

FUTURE POPULATION PREDICTION 2050 OF BANTEN PROVINCE, JAKARTA, JAWA BARAT, JAWA TENGAH, DAERAH ISTIMEWA YOGJAKARTA, JAWA TIMUR, USING WORLDPOP DATA WITH GOOGLE EARTH ENGINE

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ABSTRACT

This study uses WorldPop data and the Earth Engine platform to predict population in Banten, Jakarta, West Java, Central Java, Special Region of Yogyakarta and East Java Provinces. Through high-resolution grid-based analysis, the study identifies patterns of population growth that are not visible with traditional, more aggregated data. Prediction results show significant population increases from 2020 to 2023, with Jakarta and West Java experiencing the most notable growth. Predictions for 2050 show significant population increases in all provinces, with Jakarta and West Java being the provinces with the highest populations. The implications of these population dynamics for infrastructure planning and public policy are critical to anticipate rapid population growth. This information can be used for more effective resource allocation, targeted infrastructure planning, and improved public welfare. Thus, this research is expected to make a significant contribution to regional planning and sustainable development, as well as in facing future demographic challenges.

Keywords: Population prediction, Google Earth Engine, WorldPop

INTRODUCTION

Effective regional development planning requires a deep understanding of future demographic dynamics. The provinces of Banten, DKI Jakarta, West Java, Central Java, Special Region of Yogyakarta, and East Java are regions that play an important role in Indonesia's economy and governance. Population dynamics in these provinces have significant implications for infrastructure planning, public policy, resource distribution, and social services. Population prediction is a key element in regional planning [1]. By knowing the estimated future population, the government and stakeholders can make more informed decisions in various sectors, including housing, transportation, education, health, and the environment [2]. In particular, the provinces of Banten, DKI Jakarta, West Java, Central Java, Special Region of Yogyakarta, and East Java face major challenges such as rapid urbanization, regional inequality, and the need for adequate infrastructure.

Rapid urbanization in these areas has resulted in various problems such as high population density, traffic congestion, environmental degradation, and pressure on public services [3]. Jakarta as the nation's capital, for example, continues to face a significant increase in population, which poses major challenges in terms of the provision of public facilities and quality of life. Meanwhile, neighboring provinces such as West Java and Banten are also experiencing rapid population growth as a result of

urban sprawl and population migration. In this context, the use of WorldPop data integrated with Google Earth Engine offers new opportunities to conduct population analysis with higher accuracy [4]. WorldPop provides population data developed with sophisticated methods and high spatial detail, while Google Earth Engine is a computing platform that enables large-scale geospatial analysis with high efficiency. Combining these two resources enables more precise and reliable predictions.

Google Earth Engine facilitates big data processing and complex spatial analysis, allowing researchers to explore and predict population change more effectively [5]. By utilizing WorldPop data that provides high-resolution grid-based population estimates, we can identify patterns of population growth that are invisible to traditional, more aggregated data. The integration of these technologies supports the creation of population prediction models that are not only accurate, but also accessible and understandable to a wide range of stakeholders[6]. The results of these population predictions will be valuable for public policy planning at the provincial level [6]. The information obtained can be used to allocate resources more effectively, plan targeted infrastructure development, and improve public welfare [7]. For example, accurate predictions of high population growth areas can help in planning for additional education and health facilities, as well as in designing policies that can reduce pressure on congested urban areas. Given the importance of demographic information for future planning, this study aims to predict the future population in Banten, DKI Jakarta, West Java, Central Java, Yogyakarta Special Region, and East Java Provinces using WorldPop data with the help of the Earth Engine platform. Thus, this research is expected to make a significant contribution to regional planning and sustainable development, as well as in facing upcoming demographic challenges.

RESEARCH METHODS

This research was conducted in Banten Province, Jakarta, West Java, Central Java, Special Region of Yogyakarta, East Java. This research uses administrative boundaries obtained from the Geospatial Information Agency and WorldPop Global Project Population Data: Estimated Residential Population per 100x100m Grid Square which can be accessed on Google Earth Engine. Data analysis for this study was conducted on Google Earth Engine: <https://earthengine.google.com/>. WorldPop Global Project Population Data: Estimated Residential Population per 100x100m Grid Square is a high-resolution global dataset that provides estimates of the number of people living in each grid cell of approximately 100x100 meters. This dataset is designed to support accurate measurement of the impact of population growth, change monitoring, and intervention planning. These estimates are based on an enumeration of recent census data matched to their administrative units, then used to distribute the population to grid cells through a machine learning approach that utilizes the relationship between population density and various layers of geospatial covariates. This mapping approach is based on dasymetric redistribution using Random Forest.

This dataset includes the estimated number of people living in each grid cell for 2010, 2015, and other years. For 2020, the dataset is available with a population split by age and gender. In addition, there are also other WorldPop gridded datasets that address population age structure, poverty, urban growth, and population dynamics that are freely available on the WorldPop website. WorldPop is a collaboration between researchers from the University of Southampton, Universite Libre de

Bruxelles, and the University of Louisville, and is primarily funded by the Bill and Melinda Gates Foundation. The following is a detailed description of the methods that will be used:

- 1) **Data Collection:** The first step involves collecting population data from WorldPop, a project that provides high-resolution global datasets on the distribution of human populations. This dataset includes estimates of the number of people living in each grid cell of approximately 100x100 meters, which is very useful for spatial analysis and population prediction at the provincial level.
- 2) **Selection of Study Area:** The research will focus on six provinces in Indonesia, namely Banten, Jakarta, West Java, Central Java, Special Region of Yogyakarta, and East Java. These provincial boundaries will be used as a filter to select relevant data from the WorldPop dataset.
- 3) **Data Analysis and Visualization:** The selected data will be analyzed and verified using Google Earth Engine (GEE), a geospatial analytics platform that allows users to process and analyze global-scale geospatial data. Data visualization will be conducted to understand the current population distribution and population growth trends in the provinces.
- 4) **Future Population Prediction:** To predict the population in 2023 and 2050, researchers will use the linear regression method. This method will utilize historical population trends and demographic factors to estimate future population development. The script uses the `reduce(ee.Reducer.linearFit())` function to calculate the linear regression:

```
var regression = popYearBand.reduce(ee.Reducer.linearFit());
```

This calculates the linear regression parameters, namely scale (slope) and offset (interception). These parameters are used to describe the relationship between year and population in the form of a linear equation $y = mx + b$ where: y is population, m is scale or slope, x is year, b is offset or interception.
- 5) **Validation and Interpretation of Results:** The prediction results will be validated and interpretation will be done based on the local context and demographic conditions of Indonesia. This validation is important to ensure that the predictions are accurate and relevant to the reality on the ground.

Through these methods, this research aims to provide valuable insights to the government, planners, and the academic community on the population dynamics in Indonesia and how it may affect future social, economic, and environmental developments.

RESULTS AND DISCUSSION

Results show that all provinces in the study showed an increase in population from 2020 to 2023, with the most significant increases occurring in Jakarta and West Java. This suggests that population growth is still taking place in these provinces, although growth rates vary. Predictions for 2050 show that all provinces will experience significant population increases, with West Java and Jakarta being the provinces with the highest populations. This highlights the importance of proper planning and resource management in anticipation of rapid population growth. The total population can be seen in Table 1

Table 1.
Population Data

<i>Province</i>	<i>Population in 2020</i>	<i>Population in 2023</i>	<i>Population Predictions for 2050</i>
Banten	12,236,263	12,267,179	19,215,522
Jawa Barat	45,347,231	45,023,855	64,670,383
Daerah Istimewa Yogyakarta	3,309,110	3,221,077	4,065,341
Jakarta	9,197,899	9,447,122	12,460,948
Jawa Tengah	28,921,652	27,568,406	30,791,867
Jawa Timur	34,361,952	32,629,895	39,171,895

Based on the results of linear regression analysis conducted in Google Earth Engine, the research results are obtained in the form of statistical (Table 1) and spatial (Figure 1) data. The following is an explanation of table 1.

1. Banten
 Growth Trend: Banten's population is projected to increase from 12,236,263 people in 2020 to 19,215,522 people in 2050. Growth Rate: This increase represents a significant growth rate, reflecting the development of urbanization and in-migration to the region. This growth may be driven by economic expansion around the Jabodetabek area and infrastructure improvements that attract population migration from other areas. Implications: This increase in population will require better planning of infrastructure and public services to accommodate the needs of the increasing population.
2. Jawa Barat
 Growth Trends: The population of Jawa Barat is expected to increase from 45,347,231 in 2020 to 64,670,383 in 2050. Influencing Factors: As the province with the largest population in Indonesia, this increase can be attributed to high birth rates as well as migration from other regions to economic centers in West Java. Rapid growth in major cities such as Bandung and Bekasi also contributed to this increase. Implications: A large population increase requires serious efforts in spatial planning, transportation, housing, and environmental management to maintain a good quality of life.
3. Daerah Istimewa Yogyakarta
 Growth Trends: The population is projected to increase from 3,309,110 people in 2020 to 4,065,341 people in 2050. Growth Rate: This increase is relatively moderate compared to other provinces. Yogyakarta is known as an educational and cultural center, which attracts migration but on a more limited scale. Implications: This moderate growth allows Yogyakarta to plan for more controlled development, maintaining a balance between economic development and cultural and environmental preservation
4. Jakarta
 Growth Trend: Jakarta's population is projected to increase from 9,197,899 in 2020 to 12,460,948 in 2050. Urbanization: Jakarta as the nation's capital

and major economic center continues to attract in-migration. Nonetheless, its growth rate may be hampered by space constraints and high urbanization challenges such as congestion and overcrowding. Implications: Jakarta needs to focus on efficient infrastructure development, adequate public transportation, and water resources and environmental management to address urban challenges.

5. Jawa Tengah

Growth Trends: The population of Jawa Tengah is expected to increase from 28,921,652 in 2020 to 30,791,867 in 2050. Steady Growth: This increase is slower than other provinces, possibly due to lower urbanization rates and out-migration to other provinces. Implications: Jawa Tengah needs to develop strategies to attract investment and reduce out-migration by improving employment opportunities and local infrastructure.

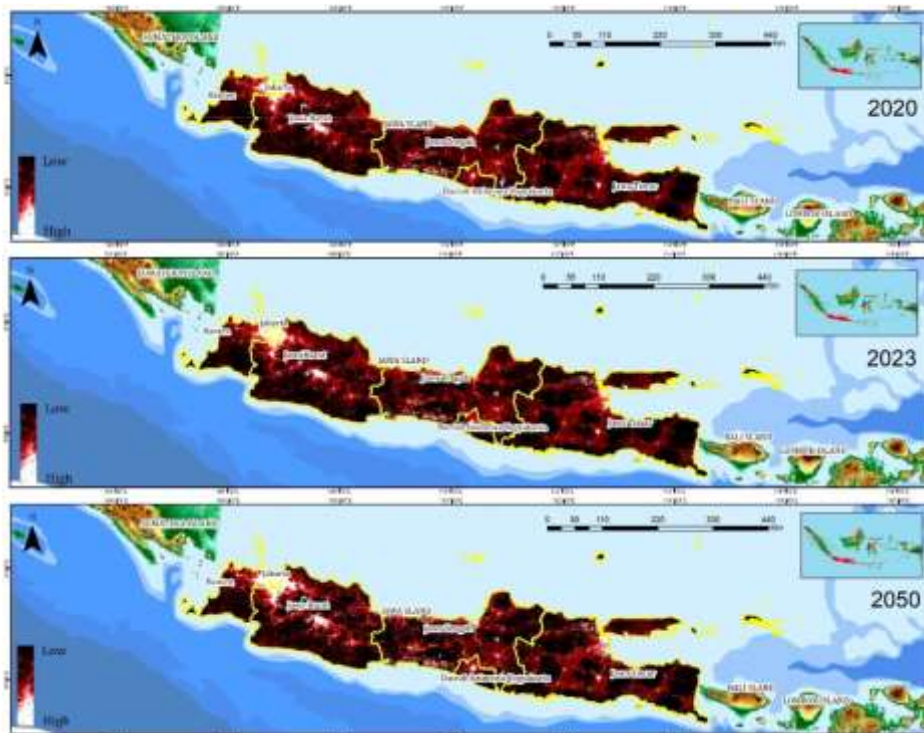


Figure 1. Population Distribution Map in the Provinces of Banten, Jakarta, Jawa Barat, Jawa Tengah, Daerah Istimewa Yogyakarta, Jawa Timur in 2020, 2023 and 2050

6. Jawa Timur

Growth Trend: The population of Jawa Timur is projected to increase from 34,361,952 in 2020 to 39,171,895 in 2050. Economic Factors: As a province with a strong and diverse economic base, this population growth reflects increased economic opportunities and quality of life that attract in-migration. Major cities such as Surabaya and Malang are the centers of population growth. Implications: Jawa Timur needs to ensure that its infrastructure, public services and environmental policies can support rapid population growth, while maintaining the quality of life of its residents.

Predicting future population for the provinces of Banten, Jakarta, Jawa Barat, Jawa Tengah, Daerah Istimewa Yogyakarta, Jawa Timur using WorldPop data with Google Earth Engine offers significant benefits including:

- 1) **Infrastructure Planning and Development:** Population predictions allow governments and urban planners to prepare infrastructure to match population growth. This includes transportation planning, road construction, provision of electricity, water, and sanitation services.
- 2) **Resource Management:** By knowing the estimated future population, management of natural resources such as clean water, energy, and agricultural land can be done more effectively. These predictions help in avoiding resource shortages and ensuring equitable distribution [8].
- 3) **Education and Health Planning:** Future population data is essential for planning education and healthcare facility needs. This includes building enough schools, universities, hospitals, and clinics to accommodate the increasing population [9].
- 4) **Economic Development:** Information on future population can help in economic planning, including job creation, industrial development, and market regulation. The government can attract investment and plan workforce training according to future needs [10].
- 5) **Climate Change Mitigation and Adaptation:** Population forecasts help in planning mitigation and adaptation measures to climate change. For example, areas with predicted population increases need to plan for more green space to reduce the urban heat island effect [10], [11].
- 6) **Housing Planning:** Population prediction data helps in planning adequate housing to avoid future housing shortages. This includes construction of affordable housing and vertical housing development in congested cities [12].
- 7) **Disaster Preparedness:** By knowing the population forecast, disaster risk management can be more effective. This includes evacuation planning, provision of shelters, and strengthening infrastructure to deal with natural disasters [13].
- 8) **Social Policy:** Population forecasts can help in designing social policies such as welfare programs, social assistance, and other community services. The government can allocate the right budget for these programs based on population predictions.
- 9) **Research and Analysis:** Future population data provides a strong database for academic research and analysis by scientists and policy makers. This includes studies in demography, sociology, economics, and environmental science.
- 10) **Rural Area Development and Urbanization:** These predictions help in identifying areas that need rural development and urbanization. The government can develop policies to balance development between rural and urban areas.

Overall, the benefits of population prediction using WorldPop data with Earth Engine cover a wide range of aspects from planning to management, all of which are important for sustainable development and improving people's quality of life.

CONCLUSION

The prediction results show significant population growth in all provinces studied until 2050. Some of the main factors influencing this growth include urbanization, migration, and economic development. West Java is expected to experience the most growth, while the Special Region of Yogyakarta shows more moderate growth. Jakarta remains the main magnet for urban migration, albeit with growth limited by its regional capacity. This research provides important insights for development planning and public policy to manage future population growth, including the need for spatial planning, infrastructure development, and sustainable social and economic policies.

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