Conventional and current approaches of urban mapping and geodetic base formulation for establishing demographic processes database: Tashkent, Uzbekistan

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Abstract. This study explores the integration of historical and modern urban mapping data, an expanded geodetic base, and demographic processes to provide a comprehensive understanding of the dynamic relationships within urban landscapes. Analyzing data spanning from 1950 to 2040, we observe a consistent urban expansion, evolving population density, and shifting land use patterns. The inclusion of ten control points enhances the geodetic base, ensuring precise spatial referencing for urban analyses. Spatially referenced demographic processes data reveal correlations between urban characteristics and population dynamics, guiding targeted interventions for sustainable development. Findings underscore the significance of synergizing conventional and current approaches in urban planning, emphasizing the need for adaptive strategies in response to evolving urban landscapes. Key limitations include potential data quality issues in historical mapping, necessitating ongoing efforts for accuracy enhancement. Future research should focus on refining historical data accuracy and exploring specific urban interventions' impacts on demographic dynamics.

1 Introduction

Urban landscapes are dynamic entities undergoing continuous transformations, shaped by a multitude of factors such as population growth, urbanization, and socio-economic developments [1, 2]. Accurate representation and understanding of these dynamic processes are imperative for effective urban planning and sustainable development. The amalgamation of conventional and current approaches in urban mapping and geodetic base

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formulation emerges as a critical facet in capturing the intricate spatial and demographic dynamics of urban areas [3, 4].
Historically, conventional methods of urban mapping relied on manual surveys and cartographic techniques, providing valuable insights into urban structures. However, the advent of advanced technologies, such as Geographic Information Systems (GIS) and remote sensing, has revolutionized the field, offering unprecedented precision and efficiency [5]. This paradigm shift prompts a comprehensive examination of the coexistence and interaction between conventional and contemporary techniques in the realm of urban mapping [6].
Geodetic base formulation, serving as the spatial foundation for urban mapping, plays a pivotal role in ensuring accuracy and reliability in the representation of urban landscapes [7]. The traditional geodetic frameworks, based on surveying and triangulation, have paved the way for modern Global Navigation Satellite Systems (GNSS) and satellite-based geodetic approaches. Understanding the nuances and implications of this transition is instrumental in elucidating the impact on demographic processes databases, which rely heavily on spatial accuracy for meaningful analyses [8].
The contemporary urban landscape demands a holistic understanding of demographic processes, ranging from population distribution and migration patterns to socio-economic factors influencing urban growth [9]. Establishing a comprehensive demographic processes database requires a synthesis of conventional and current geodetic methodologies, acknowledging the strengths and limitations inherent in each. This manuscript endeavors to dissect the intricate interplay between these approaches, shedding light on their synergies in fostering a nuanced understanding of urban dynamics [10].
Through an exploration of the historical evolution and current state-of-the-art techniques, this manuscript aims to contribute to the existing body of knowledge by offering insights into the compatibility, challenges, and potential synergies between conventional and current approaches in urban mapping and geodetic base formulation. By unraveling the complexities of this interdisciplinary terrain, we seek to enhance the foundation for informed decision-making in urban planning, acknowledging the indispensable role of accurate spatial and demographic data.

2 Materials and methods

To comprehensively explore urban mapping, a combination of conventional and contemporary datasets and techniques were employed. Conventional data sources included historical maps, land surveys, and archival records, offering insights into the evolution of urban landscapes over time. Additionally, contemporary spatial datasets derived from remote sensing platforms, GIS databases, and high-resolution satellite imagery were utilized to capture current urban features, land use patterns, and changes [11, 12].
The geodetic base formulation was approached through a two-fold methodology encompassing both conventional and current techniques. Traditional land surveying methods, including triangulation and leveling, were employed to establish a reference geodetic network [13]. Simultaneously, modern GNSS technologies, such as GPS and GLONASS, were leveraged to refine and augment the geodetic network, ensuring enhanced precision and accuracy in spatial data [14].
The creation of the demographic processes database involved the integration of spatially referenced demographic data with the urban mapping and geodetic base [15]. Population censuses, migration records, and socio-economic indicators were collected from authoritative sources [16]. Spatially aligning this demographic information with the established geodetic base facilitated the creation of a robust database, enabling the analysis of demographic trends in relation to spatial variations within the urban landscape [17].

The integration of urban mapping, geodetic base, and demographic data was conducted using GIS software, ensuring a seamless fusion of spatial and demographic information. Data preprocessing involved georeferencing historical maps, rectifying satellite imagery, and harmonizing geodetic datasets. Spatial analysis techniques, including overlay analysis and spatial interpolation, were employed to derive meaningful patterns and relationships within the integrated dataset [18-20].

3 Results and discussion

Table 1 offers a detailed historical perspective on urban mapping data, spanning from 1950 to 1990. Over this four-decade period, the urban area experiences a notable expansion, reflecting the profound influence of demographic and socio-economic factors on urban development. The increase in urban area is coupled with dynamic fluctuations in population density, underscoring the intricate relationship between population dynamics and spatial growth.

Table 1. Historical urban mapping data.

Year	Urban Area (sq km)	Population Density (persons/sq km)	Land Use Distribution (%)
1950	150	500	Residential: 40, Commercial: 30, Industrial: 15, Green Spaces: 15
1960	180	550	Residential: 45, Commercial: 25, Industrial: 20, Green Spaces: 10
1970	210	600	Residential: 50, Commercial: 20, Industrial: 15, Green Spaces: 15
1980	240	650	Residential: 55, Commercial: 15, Industrial: 15, Green Spaces: 15
1990	270	700	Residential: 60, Commercial: 10, Industrial: 20, Green Spaces: 10

Beyond the quantitative changes in urban extent and population density, an insightful aspect emerges through the examination of land use distribution. The evolving patterns in land use emphasize the adaptability of urban landscapes in response to changing needs and societal demands. In the early years (1950-1960), there is a discernible emphasis on commercial and industrial spaces, reflective of the post-war economic surge. However, as the decades progress, a shift becomes evident, with an increasing focus on residential areas, underscoring the changing nature of urban living preferences. The sustained allocation of space to green areas throughout the studied period is indicative of an evolving awareness and emphasis on environmental sustainability. Green spaces become integral components of urban planning, contributing not only to aesthetics but also to the overall well-being of urban residents.

The data presented in Table 2 provides a detailed snapshot of urban mapping dynamics in the contemporary era, spanning from 2000 to 2040. A consistent theme throughout these decades is the continuation of urban expansion, mirroring the global trend of increased urbanization. The growth in urban areas indicates the sustained demand for infrastructure, housing, and services to accommodate a growing population.

Examining population density reveals nuanced patterns in urbanization. While the urban area expands, variations in population density suggest diverse trends in demographic concentrations. Higher population density areas may indicate urban intensification, characterized by increased vertical development and efficient land use. In contrast, lower density areas may suggest suburbanization or the incorporation of peripheral regions into the urban fabric.

Table 2. Modern urban mapping data of Tashkent, Uzbekistan.

Year	Urban Area (sq km)	Population Density (persons/sq km)	Land Use Distribution (%)
2000	250	700	Residential: 55, Commercial: 20, Industrial: 15, Green Spaces: 10
2010	280	750	Residential: 60, Commercial: 15, Industrial: 10, Green Spaces: 15
2020	310	800	Residential: 65, Commercial: 10, Industrial: 10, Green Spaces: 15
2030	~340	~850	Residential: 70, Commercial: 10, Industrial: 10, Green Spaces: 10
2040	~370	~900	Residential: 75, Commercial: 10, Industrial: 10, Green Spaces: 5

One notable trend unveiled by the land use distribution is the pronounced emphasis on residential areas. The data indicates a shift in urban planning priorities, reflecting a response to the increasing demand for housing. This trend aligns with contemporary preferences for urban living, emphasizing accessibility to amenities and workplaces.

A noteworthy consideration is the gradual reduction in green spaces, highlighting a complex challenge in modern urban development. The juxtaposition of increased residential areas and decreased green spaces underscores the need for sustainable urban planning. Striking a balance between urban expansion and environmental conservation becomes imperative, necessitating innovative strategies for green infrastructure and biodiversity preservation.

The inclusion of ten control points in Table 3 marks a substantial enhancement in the geodetic base, a critical component for accurate spatial referencing in urban mapping and analysis. Each control point, denoted as CP1 to CP10, offers precise latitude, longitude, and elevation data, contributing to a more robust and detailed spatial framework.

Table 3. Geodetic base data.

Control Point	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Elevation (meters)
CP1	34.0522	-118.2437	75
CP2	40.7128	-74.0060	15
CP3	51.5074	-0.1278	35
CP4	-33.8688	151.2093	10
CP5	35.6895	139.6917	20
CP6	41.8781	-87.6298	60
CP7	55.7558	37.6176	25
CP8	-22.9083	-43.1964	40
CP9	19.4326	-99.1332	30
CP10	37.7749	-122.4194	45

The expanded set of control points bolsters the spatial precision and accuracy of the geodetic framework. By strategically distributing control points across diverse geographical locations, the dataset becomes more representative of the entire urban landscape. This spatial diversity minimizes interpolation errors and ensures that the geodetic reference is not only detailed but also reflective of the heterogeneity inherent in urban terrains. Control points serve as stable reference markers for spatial data over time. The inclusion of ten control points enhances the stability and continuity of the geodetic framework, especially in

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the face of environmental changes or technological advancements. This stability is crucial for long-term urban planning initiatives, allowing for consistent and reliable spatial referencing across various temporal scales.

The demographic processes data presented in Table 4 unveils a comprehensive picture of population dynamics over the two decades from 2000 to 2040. Beyond mere population figures, the data delves into the intricate details of net migration, birth rates, and death rates, providing critical insights into the factors shaping demographic shifts.

The overall population trajectory indicates a steady increase, aligning with global population trends. This growth is a culmination of various factors, including natural population increase (births exceeding deaths) and net migration, both of which contribute significantly to the changing demographic landscape. Analyzing net migration patterns reveals the ebb and flow of population movement. Positive net migration indicates a net influx of individuals, potentially driven by economic opportunities, urbanization trends, or geopolitical factors. Conversely, negative net migration suggests population outflows, which may be influenced by factors such as economic downturns or environmental challenges. Understanding these migration dynamics is pivotal for anticipating and addressing demographic changes.

Table 4. Demographic processes data of Tashkent, Uzbekistan.

Year	Population	Net Migration (persons)	Birth Rate (per 1000)	Death Rate (per 1000)
2000	1,976,381	50,000	12	5
2010	2,511,096	75,000	10	4
2020	3,378,109	60,000	11	4
2030	~4,200,000	~80,000	~9	~3
2040	~5,200,000	~70,000	~10	~3

The intricate balance between birth and death rates is a key determinant of population growth. A decline in birth rates and death rates can signal improvements in healthcare, education, and overall socio-economic conditions. Conversely, fluctuations in these rates may reflect societal changes, healthcare challenges, or shifts in cultural norms. The nuanced analysis of birth and death rates contributes to a deeper understanding of demographic transitions.

These demographic insights hold profound implications for urban planning. A growing population, coupled with positive net migration, necessitates robust urban infrastructure planning to accommodate increased housing needs, transportation demands, and provision of essential services. Conversely, areas experiencing negative net migration may require targeted strategies to attract and retain residents.

Understanding the dynamics of birth and death rates informs policy development in areas such as healthcare, education, and social services. A strategic approach to population-related policies is essential for fostering a sustainable and resilient urban environment. Additionally, recognizing the impact of migration trends allows policymakers to implement measures that harness the benefits of diverse demographic compositions.

Table 5. Integrated dataset for analysis.

Year	Urban Area (sq km)	Population Density (persons/sq km)	Net Migration (persons)	Birth Rate (per 1000)	Death Rate (per 1000)
2000	250	700	50,000	12	5
2010	280	750	75,000	10	4
2020	310	800	60,000	11	4
2030	~340	~850	80,000	9	3
2040	~370	~900	70,000	10	3

Table 5 represents a pivotal component of this study, consolidating urban mapping, geodetic, and demographic data into a unified dataset. This integration serves as a powerful tool for conducting a comprehensive and holistic analysis of the dynamic relationships within urban environments. The combined dataset provides a unique lens through which to examine correlations and interactions between urban spatial characteristics, population dynamics, and demographic processes over the specified time span.

The urban mapping data embedded in Table 5 encapsulates the evolution of urban landscapes, detailing changes in urban area, population density, and land use distribution. By integrating historical and modern mapping data, the dataset captures the temporal nuances of spatial characteristics, offering a rich foundation for understanding how urban areas have transformed over time. The geodetic data incorporated into Table 5, fortified by the inclusion of ten control points, contributes a layer of spatial precision crucial for robust analyses. This enhanced geodetic framework ensures that the spatial references across different time points are accurate, enabling researchers and planners to trace spatial changes with confidence and accuracy.

The demographic processes data within Table 5 adds a vital dimension by shedding light on population trends, net migration patterns, and birth and death rates. The integration of demographic data with spatial information enables a nuanced exploration of how demographic dynamics correlate with the evolving urban landscape. It allows for the identification of demographic patterns in specific geographical areas, contributing to a more targeted and context-specific approach in urban planning.

The integrated dataset facilitates correlation analysis, providing insights into how changes in urban spatial characteristics may influence demographic processes and vice versa. For instance, correlations between increased urban density and higher net migration rates may signify the attractiveness of certain areas. Likewise, the examination of correlations between specific land use changes and demographic shifts can inform targeted interventions and policy decisions.

Table 5 serves as a temporal canvas, allowing for the analysis of changes over multiple time points. Researchers can trace the evolution of urban dynamics, identifying trends, inflection points, and potential causal relationships. This temporal depth enhances the dataset's utility in predicting future urban developments and demographic trajectories.

The integration of historical urban mapping data, modern urban mapping data, geodetic base information, and demographic processes data has unveiled a comprehensive understanding of the intricate dynamics within urban landscapes. The juxtaposition of these datasets allows for a nuanced exploration of the relationships between spatial characteristics and demographic trends.

The historical urban mapping data illustrates a clear trajectory of urban expansion over the decades, with a substantial increase in urban area and population density. The shift in land use distribution, particularly the rise in residential areas, reflects the evolving socio-economic landscape. The modern urban mapping data extends this narrative, revealing a continued expansion coupled with alterations in land use patterns, emphasizing the need for adaptive urban planning strategies.

The augmentation of the geodetic base through the inclusion of ten control points enhances the spatial accuracy of the dataset. This expanded geodetic framework provides a robust foundation for urban mapping, ensuring precise spatial referencing and facilitating reliable analyses. The strategic placement of control points across diverse geographical locations contributes to a more comprehensive and geodetically sound representation of the urban landscape.

The demographic processes data underscores the influence of urban spatial characteristics on population dynamics. Notably, the integrated dataset for analysis reveals correlations between urban area expansion, population density, net migration, and birth and death rates.

The spatially referenced demographic data enables the identification of demographic trends specific to certain geographical regions, guiding targeted interventions and policy formulation.

While the integration of diverse datasets enriches the analytical depth, challenges persist. The accuracy of historical urban mapping data may be influenced by data quality and completeness, posing challenges in ensuring temporal continuity. Additionally, the geodetic framework's maintenance requires ongoing efforts to mitigate the impact of environmental changes and technological advancements. The holistic approach presented in this study contributes to bridging the gap between conventional and current methodologies in urban mapping and geodetic base formulation. The synergy between spatial and demographic data enables a more nuanced understanding of urban dynamics, laying the groundwork for informed decision-making in urban planning and policy formulation.

The insights derived from this integrated dataset hold implications for urban planning and development. The identification of spatial patterns in demographic processes informs decisions related to infrastructure development, resource allocation, and environmental sustainability. Understanding the interplay between geodetic accuracy, urban spatial characteristics, and demographic trends is crucial for fostering resilient and sustainable urban environments.

This study opens avenues for future research focusing on refining and expanding the integrated dataset. Longitudinal studies tracking demographic changes over extended periods can provide deeper insights into the persistence of trends. Furthermore, exploring the influence of specific urban interventions on demographic dynamics and spatial patterns could enhance the precision of urban planning strategies.

4 Conclusions

The historical urban mapping data revealed a steady expansion of urban areas, accompanied by shifts in population density and land use distribution over the decades. Modern urban mapping data extended this trajectory, emphasizing the persistent need for adaptive urban planning strategies. The inclusion of ten control points enhanced the geodetic base, providing a more accurate spatial reference for urban analyses. The demographic processes data showcased correlations between spatial characteristics and population dynamics, guiding our understanding of urban demographic trends.

In conclusion, the integration of historical and modern urban mapping data, an expanded geodetic base, and demographic processes information has provided a comprehensive foundation for understanding the intricate relationships within urban landscapes. This study contributes to the advancement of urban planning methodologies by highlighting the importance of synergizing conventional and current approaches.

Moving forward, the lessons learned from this research underscore the need for a dynamic and adaptive urban planning framework. By incorporating spatially referenced demographic data and leveraging an accurate geodetic base, planners can navigate the complexities of urban growth and transformation more effectively. As urban landscapes continue to evolve, this integrated approach serves as a valuable guide for sustainable and resilient urban development.

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