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Modeling the catastrophe, and beyond.
Digital History and Visualization methods for multiscalar process description of the Nubia Temples flooding

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Abstract
World heritage sites are exposed to the impacts of natural and human-induced catastrophic events which threaten their integrity. According with UNESCO the loss or deterioration of these outstanding properties have severely negative impacts on local communities because of their cultural importance and because of their socio-economic value.
The paper focuses on a multiscalar human-induced environmental change with catastrophic effects on the Nubia temples and on the prospective of using a multiscalar process description for studying and visualizing historical and environmental changes related to disasters. Beyond the disaster, the displacement both of temples and villages provoked other kind of damages. The case study presents how the disaster and the risk of damages on Cultural Heritage can be recorded and monitored at the scale of temples, artistic elements (i.e. statues, decorations), till the large portion of territory including villages.
The paper highlights the disaster caused by the High Aswan Dam as a warning for an international awareness on a sustainable development that needs to take into account the cultural heritage. It discusses the cultural memory as crucial for Disaster Risk Reduction strategies. Our approach uses 3D models in order to collect data and to make understandable risks, damages and solutions. Historical research and Visualization methods create a fresh context of knowledge for a case study strongly representative of the World Heritage Disaster.

Keywords: flooding, cultural heritage, Nubia, 3D modeling, digital history

1. Introduction
World heritage sites are exposed to the impacts of natural and human-induced catastrophic events which threaten their integrity. According with UNESCO the loss or deterioration of these outstanding properties have severely negative impacts on local communities because of their cultural importance and because of their socio-economic value. [1]
One of the priority pillars recently set by United Nations for Disaster Risk Reduction (DRR) policies focuses on the understanding of disaster risk in all its dimensions and on the “Build Back Better” approach in reconstruction. One of the ways to achieve this is “to build the knowledge of […] civil society […] through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction”. [2]
In the last few years the impact of many recent natural or war catastrophes on relevant historical sites - some of them listed as world cultural heritage - has pushed to develop new specific approaches and methodologies. The purpose of an environmentally sustainable development that includes the preservation of Cultural Heritage strongly demands for a multidisciplinary approach, as it needs to take into account different kind of targets. Recent experiences are developing platforms of shared knowledge for surveying, analyzing, collecting information, monitoring and involving a large community of experts in order to preserve and plan complex systems (see Educen - European Disasters in Urban centres: a Culture Expert Network). [3]

This approach, combined with ICTs, allows to link many different stakeholders for a common knowledge in the aim of a multifaceted approach to different goals. Some main goals consist in checking clues of environmental risk and processing their possible effects, or to analyze the state of the art post-catastrophe in order to provide expertise for intervention and preservation of remains. Other purposes also include the preservation of cultural heritage as part of a cultural and social notion

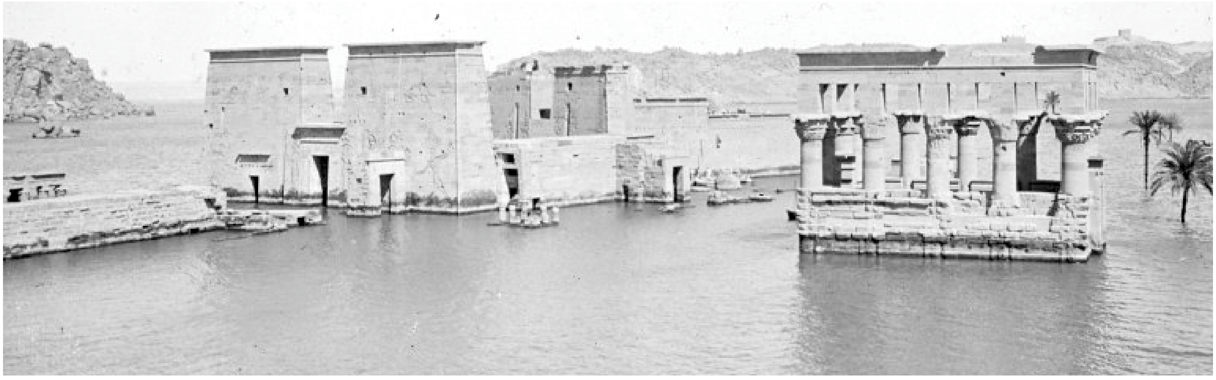


Fig. 1: The temple of Philae was periodically submersed after the construction of the first dam in 1902 (Historical picture, Brooklyn Museum).

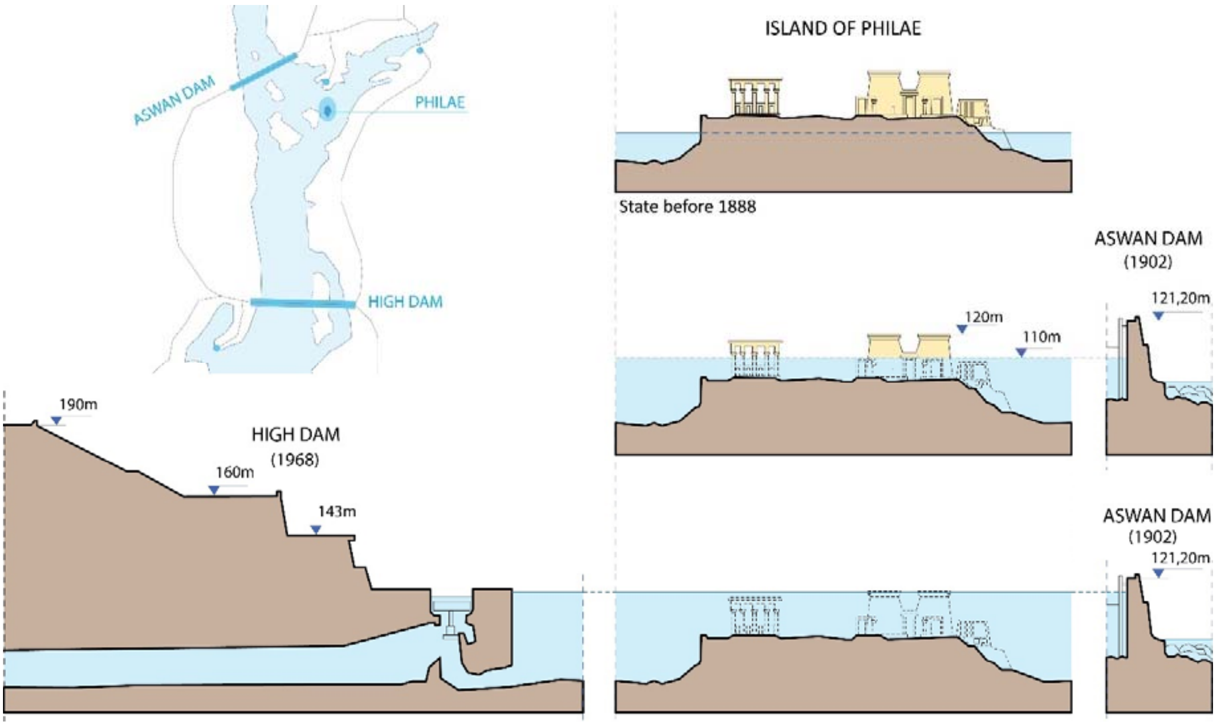


Fig. 2: Schematic plan and sections to explain the effects of the construction of the dams in the case of the temple of Philae (drawing by Del Fabro M., Marchisio V. and Zanardo E. as part of the courses "Digital Urban History" and "GIS and 3D for Cultural Heritage A").

Fig. 3: Three frames of a video clip that shows a virtual reconstruction of the potential submersion of the temple of Philae due to the construction of the High Assuan Dam (3D digital model by Del Fabro M., Marchisio V. and Zanardo E. as part of the courses "Digital Urban History" and "GIS and 3D for Cultural Heritage A").

of sustainability. In this acceptation the awareness of cultural values of the tangible and intangible heritage of the interested territory is very important. It asks for inhabitants as active stakeholders and it communicates new understandings on cultural heritage.

For this reason digital tools are very important in order to collect data and to create a digital environment for accessing a critical historical framework of knowledge. The methodologies of Digital history allow to create new knowledge on cultural heritage as well as the basic context for sharing it. In this framework 3D models can be especially useful for 'modelling' the catastrophe as they make more understandable risks and damages by visualizing possible risk process.

In our article we discuss as a case study the multiscalar process-description of the flooding and environmental change of Nile valley in Nubia following the construction of Aswan High Dam in 1964. In this context 3D modeling and videos have been created in the aim to visualize the risk of damage and the perspective of loosing Nubian temples because of the predicted flooding. Digital history combines 3D modeling with more tools in the perspective of representing the research data and outcomes. The aim of data visualization is to contribute to an inclusive platform for developing new knowledge on such world cultural heritage by creating a critical context of understanding of the past to guide future developments. Historical research includes a collection of heterogeneous materials in order to achieve the multiscalar visualisation of the flooded areas and of the sites saved from flooding.

In our case study the multiscalar process description is a basic approach because it is part of the historical interpretation key of the site. In the multiscalar process description 3D models and videos link the architectural scale of the monuments to the scale of the territory. This multiscalar approach allows to visualize the different elements of an environmental system together with risks and damages to cultural heritage sites.

1.1 Digital History and Visualization tools to accomplish the understanding of disaster risk

Disasters have various kinds of impacts at different scales. Face to cultural heritage and the relationships between monuments and environmental factors, the description of possible effects and consequences of a catastrophe needs to take into account these different scales, from the building scale to its surroundings and to the territory where the extraordinary event takes place. Digital history can help in recreating the framework of the facts and the links to understanding natural and cultural conditions of happenings by shaping a context of interpretation through premises, stakeholders and actors. Furthermore the historical approach looks at the events in a diachronical perspective in which it

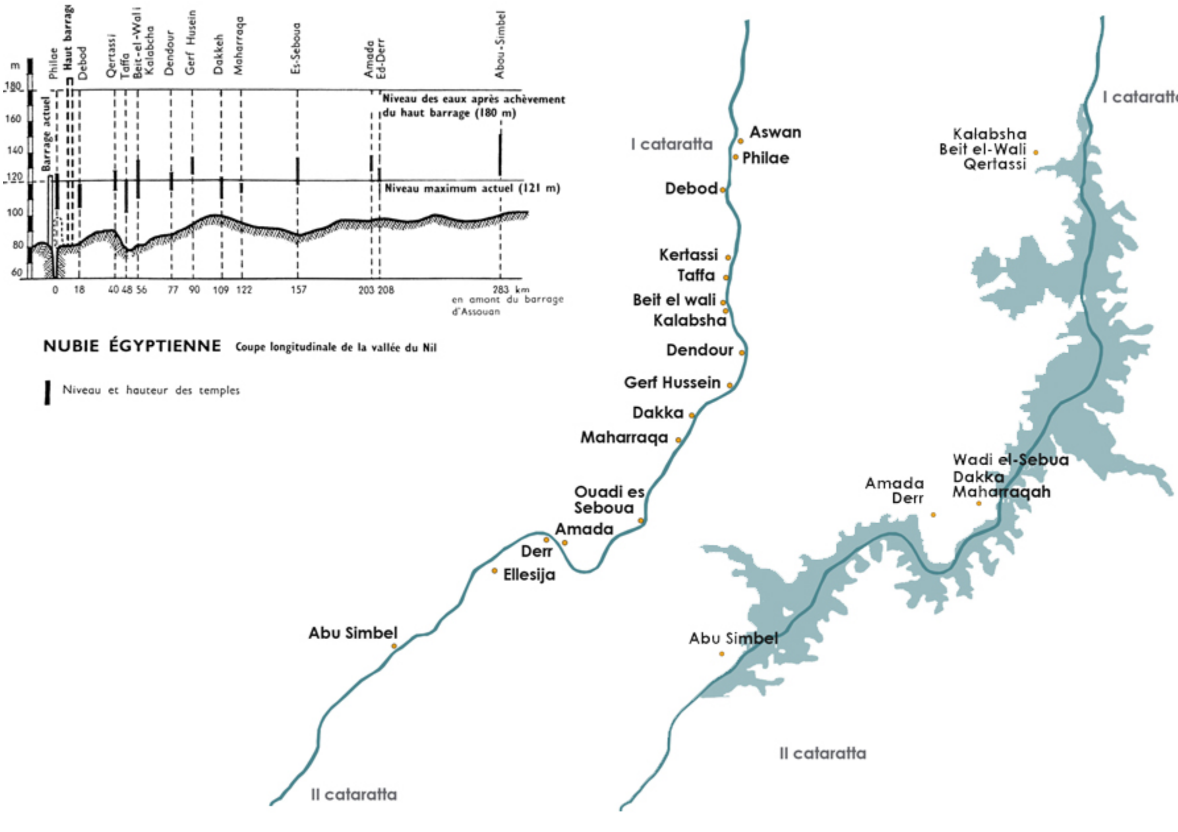


Fig. 4: Graphical elaboration showing the effect of the flooding and the solution to the risk. From left to right, an historical document assessing the risk of submersion of the main temples of the Nile valley, the location of the main temples before the flooding, the current extension of the lake Nasser and the new location of the temples.

highlights and explains the change that a catastrophe represents.
In a long period of slow developments which characterize the history of a territory, the catastrophe is an extraordinary event that represents a break within the continuity of normal developments of a territory. Its effects are on the time and on the space, as it accelerates normal dynamics of change but also provokes special conditions for an historical survey. This shorter extraordinary period could be very important for providing evidence also of the longer periods, as catastrophes also create problems, contrasts, and needs beyond the state of the art. Risks and consequences push to undertaken special acknowledgements or to provide unusual solutions. [4] New documentation is produced and archived as a consequence in addition to the traces left by the ordinary government of a territory. In a way catastrophes provoke very precious sources that enlighten the historical research on different elements and stakeholders playing a role on the event but also on the broken normal condition. A catastrophic event requires to survey and to collect information. In the case of the evidence of risk a huge documentation is even produced before of the event. That was the case of the Nubia where surveys were organized, data collected, architectural drawings commissioned. The catastrophe has been announced some years earlier at the time of the decision (that dates at 1948) of building a new dam. The first dam of the beginning of the 20th century had caused already several changes by flooding partially lands and temples along the river.
Nevertheless the scale of flooding provoked by the construction of High Aswan Dam was completely new and was at the origins of a huge environmental change of the Nile region with the creation of the lake Nasser. Because of the barrage a large territory changed forever by transforming the hundreds years old structure of the river Nile - feeding relationships, functions and people in its valley - into a lake from which people and monuments needed to be removed.
The multiscalar disaster can be analyzed by using a multiscalar process description for studying and visualizing historical changes related to the event and its developments. Digital reconstructions can highlight the flooding in the case of Nubia Temples and its possible consequences. Both the disaster and the risk of damages can be recorded and monitored at the scale of temples, artistic elements (i.e. statues, decorations), till the large portion of territory including villages.
Digital Humanities methodologies have created new prospective for historical research. Documentation can be collected by digital datasets that allow managing a new quantity of data. Data can be spatialized and modeled for returning into spatial-temporal settings all information recorded in written texts, historical cartography and iconographical sources in order to recreate a new scenario of understanding. In the case of catastrophe is especially relevant how to represent historical research by visualizing the dynamics of change. This approach in fact can allow recreating VR of the previous condition in order to recreate a rich framework of information for better understanding the relationships at different scale. It is particularly effective in the case of archaeological remains where 3D models allow to recompose the ancient fragments. Digital modelling is present in many forms in the archaeological process: in teaching and communicating digital archaeology, in modelling the archaeological process, in virtual simulations, for recording and linking data. [5] The possibility of effective use of 3D models is related to the reliability of the model, that can be demonstrated using paradata to give information about human processes of understanding and interpretation of data objects. Without paradata, photorealism - as a computer-based visualisation outcome - has proven to be scientifically misleading. [6] To obviate to this situation, the *London Charter for the computer-based visualization of cultural heritage* underlines the fundamental importance of the Documentation of Process: “documentation of the evaluative, analytical, deductive, interpretative and creative decisions made in the course of computer-based visualization should be disseminated in such a way that the relationship between research sources, implicit knowledge, explicit reasoning, and visualization-based outcomes can be understood.” [7] [8] In the last decade some approaches are under development for exposing the knowledge and research claims made with virtual environments, such as the annotation system developed for VSim, a software prototype for interacting with 3D computer models in educational settings. [9]

1.2. Times and spaces of the catastrophe: the changes of Nubian valley

The catastrophe of Nubia valley and its cultural heritage wasn’t an unexpected event. The times of the catastrophe shapes a period not very short. While the barrage was opened in 1964, , it needs to take into account documents since first political decisions undertaken in 1948 to understand the whole process.
The perception of risk for the monuments provoked the consequent decisions of displacing some of them and the participation of the international community - through the Unesco - in their rescue. The effects of this started in the 1950s and was accomplished not before of the 1980s. It should be noted that the dam was conceived as an improvement of the economic development of these lands. In a way it was presented as a human change that stopped the hazard of the usual natural flooding of the valley of the Nile. [10] Many different beneficial purposes for the uses of Nile water pushed to consider this infrastructure as the best solution for the development. The required ‘large sustained multidisciplinary

effort combining economic analysis, engineering design, and governmental planning' was emphasized at that time from many perspectives. Seasonal water had to be considered for agricultural uses and power generation, and the dam allowed a new effective water resource system. Mathematical analysis and simulation techniques were used for prefiguring a new efficient scenario for irrigation and water-resource economic development. [11] [12]

Effects on cultural heritage also were considered but the needs of fostering the development that could improve life in this region was conceived as an imperative goal. The flooding of monuments consequent of first dam maybe made convinced that the change was something that couldn't be avoided even if since the beginnings of the century the effects have been presented discussed by archeologists. [13]

The High Dam produced several different effects: as risk prevention the relocation of temples; as consequences of the flooding the lost of cultural heritage that wasn't displaced because of lack of money and time; and finally important environment and landscape changes due to the modifications of groundwater layers and terrain, and finally the change of the habitat. The planning of this infrastructure wasn't able to integrate the traditional rural uses of these lands and their populations.

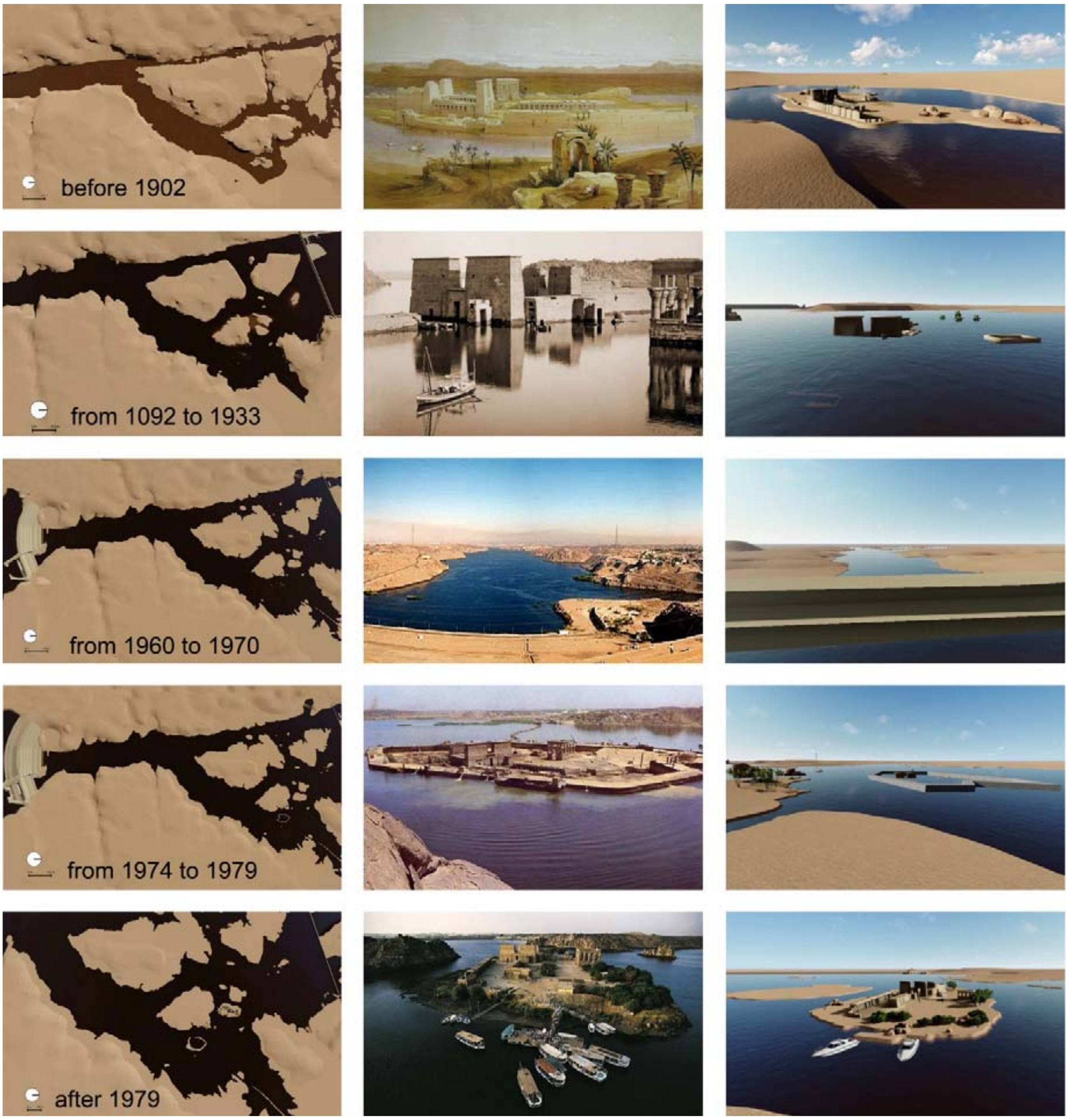


Fig. 5: Graphic elaboration showing the progressive flooding of the region between the first (1902) and the High Assuan Dam and the subsequent displacement of the temple of Philae from the island of Philae to the new island of Agilkya (3d models by E. Aragno, A. Bisoli and F. Fina as part of the courses "Digital Urban History" and "GIS and 3D for Cultural Heritage A").

2. Methodology overview: multiscalar 3D digital reconstruction of the catastrophe before and after the flooding.

The visualization aims to produce some computer-based outcomes: firstly a 3D digital model of the portion of the Nile valley that was submersed by the flooding - before and after the disaster -, and secondly other specific 3D digital models in order to investigate and visualize particular aspects related to the history of the salvage of the main archeological monuments.
The area of interest is the area along the river Nile that now is submersed by the waters of the artificial Lake Nasser, between the first and the second cataract of the Nile, and in particular between the Assuan Dam in the north and the temple of Abu Simbel in the south. The distance between the two sites is approximately 280 km; in such area there were many villages, with thousands of buildings, that have been submersed, and 15 major temples that were saved by displacing in higher sites or in foreign countries.
In this research 3D models are used as a tool to digitally collect, organize and visualize data starting from heterogeneous historical documents. In particular 3D models are conceived and used to study the transformations of the landscape, urban settlements and temples before and after the flooding due to the construction of the High Assuan Dam.
The digital modeling methodology is based on three levels of detail, that correspond to three scales of representation:
level 1 – territory: 3D modeling of the Nile valley as before the displacement of the temples;
level 2 - the building's context: 3D modeling of the temples in their original context;
level 3 – building's subsystems: 3D models of the temples as database and building information models.
The result of these three levels of modeling is the creation of 2D and 3D content suitable for building a comprehensive multilayered model and multimedia products - animations and simulations - both for research and dissemination purposes.

2.2 3D modeling of the Nile valley as before the flooding

The 3D model of the state of the Nile valley before the flooding is based on various historical cartographical sources, in particular the drafts of an aero-photogrammetric survey carried on in 1959 as part of UNESCO campaign, in scale 1:10 000, and maps in scale 1:250 000 printed in 1958-1960 by the US Army.
In order to produce the 3D model of the terrain, three tasks were performed:
task 1.1 - georeferencing of maps (with software open source QGis; the georeferenced maps exported in AutoCad for the digitalization);
task 1.2 - digitalization of maps. The digitalization is mainly carried on the maps in scale 1:10000, using the 1:250000 maps to integrate the missing parts, such as 5 missing drafts and the contour lines above the 182 meters elevation;
task 1.3 - Generation of 3D surface of terrain based on contour lines. The generation of the mesh surface of the terrain is based on the digitalization of the contour lines. In the maps in scale 1:10000 the equidistance of contour lines is 10 meters, with auxiliary contour lines every 5 meters; the contour lines are limited between the elevation of the Nile water surface and the elevation 182 meters. The surface of the terrain above the 182 m elevation is obtained starting from the contour lines of the US Army map (equidistance 50 meters) and from elevation points. The mesh surface is generated with the software Autodesk 3DStudioMax and the plug in Populate Terrain.

2.3 3D modeling of the temples in their original context before the flooding

Task 2.1 - Detection of the original position of temples on the maps in scale 1:10000, when possible. Verification of the hypothesis - through interpretation of historical images and archival documents.
Task 2.2 - 3D modeling of the temples and of adjacent context, on the basis of maps and archival documents. The main elements of modeled context are: terrain, villages, vegetation. The terrain model obtained in the previous task is refined using historical iconography, when existing. The vegetation and vegetation are modeled according to the 1.10000 maps and historical iconography. Currently the villages are modeled only in the areas near the main temples, since a further procedural modeling of the villages constitutes a future work of the project.

2.4 Detailed 3D models of the temples

Task 3.1 - 2D digital drawing according to historical documents. The Level of Detail is variable, from one temple to another, according to the type and reliability of historical documents.
Task 3.2 - Geometrical 3D modeling or BIM (Building Information Modeling) of the temple. 3D geometrical modeling or Building Information Modeling are used in order to associate to building components additional information, such as alphanumerical data (for example date, material, state of degradation, management of restoration, etc.) or other files (for examples images, archival documents, etc.).

3. First results

The project is ongoing, but some remarkable results are evident. The first results consist in an original system of multiscalar 3D models: the 3D model of the terrain as before the flooding, and systematic models of all the 15 temples that were saved, both before and after the displacement from their original site. It is worth considering that, despite some systematic database of 2D drawings was already carried on [14], before the start of the research project there was no certainty about the possibility of creating 3D models of every temple and about the Level of Detail obtainable for every site.

These are preliminary digital models, that are going to be improved in the second part of the project, and consist in:

- 3D model of the terrain surface along the Nile, from Assuan to Abu Simbel, before the creation of Lake Nasser;
- 3D model of terrain, villages and land cover in selected portions of Nile's shores, before the creation of Lake Nasser;
- database of historic data, hypertext, educational videos and 3D models of all the 15 temples, before and after the displacement.

4. Digital Visualization of risk, damage and recovery. Considerations and future works

The effort to create a digital environment for combined visualization and study of the environment at risk, of the damages and of the recovery strategies adopted to save the world heritage of the Nubian temples is giving the first results, but some future works are necessary. In accordance with the Principles of Seville – an implementation of the London charter in digital archaeology - the project underlines that "the environment, landscape or context associated with archaeological remains is as important as the ruin itself" [15]. As a consequence of strong connection between computer based visualization and digital history, future work will be focused in materialize the principles of Scientific transparency: to achieve scientific and academic rigour in this virtual archaeology projects the project plans to prepare documentary bases in which to gather and present transparently the entire work process: objectives, methodology, techniques, reasoning, origin and characteristics of the sources of research, results and conclusions. For this reason we are testing the adoption of the software prototype VSim [16], because the project aims at incorporating metadata and paradata in 3D models, as they are crucial to ensure scientific transparency.

Fig. 6: Some historical documents showing the progressive abandonment and the ruins of the villages along the shores of the Nile (from left to right: frames from the video documentary "Nubie 64" and detail of the survey in 1959).

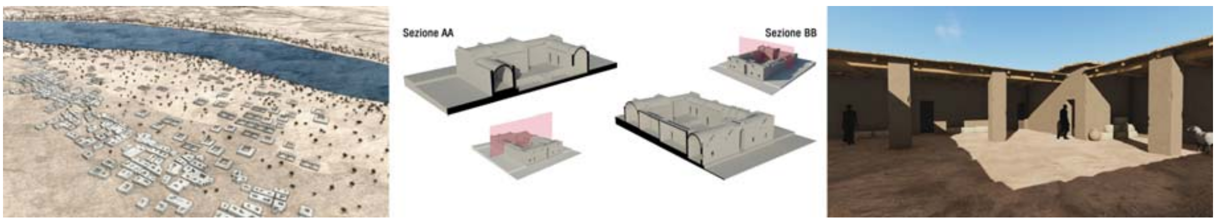
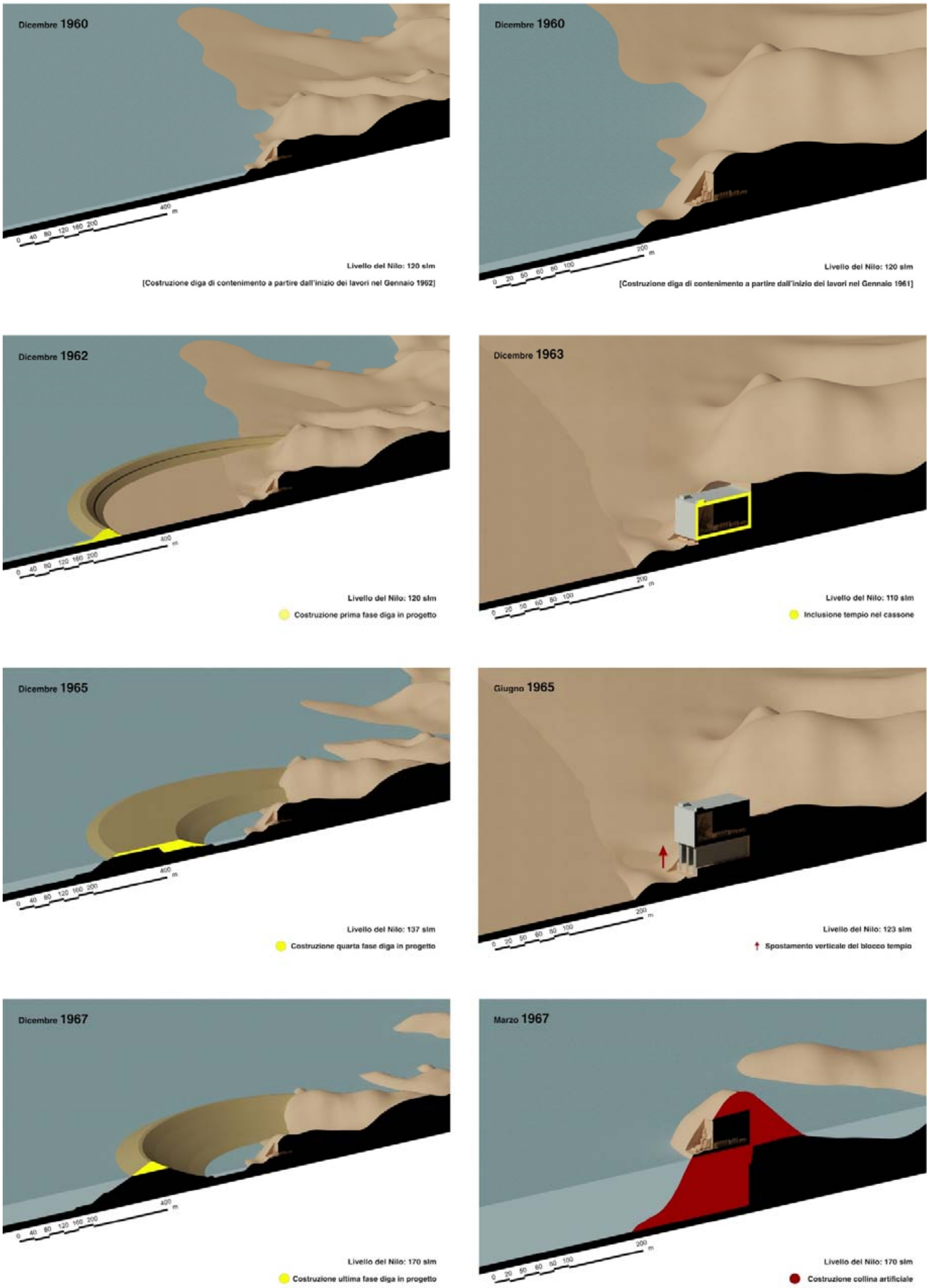


Fig. 7: Digital reconstruction of villages and traditional Nubian houses as before the submersion (3D models by Arato M., Bianco G., Chialva A., and A. Coccolo, C. Blangetti, V. Dutka, D. Rosso, F. Rossi as part of the courses "Digital Urban History" and "GIS and 3D for Cultural Heritage A and B").

French project.
A. Coyne & J. Bellier, 1960

ITALCONSULT project.
Ing. Colonnetti, 1960



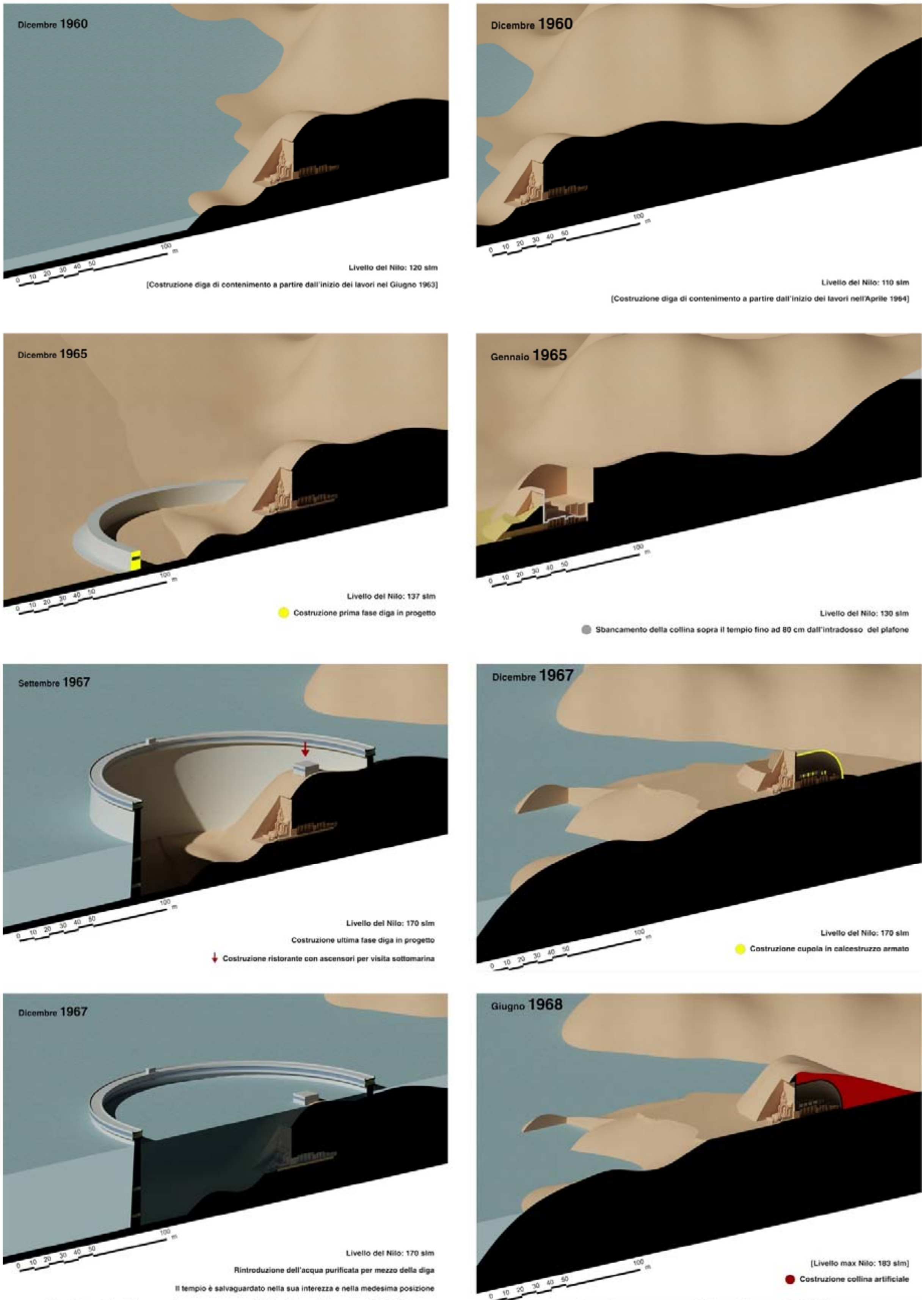
Estimated cost approx. 80 milions US$

Estimated cost approx. 63.5 milions US$

Fig. 8 (a): Graphical elaboration of the digital 3D reconstruction of four alternative projects for reducing the effects of the flooding in the case of the temple of Abu Simbel. Every column refers to a different design hypothesis, with progressive time phases. The reconstruction of digital 3D models allows the comparative visualization and study of the various alternative projects, by overcoming the graphical inhomogeneities oh the historical documents.

English project.
T. Happold, M. Fry & J. Dew, 1963

JOINT-VENTURE project.
"VBB", 1962



Estimated cost approx. 63.5 milions US$

Cost approx. 40 milions US$

Fig. 8 (b): The comparative visualization is achieved by adopting homogeneous graphical standards: axonometric method of projection, identical relative position of plane and center of projection, congruent scale of reduction, similar Level of Detail, similar rendering lights and textures (3D models by P.E. Dalpiaz and G.M. Infortuna as part of the courses "Digital Urban History" and "GIS and 3D for Cultural Heritage A").

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