pISSN 2302-1616, eISSN 2580-2909
Vol 14, No. 1, 2026, pp. 85-92
Available online http://journal.uin-alauddin.ac.id/index.php/biogenesis
DOI https://doi.org/10.24252/bio.v14i1.47115

Spatial distribution of mango *Mangifera indica* plant populations in Situbondo, East Java

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ABSTRACT. Situbondo is a district in the province of East Java, Indonesia. Situbondo is a mango production center, in 2019, based on BPS East Java data, produced mango fruit reaching 23,511.70 tons. This research is basic research to determine the potential of mangoes as a food diversification and energy diversification product in Situbondo. Mango mapping in Situbondo Regency is essential as mango is a leading horticultural commodity with high economic value and a strategic role in supporting farmers' livelihoods. Despite its status as a major mango production center in East Java, spatially explicit information on mango tree distribution, planted area, varieties, and productivity remains limited and unsystematic, hindering effective and sustainable development planning. Moreover, mango cultivation faces increasing threats from land-use change, climate variability affecting flowering and fruiting, pest and disease attacks, and the aging of mango trees, which collectively reduce productivity. Therefore, mango mapping is crucial to provide accurate spatial data for identifying production centers, and conserving local mango varieties, ultimately enhancing sustainable mango management and regional competitiveness. The method used in this research is a survey method with descriptions (explanatory research) of primary data and secondary data. The sample in this study were all mango farmers in Situbondo district. The data obtained was then analyzed using the Simpson's dominance index (D). This index is used to determine the dominance of mango types for each district in Situbondo. The results of mapping and surveying the mango plant population in Situbondo found 3869 trees spread across in 17 district and 28 populations points. The largest population is in Arjasa district with 1872 trees. The mango cultivars recorded in Situbondo district are gadung, manalagi, arum manis, arum merah and garifta.

Keywords: agricultural diversification, mango, mapping, Simpson's dominance index, Situbondo

Article History: Received 15 May 2024; Received in revised form 24 Noveber 2024; Accepted 28 January 2026; Available online 30 June 2026.
How to Cite This Article: Elhany NA, Fajar MTI, Rani DEP, Dewi YK, Hudha MN, Rahmah M. 2026. Spatial distribution of mango *Mangifera indica* plant populations in Situbondo, East Java. Biogenesis: Jurnal Ilmiah Biologi, vol 14(1): 85–92. doi: https://doi.org/10.24252/bio.v14i1.47115.

INTRODUCTION

Situbondo is a district in the province of East Java, Indonesia (Wibowo *et al*., 2020). Situbondo Regency has an area of 1,638.50 km² or 163,850 Ha and has an elongated shape from west to east approximately 150 km on the north coast of the Tapal Kuda area, East Java (Afif *et al*., 2022). Situbondo area is divided into 17 sub-districts (Mudhari, 2018). Situbondo sub-district which consists of 17 sub-districts including, Arjasa, Asembagus, Banyuglugur, Banyuputih, Besuki, Bungatan, Jangkar, Jatibanteng, Kapongan, Kendit, Mangaran, Mlandingan, Panarukan, Panji, Situbondo, Suboh and Sumber Malang (Supriyanti, 2020). The natural landscape of the Situbondo region, which consists of 17 sub-districts, has pristine land and sea areas, making the Situbondo region rich in natural resources (Zakiyah *et al*., 2022). The natural wealth of the Situbondo region which has economic value includes vaname shrimp ponds, tobacco, grouper fish, sugar cane and mangoes (Wibisono, 2015). The city of Situbondo is a famous producer of mango fruit commodities (Nurtyara *et al*., 2023). Situbondo mango fruit is known for its sweeter taste so it is popular with many people (Fitranto *et al*., 2020).

Situbondo Regency, which is a mango production center, in 2019, based on BPS East Java data, produced mango fruit reaching 23,511.70 tons (Firmansyah *et al*., 2022). Generally, environmental factors in the form of lowland to medium land with an altitude of less than 300 meters are suitable for growing mangoes, but they do not grow well in the highlands (Puspita *et al*., 2021). The Situbondo area is a weathered lowland hot, so it is very suitable for the growth of mango plants and produces

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quality mango fruit (Muhlis *et al*., 2017). Apart from that, other factors such as climate can influence the growth of mango plants (Triani & Ariffin, 2019). The ideal climate for the growth of mango plants is a slightly dry climate with rainfall of 750 - 2000 mm, with a dry season of four to seven months, an altitude of less than 300 meters and an ambient air temperature ranging from 25°C – 32°C (Suwardike *et al*., 2018). Apart from the weather and climate factors in Situbondo which support the growth of mango quality, soil fertility factors also influence mango growth (Harhash *et al*., 2022). Good soil for cultivating mango plants is soil with a pH of 5.5-7.0 (Salehin *et al*., 2020). Soils with a pH below 5.5 generally mango farmers will sprinkle lime with dolomite to increase the soil pH (Correia *et al*., 2018). Mango plant farmers can also apply liming and manure to increase soil pH (Firdaus *et al*., 2023). Then another factor, mango plants need to have a dry season for flowering, fruiting, reducing disease and shedding of flowers or fruit (Iqbal *et al*., 2022).

Mango plants in the Situbondo area are generally planted in government-owned plantations, private community gardens and the yards of every house (Puryantoro & Mayangsari, 2020). Mango mapping in Situbondo Regency is necessary because mangoes are a leading horticultural commodity in the region and play a strategic role in the local economy, particularly for farmers. Situbondo is known as one of the mango production centers in East Java, boasting a variety of local varieties with high economic value. However, accurate spatial information on the distribution of mango trees, planted areas, cultivated varieties, and productivity remains limited and has not been systematically documented. This situation complicates targeted and sustainable mango commodity development planning. In addition to limited data, mango trees in Situbondo also face various problems and threats. The conversion of agricultural land to residential areas and infrastructure has the potential to reduce the area of mango orchards year after year. Climate change, such as shifts in the rainy and dry seasons, impacts the flowering and fruiting phases of mangoes, resulting in unstable productivity (Rozi *et al*., 2023). Attacks by plant pests (OPT), including fruit flies and fungal diseases, also pose a serious threat, reducing the quality and quantity of the harvest (Yuniarti *et al*., 2022). Furthermore, most of the existing mango trees are old and have received less than optimal care, putting them at risk of decreased productivity or even death.

Mango mapping is crucial because it provides a clear spatial picture of the location, density, and condition of mango trees throughout the Situbondo region. This mapping data can be used as a basis for policy-making, such as determining production centers, planning plant rejuvenation, area-based pest and disease control, and mitigating the impacts of climate change. Furthermore, mapping also supports efforts to preserve local mango varieties to prevent them from being eroded by introduced varieties or lost due to land conversion (Anggraini *et al*., 2023). With comprehensive, data-driven mapping, mango commodity management in Situbondo is expected to become more effective, efficient, and sustainable, thereby improving farmer welfare and the competitiveness of Situbondo mangoes at the regional and national levels. This mango variety mapping research will be able to determine the distribution of mango types in each district of the Situbondo region and their dominance.

MATERIALS AND METHODS

Study area. This research was carried out in Situbondo, East Java, Indonesia. The location of this research can be seen on fig. 1. This study was conducted across all sub-districts in Situbondo to obtain comprehensive and representative data on the research object.

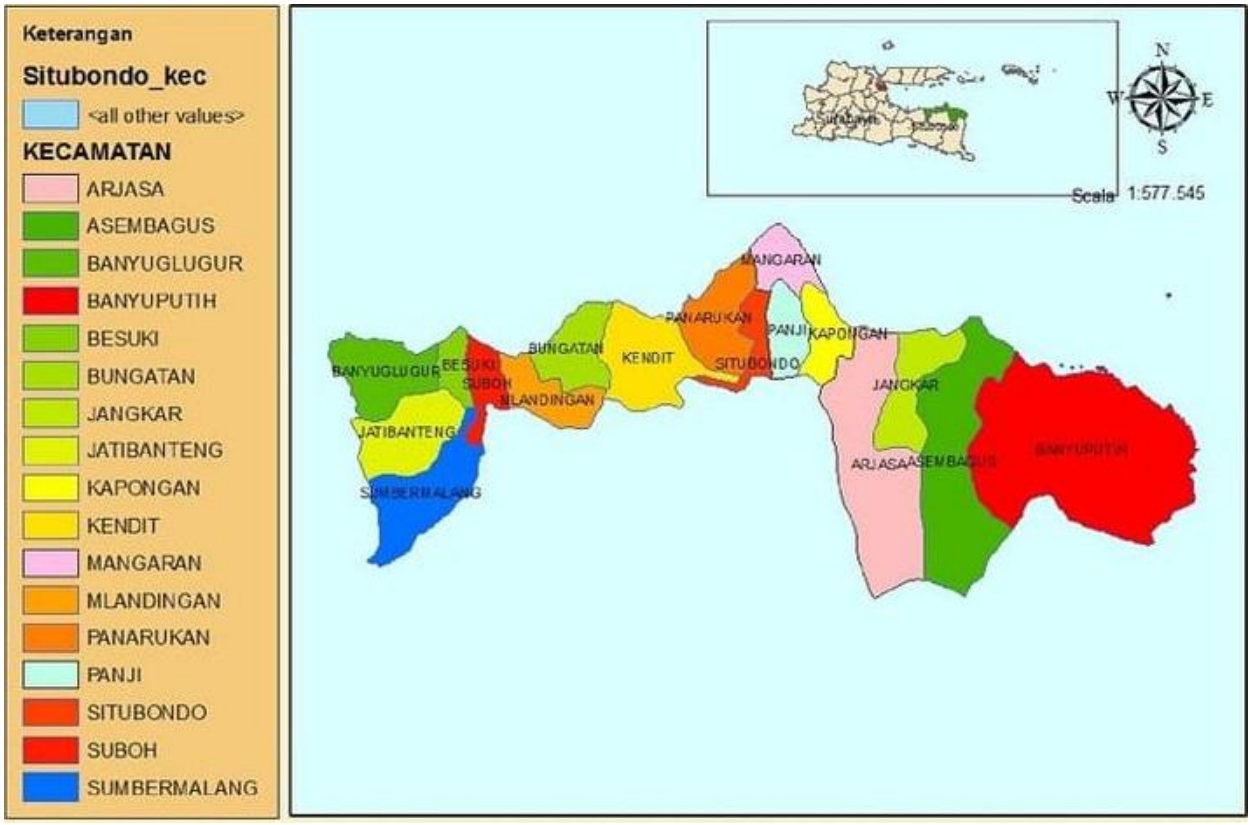


Fig. 1. The observation location (Situbondo, East Java)

Data collection. The method used in this research is a survey method with descriptions (explanatory research) of primary data and secondary data. The sample in this study was all mango farmers in Situbondo district. Data were collected used a multistage sampling approach to describe the spatial distribution of mango (Mangifera indica) plants in Situbondo Regency, East Java. Data were collected through 20 m × 20 m plots systematically placed along transects in mango-growing areas in each district. The coordinates of plots and individual plants were recorded using GPS, then analyzed and visualized using GIS software (QGIS) to identify distribution patterns and mango population densities across regions.

Data analysis. The data obtained was then analyzed using the Simpson's dominance index (D). This index is used to determine the dominance and abundance of mango types for each district in Situbondo, with the formula as following (Salamah *et al*., 2023).

$$D = \Sigma (ni/N)^2 \text{ atau } D = \Sigma pi^2$$

Notes:
D = Dominance index
Ni = Number of individuals of the type
N = Total number of individuals
The criteria used were high if the D value is $0.60 < D \leq 1.00$, moderate if the D value is $0.30 < D \leq 0.60$, and low if the D value is $0.00 < D \leq 0.30$.

$$D = N/A$$

Notes:
D = Mango density (trees/ha or trees/m²)
N = Total number of mango trees counted
A = Area of observation area

RESULTS AND DISCUSSION

The result of mapping mango plants in Situbondo using the survey method were carried out and recorded in a table per district. A total of 17 district in Situbondo as data in this research are Sumbermalang, Jatibanteng, Banyuglugur, Besuki, Suboh, Mlandingan, Bungatan, Kendit, Panarukan, Situbondo, Mangaran, Panji, Kapongan, Arjasa, Jangkar, Asembagus dan Banyuputih. Each district has mango population with a varying number of individuals. Detailed data on the number of mango plants per district and the district is shown in Table 1.

Table 1. Population. abundance and dominance of mango in Situbondo

Num	District	Amount		District area (km²)	Abundance	Dominance
		Population	Tree			
1	Sumbermalang	1	42	129.47	0,32	0,01
2	Jatibanteng	1	30	66.08	0,45	0,01
3	Banyuglugur	2	272	72.66	3,74	0,07
4	Besuki	2	115	26.41	4,35	0,03
5	Suboh	1	28	30.84	0,91	0,01
6	Mlandingan	1	36	39.61	0,91	0,01
7	Bungatan	1	48	66.07	0,73	0,01
8	Kendit	1	40	114.14	0,35	0,01
9	Panarukan	1	58	54.38	1,06	0,01
10	Situbondo	1	56	27.81	2,01	0,01
11	Mangaran	1	50	46.99	1,06	0,01
12	Panji	1	72	35.7	2,02	0,02
13	Kapongan	1	38	44.55	0,85	0,01
14	Arjasa	5	1872	216.38	8,65	0,48
15	Jangkar	3	504	67	7,52	0,13
16	Asembagus	3	328	118.74	2,76	0,08
17	Banyuputih	2	280	481.67	0,58	0,07
	Jumlah	28	3869	Mean	2,76	0,06

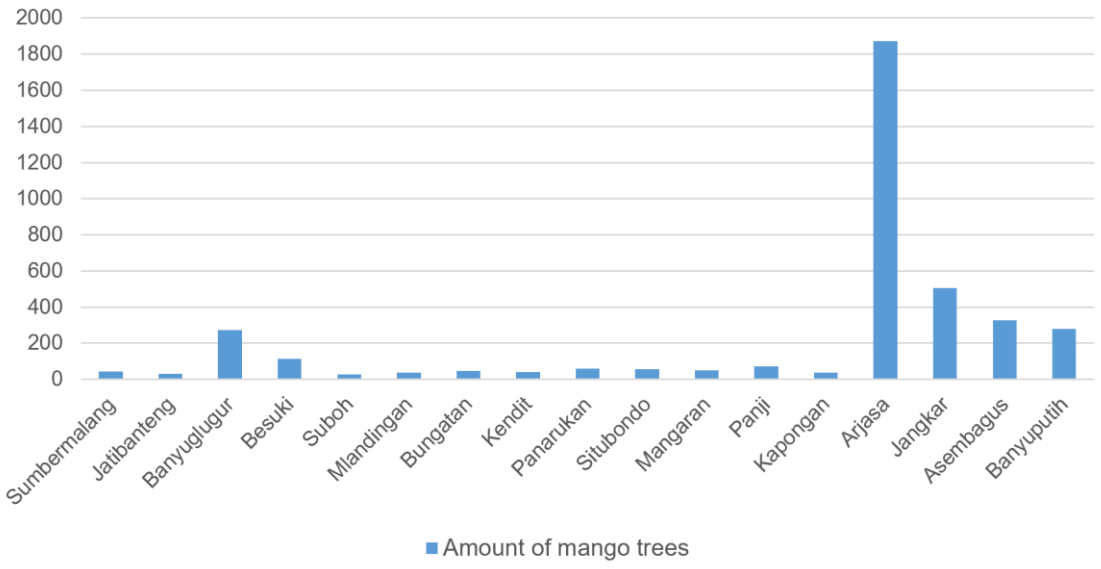


Fig. 2. Distribution of mango plant populations in each district in Situbondo

The results of mapping of mango plants in Situbondo using the survey method were carried out and recorded in tables per district. There are 17 district in Situbondo with a total population of 28 mango trees. Each district has varying number of mango trees. Detailed data on the number of mango plants per district and the are of each district is shown in table 1.

Measuring abundance and dominance values in mango mapping is crucial for understanding the distribution and population structure of mango plants in a region. Abundance values reflect the number and density of mango trees in each location, thus identifying areas with high potential as production centers and areas that are still less than optimal. Meanwhile, dominance values indicate the extent to which mangoes dominate land use compared to other vegetation, reflecting the region's level of dependence on mangoes. This information serves as an important basis for planning sustainable mango management, development, and protection, including determining priorities for cultivation interventions, conservation, and policies for developing superior regional commodities (Salamah *et al*., 2023).

A comparison of the number of mango trees from each district can be seen in Fig 2. From this fig, it can be seen that Arjasa district is the district with the highest number of mango plants, namely 1872 trees. Jangkar dan Asembagus ate the district with the second and third highest number of mango plants with the number of mango plants with the number trees in each district being 504 and 328. Meanwhile, the district that has the fewest number of mango trees is Suboh with a total 28 treess.

Based on data, the abundance of mango plants in each district in Situbondo was obtained. The highest abundance is in the Arjasa district, namely 8,65 trees/km^2. In Arjasa district, the dominance of mango plants is 0,48 with mederate category (analyzed using the Simpson's dominance index). In a mango mapping study in Arjasa District, Situbondo, high abundance and dominance values indicate that mango plants are widely distributed with a large number of trees and are the main vegetation that dominates land use in the area. High abundance values indicate that mangoes have significant density and population, so that Arjasa has strong potential as a mango production center area. Meanwhile, high dominance values indicate that mangoes are more prominent than other types of plants, reflecting the suitability of environmental conditions (Muhlis, 2017).

Arjasa District in Situbondo Regency was found to have the highest mango tree population due to a combination of several mutually supporting ecological, agronomic, and socio economic factors. This condition is not caused by a single factor, but rather by the integration of environmental characteristics and the history of agricultural development in the region. In terms of agroecological conditions, Arjasa District has soil characteristics that are relatively suitable for mango growth, namely medium to slightly sandy texture with good drainage. Mangoes are intolerant of waterlogging, so soil with good water drainage is highly conducive to root development and plant health. Furthermore, Arjasa is located in Situbondo's typical dry climate zone with moderate to low rainfall and a relatively long dry season. These conditions are ideal for stimulating optimal flowering and fruit formation of mangoes. In terms of land availability and utilization, Arjasa still has a relatively large area of agricultural land and yards compared to several other districts that are more stressed by land conversion. Mango trees are widely planted not only in dedicated gardens but also in home gardens. This planting pattern has cumulatively resulted in a very high mango tree population.

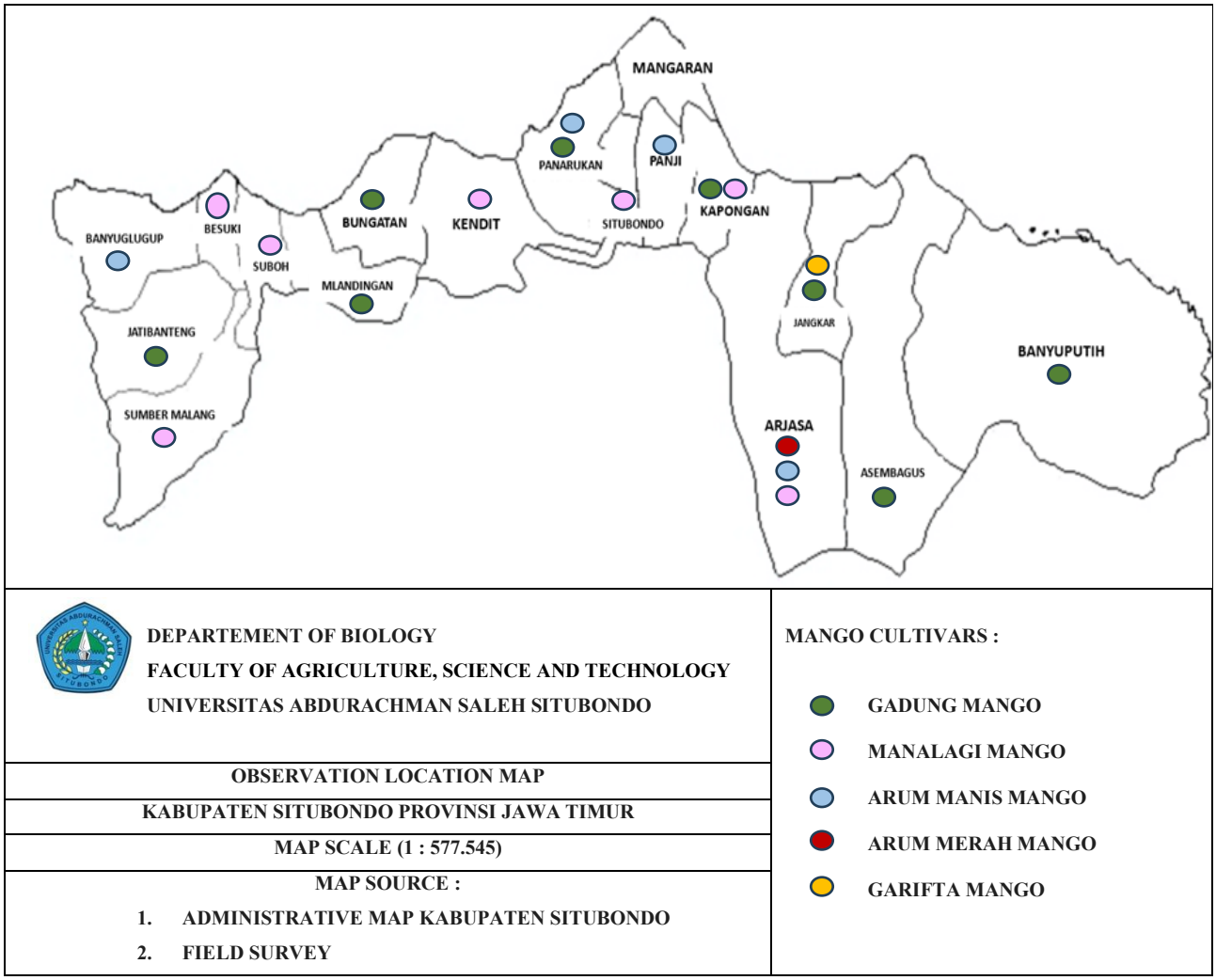


Fig. 3. The distribution map of mango plant in Situbondo, East Java

The distribution map of mango plant can be seen in details on Fig. 3. Based on their distributions, gadung mango and manalagi mango distribute most dominan in each district. There are 5 types of mangoes found in Situbondo, namely gadung mango, manalagi mango, arum manis mango, arum merah mango and garifta mango. Garifta mango and arum merah mango are superior mangoes that are being developed in Situbondo. Garifta mango is in Jangkar district and Arum merah mango is in Arjasa district.

Based on this distribution, it can be seen that mango plants can grow in all district in Situbondo. Situbondo is a lowland area with hot weather, so it is very suitable for growing mango plants and producing good mango fruit (Puspita *et al*., 2021). Apart from that, other factors such as climate can influence the growth of mango plants (Triani & Ariffin, 2019). The ideal climate for the growth of mango plants is a slightly dry climate with rainfall of 750 - 2000 mm, with a dry season of four to seven months, an altitude of less than 300 meters and an ambient air temperature ranging from 25°C – 32°C (Suwardike *et al*., 2018).

CONCLUSION

The results of mapping and surveying the mango plant population in Situbondo found 3869 trees spread across in 17 district and 28 populations points. The largest population is in Arjasa district with 1872 trees. The mango cultivars recorded in Situbondo district are gadung, manalagi, arum manis, arum merah and garifta. The most commonly found mango cultivar in Situbondo is Arum Manis.

ACKNOWLEDGEMENTS

This research was conducted as part of a research group project. We thank to LP2M Universitas Abdurachman Saleh Situbondo for the research funding support (084/UNARS/PT.SK/P/XII/2023).

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