

THE RISK MAP FOR NORTH SAQQARA SITE: A BRIEF REVIEW

The *Risk Map for North Saqqara Site* it's a project started in the year 2000. This experimental program it is one of the first attempts to afford the problems in the management of the archaeological sites under a complex point of view: archaeological, environmental, socio-economical, conservation and monitoring questions¹. The project has been organized and developed by the Supreme Council of Antiquities (S.C.A.) of Egypt and the *Direzione Generale per la Cooperazione allo Sviluppo* (D.G.C.S.) of the Italian Foreign Office, together with the Egyptian Environmental Affair Agency, in the ambit of the National Environmental Action Plan (NEAP) of Egypt. The scientific direction of the project belongs to the Department of Historical Sciences of the Ancient World of the University of Pisa.

The aims of the project are:

1. The Creation of a computer model as analysis support for the minimization of the environmental decay of the Egyptian archaeological sites.
2. Aids to S.C.A. for the development in the management of the archaeological sites.
3. Creation of a development and support integrated system for the Egyptian public administration interested in the prevention of the environmental risks and the socio-economic development of the cultural resources of the Country.
4. To organize a specialized working group in the elaboration of integrated models for the management of the historical sites.

THE SITE

The site selected is North Saqqara which, owing to its wideness, number of visitors, state of preservation and environmental problems, is suitable to project and test the model of intervention². Saqqara is the most important necropolis in Memphis, the ancient capital city, and remained a cemetery during four millennia: from the beginning of the Egyptian History up to the Christian era.

¹ I want to underline that I'm writing in name of all the persons which have been involved in the project. It happens that I'm the author of this article because it has been possible for me to participate to the AIVA 2002, which has been a very important experience. All my best thanks goes to all the members of the project staff who gave an indispensable contribution to this article .

² The chair of Egyptology of the University of Pisa has long investigated this area: records and studies of the pit tombs of Ciennehebu and Padineit and the monumental complex of Bakenrenef hypogeum, where the programme of development cooperation called "Workshop in Saqqara" took place.

It spreads for an area even more than 12 sq. Km and retains over 600 monuments till now investigated.

However Cairo proximity and the consequent urban and industrial attack have caused, and still cause, an irreparable environmental degradation, which until now has forced into closing the 90% of the monuments. At the same time the flow of mass-tourism, without an organization well integrated with the conservation thematics, often produces an anthropic negative impact on the site.

THE STAFF

To develop and apply a new tool for the management of the necropolis and its environment, a staff of experts, in different science sectors, Italian and Egyptian, has been working together in full coordination. This is the list of all the experts.

Project Staff

Co-manager:	Shawki Nakhla
Co-manager:	Fabrizio Ago
Scientific Direction:	Edda Bresciani
Cooperation Attache':	Guido Benevento
Assistant Co-manager:	Tiziana Lucidi
Technical Director:	Antonio Giammarusti
Saqqara Site Director:	Adel Hussien
Architect:	Paola Galli
Cad:	Abdel Hamied Kotob
Cad:	Mahmoud Helmy
Cad:	Rosa Maria Iglesias Morsilli
Egyptologist:	Emad Khater
Egyptologist:	Mahmud Afifi
Egyptologist:	Roberto Buongarzone
Environmental Monitoring:	Atef Abdel Kawy
Environmental Monitoring:	Franco Pizzi
Environment:	Wagdi Youhanna
Environment:	Gennaro Papa
Gis:	Ali Yehia
Gis and Gps:	Renzo Carlucci
Gis and Database:	Emanuele Brienza
Gis:	Livia Peiser
Photographer:	Kirols Barsum
Photographer:	Carlos de la Fuente
Preservation:	El Hussien Ahmel El Said

Preservation:	Carlo La Torre
Preservation:	Marina Paris
Socio - Economical	Elvira Morella
3D Reconstructions:	Giovanni Marchionne
3D Reconstructions:	Maria Laura Fanni
Administration:	Gianluca Mattioli
Administration:	Massimo Testardi
Secretary:	Hebat Allah Ismail

THE FIRST PHASE

To analyze the pressures that Saqqara is bearing as a consequence of the urban and industrial assault and determinate the critical elements many factors have been studied like: damages related to the accessibility to the area, decay due to fruition of interior spaces, decay due to the absence of protection and/or maintenance interventions, sources of atmospheric pollution and trouble of the geological balance.

In this phase it was clear that many resources were available to apply the research but they were of different nature. Archaeological publications about the necropolis, publications about the environment of the site, data already recorded by Egyptian monitoring stations present in the surroundings, old photographic documentation, an huge architectural and archeological graphic documentation, cartographic documentation.

Complex instruments were necessary to acquire all these notices. A collecting and updating system information has been established by a special recording network that use:

1. fixed monitoring
2. instruments
3. file card
4. measuring tools
5. information pick up by database or from specialized researches.

One of the first step of the project has been the planning and developing of a database, realized in Microsoft Access, for the entry and editing of all the data: environmental, archaeological, about tourism and about conservation (**cfr tavv. I-II-III**).

Another step has been the creation of a new map of north Saqqara site.

The base map for this cartography are two very important documents released in the previous years:

1. Saqqara Base Map 1:5000. Survey of Egypt Topographical Series ‘ BLOC U.T.M. 36-46.660/1
Based on: ”*Stéréopreparation appuyée sur le canevas géodésique du SURVEY OF EGYPT*”

1:5000, CONSORTIUM S.F.S./I.G.N. – FRANCE in 1978, according to aerial photos 1:15.000, April 1977.

2. Saqqara Aerial Photographs provided by the National Authority for Remote Sensing and Space Sciences of Egypt. These Aerial photographs have been straightened and mosaiced in order to make a raster photographic image of the area.

The photogrammetric map has been digitalized, in CAD, according to the georeferenced aerial photomosaic. The published archaeological cartographies, collected by Egyptologists, were digitized and introduced in the cartographic system. In this way it was possible to link the data base to the cartography. All this map have been georeferenced to identify the tombs position on the general map. Several site survey by GPS have been carried out with the purpose to find the topographic benchmarks according to the aereophotogrammetric maps and the most accurate archaeological maps (**cf. tav. IV**). The equipments used during these surveys were:

1. Mobile device CompaQ Ipaq 3600 (Windows CE)
2. GPS Garmin III
3. Esri Arcpad 5.0.1
4. Digital camera Nikon Coolpix 800.

This new planimetry of north Saqqara shows all the tombs excavated from the XIXth Century until today (**cf. tav. V**).

THE SECOND PHASE

Most of the activities of the second phase have regarded the conservation aspects of the project.

The survey of the preservation status and then the effective vulnerability of the necropolis tombs, has been developed in three different levels:

At first level the survey is extended to all published monuments, and only cataloguing instruments are adopted.

In the second level the survey includes 13 sample tombs, chosen on the basis of epoch, typology and suffered damages.

One section of the database has been developed to record the typology and the conservation status of all the walls of every room of each tomb(**cf. tav. II**).

This is the list of the 13 tombs:

<i>NOTOMB</i>	<i>Owner</i>	<i>period-dinasty</i>	<i>Typology</i>	<i>Location</i>
PS05A	Djoser (Netjerykhet)	Old Kingdom III Dyn.	pyramid complex	north Saqqara
WSP09	Ptahhotep II and Akhethotep	Old Kingdom V Dyn	mastaba	West of the Step Pyramid
PS05	Djoser (Netjerj-khet)	Old Kingdom III Dyn	pyramid complex	north Saqqara
PS01	Teti	Old Kingdom VI Dyn	pyramid complex	north-East of the Step Pyramid
NSP45	Unknown	Early dinastic Dyn I	mastaba	north of the Step Pyramid
ATP18	Mereruka - Meri	Old Kingdom VI Dyn	mastaba	north of Teti Pyramid
ATP17	Kagemni - Memi (also Gemni)	Old Kingdom VI Dyn	mastaba	north of Teti Pyramid
APU55	Padienis (Pedenisi)	Late period XXVI Dyn	shaft tomb	South of the pyramid of Unas
APU53	Tjaiennahebu (Ciennehebu)	Late period XXVI Dyn	shaft tomb	Around the pyramid-complex of Unis
APU43	Nefer and Kahay	Old Kingdom V Dyn	hypogeum	Around the pyramid-complex of Unis
WSP06	Ptahhotep [I]	Old Kingdom V Dyn	mastaba	west of the Step Pyramid
PS08	Unas	Old Kingdom V Dyn	pyramid complex	Sout-west of Djoser complex
NSP109	Ty	Old Kingdom V Dyn	mastaba	north of the Step Pyramid

*** Monitored Tombs**

To draw thematic maps about the preservation status of these decorated walls have been use photogrammetric techniques to generate photomosaics of the walls. From several rectified images of the structures, all referred at the same scale, it is got an unique image. Using the software Archis 2D, by Sysscarn, the images are overlapped, adjusted in tone, colour and brightness in order to render them homogenous and to give the harmony of one only whole image. Subsequently the high-resolution photos obtained by photo mosaic are ready for the final use: prepare a thematic map for the state of conservation of the wall paintings(cfr. tav. VII).

The third level of analysis consists in the installation of monitoring equipments and it's concerning three tombs, which are highlighted in blue in the table shown above.

The type of monitoring preview is fully automatic and consists of checking both the general external environmental conditions and those characteristics internal. The systems applied on the three tombs are unrelated among them. Each system consists of the following technical equipments:

1. Sensor unit.
2. Data acquisition system and downloading manual unit.
3. Solar panel power group.

The three systems share a remote PC software for processing and filing data, as well as for numerical and graphical representation of them(**cf. tav. VI**).

During these specific investigations another study-sector of the project has been started off: the socio-economic analysis, having the task of analyzing the contexts of north Saqqara.

The purpose of this analysis is to study the general economy of the area and its social reality, with a specific attention to tourism activities and their importance in terms of local development.

The data collected are about demographic aspects, the economy of the area, the tourism presence in the area, the updated situation about access to the site.

The elaboration of the collected information, integrated in the GIS system, will regard comparative analysis with the conservation data and hypothesis about tourism flow regulation inside the archaeological site.

THE THIRD PHASE

The third phase has focused its activities in the construction of the GIS system, and in planning and developing the automatic procedures of vulnerability and risk evaluation.

The computer system which allows the visualization of data with relations between the database and the cartographies is ArcView G.I.S by ESRI.

A user interface written on Avenue (the programming language working on the ArcView platform) allows the user to display the data about the tombs. It is possible to select all the tombs, wich have been georeferenced, to display the relative data, by an SQL connection with the MS Access database, in dialog-windows planned in Avenue. Several menus have been planned also to display all the collected graphic documents (**cf. tav. VIII**).

For the 13 sample tombs it is possible to act deeper inquiries. The scripts allows the user to get inside the map of the tomb to explore all its rooms and make inquiries about the wall and their

decoration. It is possible also to display the photo and the photomosaics of each wall. It is possible also to display a virtual 3D reconstruction, developed in the basis of the photomosaics, to display the internal rooms of the tombs, at their present state (**cf. tav. IX**).

Some other function have been written to the user to explore the GIS system on it's general view. A research menu allows the user to group and find the tombs using different research-keys like the typology, period, owner ecc.

It is, therefore, possible to produce thematic cartographies with varied contents such as the structures subdivision according to their age, typology, state of conservation or level of relative moisture (**cf. tav. X**).

During this phase, the previously drawn up numerical cartographies, which include a division by categories of the phenomena taken into consideration (for example: monuments, routes, services, level curves, wind exposition, geology, anthropic impact, ecc.) constitutes a reference grid for all the main analysis.

Every single monument is taken on as a base element, whose loss or damage risks need to be assessed or whose possible enhancement needs to be evaluated.

Hazard depends on the chances that particular dynamics develop in the area where the monument is located, causing the monument partial or total damage. Such dynamics are mainly physical-environmental and atrophic phenomena. The process adopted to draw up requires assigning to each sector of territory risk maps an indicator of its potential danger. This process is first repeated for each of the potentially dangerous situation. By normalization (standardization) of the data and assignment of reciprocal importance an overall definition of hazard is drawn up for each homogeneous sector. By analogy with the Italian experience, the word "risk" means the possibility that a certain monumental structure is exposed to the occurring or the prolongation of a decay process. In particular, the relation to which we have referred to, linking the words "risk", "vulnerability", "danger" and "value" corresponds to the one adopted also by UNESCO ($RISK = VALUE \times VULNERABILITY \times HAZZARD$).

Through the "overlay mapping" process it is possible to point out the link between environmental risks in Saqqara site and the real risks for the monuments in the area.

Using the menu "Risk" in the GIS system it is possible to activate the procedures of spatial analysis from the overlapping of the different thematic maps, with the different values of everyone of their features which can define particular zone of danger. In the same way the vulnerability zones are generated by the vulnerability indexes of each tomb, calculated automatically by the typology, the architectural and decoration features, and the present status. The interaction between vulnerability maps and danger maps generates risk maps by zone.

CONCLUSIONS

As you have seen all the different documents of different type elaborated by the project staff flow together in the GIS system.

All the written data are imported using a sequel procedure with the tables of the access database. The data haven't been transformed in dbf tables, the physical format of the ArcView gis tables, because the editing and the appending of the records has been performed until now. In this way all changes made on the access database were automatically and dynamically imported on the gis system. However all the tables are joined and linked to select, filter and show the data in the same way of the database forms.

Following a similar procedure all the digitized maps are imported in the system with a dwg format, the normal autocad files extension. These maps haven't been transformed in shapefiles, the format of the arcview maps, for the same reason of the data. A big work of continuous control and editing was needed and all the changes had to appear, at the same time, on the gis system.

To maintain these dynamical shape of the documents in the GIS we had to elaborate an *ad hoc* procedure to link the Autocad maps with the tombs of the database.

This procedure is based on the possibility to record the names of particular graphic elements in the "blocks" of CAD drawings. During this procedure we have been able to display the results of the work in progress, to verify and to check them.

At the end of this brief report I would like to spend some words about the use of information systems like GIS in archaeology. Many experiences about GIS have been carried out in all part of the world. At a certain moment it seemed that the gis systems represented the resolution of all problems concerning the archeological activity, and the treatment for every activity troubles.

Personally I would point out that the archaeology and informatics sectors use totally different approaches and also different languages.

The computer performs on undoubted data and objects while the archaeologists reconstruct puzzles from uncertain excavated ruins. That's the reason for which the archaeological language is more pondered and seems less precise than the computer language. The confrontation with these new technologies can be a challenge for the archaeological science that has to be integrated in the world of the hi- tech. This means that the archaeologist has to adopt a challenging attitude, and the capacity to work in multi-disciplinary teams.

Emanuele Brienza

I – Main data entry form

The screenshot shows a Microsoft Access form titled 'Main Data Entry Form'. The form is divided into several sections for data entry:

- GENERAL INFORMATION:** Includes fields for 'TOMB ID', 'No. Tomb', 'Found M. No.', 'Type of Tomb', and 'Level'.
- DESCRIPTION:** Includes 'Number' (with a dropdown menu), 'Type of Tomb', 'Period', 'Coordinates', and 'Location'.
- MATERIALS:** A dropdown menu for 'Principal Building Materials' is open, showing options like 'Ritual wall masonry', 'Mud brick masonry', 'Burnt brick masonry', 'Limestone masonry', 'Sandstone masonry', and 'Gypsum masonry'.
- ACCESSIBILITY:** Includes 'Accessibility' (with a dropdown), 'Dated Date', 'Written Visitors', 'Dashed Visitors', and 'Preservation Status'.
- ADDRESS:** A large text area for 'Address' with a small map icon.
- DETAILS:** A section for 'Titles of the Owner' with a list of tabs: 'RELATIVES', 'EXCAVATIONS', 'OLD SIGNIFIERS', 'NEW SIGN. PHOTOS', 'SIGNIFYING', 'DISEASES', and 'DETAIL DESIGN'.

On the right side of the form, there are several action buttons: 'ADD NEW TOMB', 'FIRST RECORD', 'LAST RECORD', 'PREVIOUS', 'NEXT', 'NEW RECORD', 'PRINT RECORD', 'OPEN MAIN TABLE', 'EDIT DATA', and 'DELETE'.

II – Data entry form for conservation data of 13 sample tombs

The screenshot shows a Microsoft Access form titled 'Conservation Data Entry Form'. The form is designed for entering conservation data for 13 sample tombs:

- TOMB NAME:** Includes 'TOMB NAME', 'Status' (with a dropdown), 'Color', 'Material', and 'OF' (with a dropdown).
- STRUCTURAL DATA:** Includes 'Building Conservation' (with a dropdown), 'Planks of the Building and its Locations', 'Address', 'Description', 'Material', and 'Remarks'.
- BUILDING CONSERVATION STATES:** Includes 'Building Conservation State', 'External Temperature', 'Moisture', 'External Relative Humidity', 'Moisture Date', 'Moisture Time', 'Partial Collapse', 'Subsidence', 'Joint Opening', 'Structural Damage of the Roofs', and 'Damage Assessment'.
- RESTORATION:** Includes a table for 'Restoration Data' with columns for 'Restoration Date' and 'Restoration Description'.

On the right side of the form, there are several action buttons: 'ADD NEW TOMB', 'FIRST RECORD', 'LAST RECORD', 'PREVIOUS', 'NEXT', 'NEW RECORD', 'PRINT RECORD', 'OPEN MAIN TABLE', 'EDIT DATA', and 'DELETE'.

III – Data entry form for environmental data

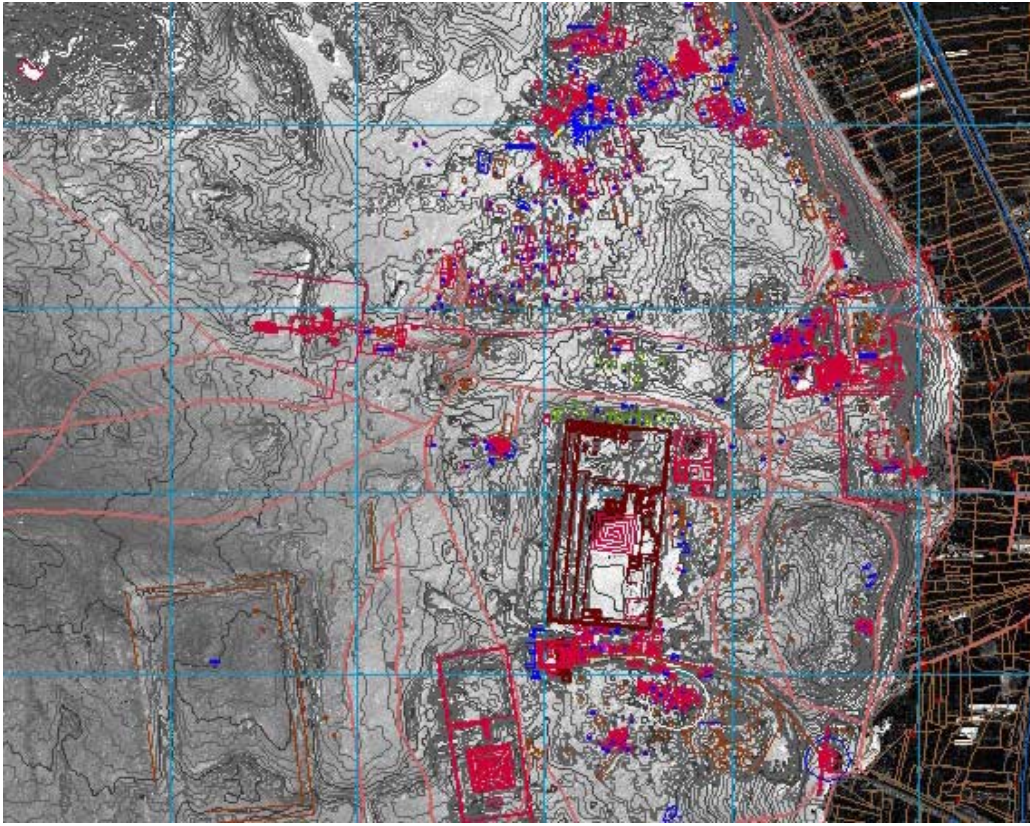
The screenshot shows a Microsoft Access database window titled "MS Data Entry". The form is divided into several sections:

- DATA ABOUT THE MONITORING STATIONS:** Includes fields for "STATION" (with a dropdown menu), and six distance fields: "DISTANCE FROM SAGARA (km)", "DISTANCE FROM CEMENT PURULAND FACTORY (km)", "DISTANCE FROM CEMENT FACTORY (km)", "DISTANCE FROM PINE CEMENT FACTORY (km)", "DISTANCE FROM MAAT FACTORY (km)", and "DISTANCE FROM TORA CEMENT FACTORY (km)".
- DAILY DATA OF THE STATIONS:** Contains a sub-section for "STATION COLLECTED DATA" with input fields for "NO.", "TEMPERATURE (C)", "REL. HUMIDITY", "WIND SPEED", "WIND DIRECTION", "WIND PRESSURE", "SMOKE", and "T.S.P.". There are also "GO NEXT RECORD" and "GO PREVIOUS RECORD" buttons.
- CHRONOLOGICAL DATA:** Includes fields for "DATE", "YEAR", "MONTH", and "SEASON".
- Navigation Buttons:** A row of buttons at the bottom includes "ADD NEW RECORD", "GO NEXT RECORD", "GO PREVIOUS RECORD", "GO FIRST RECORD", "GO LAST RECORD", "FIND RECORD", "DELETE RECORD", and "SAVE DATA".

IV – GPS Survey



V – New map of north Saqqara



VI – Monitoring tools



VII – Creating photomosaics of the walls of the tombs



VIII – GIS first level inquiries

