



## Original Paper

# A comparative analysis of two century-old historical map and satellite images for assessing land use transformation and preservation of the historical monuments of the Ahmad Shahi old city, Kandahar

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### Funding information

No funding information is provided.

Received July 12, 2023; Accepted December 10, 2023

doi: 10.1002/2475-8876.12428

### Abstract

This study evaluates land use transformation in Kandahar's old city, also known as Ahmad Shahi city, the birthplace and first capital of modern Afghanistan. The city consists of four rectangular quarters and is surrounded by a high strong mud wall, entrance gates, and a moat. In the early 20th century, the city experienced significant and arbitrary expansion, which certainly affected the urban fabric of the area, the streets were widened, and the city wall, towers, and gates were demolished, and the area was added to the construction of new government buildings, commercial establishments, and residential plots. This study aims to evaluate the alterations in the old city's urban morphology, culture, and sociology by conducting a comparative analysis of three maps from different time periods and considering various factors within the target area.

### Keywords

Ahmad Shahi old city, GIS, Kandahar, land use transformation, old map accuracy, urban morphology

## 1. Introduction

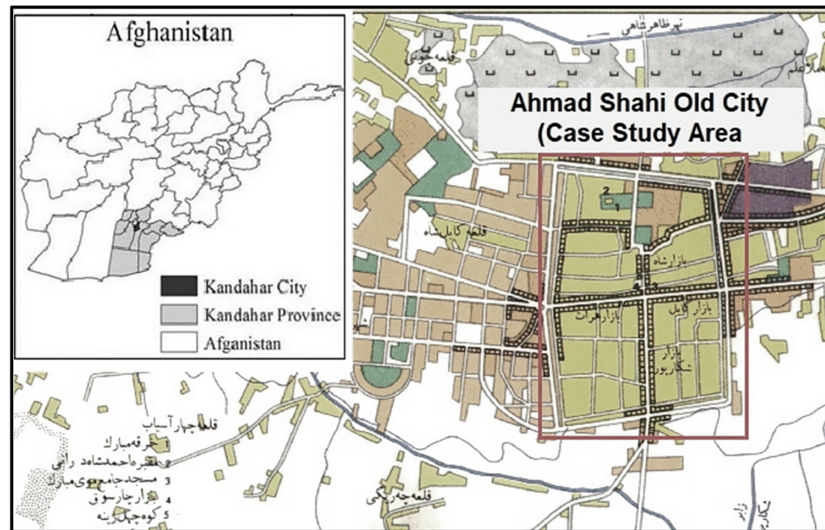
Kandahar, the birthplace and first capital of modern Afghanistan and today the second largest city in the country (Figure 1), is located in the southern part of the country on the Asian Highway between Kabul and Herat provinces, with a population of approximately 614118 people.<sup>1</sup> The area is rich in ancient history due to its strategic location along south, west, and central Asian trade routes.<sup>2</sup> Here Alexander the Great founded Alexandria of Arachises, and the region was reputedly fought over by the Safavids and Mughals.<sup>3</sup> In the mid-18th century, King Ahmad Shah Abdali established Ahmad Shahi Kandahar for the capital of Afghanistan, which is situated to the north of Kandahar city and covers an area of approximately 1.2 square kilometers.<sup>4</sup> (Figure 2).

The city was planned in a rectangular form and divided into four quarters by two main roads that run from north to south and east to west directions.<sup>5</sup> The city is still famous for its old traditional shape in many respects.<sup>6</sup> The citadel is situated in the north of the city named Arg (King palace), and the city

was surrounded by a strong mud wall until 1945 with four primary gates, two smaller gates, and four large towers.<sup>7,8</sup> The towers of the city were constructed using a combination of Indian and Iranian architectural styles. The names of ethnic groups, industrial groups, religious scholars, and historic sites were used as criteria for dividing land and naming streets.<sup>9</sup>

Furthermore, the Ahmad Shahi old city was well projected to have enough land to accommodate its inhabitants for more than a century. The traditional houses were designed based on environmental, cultural, and religious influences. The houses were generally one-story buildings with basements. Almost the majority of them were made of wood and unburned bricks, with flat and dome-shaped roofs.<sup>10</sup>

After the formation of the Islamic Republic of Afghanistan in 2001, several organizations, including SPACH, AKTC, and UNESCO, expressed interest in the cultural significance and heritage of Afghanistan. They initiated conservation projects in various parts of Afghanistan, such as Kabul and Herat, among others. Unfortunately, only a few studies have been conducted regarding Ahmad Shahi Kandahar, focusing on specific issues.



**FIGURE 1** Kandahar province and location map of the study area

For example, William B. Trousdale's study, "Kandahar in the Nineteenth Century," offered a comprehensive historical analysis of the 1839 plan of Kandahar, shedding light on its unique features, cultural context, and potential authorship while also contributing to a deeper understanding of the city's history during the 19th century.<sup>11</sup> Another study conducted by M. M. Hotak in 2004 explored Ahmad Shahi Kandahar's identity, the city's morphology, and the significance of its valuable historical monuments and architecture.<sup>4</sup> Additionally, SPACH conducted a study in 2004 on Kandahar's monuments and urban history, evaluating both traditional and religious structures. This survey mission also included an assessment of the physical appearance of the historic sites and buildings.<sup>10</sup> However, none of these studies have covered the land use transformation of the old city of Kandahar. Therefore, this study intends to contribute to a better understanding of how changes in the residential areas are transforming the historical area of an old city by examining the multiple factors that simulate the transformation of the old city. The study also proposes the implementation of a preservation plan for the urban development and planning authorities to address this issue and the urgent need for adequate care and professional maintenance to preserve the cultural value of the Ahmad Shahi old city.

After the establishment of a new government Islamic Republic of Afghanistan in 2001, the reconstruction process went on; the rapid population increases, rapid urbanization, economic growth, and changes in the lifestyle and culture of the citizens have affected most of the areas in Kandahar city, including the Ahmad Shahi old city. As a result, this caused a massive land use transformation, land cover change, and many of the traditional old houses which are constructed from the traditional materials and sun-dried bricks with dome and vault roofs have been demolished and replaced by new RC houses which have recently built in the old city. The absence of policies and regulations related to the conservation of traditional houses is viewed as a significant threat. Therefore, our initial study on the first quarter of the Ahmad Shahi old city in 2021 showed physical changes in land use (Javed, Ono Hiroko, and Mustafa).<sup>12</sup> It was found that the traditional old houses in the first quarter of Ahmad Shahi old city were restored with modern materials or destroyed to build new houses. Most of them were transformed into commercial buildings.

At first, the goal of this study is overlapping the 1839 map, which was prepared by Fraser Tytler for the fortified city of Kandahar and the satellite image of 2018, particularly the boundaries, king's tomb, Shah Mosque, and other public facilities; it helped us to figure out the accuracy of the 1839 map. Furthermore, this study focused on comparing a historical map of 1839 and satellite imagery of 2011 and 2018 to determine transformation and detect land use alteration in Ahmad Shahi City urban morphology. Finally, several preservation recommendations have been proposed, considering the country's cultural and socioeconomic circumstances.

## 2. Methodology

The primary objective of the current study is to compare a historical map of Fraser Tytler 1839 and land use of 2011 and 2018 to find out the land use changes in the urban fabric of the old city within the period. Data regarding the aerial photos of 2011 and 2018, current land uses, current public facilities, and other relevant information pertaining to the study area were acquired from multiple government agencies such as Kandahar Municipality, the Directorate of Information and Culture, and the Directorate of Urban Development. Also, some books, academic journal articles, multiple reliable and valuable online data sources, and digital libraries are explored and used. In addition, the author conducted a socioeconomic survey of 75 houses in various parts of the study area in January 2020 and March 2023. During the fieldwork, residents of the surveyed houses were interviewed using a questionnaire format, focusing on specified criteria, including housing typologies, lifestyle, duration of residency, and number of families.

A historical map of Fraser Tytler was geo-referenced into GIS to digitize new maps and overlap it with the existing map of 2011 and 2018 to find out the accuracy and changes in the road pattern.

The ArcGIS software was utilized for digitization and generate new maps for this study in order to identify the changes between 1839, 2011, and 2018. Totally 12 maps were digitized from Fraser Tytler and satellite images of 2011 and 2018, titled as building coverage area, land use, area base runoff coefficient, and street network. The entire methodology for this research is illustrated in Figure 3.



FIGURE 2 Ahmad Shahi Kandahar 1839 old map

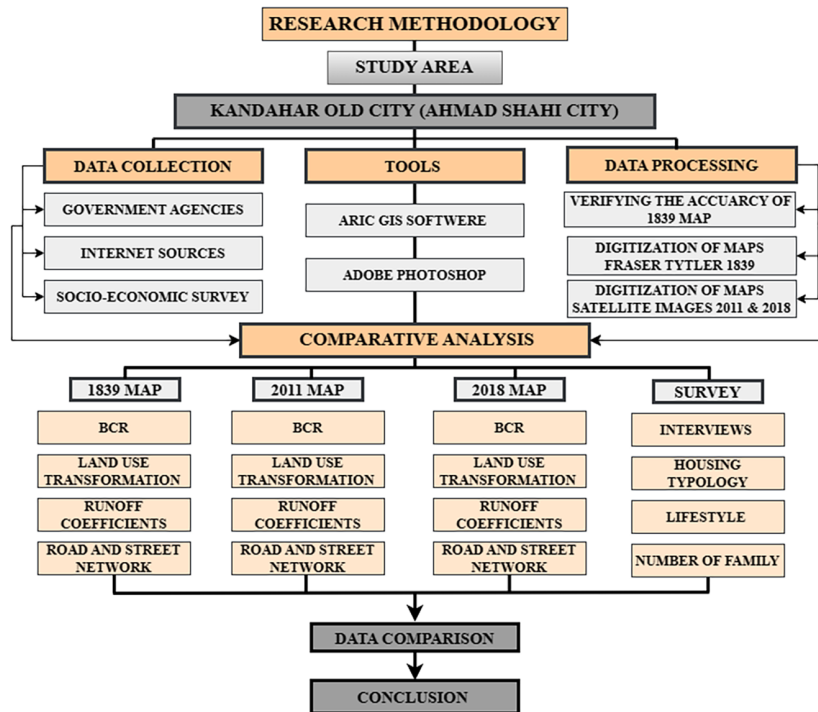


FIGURE 3 Research methodology

### 3. Verification of the Accuracy of the 1839 Map

The Ahmad Shahi city was planned in a rectangular form and divided into 4 quarters by 2 main roads that intersect in the center of the city. The city was surrounded by a strong mud wall, 4 major gates, 2 minor gates, and 4 towers at each corner as depicted in Figure 4. The city's gates include the Eidgah gate in the northern direction (Figure 5), Shikarpur gate in the southern direction, Herat gate in the western direction, and

Kabul gate in the eastern direction. These gates connect the city's primary roads, which intersect at the city center. Additionally, there are 2 smaller gates: Bar Durrani on the north-eastern side and Top Khana on the northwestern side. The wall was divided into two parts, the lower part was about 7.3 m tall and 5.5 m thick at the bottom and 4.45 m at the top, while the above part was about 2 m tall and 0.7 m thick. It was also protected by an approximately 4.8 m deep and 7.3 m wide moat around the wall (Figure 6). The wall was



FIGURE 4 Fortified mud wall of Ahmad Shahi old city



FIGURE 5 Eidgah Gate in the 19th century

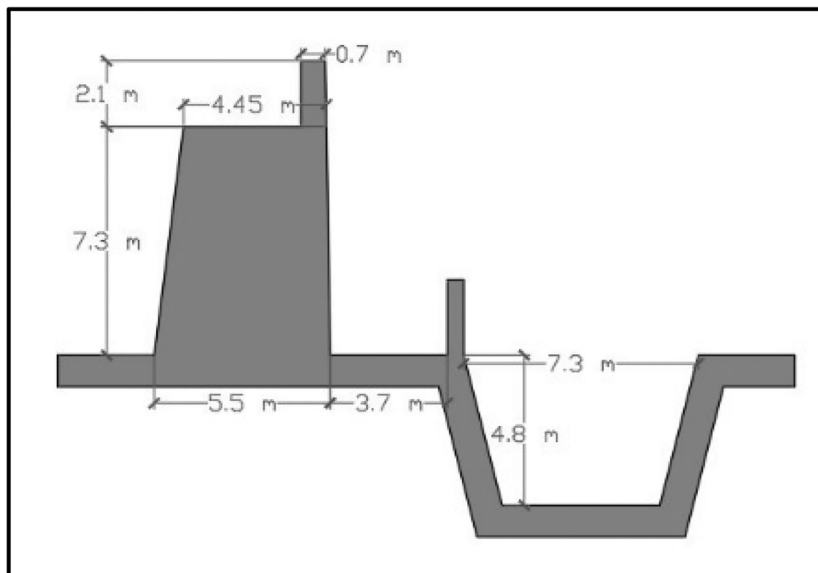


FIGURE 6 Cross section of the mud wall and moat

constructed for security concerns to defend the city against enemy invasions. Later on, the city gates, towers, and walls were dismantled in 1945 except for a short length of a wall along the south side (Figure 7); Moreover, the construction of new infrastructures, governmental buildings, roads, and streets were widened simultaneously. And beside some stretch or shorten of the map, because this research map base analysis of each land usage ratio is measured map by the map is not affected by these fitting steps.

The outline of the city wall was produced by utilizing existing parts. Dimensions are determined at a different point in both the 2018 satellite image and the 1839 map of Fraser

Tyler for more accuracy. The digital version of the old 1839 map was used for overlaying with the 2018 satellite image, but there were some differences in the scales of the maps; the old map north part was stretched, and the south part was shrunken. As well as Adobe Photoshop software was employed to rectify these scale differences while ensuring that the city area and settlements remained in their original positions. Furthermore, the measurements were obtained from the northeast corner to the center of King Ahmad Shah Abdali Tomb, Shah Masque, northwest, southwest, and south-east corners of the road around the city wall and Charsoo, the city center.



**FIGURE 7** Remaining part of the old mud wall

Moreover, comparing the dimensions on the 2018 satellite image and the Fraser Tytler map of 1839 confirmed that the 1839 map is substantially reliable.

The most significant variation was discovered in the location of the King Ahmad Shah Abdali Tomb and Mosques, where the distance difference was 7.28%, 1.66%, and 7.28%. The exact measurement is with the city center of Charsoo, which corresponds perfectly to the 2018 satellite image. Considering the length of the city, where the east to the west side is 1070 m long, and the north to the south side is 1812 m long. Thus the 1839 map is remarkably accurate (Figure 8 and Table 1).

Furthermore, the 1839 Fraser Tytler map illustrates the city's major buildings and infrastructure, which are the King Ahmad Shah Abdali Tomb, Shah Mosque, citadel, grass market, cattle market, Shalimar Bagh, military field and city wall, city gates, 4 large towers, 54 small bastions, and so on. The intersection of the 2 major roads is known as Charsoo, and until the 1930s, it was covered by a huge dome as the central market. And the city consists of 4 bazaars: Herat Bazar, Kabul Bazar, Shikarpur Bazar, and Shah Bazar; from these infrastructure and major buildings, Ahmad Shah Abdali Tomb, Shah Mosque, religious buildings, and 4 bazaars are still visible in their original locations in the city (Figure 8). The perimeter road around the city walls and the 2 primary roads that are oriented from north to south and east to west on the 1839 map, which connect at the city's center named Charsoo, are comparable to the city's current routes. A comparison of the street network between the map from 1839 and the satellite image from 2018 reveals that the interior streets of each quarter do not match exactly; however, the roads around the city wall, the corners of each quarter, and the main 2 roads that intersect at the city center are more accurately drawn (Figure 9), while the streets mostly having various shapes despite 25.7% of the streets and roads can be traced in the current street network. Measuring the street network inside each quarter was more difficult because the streets generally changed their widths and lengths over time.

In Figure 8, the gray lines represent roads and streets only found on the 1839 map, the red lines represent streets only revealed on

the 2011 and 2018 satellite images, the yellow lines represent roads and streets only found in 2018, and the brown lines represent only the joint road and streets of 1839, 2011, and 2018 maps. In fact, 25.7% of the streets and roads are joint streets in all 4 districts. Thus, it suggests that the 1839 map is slightly accurate.

#### 4. Data Analysis

##### 4.1 Land use transformation

We conducted a comprehensive analysis of the study area by comparing historical maps from 1839 with satellite imagery from 2011 and 2018. This encompassed an assessment of land use and building usage and distribution within the designated study area. All information about the study area has been organized and compiled to facilitate this analysis; we integrated Fraser Tytler's 1839 historical map and 2011 and 2018 satellite images into GIS software. Subsequently, we digitized land use such as infrastructures, public facilities, commercial residential, walls, forts, citadels, military compounds, cattle markets, grass markets, green areas, freshwater canals, and vacant lots within the designated area. This digitization process allowed us to determine key parameters, including distances to public facilities, lot sizes, building coverage area (BCR), housing types, runoff coefficients, street, and road networks, as well as other pertinent land use specifications. Furthermore, the city was organized correctly in its initial plan, which was similar to a rectangular shape, and the city has been kept within the same area and boundaries for more than 250 years, as documented in historical records dating back to its founding in 1756 (Map base confirming almost 250 years keep from 1839). From the social aspect, changes in people's lifestyles and requirements have resulted in a shift from extended to joint and nuclear family typology in the area, ultimately impacting the building lot area, building coverage ratio (BCR), and overall urban morphology of the area. Analysis of the building coverage ratio (BCR) in the target area demonstrates a 12% increase from 1839 to 2011 and a 5% increase from 2011 to 2018. Furthermore, the average lot size of housing in the target area shows an 86% decrease from

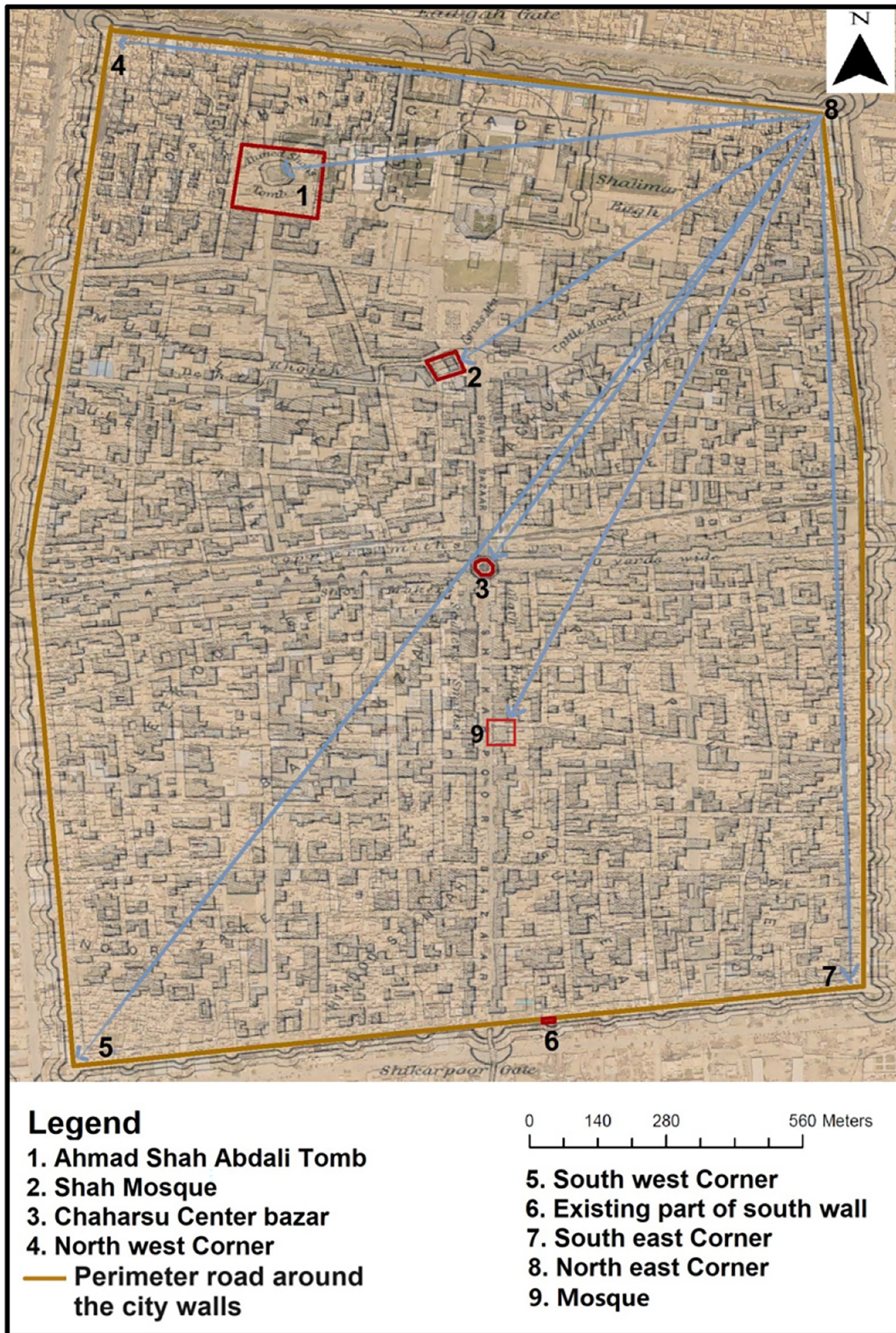


FIGURE 8 Measure points based on 1839 map and 2018 satellite imagery

**TABLE 1** Dimensions of the measured points

No	Measured point	Old map 1839 (Dimensions meter)	Aerial photo 2011 (Dimensions meter)	Differences (Meter)	Differences (%)
1	King Ahmad Shah Tomb	825	769	56	7.28
2	Shah Mosque	711	723	-12	1.66
3	Charso Center Bazar	936	936	0	0.00
4	Northwest Corner	1040	1070	-30	2.80
5	Southwest Corner	2001	1998	3	0.15
6	Existing Part of South Wall	1521	1521	0	0.00
7	Southeast Corner	1521	1521	0	0.00
8	Northeast Corner	-	-	-	-
9	Mosque	1159	1250	-91	7.28

1839 to 2011 and a 2.26% decrease from 2011 to 2018 (Figure 10).

The Maps of 1839, 2011, and 2018 were digitized; land use, particularly residential lots, were highlighted in all three maps to demonstrate the extent of transformation and destruction that had taken place over the given period (Figure 11 and Table 2).

#### 4.2 Housing types

We analyzed all the houses in the old city using housing data from 2011 and 2018 in conjunction with aerial photos and surveyed houses of the old city to assess and compare different building typologies, considering aspects such as their architectural form and construction materials. The 2018 land use maps clearly illustrate a significant increase in the number of new houses built within the residential neighborhood. Constructing of new houses along roads with less than 4 m widths in historical areas are illegal due to the urban planning principles of Kandahar province.<sup>12</sup> In addition, according to the Kandahar CDCs (Community Development Councils), constructing new houses along 4 m roads will affect the sun and wind orientation, as well as the privacy of the surrounding dwellings. Additionally, it is worth noting that the Strategic Development Planning (SDP) project initiated by the Ministry of Urban Development and Land (MUDL) proposes the inclusion of both 6-m and 4-m width streets within the old city, suggesting a comprehensive approach to address the city's development needs. Moreover, the author conducted a socioeconomic survey of 75 houses and fieldwork in the study area in 2020 and 2023. Based on the survey and fieldwork conducted, the site contains several historic buildings that contribute to the area's historic character. Despite the considerable impact of war and land use changes on this area, it is still recognized for its historical and cultural significance. Currently, there are three types of housing in the old city of Ahmad Shahi, traditional old houses with courtyards, new houses, and mixed houses. The primary focus of Traditional old courtyard houses is on privacy and security; the architectural elements are strategically arranged to maximize privacy within the building complex. These types of houses serve various functions and facilitate a range of activities in the central courtyards, such as family gatherings, cultural and ceremonial events, and workspaces that use for cooking, dining, laundry, sleeping, and gardening and provide a safe and controlled environment for children to play and engage in recreational activities. Typically, such houses are constructed on a shallow foundation made of stonemasonry. The ground floor walls are generally

made of sun-dried bricks and covered with mud plaster with clay and straw. New Houses, these types of houses stand as separate buildings and add an open area surrounding the houses; these houses are made from modern materials with an RC structure. Mixed houses are new houses or living spaces constructed using modern materials that are added to the courtyard of an existing traditional house or a part of the original traditional old house demolished to accommodate modern extensions. These extensions typically include bedrooms, guestrooms, modern kitchens, and toilets, all constructed using modern construction methods and materials. The mix of old and new elements changed the appearance of traditional old houses and created the composition of new and traditional houses (Figure 12).

#### 4.3 Urban challenges and problems

Kandahar has one of the highest migration rates in the country due to social and economic opportunities and its strategic location. According to a 1990 report by UNHCR, 80% of migrants, who were mainly occupied in agriculture, returned to Kandahar. This influx of people gradually resulted in arbitrary extension and transformation of land use in violation of the master plan. Consequently, the city has been confronted with numerous urban challenges and problems. On the other hand, the target area's close proximity to the central business district (CBD) has considerably increased its land value. As a result, most residential lots have been illegally converted into commercial lots, leading to various social, cultural, and environmental issues for the area and its inhabitants. The transformation of land use has also resulted in a significant increase in building heights and noise pollution, which has obviously impacted the indoor and outdoor privacy of residential lots. It has also had an impact on the sun and wind orientation of the surrounding residential lots. Moreover, the construction of new infrastructure, road extension and most commercial lots have increased their BCA to 100% as a result of land use transformation, which undoubtedly affected the rainfall infiltration and increased the surface runoff.

#### 4.4 Runoff coefficient and implications

We conducted a GIS-based analysis by digitizing land use maps from 1839, 2011, and 2018, using Afghanistan runoff coefficient<sup>13</sup> ratios. This analysis has yielded valuable insights into changes in runoff coefficients over time. A comparison of the runoff coefficient from all three maps shows that the average runoff coefficient has increased by 150.84% from 1839 up to 2018. In 1839, the average runoff coefficient was 0.59,



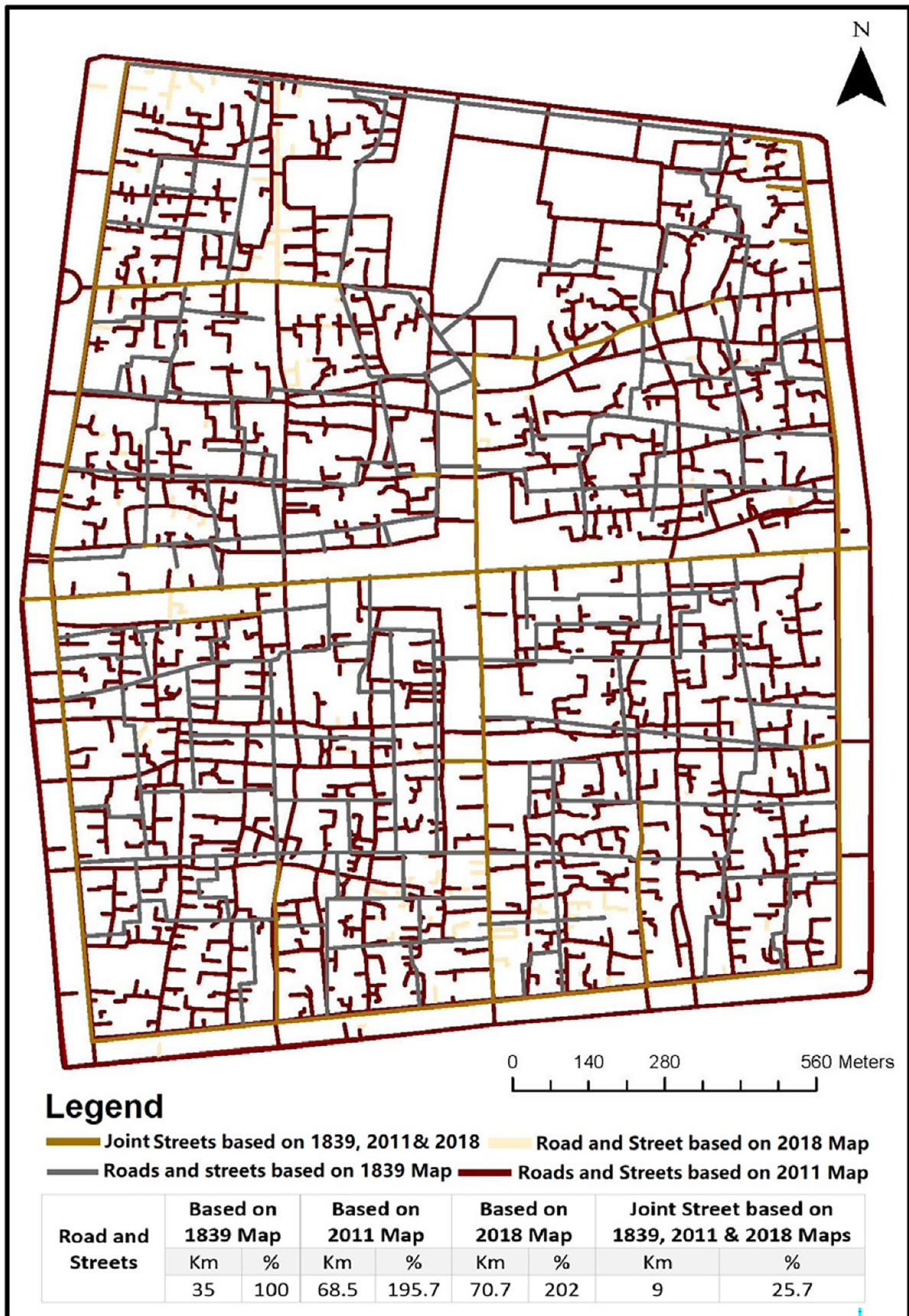


FIGURE 9 Joint roads and street network map

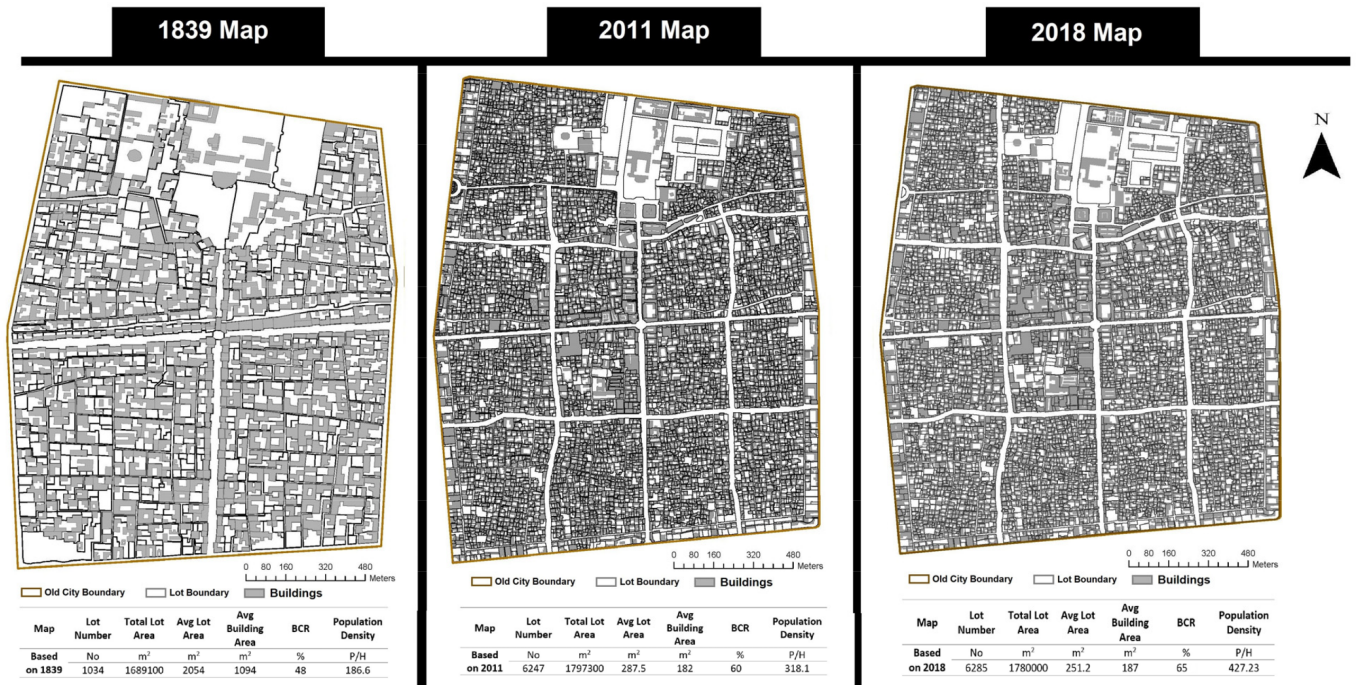


FIGURE 10 Building coverage area and lots area maps for 1839, 2011, and 2018

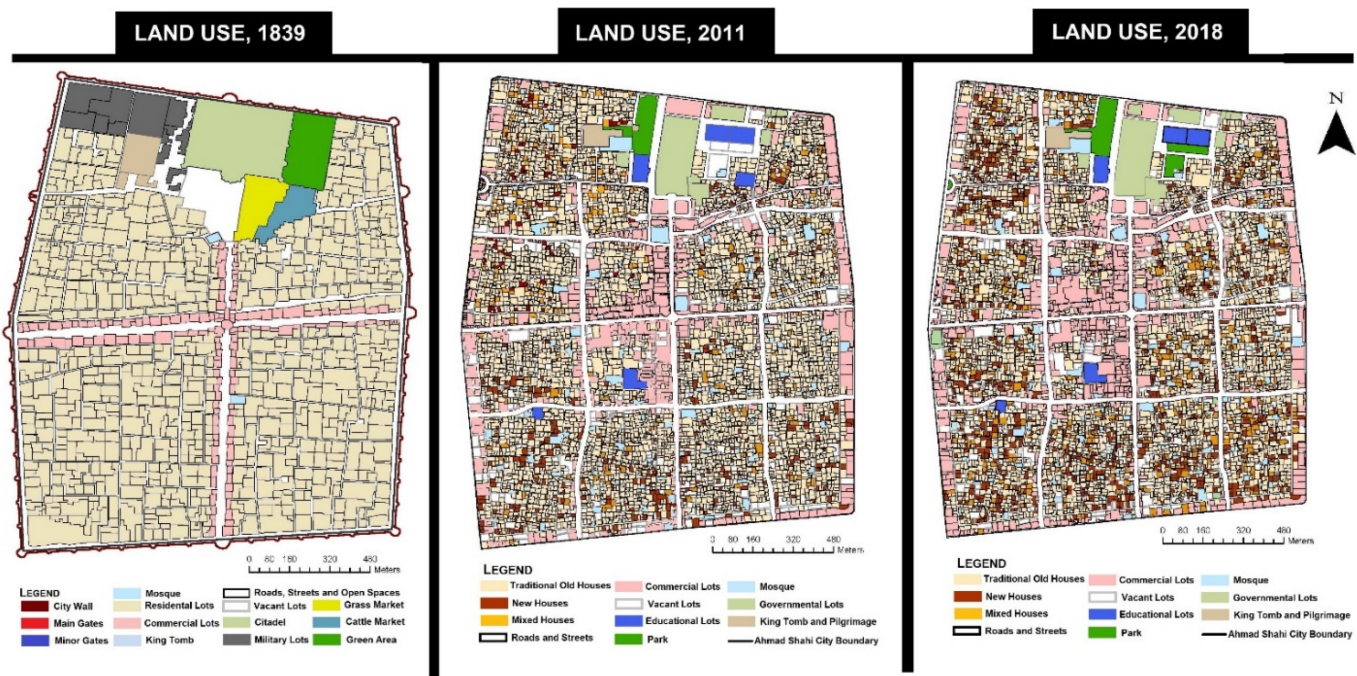


FIGURE 11 Land use maps based on 1839, 2011, and 2018

which increased to 0.86 in 2011, and further increased to 0.89 in 2018 (Figure 13 and Table 3). The increasing tendency in the runoff coefficient suggests that there have been greater changes in the land use and land cover of the study area that have led to increased surface runoff and reduced infiltration. Moreover, this phenomenon is referred to as the greater changes in the land use and land cover of the study area that

have led to increased surface runoff and reduced infiltration and have implications for stormwater management, as it affects the volume and velocity of runoff, potentially leading to increased flood risk and water quality issues. These are serious issues in such kinds of city area where a lot of houses pump up underground water through private wells without a public water pipeline.<sup>14</sup>

TABLE 2 Land use change based on 1839, 2011, and 2018

No	Land Use	1839 map			2011 map			2018 map		
		Area (Ha)	No of Lots	%	Area (Ha)	No of Lots	%	Area (Ha)	No of Lots	%
1	Residential lots									
	Traditional houses	127	879	64.48	101.04	4206	46.10	79.70	3417	37.04
	New houses	–	–	–	7.16	349	3.26	11.70	623	6.13
	Mixed houses	–	–	–	7.20	327	3.28	11.22	471	5.63
2	Mosque	0.33	2	0.17	6.08	109	2.71	6.15	119	2.82
3	Park	0.024	1	0.01	1.67	1	0.76	2.77	3	0.79
4	educational lots	–	–	–	2.66	6	1.22	2.66	6	1.21
5	Vacant lots	–	–	–	15.79	421	7.21	15.34	364	7.01
6	commercial lots	11.66	147	5.83	31.40	808	14.35	39.10	1112	16.95
7	Pilgrimages and cultural lots	4	1	2.00	0.90	3	0.41	0.90	3	0.41
8	Governmental lots	–	–	–	5.84	17	2.66	6.12	19	2.79
9	Citadel	8	1	4.00	–	–	–	–	–	–
10	Military lots	11	1	5.50	–	–	–	–	–	–
11	Cattle market	2	1	1.00	–	–	–	–	–	–
12	Grass market	2	1	1.00	–	–	–	–	–	–
13	City wall	2.9	–	1.45	–	–	–	–	–	–
14	Roads, street and canals	28.04	–	14.02	39.43	–	18.04	43.51	–	19.11
15	Total area	196.95	1034	100.00	219.16	6247	100.00	219.16	6137	100.00



FIGURE 12 Type of houses

#### 4.5 Destruction of historical buildings and changes in house area and family typology

The analysis reveals that 306 traditional courtyard houses (6.49%) which defined houses with courtyard in aerial photographs taken in 2011 as traditional courtyard houses, in residential areas have been demolished and converted into commercial lots by the private sector. Additionally, the public sector has destroyed 65 traditional courtyard houses (1.38%) over the past 7 years to facilitate the construction of new infrastructure and road extensions. It is essential to recognize that historical structures play a vital role in an area's socioeconomic development and identity. Due to the lack of statistical data on the 1839 map, there is no information on the exact number of families, but

considering the ancient traditional culture of this city, people used to live as extended families in large-size courtyard houses. The Figure clearly shows that the average area of the houses was 2054 m<sup>2</sup> according to 1839; this number dramatically decreased to 287.5 m<sup>2</sup> in the 2011 map and 251.2 m<sup>2</sup> in the 2018 map. However, this decrease happened when extended families wished to live in joint and nuclear-type families. During our fieldwork in the study area, we conducted interviews with 75 households. Among them, 7 households reported living as extended families, while 50 households were structured as joint families, and 18 households followed a nuclear family type. According to the statistical data of MUDH (Ministry of Urban Development and Housing), it has been determined that the

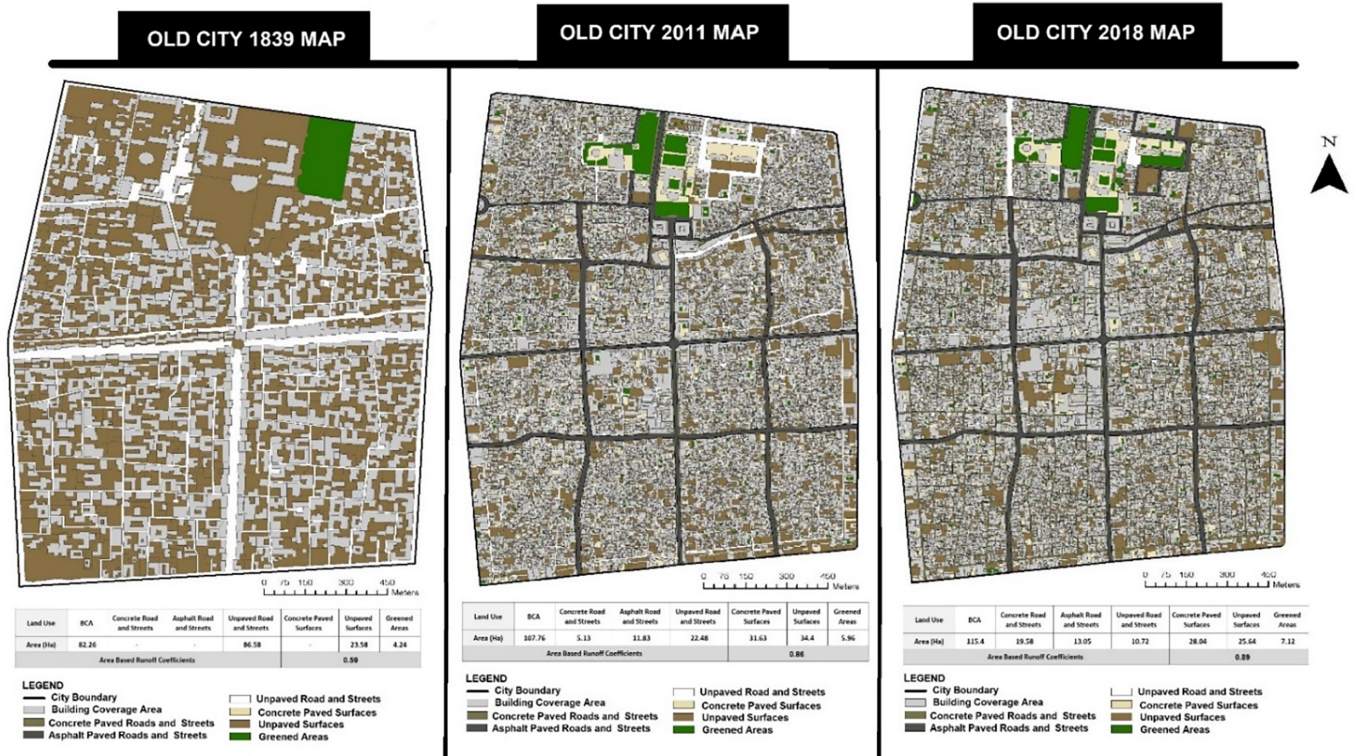


FIGURE 13 Average area-based runoff coefficient maps for 1839, 2011, and 2018

TABLE 3 Average runoff coefficients calculation table

No	Land cover	1839 map			2011 map			2018 map		
		Surface area (Ha)	Runoff coefficient	Σ	Surface area (Ha)	Runoff coefficient	Σ	Surface area (Ha)	Runoff coefficient	Σ
1	Building coverage area	82.26	0.6	0.25	107.76	0.6	0.49	115.04	0.6	0.53
2	Vacant lots	–	0.6	0.00	15.79	0.6	0.05	15.34	0.6	0.05
3	Greened area	4.24	0.15	0.00	5.96	0.15	0.00	7.12	0.15	0.01
4	Concrete paved surfaces	–	0.8	0.00	31.63	0.8	0.13	28.04	0.8	0.11
5	Unpaved surfaces	86.58	0.6	0.26	18.61	0.6	0.06	10.3	0.6	0.03
6	Concrete paved roads and streets	–	0.9	0.00	5.13	0.9	0.02	19.58	0.9	0.09
7	Asphalt paved roads and streets	–	0.7	0.00	11.83	0.7	0.04	13.05	0.7	0.05
8	Unpaved road and streets	23.86	0.6	0.07	22.48	0.6	0.07	10.72	0.6	0.03
Total		196.94	–	0.59	219.19	–	0.86	219.19	–	0.89

average size of a nuclear family consists of 7 people.<sup>15</sup> As a result, subdivision and distribution of houses are frequently done after a few generations. Consequently, these changes have significantly impacted the functions and activities of the central courtyards, privacy, and security, including cooking areas, dining areas, sleeping spaces, gardening spaces, and ceremonial spaces, and the architectural design of traditional old houses has also been affected by these changes. And as well the decrease in house area can be attributed to the increased pressure on the central city area and changes in people’s lifestyles.

#### 4.6 Transformation of road and street network

The old city is famous for the congested neighborhoods of today’s Kandahar city and is well known for having the highest residential density. The settlements covered all open space areas, and the division of the houses and land among family members had no regularity. Furthermore, we conducted GIS-based analysis to measure all the roads and streets in the study area, utilizing the 1839 map and aerial photos from 2011 and 2018. As a result, the number of lots has increased; on the other hand, regular and broad streets have been significantly

transformed into irregular, narrow, zigzag, and dead-end streets, which has obviously impacted infrastructure and residents' daily lives. According to the 1839 map, the city had only two trunk roads with a 2.57 km length that ran through the center of the city from north to south and east to west and streets that were no longer than 33 m. However, the road and street networks are highly alternated in the 2011 and 2018 maps due to the establishment of new roads and streets. In the map of 2011, the overall length of the road was 17.5 km, and the street was 51 km long. Based on the map from 2018, the total length of the road is 19.3 km, and 51.1 km of streets connect the city's inhabitants. Figure 14 illustrates the street and road pattern and morphology of the area, utilizing various maps and timelines. The streets and roads in the specified area have been classified into four categories, namely A, B, C and D, based on road width and mobility, measurements of all roads and streets in the target area were obtained from geographic information systems (GIS). These categories serve as a convenient way to group the width and patterns of all roads and streets of the old city according to the current urban planning guidelines. Roads that have widened in recent years as city planning roads with a width of 13 meters or more are designated as type A; currently, these roads are the arterial roads of the city allowing for the passage of trucks, passenger cars, bikes, and pedestrians. Type B includes roads with a width of 6 m or greater; these types of roads were created after 1980; the aim of these roads was for the development of the city and the needs of the residents, and the mobility of these types of roads are trucks, passenger cars, bikes, and pedestrians. Streets with a width of 4 meters or more fall under type C; these streets are still in their original form and famous for their historical value; the mobility of streets are passenger cars, bikes, and pedestrians and some streets are in the shape of zigzag. While type D streets narrower than 4 m, including those with widths less than 2 m that cars cannot pass through, most of the streets are narrow, zigzag, and dead-end; these are the pedestrian alleys which are connected with residential lots, are designated as D (Table 4). Additionally, in the 1980s, Kandahar was one of the major cities in Afghanistan, and it played a significant role in

the country's history and development. During this time, urban planning and development in Afghanistan were influenced by various factors, including political changes, social dynamics, and economic conditions. One important aspect of urban planning in Kandahar during this period was the 1980 master plan (Figure 15). This plan aimed to guide the city's growth and development, considering its historical significance and the needs of its residents. It is worth noting that Afghanistan was undergoing a period of instability and conflict during the 1980s due to the Soviet-Afghan War, which lasted from 1979 to 1989. This conflict significantly impacted the country's infrastructure and development, including in Kandahar. However, the ongoing conflict and political turmoil in Afghanistan may have disrupted or altered the implementation of this master plan. As a result, it was clarified that the road and street network of the study area had been practically adapted according to the 1980 master plan. However, the width of the roads and streets planned in the master plan is different from the width of the existing roads and streets. The proposed road width in the master plan is 75 m, 40 m, 30 m, and 20 m, but in the current state, the road width is 13 m or more and streets are more than 4 m or less than 2 m wide.

## 5. Data Comparison

The wall around the city was demolished, the ditch was filled up, and the city land area was increased from 196.96 ha to 219.16 ha; the study also discovered a considerable land use transformation by comparing the figures of three different maps in Table 2. Additionally, the lands from Military compounds, green spaces, cattle market, grass market, citadel, and other structures were added for the extension of commercial and residential areas. Moreover, the traditional historical houses in the study area which have faced drastic changes and transformations; according to the spatial analysis from the satellite imagery of 2011 and 2018, 306 (6.49%) residential lots have transformed into commercial lots regardless of the master plan, and as well the roads and streets were increased in number and length from



FIGURE 14 Maps depicting the road and street networks from the years 1839, 2011, and 2018

TABLE 4 Types of roads and streets

No	Types	Width (Meter)	Fraser Tytler map 1839 Length (km)	Satellite image 2011 Length (km)	Satellite image 2018 Length (km)	Type of mobility
1	Type A	13 < 25	10.2	13	14.8	Trucks, Passenger cars, Bikes and Pedestrian
2	Type B	6 < 13	–	4.5	4.5	Light Trucks, Passenger cars, Bikes and Pedestrian
3	Type C	4 < 6	24.8	4.7	4.8	Passenger cars, Bikes and Pedestrian
4	Type D	<2 <4	–	46.3	46.6	Bikes and Pedestrian
Total length			35	68.5	70.7	

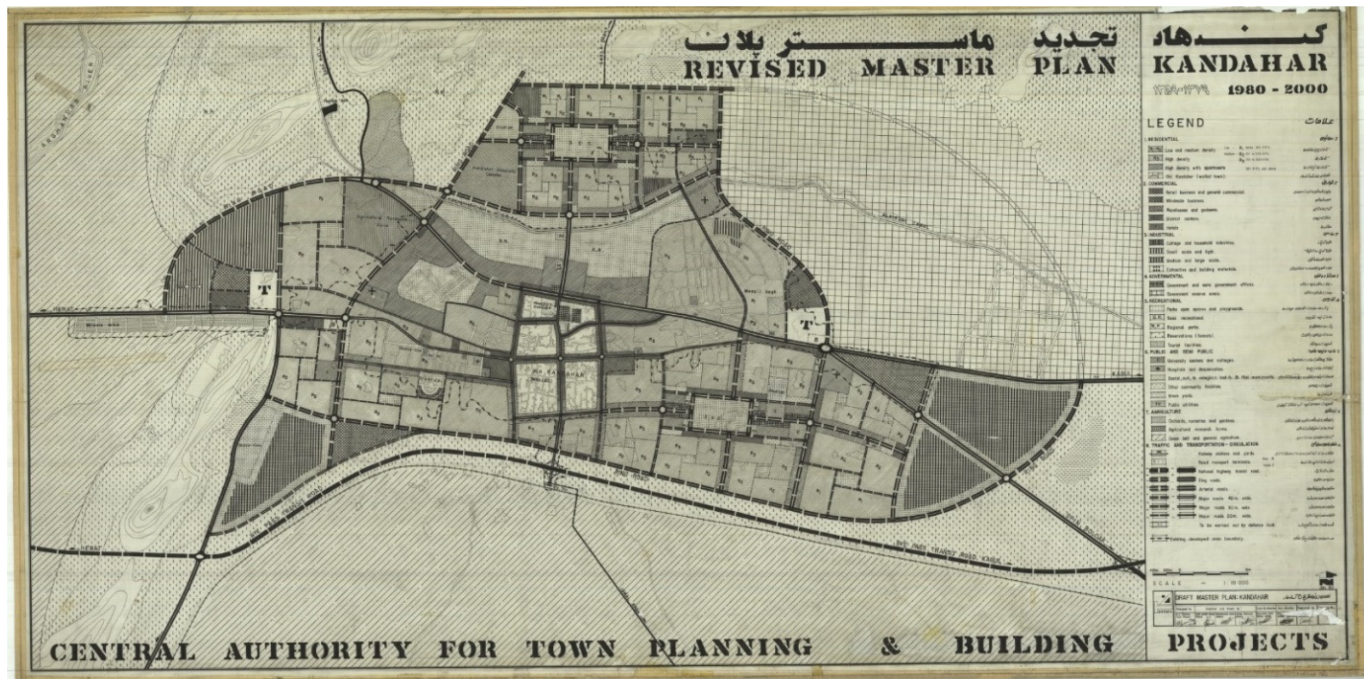


FIGURE 15 Kandahar city revised master plan for 1980

than 35 km to about 70.7 km, but their width decreased to less than 4 m. Furthermore, the historical houses have several advantages, such as their compatibility with the climate, environment, and aesthetic aspects of the area. However, there are financial and legal constraints that prevent the government from imposing restrictions on people making changes to these houses. Consequently, residents are also facing in terms of social and quality of life issues. The majority of dwellings are at a high risk of collapsing or experiencing structural failures due to poor construction maintenance. The area features numerous historical houses that are over a century old and hold significant cultural value for the area. Unfortunately, the preservation and rehabilitation of these assets have been hindered by various factors. These include the absence of preservation guidelines, a suitable and implementable plan, local experts within preservation, limited financial resources, and a lack of coordination among the urban sector and organizations.

Consequently, the Kandahar local government has been unable to undertake any concrete measures to preserve and restore these valuable historical assets. As a result, these historical buildings have been subjected to gradual demolition, leading to the rapid disappearance of their architectural design and distinctive features of these houses that serve as tangible representations of the area's ancient history and morphology.

The preservation law for historical and cultural heritages was established in 2004, but it has proven insufficient in effectively addressing the existing problems due to the abovementioned reasons. As a result, there has been a significant transformation in land use and a loss of cultural heritage in several historical and important sites throughout the city.

## 6. Conclusion

This study comprehensively analyzes the land use transformation and preservation status of the Ahmad Shahi old city in Kandahar, utilizing historical maps of 1839 and satellite images of 2011 and 2018. Critical insights into the urban morphology, cultural heritage, and socioeconomic changes within the old city have been found through accurate data acquisition, digitization, and spatial analysis.

First, the accuracy of the 1839 historical map by Fraser Tytler was verified through an accurate process of geo-referencing and overlaying with old map and satellite images. The results demonstrated that the 1839 map remains remarkably accurate, with minor scale differences that do not significantly impact its reliability. Particularly, the King Ahmad Shah Abdali Tomb, Shah Mosque, religious buildings and 4 bazaars have maintained their original positions in the city. Moreover, the cattle market, green

spaces (Shalimar Bagh), military complex, city defensive wall, gates, and towers are not there anymore; these spaces have been changed for residential and commercial purposes.

The analysis revealed several critical trends in land use transformation within the Ahmad Shahi old city. Notably, there has been a significant increase in building coverage ratio (BCR) 12% from 1839 to 2011 and 5% from 2011 to 2018. Furthermore, there are several traditional old houses in the Ahmad Shahi old city that have experienced significant transformations in the last 3 decades. These changes are a result of various factors, including rapid population growth and urban expansion. And according to analysis that 306 traditional courtyard houses (6.49%) have been demolished and transferred to commercial lots, and the average area of the houses decreased from 2054 m<sup>2</sup> to 251 m<sup>2</sup> regardless of the master plan and as well the roads and streets have taken zigzag and narrow shapes which have increased in number and length from 35 km to about 70 km. These circumstances have undoubtedly affected both the environmental and social aspects of the residents' lives as well as altering the characteristics of the area. These changes happened as a result of the land value, close to the CBD transition of the family typology, and some other minor factors.

It focuses on the traditional houses in the old city of Kandahar and discusses the importance of their historical value, land use transformation, and their impact in the last few decades. While the 1980 master plan was a pivotal point in the city's development, significant changes have occurred in the urban landscape since then, particularly after 2001 when the new government was established. Furthermore, these monuments are an essential component of today's cities. Moreover, the Ahmad Shahi old city of Kandahar has experienced significant land use transformation over the years, impacting its urban morphology, cultural heritage, and quality of life for its inhabitants. To address these issues, it is essential that urban development and planning authorities prioritize their preservation plans, allocate sufficient resources, and engage with local experts and organizations to preserve the city's unique historical and cultural identity. Failure to do so may result in further loss of historical assets and irreversible changes to the city's landscape.

### Acknowledgments

The authors would like to thank the Directorate of Kandahar Municipality and the Directorate of Kandahar Urban Development and Land for providing valuable data for our research and also express gratitude to the University of the Ryukyus for providing the facilities for carrying out this research.

### Disclosures

The authors have no conflict of interest.

### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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**How to cite this article:** Farooqi JA, Ono H. A comparative analysis of two century-old historical map and satellite images for assessing land use transformation and preservation of the historical monuments of the Ahmad Shahi old city, Kandahar. *Jpn Archit Rev*. 2024;7:e12428. <https://doi.org/10.1002/2475-8876.12428>