

# MONITORING THE DEVASTATION OF ISFAHAN ARTIFICIAL WATER CHANNELS USING REMOTE SENSING AND GIS

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### ABSTACRT:

One of the most important rivers in central parts of Iran which has the major effects in the ecology of region is named "Zayanderood". This river divides Isfahan city into north and south parts. "Sheikh Bahae" (one of the most famous Iranian scientists) designed an intelligent water network (cannels derived from Zayanderood and passed through Isfahan city). The innovative and intelligent construction of this water network called MADIs was cited by many researchers. However, some changes have been applied to it which seem to have devastating influences especially in agricultural, urban and suburb environments. The aim of this paper is to design and develop a spatio-temporal GIS for analysing and querying the changes of this water network. The proposed system are designed and developed using two historical datasets; a map which has been produced in 1972 and a new map which is produced from Ikonos images using remote sensing techniques. The analyses show that the changes are mostly applied to ..... parts of the water network.

## 1. INTRODUCTION

Most of existing geospatial information systems (GIS) lacks the capabilities to handle dynamic phenomena. It is now evident that there are some properties in real world which deal with most of phenomena, events and objects. Among them uncertainty and temporality have been received attention in recent years. This paper highlights the temporality of some phenomena in our natural environment. We have focused on the way our natural and national heritage can be monitored and documented so that necessary measures can be taken to maintain their properties. A number of Iranian scientists have worked on different natural and man made monuments and also developed algorithms to handle spatio-temporal events. Among them Sheikh Bahae has been highlighted in this paper due to his novel research and design methodologies. In section 2, an investigation on history of Zayanderood River is introduced. Section 3 illustrates the preparation of the required data. In section 4, the designing and developing a spatio-temporal GIS for investigating MADIs' changes are described and finally, section 5 concludes the research.

## 2. THE HISTORIY OF "ZAYANDEROOD" RIVER AND ITS BRANCHES

Sheikh Bahae was one of the greatest scientists and politicians in the era of the Great Shah Abbas (one of the Iranian kings in the 16<sup>th</sup> Century). Sheikh Bahae has designed some magnificent monuments. His wonderful designs have amazed a number of urban planners [Hosseini Abari, 1982; Honarfar, 1965]. "Monarjomban" towers in Isfahan and Sheikh Bahae Bath are two of his most famous inventions which have attracted a great number of tourists each year to Isfahan city, located in centre of Iran (Nafisi, 1932). Other invention of "Sheikh Bahae" is the design of a channel network for water transfer through the Isfahan city and its suburbs from Zayanderood that is well- known as "Sheikh Bahae Toomar"

(scroll). This water network and its channels (named MADIs) have major roles in water management and transfer to agricultural and other parts of Isfahan city as illustrated in Figure 1. (Alipoor, 1985; Faculty of Economics, 1965). Although Sheikh Bahae have designed some channels (named Quanat) in Shiraz and Neiriz cities in Fars Province and another cases in Najafabad (near Isfahan city), however, some researchers have claimed that Zayanderood water transfer network had implemented before Sheikh Bahae, in 1700 years ago, in the era of Ardeshir Babakan (Empire of Iran) (Nafisi, 1932).



Figure 1. Isfahan Map

As illustrated in Figures 2 and 3, there are seventy seven MADIs branched from left side (north) of Zayanderood river while there are only seventy one MADIs branched from right side (south). (Sattari et al., 2003).

MADIs are essential in agricultural, Industrial and urban development in Isfahan. Based on the reports from Isfahan Regional Organization of Water Resources (Isfahan Water Administration 1993), the MADIs provide 91% of agricultural, 4% of industrial and 5% of urban water requirements.

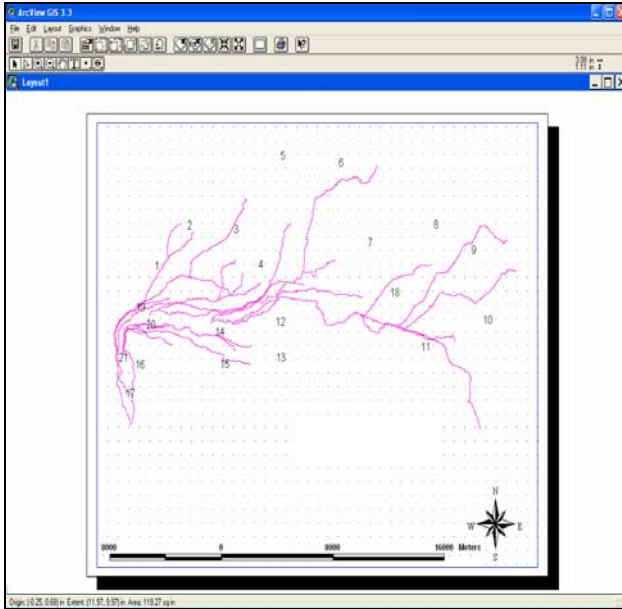


Figure 2. MADIs' Map

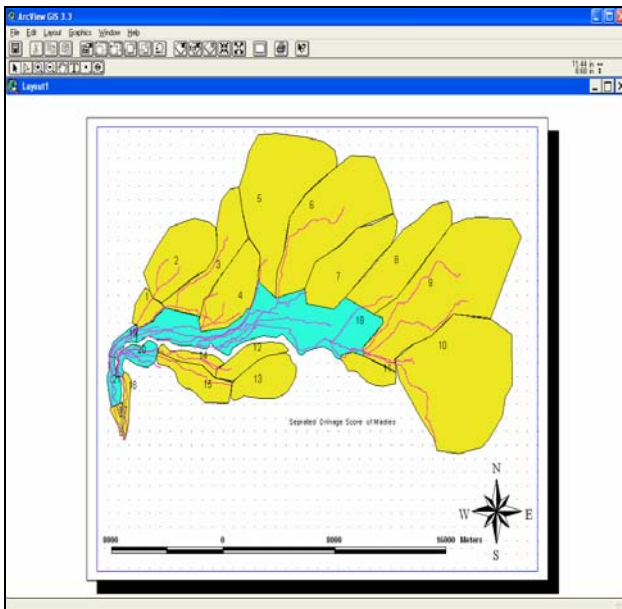


Figure 3. Isfahan Watersheds

### 3. DATA PREPARATION

For fulfilment of this project some maps produced in the 1972 by National Geographical Organization have been collected in

which all of the branches were taken into consideration by means of Isfahan Cultural Heritage Agency and eighteen Ikonos satellite images were also used.

Following geometric correction of the images using ground control points (GCPs) collected using GPS, features of the "MADIs" such as Zayandehrood river channels and their junctions are identified using AutoCAD, Arc/Info and Geomatica software.

The maps collected from National Geographical Organization were at a scale of 1:20000. On the other hand, Ikonos images have been used to update existing maps of the river channels and other planimetric features considered in this study. Maps and Ikonos images collected were two kinds of visual data implemented for some spatio-temporal analysis of monitoring Sheikh Bahae scroll destruction in Isfahan. Ground control points collected using GPS have been implemented for image registration process.

Clearly speaking, as shown in Figure 4, 400 ground control points extracted from National Cartographic Centre (NCC) maps are used for rectification of Ikonos images using PCI Geomatica software (Ortho Engine Module). Finally high oblique images (almost 40) eliminated and remaining ones were edge matched.

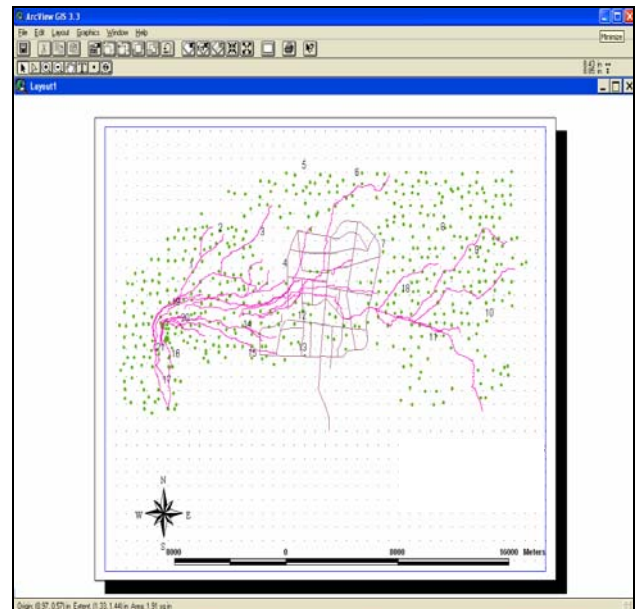


Figure 4. GCPs Distribution

### 4. INVESTIGATION ON MADIs' CHANGES

As illustrated from the images, most of the MADIs have been destroyed because of different changes in the city environment such as road construction, housing and establishment of industrial centres (Shafaghi, 1973). The level of destruction of the MADIs is so high that there is no indication from them in the recent images acquired (Yemefak, 2005). The maps of Cultural Heritage Organization of the Isfahan are the only available evidence that dates back to 60s and 70s decades which can be used to track the history of the water channels in Isfahan (Hosseini Abari, 1977). Therefore, all available maps and images from Isfahan covering the period of design of the MADIs till their total destruction have been acquired and used in this research in order to respond to some spatio-temporal queries relating to physical and environmental characteristics of

the MADIs in Isfahan (Abobakr, 1966; Mahmodian, 1969). Necessary GIS ready operations have been applied to the collected data to establish a spatial database. A number of spatio-temporal queries have been made on the developed GIS system to assess the level of changes in the MADIs (Zuviria, 1992).

Some of the queries considered in this research are as follows:

- 1-What was the length of the MADIs of Isfahan in 1972?
- 2-What was the length of the MADIs of Isfahan in 2004?
- 3-What was the length of the main streets of Isfahan in 1972?
- 4-What was the length of the main streets of Isfahan in 2004?
- 5-What was the area of watersheds of Isfahan in 1972?
- 6-What was the area of watersheds of Isfahan in 2004?
- 7-What is the balance of streams and Zayanderood river flow in a given year?

Some of the answers to these questions are shown in Figures 5 and 6. A spatio-temporal analysis system has been developed and successfully tested in Isfahan in this research based on the available historical maps updated using high resolution remote sensing images to monitor urban changes in Zayanderood River channels and to evaluate the hydraulic calculations undertaken by Sheikh Bahae in proper distribution of water using his novel approach undertaken more than four centuries ago.

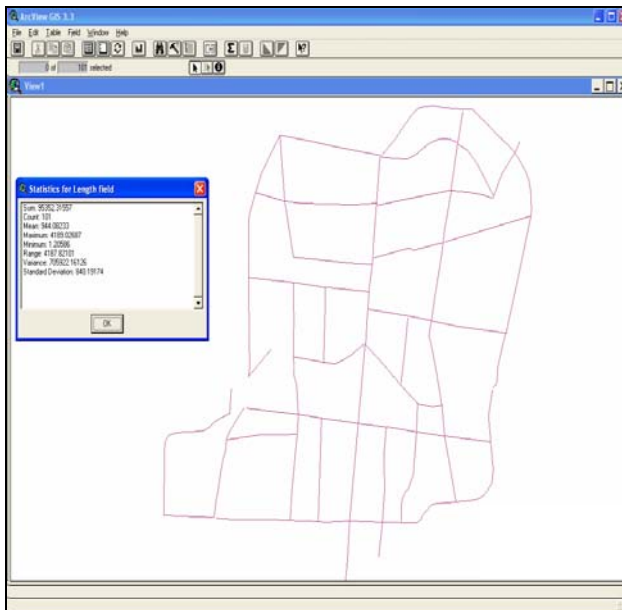


Figure 5. Isfahan main Streets in 2004 (not to scale)

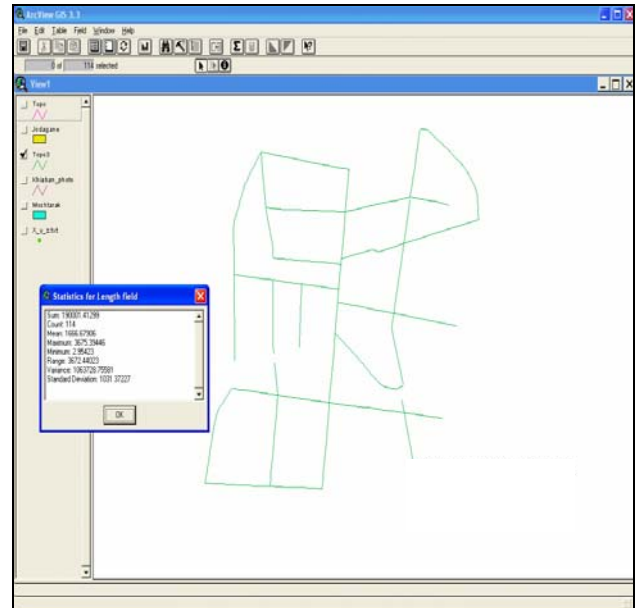


Figure 6. Isfahan main Streets in 1973 (not to scale)

## 5. CONCLUSION

Unfortunately, the high rate of urban expansion in Isfahan has shown a negative impact on most of the heritage and natural environment of the city. Especially the destruction of the MADIs has made an adverse effect of urban economy especially in agricultural sectors (Yavari, 1980). Using temporal GIS analysis using temporal data including existing maps and images assist monitoring land use/land cover changes in urban environment. Temporal remote sensing and spatio-temporal GIS analyses have been implemented in this research to effectively monitor the destruction level of MADIs in Isfahan in order to take precautionary measures to protect such an important natural heritage of our country.

In this research the following results have been achieved:

- About %35 of Isfahan MADIs have been destroyed which leads to significant reduction in agricultural water resources.
- Damages to cultivated areas have been about 42%.
- A great number of green lands have been converted to urban environments which lead to increase the level of environmental pollution.
- Due to the changes applied to the ecosystem of the region as a result of the destruction of the MADIs, the risk of Zayanderood River overflowing have been increased.
- The quality of urban landscape has been reduced because of MADIs destruction.

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