Analytical Approach for Representing the Water Landscape Evolution in Samarkand Oasis (Uzbekistan)

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Abstract

In the oasis of Samarkand the water supply depends on a complex system of artificial channels of different sizes that enclose the region in several *mesopotamias*, each one with its ecological and environmental characteristics. This paper describes the methodological framework applied to study the origin, chronology and use of this hydraulic network by combining the data obtained by Soviet, Uzbek and International Teams with topographical maps, satellite images and aerial photos of different periods.

Keywords

Irrigation Systems, Landscape Archaeology, Samarkand, Analytical Methods

1. Introduction

Central Asia can be seen as a mosaic of different environments, consisting of piedmont zones, steppes, oases, deserts and mountains, offering different potentials for land use strategies. Samarkand and its territory, at the heart of Central Asia, thus provide an excellent case study to evaluate the impact of human activities on landscape transformations (*Fig. 1*).

The region has been historically characterized by the interaction of two strikingly different socio-economic realities: irrigation agriculture and nomadic or semi-nomadic stock-breeding. They entertained a complex relationship, which ranged from close collaboration to conflict (Khazanov 1994) and fashioned to a large extent the long term history of the region. The present work is limited to the "water landscape" and will therefore not include any discussion of the pastoral landscape (see Stride *et al.* 2009; Rapin 2007; Rondelli and Tosi 2006). Various scholars have proposed syntheses of the irrigation history of the Samarkand water landscape (Isamiddinov 2002; Gentelle 2003), however, despite their efforts, major questions such as the method of construction, the degree of transformation of natural water courses into new channels or the chronology of the main hydraulic works still remain open. This is

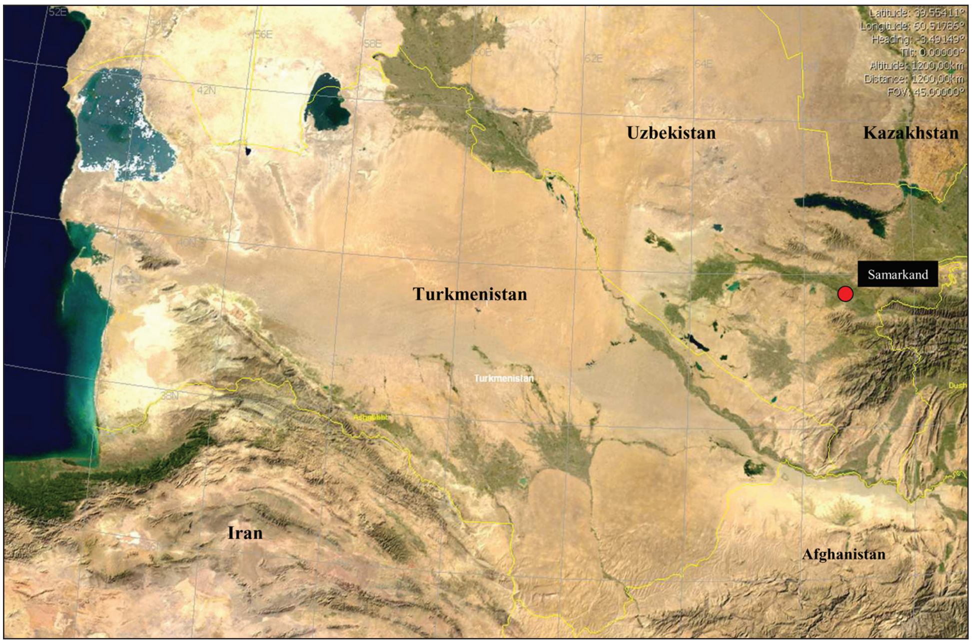

Fig. 1. The Middle Zeravshan valley, with the city of Samarkand.

due to the difficulty of integrating the large amounts of available data into an overall framework, which enables an evaluation of the different proposals, the pinpointing of specific problems and the formulation of concrete research proposals.

This paper describes the methodology employed to attempt to solve these problems. The research is part of a multidisciplinary project including several teams from France, Italy, Japan, Spain and Uzbekistan carried out under the aegis of the Institute of Archaeology of the Academy of Sciences and devoted to the reconstruction of the settlement dynamics and landscape transformation in Samarkand Oasis.[1]

2. The water landscape

The Middle Zeravshan Valley is a depression stretching in an east-west direction between offshoots of the Turkestan and Zeravshan ranges, with a total extent of about 230km and a maximal width close to 70km. The braided river beds and their spanning irrigation systems form a cultivated oasis, surrounded by gently sloping loess foothills only partly used for rainfed agriculture, but intensively exploited for ovi-caprids and cattle pasture. The total cultivated area of the Middle Zeravshan Valley measured on satellite pictures (from ASTER imagery in 2002) is approximately 6.600 sq.km, making this area one of the main oases in Central Asia.

The irrigated area depends on a complex network of canals crisscrossing the alluvial plain and bringing water to the settlements and their fields. This network is in constant transformation, both due to natural phenomena such as erosion, deposit of alluvium, floods and meandering and artificial interventions, to preserve, modify or expand an existing system or to build a new one.

The contemporary landscape can thus be read as a complex palimpsest of human and natural events and processes, which can be studied by reconstructing the evolution of settlement pattern and the key hydraulic infrastructures (such as the Dargom canal) and combining these with palaeoenvironemental analysis.

3. Mapping the landscape

If we consider the contemporary landscape as the result of a long and complex history, it is logical to start by mapping the current reality. However, the

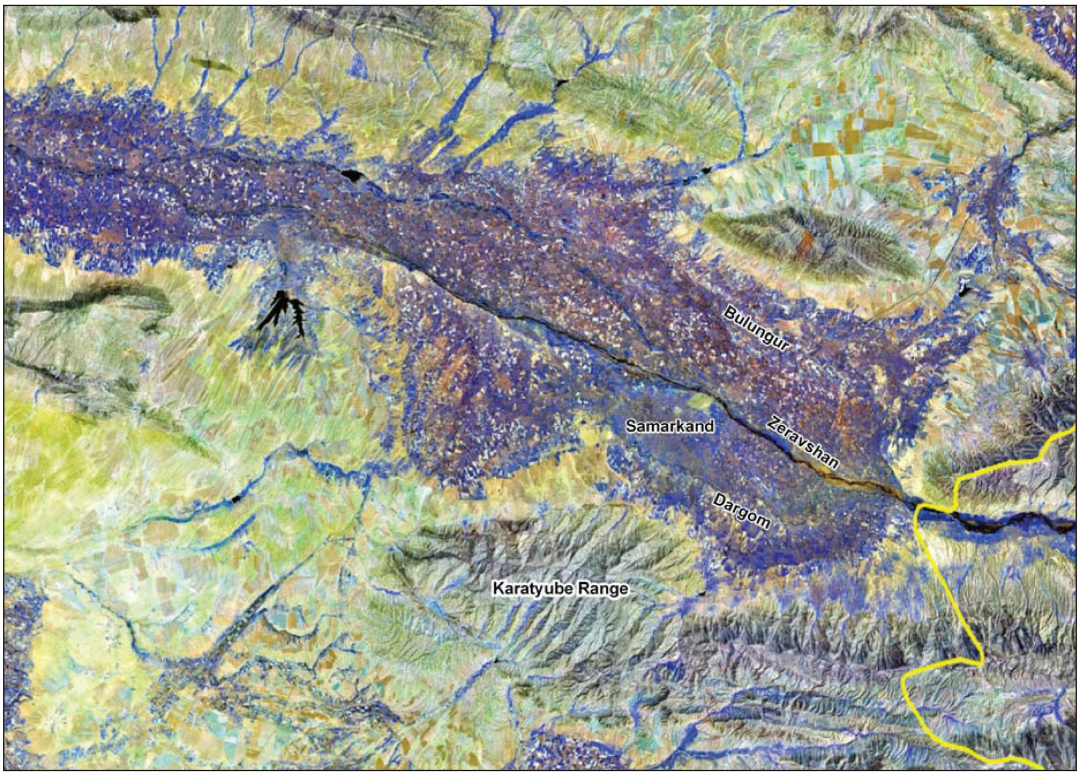

Fig. 2. A Landsat 7 satellite imagery shows the areas irrigated by artificial and natural watercourses.

[1] Actually the investigations covered the full administrative districts of Samarkand City, Taylak and Urgut and partially Samarkand Selsky and Pasdargom, for a total surface of 1.500 sq. km.

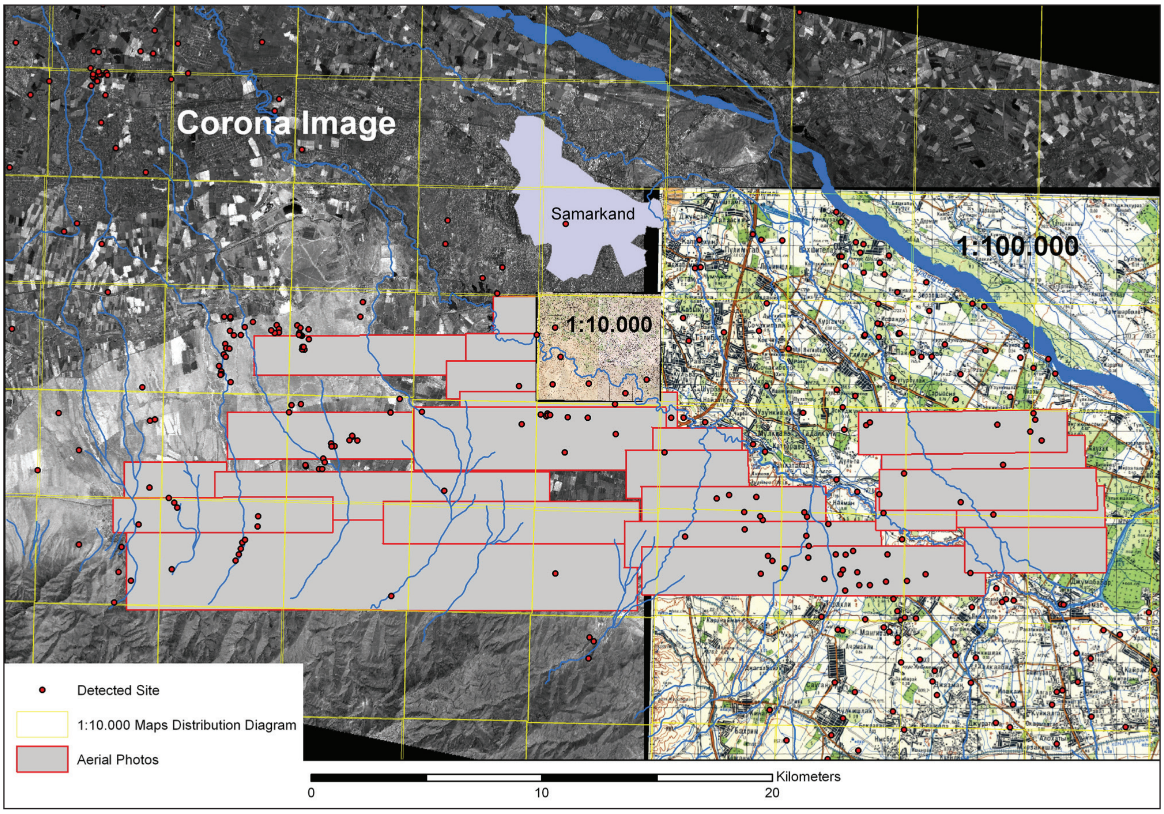

Fig. 3. A GIS screenshot with overlapped images and maps of the southern part of Samarkand Region.

introduction of mechanised agriculture, in the last 50 years, has caused a radical change in the way the landscape is being modified. For this reason, our first task was to try to reconstruct the landscape as it was before the major agricultural development projects of the 1960s and 1970s. This was done by integrating Satellite Images (Corona 1964, Landsat TM5 and TM7 1999, 2001; ASTER 2002), Aerial Photos (1970s–1980s) and Topographical Maps (1890s, 1930s, 1950s and 1980s) in order to record and map the landscape changes and to provide a more reliable, pre-mechanized, starting point (Komedchikov 2000; Minashina 2006).

The use and benefits of Corona images in Near Eastern Archaeology are established (Bitelli and Girelli 2009; Casana and Cothren 2008) and several projects have used them in Central Asia (Cerasetti 2008; Bourgeois 2007; Ogata 2003). This satellite imagery provides important information for the investigated area, however the most useful information was supplied by Soviet Military Maps, in particular those at a 10,000 scale (contour lines every 1m) and at a 25,000 scale (contour lines every 5m) from the 1950s, produced before the extensive amelioration projects of the Soviet period that caused the destruction of many archaeological sites. The legends of the maps (US Department of the Army 1958) include categories such as multilayered tells (locally known as *tepa* or *tepe*) and burial mounds, and Soviet cartographers were aware that many of the mounds that they recorded corresponded to archaeological sites. Furthermore, topographers also included any other special feature within the cultural landscape, including cattle enclosures, every single tomb or yurt (nomadic tent), wall and cave, but also chapels, mosques, Buddhist lamaseries and temples drawn to scale, as well as single isolated trees and the local toponyms.

These incredibly precise maps enabled us to localize archaeological sites of less than 30cm high and 5meters in diameter, including those which have since been destroyed, since they are systematically indicated on the maps as topographical anomalies in the alluvial plain. The extraordinary quantity and quality of information available from soviet maps is still underrated (Stride 2004) and, unfortunately, unlike with satellite images, we have not been able to develop a good system of automatic detection and recognition of topographical anomalies on the map. For this reason we proceeded with a systematic manual recognition of all anomalies for each map (*Fig. 4*), as well as tracing the limits of terraces and possible ancient watercourses.

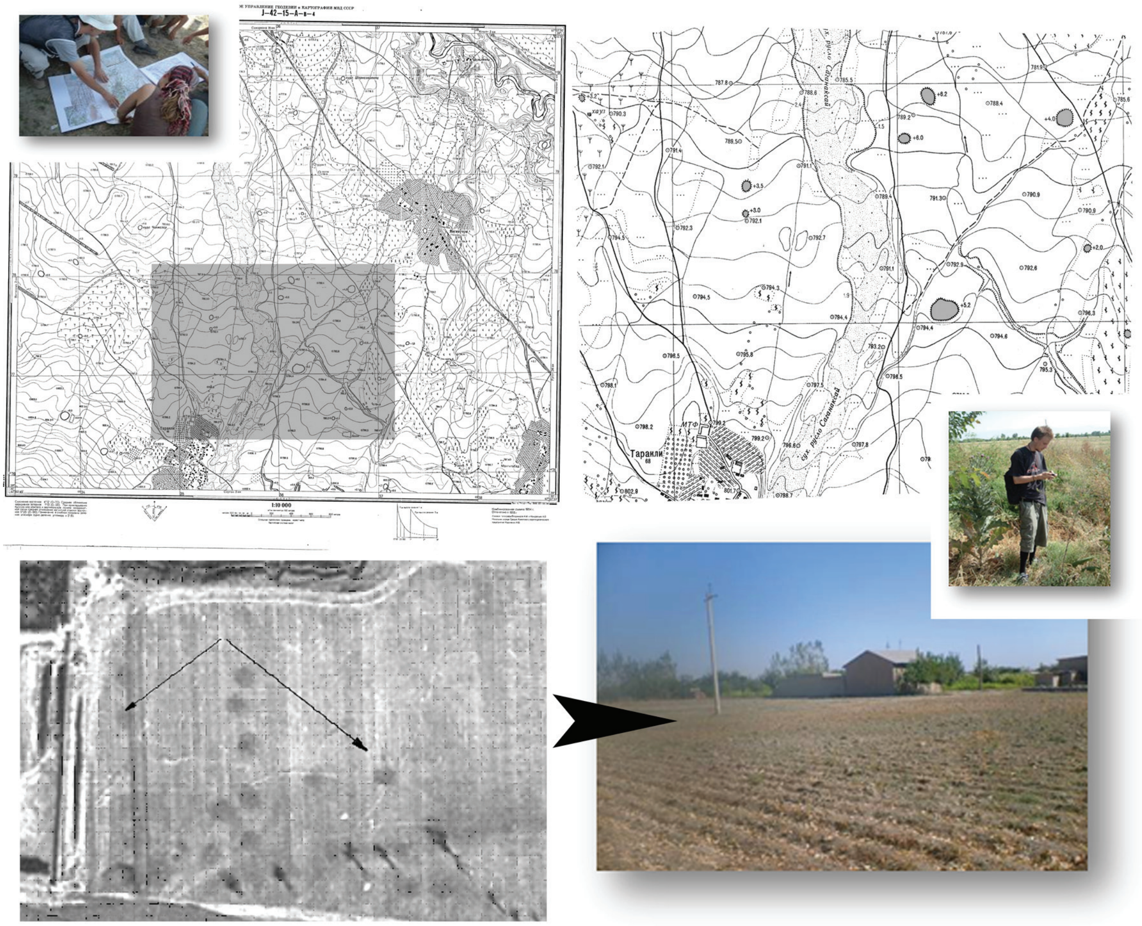

Fig. 4. Top: Soviet topographical map of the 1950s (1:10.000) with detail and photos. Bottom: Corona image showing topographical anomalies today completely destroyed (photo on the right).

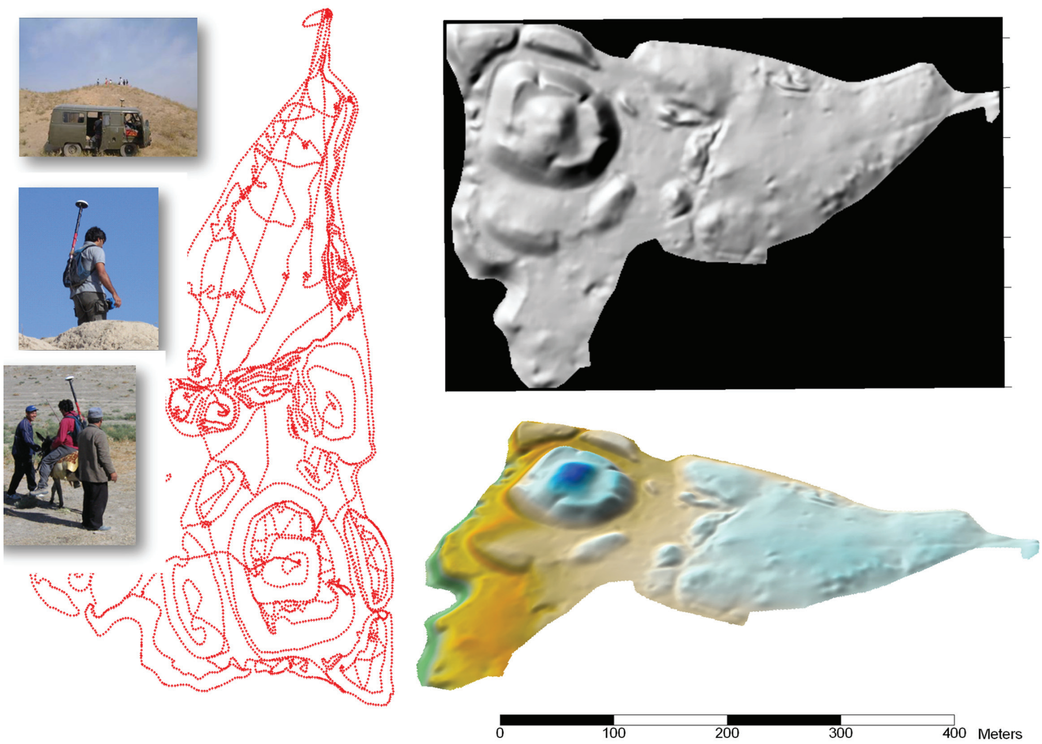

Fig. 5. An example of GPS survey and elaboration. With kinematic GPS surveying, the roving receiver visits the locations to be surveyed (as seen in the different photos). This set up allows a high productivity in collecting geometric information and instant on-field visualisation.

We then created a complete and detailed catalogue of the supposed archaeological evidence in the whole area

4. Recording the evidence

Because the landscape and the topography have been completely transformed in the last 50 years we then proceeded to verify the results in the field. We used Google Earth data in offline mode and palmtop GIS to localize the evidence recorded from maps. During the survey each site was fully recorded with its topographical characteristics, morphology and aspect, and a kinematic GPS survey (*Fig. 5*) with high resolution was conducted to create topographical plans[2] (Rondelli and Tosi 2006; Vittuari 2008). This enabled a detailed morphological study of mound shape to be undertaken. In many cases the sites themselves no longer exist, however we were able to identify and collect archaeological evidence in the area previously occupied by the mound and, by combining topographical data, aerial photos and Corona images, we propose a reconstruction of the shape (c. 1950) and approximate elevation of the totally or partially destroyed mounds. This work is particularly important because certain types of

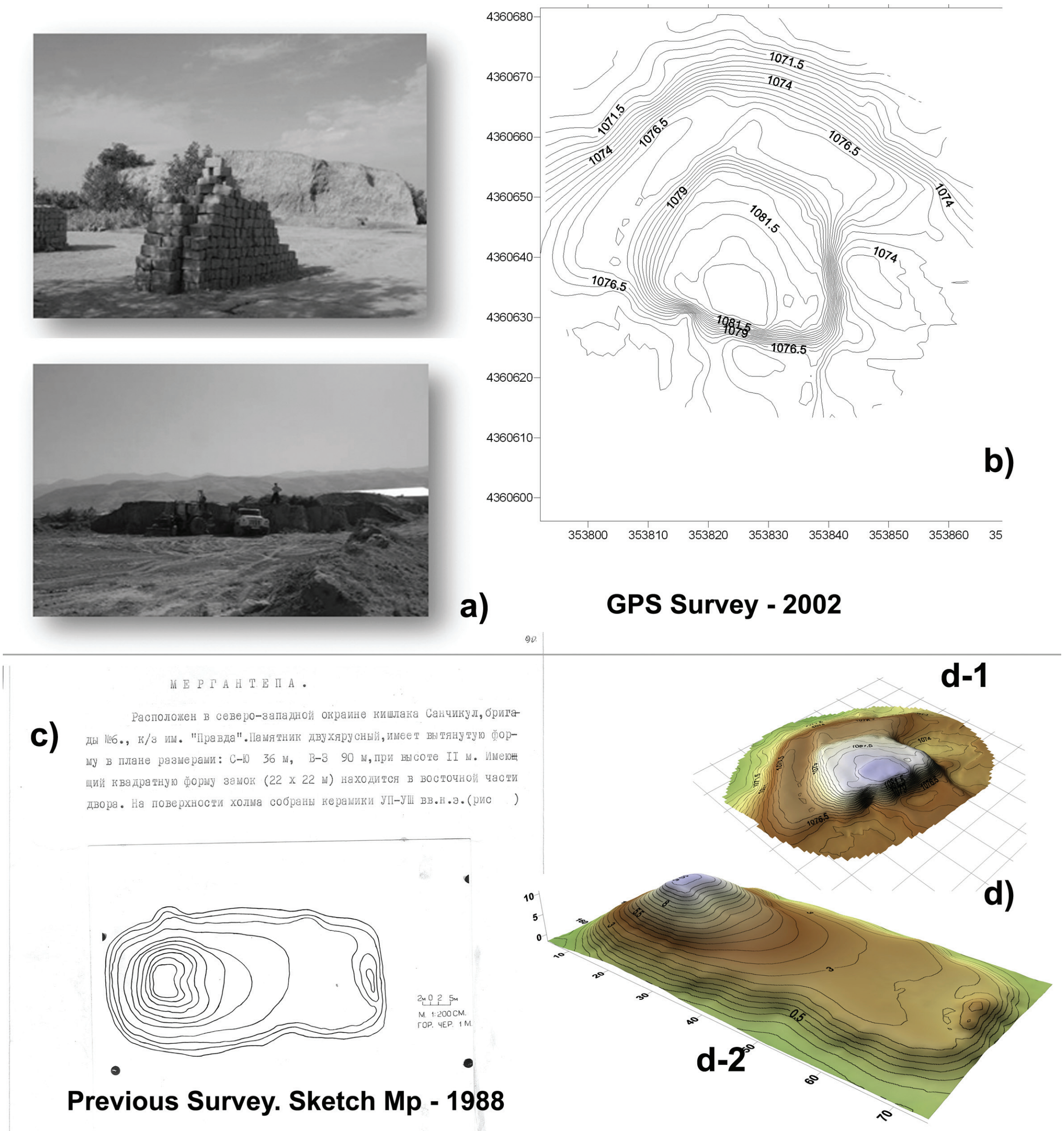

Fig. 6. Different data sets from the same archaeological site (Mergantepa, Urgut District): a) the current situation, b) GPS survey (2002), c) previous survey and sketch map of the same site (1988), d) a comparison between DEM elaboration with data from GPS survey (d-1) and from the old sketch map (d-2).

[2] GPS survey was carried out by Luca Vittuari and Valentina Girelli (DISTART, University of Bologna).

site appear to be quite clearly associated to specific periods of occupation.

As is often the case, the main problem of the survey was the dating of the archaeological sites because the pottery collected in the field was often not enough to establish the different periods of occupation. This was clearly proven when we resurveyed sites, which had been partly destroyed since the previous archaeological study and on which new layers were exposed (*Fig. 6*). In these cases the material collected often provided us with a distinct date from that of the previous survey.

In order to mitigate this problem, we integrated the topographical information from well-dated sites (in particular from those which had been excavated) and used this information to suggest the existence of occupation levels, which were not present in the material collected on the surface.

One of the major unexpected results of the systematic survey has been the tracing of the degree

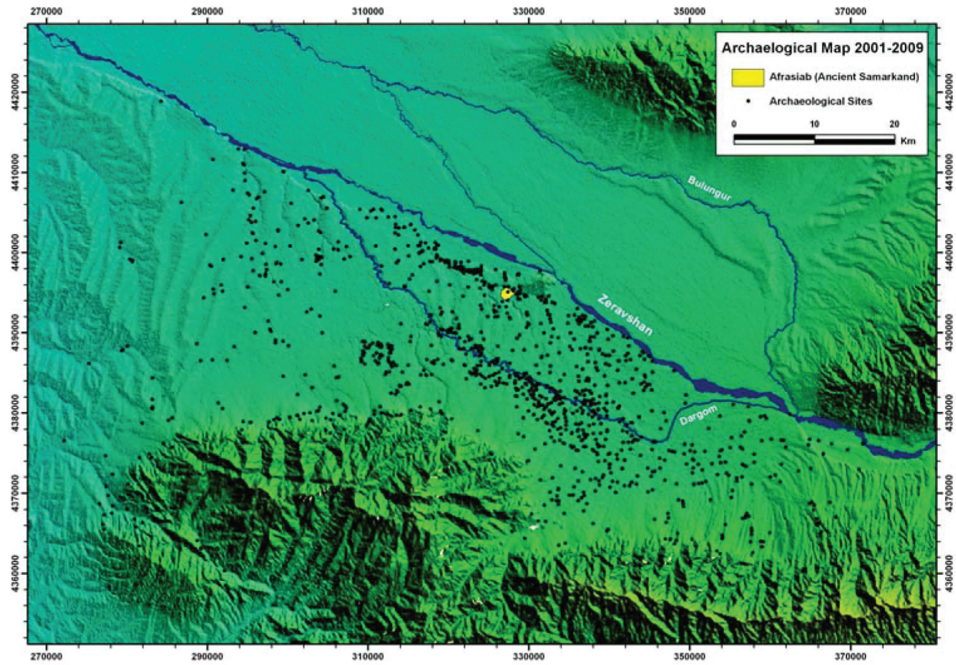

Fig. 7. The archaeological map fo the Southern Middle Zeravshan Valley updated to 2009 season.

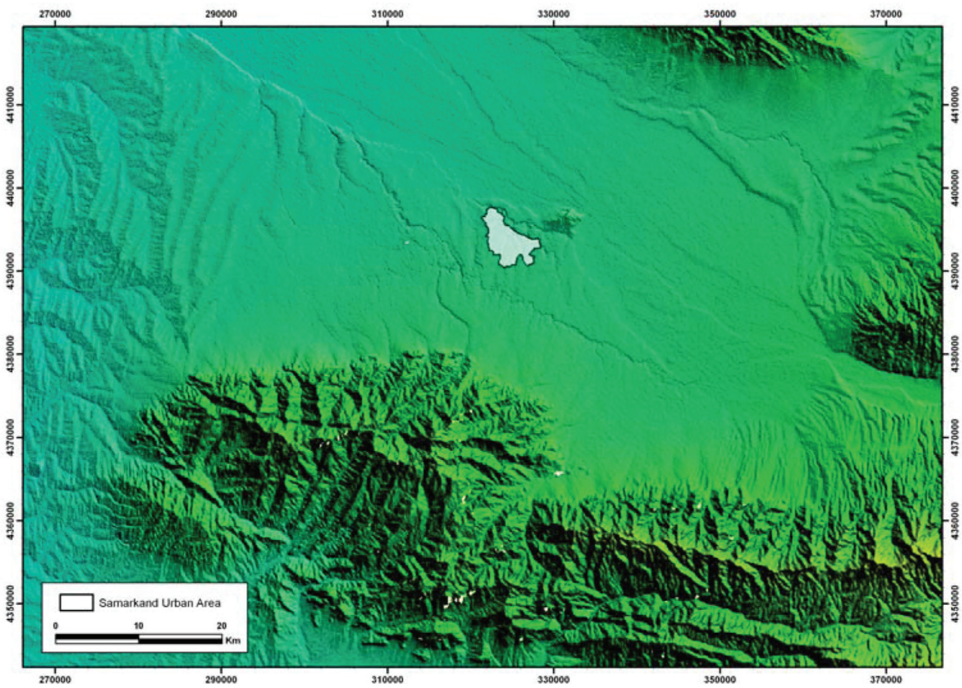

Fig. 8. The DEM of the Middle Zeravshan Valley, showing evidence of depth and intensity of the traces of natural bed rivers and artificial canals.

of destruction of archaeological sites. The quality of the cartographic material and fieldwork, have enabled us to evaluate the degree of destruction of archaeological sites in the last 50 years, which can be estimated at around 40 % (*Fig. 7*), taking into account only completely destroyed sites.

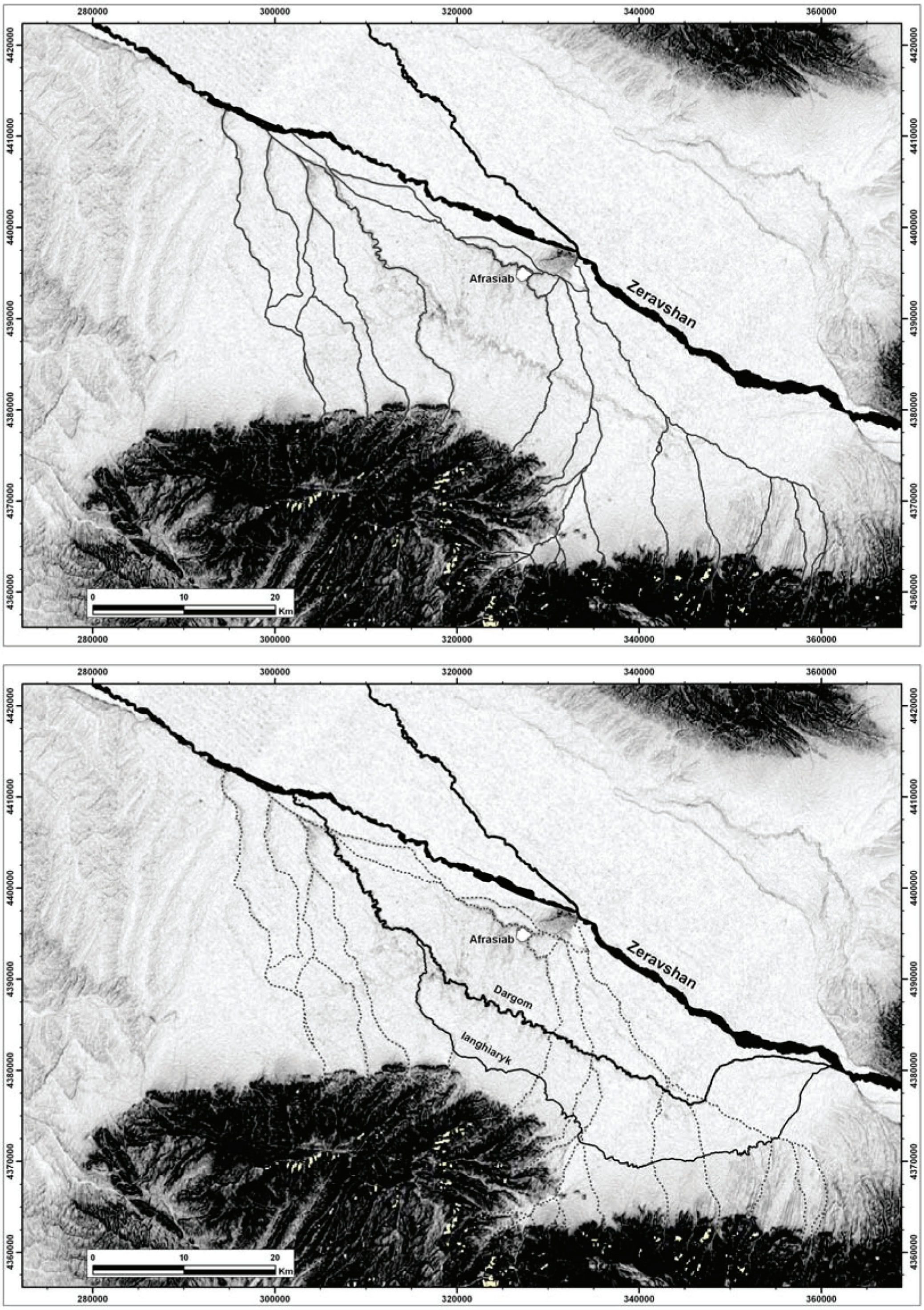

Fig. 9. Combining traces detected from DEM (a); maps and geological data (b); for the reconstruction of the evolution of the Dargom, the main canal supplying water to the Southern part of Samarkand Oasis (c). Hydrographical network of the surveyed area, showing the Dargom canal cutting through piedmont streams. Originally the piedmont rivers flowed without interruptions to the Zeravshan, but, the need to irrigate greater surfaces led to the creation of new canals that exploited the pre-existing ancient river beds.

5. The irrigation system

We also relied on remote processing to detect ancient watercourses. First, we analysed the topographical maps at different scales in order to record all possible evidence of ancient riverbeds and palaeochannels, then we combined the information provided by the maps with SRTM data (*Fig. 8*) and ASTER to obtain a Digital Elevation Model of the area (Siart *et al.* 2009).

As in other parts of the World, where DEM data reveal the palimpsest of multi-period levees connected with sites of different periods (Hritz and Wilkinson 2006, 423), in Samarkand the high resolution DEM made it possible to recognise many paleohydrographical traces, including underground evidence not visible in the field or on the topographical maps. By analysing the depth and intensity of these traces, and combining the results with the data available in topographical and geological maps of the 1970's at a 100,000 scale, we were able to distinguish the traces belonging to the main artificial canals (*Fig. 9*).

6. Results: Deconstructing and reconstructing the history of the water landscape of Samarkand's oasis

When we started this project, we expected that our results would provide a confirmation of the generally accepted interpretation of the irrigation system surrounding Samarkand.

This interpretation was based on the traditional theories of development proposed by Soviet scholars such as S. P. Tolstov and defended, in another context, by K. Wittfogel (1957), and assumed that the emergence of the city of Samarkand was necessarily linked to the construction of a massive irrigation system, represented here by the Dargom canal (Isamiddinov 2002; Gentelle 2003).

The integrated approach, which we have adopted, indicates a much more complex reality, where natural and artificial water courses are not easy to distinguish because their history has been marked by a constant interaction of both natural and artificial factors. In the case of the Dargom, for example, it thus appears that the canal/river combines natural watercourses with artificial sections and that the natural courses are themselves canalised whilst the artificial sections often revert to natural ones (Mantellini 2003). Furthermore, the sites associated with the canal do not enable it to be conclusively dated to the early to mid 1st millennium BCE (Isamiddinov 2002, 24), which is when the city of Samarkand presumably emerges. Whereas the original network of watercourses running down from the mountains, which can be reconstructed using the complex data set that we have described, can serve to provide an alternative history of the emergence of the city of Samarkand (Mantellini *et al.* 2009; Stride *et al.* 2009). To test this proposal we are planning to undertake a paleoenvironmental study of the area.

The application of the methodology described in this article has thus had a major impact on our interpretation of the historical reconstruction of the irrigation system of the Middle Zeravshan Valley. It has also led us to create a system, which can be used by any archaeologist interested in testing a

Fig. 10. The Middle Zeravshan Valley (Landsat image), overlapped on a DEM: in green the irrigated area (left). Simplified representation of the irrigation network (right).

given theory. Furthermore, it gives us the means of developing a Cultural Heritage Management System and even of providing the local authorities with a planning instrument to define land use and the effects of haphazard, uncontrolled development, such as deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of wildlife habitat[3].

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[3] To complement data on these aspects we are working with specialists of the contemporary world and have signed an agreement of collaboration with the University of Samarkand. We are also in talks with the Board of Monuments of the Province of Samarkand, in order to work out how they can adopt and use the system for the Management of the Cultural Heritage of the Middle Zeravshan Valley.

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