5. The coordinates of some 50 sites were calculated using both methods with almost identical results. The Geographic Positioning System (GPS) ceased working in the Surkhan Darya province on the 8th of October 2001; it is now apparently working once again.

6. In the 1950's, a number of leading Soviet specialists planned to publish a Historical and Ethnographical Atlas of Central Asia, which would have included maps and catalogues of archaeological sites, ethnographical groups, specific objects, etc. [for example Litvinskii 1959]. Later Jean-Claude Gardin emphasized the need for an archaeological atlas [Gardin 1985] and laid a theoretical basis for this work in his many publications on information systems and the development of technical means of sharing data through information networks (envi-sioned in a time of punch marked cards!).

Methods and Perspectives for Ancient Settlement Studies in the Middle Zeravshan Valley

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The "Archaeological Map of the Middle Zeravshan Valley" Project, begun in 2001 [Shirinov and Tosi 2003], is a cooperation between the Institute of Archaeology of Samarkand and the Department of Archaeology of the University of Bologna. It was created and evolves with two main aims: the study of the ancient population and settlement dynamics of the Middle Zeravshan Valley (Fig.1), and the recovery, preservation and enhancing of Samarkand and its territory. This brief description will be concerned with the first.

The area around Samarkand is characterized by the existence of three "mesopotamias" (locally known as *doab* "two waters" in Persian or *jazira* "island" in Arabic). These are formed by the splitting of the Zeravshan River after its exit from the Turkestan Mountains into the Karadarya and Akdarya branches, and the two main artificial canals, the Bulungur Canal to the north and the Dargom Canal to the south. Together these four parallel trunk collectors merge their alluvial sediments and form a stretch of

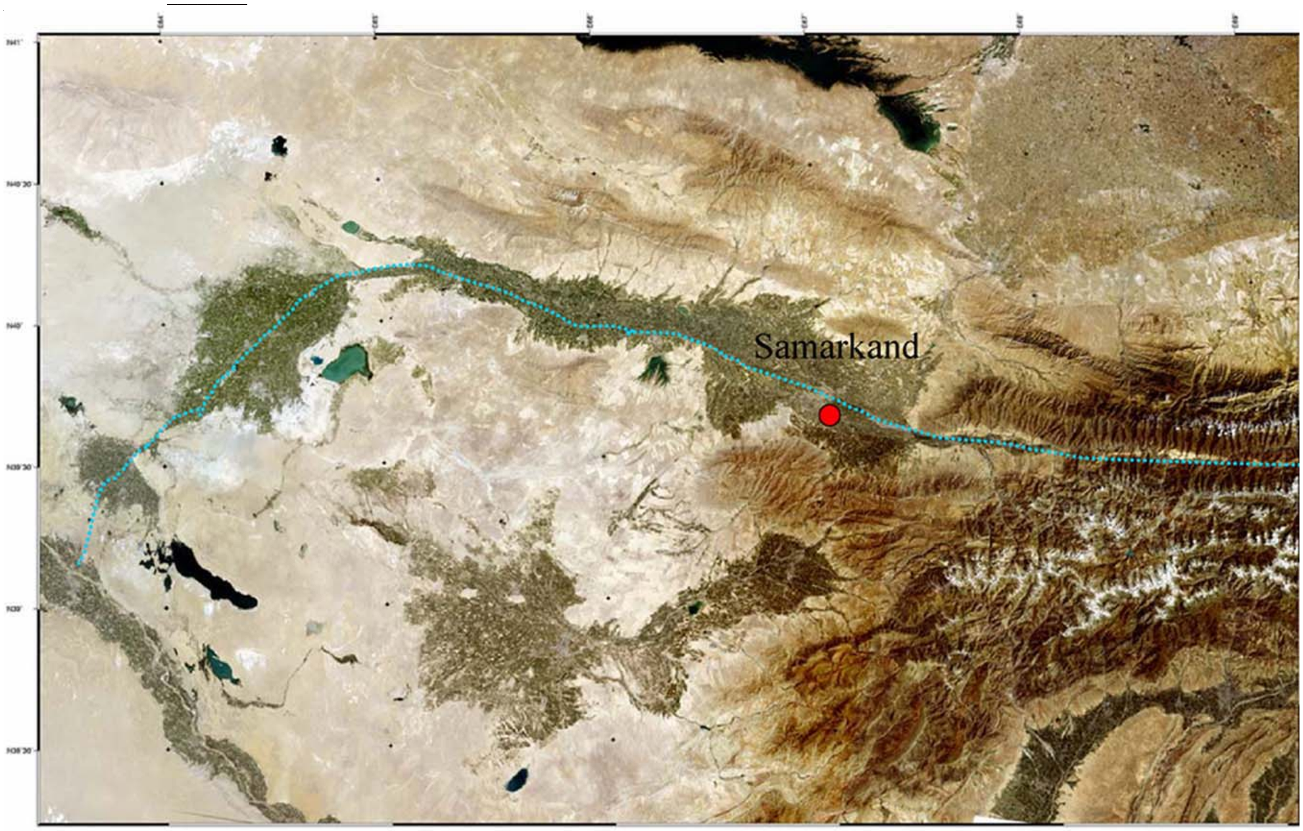

Fig. 1. The Zeravshan Valley from LANDSAT 5. The main irrigated area, corresponding to the oasis of Samarkand and Bukhara, is clearly visible.

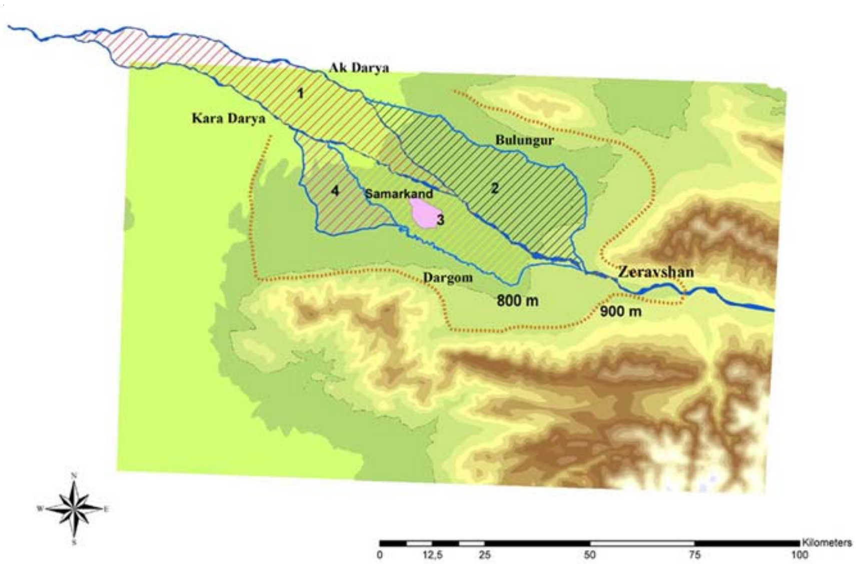

Fig. 2. The area around Samarkand (1. Doab Kara Darya - Ak Darya, 2. Doab Zeravshan - Bulungur Canal, 3. Doab Zeravshan - Dargom Canal, 4. Doab Kara Darya - Eski Angkor Canal).

irrigated farmland 40 km. wide and 100 km. long (Fig.2). This area, at the heart of the Eurasian continent, has formed the largest oasis in the whole of Central Asia at least since the middle of the first millennium BCE, comparable in size to other alluvial heartlands of civilization, like southern Iraq or Sindh.

The Middle Zeravshan Valley was subject to major, continuous and systematic development projects during the Soviet period, chiefly between the Sixties and the Eighties. The levelling of the plain, the creation of artificial terraces and the construction of new canals have destroyed or seriously affected many archaeological remains, permanently modifying the entire landscape [Zakirov 1955; Tulepbayev 1986; Dzhurakulov and Mamedov, 1986].

Today, indiscriminate soil exploitation and extensive cotton and tobacco cultivation continue to cause the loss of innumerable archaeological data. This situation has led us to develop a diversified methodological approach based on systematic surveys, the study and analysis of historical cartography, the study and analysis of satellite images and GIS data processing, analysis and modelling (Fig.3).

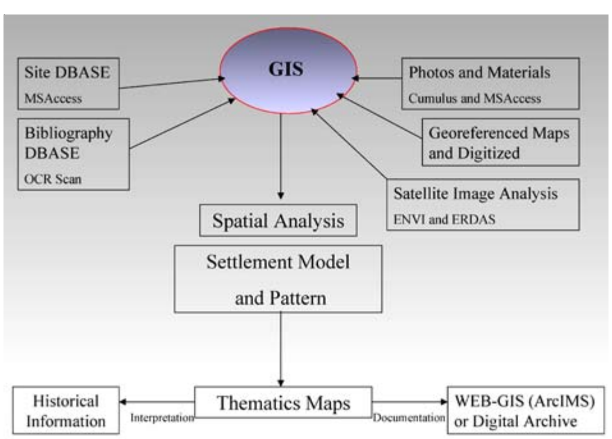

Fig. 3. Data management system.

Systematic surveys have been concentrated on the recognition and documentation of all visible structural archaeological features, in order to establish a list of preserved sites. Alluvial deposits (estimated to be several meters deep in places) and the agricultural transformations already mentioned make it difficult to undertake intensive field-walking and we have therefore limited this technique to transects or standard-areas. Each individual site was registered in digital form, with a set of different indicators that make it possible to develop distributive and relational analyses. In addition to site description and location, we also emphasized the collection of diagnostic material, and site topographical-functional information. All parameters were then compared with site explorability and preservation values, in order to establish surface datum reliability. This is a fundamental element in the attempt to compare and analyze data of different origin, typology and format. Finally, we used a centimeter-precise Total Station Geographic Positioning System (GPS) to create topographical plans of the sites (Fig. 4).

The drastic environmental changes that have affected this region, have led us to focus our research methodology on the use of historic cartography and remotely sensed satellite images. For this we were able to use material of exceptional reliability and precision, including 1:25,000 scale (with 5 meter contour lines) and 1:10,000 scale (with 1 meter contour lines) Soviet topographic maps made in 1954, where many sites are perfectly distinguishable. A standard spatial comparison between preserved sites and those obtained from the 1:10,000 cartography, from a time preceding the major agricultural development projects, shows that about 45 % of the total number of sites have been destroyed. Altimetry profiles and detailed Digital Elevation Models (DEMs) were elaborated by using 1:25,000 and 1:10,000 maps and provide

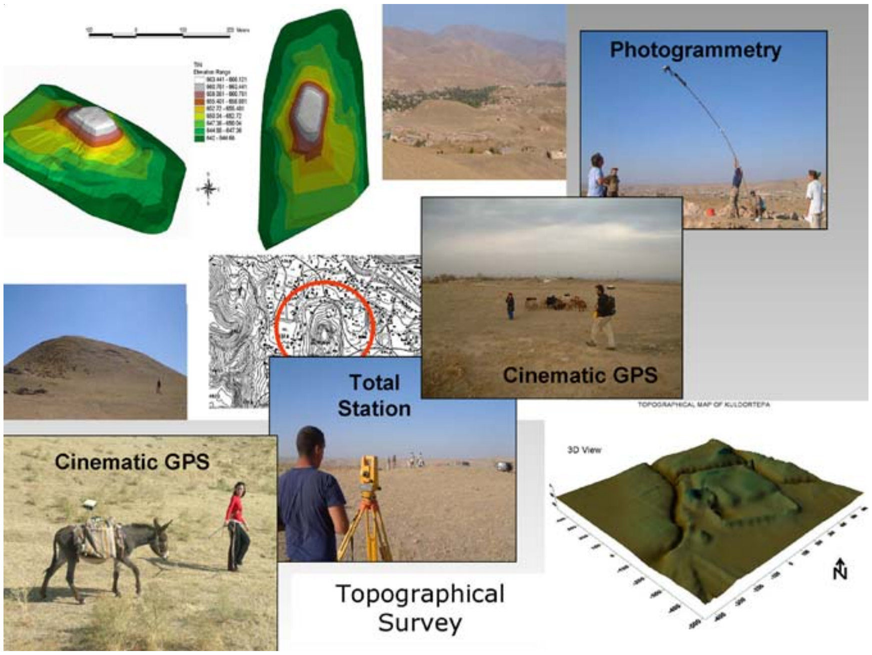

Fig. 4. Topographical site reliefs created using Total Station GPS. Recovery and digitization of former maps for a methodological comparison with the present situation.

important insights about ancient hydrography and the relationship between sites and topography.

We chiefly worked with two types of satellite imagery: multispectral Landsat TM7 and ASTER images, and Corona images. Landsat TM7 imagery (20-25 meter resolution) and the even better ASTER imagery (15 meter resolution) are especially useful in order to trace road systems, canals, ancient river beds, paleoconoids, main water flows, meanders and similar geographic information on a regional scale. It is then possible to obtain an overall view of extended areas as well as important information about the water systems that existed prior to the 20th century irrigation canals [Mantellini 2003]. It has also been possible to create vector data of the geology and current soil exploitation by working with automatic classification algorithms on ASTER and Landsat images.

Corona panchromatic images were taken by United States Defense Department spy satellites between 1960 and 1974, and have been made commercially available by the United States Geological Survey (USGS) since 1995. The use of these images, which pre-date many of the major agricultural reclamation projects, proved itself equally precious for their high spatial resolution (8, 5, 3 meters) and for their historic value. By digitizing these images and using specific software for their analysis, it has been possible to identify sites which are today destroyed and thus obtain important topographical and spatial information. In these areas, surveys were then conducted in order to verify the presence of sites or of concentrations of archaeological material [Mantellini and Rondelli 2003].

All the data gathered has been brought together in a GIS archive, which makes analytical elaboration and modeling possible. The capacity of GIS for overlaying geographical and environmental maps with those representing the archaeological record provides a baseline for making synchronic and diachronic distributive analysis. This also enables us to integrate the former studies about the area, by incorporating the information available in the literature into relational databases [Isamiddinov 2002], and by Optical Character Recognition (OCR) text scanning [Shirinov and Tosi 2003].

The GIS thus developed can then be applied to the analytical phase of our work. Indeed, GIS is an excellent instrument for the development of geographical, mathematical, and quantitative systems and models (from trade, traffic and management functions to dynamic-hydrodynamic systems application in the reconstruction of territorial evolution), while the treatment of statistical data, processed according to relations and combinations, makes it possible to formulate predictive models of settlement.

To better understand these settlement modalities it is particularly important to render and simulate the ancient landscape. This can be achieved by applying specific software and through mathematical interpolations based on *net* and *fractal fragmentation* theories [Buchanan 2002; Gardenfors 2004]. This particular approach will allow the creation of a Geographic Modeling System (GMS) where spatial information will be connected to the temporal variable in order to create thematic representations of the evolution of the landscape and the hydrographic network through time (Fig. 5, next page). Present-day DEM, thematic GIS, and archaeological paleoecologic data are used to create a scientific simulation, based on a process of spatial-chronological subtraction using specific ecological-environmental simulation software. This leads to

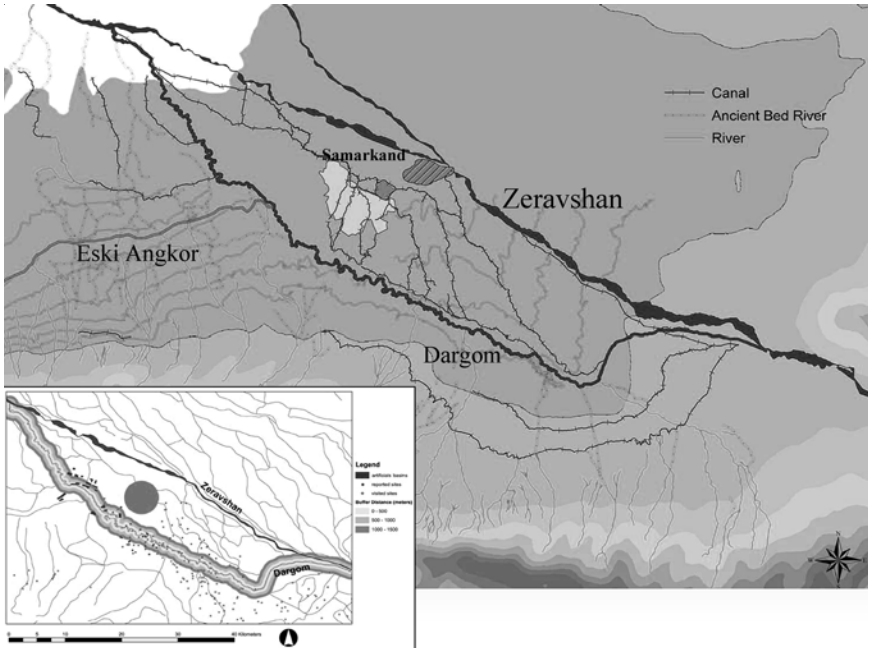

Fig. 5. The history of human settlement appears substantially connected to the "history of rivers" as an element, readable on the landscape, of what for populations is the "network effect" of a careful planning of resources and exploitation.

the creation of knowledge models that can explain data, and allow them to be verified and replicated in the next interpretative phase [Cattani et al. in press; Costanza and Voinov 2004].

The development of this project, and the necessity of incorporating the diverse data already existing, made the cooperation between our team and local institutions indispensable (in particular the State University Geographical Institute in Samarkand and the National Geological Institute in Tashkent). We are now planning the creation, in the Samarkand Region, of a Territorial Information Systems (TIS) office in order to insure the continuous and updated management of all data related to Samarkand and its territory, of which a central basis will be the creation of a Master City Plan and the Archaeological GIS archive.

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Reasoning with GIS : Tracing the Silk Road and the Defensive Systems of the Murghab Delta (Turkmenistan)

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Over the past fifteen years, a major joint Italian-Russian-Turkmen project has enabled the creation of an archaeological GIS of the Murghab delta. This project has involved some fifty different specialists, resulting in numerous studies and a preliminary project publication [Gubaev et al. 1998]. The GIS is still under construction. However, it already includes over 1000 sites with associated archaeological data and a great deal of cartographic and other geographical information. The project evolved at a time when GIS was only just starting to be applied to archaeology, and all information was classified in codified categories developed *ad hoc* for this purpose.

The Murghab delta is a terminal alluvial cone situated in the Karakum desert of Turkmenistan (Fig. 1). The only supply of water before the construction of the massive Karakum Canal during the Soviet period came from the Murghab River itself, a single trunk-course deeply encased near its source in the hilly piedmont of the northern Paropamisus (Afghanistan), which spreads into a wide alluvial fan of rich farmlands in the terminal delta. This became one of the largest irrigated areas in Central Asia as early as the Bronze Age. After Alexander's conquest in 332 BCE, Margiana, and in particular the ancient capital of Merv, developed as a nodal point along one of the most active Silk Road sections, opening direct trade relations with China [Cattani et al., p. 125; Bader et al. 1993-94, p. 51].

While developing the archaeological map of the Murghab delta from field surveys and archival data of the Soviet period, we have assembled a vast collection of maps and rare data concerning the climate, soil, vegetation and economy of the region, including statistical spreadsheets from government agencies from the late 19th century to World War II [Cerasetti 2000-2001]. One of the main aims of our research concerns the definition of the chronological sequence and reconstruction of the main irrigation systems, elaborating the data on the river's morphological evolution by means of GIS applications. Surface and historical mapping [Abbott 1843; Stewart 1881;

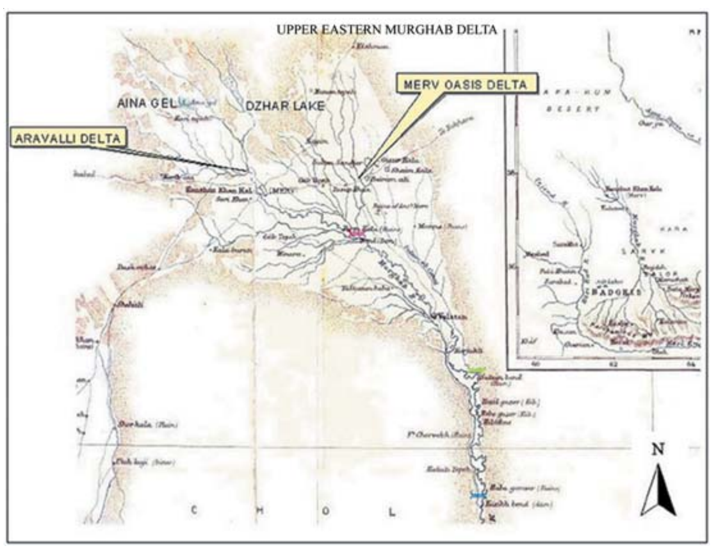

Fig. 1. The Upper Eastern Murghab Delta.