



An investigation of urban development with geographical information systems: 100-year change of Sivas City, Turkey

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Keywords

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ABSTRACT

One of the most important duties of urbanism is to meet the basic needs of people. The need for shelter takes a significant place among the basic needs of people. Urban populations, which are increasing very rapidly nowadays, have made urban development a non-negligible situation. Urban planning should be done by ensuring urban development and without losing the city identity, and a regular development strategy should be adopted according to objective criteria in order to manage the available resources correctly. In this study, the 100-year urban development of Sivas city center was examined with the Geographical Information System (GIS) by considering historic buildings and population projection, and the relationship between housing in the city in this process and complementary zoning plans was investigated.

1. INTRODUCTION

The need for shelter, which is the most basic need of people living in a community due to their nature, takes a significant place at every stage of history. While people used to use sheltered, safe, and high areas for shelter in historical processes, collective shelter areas have started to be formed near water resources with the transition to the settled order, and then the concept of city has emerged. Nowadays, migration movements from rural to urban areas continue at an accelerated rate. Although the world population increased by 6 times on average in the past two hundred years, urban populations increased by more than 100 times (Stalker 2000). According to the 2017 report of the United Nations Population Organization, it is estimated that the world population will be around 10 billion in 2050 and 80% of this population will live in cities (U N 2017). The population density, which occurs with the increase in urban populations, increases the social and economic needs of the society and causes resources to be consumed rapidly. As a result, the natural balance deteriorates, vegetation cover, agricultural areas, and ecological

structures are destroyed to an irreparable extent, and even the danger of extinction is faced (Özyavuz 2011). In the literature, there are various studies for the examination of urban development by remote sensing and GIS methods (Göksel and Doğru 2019; Song 2005; Sağır and Nacar 2008; Selim and Demir 2019).

İşcan and Ilgaz (2017) stated that GIS is used by municipalities to provide better services and to improve decision-making mechanisms including tax administration and city planning. Since urban development is inevitable, urban planning should be done very well, and the identity of the city, its historical and cultural values should be preserved. Furthermore, a sustainable urban zoning plan should be made by considering the socio-economic structure, demographic structure, geographical structure, cultural structure, and population density of the city (Yılmaz et al. 2007). The concept of urban development includes many parameters. The social and economic structure of the society, geographical location, topography, land use, population density, individual and social needs, the sense of belonging to the city, and political will are only some of these parameters (Erarslan and Kolay 2005). Unforeseen

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growth rate with industrialization and technological developments is another parameter in urban development (Kasanko et al. 2006). All parameters should be evaluated together, and low-density cities should be planned. Along with rapid urbanization and land cover changes in recent years, led to a decrease in natural habitats especially in developed and developing countries (Selim and Demir 2019).

Nowadays, since urban development progresses rapidly, rural settlements face the threat of extinction, and green areas are rapidly concreted. The densities of cities, which are rapidly becoming complicated and in which green areas are depleted, should be reduced, and planning should be done well (Haaland and Bosch 2015).

Urbanization, by its simple definition, means an increase in the population living in cities (Sağır and Nacar 2008). Urbanization in developing countries occurs in the form of population raids. However, urbanization should not be considered only in the context of population movements. Urbanization can also be defined as the transition from agricultural production to a higher level of production (Uysal et al. 2016). This transition has necessitated the gathering of all production control functions in cities and also has led to the growth and density of cities and has caused the increase in the degrees of heterogeneity and integration (Tekeli 1997). Therefore, while defining urbanization, it is also necessary to include social and economic changes that create that population movement. Considering in this way, urbanization can be defined as “a population accumulation process that results in the increase in the number of cities in parallel with industrialization and economic development, the growth of today’s cities, that creates organization, division of labor and specialization at an increasing rate in the social structure, and causes city-specific changes in human behaviors and relationships.” It is possible to list the reasons affecting urbanization as economic reasons, technological reasons, political reasons, and socio-psychological reasons (Sağır and Nacar 2008).

Good planning should be done for healthy and livable places, vehicle traffic, pedestrian traffic, living areas, natural and green areas should be planned well, and accommodation styles suitable for the topography and nature of the land should be created. The sun, which is indispensable for life, should be able to enter all houses, and life-threatening elements, such as dust, noise, and exhaust gas, should be minimized. Sunshine durations should be estimated in all buildings to be planned, and the soil policy should be developed for this purpose (Corbusier 1933). Empty places that will allow people to rest, have fun, and relax physically and mentally after intensive working hours have been concreted rapidly in recent times, and people are condemned to live among massive concrete piles of their own scales. It is indispensable for the future of cities to create areas where people can spend daily, weekly, and annual leisure time and rest. Parks and

green areas, areas of sports activities, beaches, forests, recreation and entertainment places should be placed in a certain order among the concrete piles of the city and turned into common living spaces of people (Corbusier 1933).

One of the most critical problems in the development of cities is the transportation problem. The dimensions of streets are insufficient for the speed of motor vehicles, and they cannot bear the load increasing every day. The shortness of the intersection points of roads, huge houses situated close to each other, insufficient street widths, high costs of expansion works, and insufficiency in the solution of the problem emerge as major obstacles to the development of the city (Song 2005).

The first parameter that comes to mind when talking about the city is the “City identity.” The heritage of the city is provided by the existence of that city, its development, circulation, and survival of the existing historical monuments. (Yakar and Doğan 2018) Every person wants to see the traces of the environment where he was born and raised. The sense of belonging of people who see their past is reinforced, and they see their roots in that city. At the stage of planning a city, first of all, it is necessary to protect the buildings that the city has and which have the identity of the city, to green its surroundings, and to turn it into places where people can spend time (Corbusier 1933).

As a result of storing the temporal data of a city in the GIS environment, it is possible to make temporal change analysis and future-oriented models in the city (Liu 2008). Thus, the temporal changes occurring in the cities can be introduced quickly and effectively and necessary planning strategies can be developed in line with this change. In this process, GIS provides many advantages in terms of time, cost and labor (Kızılelma et al. 2013).

In this study, temporal changes occurring in Sivas city center within 100 years were analyzed in the GIS environment using data such as zoning plan, ortho-photograph, population, and current map within the boundaries of Sivas city center.

2. STUDY AREA

Sivas province, which is one of the oldest settlements in Turkey’s history with an area of 28,488 km² consisting of 16 districts, is the second largest province in terms of Turkey’s territory. Upon examining Sivas settlement, which has hosted different civilizations in different periods of history, it is clearly observed that every civilization has added its own culture to the city and left a trace on the city settlement. The city, which has been integrated with its historical monuments that challenge the years among the building stocks that are constantly transforming, developing and concentrating, has gained the title of the “Sultan City” with its cultural values and rich history.

Since Sivas city is located at a point where the transportation networks of the country in the north-

south and east-west directions are knotted, it is a pass between the central and eastern Anatolian regions and is on the historic trade routes. It is possible to come across traces of history in almost every street of Sivas, which has hosted many civilizations. The structures built by civilizations to meet their shelter and social needs are monuments that have survived to the present day. The oldest settlement plans of Sivas city center that have been encountered recently are the city fortification wall map and city map of (Albert Gabriel 1934) and the city plan of Arakel Badrik 1915 (Natanyan 2008) .

The municipal boundaries of the central district of Sivas province, which is selected as the study area, have a surface area of approximately 192 km² and an average height of 1200 meters (Fig. 1).

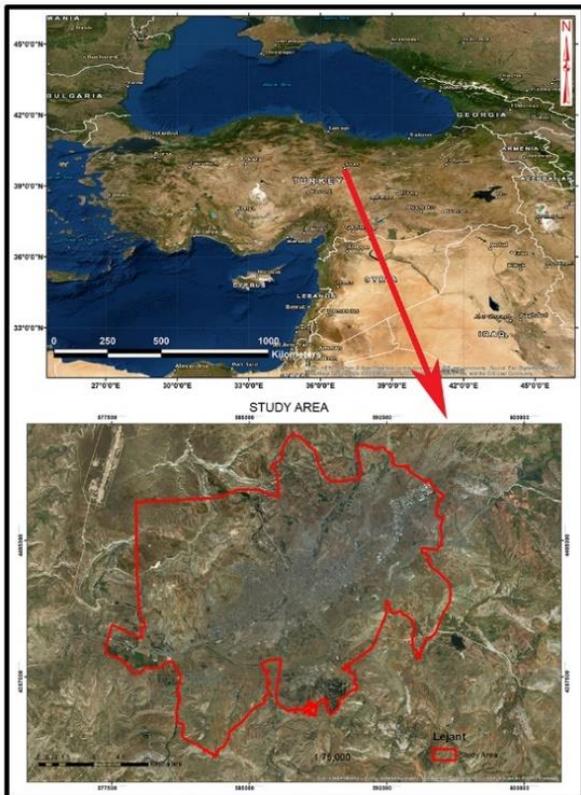


Figure 1. Study Area (Sivas City Center)

3. MATERIAL and METHODS

Within the scope of this study, different data, such as the population data, administrative boundary data, and land use of Sivas province between 1927 and 2017, the City Fortification Wall Map of Sivas city center of Albert Gabriel with the

unknown exact date and turned into a book in 1928, the City Plan of Arakel Badrik dated 1915, current maps of different years, zoning plans, and ortho-photographs, were used. The details of these data are presented in the table below (Table.1).

Table 1. Data used in the study

Data Name	Year	Data type
City plan (Arakel Badrik)	1915	Plan
City fortification wall map) (Albert Gabriel)	1928	Plan
Implementary development plan	1937	Plan
Aerial photos	1949	Ortho-photo
Implementary development plan	1968	Plan
Aerial photos	1975	Ortho-photo
Implementary development plan	1984	Plan
Neighborhood map	1992	Map
Base map	2007	Map
Implementary development plan	2018	Plan

The population data of Sivas province between 1927 and 2017 were obtained, and the projection of the city and village populations of the study area was examined. While the city population and the village population were balanced in the first years of the Republic (approximately 50.21% of the population lived in the city in 1935), the population of the city reached 92.45% in 2017 as a result of an increasingly continuing migration wave from villages to the city center at a present time (Fig. 2).

Various maps have been produced for the city of Sivas, and there are many studies on this issue. In this study, in addition to the map and plans produced by Albert Gabriel and reflecting the oldest accessible plans of Sivas city (Fig. 3), the city plan produced by Arakel Badrik (Fig.4) (Natanyan 2008) was also included. The circle observed in the 1915 city plan produced by Arakel Badrik covers the city's craft and trade area (Fig. 4). While these maps are available only as sheets, they were scanned and geo-referenced and transferred to the GIS environment within the scope of this study.

While the graphical method is used for coordinate transformation of sheet maps of the study area, helmert transformation method is used for the coordinate transformation of other maps. For all data considered in the study, the ITRF-96 datum was taken as reference.

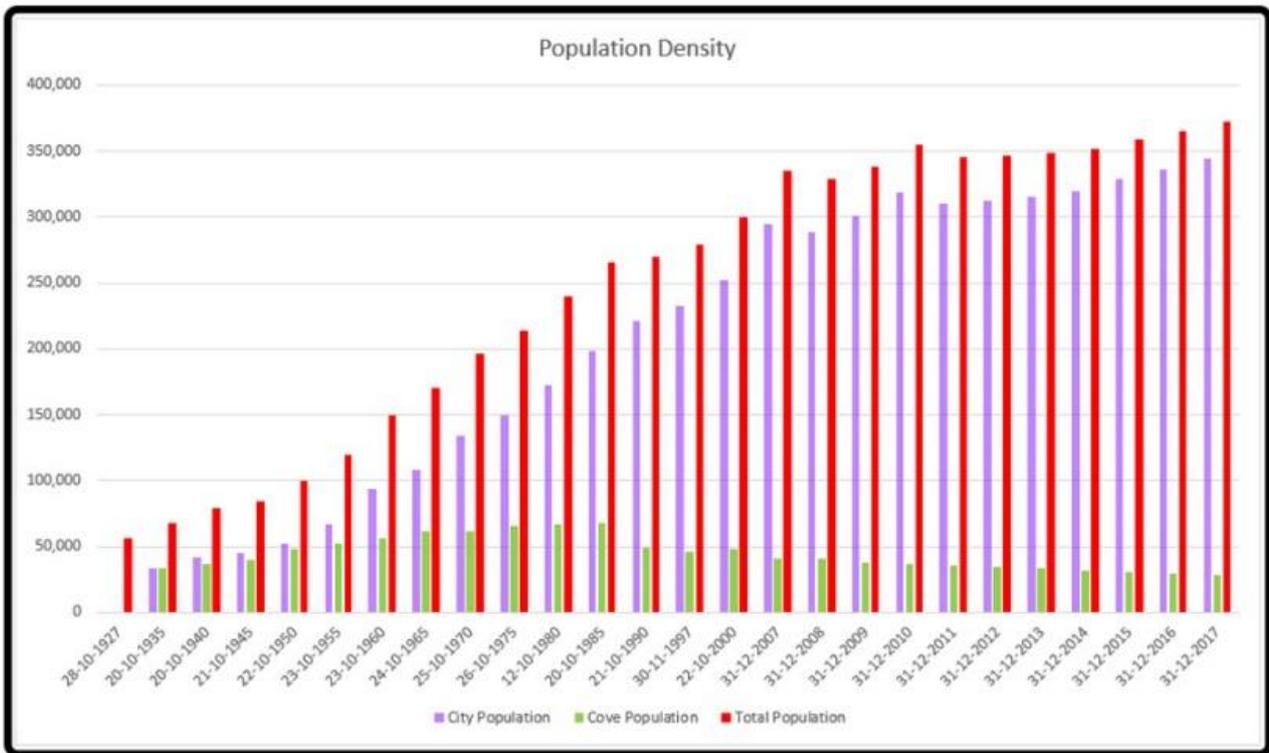


Figure 2. Population of the study area in different years

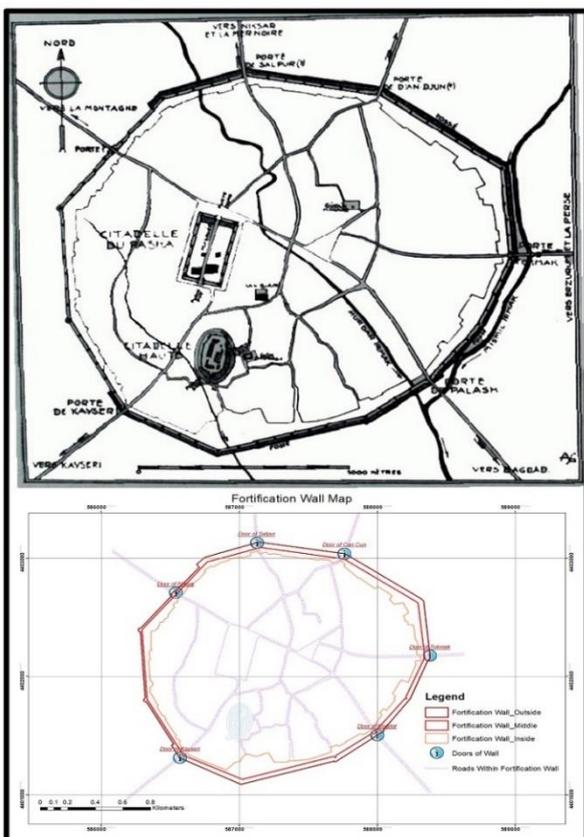
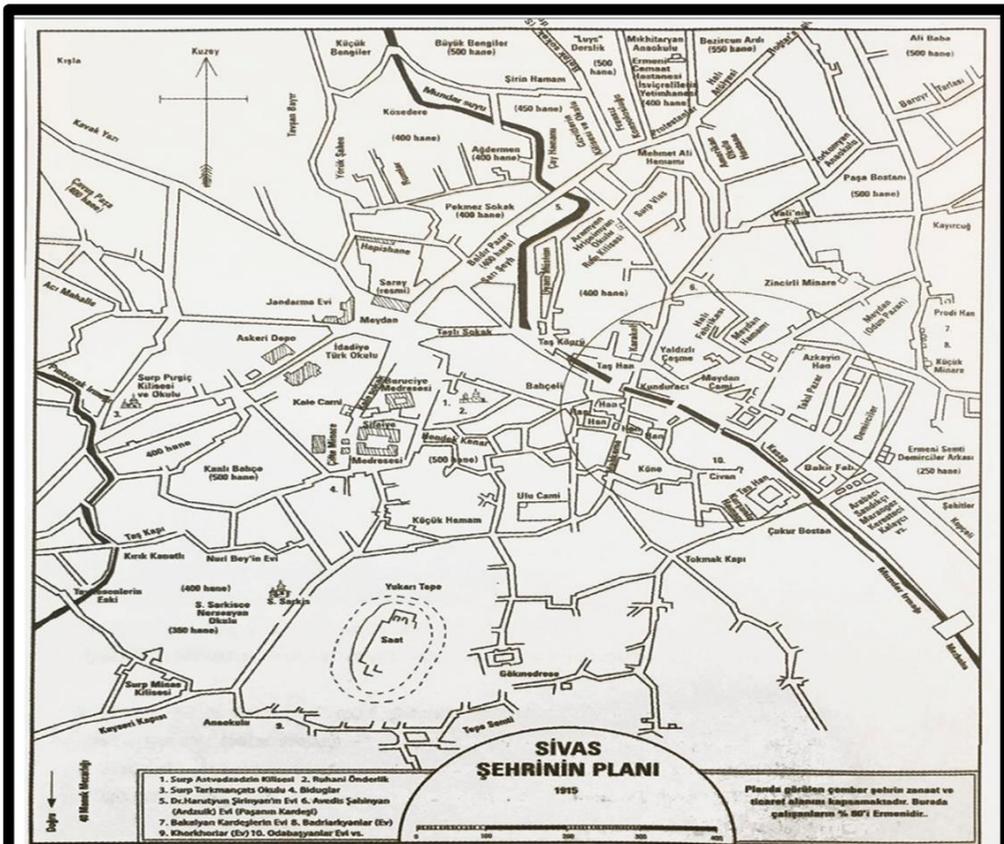


Figure 3. City Fortification Wall Map (Albert Gabriel, 1928)

The settlement direction of Sivas city center has constantly changed in the historical process. A lot of different data since 1915 were used in this study. The zoning plans and base maps for each period were digitized and overlapped. As a result of this process, settlement boundaries by years were obtained. All data were collected in a single database in the GIS environment and converted into the same coordinate system. Geographical and non-geographical data were integrated and made inquirable and analyzable (Fig. 5).

The settlement boundaries by years were divided into 100 m x 100 m grids and overlapped separately with each period. The value of 1 was assigned to the squares within the settlement boundary obtained by digitizing the zoning plan/map for each period, and the value of 0 was assigned to the squares outside the settlement boundary. Afterward, all the values were summed, and the grid value of each square was calculated. The Historic City Square (Historic Governorship City Square) was taken as a reference and divided into 8 zones, 4 main and 4 intermediate directions, and the direction information was defined. The urban development direction map of the city of Sivas was obtained by classifying according to the defined direction and grid values (Fig. 6). Here, the squares represented in green indicate the oldest settlement areas, while the areas represented in red indicate new settlement areas.



City Plan-Digital Map (Arakel Badrik-1915)

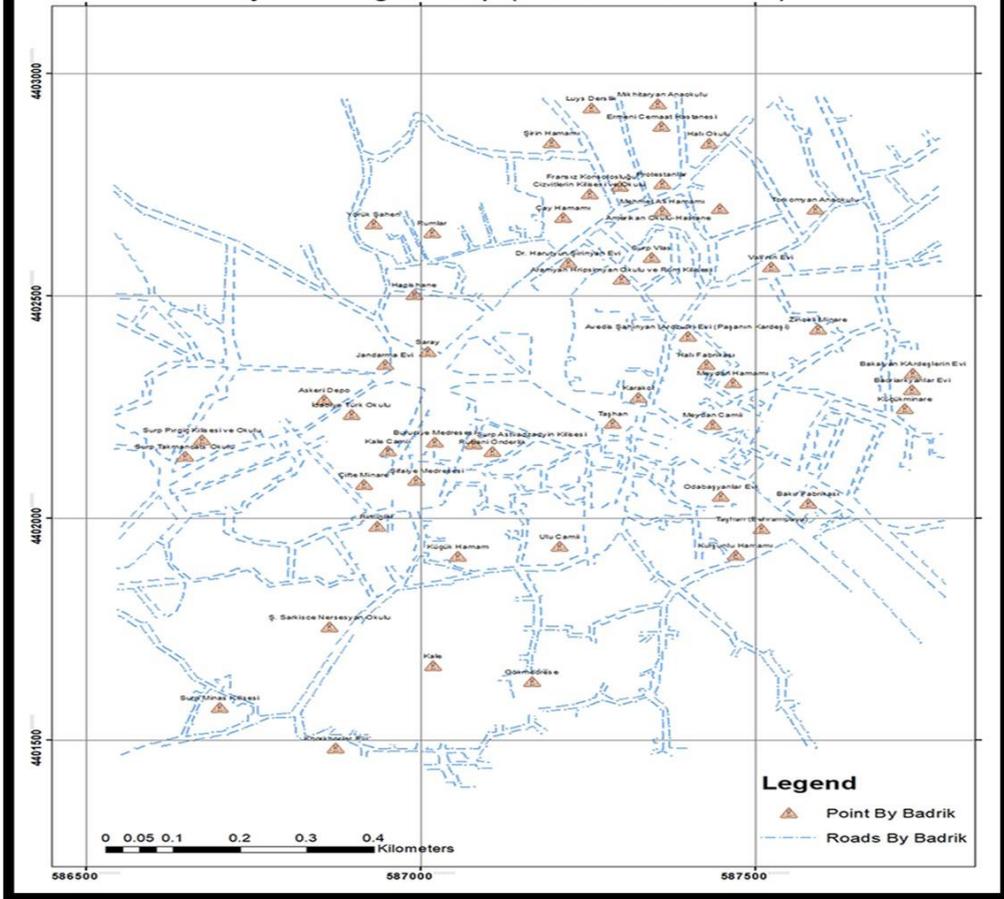


Figure 4. City Plan Map (Arakel Badrik-1915)

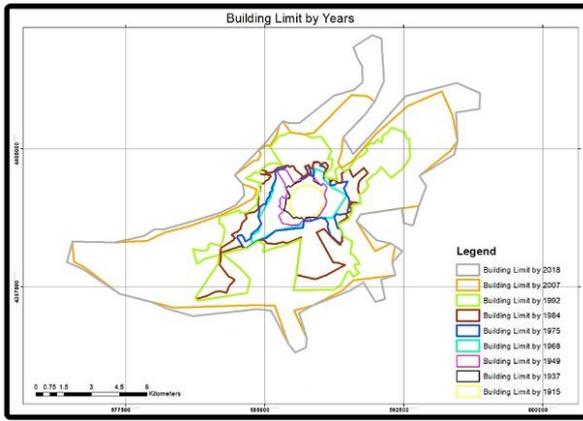


Figure 5. Settlement boundary in Sivas city by years



Figure 6. Urban development direction map of the city of Sivas

4. RESULTS and DISCUSSION

Upon comparing the estimated zoning plans with the analyses conducted, it is impossible to talk about regular growth for Sivas city. The city has frequently undergone directional changes during the expansion, both under the influence of the locations selected for investments and decision-makers within historical phases (Table 2).

As the Paşabahçe power plant started production in 1934, urban development directed to the north. With the establishment of the State Railways Traction workshop in 1939, the city development directed toward the west, and with the coming of the Cement Factory into service in 1943, this orientation continued increasingly. With the establishment of Sivas Numune Hospital in 1953, the city development directed toward the north, but this development shifted to the northwest direction with the construction of the Nuri Demirağ Airport in 1966. Sidaş Spinning Factory, which was put into service in 1972, led the development in the east direction, and then the establishment of the Sivas Organized Industrial Zone in 1976 supported this development. In parallel with this period, with the coming of Sivas Cumhuriyet University, the foundations of which were laid in 1974, and the Faculty of Medicine in 1982, a very fast urbanization

trend in the south direction started, and as a result of this trend, the “Yenişehir District Mass Housing” project supported urbanization in 1987. In historical processes, public buildings, mass housing, and industrial areas have affected the direction of development of Sultan City Sivas. In addition to the fact that the city is not regular, it can be said that it expanded primarily to the south-west direction, to the north-east direction in the second place, and then to the west and south directions. The least expanding directions of the city are the north and north-west directions. The amount of changes that occurred in Sivas city in the last one hundred years is presented in detail in Table 3.

On the other hand, there are many important historic and cultural buildings in the city. While some of these structures are not available today, many of them still preserve their historical identities. The Twin Minarets Madrasah, Şifahiye Madrasah, Kale Mosque, Buruciye Madrasah, Governorship Building, Gendarmerie Building, and Congress Building in the historic city square are among the important structures that have survived until today. In addition to these, the Ulu Mosque (Grand Mosque), Taşhan, Eğri Bridge, Kurşunlu Turkish Bath, Behram Paşa Han, Meydan Turkish Bath, Güdük Minaret, Kangal Ağası Mansion, Ziya Bey Library, Kesik Bridge, Eski Paşa Turkish Bath, and Susamışlar Mansion located in various parts of the city are important buildings that shed light on the history of the Sultan city (Fig. 7, Fig. 8, Fig. 9 and Fig. 10). The geographic location and distribution of the historic buildings in Sivas are shown in Fig. 11.

Table 2. Parameters affecting urban development

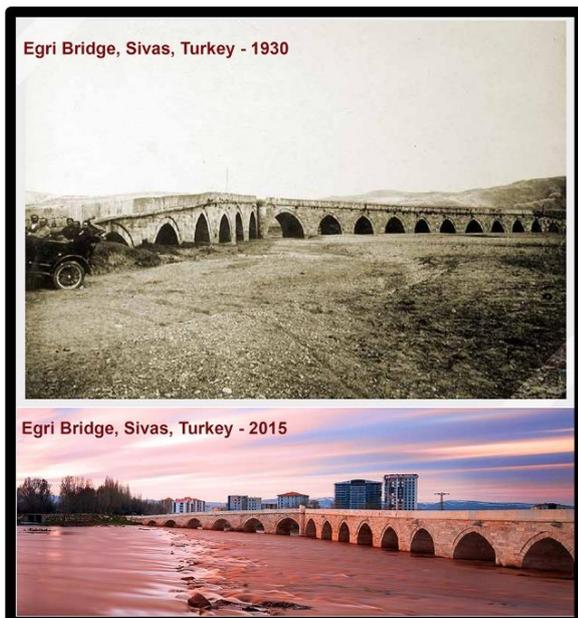
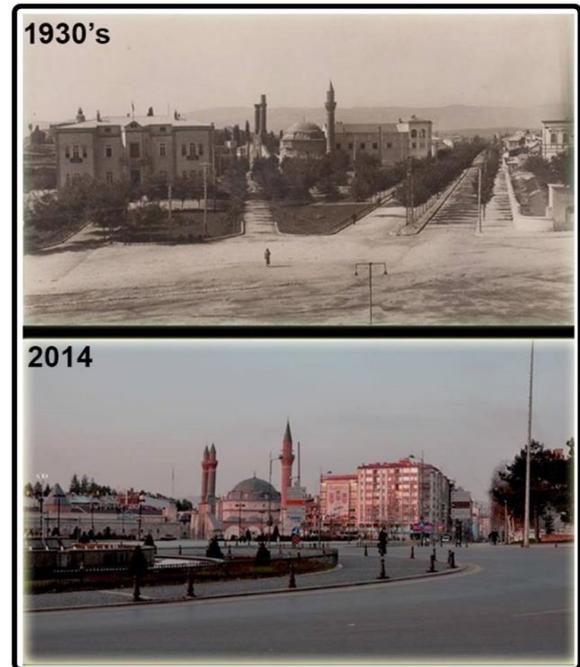
Parameter causing change	Year	Change in the city
Paşabahçe power plant	1934	The city development directed toward the North.
The state railways traction workshop	1939	The city development directed toward the east.
Cement Factory	1943	West orientation continued increasingly.
Sivas Numune Hospital	1953	The city development directed toward the North.
Nuri Demirağ Airport	1966	The city development directed toward the Northwest.
Sidaş Spinning Factory	1972	The city development directed toward the east.
Sivas Cumhuriyet University and the faculty of Medicine	1974 1982	A very fast urbanization trend in the South direction started.
Sivas Organized Industrial Zone	1976	East orientation continued increasingly.
Yenişehir District Mass Housing	1987	South orientation continued increasingly.

Table 3. Urban change rates in Sivas city by years

Settlement border year	Urban growth area (km ²)	Urban growth rate (%)	Difference between years (km ²)	Direction
1915	2.67	47.57	1.27	The north direction is weighted. Balance in all directions.
1937	3.94	37.56	1.48	Northwest and Northeast
1949	5.42	98.52	5.34	West, Southwest, Northwest, Northeast and East
1968	10.76	24.91	2.68	Southwest, southeast, Northeast, East
1975	13.44	93.45	12.56	South, Southwest and Northeast
1984	26.00	84.08	21.86	All directions except west and east
1992	47.86	145.13	69.46	Southwest and Northeast direction is weighted. Expansion in all directions.
2007	117.32	17.87	20.97	Southwest and Northeast
2018	138.29	-	-	-

Historical buildings in the city center are of great importance in terms of planning. Historical buildings supported certain housing around them according to their intended use and with this aspect, they contributed to the transformation of the city in time. These structures were sometimes used in accordance with the public service, and in others, they were used for different purposes in accordance with the flow of social life. Some of these historical buildings are introduced below.

The Eğri Bridge on the Baghdad (Silk) Road in ancient periods has provided transportation to the Sivas-Malatya road and Southeastern Anatolia until recently. The bridge, which is a Seljuk structure, is 173 m in length. It consists of two parts; one is 12 and the other one is 6. While the bridge continues in a straight way in the west direction, it was constructed from cut stones as inclined northward in the middle parts (Kültür Portalı 2019).

**Figure 7.** The Eğri Bridge (Adapted from Sivas Municipality archive)**Figure 8.** The city square of Sivas city (Adapted from Sivas Municipality archive)

There are many monuments in the Historic City Square. Information on these monuments is presented below.

The Government House was built in 1884 by Halil Rifat Paşa, the Governor of the city at that time. The first two floors of the building were built from cut stones, and the third floor was built from wood in 1913. As a result of a fire, the third floor was completely burned, and only the walls of the first and second floors were left. At the end of 2005, it regained its former appearance and function (Kültür Portalı, 2019).

The Kale Mosque was built by the Governor of Sivas, Ali Beyoğlu Mahmud Pasha, the vizier of Murad III in 1580 (Kültür Portalı 2019).

The Twin Minarets Madrasah is understood to be constructed by the İlhanlı Vizier Sahip Şemseddin Mehmet Cüveyni in 1271/1272 according to the inscription flowing in three directions just above the Crown gate. The only unique feature of the building

that has reached the present day is the magnificent front facade with the highest crown gate in Anatolia. The two minarets rising above the crown gate have become the symbol of Sivas. It is one of the most monumental madrasahs constructed in Anatolia and is also known as Dârü'l-hadis. It is still in good condition and open to visitors (Kültür Portalı 2019).

The Buruciye Madrasah is among the most famous structures in Sivas and Anatolia with its magnificent crown gate that has remained intact. The madrasah built in the period of the Seljuq Sultan Kaykhusraw III in 1271 was built by Muzaffer Burucerdî from Burucerd near Hamedan (Iran) to teach physics, chemistry, and astronomy. The structure, the architecture of which is not clear, has the madrasah plan with the most proper symmetry in Anatolia. Nowadays, it is used by Sivas Provincial Office of Mufti for various educational activities (Kültür Portalı 2019).

The Şifaiye Madrasah (Sivas Darüşşifa) is one of the most important madrasahs where patients were treated during the Seljuk Period and medical training was also provided. The part that has reached nowadays is the largest şifahane (hospital) of Anatolia. It was built by Izzeddin Keykavus I in 1217-1218. There are sun and moon symbols on the crown gate and reliefs in the form of a female and male head in the main iwan. After Izzettin Keykâvus I was buried here in 1220, the southern iwan was turned into a tomb (Kültür Portalı, 2019).

The Gendarmerie Building was built in 1908 as the Gendarmerie Office in the time of the Governor Vali Reşit Akif Pasha. The plan of the Gendarmerie Building extending in the west and north directions is in the form of "L." The corner where both arms meet is the center of gravity of the building. At this corner, the building was arranged as three floors. It is still used as a social facility (Kültür Portalı, 2019).

The Congress Building was built by the Governor of Sivas Mehmet Memduh Bey in 1892 as the Sivas High School, and the building served first as a high school during the Ottoman period and then as a sultani (lyceum) for long years. The Sivas Congress was held in this building on the 4th of September during the National Struggle Period, and the foundations of the Republic of Turkey were laid here. The founder of the Republic of Turkey, Gazi Mustafa Kemal ATATÜRK, and his friends were guests in this building for 108 days between 2 September–18 December 1919, and the building served as the "National Struggle Headquarters" during the most difficult days for the Turkish people. The school, which served as the Non-commissioned Officer School for a short time after the congress activities, was used as the "Sivas High School" from the first years of the Republic until the 1970s, and then as the "Congress High School" until 1981, and its ownership was transferred to the Ministry of Culture in 1984. After the repair, it started to serve on 19 December 1990 under the name of "Atatürk Congress and Ethnography Museum." It is still used as a museum (Kültür Portalı, 2019).

The Ulu Mosque (The Grand Mosque) is one of the oldest mosques in Anatolia. In the history of architecture in Anatolia, the mosque is an essential structure in the development of the idea of interior space. It is one of the rare examples of the Kufa-type mosque class that enters the courtyard from three directions and has a flat roof and a rectangular plan. It was built during a period when the idea of the dome had not developed yet. According to some scientists, it is also considered to be a work of the Danismendi period. Although the Danismendians were connected to the Seljuks in 1178, the structures built under their names date back to the end of the century. It is possible to count the Ulu Mosque (the Grand Mosque) of Sivas among the important works of the Danismendi period. According to the inscription that was revealed during the repair in 1955, it is understood that Kul Ahi was made to build it by Kızılarslan bin İbrahim during the period of Kutbettin Melikşah in 1196-1197 (Kültür Portalı 2019).

The building, called the Kurşunlu Turkish Bath since it was built by pouring lead into the iron connections on the main walls, was built in 1576 by Behram Pasha as a double Turkish bath from cut stones. There are separate sections for women and men in this structure, which bears the characteristics of classical Turkish baths of the Ottoman Period. It still serves as a Turkish bath (Kültür Portalı 2019).

All of the above-mentioned historic buildings can be inquired and analyzed within the GIS-based system presented within the scope of this study. On the other hand, many historic buildings indicated on the City Fortification Wall Map produced by Albert Gabriel approximately 100 years ago for Sivas city and on the City Plan Map produced by Arakel Badrik (Natanyan 2008) are still preserved nowadays and used effectively. On the contrary, six gates, through which it was possible to enter the city settlement center of that period, were marked on the city fortification wall map by Albert Gabriel. The gate names indicated on the map continue to exist as the location name nowadays. There are craftsmen who deal with handicrafts even today in the circle shown as the craft and trade area of the city in the city plan drawn by Arakel Badrik in 1915. While Sivas city center has continued its development for 100 years, it has also continued to be a city that bears the traces of history. Therefore, it is known as a city of culture and history.

While the oldest zoning plan of Sivas city center was created in 1937 in the historical archives of the Republic, the first orthophoto was produced in 1949. Within the scope of this study, data obtained from various archives between 1915 and 2018 were divided into 9 main periods and the growth direction in each period and its relationship with other periods were investigated. As a result, it has been observed that the investments specified in Table.2 directly affect the direction of development found in Table.3 and the residential areas in the immediate vicinity of the built public buildings are developing rapidly.

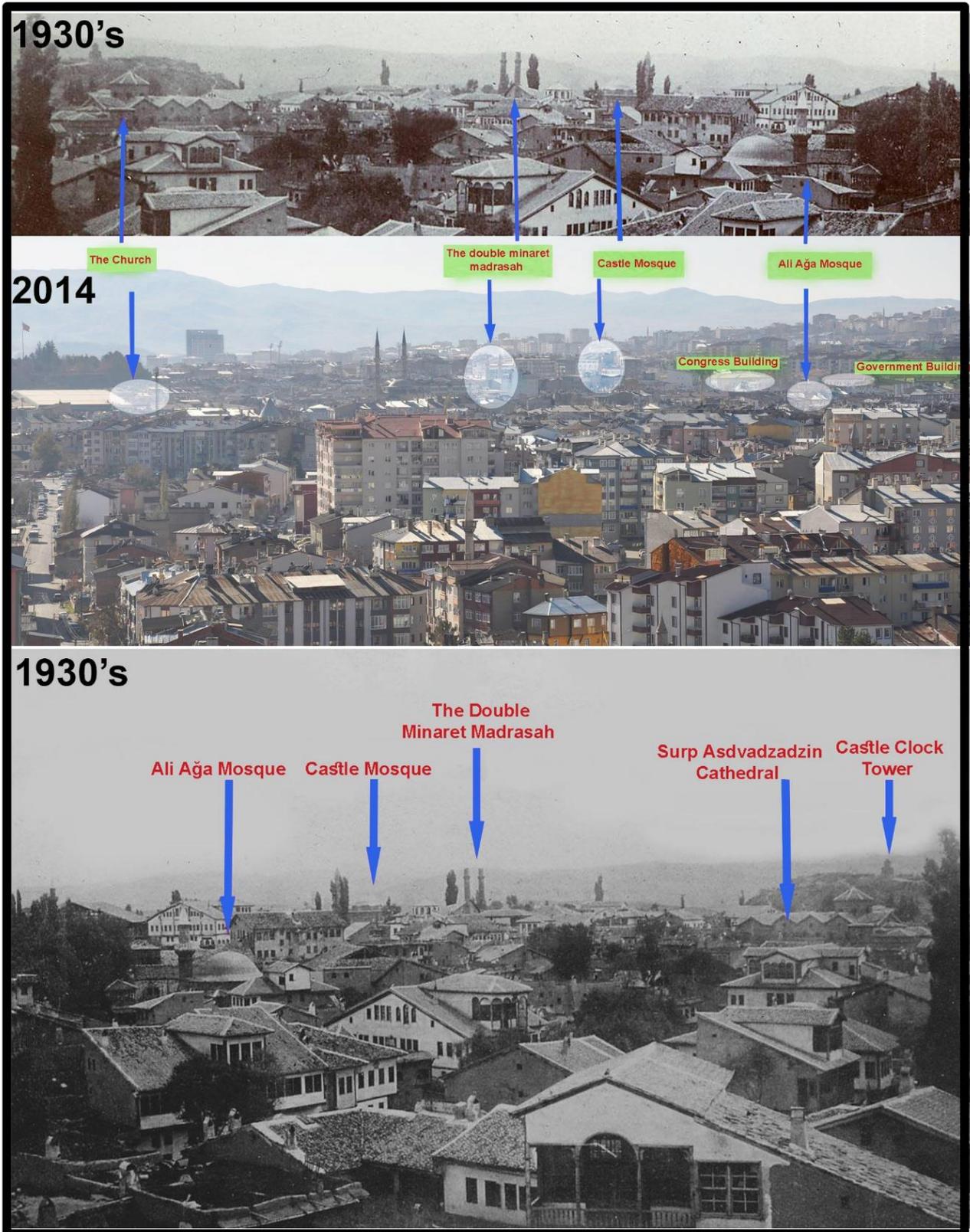


Figure 9. The appearance of some historic buildings at different dates (Adapted from Sivas Municipality archive)

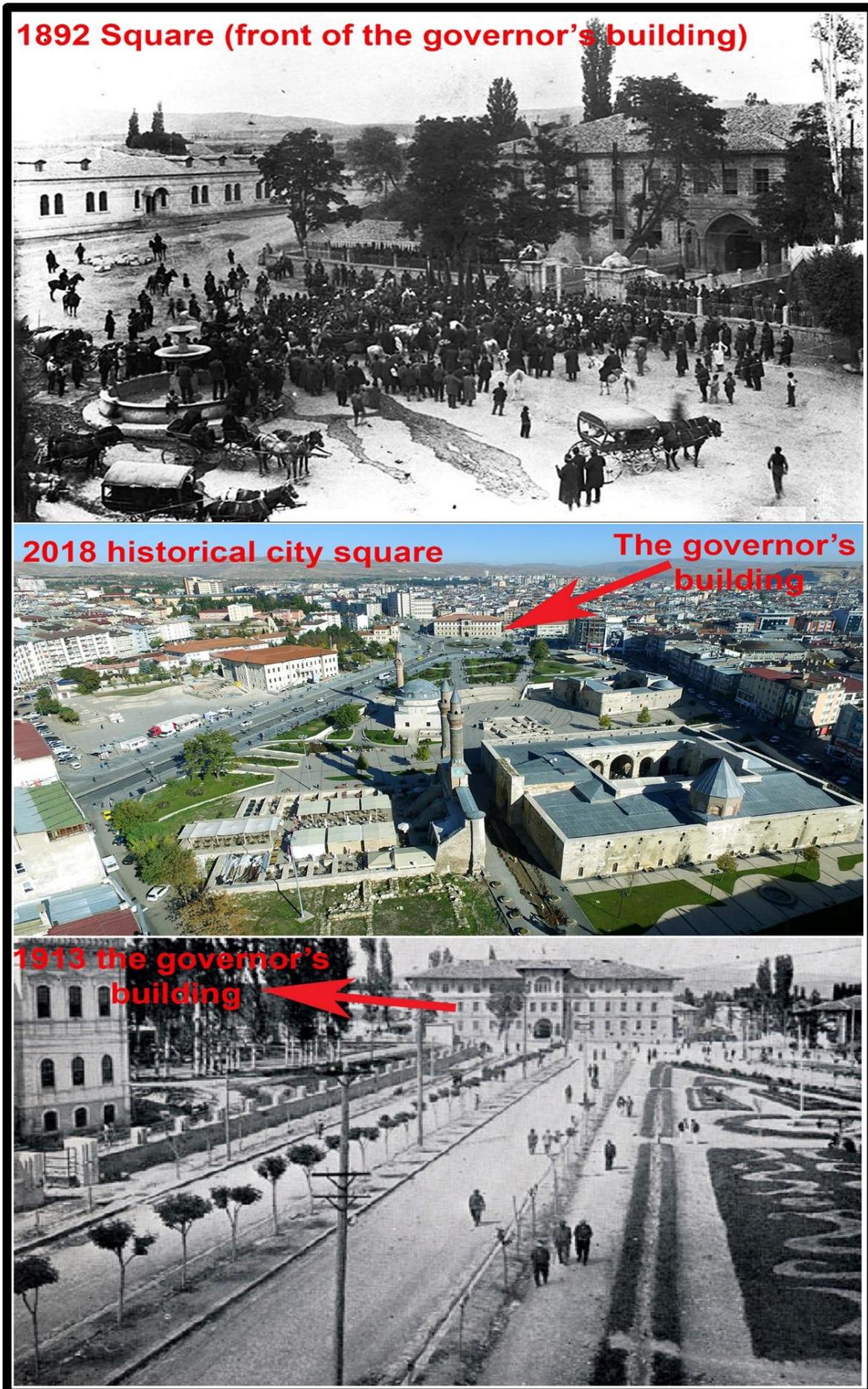


Figure 10. The historic city square (Adapted from Sivas Municipality archive)

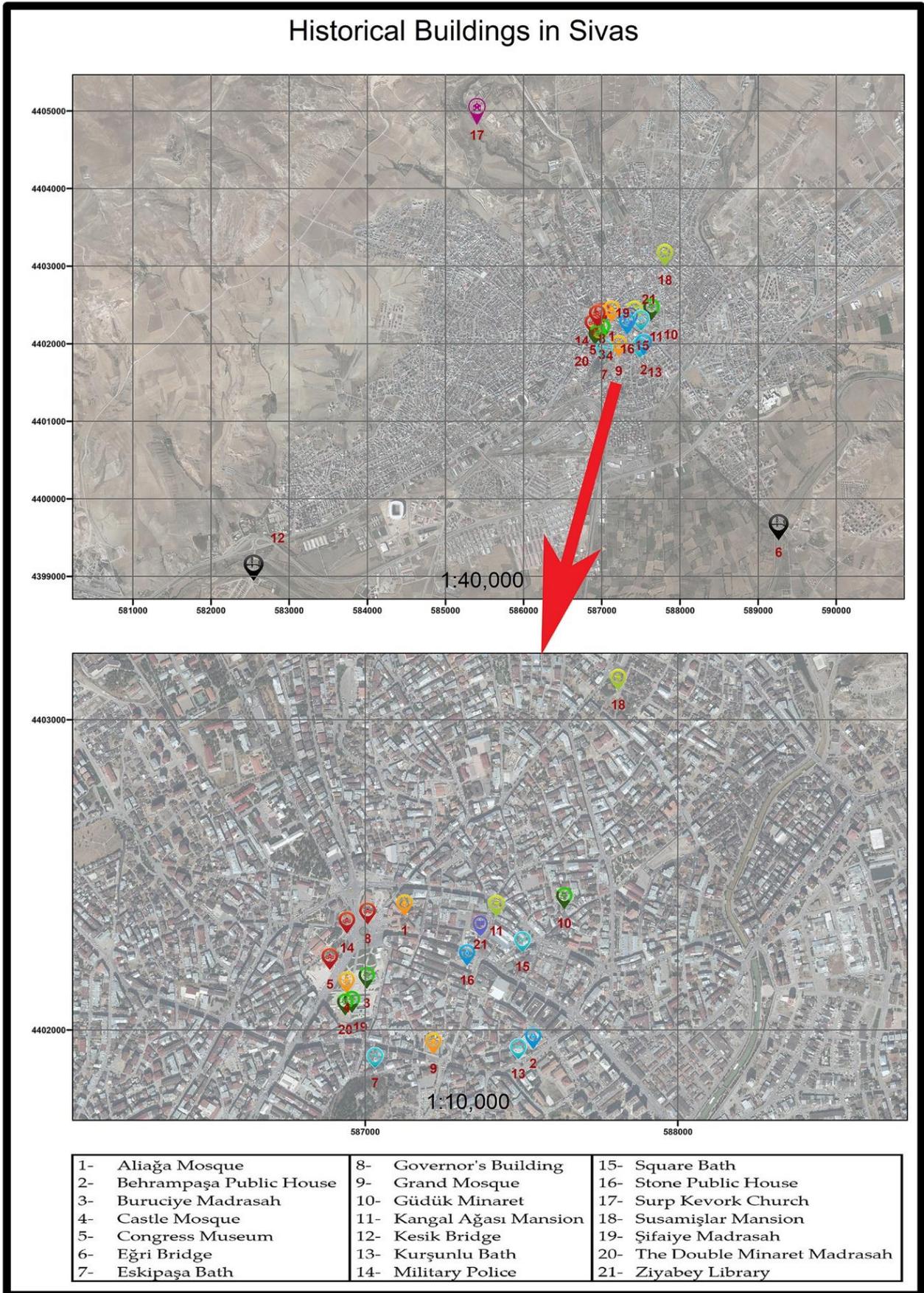


Figure 11. The geographical location and distribution of historic buildings in Sivas

5. CONCLUSION

Urban information systems are indispensable for decision-makers in managing a city. In this process, GIS is used as an effective tool to create scenarios, make analyses, and make predictions about the future during the planning of the city by conducting interdisciplinary studies. Planning that is performed independently of GIS is very likely to fail.

Sivas is a significant center that has witnessed many critical times in history. Therefore, in the plans to be made, the city identity should be protected, historic buildings should be taken into consideration, if possible, green belts should be created by opening the surroundings of buildings, and the surroundings of buildings without the possibility for opening should be arranged in accordance with the texture of the building to be protected. The city skyline should be calculated well, and sunshine durations should be predicted. To this end, soil policies should be created. The connection, apart from the intersection points of intercity transit roads and urban roads, should be disconnected, and areas to be afforested should be planned in accordance with the microclimate of the city.

One of the most important phenomena ignored by the city administration bodies is disaster scenarios. Natural disasters can cause significant destruction; one natural disaster can trigger another one. Therefore, the crisis management plan of the city should be created, and how and in what areas the vital needs will be met for people to be able to continue their lives in case of natural disasters should be planned well.

Sivas city is an important center of Anatolia due to its location. The findings obtained within the scope of this study demonstrate that the city is not expanding in a regular direction. Due to these findings, planning decisions should be revised, and the future planning of the city should be performed by conducting multidisciplinary studies.

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