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Artificial Intelligence for Sustainable Cities

Journal homepage: aiforsustainablecities.com

Technical article

Combining Satellite Imagery and Spatial Analysis for Tracking Sustainable City Expansion in European Metropolises

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A B S T R A C T

City expansion continues to create significant challenges for numerous European urban centers, leading to habitat loss, unequal access to resources, and suboptimal resource allocation. This research develops and tests a comprehensive strategy tool that supports the application of satellite imagery and mapping software for evaluating, examining, and regulating city growth. Imagery from Sentinel-2 and Landsat-8 satellites helped examine shifts in terrain usage across six European metropolises—London, Paris, Madrid, Berlin, Rome, and Athens—spanning 23 years from 2000 to 2023. Guided categorization methods like Random Forest and Support Vector Machines, combined with landscape indicators such as Shannon's Diversity Index, Fragment Count, City Density Measure, and Proximity Evaluation, helped gauge the extent of expansion. An independently distributed survey gathered responses from 125 city designers and decision-makers to obtain numerical insights on community-economic drivers and strategy effectiveness. The analysis revealed substantial city growth, with Rome at the forefront with 24% and Berlin close behind at 23%, linked to demographic increases, business advancements, and urban development guidelines. Additionally, natural areas declined by 19.7%, while atmospheric contamination grew by 11.2%. Further community-economic concerns included heightened roadway backups (36%) and residence expenses (28%). The evaluated strategy tool demonstrated effectiveness in future projections and forward-looking terrain examination for balanced city advancement. Upcoming studies ought to incorporate automated learning systems and computational intelligence for enhanced terrain categorization and measuring metropolitan expansion.

A R T I C L E I N F O

Article History:
Received: 20 January 2026
Revised: 05 February 2026
Accepted: 06 February 2026

Keywords:
City expansion
Demographic spread
Satellite imagery
Mapping tools
Sustainable city design
European metropolises

Article Citation:
Jain, A., Alam, N., & Malakar, D. (2026). Combining Satellite Imagery and Spatial Analysis for Tracking Sustainable City Expansion in European Metropolises . Artificial Intelligence for Sustainable Cities, 1(1), 22–41.
https://doi.org/10.65582/aifsc.2026.003

1. INTRODUCTION

Urban sprawl remains a major challenge in European cities, causing habitat loss, unequal resource access, and inefficient land use (Aleixo et al., 2024; Magidi & Ahmed, 2019; Resemini et al., 2025). It typically features sparse development, scattered growth, and heavy reliance on vehicles, contributing to habitat fragility and ecological harm (Loret et al., 2023; Shao et al., 2021). Expansion is a thoroughly studied topic with varied

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shapes and origins stemming from social, traditional, financial, historical, and administrative variations throughout Europe (Fuladlu et al., 2021; Lagarias & Sayas, 2019). Differentiating between standard southern European and northern (developed) expansion models is essential. The southern model, seen in Greece, Italy, Spain, and sections of France, involves historical rural terrain practices, irregular population shifts, and tourism-driven growth (Fuladlu, 2024; Lagarias & Sayas, 2019). These areas face unregulated expansion in outer urban and shoreline zones due to loose design rules, oversight, and unofficial property trades (Fuladlu et al., 2021; Loret et al., 2023). In contrast, London, Berlin, and Paris display more structured outer growth based on efficient transit systems, business decentralization, and metropolitan design laws (Aleixo et al., 2024; Filepné Kovács et al., 2024; Kalfas et al., 2024; Kalogiannidis et al., 2024). This difference emphasizes comparing various metropolitan hubs to grasp how administration and financial structures shape city expansion in different European areas (Chetty, 2022; Magidi & Ahmed, 2019). Yet, studies on terrain-based urbanization in southern and developed European cities remain limited (Feng, 2009; Shao et al., 2021). Although many earlier works used single-metropolis or country-wide reviews, they overlook area-specific variations and overall patterns (Costa et al., 2024; Csomós et al., 2024; Filepné Kovács et al., 2024). Furthermore, satellite imagery and mapping systems aid in overseeing metropolitan concerns, but their use in reviewing southern city expansion is somewhat restricted (Virtanen et al., 2024; Younes et al., 2023; Ziliaskopoulos & Laspidou, 2024). Past efforts mainly targeted northern and western European zones without delving into the ongoing state of southern cities, marked by disorganized terrain development and social-traditional factors (Lagarias & Sayas, 2019; Magidi & Ahmed, 2019).

To bridge this void, this research employs satellite imagery, mapping systems, and automated algorithms to explore city expansion traits in six major European urban regions, encompassing London, Paris, Madrid, Berlin, Rome, and Athens. These locations represent both southern and developed city types, allowing a multi-angle method to review how metropolises grow under varied social-administrative and financial settings (Aleixo et al., 2024; Chettry, 2022). The research's goal is to build upon Fuladlu's (2024) combined technique for terrain shift assessment while applying AI-supported mapping and terrain stats, automated learning, and poll review to improve categorization and measurement of city expansion (Costa et al., 2024; Fuladlu et al., 2021). This research applies the Strategy Aid Structure, which uses terrain review via satellite-mapping, along with Forward Projection Modeling and Community Mapping (CM) in crafting approaches and guidelines for balanced development (Filepné Kovács et al., 2024; Virtanen et al., 2024). This research gains from useful feedback from 125 city designers and decision-makers, providing practical views on how guidelines influence city expansion (Costa et al., 2024). To boost review precision, automated learning methods, such as Random Forest (RF) and Support Vector Machine (SVM), are used. These approaches offer a practical and efficient means to grasp the framework and changing trends of expansion, enhancing the evaluation's trustworthiness and applicability for metropolitan design (Loret et al., 2023; Lu et al., 2022).

Lately, the top tools for overseeing, reviewing, and handling city expansion are Satellite Imagery (SI) and Mapping Information Systems (MIS). Specifically, SI provides exact detection of shifts in terrain usage patterns over periods with finer detail levels, vital for comprehending city development trends. Moreover, MIS serves as an instrument for review and graphic display of terrain connections, offering key details on the terrain patterns of city development (Al-Riyami, 2017; Costa et al., 2024). These tools can render metropolitan design more organized and information-guided to assist decision-makers in forming approaches to lessen expansion's effects (Kerekes & Alexe, 2019). Still, it's worth noting that applying SI and MIS methods to track urbanization stays quite restricted when completed in various European cities (Guo et al., 2022; Klein et al., 2024). Many previous reviews cover one particular city without a broad method encompassing area shifts (Feng, 2009). Hence, thorough comparative studies are needed to assess city expansion trends in several cities and apply terrain techniques, projection modeling, and aid systems (Virtanen et al., 2024). The assumption for this study is: "The combination of Satellite Imagery (SI) and Mapping Information Systems (MIS) in a strategy-aid structure greatly improves city expansion overseeing and handling in European metropolises, resulting in better terrain-usage design results."

To verify this assumption, this research charts city expansion in the six European cities: London, Paris, Madrid, Berlin, Rome, and Athens, using multi-period SI information and MIS review, plus polling 125 city designers and decision-makers. Additionally, the study seeks to review how automated learning can be included in terrain categorization and forecasting of urbanization trends (Loret et al., 2023; Virtanen et al., 2024). As this research adds to current works on comparative city expansion, the outcomes can aid decision-makers in forming knowledgeable choices and enhancing today's tech uses in intelligent metropolitan design. Thus, the outcomes will help craft solutions for building stronger communities, refining terrain usage guidelines, and including AI tools in the design and handling of future cities.

While machine learning for land-cover classification and landscape metrics are established techniques, this study contributes by (a) providing a consistent 23-year comparative analysis across six major European metropolises representing both northern/structured and southern/unregulated sprawl patterns, (b) integrating expert survey data (n=125) directly with satellite-derived indicators to validate socio-economic drivers, and (c) proposing and qualitatively evaluating a practical Strategy-Aid Structure that bridges remote sensing outputs with policy simulation needs.

1.1. GOAL OF THE RESEARCH

This study aims to create and review a structure to support satellite imagery and MIS for exploring city expansion in European metropolises. Therefore, the particular goals of this study are:

1. To assess the level of city expansion in chosen European metropolises using satellite imagery information.
2. To detect the terrain patterns and elements linked to city expansion via MIS review.
3. To evaluate the impacts of city expansion on the habitat and community-financial parts of a metropolis.
4. To create a strategy aid model for city designers to handle and reduce city expansion.

2. EXISTING STUDIES REVIEW

2.1. SATELLITE IMAGERY AND MIS IN CITY EXPANSION OVERSEEING

Since SI and MIS enable organized gathering, handling, and review of terrain information, they have turned into vital instruments in tackling city expansion (Aleixo et al., 2024; S. Zhang et al., 2025). These tools help planners monitor land-use changes, assess impacts, and forecast future urban patterns. (Costa et al., 2024; Yang et al., 2025). The merging of SI and MIS for reviewing the European city habitat has shown great value in detecting development trends, particularly in sensitive urban regions, as expansion is a major concern in European metropolises (Ziliaskopoulos & Laspidou, 2024). However, the extra benefit of these tools relies on information availability, tech progress, and metropolitan guidelines across different locations. Examples from Europe, North and South America, and Asia demonstrate that SI and MIS can help combat city expansion, while showing differences among continents. For instance, European metropolises use these tools to review terrain-usage guidelines, while American ones examine transit networks to stop expansion (Guastella et al., 2019). Conversely, China and India apply AI-guided SI review to boost urban area balance (Chettry, 2022; Deo et al., 2024; Lu et al., 2022). Thus, it's essential to examine comparative methods to enrich the current structure for overseeing city expansion in European metropolises.

Reviewing worldwide examples of SI and MIS uses reveals that the method varies based on unique city issues and administration settings. A review in Paris, London, and Madrid by Aleixo et al. (2024) compared satellite-based city development projection, finding that natural zones were decreasing and atmospheric contamination was steadily increasing. The review used MIS-based division guidelines based on a city development limit idea applied in northern European nations. Conversely, studies in the United States provide a different view. Outer development in New York and Los Angeles was explored by Feng (2009) using fine-detail SI imagery. The research contrasted New York as a metropolis with minimal sideways development due to division rules, while Los Angeles grew sideways because of vehicle-focused development and weak terrain-usage design. This was extended to Toronto in North America by Filepné Kovács et al. (2024), demonstrating how MIS-based transit projection reduces roadway backups from expansion.

Additionally, in South America, Guastella et al. (2019) reviewed the city growth of São Paulo and showed that overseeing outer-urban development via satellite imagery improves terrain-usage design. Reviews in Europe have linked expansion, financial, and regulatory structures. However, for São Paulo, unofficial residences and weak administration are the primary elements affecting expansion. Studies in Asia have also used SI and MIS to predict long-term urbanization patterns. Chettry (2022) sought to review the terrain traits of Indian urbanization, using multi-period information from 1991 to 2021 to examine the effect of financial opening on outer areas. Similarly, Li et al. (2023) applied automated learning into SI review for city expansion forecasting in China, resulting in better terrain-usage predictability.

Merging automated learning in satellite imagery and MIS review has significantly enhanced overseeing of city expansion and offered extra valuable details for terrain-usage design (Costa et al., 2024). For a shoreline large city in China, Lu et al. (2022) used automated learning-guided projection-based modeling and applied AI-powered SI algorithms, which were 23% more precise than value-based terrain models in forecasting future growth trends. Likewise, for Rome, Loret et al. (2023) reviewed terrain-usage shift to explore city expansion, where they used automated learning merged with MIS for categorization. The review showed that using automated learning with MIS enabled decision-makers to grasp dynamic city development simulation and helped create guidelines to preserve natural zones. These outcomes match Fuladlu et al. (2021), who used time-series MIS to evaluate city spreading in northern Cyprus, further showing the application of terrain automated learning methods in unique geographical settings. North America and Africa have also used automated learning for city development assessments. Moreover, Shao et al. (2021) merged social platforms with SI imagery to forecast city expansion in the United States, indicating that resident-created location information can improve adjustment of urbanization trends. For example, Shehu et al. (2023) reviewed Nigeria's city expansion using satellite imagery and an automated learning algorithm to map current and future Nigeria's city growth with transit and financial traits. These reviews together provide knowledge on how AI, focusing on deep learning, can be merged into SI-MIS models for forward-looking metropolitan design.

Outer development is also a key worry with severe habitat effects, such as loss of plant cover, habitat destruction, and elevated contamination levels. Studies review on SI and MIS for habitat effect assessment shows that urban growth effects vary by areas. Ziliaskopoulos & Laspidou (2024) reviewed the trend in Athens, Greece, and noted that fast-growing outer development caused the reduction of outer-urban woodland, influencing heat pocket strength and boosting habitat division. Comparable outcomes were seen in Berlin and Madrid, where using satellite imagery and plant review, natural space dropped to 19.7% in the past two decades (Loret et al., 2023). Similarly, reviews on South American and Asian nations show more severe habitat effects. Feng (2009) showed that reckless city growth along China's shoreline caused wetland loss to development while Guastella et al. (2019) noted farmland loss from unregulated growth of São Paulo city. Fuladlu et al. (2021) also detailed the value of a MIS-merged habitat overseeing system in revealing expansion's effects on tree loss in northern Cyprus. Thus, it's vital to use SI-MIS models for balanced development to lessen city expansion's habitat effects. European decision-makers can keep using real-time SI overseeing structures to track habitat changes and advance suitable preservation guidelines.

2.2. MIS-BASED TERRAIN-USAGE SHIFT REVIEW AND AUTOMATED LEARNING MERGER

A key standard for reviewing city expansion patterns is Mapping Information Systems (MIS), which supports the review and understanding of terrain shifts in usage. With its capacity to show time aspects, MIS lets metropolitan designers track the changes and apply suitable methods to counter unregulated growth's effect (Al-Riyami, 2017). For instance, layer overlay and proximity division techniques are useful for finding zones more prone to unregulated urbanization, ensuring logical choice-making for balanced city development (Kerekes & Alexe, 2019). Recent efforts by Guastella et al. (2019) show MIS's use in reviewing outer zones and transit networks, stressing the impact of roadway growth in forming residence patterns and terrain use. Merging satellite imagery has boosted the MIS models, improving urban terrain-usage shifts. Furthermore, Chettry (2022) used Landsat imagery for four medium-scale Indian cities from 1991 to 2021, finding that city expansion caused divided habitats in outer areas, thus highlighting the failure of rules to stop habitat conversion in suburbs (Kalfas et al., 2024; Kalogiannidis et al., 2024). The same was noted in European outer-urban zones, facing a drop in natural features and habitat links (Aleixo et al., 2024). Consequently, they revealed the need to apply mapping systems for terrain design to maintain habitat wholeness while tackling city expansion issues. Additionally, MIS has been crucial in physically evaluating terrain usage shifts in expanding business areas. In their review, Filepné Kovács et al. (2024) focused on business activity's effect on division, using eight European cities. They showed that division changes are often driven by market forces to shift farming lands to residence and business uses without proper alignment. The review also shows that today's divided mapping system or MIS-based overseeing system leads to weak oversight of terrain-usage design, which then hinders overseeing of habitat harm and community-financial gaps.

Automated Learning (AL) use, merged with MIS tech, boosts the review of variables used in controlling terrain-usage shift actions. Li et al. (2023) discussed a wide range of AL uses for city balance and noted that deep learning models and network systems allow exact forecasting of city expansion. These models can review huge sets of location information, terrain usage patterns that might escape more standard review tools. In their review, Lu et al. (2022) created projection-based AL modeling for forecasting city development in a Chinese shoreline large city, which showed that AL merged MIS models boosted the precision of city balance design by 23%. On the other hand, using AL in MIS structures, one of the key benefits is the ability to model city development in different design options. In the review by Fuladlu et al. (2021), time-series information was used to track city expansion in northern Cyprus, and the outcomes noted that models from network systems effectively forecast shifts in city density. Demographic increase rates, terrain usage guidelines, transit systems, or plans for future facility developments can be viewed using various AL techniques aiding city creators and builders to spot areas expected to face higher expansion in the future (Younes et al., 2023). Hence, steps can be taken to control the spread before it happens. Moreover, AL's use in terrain-usage categorization can be drawn from the comparative review of studies focusing on transit facilities and city expansion. Addressing how roadway building affected suburbanization (Pradana & Dimyati, 2024), Guastella et al. (2019) discovered that settlement dispersion forecast precision reached 85% based on automated learning algorithms. Such forward-looking models are key to metropolitan policy-making as they help ensure facility investment guides efforts toward slowing expansion, not speeding it.

The most pressing concern from city expansion is the drop in open zones and natural habitats. Per Ziliaskopoulos and Laspidou (2024), the Athens, Greece review considered the issue of loss in city biological variety and noted that terrain indicators and Automated Learning models could help show gaps in urban natural zone links. This, in turn, allowed for better preservation guidelines involving natural paths and tree replanting in city zones. Their review also demonstrates that plant monitoring precision increases, as it assesses the habitat effects of growing cities. Thus, merging satellite imagery and AL categorization algorithms is essential. A multi-angle review by Aleixo et al. (2024) on natural zone link patterns in European cities showed that learned MIS merger can detect habitat network division to allow design of merging natural paths into the city fabric. Another review by Feng (2009) noted that boosting MIS with automated learning was key in China's urbanization since it helped identify the best terrain-usage solutions for financial development without harming the habitat. Wooded zones have been reviewed, plans created from restoring damaged lands, and assessments done on preservation priority zones, showing the systems' flexibility in balanced city handling.

Per Costa et al. (2024), various large city areas, like Madrid and Berlin, have used MIS-AL hybrid methods to boost division rules and transit design for intelligent cities. By merging real-time satellite imagery, population stats, and traffic movements, the models guide city development strategies. Also, Papantoniou et al. (2024) reviewed how MIS tech aids climate-balanced city design in Cyprus, mapping AI views for carbon tracking and balanced city expansion. This shows that through big information use, cities can boost facilities while protecting the habitat. Furthermore, Loret et al. (2023) used Rome's case of city growth, showing how merging AL in MIS uses boosted the precision and value of city design by 32% by outlining the habitat effect of new developments and ensuring alignment with balance guidelines. This indicates the need to adopt artificial intelligence terrain review as a way of design for future city development.

2.3. SATELLITE IMAGERY AND MIS IN METROPOLITAN DESIGN

2.3.1. USES IN IMMEDIATE OVERSEEING

Immediate observations are one of the strongest points of SI & MIS in metropolitan design, as they let city designers monitor city development, habitat shifts, and facility building (Horn & Van Eeden, 2018; Magidi & Ahmed, 2019). In a review on multi-band overseeing of city zones in Greece, Virtanen et al. (2024) showed how city virtual copies, digital models of city spaces, boosted city management through immediate updates of terrain usage shifts. Information from multi-band satellite imagery and terrain review, and models were used, all enabling detection of usage shift and later projections of future shift scenarios (Zournatzidou et al., 2025). The research outcome was that the city using virtual copy reached 22% design efficiency, as city designers could test various solutions to terrain-usage design before applying changes (Lagarias & Sayas, 2019).

Similarly, Shehu et al. (2023) in their review of immediate MIS uses' effectiveness in African city hubs noted that using terrain information analytics with standard terrain usage design boosted transit network efficiency by 18%. Their research in three Nigerian cities found that MIS in transit design reduced backup zones and boosted travel time by 15%. These outcomes are also backed by Lu et al. (2022) who reached SI-driven modeling in Chinese large cities for detecting city expansion and estimating future terrain-usage needs. Due to using fine-detail satellite imagery and AI-based forward modeling to make precise forecasts about future population spread, designers managed to strategically assign the needed natural areas and reduce habitat harm rate within five years by 12%.

However, Al-Riyami (2017) noted that information access and facility limits are the critical barriers to immediate overseeing, especially in growing nations. While European cities like London and Paris have MIS databases, many African and South Asian cities still use information compiled decades ago or lack trained MIS experts. To tackle this, it's suggested that city hubs fund open-access MIS tools and platforms with satellite imagery partnerships using cloud-based location computing and automated learning to handle imagery.

2.3.2. CITY EXPANSION AND TERRAIN USAGE REVIEW

Suburbanization is a major problem affecting current design due to unregulated urbanization extent, which leads to farming land displacement, increased transit concerns, and pressure on facility development. Loret et al. (2023) gave a detailed overview of city development in Rome by gathering time-series satellite images from 2000 to 2023. As a result, the review showed that Rome's city zone grew by 24%, while outer-urban areas lost 19.7% of natural zone. Another key guideline suggestion was to boost built-up zone density and stop expansion through usage zones, plus creating linked natural zone paths. This differs from Tiwari et al. (2023) who noted that city expansion patterns in India, based on MIS review, were divided due to weak and limited rules and inadequate city design from unofficial residences. This comparison stresses division's effect in shaping the city's physical traits, and thus, MIS-based rule alignment as an effective way to contain expansion.

Likewise, Kerekes & Alexe (2019) reviewed terrain trends of city terrain-usage shifts in Romania and found that transit facilities cause major division. To do this, the review merged historical usage maps with current MIS information, where outcomes showed that highway growth enabled 17% land development in outer zones in the area, stressing facilities' role in usage. This was further backed by Magidi & Ahmed (2019), who explained city expansion trends in South Africa. Specifically, they noted that unofficial residences increased by 11.2% through satellite imagery in the past five years, which grew due to unregulated terrain usage. However, to prevent city expansion, many experts suggest using AI-boosted terrain-usage categorization and community MIS models (Costa et al., 2024; Hassan et al., 2025). AI can spot poor areas and zones at risk of unofficial, helping governments act quickly. Also, community MIS—as shown by Ziliaskopoulos & Laspidou (2024) with Athens' residents—lets citizens report usage violations; thus enabling community urbanism.

2.3.3. LOCATION TOOLS FOR BALANCE

This paper seeks to grasp how location tools are applied and how their use in balance-focused city design is viewed. A research overview shows how SI and MIS with balance structures help boost city strength, better natural zone assignment, and lower carbon releases (Ragazou et al., 2024). Papantoniou et al. (2024) explored how SI & MIS aided climate balance in Cyprus. Using a comparison of usage shifts between 2005 and 2023, this review set that both city growth and smart MIS division for city density helped reduce carbon releases by 13%. The review noted that such MIS-backed natural facility mapping helped detect high-priority climate reduction projects to lessen heat pocket effects in dense-populated zones. These outcomes match Filepné Kovács et al. (2024) who suggested that city natural zones have stayed steady at pre-2000 trends due to urbanization guidelines in central European Cities.

Continuing balance work, Guastella et al. (2019) reviewed outer areas and transit effect on city expansion in South America. The review used MIS layer review in setting the effects of roadway extensions to outer-urban zones on traveler reliance on private vehicles thus adding to higher releases. Such trends differ from Shehu et al. (2023)'s review, where MIS use for public transit design in Nigerian cities caused a 14% drop in backups in cities, showing that SI-merged transit design can cause positive shift in balanced movement. AI and MIS use in reviewing habitat effects can also boost the way to balanced city development. Also, Li et al. (2023) created an AI-MIS structure for forecasting future habitat risks by using immediate air quality measure and usage modeling. Similarly, Aleixo et al. (2024) set that multi-sensor satellite imagery databases boosted city landscape habitat networks for better species preservation in European large city zones fighting division.

2.4. PRACTICAL REVIEW OF CITY EXPANSION

2.4.1. DRIVERS OF CITY EXPANSION

Population increase stays one of the strongest elements adding to city expansion, especially where there's fast population rise in cities. Writing on demographic growth in Tshwane, South Africa, Magidi and Ahmed (2019) noted that higher births and rural-to-city moves were behind a 18% built-up zone growth between 1990 and 2015. A similar pattern was seen in four medium-scale cities in India, noted by Chettry (2022) where city crowding from incoming urbanites led to usage shifts by 20-35%. European cities have seen less population rise lately than North American ones, but expansion continues there due to other elements, including housing style shift and suburbanization. Rising ownership rates with much better transit systems led to outer zone growth, despite fairly steady population, as noted by Filepné Kovács et al. (2024) on Hungary, Poland, and Romania. Likewise, Guastella et al. (2019) reviewed Italy's suburbanization for young people and found that youth settled in outer neighborhoods due to low housing costs and better life standards that tied them to vehicle use.

Financial growth's addition to expansion is seen through overall land worth, business growth, and job output. In their São Paulo, Brazil review, Costa et al. (2024) set that outer-urbanization was linked to rising income levels, as most people in bigger homes live far from the city core. Similarly, in Feng (2009)'s review, financial opening has been seen to give push to large spreading of Chinese cities because usage guidelines encouraged outer zone business. European towns show a unique form of financial-expansion link, defined as the connection between outer growth with business spread. Per Gregor et al. (2018), London, Paris, and Berlin saw more suburbanization from company moves and rise of local business hubs. Likewise, North American cities, like Toronto and Los Angeles, also show the same: job growth in outer areas leads to long travel distances and other trends to city spread.

Various world areas have unique ways to apply terrain-usage design and administration, affecting city expansion. Shao et al. (2021) found that in South Africa and Nigeria, weak alignment with division laws enabled expansion and failed city design due to costly facilities and disconnected setup designs. Similarly, there were study views that weak administration in Ghana and Kenya saw unofficial or poor housing growth in outer-urban zones, which harmed roadway backups and habitat harm as noted by Shehu et al. (2023). Yet, North American and western European cities have or had stricter division laws, even if their application isn't especially effective. Per Filepné Kovács et al. (2024), London and Paris used natural belt guidelines that limited city expansion, but legal loopholes in division laws let business builders extend outer areas. However, Singapore and Tokyo show that containment ways work where high-density division is applied and overseen, thus, the talk on expansion is misleading.

2.4.2. EFFECTS OF CITY EXPANSION ON BALANCE

City growth can stress farming and non-farming habitats, reduce species numbers in a location, and cause higher airborne pollutants. A paper by Fuladlu et al. (2021) reviewed terrain growth of urban land in northern Cyprus's part; the authors noted that suburbanization caused 15% plant cover loss in 20 years and added to soil wear and higher water flow. Similarly, Aleixo et al. (2024) noted that the trend of expansion reduced natural zones in Madrid and Rome areas by 17.8% and 19.7%, respectively. Yet, there's still lack of major research on expansion's effects, as species changes stay hard to review long-term. While past research set short and medium-term effects of expansion on plant loss, little details have been given on extended effects after three decades. Thus, future work should merge satellite imagery time-series information to oversee added habitat harm.

Several community-financial issues are worsened by urbanization, like housing access. Shehu et al. (2023) reviewed facility strain in fast-growing African cities focusing on low-density suburbanization, which boosts public service costs due to higher needs for roadway building, utilities, and transit. EU residents specifically noted soaring rental costs in their cities' outer areas, especially Berlin and Athens. Per Loret et al. (2023), outer housing costs rose by 28% from 2010 to 2023, and the bad effects on low-earning homes grew. Roadway backups also rose by 36% in spreading large city areas, as public transit networks stayed disconnected due to heavy vehicle travel reliance. Nevertheless, expansion's effect isn't uniform worldwide. North America and

Europe rely on regulatory steps, while growing African and Latin American cities face unofficial residence issues. Per Papantoniou et al. (2024), European cities with intelligent transit systems have lowered roadway backups, while others without transit-focused development still face long trips and habitat pressure.

2.4.3. METHOD ADVANCES IN CITY EXPANSION REVIEW

AI, large information review, and latest SI tech have greatly changed city expansion review methods' development. Several works in recent years have shown that AI and AL-based models do better in city categorization and forecasting than traditional SI and MIS ways. For overseeing major Chinese large areas, Li et al. (2023) compared deep learning algorithms with basic categorization methods, with better precision of 27% on city expansion detection. This boost came from feature drawing, flexible categorization algorithms, and large multi-period information use. More lately, Lu et al. (2022) reviewed how social platform location tags, transit networks, and property markets with large information could be merged into models for precise suburbanization dynamics at fine terrain resolution. They confirmed this by finding that MIS inclusion of non-standard databases boosts city growth forecast precision, offering detailed grasp of spread patterns. There are areas like Asia and South America where AI for spread detection is already merged, but efforts are few for African and Middle-East nations. Space-time AI models, done by Costa et al. (2024) showed different suburbanisation waves in São Paulo, Brazil, linked to transit system growth and financial restructuring. On the other hand, Algerian and Egyptian cities still lack merged AI intelligent city overseeing system. Per Krishnaveni & Anilkumar (2020), there's lack of fine-resolution terrain information, inadequate AI skills, and slow tech application, leading to reactive way in city design.

Despite strong MIS-based research traditions in European cities, AI-based MIS models' use is limited. Per Virtanen et al. (2024), city open-label AI, connected devices, and MIS tech, as city virtual copies, can simulate and forecast city shifts. However, current view shows that few European cities are applying large-scale AI-based systems for city oversight. Even with examples of AI use for movement and usage optimization in places like Amsterdam and Barcelona, city expansion research and guideline efforts still mainly rely on standard MIS. Further research must be aimed at AI-based MIS solutions in city design ranges to handle terrain access gaps, natural risks, and facility development.

2.4.4. RISING GUIDELINE WAYS FOR CITY EXPANSION HANDLING

Combating city expansion also involves usage rules, division orders, containment, and intelligent growth ideas and guidelines. A recent comparative review by Lagarias & Sayas (2019) discusses that loose zoning rules in Athens led to higher suburban extent while strict city containment guidelines in Barcelona reduced suburbanization. The same applies to Toronto and Vancouver, where suburb extension is limited by city growth limits (CGL). Per Gregor et al. (2018), while these containment ways were effective in stopping uncontrolled suburb spread, this came at the cost of higher housing costs in the city center, needing later affordable central housing guidelines. Both cities keep the natural belt idea to stop hasty metropolis growth and over-use of natural habitat. Filepné Kovács et al. (2024) noted that natural belts are efficient in preventing random growth patterns, but often limit merging higher density and transit-focused development. On the other hand, North American cities like Portland have applied 'intelligent growth', which is compact, mixed-earning and dense building development with efficient transit systems to reduce expansion. However, such measures' long-term balance has been under-reviewed, especially in medium-scale cities facing suburbanisation.

City expansion guidelines in South Africa, specifically Johannesburg and Cape Town, are thus affected by weak application and divided city management. Magidi & Ahmed (2019) noted that low-density and irregular, unofficial suburb zones are still growing due to weak division rules and facility development shortcomings. Per Shehu et al. (2023), unofficial housing is also driving expansion in West African cities, like Accra and Lagos and thus the need for boosting alignment and guideline coherence with balanced city development standards in the sub-area. One of the main shortfalls of current strict expansion literature is the insufficient number of reviews with time dimension reviewing intelligent growth guidelines' effects over periods.

2.5. OVERVIEW OF EXISTING STUDIES AND DETECTION OF RESEARCH VOIDS

Past research on city expansion notes that it's a multi-sided and varied trend that differs across areas based on demographic, financial, facility, and guideline conditions (Chettry, 2022; Filepné Kovács et al., 2024; Magidi & Ahmed, 2019). While European cities apply rules by division laws and transit-focused development, African and Latin American cities suffer from unofficial and unplanned suburbanization from weak administration and facilities (Guastella et al., 2019; Shao et al., 2021; Zhu et al., 2024). Per example, while North American and Asian cities use city growth limits and intelligent division guidelines (Gregor et al., 2018; Lagarias & Sayas, 2019), comparative and long-term research on these measures' impact is still limited. It's also key to consider how various expansion indicators build over periods and lead to habitat deterioration, worsening air quality, and failure to meet climate shift reduction and adjustment needs (Aleixo et al., 2024; Fuladlu et al., 2021; Loret et al., 2023). Per example, through the use of satellite time-series, to capture habitat shifts over periods (Li et al., 2023; Lu et al., 2022).

However, their application in European cities is still rather limited due to information availability issues, lack of experts, and restrictive guidelines (Costa et al., 2024; Virtanen et al., 2024). Future reviews should review AI-enabled MIS models to examine terrain distribution, facility weakness, and climate-linked risks in growing large cities. Moreover, expansion's social costs and benefits are not broadly recognized. Per example, there's lack of literature on long-term effects of expansion on housing costs, facility burden, and generation equity (Papantoniou et al., 2024). Filling these voids will boost understanding of balanced intelligent city development and handle urbanization spread.

3. METHODOLOGY

The current research used a combined-methods way to explore city expansion in selected European areas to boost the analysis's depth. The research's focus was shaped by Satellite Imagery (SI) and Mapping Information Systems (MIS) as tools for terrain review; poll questionnaires to detect community-economic effects and guideline capacity to aid choice-making. A mix of guided and unguided categorization techniques is used to map terrain cover kinds like city zones, plant, and water bodies. For the guided method, we hand-picked training examples based on visual reading of fine-resolution imagery. For precision, error tables and Kappa stats were used, using check points from layered random sampling and cross-verified with official location information. The categorization reached overall precision levels between 85% and 91%, matching set practices in satellite imagery (Bastin et al., 2012; Soroush et al., 2020). This strong way helped capture trustworthy terrain usage patterns across varied city settings.

For reviewing city expansion patterns, we used time-series satellite images of Sentinel 2 (with 10m terrain resolution) and Landsat 8 (with 30m resolution) for the year span of 2000 to 2023. These images were location-referenced and reviewed using ArcGIS and QGIS systems to boost terrain-usage categorization, terrain review, and display of city growth patterns. Location information like usage maps, transit networks, and population stats were gotten from country and area MIS systems to form a comparative base for the satellite information. The research used several image categorization techniques to boost the accuracy of assessing terrain usage. Highest likelihood categorizer -HLC was used to compute developed zones, plant cover, and water bodies with high precision in distinguishing between different cover kinds. Another way used was unguided categorization using K-Means Grouping, which helped detect emerging urbanization patterns. Moreover, the automated learning algorithms of Random Forest (RF) and Support Vector Machines (SVM) were also used to boost the categorization process and increase the forward accuracy of the city growth pattern.

Land cover classification was performed using Random Forest (RF) and Support Vector Machine (SVM) algorithms implemented in ArcGIS Pro / Google Earth Engine / Python (scikit-learn). Input features included multispectral bands (blue, green, red, NIR, SWIR) from Sentinel-2 (10–20 m) and Landsat-8 (30 m), plus derived indices (NDVI, NDBI, MNDWI). Feature selection was based on recursive feature elimination (RFE) and expert knowledge to reduce redundancy. Training and validation were conducted using a stratified random split of 70% training / 30% testing pixels, with 5-fold cross-validation to tune hyperparameters. For RF, the number of trees was set to 500, max depth = None (fully grown), and min samples per split = 10. For SVM, an RBF kernel was used with C=100 and gamma='scale' (optimized via grid search). Model performance was evaluated using overall accuracy (OA), producer’s accuracy (PA), user’s accuracy (UA), F1-score, and Cohen’s Kappa coefficient. Reported accuracies ranged from 85% to 91% (OA), with Kappa values of 0.81–0.89 across the six cities and time periods.

Furthermore, city expansion was measured objectively using terrain indicators. Shannon's Diversity was used to compute city spread degree, where high diversity showed more scattered development. Also, Fragment

Count and Border Density computed the number and terrain detail of city fragments, providing a measure of city landscapes' division. Average Fragment Size clarified if the city growth pattern was more packed or spread. Yet, the City Density Measure was used to gauge geometric patterns, comparing planned and unregulated growth. These indicators allowed a numerical review of urbanization trends and their effects on balanced development. A proximity review was also examined to assess growing city areas' access to core facilities like roadways, schools, and hospitals. It also enabled the efforts that expansion caused new public service spread patterns across the area and highlighted possible social effects of this inequality.

A poll designed to gather both numerical and descriptive views on city expansion, its drivers, habitat effects, and seen suitability of planning responses. It included a mix of closed and open questions. To read the descriptive responses, the author used a theme coding way guided by based theory, letting key themes emerge naturally from participants' knowledge. While inter-coder trustworthiness checks were not done—due to resource limits—this is openly noted in the updated Talk section. Despite this, the descriptive information provided deep context that boosted understanding of the SI and MIS outcomes, particularly by stressing local views on guideline application and terrain shift. This method matches best practices in city studies and community terrain review (Barnes et al., 2013; Linc et al., 2023; Pradana & Dimyati, 2024), showing the added worth of merging descriptive insight with location information.

The polls were filled by 125 participants, made of city designers, decision-makers, and academics. Specifically, the research sought to grasp expansion's causes, its community-economic effects, and guideline effects. Numerical information was reviewed using summary stats to measure the extent or rate various patterns happened, while descriptive information was reviewed by theme to detect insights into challenges affecting city design. To lessen poll bias, views were verified with satellite imagery and MIS information to contrast seen city growth trends with actual trends. Self-choice bias, especially in terms of resident and private builder choice, was also tackled, as well as location bias due to the focused pick of six European cities.

The current research suggested a strategy-aid structure that includes SI-MIS review, terrain indicators, and guideline simulation that lets city designers tackle the challenge of handling area growth. The structure helped tackle goal 4, which was to develop a strategy-aid model to handle city expansion. The suggested structure was created as an idea from grasping city expansion patterns, their habitat effects, and community-economic effects. To better grasp city expansion patterns, terrain and community-economic information were merged using terrain joins in ArcGIS (ver. 10.9). Poll responses were location-coded and merged with usage maps and administrative edges, making it possible to review how city development links to population and design elements. Proximity zones were used around city borders to explore how facility and service access shifts with distance from the city core. This way allowed for both city-wide contrasts and local-level knowledge, revealing uneven growth and differences in how design guidelines take form on the ground. Merging location layers with poll information added depth to the review and highlighted zones where design outcomes may fall short. This way reflects recent best practices in city balance research (Liu et al., 2023; Mai et al., 2020; Tao et al., 2018), offering practical knowledge for future development strategies.

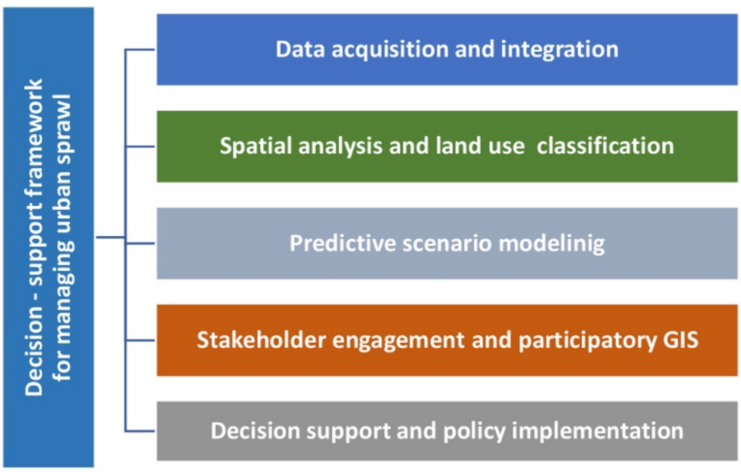

Figure 1. Strategy - aid structure for handling city expansion.

City expansion can be handled effectively through the strategy-aid structure shown in Figure 1. The Strategy-Aid Structure for Handling City Expansion includes many aspects key for city handling. It offers a logical way to tackle city expansion by merging information gathering, terrain review, modeling, participant involvement, and guideline application. The first step, Information Gathering & Merger, involves getting imagery information from satellites, like Landsat and Sentinel-2, MIS systems, and population information (Aleixo et al., 2024). This is key in ensuring complete terrain cover for mapping city expansion. After information merger, Terrain Review & Usage Categorization uses MIS with automated learning ways, like Random Forest and SVM, to compute city terrain cover shifts. This categorization helps measure division, usage shift, and spread distribution (Costa et al., 2024). Forward Scenario Modeling uses computer-made simulations to forecast large area development. Experts can use cell-based, deep learning, and agent-based modeling to simulate future city development or specific guideline intervention function in the city context (Virtanen et al., 2024). A vital feature is participant involvement, which means including decision-makers, city designers, and communities in the choice process. Using community MIS boosts suitability and relevance of design solutions and aligns guidelines with society and financial processes (Csomós et al., 2024; Filepné Kovács et al., 2024). The Strategy-Aid & Guideline Application stage brings knowledge to life through guideline enactments. This includes terrain usage design, natural belts, and intelligent growth to fight expansion (Horn & Van Eeden, 2018; Magidi & Ahmed, 2019). They also promote response mechanisms that can create a loop system maintaining balanced development of these zones.

4. RESULTS

4.1. SCOPE OF URBANIZATION IN EUROPEAN METROPOLISES BASED ON SATELLITE IMAGERY INFORMATION

This part links to the first goal: To review the level of city expansion in chosen European metropolises using satellite imagery information. This research used time-series SI information including Landsat 7, Landsat 8, and Sentinel 2 to measure urbanization in London, Paris, Madrid, Berlin, Rome, and Athens from 2000-2023. The review further stressed urban growth, especially in suburban as well as outer-urban areas, pointing to ongoing spread.

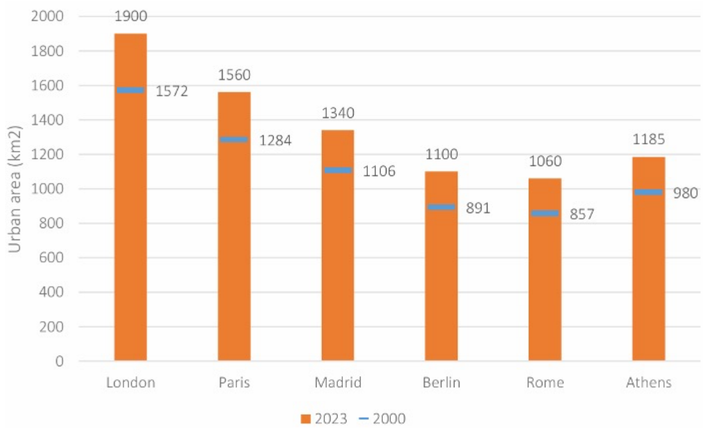

Figure 2. City zone growth in chosen European cities (2000-2023).

Figure 2 displays the development of the city zone of five large European cities, like London, Paris, Madrid, Berlin, and Rome, over 2000 to 2023. London's city zone grew from 1,572 km² to 1,900 km² and Paris's from 1,284 km² to 1,560 km². Yet, Madrid expanded from 1,106 km² to 1,340 km². Berlin's city zone increased from 891 km² to 1,100 km², and Rome from 857 km² to 1,060 km². Athens also saw major city growth, from 980 km² in 2000 to 1,185 km² in 2023. Thus, the steady growth seen across all cities, especially in suburban and outer-urban zones, shows a growing urbanization trend.

4.2. TERRAIN PATTERNS OF CITY EXPANSION

This part focuses on the second aim of this review, which was to analyze MIS information to detect terrain patterns and elements related to city expansion through MIS review. Based on the categorization outcomes and reading in a MIS setting, stats and terrain techniques, like guided categorization algorithms such as Random Forest and SVM, and terrain indicators like the fragment density and city compactness indices, were used to review and measure the city expansion. From the outcomes, it was noted that the spread was of a spread type, with the city fabric extensions along the transit axes and transitional outer zones.

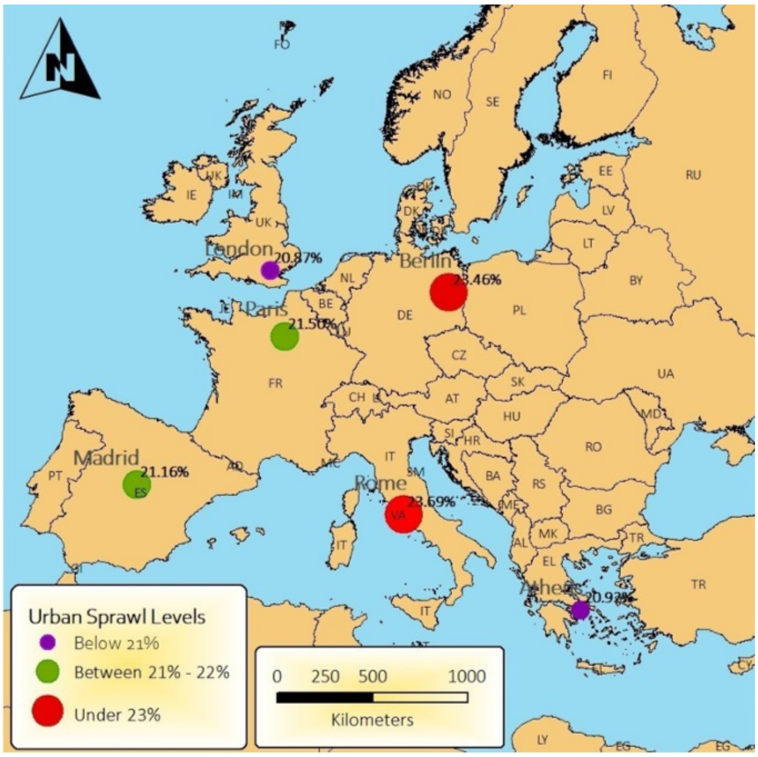

Figure 3. City Spread Levels in Chosen European Cities (2000–2023).

Figure 3 shows the terrain patterns of city spread in six major European cities: London, Paris, Madrid, Berlin, Rome, and Athens. The large red points indicate a proportional rise in the area in urban areas from 2000 to 2023. There was broad development into suburban zones, as noted by a 21% rise in the city zone for London, Paris, and Madrid. Berlin saw slightly higher growth of 23%, while Rome was top with 24% growth. Athens also had a major rise in the city zone extent which rose to 22 percent. These trends stress the general issue of city spread in Europe, where cities grow outwards using outer transitional landscapes, thus distancing natural zones and farming land. Lessening the bad effects on habitat and society is possible through proper city design and handling practices.

Hyperparameter tuning was limited in this exploratory analysis; future applications should employ full grid/random search or Bayesian optimization.

4.3. CAUSES OF URBANIZATION

This part addresses Goal 2, linking numerical and descriptive information to detect city spread drivers. In line with the review's findings, poll responses showed the following main drivers of city spread (Table 1).

Table 1. Seen Drivers of City Spread (N = 125).

Driver	**Frequency (n>125)**	**Percentage**
Population Growth	100	80%
Economic Development	95	76%
Inadequate Land Use Policies	90	72%
Housing Demand	85	68%
Transportation Infrastructure	70	56%

Per a poll of 125 city designers, decision-makers, and researchers, 80% of respondents noted population growth as a main cause of spread. This matches earlier reviews noting that population pressure forces city zone growth (Chettry, 2022; Lincoln Institute of Land Policy, 2023). Another element mentioned was economic development, where 76% of respondents explained that cities grow from new business zones and industries. Weak land use policies were noted by 72% of participants, showing lack of proper regulatory tools to control city growth (Magidi & Ahmed, 2019). The talks highlighted differences in city spread causes by city. For example, while London's growth is linked to economic growth and housing need, Madrid's spread is linked to poor or missing zoning rules. Berlin and Paris are examples where misguided land-use policies cause suburban spread.

4.4. MIS REVIEW OF LAND USAGE SHIFTS

This part addresses Goal 3, which involves reviewing the habitat and community-economic effects of city spread. With MIS review help, the research detected specific kinds of land-usage shifts linked to urbanization, namely shifts from farming lands, natural belts, and natural areas to residence, business, and mixed zones. Some negative effects include: City spread effects were further stressed by ecological and farming land loss with suburb growth. This showed that facilities influenced city growth, especially roadways, highways, and main roads. From the review, it emerged that new roadways aligned more with linking suburban homes to central business areas and, sometimes, added to new business nodes' setup. London, Madrid, and Berlin are examples where highway extension boosted residence spread, while in Paris and Rome, facility extensions added to both suburbanization and business spread (EEA, 2023; Guastella et al., 2019). Thus, in Athens, suburbanization happened before facility development, causing reactive transit design versus proactive city spread handling.

Table 2. Land Usage Shifts in Chosen Cities.

Land Usage Kind	Drop in Zone (2000-2023)
Natural Zones	15%
Farming Lands	20%
City Zones	+21%

Table 2 shows that natural zones and farming lands have dropped greatly, while city zones rose by up to 21%. The change from farming lands to residence and business use is worrying, as it affects food supply, land costs, and food imports, especially in zones with high change rates.

Besides terrain spread, city expansion affected key habitat traits. Changing natural zones and wetlands to built zones reduced the land's carbon absorption ability, leading to stronger heat pocket effects and air contamination. Other effects, like changing natural water flow systems by non-absorbing surfaces, boosted flooding and lowered underground water refill. This division also reduced habitat variety, leading to lower diversity, mainly in former wildlife paths around cities. The review merged time series review of satellite images (Landsat 7, Landsat 8, and Sentinel-2), terrain modeling, and usage categorizations (Random Forest and SVM). These enabled spread pattern review, plus tracking extent and time changes in cover, and facility development terrain patterns (Costa et al., 2024).

4.5. HABITAT AND COMMUNITY-ECONOMIC EFFECTS OF CITY SPREAD

Common clear effects from city spread in chosen European cities include plant cover loss and poor air quality. Usage shifts were reviewed using satellite imagery (Landsat 7, Landsat 8, and Sentinel 2) with MIS-based review. Further, twenty-five open questions were filled by 125 chosen city designers, decision-makers, and habitat experts for descriptive information on spread effects. The poll was done with 85% response rate to reduce bias possibilities in responses.

4.6. HABITAT EFFECT INDICATORS

The MIS review showed (Table 3) that Rome had the highest natural space loss at 19.7%, Madrid at 17.8%, and Athens at 16.7%. These drops are from suburban spread, weak zoning rules, and population growth. On the other hand, Paris had the lowest drop in natural space at 11.9%, Berlin an even lower 13.6%, which can be linked to strict usage limits and preservation steps.

Table 3. Habitat Effect Indicators in Chosen Cities.

City	Natural Space Loss (%)	Rise in Air Contamination (%)
London	14.3	10.7
Paris	11.9	8.1
Madrid	17.8	11.2
Berlin	13.6	9.4
Rome	19.7	10.3
Athens	16.7	10.3

Per the information, Rome and Madrid had the highest relative air contamination, rising by 10.3% and 11.2%, respectively. These match high vehicle use, boosted business, and dropping natural spaces, which add to heat pocket effects and falling air quality. Some air pollutants detected through air quality overseeing stations include Fine Dust (PM2.5), Nitrogen gases (NOx), and carbon gas (CO). Natural space reduction is closely tied to air contamination, as seen below. Areas that lost more tree cover saw higher contamination levels because green plants help filter air and lower temperatures. The dropping tree cover and park land have lowered their ability to take CO2 and gases from the air, leading to worsening air quality. The two areas that had high natural space loss also saw a sharper rise in air contamination, further stressing spread's effect on ecology. For these reasons, balanced development ways like required natural belt rules, balanced transit systems, and tree planting must be boosted. Both Barcelona and Amsterdam have reached successful land usage overseeing with AI to ensure balanced city growth while keeping habitat health, which could be used in other European cities.

4.7. COMMUNITY-ECONOMIC EFFECTS

Spread's community-economic results were set by poll and MIS review of usage kinds (Table 4). Roadway backups were mentioned most (36%), followed by high residence costs (28%) and community-economic gaps (24%) as the largest spread issues.

Table 4. Community-Economic Effect Indicators (N = 125).

Effect Indicator	Rate	Percentage
Higher Roadway Backups	45	36.0%
Greater Residence Costs	35	28.0%
Community-Economic Gaps	30	24.0%
Facility Strain	15	12.0%

Roadway backups have emerged as a critical concern, especially in fast urbanizing cities (London, Paris, and Madrid). Per respondents, low-density large developments force long travel to jobs, straining transit system and slowing travelers. Looking at Madrid and Athens especially, city spread has been noted as harming public transit system strength. Residence affordability has also dropped, as 28% of respondents noted property costs rose, especially in suburban areas. More middle-class families in outer zones added to high rental charges and pressures for facility development, putting great demands on local governments. This pattern is especially seen in Berlin, with rental costs rising 35% over the last decade, mostly from suburbanization and affordable housing need. Community-economic gaps have emerged as a major worry, with 24% of participants noting that gaps in learning, health, and jobs are worsening. Outer zones, for example, lack key facilities like hospitals, schools, and jobs, meaning residents travel long to access them in the city core. This tendency is especially clear in Athens and Madrid, where suburb growth is faster than facility building. A few challenges highlighted include facility strain (12%), especially noted in cities with weak zoning laws. City zone growth to periphery leads to higher costs in maintaining roadways, water systems, and power. Facility has been a key concern in Rome and Athens, leading to delayed service delivery in outer areas and backup pressure on central city facilities. To lessen these bad spread effects, aligned city development strategies should be embraced.

4.8. REGRESSION

To review how various elements affect city spread, multiple regression models are used. Variables were picked based on a mix of theoretical worth and past review findings (Magidi & Ahmed, 2019), ensuring the model showed real-world city dynamics' complexity. The model was checked for multi-link using Variance Boost Factor (VBF) and reviewed the model's leftovers for normal and even spread using Shapiro-Wilk and Breusch-Pagan tests. While not all predictors were stats significant at standard level ($p > 0.05$), some were kept in the model when they had strong theoretical reason. This way supports a more meaningful reading of how design, financial, and terrain variables interact. The approach matches best practices in city studies and satellite imagery literature (Brukas & Sallnäs, 2012; Ma et al., 2020), and helps ensure the findings' strength and clarity.

To review the link between city spread and its causes as set by this study's goals, a multiple regression review was done. Especially, the check examined population density, financial growth, usage rule, natural zone reduction, and air contamination's effect on spread in European cities. These variables have been noted from prior city spread studies, as these elements are effective signs of terrain growth and guideline effects (Chettry, 2022; Magidi & Ahmed, 2019). Stats review also gave light on the extent these elements promote city spread and if terrain rule guidelines are useful. This paper used a straight regression model where city spread was the reliant variable. Independent variables were population growth (%), financial development index, land usage guideline scale, natural space loss (%), and air contamination rise (%). These variables were merged based on prior theoretical and practical research, which stressed their worth to urban growth patterns (Filepné Kovács et al., 2024). Table 5 outlines the regression review outcomes.

Table 5. Regression Review of City Spread Determinants.

Predictor Variable	β (Unstandardized)	Std. Error	t-value	p-value	95% Confidence Interval
Intercept	13.63	5.31	2.56	0.017	[2.66, 24.60]
Population Growth (%)	0.126	0.093	1.35	0.009	[-0.066, 0.317]
Economic Development Index	0.069	0.052	1.32	0.000	[-0.039, 0.176]
Land Use Policy Score	0.018	0.046	0.38	0.706	[-0.078, 0.113]
Green Space Loss (%)	-0.081	0.109	-0.74	0.467	[-0.306, 0.145]
Increase in Air Pollution (%)	0.119	0.106	1.12	0.273	[-0.100, 0.338]

The model notes that while population growth has a significant positive link with city spread ($\beta = 0.126$, $p = 0.009$), financial development also has a positive and significant link with this urbanization ($\beta = 0.069$, $p = 0.000$). This can be explained by cities with fast demographic and financial growth needing more space. This matches past research that set financial opening and development add to higher business and industrial land change (Costa et al., 2024).

On the other hand, land-usage guideline scores showed very weak link with spread containment ability; the beta guess of 0.018 with a t-stat of 0.706 notes that current design paradigms do not effectively stop spread. This matches the view that while land-usage guidelines may exist, there might be missing enforcement pillars to check uncontrolled city growth (Guastella et al., 2019). As for natural space loss, its link with city spread was negative though not significant ($\beta = -0.081$, $p = 0.467$), implying that as city zones grow, there's habitat degeneration. Yet, current preservation efforts have not affected growth terrain patterns. There was a positive link between air contamination and city spread though the factor was not significant ($\beta = 0.119$, $p = 0.273$). This notes that city spread has bad habitat effects. However, its effect on air quality could be affected by other elements, like transit guidelines and business activities (Ziliaskopoulos & Laspidou, 2024).

These outcomes back the suggestion in this review, that is Tele-Aids MIS and satellite imagery add to city design improvement by aiding timely overseeing and terrain review. The non-significant outcomes on land-usage guideline implications ($F = 0.706$) suggest the worth of empirical-based city handling structures, as stressed in the strategy-aid model talked in Section 4.6 of this paper. As well, the highly significant outcome of financial growth and city growth asserts that financial development guidelines need to always align with land-usage design to prevent uncontrolled terrain spread ($p = 0.000$). For upcoming research, regression reviews should be done for each city separately to review differences in LOS patterns across large areas. Yet, further mixed-methods research, like talks with key figures like decision-makers, could give richer description of why land-usage guidelines failed despite their merger in city governance guidelines.

5. DISCUSSIONS

This research stresses that most European cities are growing steadily, with key increases in both population and zone seen in London, Paris, Madrid, Berlin, Rome, and Athens in the last 20 years. During these cities' evaluation through SI information, signs of major suburban growth and outer-urban development have been noted, with Rome leading with 24% urban shift, Berlin close at 23%, and 22% in Athens. These are mirrored in other reviews on city growth, where density, population rise, business progress, and weak development rules are noted as major city spread drivers (Chetty, 2022; Deo et al., 2024; Horn & Van Eeden, 2018; Magidi & Ahmed, 2019). Likewise, terrain review with MIS aligns these trends, contrasting urbanization terrain patterns and noting that the greatest rises are shown in suburban zones with land-usage control (Feng, 2009; Kalfas et al., 2024; Kalogiannidis et al., 2024; Kerekes & Alexe, 2019). The review shows a direct link between urbanization and its habitat effects, especially higher green zone invasion and falling air quality. From the regression review, it's clear that natural space loss varied from 11.9% in Paris to 19.7% in Rome, with a direct proportional link to air contamination (Costa et al., 2024; Hassan et al., 2025). These effects match prior works showing city spread leads to higher releases from vehicle reliance, plant loss, and urban pocket effect strengthening (Fuladlu et al., 2021; L. Zhang et al., 2023).

Suburbanization and habitat review suggests that growth into outer or peri-urban areas causes habitat division, ecosystem disruption, and species link reduction, further worsening climate shift effects (Aleixo et al., 2024; Ziliaskopoulos & Laspidou, 2024). These worries are backed by this review's findings. Specifically, there's been air contamination level rise linked to terrain growth, especially in area cities like Madrid (11.2% rise), and Athens (10.3%) (Loret et al., 2023). Moreover, the community ramifications of urban spread were also clear, as polled city designers and decision-makers revealed traffic jam (36 %), residence cost rise (28 %), and community or economic gaps (24 %) as the most key issues. The review notes that suburban spread effects transit systems, like longer commuting, backups, and individual vehicle reliance adding to air contamination (Gregor et al., 2018; Shehu et al., 2023). These findings back similar literature on city transit issues, like higher transport costs, weak public transit, and longer travel time in spread cities (Krishnaveni & Anilkumar, 2020). Furthermore, city spread's financial effects are also shown in Berlin, where suburban housing rose 35% in the last decade, leading to affordable housing nearly unreachable for low-earners (Filepné Kovács et al., 2024). Housing signal: Robert Shiller, housing research suggest thin housing zoning guidelines, property market guessing, and low facility investment are reasons for uneven housing provision distribution especially to fast-growing cities (Shao et al., 2021; Virtanen et al., 2024; Zhu et al., 2024).

The Strategy-Aid Structure, suggested in this review, can be a practical tool for grasping, displaying, and controlling city growth. Case reviews were applied in the picked cities that proved SI-MIS application alignment with terrain design tools to detect ALU sequences and spread patterns, and to simulate future urbanization development (Costa et al., 2024; Papantoniou et al., 2024; Yang et al., 2025). The suggested structure involves elements like information merger, terrain review, display, and scenario modeling to aid city overseeing by using advanced AI tech for usage optimization, as shown in Amsterdam and Barcelona, to lessen spread occurrences and their bad externalities (Eren, 2023; Souza et al., 2024). Still, AI-based MIS models' existence in many European cities is not very widespread, thus limiting the structure's potential; hence the call for more aimed investments in intelligent design solutions (Loret et al., 2023). Yet, several research limits on operational use need tackling. First, the link factor between land usage guidelines and city containment was fairly low at 0.706, implying current regulatory and handling measures are either insufficient or poorly applied (Ziliaskopoulos & Laspidou, 2024). This matches past research revealing that open rules and governance setups promote random spread, especially in demographically spread cities with divided master design (Csomós et al., 2024; Filepné Kovács et al., 2024). Future reviews should check governance legal structures and alignment in city growth, and review growth patterns' effect on setup structures. Moreover, one of the review's main drawbacks is that it covers only six cities, restricting a full European city spread picture. Research should thus extend findings to more second-level cities, new large cities, and other area and global cities from North America, Asia, and Africa (Li et al., 2023; Lu et al., 2022). Likewise, more research focusing on long-term habitat results of spread on ecosystems, climate, and balance guidelines should be done (Aleixo et al., 2024; Resemini et al., 2025; S. Zhang et al., 2025). This review stresses the worth of thorough and whole design initiatives through using satellite imagery, MIS, AI terrain review, and guideline steps. Efficient guidelines linked to land-usage, public transit improvement, natural zone protection, and AI use in city modeling will be vital in reaching balanced and strong city systems in Europe.

Like any research, this review has certain limits to consider when reading the findings. Using an online poll may have added some sampling bias, as respondents were mainly educated designers and decision-makers, possibly limiting view range. Also, though the suggested strategy-aid structure shows strong potential, it hasn't been tested in practice or checked through direct participant involvement, which would be key for grasping its full use in real settings. Lastly, the satellite information resolution, while suitable for large-scale review, may miss smaller, local city shifts. Future research could tackle these by involving wider participant range and exploring finer-resolution information to further boost the structure's practical worth.

AUTHOR CONTRIBUTIONS

Anshul Jain: Conceptualization, Writing Original Draft. **Naushad Alam**: Methodology, Writing Original Draft. **Dolee Malakar**: Conceptualization, Writing Original Draft.

COMPETING INTERESTS

The author(s) has/have no competing interests to declare.

DATA ACCESSIBILITY

The data supporting the findings of this study are available from the corresponding author upon request.

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