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# Identification of Archaeological Sites in Samarkand Region and Gis-Based Cartographic Monitoring

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**Abstract:**

The integration of Geographic Information Systems (GIS) has transformed archaeological research by enabling the precise identification, mapping, and monitoring of heritage sites. In the Samarkand region and the Middle Zeravshan Valley, GIS technologies have been applied through the Uzbek-Italian Archaeological Project (UIAP) to document and protect archaeological resources. Despite the availability of satellite imagery and digital cartography, there remains a lack of comprehensive and spatially integrated systems for monitoring threats to archaeological assets in Uzbekistan. This study aims to demonstrate the effectiveness of GIS and cartographic methods in identifying, documenting, and conserving archaeological sites in the region. Over 2,000 archaeological sites were identified within a 2,500 $km^2$ area using various GIS layers such as Open Street Map, ESRI World Imagery, and topographic datasets. The analysis revealed that approximately 40% of sites have been lost to development and agriculture. High-resolution satellite imagery, digital surface models, and legacy site plans were combined to produce detailed 3D visualizations and interactive maps. The research provides a novel, multi-layered GIS-based monitoring platform—"OrientGIS"—for virtual reconstructions and detailed site analysis, including the Kafir Qal'a complex. These findings contribute to improved strategies for preserving cultural heritage in regions facing rapid urbanization and infrastructure growth. The outcomes serve both scholarly inquiry and practical conservation, supporting long-term heritage management and regional planning.

**Keywords:** Samarkand, archaeological research, GIS technologies, cartographic methods, ancient irrigation systems, settlements, trade routes, cultural heritage, monitoring, mapping, conservation, archaeological sites

## 1. Introduction

The introduction of this study emphasizes the integration of Geographic Information System (GIS) technologies and advanced cartographic methods in archaeological research within the Samarkand region and the Middle Zeravshan Valley. Using the Uzbek-Italian Archaeological Project (UIAP) as a case study, it highlights how GIS enables detailed examination of ancient irrigation systems, settlements, and trade routes. The project demonstrates the effectiveness of combining high-resolution satellite imagery, topographic data, and historical site plans to create precise maps that

support monitoring and preservation of archaeological heritage. This approach addresses the ongoing challenge of protecting cultural assets from threats such as urban expansion, infrastructure development, and agricultural activities. The research also underscores the value of multi-layered geospatial data in visualizing spatial patterns, assessing risks, and guiding conservation priorities. By integrating diverse mapping resources, the study provides an advanced analytical framework for documenting and safeguarding archaeological sites. Ultimately, this work reflects the growing importance of digital geospatial tools in heritage management, fostering both scholarly inquiry and practical conservation strategies for the long-term preservation of Samarkand's cultural legacy.

This study analyzes the use and practical results of geographic information system (GIS) technologies and advanced cartographic methods in archaeological investigations within Samarkand oblast and the Middle Zeravshan Valley. To explore and preserve Samarkand's rich historical and cultural legacy, the Uzbek-Italian Archaeological Project (UIAP) serves as a case study, demonstrating how GIS is instrumental in examining ancient irrigation systems, settlements, and trade routes. Using GIS applications, precise maps have been generated, laying down the groundwork for strategies to monitor and protect these archaeological assets [1].

## 2. Materials and Methods

The research methodology is grounded in scholarly source analysis, theoretical and practical field investigations, and empirical verification to ensure reliability. Data processing and analytical techniques rely on principles of mathematical statistics and error theory. We analyzed GIS technologies developed by countries with extensive experience in this domain to guide our approach [2].

## 3. Results and Discussion

The project aimed at identifying archaeological heritage sites and monitoring their current state through modern methods. Employing GIS, data was collected on ancient irrigation systems, settlements, and trade networks. Within its study area of 2,500 km², over 2,000 archaeological sites were identified. Regrettably, nearly 40% of these have been lost in recent years due to infrastructure projects and agricultural development [3].

**GIS and cartographic methodologies were utilized across various map types:**

1. **Open Street Map** – baseline geographic data via open-source maps
2. **ESRI World Imagery** – high-resolution satellite imagery for detailed modern land overview
3. **Mundialis TOPO-WMS and TOPO-OSM-WMS** – topographic and open-source layers to illustrate terrain and natural features
4. **Site-specific maps** (e.g. Kafir Qal'ah, Koytepa, Kurgan Kadirbek) – orthophotos and digital surface models (DSM) plus legacy site plans (e.g. Masson 1928, Nilsen 1966)
5. **RS Detection (Sites_NMZV_RS)** – remotely sensed layers illustrating detected features
6. **Survey** – administrative boundaries and UIAP field zones in Samarkand region
7. **Topographical Maps 1:10,000** – detailed landscape data for site analysis

These layers enabled extensive spatial analysis and effective monitoring. The primary threats to archaeological assets include urban expansion, new road construction, and irrigation infrastructure [4].

**Figure 1** presents a geospatial visualization of archaeological sites examined during the Uzbek-Italian Archaeological Project (UIAP). Each red dot on the map indicates the location of an identified site, distributed primarily across the middle Zeravshan Valley in Uzbekistan. The clustering of sites suggests a high density of cultural heritage remains in this region, likely corresponding to historical settlement patterns, trade routes, and agricultural zones. The underlying basemap includes modern cities, transportation networks, and natural features, enabling comparative spatial analysis between

contemporary infrastructure and heritage zones. This mapping was essential for understanding the spatial distribution of archaeological resources and assessing threats such as urban sprawl, road construction, and irrigation expansion. Overall, the figure illustrates the extent and density of archaeological heritage requiring protection, and serves as a foundational tool for targeted conservation and management planning within the UIAP framework [5].

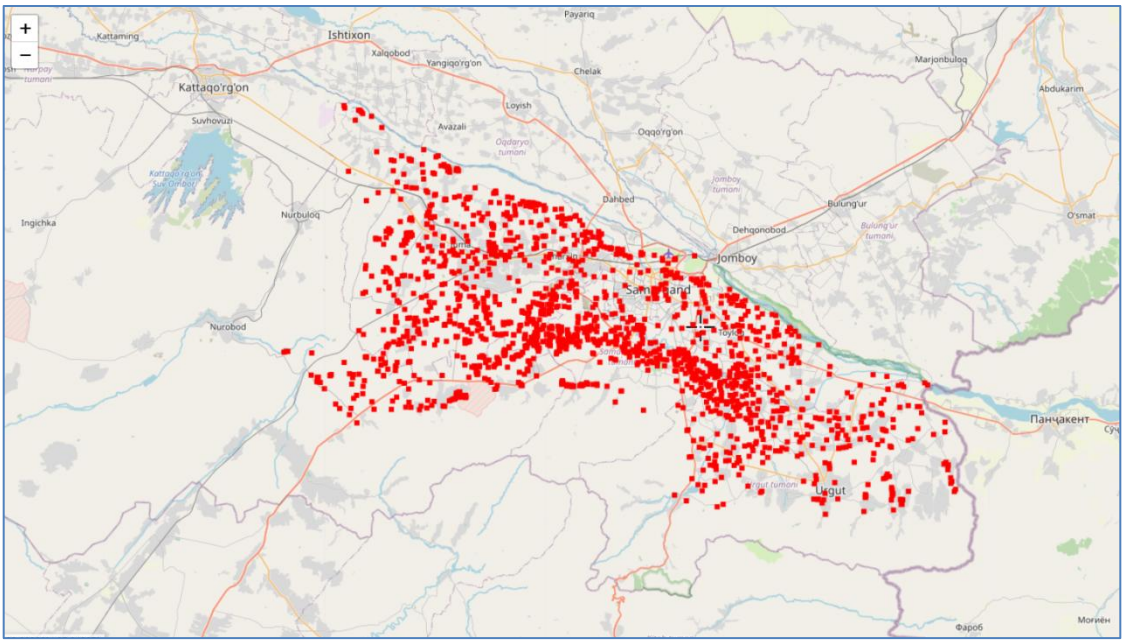


**Figure 1.** Location map of archaeological sites subject to investigation within the framework of the Uzbek-Italian Archaeological Project (UIAP)

Based on the findings of the UIAP, essential recommendations have been developed for the preservation and sustainable management of the identified archaeological sites. These recommendations facilitate the effective organization of monitoring and conservation activities, ensuring the long-term protection of these valuable cultural heritage objects [6].

**Figure 2** presents a high-definition satellite view of the study region, generated using the ESRI World Imagery layer. The red dots correspond to archaeological sites mapped within the Uzbek-Italian Archaeological Project (UIAP). The satellite base layer delivers a clear and detailed representation of the contemporary landscape, allowing researchers to accurately correlate archaeological features with present-day topographical and infrastructural elements. This visualization enhances the capacity for site recognition, spatial pattern analysis, and risk assessment related to modern development, such as road construction or agricultural expansion. The overlay of archaeological data on satellite imagery aids in understanding spatial distribution and prioritizing conservation efforts by highlighting the proximity of cultural heritage to potentially disruptive land use changes. This figure serves as a valuable tool for both field planning and long-term monitoring in archaeological heritage management [7].

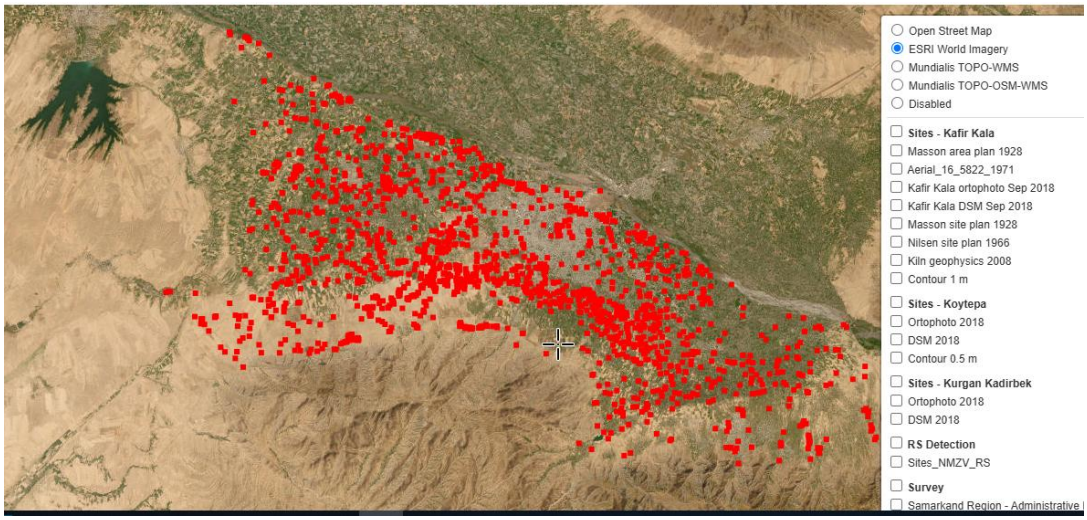


**Figure 2.** ESRI World Imagery – High-resolution satellite imagery providing a modern and detailed view of the area

This layer offers up-to-date, high-definition satellite images that allow for a comprehensive and precise visualization of the region's current landscape, which is essential for identifying and analyzing archaeological features in their contemporary geographic context [8].

**Figure 3** displays the application of Mundialis TOPO-WMS and TOPO-OSM-WMS layers, which present topographic and open-source mapping of the surveyed region. These tools are essential for visualizing terrain variations and natural land features, thereby enhancing the spatial context of archaeological sites. The overlay of red markers pinpoints the locations of sites identified within the Uzbek-Italian Archaeological Project (UIAP), enabling detailed layer-based observation. Such visualization aids in understanding site distribution relative to natural formations, elevation, and landscape contours. These mapping technologies play a critical role in archaeological research and conservation, offering geodesists, archaeologists, paleontologists, and historians the capability to interpret historical significance through physical geography. By integrating this cartographic data, the figure supports improved decision-making in heritage management and promotes a more holistic approach to documenting and protecting cultural landscapes [9].

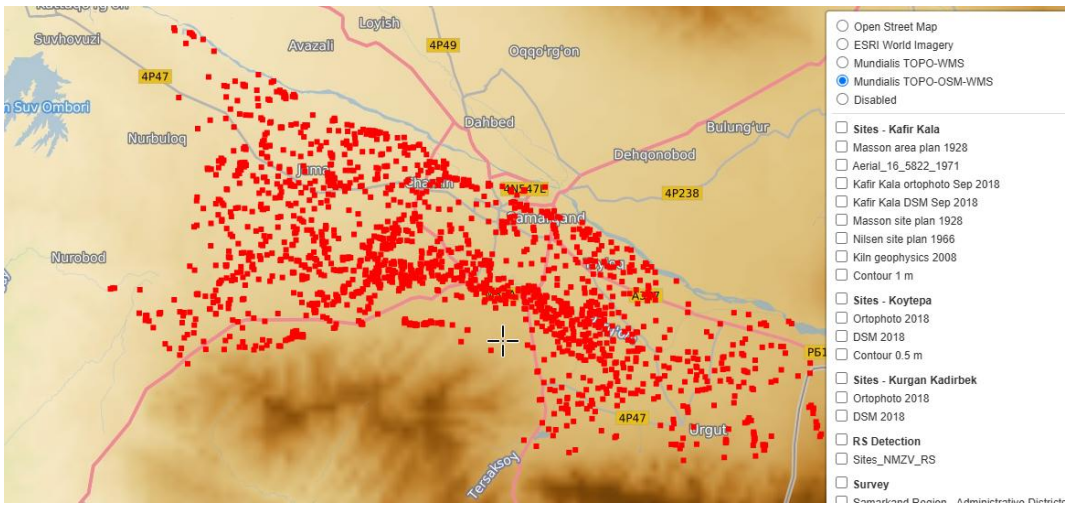


**Figure 3.** Mundialis TOPO-WMS and TOPO-OSM-WMS – Layers providing topographic and open-source maps, illustrating the terrain and natural features of the area

These mapping tools enable effective layer-based monitoring of archaeological resources. In the process of investigating archaeological monuments, these applications support vital tasks

alongside geodesists, archaeologists, paleontologists, and historians, contributing to a more accurate understanding of the landscape and its historical significance [10].

Figure 4 demonstrates the use of the Desablet platform for the visualization of archaeological resources within a designated region. The dense clustering of red points represents the spatial distribution of numerous archaeological sites identified through Geographic Information System (GIS) technologies. These tools have enabled the integration of multi-layered data to support efficient site documentation and historical analysis. Specifically, the visualization highlights critical areas such as the Kafir Qal'a and Boyssartepa archaeological zones near the Darg'om Canal, south of Samarkand. These locations, as shown in the figure, are of significant historical interest due to their association with ancient irrigation systems, settlement patterns, and socio-cultural transformations. The graphical interface used in this map allows researchers to interactively manage and analyze archaeological datasets, enhancing the accessibility and precision of archaeological information. Thus, this figure illustrates how digital mapping platforms like Desablet contribute to data-driven archaeological research and heritage management **[11]**.

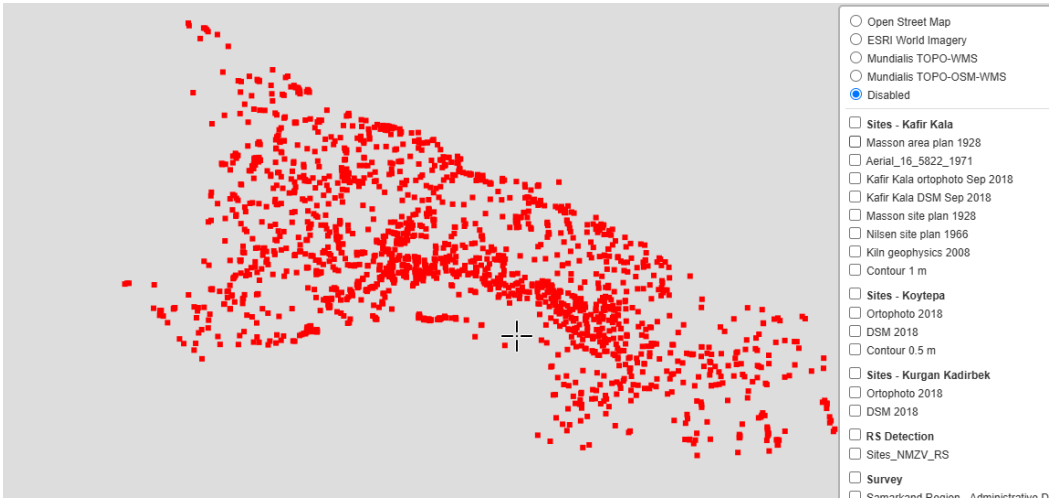


**Figure 4.** Visualization of archaeological resources using Desablet

GIS technologies are widely applied in the field of archaeology, enabling more efficient and accurate research. A prime example is the Kafir Qal'a archaeological site, located 18 km south of Samarkand, on the left bank of the Darg'om Canal, covering a total area of 16 hectares. Excavations carried out in the Kafir Qal'a and Boyssartepa areas near the Darg'om Canal have provided valuable evidence of ancient irrigation systems, settlement patterns, and cultural transformations [12].

At Kafir Qal'a, over 700 clay seals and an administrative archive dating back to the late 7th century AD were discovered, highlighting the site's significant role during the Arab conquest period. The site consists of three main parts: the ark (citadel), shahristan (urban area), and rabod (suburbs). The ark measures 76x76 meters and stands 25 meters high, with an overall perimeter of 360 meters [13].

Kafir Qal'a is one of the largest and most actively studied archaeological monuments in Uzbekistan. Laser scanning technologies using a variety of lenses are employed to document everything from delicate jewelry artifacts to large mud-brick walls, creating detailed 3D models of the site. Such archaeological research impacts soil dynamics and landforms, making it crucial to map changes accurately and record the precise spatial locations of discovered objects. These geodetic surveys provide a comprehensive understanding of the archaeological landscape [14].

**UIAL "OrientGIS" Platform:**

Currently, the UIAL presents its research results through an online platform named *"OrientGIS"*. This platform offers users access to interactive maps, photo galleries, and various spatial data layers. It serves as a valuable tool for researchers and history enthusiasts to explore the historical

processes of Samarkand and the Middle Zeravshan Valley in greater depth. GIS technologies allow for rapid evaluation and dissemination of archaeological information, significantly enhancing the preservation and study of the region's cultural heritage [15].

**Figure 5** presents a detailed, layered visualization of the Kofir Qal'a archaeological site using the "OrientGIS" online mapping platform. The map integrates various spatial data layers, including high-resolution satellite imagery and historical plans, allowing for precise geolocation and analysis of the site's topography and infrastructure. The highlighted orange overlay represents archaeological features such as structural outlines and excavation zones, superimposed on a contemporary map of the Samarkand region. Through the application of geoinformation systems (GIS), this platform provides researchers and archaeologists with an advanced tool for virtual site exploration, 3D visualization, and spatial analysis. The map enables comprehensive documentation and interpretation of the site's layout and historical context, facilitating preservation planning, virtual reconstructions, and scholarly investigations. As shown in this figure, the combination of old and modern spatial datasets enhances understanding of cultural heritage and supports informed decision-making in archaeological research and conservation [16].

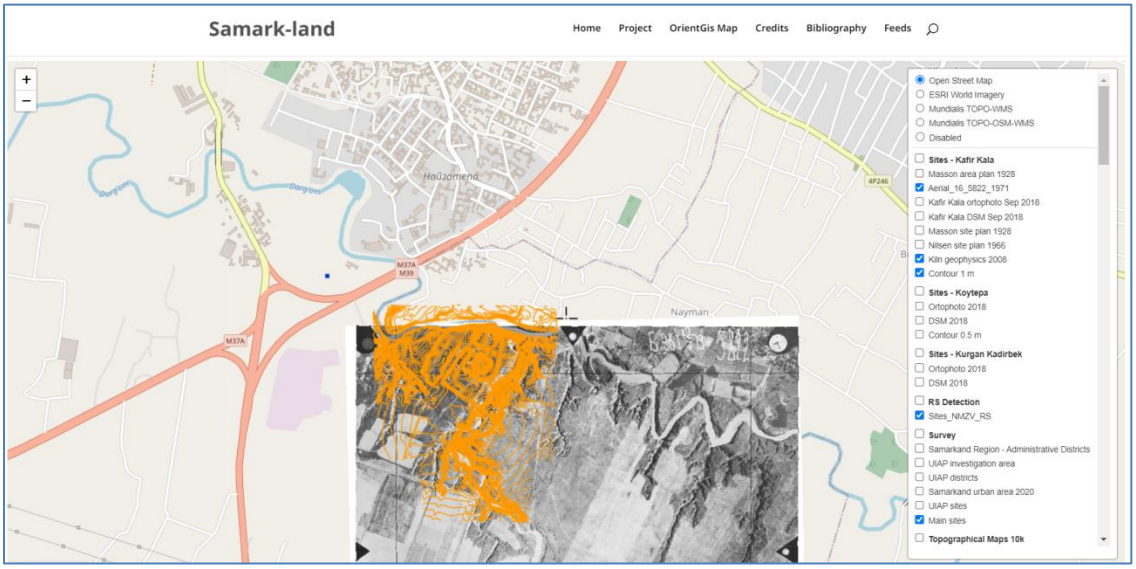


**Figure 5.** Layered view of the Kofir Qal'a archaeological site on the "OrientGIS" online platform

Using geoinformation systems (GIS), the exact coordinates of the Kofir Qal'a archaeological site can be identified, and its structure can be visualized in 3D format. This functionality allows researchers to explore the site's spatial layout in detail, facilitating comprehensive analysis, virtual reconstruction, and more effective preservation planning through advanced digital mapping techniques [17].

**Figure 6** displays two advanced 3D visualizations of the Kofir-Qal'a archaeological site, demonstrating the application of GIS-based topographic modeling techniques. The left image illustrates a three-dimensional digital elevation model (DEM) rendered in color, showcasing elevation gradients and structural depth of the archaeological landscape. The blue and green axes indicate spatial coordinates and altitude, enabling precise geo-referencing. The right image features a grayscale contour map, presenting the site's terrain morphology with topographic lines that reveal elevation changes and fortification outlines. These visualizations allow researchers to analyze the site's geomorphological structure and historical configuration without intrusive fieldwork. By leveraging these technologies, archaeologists gain deeper insights into spatial relationships, site development, and potential excavation zones. The integration of such digital tools facilitates efficient heritage management, risk assessment, and preservation strategies, reinforcing the role of geospatial science in safeguarding Uzbekistan's historical legacy.

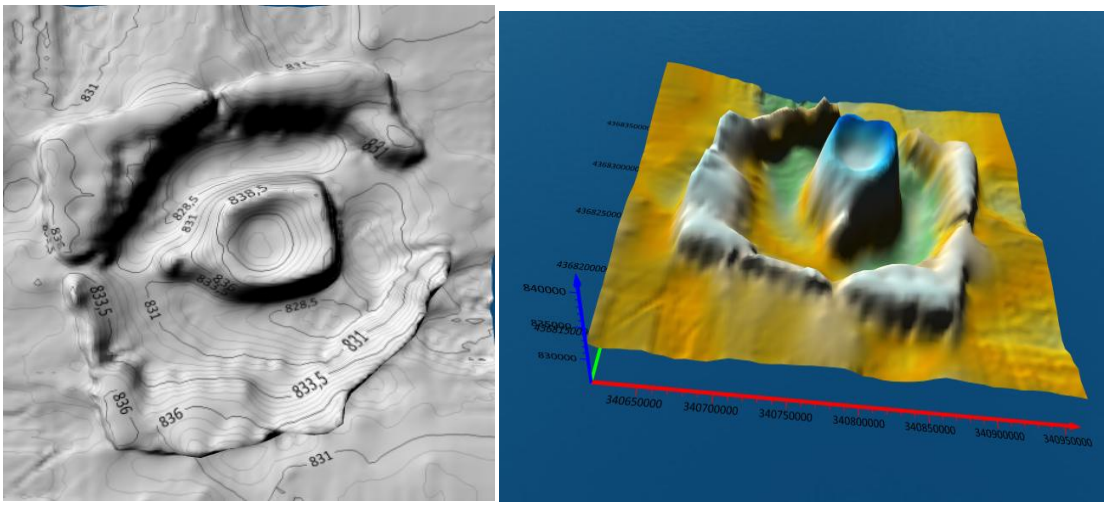


**Figure 6**. Kofir-Qal'a Archaeological Site

GIS technologies are revolutionizing archaeological research by offering innovative solutions for preserving, identifying, and monitoring historical sites. Projects like UIAL (Uzbek-Italian Archaeological Project) are making significant contributions to the deeper understanding of Samarkand's rich history and the preservation of its cultural heritage. These research activities serve as important sources for the academic community and help shape strategies for the conservation of cultural heritage.

The **Uzbek-Italian Archaeological Project (UIAL)** is actively conducting archaeological research in the southern and southeastern parts of the Samarkand region. These areas are of great historical significance and are home to numerous ancient monuments and archaeological sites. The use of GIS technologies serves as an essential tool in exploring these areas, identifying ancient objects, and conducting their monitoring. Research conducted in the southern regions, including the study of ancient irrigation systems and settlements, provides deeper insight into the region's rich cultural heritage and supports its preservation.

The areas marked in **orange** on the map represent regions where ongoing investigations are being conducted. These explorations are expected to yield valuable data that will enhance the cultural and historical significance of the region in the future.

## 4. Conclusion

As part of the archaeological research being carried out in Samarkand region, the use of **GIS technologies and modern cartographic methods** has provided significant results. The achievements of the **Uzbek-Italian Archaeological Project (UIAL)** include the accurate identification, monitoring, modeling, and preservation of ancient sites. These technologies form the foundation for developing effective strategies to protect archaeological heritage in the context of infrastructure development and other potential threats.

This research holds immense value not only for the academic community but also for the long-term conservation and transmission of the region's historical heritage to future generations, opening up new opportunities for further exploration.

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