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Unplanned regional development: Public perception of urban sprawl in the Tapal Kuda Region, East Java, Indonesia

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Abstract

The northern coastal hinterland of East Java, known as the Tapal Kuda Region (TKR) and the Pendalungan cultural zone, is undergoing spatial transformation. However, community participation in the development of the TKR has remained relatively low. This study aims to analyse the Pendalungan community perceptions of urban sprawl, as understanding these perceptions is essential for increasing participatory development in the region. A mixed-methods research design was employed. Quantitative analysis used the Normalised Difference Built-Up Index (NDBI) to measure built-up area density from satellite imagery for the years 2015 to 2025. Accuracy was assessed using overall accuracy, user accuracy, and the Kappa coefficient. Qualitative data on community perceptions were collected through in-depth interviews with a purposively selected sample of the Pendalungan community and analysed using a thematic deductive method with NVivo software. The results indicate an NDBI of 0.132, reflecting significant urban sprawl characterised by low-density development along the Daendels Road in the TKR. Despite being perceived as unplanned, the Pendalungan community views urban sprawl positively, as it enhances regional dynamics, by driving land prices higher, creating diversified job opportunities, and improving economic infrastructure. The findings show a misalignment between planning policies and community needs. Recommendations include inclusive development strategies that strengthen public participation, align planning with local aspirations, and reduce the risk of social conflict associated with industrial and residential development.

Keywords: unplanned development, urban sprawl, land conversion, public participation, mixed method

OPENBARE PERSEPSIE VAN STEDELIKE UITBREIDING IN DIE TAPAL KUDA-STREEK, OOS-JAVA, INDONESIË

Die noordelike kushinterland van Oos-Java, bekend as die Tapal Kuda-streek (TKR) en die Pendalungan-kulturele sone, beleef tans ’n merkwaardige ruimtelike transformasie. Tog bly gemeenskapsdeelname aan die ontwikkeling van die streek beperk. Hierdie studie ondersoek die Pendalungan-gemeenskap se persepsies van stedelike uitbreiding, aangesien begrip van hierdie sienings noodsaaklik is vir meer inklusiewe en deelnemende ontwikkeling. ’n Gemengde-metodes benadering is gevolg. Kwantitatiewe analise het die *Normalised Difference Built-Up Index* (NDBI) gebruik om die digtheid van beboude gebiede vanaf satellietbeelde tussen 2015 en 2025 te meet. Akkuraatheid is beoordeel deur algehele akkuraatheid, gebruikersakkuraatheid en die Kappa-koëffisiënt. Kwalitatiewe data is ingesamel deur middel van doelgerigte onderhoude met lede van die Pendalungan-gemeenskap en tematies geanaliseer met NVivo-sagteware. Die resultate toon ’n NDBI van 0.132, wat beduidende stedelike verspreiding aandui, veral langs die Daendels-pad in die TKR. Alhoewel dit dikwels as ongeplan beskou word, ervaar die gemeenskap stedelike uitbreiding positief, omdat dit grondpryse verhoog, werksgeleenthede diversifiseer en ekonomiese infrastruktuur verbeter. Die bevindinge wys egter op ’n wanbelyning tussen beplanningsbeleide en gemeenskapsbehoeftes. Daarom word inklusiewe strategieë

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aanbeveel wat openbare deelname versterk, beplanning met plaaslike aspirasies belyn en die risiko van sosiale konflik in industriële en residensiële ontwikkeling verminder.

MAIKUTLO A SECHABA MABAPI LE HO ATA HA LITOROPO SEBAKENG SA TAPAL KUDA, EAST JAVA, INDONESIA

Sebaka se ka leboea sa lebopong la East Java, se tsejoang e le Tapal Kuda Region (TKR) hammoho le sebaka sa setso sa Pendalungan, se ntse se feta phetohong ea sebaka. Leha ho le joalo, ho nka karolo ha sechaba nts'etsopele ea TKR ho ntse ho le tlase. Phuputso ena e ikemiselitse ho hlahloba maikutlo a sechaba sa Pendalungan mabapi le ho ata ha ditoropo, hobane kutloisiso ea maikutlo ana e bohlokoa bakeng sa nts'etsopele e kenyeletsang bohle. Mokhoa o kopanyang dipatlisiso o sebelisitsoe. Tlhahlobo ea dipalo e sebelisitse *Normalised Difference Built-Up Index* (NDBI) ho lekanya bongata ba libaka tse hahiloeng ho tloha litšoantšo tsa sathelaete tsa 2015 ho isa ho 2025. Ho nepahala ho ile ha netefatsoa ka kakaretso, ka nepahalo ea mosebelisi le ka coefficient ea Kappa. Lintlha tsa boleng li bokelitsoe ka lipuisano tse tebileng le sampole e khethiloeng ka boomo ea sechaba sa Pendalungan, 'me tsa sekasekoa ka mokhoa oa temathiki ka NVivo. Liphetho li bontša NDBI ea 0.132, e bontšang ho ata ho hoholo ha ditoropo, haholo-holo ka nts'etsopele ea bongata bo tlase haufi le tsela ea Daendels ho TKR. Le hoja ho nkoa e sa reruoa, sechaba sa Pendalungan se bona ho ata hona ka tsela e ntle hobane se phahamisa litheko tsa mobu, se hlahisa menyetla e fapaneng ea mesebetsi, 'me se ntlafatsa moralo oa moruo. Phuputso e bontša ho se lumellane pakeng tsa maano a moralo le litlhoko tsa sechaba. Ho khothaletsoa maano a kenyeletsang bohle a matlafatsang ho nka karolo ha sechaba, a hokahanyang moralo le litabatabelo tsa lehae, le ho fokotsa likotsi tsa likhohlano tsa kahisano tse amanang le nts'etsopele ea liindasteri le ea bolulo.

1. INTRODUCTION

A common phenomenon in Indonesia is the mismatch between planning and implementation of development programmes (Widodo, 2017; Wagistina *et al.*, 2025; Suroto *et al.*, 2025). The government's limited capacity for integrated planning and policy formulation has created a gap between planning and implementation (Giyarsih, 2023). Government agencies often do not work well together. As a result, development plans do not fully align with local conditions or real problems on the ground. Planning and implementation are, therefore, poorly coordinated, which leads to inefficient land use. One clear result of this problem is urban sprawl. Urban sprawl happens when cities grow outward in an unplanned and uncontrolled way. This is common in many large cities on the island of Java, where urban growth spreads unevenly and does not keep pace with overall development (Pravitasari *et al.*, 2024: 9).

Surabaya is one of the major metropolitan cities on the island of Java and serves as the main urban centre of East Java. Located along the northern coast of Java, Surabaya has experienced rapid outward urban expansion that extends beyond its administrative and physical boundaries. This outward growth has resulted in urban sprawl and has contributed to the formation of a megaregion along the northern coast of East Java (Pravitasari *et al.*, 2024: 14). Within the context of a homogeneous region, this megaregion development is occurring in an area also known as the TKR.

The emergence of this megaregion in the TKR highlights serious weaknesses in development planning. Urban growth has occurred without a clear spatial pattern, leading to several negative consequences, including environmental problems such as landslides, flooding, and the reduction of water bodies, as well as increasing traffic congestion along Daendels Road on the northern coast of East Java and rising ground surface temperatures (Indarto & Hakim, 2021: 12; Suharyanto *et al.*, 2023: 359).

Urban development in the TKR has largely occurred in a spontaneous and fragmented way, without effective planning controls. This reflects a top-down approach to development planning, where decisions are made by authorities with limited involvement from local communities. In practice, top-down planning often overlooks community participation, even though communities are the main beneficiaries and targets of development. Under the principles of sustainable development, communities are recognised as both the subjects and objects of development. As a result, community participation becomes a crucial element of effective development planning and serves as an important development instrument (Grisez Kweit & Kweit, 2007; Yuhan *et al.*, 2020).

Community participation is strongly influenced by community perception. Numerous studies show that successful development planning and implementation in Indonesia depend on positive community perceptions and high levels of public participation (Hasan, 2022; Tambunan, 2022; Heri, 2024; Yustiyanto, 2025). In the context of this study, the perceptions of the Pendalungan community, which dominates the sociocultural landscape of the TKR, are particularly important for encouraging participation in development planning and implementation (Ilham, 2024). However, levels of community participation in the development of the TKR have remained relatively low (Lasmono, 2019; Poerwati & Imaduddina, 2019; Maulinda, 2025). This is influenced by several factors, including relatively low levels of education, lower middle-income economic conditions, the strong influence of *Kyai* as Islamic spiritual leaders compared to formal leadership structures, and unequal communication between government institutions and local communities.

Previous research on urban sprawl in Indonesia has mainly focused on land-use change, particularly the conversion of non-built-up areas into built-up areas and the spatial dynamics of urban growth (Hadi & Sadharto, 2011; Mujiandari, 2014; Firdaus, Asteriani & Ramadhani, 2018; Hardiyanti, 2018; Surya *et al.*, 2020, 2021; Shofy & Wibowo, 2023; Shinta & Wagistina, 2025). Other studies have examined the relationship between urban sprawl and demographic factors such as urbanisation, poverty, segregation, and socio-economic conditions (Buchori *et al.*, 2020;

Giyarsih, 2023; Wagistina & Antariksa, 2024; Pravitasari *et al.*, 2024; Nurrokhman *et al.*, 2026).

Although urban sprawl has accelerated regional change in the TKR, public participation in development planning remains limited. Development decisions are largely made through top-down processes, with insufficient involvement of local communities. As a result, unplanned development often fails to reflect the real needs, priorities, and concerns of residents, creating a disconnect between government planning and everyday lived experiences.

This study addresses this problem, by examining how the Pendalungan community understands and responds to urban sprawl and unplanned development in the TKR. Rather than focusing only on physical land-use change, the study explores community perceptions as a key factor influencing public participation. It investigates how community members recognise, interpret, and make sense of ongoing spatial changes, and how these perceptions shape their willingness to engage in development processes.

The main objective of this study is to analyse the perceptions of the Pendalungan community regarding urban sprawl in the TKR to better understand why public participation in development planning remains weak. In this study, unplanned regional development refers to the rapid and uncontrolled spatial transformation and changes in land use occurring in the TKR, as represented as urban sprawl. By identifying how unplanned development is viewed at the community level, the study aims to highlight gaps between planning policies and community needs. The findings are expected to support the East Java Provincial Government and housing developers in designing more inclusive development strategies that strengthen public participation, align planning with local aspirations, and reduce the risk of social conflict associated with industrial and residential development.

2. LITERATURE REVIEW

2.1 Urban sprawl

Urban sprawl refers to the outward physical expansion of urban areas beyond their original boundaries (Yunus, 2000; Knox, Marston & Imort, 2016: 394; Moffat *et al.*, 2021: 47). It typically occurs as a result of unplanned and weakly controlled development and is marked by changes in land use and the spread of low-density settlements into surrounding areas. As a spatial process, urban sprawl reflects inefficient planning and fragmented growth patterns.

Urban sprawl is influenced by both physical and non-physical factors (Yunus, 2000; Wagistina *et al.*, 2023: 6). Non-physical factors include employment structure, income levels, unemployment, household composition, and housing tenure. Physical factors are largely shaped by regional morphology, particularly terrain, topography, and limited availability of land within urban cores, which together push development outward (Couch, Leontidou & Petschel-Held, 2007: 6; Chettry, 2023: 4).

As a form of horizontal urban expansion, urban sprawl is part of the broader process of mega-urban formation (Soetomo, 2009; Nyamahono, Mambiravana & Mudefi, 2024). The resulting pattern of growth is commonly referred to as suburbanisation, in which development spreads outward from the city centre into surrounding areas (Wagistina *et al.*, 2023: 2-3). This process is typically characterised by low-density development and expansion towards city outskirts (Weilenmann, Seidl & Schulz, 2017).

Urban sprawl most commonly occurs in suburban and peri-urban areas (Mujiandari, 2014: 129). Suburban areas are characterised by low-density residential development, the presence of small- to medium-scale commercial centres, city-scale road networks, and neighbourhood-level public spaces (Solihin & Kurniyanto, 2021). Peri-urban areas, by contrast, are transitional zones where urban and rural characteristics intersect and where significant land-use transformation takes place.

Urban sprawl also displays distinct spatial distribution patterns that emerge from the interaction of physical geography, spatial planning systems, transportation networks, and socio-economic dynamics. These patterns are generally classified into three types, namely low-density (concentric), ribbon (linear), and leapfrog (random) development (Yunus, 2000). Together, these patterns illustrate how urban growth extends unevenly across suburban and peri-urban zones, while reshaping urban-rural relationships (Wagistina *et al.*, 2023: 2).

2.2 Regional development

According to Badan Pusat Statistik (BPS), urban areas in Indonesia are defined by high population density and comprehensive facilities, while rural areas are characterised by agricultural activity, lower density, and limited infrastructure. As a result, dense settlements, structured road networks, and commercial centres are concentrated in urban areas, and policies such as the provision of green open space are primarily aimed at these zones (Hidayat, 2020: 248-253). With the intensification of urban expansion, peri-urban areas are undergoing rapid spatial transformation, contributing to persistent disparities, spatial polarisation, and development inequality (Buchori *et al*., 2020; Surya *et al*., 2020, 2021; Wagistina *et al*., 2023; Pravitasari *et al*., 2024; Shinta & Wagistina, 2025; Febrian, 2016; Sodik, Murdiyanto & Artaningtyas, 2025: 253).

Regional change is a continuous process shaped by a variety of decision-making mechanisms, including both planned and sporadic development. In developing countries such as Indonesia, land is a critical asset for development, often shifting from agricultural to non-agricultural uses. This land conversion leads to the loss and degradation of agricultural land, driven by population growth and development pressures (Zhang *et al*., 2023). In Indonesia, the majority of land conversion takes place in forests and agricultural

zones, with rapid changes occurring, as forests are converted into plantations and transmigration settlements, and agricultural land is transformed into residential, industrial, and infrastructural developments (Pagiola, 2000; Oktavilia, Pujiati & Aulia, 2022).

Population mobility, or migration, is a key factor in regional growth, typically flowing from areas of low productivity to those with higher economic output. This migration is driven by the promise of better opportunities, with regional growth being supported by intensive development in industry and infrastructure. As a result, migration creates a complex relationship between development and environmental factors. The movement of people is intrinsically linked to shifts in economic activity, which can have significant consequences for both environmental sustainability and the broader development process.

2.3 Governance, spatial planning, and public participation

Development planning in Indonesia blends both bottom-up and top-down approaches, adopting a participatory and region-based strategy. One key platform for public participation is the *Musrenbang* (development planning meetings), where communities engage in discussions about regional needs and local potential. During these forums, community members present their aspirations, suggestions, and programme proposals (Mahi & Trigunarso, 2017: 45). Spatial planning in Indonesia is guided by Law No. 25/2004 on the national development planning system and Law No. 26/2007 on spatial planning. However, despite the legal framework, public participation in development and spatial planning remains limited (Poerwati & Imaduddina, 2019).

A significant gap exists between spatial and development planning in Indonesia, primarily due to political factors, technical constraints, leadership cycles, and insufficient community participation. In addition, planning processes often lack evidence-based policy frameworks, exhibit inconsistencies in development programme planning, and fail to address business needs or integrate effectively with the government's vision, mission, and objectives (Kardono, 2017: 28; Widodo, 2017: 168; Widiyanti, 2019: 435; Muluk, Winoto & Anggoro, 2022: 175). At the local level, the formulation of spatial and development plans is often dominated by the government, which results in development programmes that do not fully reflect community needs. This disconnect between government and community can lead to vertical conflicts. Indonesia's geographical characteristics as an archipelago, along with economic disparities and sectoral rivalries between regions, pose further challenges in aligning spatial and development planning (Ridwan & Sodik, 2023: 122).

3. STUDY AREA

The northern coast of East Java occupies a strategically important geographical position, functioning as a major transport and trade corridor linking the islands of Java, Madura, and Bali. This corridor extends from Surabaya to Banyuwangi and is commonly referred to as the northern corridor. Spatially, this corridor directly overlaps with the TKR. Tapal Kuda is the name given to a region located in the eastern part of East Java Province. The term 'Tapal Kuda' refers to the shape of the region, which resembles a horseshoe when an imaginary line is drawn on a map (Winjaya & Taufiq, 2023: 251). Conceptually, the TKR is a homogeneous region united by shared sociocultural characteristics (Glasson, 1974; Knox *et al*., 2016: 30; Edwards, 2017: 8). This region falls within the Pendalungan cultural zone, which possesses a distinctive identity, due to its formation through deep acculturation between the Javanese and Madurese communities. Although inhabited by diverse ethnic groups, the dominant influence of the Madurese clearly distinguishes this area from other regions in East Java (Rohmah & Sari, 2018: 119).

The development of the TKR is strongly influenced by the role of Surabaya, a metropolitan area in East Java that acts simultaneously as a centripetal and centrifugal force driving regional growth (Lahuddin, 2020: 58). The dynamics of the TKR have been shaped by large-scale national infrastructure projects, particularly the construction of the Pasuruan-Banyuwangi motorway (2016-2025). The extensive scale of this project has resulted in increased land values and simulated sporadic development of planned housing estates. As a result, areas that were previously rural in character have gradually transitioned into suburban landscapes. This transformation, which occurred in the absence of effective planning mechanisms, has contributed to urban sprawl, creating ambiguity in both inner and outer boundaries, blurring land-use classifications, and producing territories that are administratively distinct yet physically continuous (Menajang, Kindangen & Waani, 2016: 255).

Although the TKR encompasses eight administrative regions, this study focuses specifically on five autonomous regions directly affected by these developments: Pasuruan City and Pasuruan Regency (Greater Pasuruan), Probolinggo City and Probolinggo Regency (Greater Probolinggo), and Situbondo Regency. To delimit the study area, specific locations within these five regions were selected based on the following criteria: proximity within a 1 km radius on either side of the Daendels Road along the north coast of East Java; direct impact from the construction of the Probolinggo-Banyuwangi highway, and areas experiencing land-use conversion from non-built-up to built-up conditions.

Figure 1 shows a map of the research location.

4. METHODOLOGY

4.1 Research design

This study adopted a mixed methods design, integrating both quantitative and qualitative approaches, to

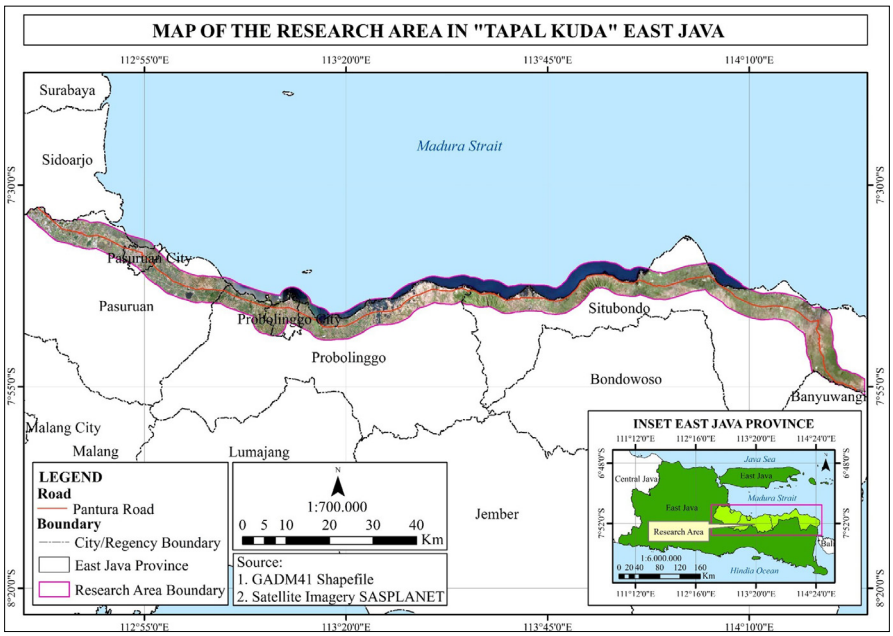


Figure 1: Map of the research area in the TKR of East Java

Source: Author using ArcGIS software, 2025

Table 1: Pendalungan community sample and response rate

Region	Potential Pendalungan community member as key informant	Selected informants (10%)	Response	Response rate (%)
Pasuruan City	143	14	5	36
Probolinggo City	477	37	13	35
Pasuruan Regency	241	25	4	16
Probolinggo Regency	368	37	8	22
Situbondo Regency	216	21	8	38
Total	1445	134	38	29 (average)

examine community participation in the development of the TKR in Indonesia (Creswell & Poth, 2016). The mixed methods approach was implemented through an explanatory sequential strategy, where quantitative findings were followed by qualitative exploration to provide deeper insights. This design enabled the use of diverse data-collection techniques, including satellite imagery, field observations, and interviews (Tomaszewski, Zarestky & Gonzalez, 2020). Quantitative data on built-up and non-built-up areas were collected and analysed for the years 2015, 2017, 2019, 2021, 2023, and 2025 to identify urban sprawl trends. This analysis was conducted using Landsat 8-9 OLI/TIRS C2L2 imagery obtained from the United States Geological Survey (USGS). The imagery was processed to calculate the Normalised Difference BuiltUp Index (NDBI). NDBI was processed using ArcGIS mapping to develop maps showing spatial changes from non-built-up to built-up areas in the TKR. Nearest Neighbour Analysis (NNA) was used to infer the spatial pattern of built-up areas, thereby identifying whether the settlement distribution is clustered, random, or dispersed (Bailey & Gatrell, 1995). Qualitative data were collected through field observations and in-depth interviews to validate and contextualise the spatial analysis results. The qualitative interview data were analysed using a deductive thematic analysis approach with NVivo software (Creswell & Poth, 2016: 258). Mapping quantitative geospatial (remote sensing) data is essential to validate key community perceptions related to spatial changes, thereby identifying gaps between government policies and community needs in the development of the TKR. The results prompted inclusive development strategies that strengthen public participation, align planning with local aspirations, and reduce the risk of social conflict associated with industrial and residential development.

4.2 Participants

Key informants were purposively selected from the Pendalungan community in areas that experienced land-use change between 2015 and 2025. Purposive sampling was adopted to recruit information-rich participants with relevant lived experience (10 years or more), consistent with qualitative research best practice (Ahmad & Wilkins, 2024). As shown in Table 1, approximately 10% of the community in each study area was selected as potential informants, with final participation determined by data saturation rather than predetermined sample size (Creswell & Poth, 2016). Of the 134 individuals invited, 38 participated, yielding an average response rate of 29%.

4.3 Data collection

4.3.1 Remote sensing data

Remote sensing data were obtained from two platforms, namely satellite-based sensors for spatial-temporal analysis, and drones for local-scale validation (Hultquist, 2022).

Satellite imagery forms the core dataset, consisting of multi-temporal Landsat imagery obtained from the USGS. Landsat 8-9 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) Collection 2 Level-2 images were selected for the years 2015, 2017, 2019, 2021, 2023, and 2025. To minimise atmospheric interference, imagery captured during the dry season (July and October) was prioritised, as these months exhibit the lowest cloud coverage in the study area (approximately 7% in July and 1% in October).

Additional datasets included administrative boundary shapefiles for Java and East Java; East Java Rupa Bumi Indonesia (RBI) base maps; northern coastal geological maps of East Java, and high-resolution Google Earth imagery used for visual interpretation and validation.

All satellite and spatial datasets were compiled and pre-processed using ArcGIS software to ensure spatial consistency and correct coordinate reference systems.

Drone-based aerial surveys were conducted in selected locations experiencing significant land-use change (Zhang & Zhu, 2023). A DJI Phantom 4 Pro drone was used to capture high-resolution aerial photographs, which provided detailed ground-level information on built-up density and land-cover characteristics.

4.3.2 Observations (field surveys and ground checks)

Field observations were conducted to validate and complement the results of GIS and remote-sensing analysis. Observations focused on areas experiencing land-use change, particularly the conversion of non-built-up land into residential, industrial, and public facility uses. Field surveys and ground checks were used to verify satellite-based classifications against on-site conditions, strengthening the reliability of spatial analysis (Hultquist, 2022; Zhang & Zhu, 2023). Observation data were collected using structured observation sheets, photographic documentation, and selective drone-based imaging to obtain high-resolution visual evidence of built-up density and land-use characteristics. The observation checklist recorded geographic coordinates, administrative location, dominant land-cover type, and photographic evidence. This combination of field observation and remote-sensing validation is widely used to improve the accuracy of land-use and urban sprawl analysis (Creswell & Poth, 2016; Zhang & Zhu, 2023).

4.3.3 Indepth interviews

In-depth interviews were conducted with 38 members of the Pendalungan community to examine perceptions of urban sprawl in the TKR. A semi-structured interview guide, consisting of ten open-ended questions, was used to explore perceived changes in land-use and regional development over the period 2015-2025, including land-use conversion, infrastructure expansion, the emergence of shops and activity centres, residential development, and other public facilities. The interviews also examined perceived opportunities and challenges arising from urban growth, as well as experiences of community involvement in development planning and decision-making processes. Each interview lasted approximately two hours, allowing for in-depth exploration of participants' experiences and views (Creswell & Poth, 2016).

4.4 Data analysis

4.4.1 Spatial analysis

Spatial analysis was conducted to identify, quantify, and interpret urban sprawl patterns in the TKR over the period 2015-2025. The analysis combined remote sensing and GIS-based methods, including Normalised Difference Built-Up Index (NDBI) analysis, classification accuracy assessment, and Nearest Neighbour Analysis (NNA). These methods were applied sequentially to ensure analytical consistency and validity of results.

Urban development was identified using the NDBI derived from multispectral Landsat imagery. NDBI was calculated, by comparing the reflectance values of the Near-Infrared (NIR) and Shortwave Infrared (SWIR) bands using the following formula:

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}$$

This index is effective in distinguishing built-up surfaces from non-built-up land covers such as vegetation and water bodies. A positive NDBI value indicates built-up areas, whereas negative values correspond to non-built-up land cover (Hadi & Sadharto, 2011; Solihin & Kurniyanto, 2021). Based on established thresholds, built-up density was classified into four categories, namely non-built-up: NDBI −1.0 to 0.0; sparse built-up: NDBI 0.0 to 0.1; dense built-up: NDBI 0.1 to 0.2, and very dense built-up: NDBI 0.2 to 0.3 (Sampurno & Thoriq, 2016).

Multi-temporal NDBI results from 2015 to 2025 were compared to identify spatial expansion and densification of urban areas over time. This analysis provided the primary spatial indicator of urban sprawl in the TKR.

To ensure the reliability of the NDBI-based classification, an accuracy assessment was performed using a confusion matrix (error matrix) including the overall accuracy, user accuracy, producer accuracy, and kappa coefficient values (Sampurno & Thoriq, 2016). Reference data were obtained from high-resolution imagery and field observations. The following metrics were calculated:

Overall Accuracy (OA), measuring the proportion of correctly classified pixels relative to total samples:

$$\text{OA} = \frac{\text{Number of pixels correctly classified}}{\text{Total number of pixels}} \times 100\%$$

User Accuracy (UA), indicating the probability that a pixel classified into a given category represents that category on the ground:

$$\text{UA}_i = \frac{\text{Number of correct pixels in } i}{\text{Total number of pixels classified as class } i} \times 100\%$$

Producer Accuracy (PA), assessing how well reference land-cover types were correctly classified:

$$\text{PA}_i = \frac{\text{Number of correct pixels in each class } i}{\text{Number of correct classes } i \text{ based on actual conditions}} \times 100\%$$

Kappa Coefficient (κ), measuring the level of agreement between classification results and ground truth beyond chance:

$$\kappa = \frac{P_o - P_e}{1 - P_e} \times 100\% \text{ with } P_o = \frac{\sum X_{ii}}{N},\ P_e = \sum_{i=1}^{k} \left(\frac{X_{i+} \cdot X_{+i}}{N^2}\right)$$

where X_{i+} is number of pixels in entire row, X_{+i} is number of pixels in entire column, X_{ii} is total number of pixels in error matrix table, and N is total number of pixels.

Kappa values were interpreted using standard agreement categories ranging from 'less than chance agreement' to 'almost perfect agreement' (Viera & Garrett, 2005). Only image classifications achieving an overall accuracy above 80% were accepted for further spatial analysis. If accuracy thresholds were not met,

image processing and classification procedures were repeated. This ensured that the identified built-up areas accurately represented real land-use conditions in the study area.

Following classification validation, NNA was applied to assess the spatial distribution pattern of built-up areas. NNA evaluates whether settlement patterns exhibit clustered, random, or dispersed distributions, by comparing observed mean distances between points with expected distances under random conditions (Bailey & Gatrell, 1995). The analysis incorporated indicators such as number of built-up location points; mean nearest neighbour distance, and annual extent of built-up areas.

NNA results were used to interpret the degree of urban sprawl and spatial concentration over time.

4.4.2 Observation data analysis

The primary function of the observations was not to generate independent themes, but to verify, contextualise, and interpret the spatial patterns of land-use change identified through NDBI and GIS-based analysis. Geographic coordinates were cross-checked against satellite-derived built-up and non-built-up classifications to confirm the accuracy of land-use classification results (Creswell & Poth, 2016; Hultquist, 2022). Photographic documentation and drone-based images were compared across locations to identify recurring characteristics of urban sprawl such as clustered residential development, linear expansion along road corridors, and the conversion of agricultural land into housing, industrial, or public facility uses (Zhang & Zhu, 2023). This integrative process strengthened analytical validity by linking physical spatial change, community experience, and perception-based narratives (Creswell & Poth, 2016).

4.4.3 Interview thematic analysis

Interview data were analysed using NVivo qualitative data analysis software (QSR International Pty Ltd., 2020). A deductive thematic analysis approach was employed, focusing on Pendalungan community perceptions of urban sprawl. Prior to data processing, a theoretical framework consisting of 13 priori categories was developed as parent nodes in NVivo. The analysis began with importing all interview transcripts into NVivo. Open coding was then applied, whereby relevant excerpts were systematically assigned to the pre-established nodes. During this process, data reduction was carried out, by excluding information that was not relevant to urban sprawl. Coded data were organised and explored using NVivo's analytical tools, including word frequency queries, to identify dominant concepts and recurring patterns within each theme. Coding comparison and similarity diagrams were used to examine relationships among codes, while cluster analysis helped explore inter-node connections and thematic coherence. Frequency charts (showing % coverage) were generated to visualise the distribution and intensity of coded references across themes. The analysis resulted in the identification of three overarching themes reflecting Pendalungan community perceptions of urban sprawl, namely development and physical changes in the region; social and economic changes, and changes in environmental conditions.

Throughout the analysis, the researcher moved iteratively through the interconnected stages of data reduction, data display, and conclusion drawing and verification, consistent with established qualitative research procedures (Creswell & Poth, 2016). Member checking was conducted, by returning interpretive summaries to selected participants to confirm the accuracy and authenticity of the researchers' interpretations.

5. RESULTS AND DISCUSSION

5.1 Participants' profile

The demographic profile of the 38 interviewees in Table 2 reveals a sample that is predominantly male (78.9%) and the vast majority of the respondents fall within the 40-50 years age group (60.5%). Over half of the respondents (52.6%) completed senior high school, while 34.2% attained a university-level education. This indicates a moderately educated sample, with a notable presence of higher education qualifications. Street vending emerged as the most dominant livelihood (39.4%), reflecting the informal economic structure of the community. Other common occupations included drivers and private-sector workers (both 15.8%), followed by traders (10.5%). More than half of the participants (52.6%) have lived in the community for over 41 years, indicating a highly established population with deep-rooted ties to the area. The data suggest that the

Table 2: Interviewees' profile

Demographic	Category	F (n=38)	%
Gender	Male	30	78.9%
	Female	8	21.1%
Age (years)	40-50	23	60.5%
	50+	15	39.5%
Education	Junior High School	5	13.2%
	Senior High School	20	52.6%
	University	13	34.2%
Occupation	Street vendor	15	39.4%
	Driver	6	15.8%
	Private-sector worker	6	15.8%
	Trader	4	10.5%
	Teacher	2	5.3%
	Hotel staff	2	5.3%
	Doctor	1	2.6%
	Civil servant	1	2.6%
	Housewife	1	2.6%
Living in community (years)	10-20	4	10.5%
	21-30	5	13.2%
	31-40	9	23.7%
	41+	20	52.6%

study sample is largely composed of long-term residents, predominantly middle-aged to older adults, with livelihoods centred mainly in informal and semi-formal sectors.

5.2 Spatial analysis results

The results presented in Table 3 confirm the occurrence of urban sprawl in the TKR. The average NDBI value of 0.132 indicates a predominance of low-density built-up development, which is a key characteristic of urban sprawl (Yunus, 2000; Wagistina *et al.*, 2023). This finding suggests that urban expansion in the TKR has occurred mainly through horizontal growth rather than compact densification.

The reliability of the NDBI-based classification is supported by the Kappa coefficient of 0.681, which falls within the category of substantial agreement. This indicates that the land-use change detection results are reliable and not significantly affected by data-processing bias. The acceptable accuracy level (0.838) strengthens the validity of the spatial analysis and confirms that the observed spatial dynamics represent actual land-use changes in the TKR rather than classification artefacts.

Further spatial analysis reveals substantial land-use change between 2015 and 2025 across the regions. During this period, built-up areas increased from 5,460 ha in 2015 to 13,425 ha in 2025, while non-built-up land decreased from 491,467 ha to 483,502 ha. The expansion of built-up land was dominated by low-density development (87%), followed by medium-density development (11%), and a small proportion of high-density development (2%). This distribution further confirms the low-density and dispersed nature of urban growth in the study area.

Figure 2 illustrates the spatial distribution of built-up areas and changes in land-use composition. Figures 3-5 show the conversion from non-built-up (green colour on map) to built-up (red colour on map) land over time (2015, 2019, 2025). Together, these results demonstrate a clear pattern of urban sprawl driven by gradual and uneven expansion rather than compact urban intensification.

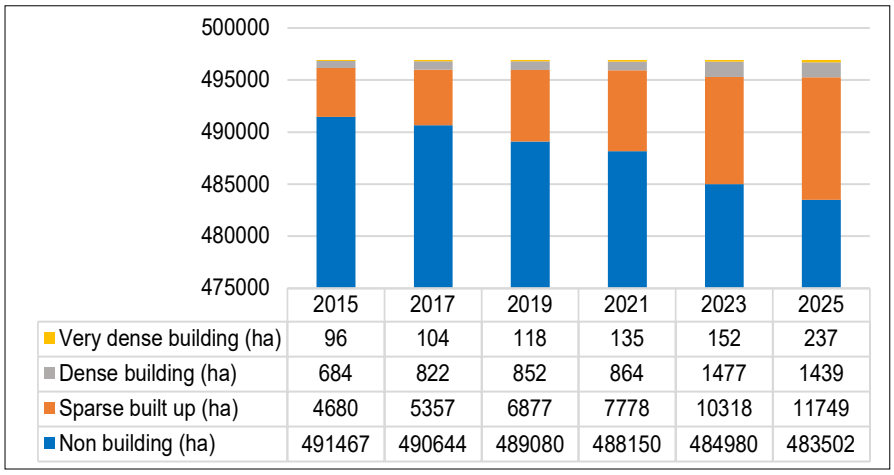
Overall, in Figures 3 to 5, changes in non-built-up areas remain relatively limited. However, they require close attention, as the extent of change has nearly tripled between 2015-2025. Most of the urban land-use changes occur gradually and on a small scale, rather than through abrupt, large-scale conversions from agricultural land to urban areas.

Rural areas in East Java are still characterised by the dominance of non-built-up land. Nevertheless, data

Table 3: NDBI and accuracy test of Landsat 8-9 OLI/TIRS C2L2 imagery

Description	2015	2017	2019	2021	2023	2025	Average
NDBI	0.129	0.162	0.125	0.157	0.104	0.114	0.132
User accuracy	0.817	0.799	0.828	0.889	0.839	0.858	0.838
Kappa coefficient	0.638	0.598	0.657	0.777	0.677	0.739	0.681

Source: Author, using ArcGIS software, 2025



	2015	2017	2019	2021	2023	2025
Very dense building (ha)	96	104	118	135	152	237
Dense building (ha)	684	822	852	864	1477	1439
Sparse built up (ha)	4680	5357	6877	7778	10318	11749
Non building (ha)	491467	490644	489080	488150	484980	483502

Figure 2: Built-up area in the TKR of East Java Province

Source: Author, 2025

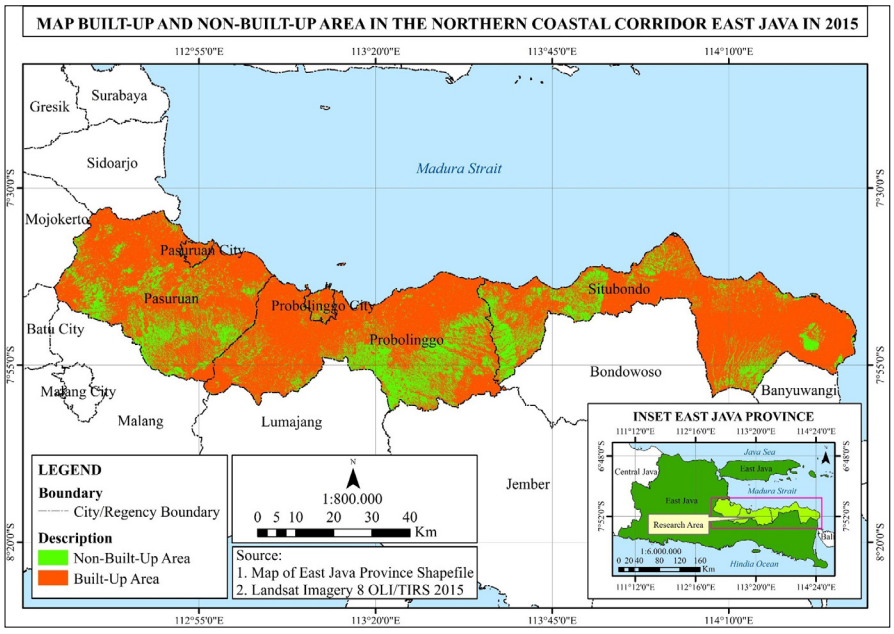


Figure 3: 2015 map of built-up area and non-built-up area in the TKR

Source: Author, using ArcGIS software, 2025

analysis indicates a steady increase in built-up areas, accompanied by high population activity in non-agricultural and informal sectors. This trend reflects the process of urban sprawl (Soetomo, 2009; Mujiandari, 2014: 129). These findings are consistent with studies by Firdaus *et al*. (2018: 100) and Wagistina and Antariksa (2024: 15), which show that areas with high accessibility are more susceptible to land degradation.

The outward-driving forces of urban sprawl in the TKR originate from within the region itself. These forces are associated with the availability of labour, work culture, and economic potential (Gardner, 2025). In terms of labour, the workforce is estimated to be 2,406,645 people in 2026, accounting for 9.57% of the total workforce in East Java Province (BPS, 2026). This represents a substantial opportunity for the manufacturing sector. The strong work ethic of Javanese and Madurese communities creates significant opportunities for employment in the private sector (Juliana & Suryandari, 2025: 8).

Outward-driving forces lead to population movement and the outward shift of regional functions from central areas to peripheral zones (Amrullah & Purnomo, 2015: 101). These forces act as drivers of the spatial concentration of activities. Variations in outward-driving movement are generally influenced by environmental conditions and the availability of natural resources. In the TKR, both water and electrical energy are relatively available. Electricity is supplied by the Paiton Steam Power Plant (PLTU), which also serves Madura Island and other parts of Java. Water resources are supported by adequate groundwater and natural springs, including the Umbulan Spring in Pasuruan Regency, the largest spring in East Java, with a discharge of 3,200 to 3,700 litres per second. Groundwater discharge ranges from 1 to 3 litres per second at depths of 30-40 meters.

Most of the non-built-up areas are allocated for planned residential development, aligning with the influence of outward-driving forces derived from environmental and resource availability. Approximately 75% of land allocation is designated for planned settlements, while the remaining 25% is used for industry, warehousing, and public facilities.

The conversion of non-built-up to built-up areas does not occur randomly; it follows a distinct spatial pattern. Based on the results of the NNA, this pattern is classified as clustered, with newly developed built-up areas exhibiting low-density characteristics. This clustered development pattern indicates the emergence of new growth centres, primarily along the main arterial road, Anyer-Panarukan, which serves as the principal transportation corridor in the TKR.

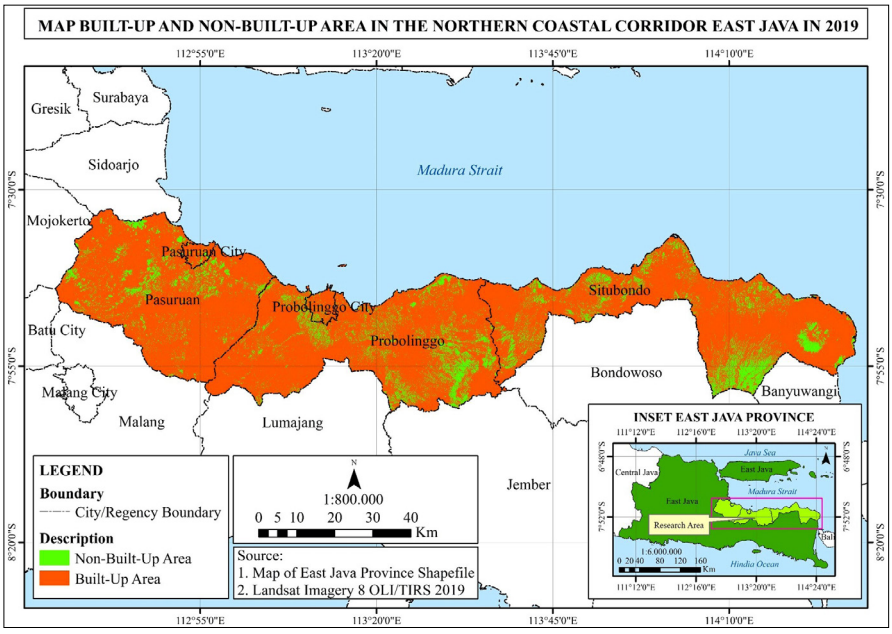


Figure 4: 2019 map of built-up area and non-built-up area in the TKR

Source: Author, using ArcGIS software, 2025

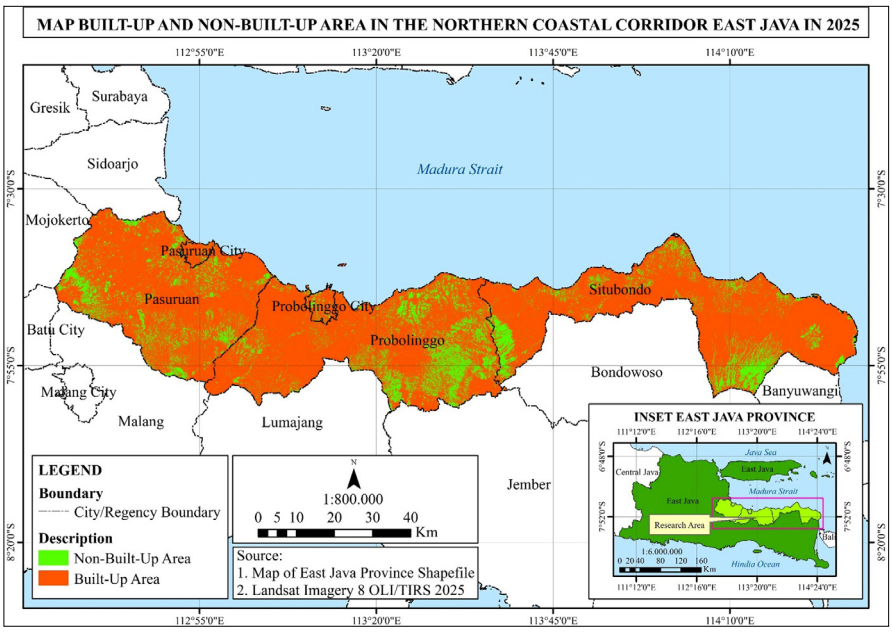


Figure 5: 2025 map of changes in built-up area to non-built-up area in the TKR

Source: Author, using ArcGIS software, 2025

Figure 6 and Table 4 present the results of the NNR analysis, which yields a value of 0.147157, clearly below 1, together with a very large negative z score (-283.15). A z score lower than -1.65 (at the 5% significance level) indicates that the spatial pattern is statistically significant. These results show that the distribution of built-up areas representing urban sprawl in the TKR is highly clustered. The p value of 0.000000 further confirms the strength of this clustering pattern.

Urban sprawl in the TKR is characterised by low-density (concentric) development, particularly along major road corridors. This pattern has emerged largely because new settlements are being developed independently of existing ones, often driven by developers taking advantage of farmers' willingness to sell rice fields at relatively low prices. Such development reflects weak government control over land-use change. In practice, private-sector planning, especially by residential developers, is communicated to government mainly through permit applications, while coordination between government agencies remains limited. As a result, spatial development is fragmented and inefficient. Low-density development requires higher-per-unit costs for infrastructure provision, particularly for water supply, electricity, and road networks. As noted by Omollo (2025: 111), rapid and uncontrolled densification is closely linked to weak development control mechanisms.

The spatial transformation from rural to peri-urban areas in the TKR is concentrated in a small number of major growth points, including city centres, the main North Coast (Pantura) corridor in East Java, and industrial zones. This pattern reflects the continued reliance on a growth-pole development strategy. However, the expected spread effects of this strategy have not yet materialised. Instead, economic activities remain spatially concentrated, limiting more balanced regional development. Even large-scale national infrastructure investments such as the Pasuruan-Banyuwangi toll road, connecting the western and eastern ends of Java, have not yet generated widespread regional benefits.

The clustered development pattern also indicates that population activities and infrastructure investment are focused in locations with high accessibility and strong economic functions. This concentration is evident in industrial areas along the Pantura corridor, including Pasuruan Raya, Probolinggo Raya, and Situbondo. The presence of the Rembang Industrial Estate (PIER) in Rembang District, Pasuruan Regency, may be viewed as a potential counterbalance to dispersed urban sprawl. However, it also raises an important question regarding causality: whether urban sprawl supports spatial transformation driven by industrial growth, or whether large-scale industrial development itself stimulates further urban sprawl.

Overall, the clustered pattern suggests that built-up areas are

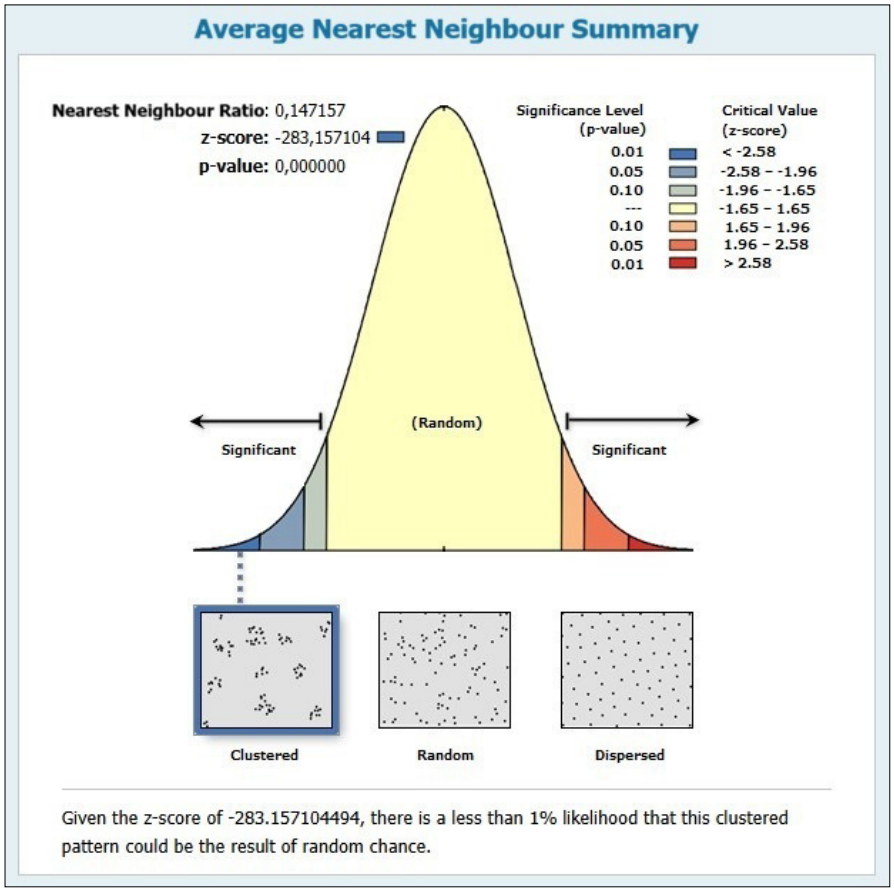


Figure 6: Average nearest neighbour analysis results (NNA)
Source: Author, using ArcGIS software, 2025

Table 4: Average nearest neighbour analysis results (NNA)

Average nearest neighbour summary	
Observed mean distance	22,5093 meters
Expected mean distance	152,9613 meters
Nearest neighbour ratio	0,147157
z-score	-283,157104
p-value	0,000000
Dataset information	
Input feature class	NDBI_15_25_ProbRay_FTPoint
Distance method	EUCLIDEAN
Study area	2818890618,031829
Selection set	False

Source: Author, using ArcGIS software, 2025

expanding outward toward city peripheries, while maintaining strong functional links to the primary metropolitan centre, Surabaya. At the same time, urbanisation, reflected in the growth of planned settlements, has not occurred evenly across the region, but is instead confined to selected development nodes. If this trend continues without stronger spatial controls, there is a risk that initially separate clusters of development will become increasingly connected, leading to more extensive and uncontrolled urban sprawl.

5.3 Interview findings

Following a quantitative analysis of the distribution of clustered, low-density urban settlements using the NDBI and NNA, qualitative interviews were conducted to uncover how local communities perceive these physical spatial changes from a social perspective. The outcomes of the deductive thematic analysis are visually summarised in Figure 7, which illustrates the hierarchical structure of themes and sub-themes derived from NVivo coding. The figure shows how coded interview data are clustered into three overarching thematic categories, namely development and physical changes, social and economic changes, and changes in environmental conditions, reflecting dominant patterns in Pendalungan community perceptions of urban sprawl. The substantive content of these themes is synthesised in Table 5, which presents a summary of Pendalungan community perceptions alongside their academic interpretation. Table 5 links recurring perceptions identified through NVivo coding with broader theoretical insights, thereby bridging empirical findings with conceptual understanding.

5.3.1 Development and physical changes

Pendalungan community perceptions are that highway construction is the main catalyst for regional change. In this instance, a catalyst is an element that can stimulate acceleration of regional development to become more advanced with increased accessibility, smoother flow of goods and people, and encourage local economic growth, especially in areas around the highway gate (Shofy & Wibowo, 2023: 1; Nouri, Muhammad & Daffa, 2024: 1130). Highway expansion as a catalyst for urban sprawl in the TKR has also occurred in several areas, as research by Lisnawati, Kasikoen and Sari (2021), Pratama, Yudhistira and Koomen (2022), and Pravitasari *et al.* (2024: 14) shows. Urban sprawl, which has driven regional development, simultaneously involves the conversion of agricultural land into planned settlements, the development of regional infrastructure, and the creation of new job opportunities. This finding is reinforced by the perceptions of informants as follows:

> "I am a native of Greater Pasuruan, and I work as a construction worker. The area has

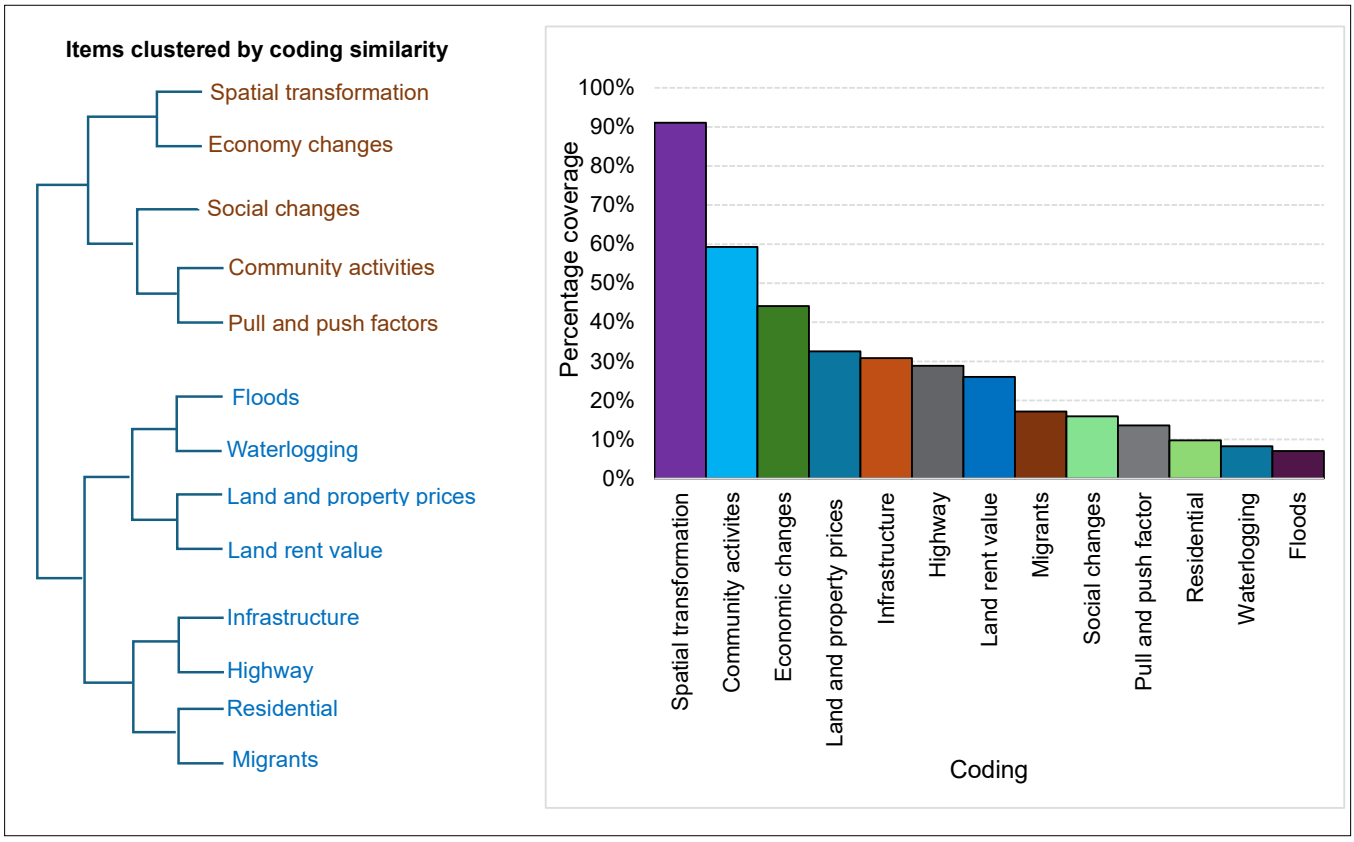


Figure 7: The hierarchical structure of themes and sub-themes derived from NVivo coding clustering Pendalungan community perceptions

Source: Author, using NVivo software, 2025

> become more crowded since the highway was built. More rice fields are being converted into land for housing development. There are also many migrants from Madura. They work as retail traders. *Cak M*''

The conversion of rice fields into residential areas indicates the embryonic beginnings of urban sprawl. As a developing country with sporadic and unplanned development patterns, the emergence of new areas is a positive development for the Pendalungan community. However, the reality of urban sprawl is also common in large countries such as China (Wang, Shi & Zhou, 2020).

5.3.2 Social and economic change

The community perceives the current reality as showing an unintegrated planning direction. Development remains concentrated in urban areas, while the outskirts have yet to experience sprawl. However, rural areas in the TKR face challenges of massive urban sprawl, contributing to a widening rural-urban divide. This situation aligns with research by Cattivelli (2021: 11), who found that urban-rural conflict has occurred in European countries. The Pendalungan community perceptions that urban sprawl has caused social and economic changes are based on increasing crowding, growing diversity of jobs, and improved access to public facilities. This shows that people place greater emphasis on economic and social benefits than on ecological risks that may arise. These findings reinforce the view of Hardiyanti (2018) that regional development often involves a trade-off between economic progress and environmental vulnerability. From a social perspective, growth in built-up areas is closely linked to a generally positive Pendalungan community perception of regional change. The Pendalungan community has a pragmatist mindset, meaning that as long as development benefits their lives, the rural-urban gap in the TKR will be ignored. The following informant explained the existence of the rural-urban development gap:

Mas I in Situbondo:

> "My current perception is that Situbondo is becoming more crowded. Although there is an urban-rural gap, there is development. There are also more jobs. There are many events that hawkers can take advantage of to increase their income''.

The community perceives that urban sprawl, as evidenced by the emergence of a new activity node, has increased land values but made housing prices unaffordable for low-income communities. This phenomenon is in line with the centre-periphery gradient theory, which states that systematic variations in land use and prices are interdependent (Nieuwenhuijsen, 2024: e8-e9). The more diverse the land use in an area, the higher the land value will be.

The NVivo analysis shows that the community accepts urban sprawl, because it brings liveliness and new forms of employment. As Menajang *et al.* (2016: 261) note, suburban and peri-urban areas often become meeting places between modern and traditional economic structures, thereby expanding the socio-economic opportunities of the community. Informants reported a shift away from agricultural employment towards informal and semi-formal jobs:

Bu A in Greater Pasuruan:

> "Many young people in this area work in factories. No one is interested in becoming a farmer anymore. The work is also quite far away, about 15 kilometres. Some have started their own businesses, such as making kites or working as construction workers. This reality has emerged in the last five to eight years, since this area began to get crowded''.

Local communities consider the presence of migrants to have a positive impact, because it brings new economic dynamics, expands social networks, puts pressure on residential space, and increases population density. Another impact is temporary congestion at highway exits. Traffic congestion at highway entrances and exits does not occur daily, but occurs during long holidays or national holidays, particularly during Eid al-Fitr. In Indonesia, there is a tradition of returning to one's hometown (*mudik*) during Eid al-Fitr. Various modes of transportation are used, and the government provides special services for this tradition.

5.3.3 Environmental change

Pendalungan community perceptions of urban sprawl impacting environmental conditions arise from flooding and waterlogging during the rainy season. While residents demonstrate awareness of spatial changes, many do not fully understand that the unplanned sprawl of new areas can cause environmental damage. Environmental damage always accompanies urban expansion, as findings by Festus, Omoboye and Andrew (2020: 114) indicate that urban sprawl has caused environmental damage such as ecosystem changes, loss of biodiversity, and loss of habitat for several animals in rural areas. In rapidly developing areas such as Greater Pasuruan and Probolinggo, the community has noticed a decrease in the functionality of drainage channels, due to the construction of new residential areas and roads. The reduced functionality of drainage channels

Table 5: Summary of interview results based on deductive thematic analysis

Deductive	Community perception	Academic interpretation
Meaning of regional change	Urban growth = economic progress	Positive perception of physical sprawl of the city, but not yet critical of spatial impacts
Land-use conversion	Considered beneficial, because it increases land value	Urban sprawl causes the loss of green spaces and productive agriculture
Mobility and migrants	Enhancing diversity and the economy	There is a distinctive socio-economic integration in peri-urban areas
Environmental quality	Flooding is considered a natural phenomenon	Low ecological awareness of the impact of spatial planning
Policy and spatial planning	The government has not been consistent and focused	Urban sprawl is triggered by weak spatial regulations and long-term planning

is caused by the accumulation of waste and building materials, leading to waterlogging when it rains.

Pak B:

> "Road renovations actually narrowed the waterways and caused flooding".

An interesting point is that the community has not yet linked the phenomenon of flooding with urban sprawl. The community perceives flooding as solely the result of weather or high rainfall, rather than changes in land cover and drainage systems. Flooding often occurs in Greater Pasuruan during the rainy season. This means that the community's environmental perception is still reactive and not yet ecological. From an environmental sociology perspective, the reality of urban sprawl in the TKR shows the limitations of the community's understanding of the relationship between physical development and environmental carrying capacity.

The findings of this study demonstrate that urban sprawl in the TKR is not only a physical land-use phenomenon, but also a socio-spatial process shaped by community perceptions and institutional practices. Spatial analysis based on the NDBI and NNA confirms that urban expansion in the TKR is characterised by low-density, clustered development along major transportation corridors. At the same time, qualitative findings reveal that the *Pendalungan* community generally perceives urban sprawl positively, primarily due to its socio-economic benefits, while environmental risks are poorly understood.

6. POLICY IMPLICATIONS

These findings imply that current spatial planning challenges in the TKR do not stem solely from technical planning deficiencies but also from a disconnect between formal planning frameworks and community interpretations of development. As shown in Table 5 and Figure 8, the community equates regional growth with economic progress and tends to legitimise land conversion, due to increasing land values. This explains why public participation in development planning remains weak: participation is constrained not by resistance, but by the absence of mechanisms that translate positive perceptions into critical engagement with spatial consequences.

Policy responses should, therefore, move beyond conventional regulatory enforcement and adopt participatory spatial governance approaches that integrate community perceptions into land-use control mechanisms. Strengthening public participation at the planning, implementation, and monitoring stages is essential, particularly in rural and peri-urban areas where development pressures are increasing (Creswell & Poth, 2016). In this context, the open, pragmatic, and solidaristic characteristics of the Pendalungan community (Ilham, 2024: 29-30) represent a strategic asset rather than a constraint for inclusive development. Involving communities can encourage a sense of ownership over spatial policies, thereby enhancing compliance with land-use controls and strengthening alignment between planning and implementation.

The study also highlights the need to better integrate development planning and spatial planning across administrative boundaries, as previously identified by Wagistina *et al*. (2025: 105-106). Fragmented permit issuance, limited inter-agency coordination, and sectoral egos have weakened spatial utilisation control, allowing developers to shape growth patterns that diverge from official spatial plans. Without improved integration, the clustered low-density pattern identified through NNA analysis has the potential to evolve into uncontrolled conurbations.

Environmental management policies require particular attention. Although communities already experience flooding and waterlogging, these impacts are still perceived as natural phenomena rather than consequences of land-use change. This low level of ecological awareness indicates the need for environmental literacy programmes that link everyday environmental problems to spatial development decisions (Festus *et al*., 2020: 114). Incorporating local knowledge and religious leadership, particularly through collaboration with *Kyai* in the TKR, could help bridge scientific planning perspectives and community understanding.

Investment policies should prioritise labour-intensive and environmentally appropriate industries to align with the region's workforce potential and resource availability (Juliana & Suryandari, 2025: 8; Gardner, 2025). Such alignment would help ensure that economic benefits associated with urban sprawl do not come at the expense of long-term environmental sustainability or agricultural resilience.

7. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that urban sprawl in the TKR is characterised by low-density and clustered development patterns, as evidenced by NDBI values averaging 0.132 and a statistically significant NNR of 0.147157. Spatial expansion between 2015 and 2025 has predominantly followed major transportation corridors, particularly the North Coastal (Pantura) corridor and the Daendels road, reflecting horizontal growth rather than compact urban intensification. These spatial patterns confirm the presence of urban sprawl that diverges from official spatial planning documents and generates inefficiencies in infrastructure provision.

In line with the study's objective, the mixed-methods approach reveals that understanding urban sprawl in the TKR requires attention not only to physical land-use change, but also to how the Pendalungan community interprets and responds to these changes. While remote sensing and GIS analysis confirm extensive land-use conversion and dispersed settlement growth, qualitative findings show that the community largely perceives urban sprawl as a positive process. Urban expansion is interpreted as a sign of regional progress, associated

with rising land values, diversified employment opportunities, and improved access to facilities. These favourable perceptions help explain why public participation in formal spatial planning remains weak: development (urban sprawl) is not contested, because it is socially legitimised at the community level.

This study has limitations in terms of collecting primary data on public participation in development planning. This is evidenced by the low response rate from research participants. In-depth interviews were conducted during working hours, *i.e.* in the afternoon, which disrupted participants. Conducting interviews in the evening would have interfered with their rest time.

The study identifies a critical gap between community perceptions and the longer term spatial and environmental consequences of urban sprawl. Although residents experience flooding, waterlogging, and environmental degradation, these impacts are rarely linked to land-use change or weak spatial control mechanisms. This indicates that community environmental awareness is reactive rather than ecological, limiting the community's capacity to engage critically with development planning or to demand stronger spatial regulation. This gap underscores the necessity of aligning spatial policy formulation with lived community experiences.

The findings further show that weak public participation is reinforced by institutional factors, particularly fragmented permitting processes and limited coordination among government agencies. These weaknesses have enabled developer-driven expansion to occur independently of existing urban structures, resulting in low-density clustered settlements that increase infrastructure costs and spatial inefficiencies. In this context, the absence of effective participatory mechanisms means that positive community perceptions are not translated into meaningful involvement in land-use control or long-term planning decisions.

Urban sprawl in the TKR represents both an opportunity and a challenge. While it reflects socio-spatial transformation that supports economic diversification and suburbanisation, it also threatens agricultural sustainability, environmental resilience, and spatial efficiency. The study concludes that improving public participation in development planning requires aligning spatial policies with community perceptions, while simultaneously strengthening awareness of the spatial and environmental implications of unplanned growth. By integrating social and spatial planning approaches and actively involving the Pendalungan community in land-use control, local governments can address participation gaps and promote more inclusive and sustainable regional development in the TKR.

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