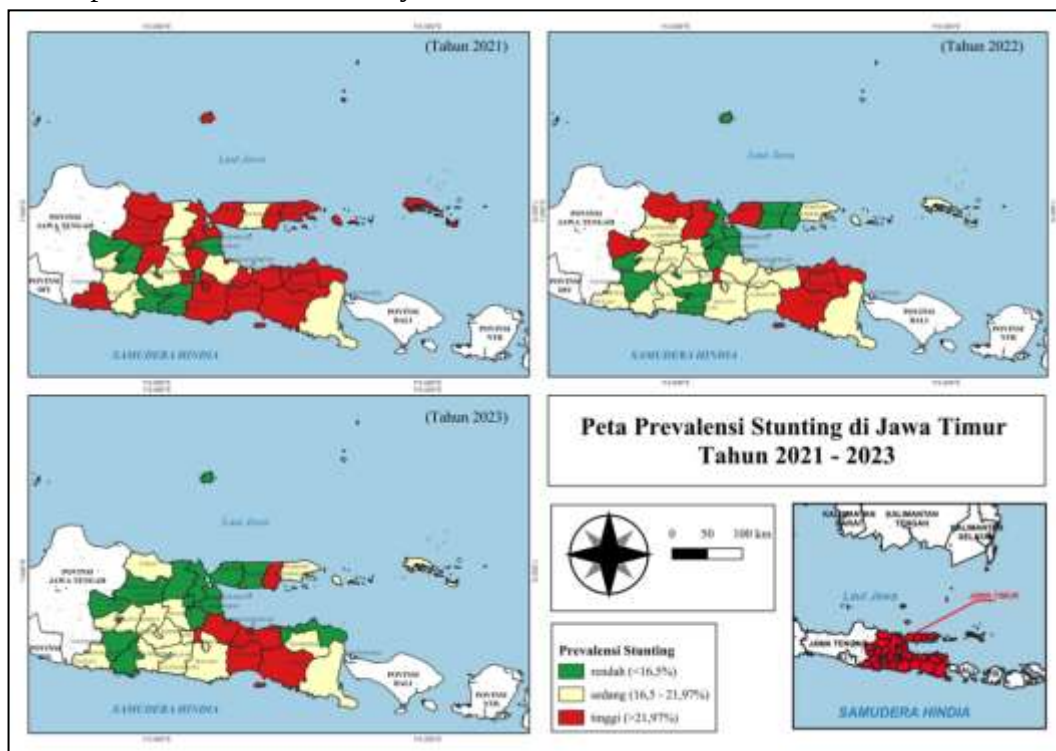


Figure 3. Map of Stunting Prevalence in East Java in 2021, 2022, and 2023

In Figure 1, the map presented the prevalence of stunting in East Java, classified by colour into three categories for the years 2021, 2022, and 2023. In the 2021 map, 18 districts/cities fall into the high-risk category (red), including Bangkalan, Bondowoso, Tuban, Jember, Situbondo, Lumajang, Sumenep, Malang, Malang City, Nganjuk, Bojonegoro, Probolinggo, Pacitan, Pasuruan City, Pamekasan, Surabaya, Mojokerto, and Gresik. The medium-risk category includes 10 districts/cities; while remaining 10 districts/cities fall into the low-risk category. In 2022, the number of high-risk areas reduced to 8 districts/cities, namely Bangkalan, Bondowoso, Tuban, Jember, Situbondo, Lamongan, Ngawi, and Batu. The medium-risk category increased to 17 districts/cities, while the low-risk category is 13 districts/cities. In the 2023 map, those in the high-risk category declined to 7 districts/cities, Jember, Batu, Lumajang, Probolinggo, Pasuruan, Probolinggo City, and Pamekasan. A total of are 16 districts/cities in the medium-risk, and 15 districts/cities in the low-risk category.

Based on the classification of stunting prevalence in East Java from 2021 to 2023, several districts/cities consistently in the same category in all three years, whether in the high, medium, or

low categories. In the high category, Jember consistently appeared. In the medium category, Jombang, Banyuwangi, and Kediri remained stable. Meanwhile, Sidoarjo, Madiun City, and Mojokerto City were always in the low category. Other districts/cities experienced changes, either moving up or down in the category.

The mapping of stunting risk in East Java, which resulted several areas falling into the high-risk category, in line with previous research on the phenomenon of stunting in Indonesia. Based on spatial analysis, there are 21 districts / cities in East Java considered prone to stunting, including Bondowoso, Jember, Lumajang, and Situbondo (Sipahutar, Eryando, & Budiharsana, 2022). Similarly, a study of stunting incidence in Indonesia using 2019 data and LISA analysis, found that the areas included in the high-high quadrant in East Java were Jember and Lumajang (Tahangnacca & Muntahaya, 2022). Jember and Bondowoso are the locus areas of stunting since 2019, and their prevalence of stunting has not decrease consistently (Hariani et al., 2023). Another spatial temporal stunting in East Java, which used data from 2017 - 2021 with fuzzy methods, found that Pasuruan and Pasuruan City in the high-risk category, while Jember fell into the medium category, and Bondowoso, Lumajang, and Situbondo fell into the low-riskcategory (Fariza et al., 2023). These differences can occur due to several factors, such as different years and the independent variables. The increase in spatial autocorrelation of stunting in East Java from 2021 to 2023 shows a spatial diffusion pattern, where stunting cases tend to spread and cluster in certain areas. Additionally, there are changes in areas that become coldspots and hotspots. This phenomenon indicates that areas with high stunting prevalence can influence surrounding areas, resulting to the geographical spread of cases. Fariza et al (2023) explained that spatial temporal visualization is crucial for understanding the distribution and clustering pattern of stunting cases [Click or tap here to enter text..](#) Studies using spatial diffusion can help identify hotspots areas that need special attention, such as improved health services or locally specific policies. Spatial diffusion also show how deaths are concentrated in clusters, potentially related to geographical access, socio-economic conditions, or health services (Chowdhury et al., 2019; Eyles & Williams, 2016). Understanding these spatial diffusion patterns is essential for designing more effective and focused interventions in high-risk areas, so that efforts to reduce stunting prevalence can be more targeted and efficient. Although temporal analysis reveals an overall decline in prevalence, stunting remains a public health challenge. Factors from health conditions contribute to its incidence. Spatial mapping and temporal analysis are essential in identifying trends and patterns of stunting distribution, which can help policymakers design targeted interventions to tackle the problem. Berti and La Vecchia (2023) explain that a robust nutrition and health surveillance system is vital for monitoring and addressing stunting effectively.

Mapping Stunting Risk Areas

The next mapping involved overlaying of the stunting map with two other variables: age at marriage and low birth weight, mapped for the years, 2021, 2022 and 2023. So that the mapping results are presented in Figure 3, is classified into three categories based on the scoring results that have previously been carried out. The categories are low (score <5), medium (score 5 - 7), and high (score >7).

In the 2021 map, nine districts that fall into the high category: Bojonegoro, Situbondo, Sumenep, Lumajang, Pacaitan, Pamekasan, Nganjuk, Malang, and Probolinggo. Additionally, 24 districts/cities are in the medium category, while five districts/cities, Sidoarjo, Blitar, Blitar City, Ngawi, and Mojokerto City, fall into the low category. In 2022, seven districts are categorized as high, Situbondo, Bondowoso, Tuban, Jember, Bojonegoro, Lumajang, and Lamongan. 19

districts/cities in the medium category and 12 districts/cities in the low category. By 2023, the number of districts in the high category decreased to five, Jember, Pamekasan, Bondowoso, Lumajang, and Probolinggo. The medium category includes 20 districts/cities, while 13 other districts/cities fall into the low category.

Based on the mapping of stunting risk areas in 2021, 2022, and 2023, several districts/cities consistently in one category. In the high-risk category, Lumajang is consistent from 2021 to 2023. In the medium-risk category, eight districts/cities Banyuwangi, Jombang, Probolinggo City, Pasuruan, Tulungagung, Kediri, Batu, Bangkalan, and Sampang were consistently classified as medium. Meanwhile, Sidoarjo and Blitar City are in the low category. Other districts/cities experienced category changes in the three years.

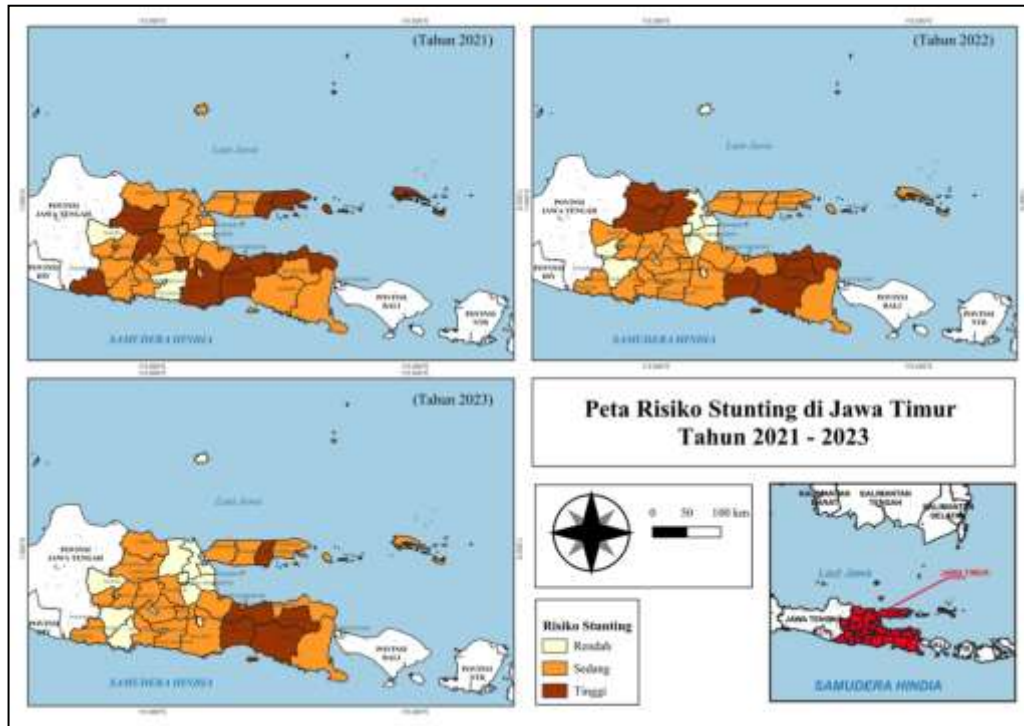


Figure 4. Stunting Risk Map in East Java in 2021, 2022, and 2023

The next mapping is an overlay of the stunting risk areas for each year 2021, 2022, and 2023 in East Java. In the final risk mapping presented in Figure 4, three categories: low (score <15), medium (score $15 - 23$), and high (score >23). The results show that four districts, Jember, Lumajang, Bondowoso, and Situbondo fall into the high-risk category during the 2021 to 2023 period. When viewed on a map, these four districts are located close to each other, not separated by land or sea from the administrative areas of other districts / cities. In the moderate category, there are 24 districts/cities, which is the majority category. The remaining 10 districts/cities, Ngawi, Ponorogo, Mojokerto, Gresik, Kediri City, Malang City, Madiun City, Sidoarjo, Blitar City, and Mojokerto City fall into the low-risk category. These low-risk areas are spread across several areas, although they tend to be around the provincial capital, Surabaya, although Surabaya itself is not included in the low-risk category. In addition, 5 of the 10 areas in the low-risk category are cities. Given that there are 9 cities in East Java, meaning that more than half of them fall into the low-risk, and none fall into the high-risk.

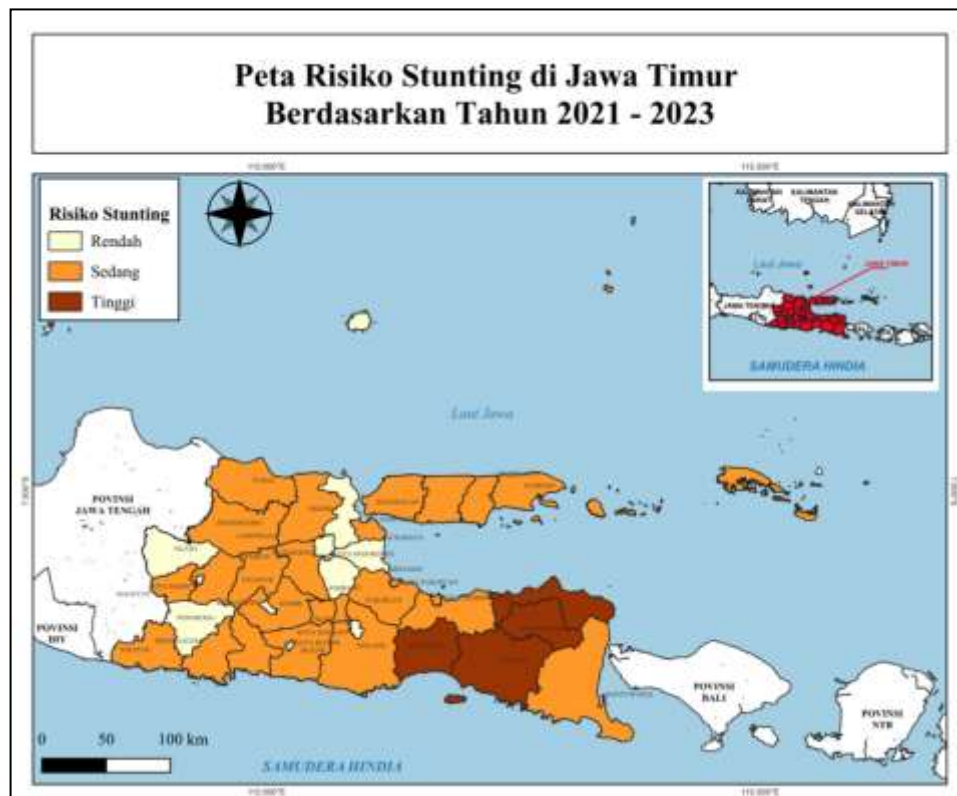


Figure 5. Map of Stunting Risk Categorization in East Java Based on 2021-2023 with Overlay Method

The marriage age factor is still a concern in the stunting prevention in East Java and is also a concern of the local government (Sekneg RI, 2023). Mothers who marry in their teenage years tend to give birth to children a higher risk of stunting. This can be caused by the high risk of pregnancy at the young age, limited knowledge about pregnancy preparation and parenting, as well as biological immaturity (Agus et al., 2022; Mahmood et al., 2022; Tshiya & Magoha, 2020). Addressing stunting among young mothers requires various approaches, including sectoral and multidisciplinary approaches, as well as actions at various levels, from local to global (Atamou et al., 2023; Jannah, 2023; Makanjana & Naicker, 2021). In addition to age at marriage, low birth weight is another factor that correlates quite highly with the prevalence of stunting (Syauqi Haris et al., 2022), low birth weight is a significant risk factor in 137 developing countries. Countries with high LBW rates tend to have high rates of stunting (Danaei et al., 2016)(Rakhmahayu et al., 2019) Infants born in the low birth weight are at greater risk for developmental disorders, which can impact their development and growth and lead to stunting, including chronic malnutrition (Girotra et al., 2023) The incidence of low birth weight is also related to the condition of the mother, especially her nutritional status. Maternal undernutrition is the main cause of low birth weight, with more than 13 million babies born with low birth weight each year, especially in underdeveloped areas (Mason, 2012).

CONCLUSION AND SUGGESTION

There are four districts in East Java identified as high-risk areas for stunting based on the mapping results: Jember, Lumajang, Bondowoso, and Situbondo. Meanwhile, ten districts/cities are categorized as low risk: Ngawi, Ponorogo, Mojokerto, Gresik, Kediri City, Malang City, Madiun City, Sidoarjo, Blitar City, and Mojokerto City. The identification of these risk areas is expected to help optimize stunting prevention in East Java, especially in areas that are in the high regions while

using. low risk regions as references or success stories in stunting prevention strategies. In the prevention of stunting, it is essential that multi-level and multi-sectoral collaboration continues to be optimized and focused. This study used secondary data from various sources, which may result differences when compared with previous studies. Therefore, a more detailed analysis is recommended for future studies to identify specific factors that contribute to stunting in East Java.

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