

GIS contribution to the collection and processing of the data for an architectural and graphic reconstruction of the Timurids' gardens in Samarkand region

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Abstract. The article is devoted to new methods of deep theoretical study and practical application of GIS tools for the architectural and graphic revival of the disappeared gardens of the Timurids of the 14th-15th centuries. The use of GIS technologies in the field of architecture and landscape art is undeniably effective, they expediently open up a number of previously unattainable opportunities. Besides, GIS provides possibilities to study the change in the geospatial environment through the ages to create data visualization and to determine historical changes in the geographical landscape of the Samarkand region. Create storytelling maps and matching them with old handmade maps, the author found out the location of 12 out of 17 Timurids' gardens. The historical locations of architectural objects, such as citadels, fortress gates, mausoleums and tombs of religious figures, were identified, according to the descriptions of historians and chroniclers of the Middle Ages and Soviet archaeologists. In order to visualize historical data, all of them were indicated on an interactive storytelling map created by Author¹ and served as reference points for the search for the disappeared gardens of Amir Temur.

1 Introduction

The President of the Republic of Uzbekistan Shavkat Mirziyoyev pays great attention to the development of the tourism sector in historical cities such as Samarkand, Bukhara, Khiva, Shaxrisiabz, etc. [1, 2] It should be noted that especially eco-tourism, agrotourism and sustainable tourism in rural areas is gaining special importance in Uzbekistan now. The political course of our government is aimed at creating a competitive brand of local historical and cultural landmarks in order to attract the flow of domestic and foreign nature-friendly tourists who are interested not only in architectural sights but also in ancient gardening art. In the history of Central Asia, the era of the reign of the Temurids is notable for the powerful development of socio-economic relations, the strengthening of political authority, culture, architecture, and their world-famous gardens. It is known that in the middle of the 14th century, the threat of an Ottoman invasion loomed over Europe. Sultan

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Bayazed I captured Bulgaria, Macedonia, Wallachia, and Thessaly and began active operations to capture other countries. A crusade was organized against the conquerors, but the best military squads of Europe were defeated by the Turks. When Amir Timur, having defeated Bayazed I and then informed Charles VI about it, the answer of the French King was full of gratitude for the help of render to Europe. In honor of this victory in 1405, a monument to Timur was erected in Paris with the inscription: "The Liberator of Europe."

Amir Temur brought scientists, artisans, artists, and architects from military campaigns. Under him, there was an active restoration of cities, the foundation of new ones, the construction of bridges, roads, and irrigation systems, as well as the active development of science, painting, and secular and religious education. In the suburbs of Samarkand, which were irrigated by the Zaravshan River, Amir Temur (14-15th cc) ordered the creation of twelve villatic gardens, which were connected to the city by boulevards – "Khiabans". All gardens differed in function, name, size, assortment of plantings, architectural design, and rich decor of palaces and pavilions. These gardens of Amir Timur and Timurids became an innovation in Islamic architecture.

Unfortunately, today no one from the seventeen gardens of Timurids in the Samarkand region exists, they were gradually destroyed during the 16-17th centuries due to the change of the ruling dynasty, the subsequent political and cultural decline, the devastating raids of nomads, that's why today we have lack of information about their exact historical locations, sizes, area.

The article briefly highlights the systematically performed work on the search for the historical location of the Timurid gardens, and the creation of detailed maps of the Timurids' gardens and "Khiaban" boulevards using GIS. Impressive data on the size, location, function and architectural features of each Timurids' garden around Samarkand was collected and systematized for their architectural revival proposal in the future.

1.1 Background. Study object

Historical data about the medieval irrigation system of the Samarkand oasis and its fabulous gardens. Exploring the gardening art of the Samarkand region, one cannot fail to pay due attention to its ancient irrigation system. Where did the main river that irrigates the oasis of Samarkand originates? How did the ancient and medieval irrigation network develop, supplying water to all favorable natural places for potential recreational areas?

The history of the oasis cities and their elaborate irrigation systems in the land between those two streams ("Beyond the Oxus River" - Transoxania) dates back more than two millennia [5]. Thus, the monuments demonstrate the continuous settlement of this region from the Hellenistic era (4th century BC) to the Timurid period (15th century AD). Figure 1 shows a map with archaeological sites, rivers, and canals of the Samarkand areas. The map also shows the change in the channels of the canals from ancient times to the period of the Timurids [5]. According to the historical chronicle of 14th century "Samaria" by Abu Tohir Khoja [3]: "... The length of the Kuhak (Zarafshan) river was 120 farsakhs (Middle Eastern measure of length. 1 Central Asian Farsakh was equal to 1,024 km).

The Dargom ditch is the first to separate from the Zarafshan River, spending its waters outside and inside the city of Samarkand, in the Ankhor and Shaudor regions, and carrying the rest back to Zarafshan. Samarkand gardens and fields are green thanks to this canal. Aryk Siyob originates from many springs gushing out of the ground and flows to the area "Kani-Gil", where one part of it flows into Zarafshan. The other is divided into two branches, of which one - the Abi-Rahmat canal, irrigates the gardens to the north from Samarkand - Motrid, Bagi-Baland and Bagi-Maidan» [3]. According to Khafizi Obru: in the immediate vicinity of the city of Samarkand in the 15th century, there were 72 villages. 5 ditches fed by water:

- Aryk of the bazaar;
- Mazdahirn (the name has been preserved since the 10th century);
- Obi Rahmat;
- Karand;
- Obi Siyah ("Kara-su").

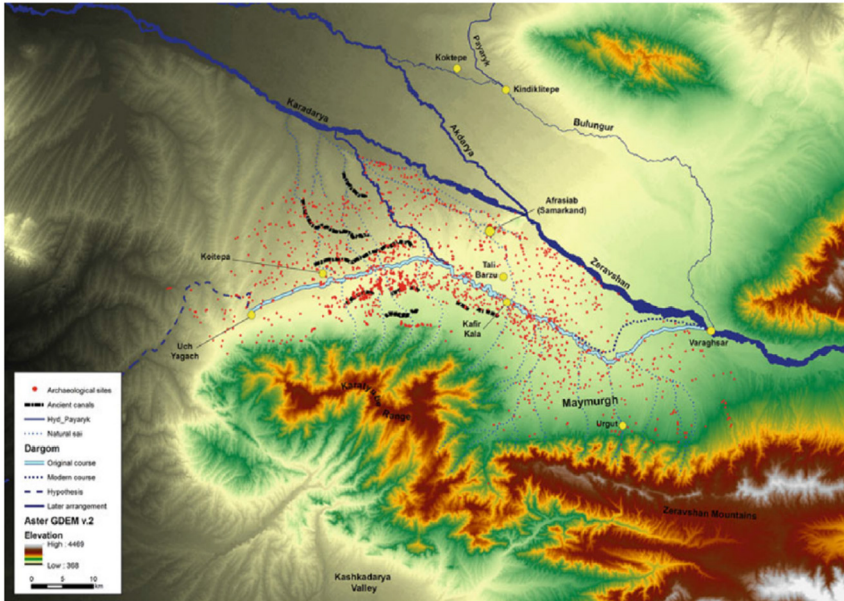


Fig. 1. Archaeological sites and canals in the Samarkand region. IT: ASTORGDM vol.2. [4]

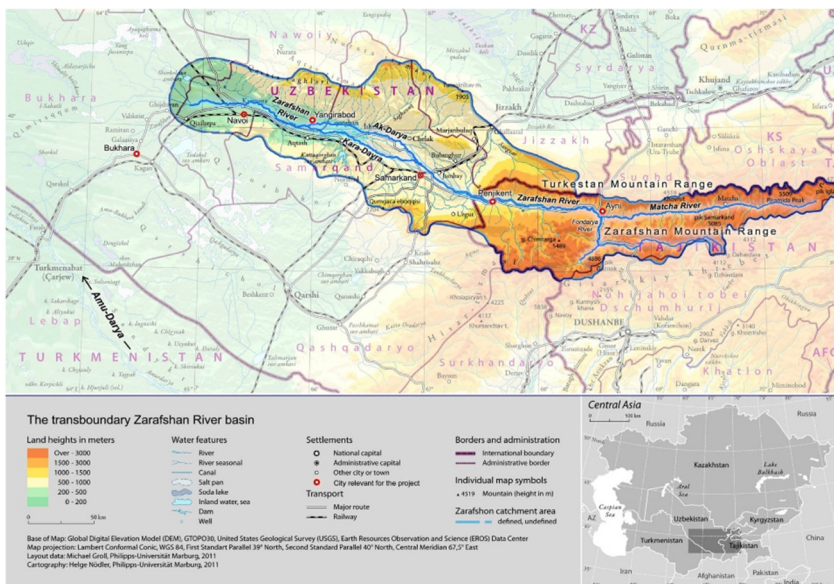


Fig. 2. The Zarafshan catchment in Central Asia. [7]

2 Materials and methods

2.1 Study area

The map shows the irrigation system of the Samarkand oasis as it was in the ancient time since the Middle Ages, confirming the assertion of many medieval historians that Samarkand in the 14-15th centuries was buried in the greenery of gardens, gardens spread throughout the town (Figure 2). The stages of development of the irrigation system of the Samarkand region in the Middle Ages should be considered. A map of the watershed area of the Zarafshan River was studied: Zarafshan is one of the most important tributaries of the river Amu Darya and provides water resources to more than six million people in Tajikistan and Uzbekistan for household, economic and agricultural needs. The sources of the river are located near the Zarafshan glacier between the Turkestan and Zarafshan ranges in Northern Tajikistan, at an altitude of 2810 m above sea level. Zarafshan is a vital source of life-giving moisture for the ancient oases of the Samarkand-Bukhara Silk Route. [7]

Since the early Middle Ages, when Samarkand was the capital of Sogd, the main scheme of the Dargom irrigation network has not changed much and has always been connected with the fate of the city. In 1220 AD, the Mongol army of Genghis Khan captured Samarkand, cutting off the reach of the city's Djui-arziz aqueduct (lit. "Lead Canal") and causing the Afrasiab Plateau to become deserted. In the following century, the irrigation systems were restored by the creative service of Amir Timur. He made Samarkand his powerful empire, spreading from Transcaucasia to India. Visiting the city in 1404, the Castilian ambassador Ruy González de Clavijo reported on the many artificial canals feeding the large and lush gardens of Samarkand. [8]

2.2 Research methodology

In order to create new tourist routes, data was collected from a variety of historical literary sources, such as "waqf" documents, legal medieval records, information from historians of the Timurid court lithographers, colourfully describing the palaces and gardens of Timur and Timurids; notes of travellers and ambassadors to the court of Amir Timur in Samarkand of 14-15th centuries.

In the process of searching for methods for identifying the historical location of the Timurid gardens for their further architectural revival, a large-scale work was carried out using the following methods (Figure 3):

1. Collection of data from medieval, Soviet, and modern literary sources.
2. Research and identification:
 - 2.1 historical garden locations;
 - 2.2 sizes of the gardens;
 - 2.3 clarification on which strategic route of Amir Timur each garden was located.
3. Fieldwork:
 - 3.1 measurements;
 - 3.2 topographic survey of the archaeological remains.
4. Compiling topographic maps;
5. Creation of maps in Google Earth and Arc GIS.

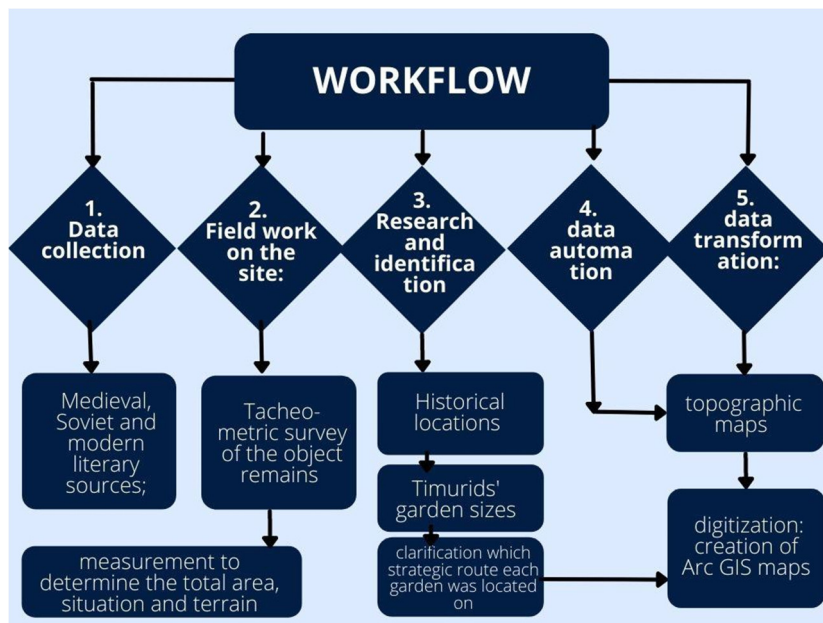


Fig. 3. The process of performing work, an overview of the workflow, and the related working steps.

Table 1. Contains processed and encrypted information about 7 gardens of Samarkand 14th century

N ^o	Name of a garden	Year of creation	Size (m)	Area (ha)	Coordinates WGS84 epsg:3857	Function	Distance to Sam (km)	Disposition
1	2	3	4	5	6	7	8	9
1.	Bagi Dilkushoi	1396-1399	1000x1000	100	39.62081, 67.04439	2	7.8	3
2.	Bagi Davlet-Abad	1397	1350x900	212,5	39.55752, 67.01323	3	11.8	4
3.	Bagi Shamal	1397		56,25	39.66578, 66.93429	1	2.9	4
4.	Bagi-Nau	1404	1000x1000	100	39.65806, 66.95619	5	0.89	5
5.	Bagi Firusa	XV _B	500x500	1,5	39.64352, 66.99156	6	2.7	3
6.	Bagi-Chinar	1397			39.66471, 67.02066	3	4.7	5
7.	Bagi Nakshi Jahon	70s 14th century			39.67327, 67.01544	2	4.63	1

3 Results and discussion

In the course of collecting data for a scientific article, a large historical material was collected and processed about the features of the medieval gardens of the Timurids. Table 1 presents the part of data (of five gardens), such as the year of creation of the garden, the size, and area of the garden, its functional purpose, the distance from the garden to the centre of the Samarkand’s citadel of the 15th century, and on which of the strategic roads

the garden was located. From the chronicles of the court scribe, we learn that Amir Timur rested in the gardens in turn on the way back from military campaigns (see information about all campaigns of Amir Timur in Table 1 and in the description of it).

Column 7. Gardens' functions description:

1. "Honour garden" – it is a private garden, created by order of Amir Temur in honour of his wife (son, granddaughter, etc.) or on the occasion of the victorious return from the campaign;
2. "Gala Palace garden" – the garden for celebrating weddings, religious holidays, and events;
3. "Recreational Nature Garden" - with various fruit trees and a zoo for rest on the breast of nature;
4. Garden for discussions and political negotiations;
5. Luxurious large palace garden;
6. Memorial garden surrounding the mausoleum;
7. An extensive landscaped terraced garden;
8. Sport Garden for active rest;
9. Garden of an art gallery;
10. Boulevard Hiabans.

Column 9. Disposition Description:

1. On the route to the Golden Horde conquering campaign
2. On the route to the Transcaucasia conquering campaign
3. On the route "Kuchai Hiaban" Boulevard
4. On the route to the India conquering campaign
5. On the route of the 7-year campaign in Asia Minor
6. On both routes of the 7-year campaign and the India campaign
7. On the route "Hoja Ahrar Hiaban" Boulevard
8. Connected Kyarizgoh gates with Hoja Ahrar Mausoleum
9. Connected Firuza gates with Bagi zagan garden

The pre-processing and visualizing of the data made it possible to create diagrams to face the results. The diagram (Figure 4) – is an overview of the functions of the Timurids' gardens. The diagram (Figure 5) shows geospatial indicators of 18 Timurids' gardens and 2 "Hiaban" boulevards. Indicators, such as distance from the garden to the citadel (km), and location on one of the strategic routes to the conquering campaign (1,2,3, etc., according to Table 1, column 9).

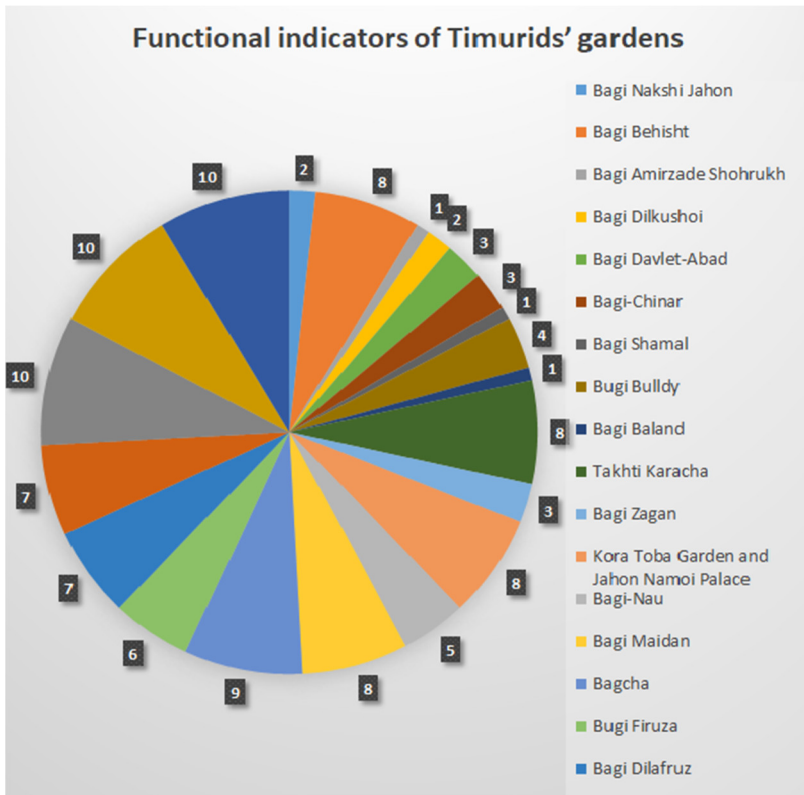


Fig. 4. Functional indicators of Timurids' gardens in the Samarkand region

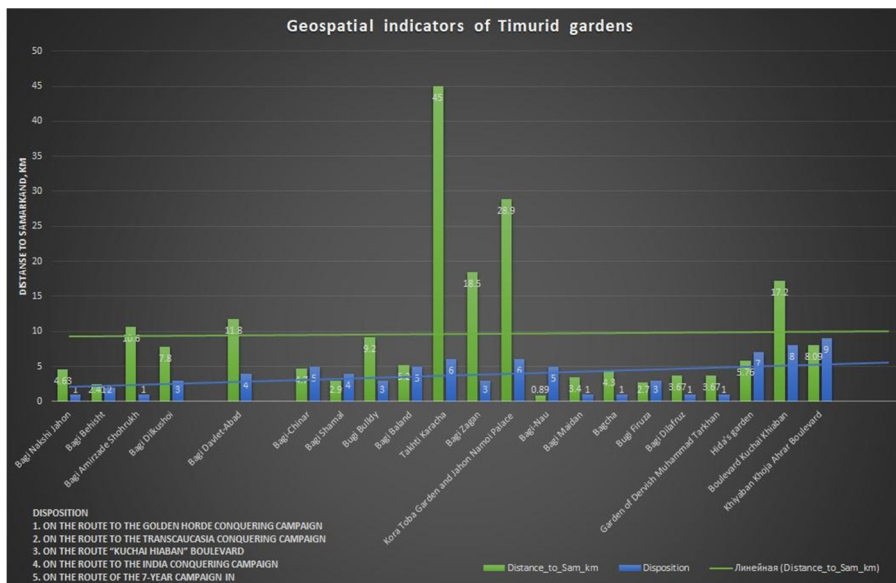


Fig. 5. Geospatial indicators of Timurids' gardens according to Table 1.

Measurements were made with a Leica TS-02 Plus tacheometer in the March 2022. The compilation of tacheometric and topographic surveys, as well as interactive thematic maps displaying and visualization collected data, provides the basis for further phased work on the architectural design proposal for the revival of the Timurid gardens, create the storytelling about them.

To carry out the executive topographic survey of the area of the historical gardens “Bogi Chinor” and “Bagi Maydon”, tacheometric survey was chosen (Figure 6 a, b). According to the opinion of the Author², tacheometric survey is one of the most effective methods of geodetic work, and the most accurate type of measurement, since the error that occurs during tacheometry is up to 2 mm in the plan.

Field work included:

- site reconnaissance (study of the terrain in order to choose the method of compiling a survey justification and places to fix its points);
- fixing the points of the shooting substantiation;
- installation of the device at the station and sequential installation of the tacheometric staff at the characteristic points of the situation and relief called survey pickets or lath points;
- aiming a spotting scope at the rail and making the necessary calculations to determine the polar and altitude coordinates of terrain points;
- in the process of shooting, the tacheometric survey log was filled in and an outline, called crochet, was drawn up;
- office work is reduced to field data processing and consists in calculating the rectangular coordinates of survey substantiation points, polar coordinates, and marks of survey pickets, plotting them on the plan, depicting the situation, drawing contour lines, and drawing a plan of the area with conditional topographic signs.

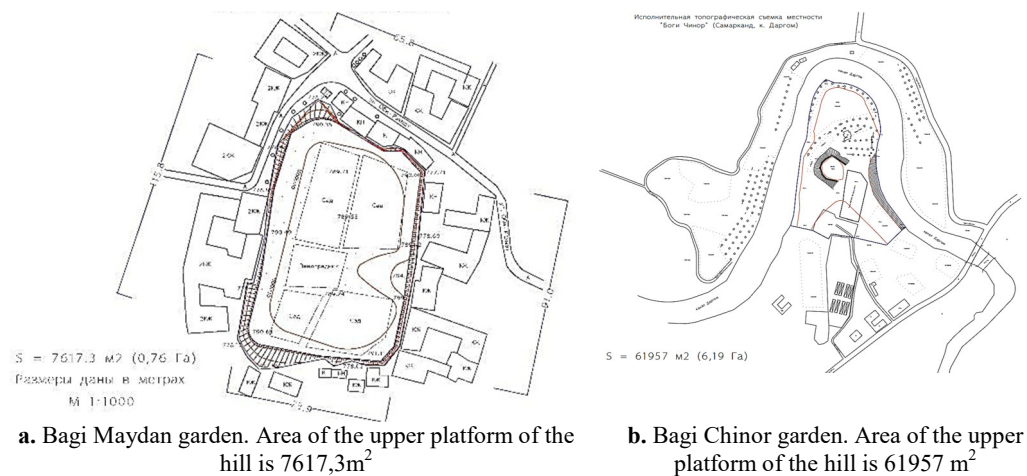


Fig. 6 Executive tacheometric and topographic surveys of Bagi Chinor and Bagi Maydon gardens.

4 Conclusions

Architecture and gardening art of Central Asia and the Middle East reached culmination development in the period of government of Amir Temur and his descendants (the 14-15th centuries) in Transoxiana. In 1370, Amir Temur has constructed a new citadel of Samarkand that was destroyed by the Mongol invasion. He built the governmental Palace “Kuk Saray” inside the citadel, reconstructed the worn-out mausoleums of religious clerics,

built shopping arcades, created canals, and irrigation networks, laid out gardens, and reconstructed cities. Later, in 1379, in Shahrisabz he built up the big park with Ak-Saray palace with a huge portal (height 50,0m). In the suburbs of Samarkand irrigated by the Zarafshan River, Amir Temur and Timurids, for the first time in Central Asia and the Middle East, created a “garland” of traditional "Chor-bagh" gardens, all over Samarkand region, to perpetuate their name as the creator of a powerful Timurids' Empire.

The Timurids' gardens around Samarkand were named by their features, function, and architectural furniture (Figure 4): Baghi Baland (that means from the Persian language - “The high garden”), Baghi Zagan (“The garden of crows”), Baghi Dilkushoi (“The garden of joy”), Baghi Nakshi Jahon (“Décor of the World” garden), Baghi Jahonnoma (“garden of Peace”), Baghi Davlat-Abad (“State prosperity garden”), Baghi Behisht (“Paradise garden”), Baghi Chinar (“Garden of Platans”), Baghi Amirzade Shohrukh (“Garden of Prince Shohrukh”), Baghi Buldi (“Connoisseur's garden”), Baghcha (“Little secluded garden”), Baghi Feruza (“Turquoise garden”).

Due to the fact that in "Google Earth" the detailing of images varies from 15 meters to 15sm, Author1 was able to study the terrain and landscape features of the Samarkand region in more detail. Further, the author carefully compared all his observations with historical descriptions from the literary sources of the chroniclers and several archival reports of archaeological excavations of Soviet scientists.

All the features of the location of the Timurid gardens mentioned in the literature, for example, the proximity to:

- worship buildings of a religious nature;
- mausoleums, burial places of clerics;
- 7 gates in the fortress wall;
- orientation according to the citadel;
- location on the route of Amir Timur's military campaigns (Figure 8).

All the aforementioned were used as "landmarks". They were marked on the map and that made it possible to determine the location of the Timurid gardens more accurately. Previously, their locations were not established and were vague and inaccurate (since information about the locations of the gardens in different literary sources was contradictory and was not linked to the map of the area).

For the most part, Google Earth uses digital elevation model data, which gives the impression of a three-dimensional relief even in a two-dimensional image, this effect was very helpful in distinguishing some specific features of such hills, "mounds" and "tepa" in the suburban areas of the Samarkand region. The problem is that these cult hills are so often found on the landscape of the Samarkand region that they undoubtedly complicate the search and identification of Timurid gardens (or rather, the remains of garden palaces that are usually erected on bulk platforms). The effect of "three-dimensional relief" from the Google Earth map effectively helped to distinguish all these religious and cult hills from the remains of authentic garden palaces of the Timurids.

This was followed by the stage of creating a map of the Timurid gardens in ArcGIS, from Esri. This made it possible to collect, organize, manage, and analyse geographic information, bit by bit collected through the analysis of historical literary sources, by observation, distinction, and identification in the Google Earth map. The ArcGIS platform helped not only to create a story-telling map of Timurids' gardens and military campaigns routes but also will to publish it in open access, including for the use of nature-friendly tourists interested in the history of medieval landscape gardening art of Central Asia (Figure 7).

Analysis and detailed study of the data of this map revealed a lot of hidden information about the location of some gardens. For example, according to Academician G.A. Pugachenkova [11], the Bogi garden "was located in the south of the city of Samarkand,

“near the Dargom canal” [12]. But, as it became known to the author from the historical chronicles, together with the analysis of the Arc GIS map, the “Bogi Chinar” garden was located on the route of Amir Timur's campaign to India after the gardens of “Davlet Abad” and “Bogi Dilkushoi” and in close proximity to the mausoleum of Kusam ibn Abbas. Thus, the author accurately established the place of the historical location of the “Bogi Chinar” garden - this is the area of Kushtamgaly, since this name is casually mentioned in an archival article of the Uzbek National Encyclopedia. “Bogi Chinar” garden is marked with red dot on the map (Figure 8).

As a vivid example of the greatness and power of the medieval Timurids' Empire - the famous gardens of Amir Timur around Samarkand (14th-15th cc) in case of revival them in suitable territories can become the objects of ecological-cultural tourism.

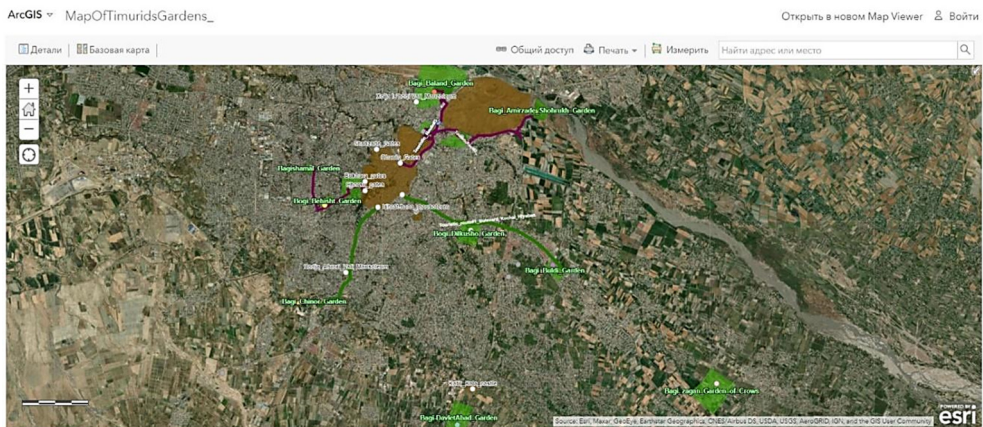


Fig. 7. The ArcGIS map of the gardens (green areas) and boulevard “Hiabans” (green lines) of Amir Timur and his descendants. The locations, sizes, and areas of the gardens correspond to the descriptions of medieval historians and archival notes of archaeological excavations by Soviet scientists.

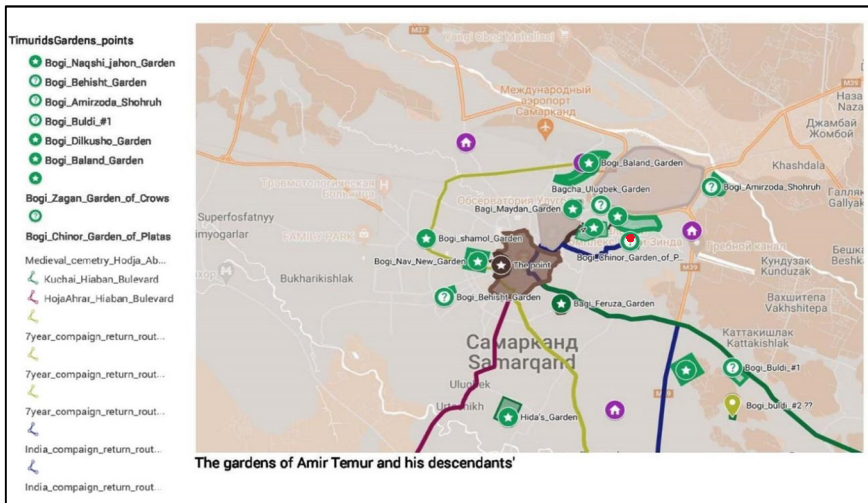


Fig. 8. The map of routes of Amir Timur on his way back from victorious campaigns. He preferred to have rest in specially devoted to the victory gardens, ordered by him before going to campaign. “Bogi Chinar” garden is marked with red dot.

Since the preservation and revival of historical heritage, as well as the development of tourism in Uzbekistan, is an important task at the state level, the revival of the luxurious

gardens of the Timurids in Samarkand will be a grandiose historical and cultural event, which will also positively affect to Uzbek agriculture and economy of the region. Figure provides an example of an architectural and graphic proposal for the revival of one of the gardens of Amir Timur - the Bogi Chinor Garden and in the city of Samarkand (Figure 9, 10).

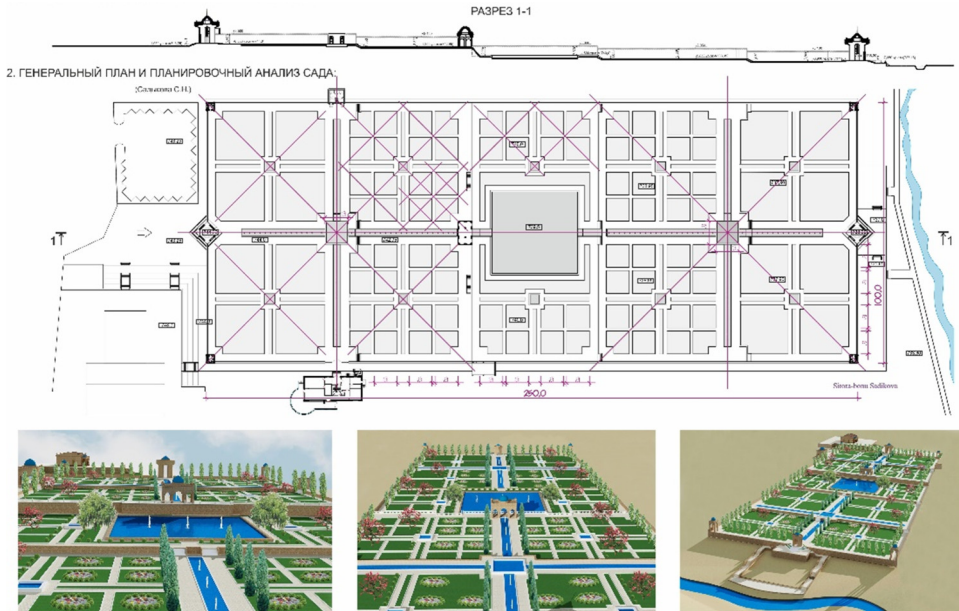


Fig. 9. An example of the architectural and graphic proposal of revival the “Bogi Chinor” garden (transl.: “The garden of Platans”) of Amir Timur in modern conditions of Samarkand region.

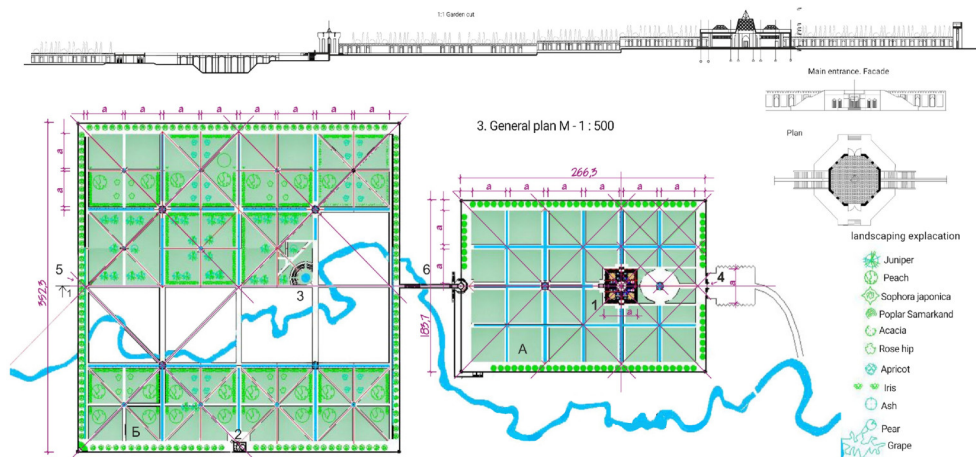


Fig. 10. An example of the architectural and graphic proposal of revival the “Bagi Maydon” (transl.: “Garden of Square”) garden of Amir Timur in modern conditions of Samarkand region.

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