EU-Project DEMOTEC-A
Work package 2: Pilot GIS development Nemi

Monitoring and risk assessment of monuments and archaeological sites in the Nemi basin, Colli Albani, Italy

Volume 1: Report

26 May 2004
This report deals with risk assessment and monitoring of monuments and archaeological sites, mainly Roman, medieval and post-medieval ruins, in the Nemi basin, Colli Albani, Italy. The Nemi basin has been selected as a model area for the development of a pilot GIS (Geographical Information System) and indicators for cultural heritage monitoring in the EU project DEMOTEC-A (Development of a Monitoring System for Cultural Heritage through European Co-operation, Work package 2).

Following a literature survey of contemporary risk assessment and monitoring of cultural heritage, the system developed for the Nemi basin focuses on single archaeological sites/objects and is based on: 1) General analysis of the history, archaeology and environment in the area; 2) Field recording and assessment of archaeological site/objects using a form/database specifically developed for the purpose; 3) Diagnostic monitoring of objects assumed to be at high risk; 4) Analysis of the data obtained and development of a GIS-based "risk and monitoring atlas" for the Nemi basin; 5) Development of and suggestions for indicators to be used for long-term systematic monitoring in the area.

Special attention is paid to the differentiation between diagnostic and systematic monitoring. The former is considered an aid in understanding specific causes of decay at specific objects and thus has to be put at work with tools, intervals and durations aimed at solving such questions. The latter is regarded an aid for general management issues, for showing trends rather than causes and for, at e.g. 5 year intervals and in the long run, enabling control of whether management goals have been achieved or not.

The report describes both the methodological development and the practical results of the work in the Nemi basin. It is concluded that much remains to be done in terms of conservation, vegetation control and accessibility to sites. The report and the complementary catalogue (vol. 2) can be regard as giving baseline information for the future management and conservation. Work on the Nemi basin as a cultural landscape is carried out by other DEMOTEC-A partners and is complementary to this report.

Preface

The fieldwork on which this report is based was mainly undertaken over a week in May-June 2003, in connection with a DEMOTEC-A workshop in Genzano di Roma. Some work has also been undertaken during short earlier visits in 2001 and 2002, as well as in February 2004. Warm thanks to Giuseppina Ghini, main responsible for the archaeology of the Nemi basin within the Soprintendenza Archeologica per il Lazio and other DEMOTEC-A partners, notably Birgitte Skar, Jørgen Solstad and Torgrim Guttormsen (NIKU), for good co-operation in the field. Also thanks to Annika Haugen (NIKU) for discussions on monitoring themes and database design. Much information on geology, land use and archaeological sites has been provided by Emanuele Loret (ESA/ESRIN) and architect Carlo Testana through the ESA GIS of Nemi/Colli Albani and personal communication. We are very grateful that all this information was made available to us! Moreover, discussions with residents in Genzano/Nemi have also been of great value for our work. Special thanks go to Christine Bläuer Böhm (Expert-Center für Denkmalpflege), Konrad Zehnder (Institute of Monument Conservation, Swiss Federal Institute of Technology - ETH Zurich) and Birgitte Skar for critical comments to the manuscript. When not otherwise stated, all photos in this report have been taken by P. Storemyr.

Supplementary to this report (volume 1) is a catalogue (volume 2) with information and pictures of all investigated objects in the Nemi basin. It should be noted that pictures included in this report are generally not copied in the catalogue (and vice versa). Moreover, a publication on the weathering of the rock-cut chapel of Romitorio S. Michele is under preparation. Thus, only a part of our documentation of the chapel has been included here.

Zurich in May 2004
Per Storemyr

DEMOTEC-A is an acronym for "DEVELOPMENT OF A MONITORING SYSTEM FOR CULTURAL HERITAGE THROUGH EUROPEAN CO-OPERATION (ACCOMPANYING MEASURE)". The project is supported by the European Commission under FP5, and contributing to the implementation of Key Action 4: CITY OF TOMORROW AND CULTURAL HERITAGE. EU-project number: EVK4-CT-2002-80011. Support for the Swiss participation through "BUNDESAMT FÜR BILDUNG UND WISSENSCHAFT" (BBW). BBW-project number: 02.0387

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MORE ABOUT DEMOTEC AT THE PROJECT’S WEBSITE:
www.niku.no/demotec
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Introduction

DEMOTECA aims to establish a network of experts with the purpose to develop a framework for an international monitoring or observation system for comparative assessment of the state of preservation of cultural heritage. The main objective is to initiate the development of a European monitoring system that establishes links between the various scales or levels of monitoring performed at cultural heritage sites today. The basic innovative idea of the project is to develop a better understanding of how monitoring results obtained at different levels relate to each other and how data from different disciplines can be integrated into one monitoring system with a maximum of inherent information at a reasonable price.¹

This ambitious project is a so-called "Accompanying Measure" within the EU 5th Framework programme and has a very short time horizon (2003-2004) – too short to undertake "demonstration"

¹ See project description at www.niku.ni/demotec
monitoring within a case study showing possible ways ahead. Nevertheless, and especially to bring the
discussions in the project down to a practical level, a case study area has been chosen, in which some
monitoring at various levels has already been undertaken. This area is the Nemi crater lake/basin in the
Colli Albani hills near Rome, a part of the Parco dei Castelli Romani and a landscape extremely rich
in archaeological features from the Roman period and later. The most famous features are the remains
of the Diana temple and the Roman ships raised from the bottom of the lake around 1930. The Nemi
landscape is seismically active and also threatened by the combined results of urban expansion (at the
crater edges), abandonment of agriculture and heavy vegetation. A very rich and valuable area from a
geological, biological and cultural point of view, the Nemi basin is protected because of its
biodiversity and is currently considered for nomination as a World Heritage Site.  

This report describes a main task of the Expert Center within the DEMOTEC-A project, which is the
inventory and investigation of archaeological sites, monuments and archaeological/architectural
(decorative) details in the Nemi basin, focusing on risk assessment and monitoring of their physical
condition. This work has been partially undertaken in co-operation with NIKU and leans on former
Italian surveys in the basin, as well as on a recently developed GIS of the landscape by ESA (see
Lenzi 2000, ESA 2002, Loret & Testana 2003). On this basis, the main objective has been to produce
a simple "GIS-ready" database structure for inventory, risk analysis and monitoring of the investi-
gated features. In turn, these data are to be included in a pilot GIS model – covering the monitoring
levels from landscape to architectural decoration – and to be developed by other project partners.

This report (volume 1) is divided in three parts:

Part 1 gives a brief introduction to current monitoring and risk assessment systems applied
internationally for cultural landscapes, urban areas, archaeological sites, architectural ensembles,
single monuments and buildings, and decorative details. Following from this introduction our own
strategic approach to the risk assessment procedures and monitoring efforts are described, as well as
specific methods applied in the Nemi basin.

Part 2 first introduces the Nemi basin, its history, archaeology and environment. Particular weight is
placed on the discussion of various natural hazards, such as earthquakes. Then follows the main results
from our investigations, including assessments and diagnostic monitoring at the object and detailed
level.

Part 3 gives a proposal for long-term, systematic monitoring of monuments/objects in the Nemi basin,
especially for management purposes and for detecting general trends and threats. It is based on a range
of indicators elaborated from various qualitative assessments and quantitative data.

In volume 2 (supplementary to this report) printouts from our database as well as sketches and photos
etc. can be found.

The approach to risk assessment and monitoring proposed is developed primarily for the Nemi basin,
which has been our experimental area. During the development, and following the objectives of the
DEMOTEC-project, we have also had a view to the use of it for more general purposes. However,
much work remains to be done before it can be used also for other purposes.

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2 [www.parks.it/parco.castelli.romani/Eindex.html](http://www.parks.it/parco.castelli.romani/Eindex.html)

3 Parco dei Castelli Romani (undated): World Heritage Convention – Tentative List for Italian Republic: Bacino
del Lago di Nemi, Manuscript
PART 1: MONITORING AND RISK ASSESSMENT STRATEGIES

In this part of the report strategies, methodologies and practical field methods for monitoring and risk assessment of cultural heritage are briefly discussed. We have used a short description of various existing programmes and projects, relating both to the archaeological and architectural heritage, as a starting point. Furthermore, this part contains a discussion of the strategies chosen for the Nemi basin.

Inventory, monitoring and risk assessment today

Inventory, monitoring and risk assessment of monuments and archaeological sites are closely linked fields of study and are carried out at various levels throughout the world. The nature of inventories, as well as of monitoring and risk assessment systems are, however, extremely variable. They range from the basic local, regional, national and international inventories for protection and legislative purposes to monitoring of valuable artefacts and decorations with the most modern high-tech scientific instruments in order to gain insight into deterioration processes and conservation options. In some countries – and also at international level – monitoring and risk assessment of monuments have been systematized for the purpose of understanding what happens in time and space, to raise political and public awareness and to design purposeful intervention programmes. Typical information that can be obtained from such systems range from where and when cultural heritage values are lost, to detailed information on risk factors, conservation interventions and prognoses for the future.

When broadly interpreting the terms monitoring and risk assessment, the following list of various systems may serve as examples of what is going on in various countries and at international level today ("pure" inventories, which can be found in practically all countries/regions are omitted, as are short-term archaeological monitoring during e.g. rescue excavations): 4

International programmes, especially related to heritage in danger

UNESCO World Heritage Centre: "Periodic reporting of world heritage sites” and the "List of World heritage in danger". A digital, internet-based tool for periodic reporting developed by the Nordic World Heritage Foundation in co-operation with GRID-Arendal (Norway) is, as far as we are concerned, in the testing phase. More info at: http://whc.unesco.org

ICOMOS: The "Heritage at Risk" programme, which includes annual national and thematic reports on cultural heritage in danger. This reporting is still in its starting phase, but is gaining in importance. So far, only written reports are provided (to be downloaded from the ICOMOS website).

National monitoring programmes for cultural landscapes

Norway: The 3Q project at the Norwegian Institute of Land Inventory. This is a national monitoring programme (based on sample inspection of aerial photos at five-year intervals) providing statistics on landscape spatial structure, biodiversity, cultural monuments and public accessibility in agrarian cultural landscapes. http://www.nijos.no/English/landscape.htm

There will be many more similar monitoring programmes throughout the world. Moreover, the Italian Risk Map for

4 The examples have been found mainly through surveying the Internet using "Google".
monuments and sites has a view to the landscape, insofar that it includes the assessment of territorial risk factors (see below).

National monitoring and risk assessment programmes related to monuments and sites

Australia: Environmental indicators for national state of the environment reporting – Natural and cultural Heritage. This is one of the very few examples of the systematic use of indicators for monitoring of cultural heritage. The indicators developed are rather simple, such as "Number of places destroyed or whose values have been severely diminished" or "The number of heritage places assessed (by sampling) as being in (i) good, (ii) average and (iii) poor condition". As can be seen, this type of monitoring is based on sampling, for which a questionnaire is used, and five year monitoring intervals. [http://www.ea.gov.au/soe/heritage/](http://www.ea.gov.au/soe/heritage/) See also: "Environmental Indicators For National State of the Environment Reporting natural and cultural heritage Australia: State of the Environment Environmental Indicator Report" (By Pearson et.al. 1998, can be downloaded from the above-mentioned website.)

Norway: Since 1997 the Directorate for Cultural heritage has conducted state-of-preservation surveys of automatically protected monuments and sites (from the time before 1537/1649; the latter year concerns buildings), comparing their condition with what was registered 20-40 years ago. 16 municipalities are included in the survey, which shows that the yearly loss of archaeological monuments reaches about 1% (of a total of 300,000 monuments nationwide). The 2008 target for loss is 0.5%. The state-of-preservation surveys must be regarded unique in an international context. More information: "State of the Environment Norway" [http://www.environment.no/templates/PageWithRightListing____2133.aspx](http://www.environment.no/templates/PageWithRightListing____2133.aspx). For the latest reports, see [http://www.niku.no/index2.asp?LanguageCode=9](http://www.niku.no/index2.asp?LanguageCode=9). For a description of the programme in Norwegian, see [http://www.riksantikvaren.no/nyheter/nyhetsarkiv/2003/20030911_rapporter.htm](http://www.riksantikvaren.no/nyheter/nyhetsarkiv/2003/20030911_rapporter.htm)

UK: HBSMR – "Historic Buildings, Sites and Monuments Record" is a comprehensive database, GIS and photographic data management system for the historic environment (monuments and sites). It also includes a simple monitoring module based on in-situ survey. The aim is to build up a history of site visits for properties that need regular monitoring, as well as to show a history of damage and the impact it has caused. A more comprehensive field-monitoring module is at the planning stage. [http://www.esdm.co.uk/HBSMR.asp](http://www.esdm.co.uk/HBSMR.asp), [http://www.english-heritage.org.uk](http://www.english-heritage.org.uk)

UK: The "Care of Cathedral Measure" and "Quinquennial Reporting". The "Quinquennial Reporting" is a traditional, "paper-based" system, in which condition is assessed, conservation work planned and status reported on a regular five-year basis. It’s a rather simple system, well secured by law and seems efficient for practical conservation purposes. [http://www.hmso.gov.uk/measures/Ukcm_19900002_en_1.htm](http://www.hmso.gov.uk/measures/Ukcm_19900002_en_1.htm) [http://www.buildingconservation.com/articles/quinquenn/quinquenn.htm](http://www.buildingconservation.com/articles/quinquenn/quinquenn.htm)

Egypt: The Egyptian Antiquities Information System (EAIS). This is a new GIS within the Supreme Council of Antiquities aiming at an overview of monuments and sites (GIS-based inventory) and a simple assessment of the risks threatening the Egyptian heritage. It does not yet include monitoring at regular intervals. [http://www.eais.org.eg/default.htm](http://www.eais.org.eg/default.htm)

Italy: The Italian Risk Map Project. This is probably the most advanced system for cultural heritage inventory and risk assessment worldwide, insofar as it is a systematic inventory of large parts of

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5 The system also includes information on the values of heritage places, whether the existing documentation is appropriate, whether there is appropriate funding for conservation etc. This must be regarded an advanced and meaningful approach, but is not a topic of this report.
the Italian territory, at the moment comprising some 60,000 monuments and sites. Simultaneously, it includes a systematic (numeric) evaluation of territorial risk factors, such as earthquake, flood, avalanche, agriculture, urban expansion, depopulation, tourist pressure etc. It also mathematically combines these two sources for assessing risks at monuments and sites, but on a very "coarse" level. Thus, it is on the one hand a very systematic normal inventory (broadened by the inclusion of condition evaluation), and on the other hand an advanced environmental GIS. The Risk map is secured by law; has one central working unit and several regional units. It does not yet include a special module for regular monitoring. http://www.icr.beniculturali.it/rischio/rischio00e.htm & http://www.uni.net/aec/riskmap/english.htm

**Regional and local monitoring and risk-assessment projects** (there are many, many more)

Italy: ArcheoRisk: a Decision Support System on the Environmental Risk for Archaeological Sites in the Venice Lagoon. This is a project with a somewhat similar design as the Italian Risk Map. It collects environmental condition info and, combined with an inventory database of archaeological sites/objects, it undertakes GIS based risk analyses related to the sites/objects. The structure of the system can serve as an example of the typical layout of GIS-based risk assessment projects (fig. 2).

![Fig. 2: The general GIS design of the ArcheoRisk system for the Venice lagoon. As can be seen, focus is at collecting information to be used for risk analysis and to facilitate intervention planning. The upper part of the figure is also relevant as a very general illustration of the Italian Risk Map. Figure from Carlon et.al., see footnote 5.](image)

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USA: The Big South Fork National River and Recreation Area. Here, a monitoring programme of archaeological sites was undertaken in 1986-89, especially in order to prevent looting. The system was based on park staff undertaking the fieldwork and had an important view to raising awareness in order to prevent looting. The monitoring programme enabled the definition of what type of looting is carried out, and the conclusion was that education is the most important means of prevention.7

UK: In connection with the new plans for management and presentation of the World Heritage Site of Stonehenge (see one of the many websites dealing with Stonehenge: [http://www.britarch.ac.uk/stonehenge/](http://www.britarch.ac.uk/stonehenge/)), much inventory and monitoring has been carried out. In the "Archaeological Site Monitoring Surveillance Report" from 1999, themes such as which sub sites has survived until the present, stability/deterioration, vulnerability, causes of damage, land cover etc. has been included and statistically analysed for help in further management and conservation. An introduction to this work (and other work related to Stonehenge) can be found in the presentations from a meeting in 2000: "Stonehenge and the roads"8.

Tibet: The Lhasa Atlas. A combined inventory and extraordinary monitoring programme of the very sad and rapid destruction of the historical core of Lhasa. The programme, undertaken by a university network Tibet-Norway and NGOs, follows the extreme urbane expansion of Lhasa and the demolition and destruction of cultural heritage practically in real-time. This is done in order to raise public awareness and fight the destruction. In addition it has a very important historical component, insofar as it, through historical plans, photos, satellite images etc., has followed the development over the last 100 years or more. This programme is based in the InterSAVE model (see below).9

Denmark/International: The InterSAVE model. "The system is a fast way of providing a view of the situation of the architectural heritage in an area which is under change. It is not particularly profound, but on the other hand the fabric of the towns is transformed in a more radical and accelerated way than hitherto known, so the time factor does not allow a procedure of long duration. The procedure should be compared to "rescue excavations", known from archaeology" (from booklet, see: [www.sns.dk/byer-byg/Netpub/INTRSAVE/TEKST/CONTENTS.HTM](http://www.sns.dk/byer-byg/Netpub/INTRSAVE/TEKST/CONTENTS.HTM)). The InterSAVE model consists of three work phases (fig. 3): 1) Preliminary investigation, including collection of historical data of the area/townscape in question in order to detect changes and risks; 2) field work following a simple procedure for assigning the values and condition of single buildings and architectural ensembles; 3) the production and publication of the "preservational atlas" – a document that is meant as an aid in further urban planning. The system uses databases and GIS for data storage and retrieval, and so far preservational atlases have been published in 60 Danish cities. It has been awarded for its success in Denmark and adopted in several other European cities. ([http://www.kuas.dk/museer/kulturmiljo/kommuneatlas/arkitekturpris.htm](http://www.kuas.dk/museer/kulturmiljo/kommuneatlas/arkitekturpris.htm)).

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8 See especially the presentation by Keith Rowe: The Stonhenge Estate” at [http://www.britarch.ac.uk/stonehenge/Stonehenge%20Roads%20NT.pdf](http://www.britarch.ac.uk/stonehenge/Stonehenge%20Roads%20NT.pdf)

Monitoring projects related to decorations of monuments

Switzerland: As far as we are concerned, in the field of the decorative dimension of monuments (e.g. facades, mural paintings and sculpture), no special, long-term national programmes exist as of today (with the possible exception of the UK Quinquennial Reporting). However, there is a wealth of smaller projects and dedicated work in this field throughout the world. One example is the work of our own institution and our partner, The Research Group for Monument Protection at the Swiss Federal Institute of Technology (ETH). Since the 1970s regular monitoring work has been carried out at a large number of Swiss monuments, especially related to mural paintings. At this level, monitoring is usually carried out with the help of visual inspection, photography, infrared thermography and various measurements (especially indoor climate logging) in order not only to detect changes, but also to understand the causes for the decay and plan sustainable, small-scale interventions and maintenance. Models for such monitoring have been developed especially with regard to salt activity and its climatic dependence.\(^{10}\)

Definitions of monitoring and risk assessment

The systems, programmes and projects mentioned above have in common that they mostly aim at understanding and showing what is taking place with regard to the physical condition of cultural heritage,\(^{11}\) usually (but not always) in high-risk areas, and in order to be able to properly react for preserving and managing cultural heritage values. In this respect a very general definition of monitoring might be:

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\(^{11}\) It is of course also possible to include other heritage aspects than physical condition in monitoring programmes. Such aspects are e.g. knowledge of heritage, the existence of oral traditions, heritage and identity etc.
Monitoring means the regular recording, evaluation and reporting of the condition of cultural heritage. This is done in order to show threats and trends (systematic monitoring) and/or to understand the risks of destruction and decay (diagnostic monitoring) and to reduce these risks by adapted indirect and direct measures. Monitoring is thus an essential instrument for management and preventive conservation of cultural heritage.\(^{12}\)

Many of the above-mentioned programmes and projects do not include monitoring as a regular activity, but are more occupied with defining, analysing and managing the actual risks threatening cultural heritage values. On the other hand, such risks are often the sole reason why monitoring is carried out in other programmes and projects. Thus, one also needs to define terms related to risks. David Ball and John Watt has outlined the following helpful thesaurus:\(^{13}\)

- Hazard – a situation which could cause harm e.g. a stockpile of nuclear waste; an earthquake fault line; a worn stair case; an excess of visitors
- Risk – the probability that a certain kind of harm is realised e.g. the probability of fire
- Risk assessment – the activity of identifying hazards and assessing the likelihood of harm
- Risk management – the decision making process following on from risk assessment

For our purpose, as seen from the perspective of the physical qualities of cultural heritage, a possible definition of risk could then be:

\[
\text{Risk is the probability that a certain harmful event (hazard) or process might take place within a certain time span. The actual destructive effect of the harmful event or process is related to its intensity and the vulnerability of the cultural heritage asset in question.}
\]

Thus, in order to assess risks – be it related to natural hazards such as earthquake, anthropogenic hazards such as aggressive urban expansion, or "normal" decay such as salt weathering – one has to consider both the probability of the event or process, its intensity, and the vulnerability of the object. If considering only one of these issues, there is a great likelihood that the assessment has little to do with practical realities. Another question relates to methodological approaches needed for sound assessment. These will be very different with regard to the actual situation at hand, and thus must be addressed in this perspective (see later in this report). For example, it is clear that the vulnerability – and usually also the risk of damage – of a valuable mural painting are very different from, say, a simple masonry wall. Thus, the assessment of vulnerability and risk has not only to consider the technicalities of an object, but also the values at stake.

Finally, risk assessment can perhaps be compared to a prognosis or a hypothesis: In order to verify or falsify the hypothesis one needs further investigation and monitoring of the evolution. If the monitoring can confirm the initial risk assessment, then things are fine (or bad), and if not, the hypothesis or risk assessment will have to be reformulated.


Present purposes and geographical levels of monitoring and risk assessment

Considering again the various monitoring and risk assessment programmes and projects mentioned above, their design is very different, which primarily reflect their different objectives, but also the kinds of risks present in the various settings they are carried out. In view of their general purposes, these may be summarised like this:

- For general environmental planning, in which cultural heritage is included, and related to landscapes, sites, townscapes and cities
- As an aid in general cultural heritage management, closely linked to the basic inventory work, at international, national and regional level
- For the (scientific) understanding of decay and destruction ("diagnostic monitoring") and as an aid in practical conservation work (related to sites, single monuments and their decorative details – mainly the local level)

Although there are gradual transitions between these purposes, in view of the methodological approaches of the various mentioned projects and programmes, they show immense differences. For example, it needs an entirely different approach to develop condition and pressure ("risk") indicators for a vast amount of heritage sites in the Australian Outback than to design a monitoring programme for saving a few mural paintings in Alpine medieval churches. In the first case, as we have seen above, it may be possible and sensible to use representative sampling procedures in order to be able to cover a large territorial area, whereas in the latter case one has to think in terms of detailed mapping and measurement methodologies. Other examples illustrating the different objectives of monitoring are reflected in various specific goals, e.g. at a national level "to reduce the loss of cultural heritage values per annum from 1 to 0.5%"\(^\text{14}\) or at a single monument "to stabilise the indoor humidity at 60%".

The different methodological approaches are thus not only related to the purpose of the monitoring or risk assessment programme, but also to the geographical level at which it is carried out. Such geographical levels may probably be defined in many ways; one possibility would for instance be:\(^\text{15}\)

- The landscape level (e.g. cultural landscapes, townscapes and cities – the "transformed natural landscape")
- The site level (archaeological sites, building ensembles etc.)
- The object or monument level (typically a building, a ruin or another archaeological feature)
- The detail, often the "decorative" level (a decorated façade, a mural painting, a sculpture etc.)

These geographical levels are all surrounded by the anthropogenically modified environment as a "whole", including the lithosphere, the biosphere and the atmosphere. Data on the evolution of the environment as a "whole" in a specific area are vital for the consistent interpretation of monitoring results at all the other levels. However, primary data on the environment as a "whole" are traditionally not collected by professionals within the field of cultural heritage,\(^\text{16}\) but obtained from other information sources, including geography, demography, infrastructure, land use, vegetation patterns, climate, weather and air quality, atmospheric and geological hazards etc.

\(^{14}\) As in Norway, see [www.environment.no](http://www.environment.no)
\(^{15}\) Adapted from the project description of DEMOTEC, see [www.niku.no/demotec](http://www.niku.no/demotec)
\(^{16}\) This is gradually changing, especially with regard to cultural landscapes, and as cultural heritage is becoming an important part of environmental planning in most countries.
Usually, such information, and of course first of all topographic maps, will represent the basis in e.g. a GIS-based monitoring system for the landscape and site levels (as in the Italian Risk Map). For the other, "lower" levels (object, detail), at which GIS-based data representation is currently much less developed, such information is of course also a necessity for interpretation and decay/risk assessment, especially with regard to the impact of weather, air quality and geological hazards.

**Tools and methods for monitoring and risk assessment at regular intervals**

Although gradual transitions exist, the actual practical tools and methods used for monitoring of the actual condition (and assessing risks) at the various levels are essentially different. The exception is manual survey and field checks, including various kinds of photography, which are undertaken with variable resolution at all levels. Moreover, the landscape level is probably the only level at which representative sampling is very systematically carried out. At the other levels monitoring is on the one hand carried out as "global overview surveys" and on the other hand directed towards known or assumed risk zones (or most damaged or vulnerable areas). Otherwise, some of the most typical methods used at regular intervals might be:

- **The landscape** level: Interpretation of satellite images and aerial photographs. Statistical analyses on the basis of representative sampling is also much used (cf. the Norwegian 3Q programme).

- **The site** level: Interpretation of aerial photographs and satellite images is increasingly used, but probably not yet very systematically. Manual survey and various kinds of manual thematic mapping are still the most important source of information. However, the efficiency of manual survey methods has increased due to the application of (differential) GPS and GIS on this level (also applicable to the landscape level). Moreover, methods such as ground-penetrating radar gain in importance for covered or assumed archaeological sites.

- **The object** level: Although the SAR satellite/radar technique now offers the possibility of regular settlement analysis at the mm level for single buildings, such advanced remote sensing techniques are still much too expensive for broad application. Thus, at the object or monument level visual inspection, manual (often digital) mapping methods and photography are still by far the most important. The use of measurements and logging techniques are also essential at this level. Typical examples include crack-, settlement and microclimate logging.

- **The detail** level: This is the level of very detailed (often digital) mapping of damages, regular high-resolution photography and the use of a wide variety of scientific measurements (usually non-destructive) and physical, chemical, biological and mineralogical analyses. One of the most

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17 See references in the first chapter of this part of the report.


19 See website of Tele-Rilevamento Europa: [http://213.215.195.35/tresite_eng](http://213.215.195.35/tresite_eng). This technique has been applied for single buildings in e.g. Milano.
important advances at this level is combined monitoring of salt crystallisation periods and indoor climate.  

Fig. 4: Examples of "retrospective monitoring" of cultural heritage at the landscape level and the detail level. Left: The expansion of urban infrastructure in Aswan (Egypt) between 1965 and 2003 seriously threatens the famous ancient stone quarries in the area. Data collected from US declassified satellite images, IKONOS satellite images, topographic maps, literature on site locations and field inspection. 

Right: Mural paintings in the small church of Zell (Zurich, CH). The paintings were in very good condition until a restoration in 1959, when heating was installed. This caused severe salt crystallisation, which has almost ruined the paintings. Historic photos from the Cantonal Cultural Heritage Authorities in Zurich.

Monitoring intervals and the historic dimension – retrospective monitoring

The selection of appropriate monitoring intervals is essential in order to detect actual changes, threats and trends. Moreover, the much overlooked historic dimension of the physical condition of cultural heritage is a vital source of information in order to interpret the current state and give prognoses for the future.

Currently employed monitoring intervals differ greatly at the various levels. Whereas at the landscape- and site levels typical intervals for e.g. manual survey and the interpretation of satellite images are 1-5 years or more, the logging of indoor climate typically takes place at 1 hour intervals. Thus, the selection of appropriate monitoring intervals is again strongly dependent of the objectives of the programme and the methods employed.

Understanding the present risks at hand and the causes for the current state of cultural heritage are essentially historically based fields of investigation. It is e.g. impossible to understand the evolution of a landscape, as we shall see in the Nemi case, without reference to historical events and processes. Luckily, there are many sources of information for what could be called "retrospective monitoring" (or the reconstruction of historical events and processes having led to the present situation). On a landscape- and site level old aerial photographs (or satellite images) might be available, old photos of a building or a mural give information on damages that were there already a hundred years ago – or appeared recently (see fig. 4). Likewise, paintings, reports, diaries etc. give the kind of information necessary for detecting the long-term evolution of the condition of cultural heritage. Thus, a very important task within monitoring programmes is to make such historical information available and, when possible, integrate it with e.g. a database system or GIS.

General considerations for the design of a monitoring and risk assessment programme for the Nemi basin

The main task of the Expert-Center within the Nemi basin, chosen for practical monitoring purposes in the DEMOTEC-A-project, has been to develop a risk assessment and monitoring programme for the physical condition of objects/monuments, of which there are c. 60 in the area, as well as their decorative details. Monitoring with regard to the landscape level has been the task of other project partners (NIKU, NINA and ESA). Thus, the overall objective of our investigations was to contribute to a wider monitoring programme considering all levels and to be developed into a pilot monitoring model for the Nemi basin – a model that might be of help for – or give ideas to – others when planning local and regional monitoring programmes with regard to the physical condition of cultural heritage.

23 See also "The Lhasa Atlas" (op. cit.) for the use of this technique at the "townscape" level. The InterSAVE method (op. cit.) uses this technique systematically, and it is also in widespread use at archaeological sites and at object level. For the use at objects and details, see e.g. Storemyr, P. (1997): The Stones of Nidaros. PhD-thesis, Norwegian University of Science and Technology, and Storemyr, P. (2003): Weathering of Soapstone in a historical perspective. In: Broekmans, M.A.T.M, Jensen, V. & Brattli, B. (eds.): Proceedings, 9th Euroseminar on Microscopy Applied to Building Materials, 9-12 September, Trondheim, Norway. Extended Abstract in Proceedings, full paper on CD-ROM.
The main purposes of "our" part of the system as seen from the perspective of actual needs in the Nemi basin have been:

- It should be useful for the archaeological (Soprintendenza Archeologica per il Lazio, SAL) and architectural (Soprintendenza per i beni architettonici e per il paesaggio, per il patrimonio storico, artistico e demoetnoantropologico per il Lazio) cultural heritage authorities and constitute a basis for further, long-term monitoring efforts in the area, showing general threats and trends. Thus, it should be a tool for the general management of the area.
- In addition, it should address damage and decay at single object level, in order to understand their causes; thus be a tool for practical restoration and conservation activities.

Moreover, the system should be helpful for ourselves and aid us through the limited periodic observations we could possibly carry out during the short project period (two visits to Nemi in 2003-2004 + two visits in 2001-2002, consisting all together of c. 2 weeks of fieldwork). Thus, since we could not undertake comparative monitoring over long time spans, we decided to split the monitoring activities in two parts:

- Undertake diagnostic monitoring during the project period, based on periodic observations and measurements of objects and details at risk and in order to, as far as possible, understand causes of damage and decay. This diagnostic monitoring should also constitute examples of how similar activities can be undertaken by SAL and others in the future.
- Develop a basis for systematic, long-term monitoring in the Nemi basin – a system closely linked to management needs and showing trends rather than specifically addressing causes of damage and decay. This should include as much baseline information as possible, and enable comparative monitoring in the future, e.g. at intervals of 5-10 years. Since an ultimate aim of the DEMOTEC-A project is to develop indicators for such monitoring, we decided to embark on this issue after having collected enough baseline information to be able to understand the Nemi basin cultural heritage and environment.

The main practical requirements of the system to be developed were:

- It should be based on filing of observations in a database, which in turn should be "GIS-ready" (point registrations) for analysis and interpretation together with data from other levels (landscape, site). This procedure can be compared with the ArcheoRisk approach.
- It should be as simple as possible with regard to filing of observations, thus as little time consuming to put into practice as possible.

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24 It should be noted that the authorities did not ask us to develop a monitoring system, and has been only little involved in designing the programme. However, Giuseppina Ghini (SAL), responsible for the archaeology of the Nemi basin has very much encouraged us to develop a system for practical monitoring purposes in Nemi (and granted us all necessary permissions). Our main contact with the authorities has been G. Ghini. Permission for work in the Romitorio S. Michele came from the architectural authorities (Ms. Marina Cogotti), with which the Romitorio is registered.

25 The two visits in 2001-2002 were not part of the DEMOTEC-A project, but of a forerunner of the project. The actual monitoring programme was thus not developed before the start of the DEMOTEC-A project in 2003.


28 See fig. 2, only upper part of this figure is relevant in our case.
• It should be carried out by professionals in the field and not be based on teaching of volunteers or others without knowledge of decay and conservation.
• It should mainly address archaeological remains (objects such as Roman ruins, ancient caves and cisterns) and their details, since there are very few architectural monuments left in the Nemi basin.

Given these objectives, purposes and requirements, we adopted a general strategy based on addressing all objects in the Nemi basin (or as many as time permitted). Thus, we did not engage in sampling strategies, as e.g. in the Australian "Indicators for Heritage Sites". 29

The general fieldwork method we more or less intuitively adopted was based on "finding the archaeological remains at risk". This means that we used the actual condition of the objects, as well as an assessment of the assumed threats to them, as the core part of our system. This approach has much in common with defining risk zones – or "the problem" – at buildings and their decorative details developed by Andreas Arnold. 30 Its main idea is that it is not necessary to address all traces of damage and decay in the same manner, but first of all detect those that seem to be active, i.e. obviously having a rather high decay rate or otherwise be at risk. Moreover, diagnostic monitoring throughout the project period was applied in order to better understand such risk zones and objects at rather high risk.

The fieldwork was supplemented with research on the historical and archaeological background of the Nemi basin, its geology, geological hazards, vegetation and agriculture and other issues relevant for understanding and explaining our findings. For this purpose information gathered by other projects members were very helpful, especially existing GIS-information collected by ESA. Also retrospective monitoring proved to be very useful.

Our method has elements in common with many of the programmes and projects described in the first part of this report, but it is perhaps first of all similar to the InterSAVE method. 31 This method considers architecture in urban settings, whereas we had to deal with archaeological remains in an overgrown landscape in a volcanic crater. Moreover, the InterSAVE methods is not particularly profound with regard to actual condition of structures investigated; it places more weight on assessment of values, whereas our approach is strongly occupied with condition and risk assessment. However, the fact that the InterSAVE method is developed for rapid assessment of relevant information in often high-risk areas with many objects makes it comparable to our approach. Furthermore, the three phases of the InterSAVE method (see fig. 3) are more or less identical to our way of working:

1. Preliminary investigation (carried out throughout the project)
   • Landscape investigation, including geology, geological hazards, vegetation, agriculture etc.
   • Historic analysis (literature research), including retrospective monitoring
   • Archaeological observation

29 op. cit.
30 Arnold, A (1993): Methodology of the Study on Decay, Weathering and Conservation of Monuments. Stone material in monuments: diagnosis and conservation. Second course, C.U.M University School of Monument Conservation, Heraklion, Crete, 24-30 May 1993, pp 11-16. This method is also advocated in the Council of Europe Recommendation No. R (97) 2 Of the Committee of Ministers to Member States on Sustained Care of the Cultural Heritage Against Physical Deterioration Due to Pollution and Other Similar Factors (Adopted By The Committee Of Ministers On 4 February 1997, At The 583rd Meeting Of The Ministers' Deputies), see http://cm.coe.int/ted/dg1/rec/1997/97r2.html. Moreover, it can bee regarded part of the risk management process suggested by Ball & Watt 2001, fig. 1, op. cit.
31 op. cit.
2. Fieldwork (carried out in specific project phases)
- Archaeological baseline information (e.g.: "where are the sites?")
- Mapping and registration using a form/database specifically developed for the Nemi work
- Diagnostic monitoring of objects at high risk

3. "Atlas" of the Nemi basin (presented in part 2 of this report)
- Analysis of the landscape, history and archaeology
- GIS-based maps of various themes related to setting, condition, risk assessment and diagnostic monitoring
- Database and photographic information related to all objects and details investigated (to be found in vol. 2, the catalogue).

The above-mentioned investigations relate to what we have actually carried out in the Nemi basin. All the information collected and interpreted can, however, also be regarded as baseline information for a systematic, long-term monitoring programme for detecting general trends and threats. Since the long-term monitoring is to be based on the use of indicators, we needed to build the registration form and database for filing registrations with this aim in mind. Moreover, we needed to have a rough idea of an approach towards indicator development. Although we did not engage in sampling procedures, the approach adopted for the actual indicator development (shown in Part 3 of this report) is very similar to the Australian system described in Part 1 of this report.³²

Registration form developed for the Nemi basin

Initially, we planned the development of a relational Microsoft Access database for the filing of registrations made in the Nemi basin. The idea was to use the site level as the starting point and develop registration and monitoring modules for the object level and the detail level, respectively. However, since the number of sites and objects in the Nemi basin is limited and there are very few decorative details, and especially because the project had such a short time span, we decided not to spend the time programming a complex database. Instead, we decided to make a simple and flat Filemaker Pro database with the object as the primary key and rather use the time for considering which kind of information would be needed according to the work method developed. This database, and simultaneously our registration form, is described below.

The registration form/database include five main "modules", of which the 1-4 include baseline information for a long-term monitoring programme and 5 the actual diagnostic monitoring carried out. (see also tab. 1):

1. Site and object information
2. Initial condition assessment
3. Initial risk assessment
4. Initial recommendations
5. Diagnostic monitoring (as applicable to the actual diagnostic monitoring carried out by ourselves)

1. Site and object information is kept at a rather superficial level and based on normal inventories for cultural heritage. It does, however, not contain information on the values, significance and authenticity of the objects in question, nor on legal protection status (since we did not have this information at the time of entering data). However, given that the Nemi area is under protection and that we are considering mainly archaeological remains from the Roman, medieval and some later periods – remains that in many ways are strongly related to each other, most of them must be regarded very significant and of high historical value.

2. Initial condition assessment is based on the assessment of two different issues: 1) the physical condition of the object and its decorations; 2) the state of the site management. For the physical condition we have assessed themes like static stability, roots bursting and weathering, whereas themes like access, gates, protective roofs and vegetation have been included in the state of the site management.

Initial risk assessment is divided in two categories: 1) Hazards relevant to the Nemi basin (earthquake, rock slide/rock fall, landslide and bushfire); 2) Decay, which may or may not be connected with hazards, but relevant to the objects, such as risk of collapse, risk of root bursting, of weathering etc. Initially, we planned to include a category related to anthropogenic risk factors; i.e. risks caused by human intervention/action in the immediate surroundings or at the sites, such as agricultural development, actual use of some objects as storerooms, inappropriate vegetation management by local owners etc. We realised that we had much too little knowledge of the local situation and the preservation regulations in the area to be able to quickly assess such risks. Moreover, some of these risks (especially related to agriculture) are also intended for coverage by GIS information on the landscape level, to be assessed by other project partners. In addition to hazard and decay, we have also included a category called "risk for people" since a few sites in the Nemi basin can be dangerous.

Initial recommendations are based on what we think is important in terms of restoration, conservation of details, maintenance, management etc. Since such recommendations will be very strongly connected to the value assessment of the object (which we did not undertake) and existing plans for development in a area (of which we have too little knowledge), we have only made simple recommendations on the basis of "yes" or "no"; thus no urgency classes have been developed.

Monitoring (i.e. diagnostic monitoring actually carried out) has been divided in two classes: 1) retrospective monitoring using available photos or other documents related to the object/detail; 2) special monitoring themes, as applicable to the actual periodic observation we carried out in Nemi, including regular photography of risk zones, observation of salt activity at details, and measuring of crack widths with simple means.

The problem of assessing condition, risk and change

One of the greatest problems in monitoring systems is related to how condition, risk and change should be evaluated and represented as objectively as possible. Since our aim has been to be able to use the data in a GIS (for making thematic maps), we have proposed a scale from 1-5 ("very good to very poor") wherever it can possibly be applied.

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33 See also Ward 1995, op. cit. It should be noted that in our system the objects have not been divided into architectural structures like roofs, walls, floors, etc.
The use of such a scale of course demands a description of how the various themes should actually be qualitatively assessed – a guide to the assessment. Still, various people with various background, various specific knowledge of an area and various general competence will tend to evaluate the same phenomenon very differently. Generally, the problem of evaluation is particularly difficult with regard to ruins, of which there is a substantial amount in the Nemi basin. The evaluation will be heavily influenced by the various ideals of how ruins should appear; overgrown and decaying or nicely trimmed and well presented to the public? The many ancient caves in the Nemi basin present similar difficult questions. Another problem concerns the fact that we as investigators have our roots in middle and north parts of Europe – in regions where decay and damage might be looked differently upon than in Italy.

An even greater problem is that many of the initial qualitative assessments should be used as baseline information upon which the long-term, systematic monitoring is undertaken. A high degree of objectivity is thus required in order to make subsequent re-assessment comparable to the initial assessments. Due to the inevitable subjective nature of qualitative assessments, we have tried to overcome this problem by proposing indicators for long-term monitoring, which are not only based on assessments, but also on more "solid facts" and measurements (see part 3 of this report). Thus, the assessments must be considered as supplementary to such "facts", of which an example can be the actual number of ruins in an area and how this number changes over time. Such a number can e.g. be an indicator of the general trends regarding the neglect/management of an area.

Tab. 1: Overview of the simple, flat database structure we have employed in the Nemi basin. The structure is based on using one record for a defined object/monument (registered as a point using GPS or other means), which may or may not be part of a larger archaeological site and which may or may not feature specific decorative details. See also volume 2 (catalogue) for a full documentation.

<table>
<thead>
<tr>
<th>Main &quot;modules&quot;</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site/object information</td>
<td>Primarily information on materials, structures, earlier excavations and restorations, as well as to which site the object belongs (if applicable)</td>
</tr>
<tr>
<td>Initial condition assessment</td>
<td>Divided in various themes with regard to physical condition and the state of the management of the object/site. A scale from 1 (&quot;very good&quot;) to 5 (&quot;very poor&quot;) is used</td>
</tr>
<tr>
<td>Initial risk assessment</td>
<td>Divided in various themes in the following classes: &quot;hazard risk&quot;, &quot;decay risk&quot; and &quot;risk for people&quot;. We also considered including an &quot;anthropogenic risk&quot; class, but decided that we had too little knowledge of the land use in the Nemi basin for this to make sense. All risks are classified from 1 (&quot;very low&quot;) to 5 (&quot;very high&quot;)</td>
</tr>
<tr>
<td>Initial recommendations</td>
<td>Recommendations with regard to restoration, conservation, smaller repairs, management etc.</td>
</tr>
<tr>
<td>Monitoring (diagnostic)</td>
<td>Information about the diagnostic monitoring we have actually undertaken</td>
</tr>
<tr>
<td>Retrospective monitoring</td>
<td>Comparison with historical photographs. Changes over defined time spans for the object as such and for details when applicable. Changes are classified according to a scale from 1 (&quot;very small&quot;) to 5 (&quot;very large&quot;)</td>
</tr>
<tr>
<td>Special monitoring themes</td>
<td>Themes selected on the basis of what appeared important and what we could possibly undertake over the project period.</td>
</tr>
<tr>
<td>Regular photography (object and details)</td>
<td>Changes throughout the project period (and from the first visits to Nemi in 2001) for selected objects, part of objects and decorative details. Photos documenting the changes have been taken at regular intervals at such places. Changes are classified according to a scale from 1 to 5. Only the last observation (as compared to the initial observation) is entered into the system. In a long-term project the history of the classified changes should be preserved.</td>
</tr>
<tr>
<td>Salt and climate</td>
<td>Evaluation of salt activity and salt analyses. Indoor climate only applicable to Romitoro S. Michele. See volume 2 (catalogue) for further description</td>
</tr>
<tr>
<td>Crack measurements</td>
<td>At some few objects very simple crack measurements are undertaken. Changes are recorded in mm.</td>
</tr>
</tbody>
</table>
Fig. 5: Form developed for field registrations, continued on next page.
Applicable to the diagnostic monitoring we have actually undertaken in the Nemi basin.

Fig. 5 (continued from previous page): Note that monitoring means the actual, diagnostic monitoring we have carried out in the Nemi basin.
In order to make the qualitative assessments as objective as possible, we have made some guidelines for consistent evaluation in the Nemi basin (see also volume 2 – catalogue).

Condition assessment

Each of the defined condition issues should be evaluated with regard to the following scale, in which "problem" generally means a risk zone, but in some cases also e.g. amount:

1. **Excellent/very little**: No particular, or only very insignificant problems
2. **Good/little**: A few small problems located in distinct areas
3. **Medium**: Small problems covering most of the object or minor problems at large
4. **Poor/much**: One or more substantial and many smaller problems
5. **Very poor/very much**: Very large, very substantial or very serious problems

Risk assessment

As defined above, risk assessment is related to type of hazard, the vulnerability of the object and the probability that destructive events or processes will happen within a certain time span. For many types of hazards (e.g. earthquakes) it is difficult to make such prognoses, for others it is much easier (heavy rainfall). The following "time guide" must thus be seen as a very rough aid to be used for each of the defined hazard types. The "time guide" has been developed especially on the basis of what is known about the historic earthquake activity, and landslides and rock falls associated with earthquakes, in the Nemi basin (see below).

1. **Very small** risk: Substantial damage not likely to happen within the next more than 100 years
2. **Small** risk: Substantial damage may happen within the next 100 years
3. **Medium** risk: Substantial damage may happen within the next 50 years or so
4. **High** risk: Substantial damage may happen within less than 50 years
5. **Very high** risk: Substantial damage may happen within the next 1-10 years or so

It should be strongly underlined that in the Nemi case the only real aid we have had for such prognoses is retrospective monitoring (and general experience).

Assessment of change

Assessment of change is applicable to retrospective monitoring (mostly based on photos), as well as to the diagnostic monitoring we have undertaken over the last 3 years, also with photos as the main method. Generally, "change" does not necessarily mean deterioration or a change to the worse, although this will usually be the case in the Nemi basin. We decided not to deepen the evaluation by including also "change to the worse" and "change to be better", but incorporate such information in the comments. Only the last observation (as compared to the initial observation) is entered into the system. In a long-term project the history of the classified changes should be preserved in the database system.

1. **Very small**: No particular, or only very insignificant, changes
2. **Small**: A few small changes located in distinct areas
3. **Medium**: Small changes covering most of the object or minor changes at large
4. **Large**: One or more substantial and many smaller changes
5. **Very large**: Very large, very substantial or very serious changes
In addition to all problematic aspects of consistent assessment mentioned above, another is the assessment as related to the size and general design of the object in question. A larger object may have a very serious problem distinctively located at one part, whereas the rest may be in perfect condition. For assessment of such phenomena sound judgement must be used – and, very importantly, there will always be the possibility to add a comment! With regard to comments, such should of course always be given in a system based on forms and databases/GIS. When the aim is to represent condition, risk and monitoring observations by such means, all that is put into a certain category will have the nature of rough classification and more or less sound interpretation – it will be metadata. Thus, a form should also allow for proper descriptions defining the phenomena encountered and how they were assessed and interpreted. Moreover, there will always be the possibility of writing a small report and taking a few pictures, to which should be referred in the form/database.

**The use of "averages" or indicators for representation in a GIS**

One of the great advantages of a GIS, when properly designed, is that it allows for rapid, visual detection of e.g. problem areas or "hot spots", and analysis of relationships between different phenomena at different scales and levels. However, with a lot of registrations and interpretations referring to one point (as in our Nemi case), one encounters the well-known problem of how to represent all these data in a sensible way. In order to deal with this problem, we have tried the use of "averages" or general/overall impression with regard to the following themes and based on the scale from 1 to 5 (see previous chapter):

- General physical condition
- General state of the site/object management
- General risk related to (natural) hazards
- General risk related to decay of the object
- General risk related to the security of people

Such general impressions are based on the individual assessments of each sub-theme; with regard to e.g. "general physical condition" these sub-themes are: stability, vegetation on structure, loose material, weathering etc. Although we have mostly used a simple average of the assessments of the sub-themes, sound judgement has also been put at work. For example, when one hazard type is considered a very great risk and others not at all, the general assessment will be "very high risk". One could have used weighting procedures to cope with this problem, but since the situation from object to object is so different, this would hardly have made much sense. Another possibility would have been to systematically use the highest risk, as is e.g. done in some systems in Norway (T. Guttormsen, pers. comm. 2004), or both the highest and the average risk.

The "averages" constitute an important part of the indicator development undertaken for long-term, systematic monitoring in the Nemi area (discussed in part 3 of this report). Since we have not been entirely consequent with regard to the assessment of the averages, it may well be that a re-assessment of our data must be undertaken for future monitoring purposes. This should not be difficult, though, since all the individual assessments are preserved in the database.
Specific methods used during our work in the Nemi basin

Data collection, including literature research, existing GIS and the Internet

Our data collection related to history, archaeology and environment of the Nemi basin was carried out throughout the project and included the following sources (see references in the bibliography):

- Literature, "excavated" through personal contact with various people, as well as searches in the public library and bookshops in Genzano di Roma
- Old photos and paintings of the area, collected rather arbitrarily, especially through digital copies of what we have seen on the walls in Museo delle Navi Romani, in hotels in the area, and in books and papers. Moreover, ESA provided very important aerial photos of the Nemi basin (the earliest ones from the 1930s).
- The Internet, on which, for example, reports from the recent Nordic archaeological excavations as well as very good databases on historic earthquakes in the region can be found
- The existing GIS of the Nemi area/Colli Albani, made available by ESA and designed by Emanuele Loret and his co-workers. Part of this GIS is available on the Internet; parts were made directly available to us. The latter include information on land use and geology, as well as a preliminary location of some of the archaeological sites (polygons) and objects (point registrations) in the Nemi basin. Other than for urban expansion over the last 20 years and vegetation change (1985 to 2000), the GIS does not yet contain information on changes and evolution (e.g. related to agriculture), neither does it contain reliable information on natural hazards yet.

The location of archaeological sites was undertaken primarily by the indispensable article on the archaeology of the Nemi basin by Lenzi (2000), the ESA GIS and our own observations.

Field methods

Visual inspection, regular digital photography and, in some cases, the production of simple maps/sketches have been the most important field methods. Moreover, in the forerunner of the project detailed digital mapping using Adobe Photoshop techniques was also undertaken with regard to the walls and mural paintings of Romitorio S. Michele. Otherwise, simple crack measurements using rulers and sampling of materials and weathering products such as crystalline salts (very small quantities) have to some extent been performed. For all sites visited GPS coordinates were taken.

Laboratory methods

Laboratory methods primarily included analyses of soluble salts for understanding weathering problems at decorative details.

34 See Storemyr 2001a (in bibliography)
Computer work

The simple database developed was made with Filemaker Pro 5.5. Here we have also included simple drop-down lists (see volume 2, catalogue). Since fields were made dBase compatible, records could easily be exported and used in ArcView 8.3 for GIS representation. We have only put very simple GIS techniques at work, such a production of thematic maps, which are presented in part 2 of this report. These maps contain "background" information from the ESA GIS (especially land use, geology and archaeological site location), and are supplemented with our own findings. We have also to some extent included topographical maps (made available through SAL) and additional archaeological surveying material (from Lenzi 2000). Throughout the fieldwork we have taken some 1000 digital photos. Those selected for monitoring purposes have been treated in Adobe Photoshop, especially in order to produce very simple panorama images. When necessary, especially for comparison of old photos with new ones, simple rectification methods (in Photoshop) have been applied.
PART 2: THE NEMI BASIN INVESTIGATIONS

Based on the methodological approach described above, this part of the report contains a brief overview of the history, archaeology and environment of the Nemi basin. It especially focuses on geologic hazards and the evolution of vegetation and agriculture over the last more than 100 years, before describing the results of our own investigations related to condition- and risk assessment and diagnostic monitoring of archaeological objects/monuments and their decorative details.

Archaeology of the Nemi basin

The Nemi basin with its crater lake and steep forested slopes is a cultural landscape extremely rich in archaeological remains. It consists of two small, superimposed volcanic craters, totally measuring some 3 x 2 km in NS and EW direction, respectively. In this fertile crater (fig. 6), flanked by the medieval towns of Nemi (NE) and Genzano di Roma (S), human habitation can be traced back to prehistory, but its fame is primarily connected with the remains of Roman structures and the myths, legends and cults related to the Diana temple, which ruins are located on the plain in the NE part of the crater. The basin is also famous for the Roman Emmissario, a tunnel built to regulate the lake level, and the two Roman ships rescued from the bottom of the lake in the 1920s. Raised and transported to the purpose-built Museo delle navi Romani by the northern shore, the ships got a sad destiny as they were completely destroyed by a fire in the museum during the last days of World War 2 in 1944. The museum was later rebuilt and is now the focal point for the history and archaeology of the Nemi basin. The basin also features a wealth of other Roman remains, such as villas, cisterns, assumed aqueducts, roads paved with basalt slabs, stone quarries, as well as structures from the medieval and post-medieval period, including remains of churches and chapels, e.g. the rock-cut Romitorio S. Michele with medieval murals, and a large, ruined mill complex (Le Mole) just below Nemi town. Moreover, in the slopes of the crater many caves have been dug in the lose pyroclastic rocks between harder basalt layers. These cover the whole period from prehistory to the post-medieval time, has been used for various purposes and often served as refuges for the local population during times of conflict. (Moltesen, ed. 1997, Stenhouse 1997, Brand et.al., eds. 2000)

With its archaeological remains and spectacular views, the Nemi basin was an attractive place for early travellers and painters on the "Grand Tour". Of particular value for us today are the many landscape paintings from the 19th century, giving evidence of the development of the landscape over some 200 years. Following the travellers and painters, archaeologists started their work in the latter half of the 19th century, especially focusing on the Diana temple, from which local people had removed a wealth of artefacts throughout the centuries. After the large rescue operation for the Roman ships, few additional excavations were undertaken until the 1980s. Again, the Diana temple was the focus of interest for the Soprintendenza Archeologica per il Lazio (SAL), and in the 1990s a Danish/Scandinavian team started an excavation of the Roman villa on the western shore of the lake. This excavation was finished in 2001-2002. Additional excavations in the Diana temple are currently underway (by SAL). (Moltesen, ed. 1997, Brand et.al, eds. 2000)

36 The study area is restricted to the Nemi basin as such. Monuments and sites on the crater edge (e.g. in the towns of Nemi and Genzano) are not included.
37 See the website of the excavations: www.dkinst-rom.dk/nemi and www.hum.au.dk/klasark/klasark/nemi.htm
Fig. 6: The archaeology of the Nemi basin.
Known and assumed features projected on a recent aerial photo obtained from ESA.
Location of sites and objects obtained from Lenzi (2000), the ESA GIS and own point registrations.
Objects investigated in the present project indicated with red points.
Geology, seismic activity and natural hazards

Being part of the Latin volcano, which consists of one main caldera and several eccentric cones (fig. 7), the Nemi crater formed during the most recent eruptive phase of the volcano, starting some 45,000 years ago.

The geology of the Latin volcano has been intensively studied (especially by De Rita and co-workers, see bibliography in e.g. Karner et. al. 2001), and here we will only give a brief review of the main characteristics of the Nemi crater, as well as a description of relevant geomorphologic features and the historic and current natural hazards, including the risk of earthquakes.

The slopes of the Nemi crater consist of pyroclastic sequences interbedded with thicker and thinner, heavily fractured basalt lava flows (fig. 8). The pyroclastic sequences vary in nature from lose, unconsolidated tuff, to worked and consolidated ash and tuff deposits. Of the latter we can e.g. find peperino (by the road from Genzano to the Museo delle Navi) and the peculiar pietra sperone, a hard, yellow, porous and pisolithic-like pyroclastic rock that was used by the Romans for building banks along the shore of the lake and for other structures, such as retaining walls at the Diana temple (a quarry can be found in the cliffs below the town of Genzano, cf. Gizzi 2000).

The lower parts of the slopes, as well as the plain in the northern part of the crater, are filled with Holocene alluvium from the erosion of the slopes. There are many smaller and two main watercourses from the crater edge. Fosso Tempesta can be found in the northern part of the crater; it has dug a deep
Fig. 8: Geological features and their relationship with archaeological remains of the Nemi basin projected on a topographic map of the area (contour interval 10 m). Note the two major creeks and the areas with known landslides (or possibly smaller scree) and rockslides (and rockfalls). Geological map provided from the ESA GIS. Location of sites and objects obtained from Lenzi (2000), the ESA GIS and own observations. The white semi circles indicate the two superimposed craters.
gully in the slope, deposited sediments in Le Valle (the agricultural area to the north of the Museo) and built up a small delta in lake Nemi. The other major creek springs from the cliffs below Nemi town and has built up a substantial delta in the area called Orti di S. Nicola, which has been inhabited since prehistory. Although the exact circumstances are not clear to us, it is possible that both of these creeks, as well as other springs from water-bearing geological layers, were utilised by the Romans as water sources (for their possible connections with cisterns and aqueducts, see Hansen 1999). The creek below Nemi town was also used for the post-medieval mills at Orti di S. Nicola.

The extensive agricultural terraces along the slopes, as well as the present thick forests (see also description below) obviously prevent the most disastrous erosion. There is some evidence that it cannot always have been like this – the erosion may have been stronger in one or more earlier periods. This evidence is especially related to several cm thick layers of debris covering the remains of the Roman villa along the west shore of the lake (see fig. 9 and Guldager Bilde 1998) and the similar phenomenon with regard to parts of the Diana temple (see fig. 10 and Guldager Bilde 1997a). However, it is not quite clear if larger landslides covered these Roman remains, or if they were rather gradually covered by smaller scree. Moreover, since agricultural activities also have contributed to movement of earth masses, it is difficult to consistently interpret such phenomena without excavation. What we do know is that the gradual filling of ancient structures with debris still can happen at certain locations. A good example is a Roman cistern in the Villa area, which was used as a refuge during WW2, but now is half-covered with debris (Hansen 1999).

Landslides, smaller scree and the movement of debris primarily take place in connection with heavy rainfall. Although the annual precipitation in the area is a moderate 1200-1400 mm, strong erosion often take place when a very dry period is terminated by heavy rain and in general by short, but very intense rainfall episodes. Such phenomena are common in the Colli Albani, and probably, beside earthquakes, account for the majority of landslide- and scree phenomena.38

38 See description of the Colli Albani climate, as related to geomorphology, in Caputo et. al. 1974. In Storemyr (2002) a short description of the Nemi basin climate, as related to weathering of cultural heritage, can be found. It should be noted that frost and snow can occur in the winter in Nemi.
Heavy rainfall may also trigger rockslides and rockfalls along the slopes of the Nemi basin. Such phenomena have been and are still common at places where cliffs of fractured basalt are situated above more friable pyroclastic rocks, for example at the cliffs representing the border between the two superimposed craters and along the eastern slopes north of Nemi town (fig. 8). In these areas there are ample evidence of quite severe rockfalls – a situation that have led to extensive security measures, the latest of which we could observe during the field work period in May-June 2003 (fig. 11). We have also observed ancient (or perhaps not so ancient?) rockfalls in the area just below Nemi town. Moreover, it is clear that the immediate surroundings of the rock-cut chapel of Romitorio di S. Michele (also below Nemi town) are heavily influenced by similar phenomena. Here the openings of flanking rock-cut caves are more or less closed by large, fallen basalt blocks.

Fig. 11: Security measures in order to prevent rockfalls from basalt cliffs in the eastern part of the crater, just to the north of Nemi town. PS 2003

Landslides, screes, rockslides and rock falls are clearly also triggered by earthquake events – and earthquakes have led to dramatic damages in the distant and not so distant past. This is well documented from various sources.

In the "Catalogo dei Forti Terremoti in Italia, 461 a.C.-1990" (http://80.117.141.2/cft/) seven major earthquakes are reported in the Nemi area between 1806 and 1927 (table 2).39 The 1806 quake, possibly the 1892 and the 1915, and particularly the 1927 quake were especially damaging in Nemi and Genzano.

39 Some earthquakes are not reported in this catalogue, for instance the event in 1892. Most events that have influenced the Nemi area are also listed in Donati et. al. 1999. This paper deals with the earthquake history from the Roman period until today, and shows how buildings in Rome situated on Holocene alluvium have suffered more damages as compared to buildings situated on sedimentary and volcanic rocks.
Tab. 2: Descriptions of effects of earthquakes in the Colli Albani area between 1806 and 1927 Sources: "Catalogo dei Forti Terremoti in Italia, 461 a.C.-1990" (http://80.117.141.2/cft/) and Donati et. al. 1999

<table>
<thead>
<tr>
<th>Date</th>
<th>Epicentre</th>
<th>Effects</th>
</tr>
</thead>
</table>
| 26 August 1806 | Colli Albani   | **Buildings:** Collapse of convent of the Minori Osservanti, and the annex church cracked in four pieces. Braschi palace weakly damaged. Genzano: Strong damage  
**Environment:** Temporary appearance of a small sulfurous basin on the Faiola mounts  
**Social:** Victims and injured people |
| 1 June 1829    | Colli Albani   | **General:** Direct earthquake damage limited  
**Environment:** Exhalation of gases from the ground, decrease of water in springs |
| 24 August 1877 | Lazio meridionale | **General:** Affected mainly some localities in the southern Lazio  
**Environment:** Increase of the gaseous emissions in the solfatara of Tivoli |
| 22 January 1892| Colli Albani   | No description, but according to the description from 1927 (see below), there must have been some effects |
| 19 July 1899   | Colli Albani   | **General:** Strongest effects in Frascati and Marino. Increased damage due to the reopening of cracks from the earthquake of 22 January 1892. |
| 31 July 1901   | Monti della Meta | **General:** Area of the Monti della Meta (borderland between southern Lazio and Abruzzo) and other localities of southern Lazio. Damage to buildings |
| 13 January 1915| Marsica (Disastrous earthquake) | **Damages general** (the effects in Nemi appears to have been weak): A macro seismic estimate was possible in 850 localities. In 80 of them there was damage to most of the built environment. In more than 200 localities buildings collapsed or the buildings were so seriously damaged that they were no longer fit for use. In another 240 there were lighter damages. Oddone (1915) pointed out that the bad geo-pedologic setting in which the buildings were built increased the earthquake damage. He also noted that the centres built on alluvial ground or on the contact zone between clayey beds and rock or on steep slopes covered by scree were the most damaged. Furthermore, the buildings were made with bad-quality sand, less lime and heavy stones. The building foundations were not deep enough and the vaults and the roofs too heavy.  
**Environment:** Remarkable effects on the ground in a wide area: fractures, in some localities with spillage of water and gases, landslides and rock falls, floods, temporary disappearance of some springs, variation of the water level in basins  
**Social:** About 33'000 victims plus 3000 dead by disease during the following months |
| 26 December 1927| Colli Albani   | **Damages in Nemi:** Nemi was the most damaged village. Almost all buildings were more or less damaged (136, according to an estimate of the "Genio Civile"). In many of them parts collapsed. The large dimension of the damage often due to the properties of the underground and the bad conditions of the buildings. The village is built on tuffaceous material, which is not very compact and was already injured by the frequent landslides. Some buildings were already damaged during the earthquake 22 Jan.1892. The most important damages were along the slope SW of the village that has an average fall of 80%. The earthquake caused several landslides. One of them broke the pipe from the "Facciate di Nemi" spring and the water flooded the adjacent lands with great damage. A big fracture opened at the foot of the Orsini castle cliff causing the danger of a large landslide. The "Fontana Grande" spring disappeared. Fluctuations of the lake level were observed. Strongly damaged buildings: town hall, parish church of Santa Maria del Poggio, collegio and church of the padri Mercedari, barracks of the carabinieri, municipal school, medieval Orsini castle |
Effects in Nemi of the 1927 quake included (see also table 2):

- 136 buildings, including several ancient monuments, were damaged, many of which collapsed
- Heavy damage occurred along the steep slopes to the SW of the village (where e.g. Romitoro S. Michele is located)
- Several landslides occurred, also causing subsequent flood damage as larger pipes broke

Clearly, many archaeological remains, especially Roman walls and cisterns, will have been severely affected or impaired by the 1927 and earlier earthquakes in the area. This is important to bear in mind when investigating such remains today.

Recent tremors include a smaller quake in 1980, a long-lasting swarm in 1989-90 and the 1995 event in Rome that also affected the Alban Hills, but apparently not led to damages (e.g. Marra 1999).

Judging from reported earthquake events and analyses undertaken in connection with the 1989-90-earthquake swarm, it seems that periods of more intense activity repeat regularly about every 30 years (see fig. 12). If this figure can be extrapolated back, there might have been about 3 earthquakes per century, one of which might have been more damaging than others. This means that the medieval structures in the area might have suffered up to 10 and the Roman remains up to 20 more or less damaging quakes. The highest recorded intensities since the 1800s are of the VIII grade at the Mercalli scale (about 5 at the Richter scale).

Earthquake activity in the Alban Hills is continuously monitored, for example at test sites where geochemical data is collected. Results from such test sites reveal that it is possible to correlate anomalies in groundwater composition with earthquake events (Quattrocchi & Calcara 1998).

The major question is when the dormant Latin volcano will wake up again. Karner et. al. (2001) argue that a new volcanic cycle started some 45,000 years ago and that the volcano will erupt again in the future. However, they also state that there is no indication that this will happen soon.

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40 “Earthquakes, crustal structure, and deformation of the Alban Hills”, see: http://www.ingv.it/~roma/SITOINGLESE/activities/seismology/sismologiavulca/testo.html
Vegetation and agriculture – the development over the last century

According to legends and myths, the shrine of Diana was situated in a heavily forested area (Stenhouse 1997). Although the slopes of the Nemi crater quite possibly were forested in Antiquity, the felling of trees must have started early, as evidenced by the extensive system of terraces (cf. fig. 13, 15). Except from the area with steep cliffs below the town of Genzano, field observations and the study of aerial photographs reveal that practically all slopes are terraced.
Fig. 14: Vegetation and land use in the Nemi basin in the late 1980s projected on a topographic map of the area (contour interval 10 m), and also showing the archaeological features (cf. fig. 6). Note that the fields (agricultural areas) are only partly productive and that several areas on the plain in the northern part of the crater are about to be repossessed by forest. Map of land use provided from the ESA GIS. Location of sites and objects obtained from Lenzi (2000), the ESA GIS and own observations.
Agriculture and animal grazing kept the vegetation down until perhaps the 1950s. From then on, and especially from the 1970s, the crater has slowly been reoccupied by trees and bushes (fig. 14, 15, 16). Today, it is only at the plain in Le Valle/Il Giardino (by the Museo delle Navi Romani) and at a few other places along the shores of the lake that agriculture is still practiced (much strawberries and flowers) (fig. 16). Moreover, there are no animals to keep the vegetation down anymore. The wooded landscape is dominated by species such as chestnut, oak and maple, but there are also alder, willow, poplar, carpinus, elder and pine. The heavy vegetation clearly prevents serious erosion, and perhaps also rockfalls, as roots tend to keep larger stones (in the basalt flows) in place. However, there is also ample evidence of root bursting (fig. 17, 18) at the archaeological sites (e.g. the Roman villa and the Diana temple). Thus, the increase in vegetation comes as a mixed blessing: It prevents erosion, but simultaneously causes cracking and destruction of masonry and ruins. Moreover, the extreme fertility in the basin means that recently excavated archaeological sites soon become covered by bushes and trees, implying that such sites are in immediate danger just after excavation.

41 Lately, goats could be seen grazing in the woods along the road down in the crater to the E-NE of the town of Genzano. This seems to be an experiment in trying to keep the undergrowth down. Interestingly, it could easily be observed that the grazing increased the erosion in the actual area.
Fig. 17: Root bursting: A basalt block is about to fall from a cliff just below Nemi town. PS 2001

Fig. 18: A fragile equilibrium: Large trees on a retaining wall in the Diana temple. PS 2003

Fig. 19 (above): Area in which one of the last larger bushfires took place. It is not known exactly when this fire took place, but it must have happened within the last 10-15 years. Another relatively recent bush fire area is shown by a red circle.

Fig. 20 (left): Map of fire risk in the Nemi basin projected on a topographic map of the area (contour interval 10 m), and also showing the archaeological features (cf. fig. 3). Map of fire risk provided from the ESA GIS. Location of sites and objects obtained from Lenzi (2000), the ESA GIS and own observations.
Due to the hot and dry summer climate, bushfires are a serious threat to the forests in the Nemi basin. In their GIS system, ESA has estimated the highest risk along the slopes of the northern half of the basin (fig. 20). Over the period from 2001 to 2004 we have not observed the results of larger fires, but every year signs of smaller ones (some few square metres) have been seen. It seems that one of the last larger fires must have taken place just below the Nemi town as indicated in fig. 19. Another has taken place above the asphalt road to the west of the Roman villa area (info from ESA GIS).

**Fig. 21: Boundaries of Parco Naturale dei Castelli Romani. Green lines: 1984. Yellow lines: 1998. Small pink squares indicate new structures built between 1984 and the 1990s. Map provided from the ESA GIS. See also Loret & Testana 2003.**

**The Castelli Romani Park and the management of the Nemi basin**

Due to protection regulations, the Nemi basin has avoided the worst consequences of the rapid urban expansion in the Alban Hills in particular and around Rome in general. Since the 1960s the urban expansion has been extreme, which was also one of the reasons for establishing the "Parco Naturale dei Castelli Romani" in 1984. Threatening the original boundaries of the park, "wild building", often not complying with regulations, made authorities widen the park area, and in 1998 new boundaries were established (ESA 2002, Loret & Testana 2003). As can be seen in fig. 21, the core part of the Nemi basin has not been particularly influenced by this wild building. However, a lot of new houses have been built along the crater edge over the last 20 years or so. This activity is part of the expansion of the towns of Nemi and Genzano.42

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42 There are now plans for developing the west crater edge ("Le Piagge"); plans which may have dramatic consequences for the landscape and the classical views in the Nemi basin. Information from Torgrim Guttormsen (NIKU) during Demotec workshop in Genzano, February 2004. See also [www.dammann.com/index_EN.html](http://www.dammann.com/index_EN.html)
The management of the Nemi basin is in the hands of the communes of Nemi and Genzano, the Castelli Romani park authorities, SAL and others. At least two major plans have been developed regarding the archaeological sites, conservation, signposting, tourism activities and marketing of the area (Commune di Nemi 1998 and Consorzio Imprese Castelli Romani 2000). A central element in these plans is the establishment of cultural and natural paths/itineraries. Some paths with signposting already exist, and they are more or less regularly maintained with regard to vegetation. However, the fertility of the area makes it difficult to keep vegetation down, and over the last 3 years we have observed that several paths have become overgrown. Several archaeological sites, and especially parts of the Diana temple area are also regularly maintained. However, the vegetation problem is also here hard to manage. Except for a part of the Diana temple area (Gizzi 2000), no larger restoration/-conservation of archaeological sites and monuments have been carried out since at least 50 years.

Considering the general objectives of the preservation and management of the Nemi basin, Giuseppina Ghini (SAL) has expressed that the idea is not to create a trimmed park landscape, but rather to preserve the "spirit of the place" by small and purposeful interventions. Moreover, measures at single sites and monuments should comply with this idea, for instance with regard to the Diana temple area, which, according to legends a myths, was a "sacred groove". It would seem, then, that vegetation management is of prime concern for future activities in the basin.

Fig. 22: The path from S. Nicola to Nemi – here passing the ruined post-medieval mill Le Mole - has signposts showing the archaeology of the area.

43 At the DEMOTEC-A workshop in Genzano in May/June 2003
Types of objects investigated in the project

At the time of writing this report, the database contains information on 59 objects in the Nemi basin, 23 of which have been investigated more or less thoroughly by us (tab. 3) and 9 of which have been selected for diagnostic monitoring within the project period (and from the first visits to Nemi in 2001, for this monitoring, see also Storemyr 2001a and 2002). Thus, the amount of data is at the moment limited, which is to be expected after only one week of fieldwork and a few shorter visits. It should be noted that we have investigated most of the larger and important objects (excluding the Emissario; the ancient tunnel used for regulating the sea level in Lake Nemi). Description of all the investigated objects can be found in volume 2. In figs. 23-25 some characteristics of the objects are shown.

**Tab. 3: Types of objects investigated - summary**

<table>
<thead>
<tr>
<th>Object type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caves, some part of a necropolis, some presently out of use or in use for storage</td>
<td>6</td>
</tr>
<tr>
<td>Various Roman structures (ruins) in temple area (Tempio di Diana)</td>
<td>5</td>
</tr>
<tr>
<td>Roman cisterns, partially reused</td>
<td>4</td>
</tr>
<tr>
<td>Various Roman structures in Villa area on W-side of lake (ruins) (north wing and Exedra)</td>
<td>2</td>
</tr>
<tr>
<td>Post-medieval mill buildings (ruins) (Le Mole)</td>
<td>2</td>
</tr>
<tr>
<td>Rock-cut chapel with medieval mural paintings (Romitorio di S. Michele)</td>
<td>1</td>
</tr>
<tr>
<td>Roman wall, part of later church (ruin) (S. Nicola)</td>
<td>1</td>
</tr>
<tr>
<td>Roman embankment at the shore of Lake Nemi (ruin)</td>
<td>1</td>
</tr>
<tr>
<td>Roman stone quarry</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 23: Graphic representation of types of objects investigated, their age and whether they are ruins or not.

Topographic maps and land use information from the ESA GIS. (Applicable for all similar figures below)

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44 One archaeological site may contain one or several objects
Fig. 24: The function and visibility of investigated objects in the Nemi basin. Medium and poor visibility means that the objects are overgrown by trees and bushes.

Fig. 25: The state of the investigated objects with regard to archaeological excavation and restoration. As can be seen from the figure, parts of the Diana temple area and the Roman villa area have been excavated (recently), whereas restoration (or rather repairs/conservation) has been carried out at 4 investigated objects.
Initial condition assessment

Generally, the physical condition of the investigated objects does not appear to be very problematic (fig. 26). The average condition has been estimated to "medium" (a little less than 3), but this figure incorporates many caves and cisterns with rather good static stability and without rapidly weathering structures and decorations. Looking at the spatial distribution of the objects assessed, the picture becomes different (fig. 27): Several ruined structures (e.g. Exedra, Le Mole 1 & 2) are in a poor state. These structures are generally having stability problems (fig. 28), and may also weather quite heavily (fig. 29). The few decorations at various objects normally also weather quite fast (fig. 29).

Fig. 26: Average physical condition (blue) and condition with regard to site management (yellow) of the investigated objects (23) in the Nemi basin. The uppermost column in each category shows the overall average.

Fig. 27: Map of the investigated objects with regard to general physical condition and the general state of the site management. As can be seen from the figure, six objects are in a poor physical condition; Exedra, Le Mole 1 & 2, Romitorio di S. Michele, the Central Peristyle at the Diana Temple (under excavation) and the Ambienti Voltati close to the museum (Le Grotte). The site management is particularly problematic at the Exedra and with regard to Le Mole 1 & 2.
Fig. 28: The static stability of the investigated objects. Two objects (part of the Exedra, the Ambienti Voltati by the museum – Le Grotte) are in acute danger of collapsing, whereas three are in a poor state (Le Mole 1 & 2) and the Central Peristyle at the Diana Temple.

Fig. 29: Weathering is particularly pronounced at the north wing of the Roman villa, in the Romitorio, at Le Mole 1 & 2 and at the Roman decorations (murals) in the Diana temple.
Fig. 30: The west wing of the Exedra: Large parts of the Roman masonry are about to collapse (the height of the structure is about 6 m). Photo 2003.

Fig. 31: Roman architectural murals on walls of the Central Peristyle in the Diana Temple. Recently excavated and protected by a temporary roof, the murals nevertheless weather very rapidly due to water infiltration and biological growth. Photo 2003. See also fig. 51.

Fig. 32: Le Mole 1 by the path from Lake Nemi to Nemi town. The abandoned mill-complex is in a very poor state, overgrown and with destroyed roofs.
The condition of the objects with regard to management, including access, keeping vegetation down, fences and protective roofs is generally rather poor (fig. 26, 27). The largest problem is keeping vegetation down, which – in order to be effective – have to be carried out several times every year. This of course demands a very effective organisation and quite a bit of funds.

Another problem is the access to the sites and objects (fig. 33). Only a couple of rather unknown caves (Grotta), as well as the Embankment (Bancina) on the south side of Lake Nemi can be said to have access adapted for visitors/the public, as they are situated close to roads or paths, which are managed with regard to vegetation. The other objects are either inaccessible due to the presence of fences and gates or heavy vegetation, or they are not meant to be accessible at the moment (e.g. due to ongoing or recently finished archaeological excavations, or because they are situated on private land). Moreover, some objects can be dangerous for untrained people, e.g. the Mill complex (Le Mole 1 & 2) and the Exedra.

Clearly, much remains to be done in order to make selected sites/objects accessible (if desirable). Several objects would have to be secured/restored, and very active management of gates, fences and vegetation needs to be carried out. Moreover, better signposting would also have to be undertaken.

A very positive result of our investigation is the relatively good state with regard to litter/garbage and vandalism in the area (fig. 34). Larger amounts of garbage can only be found in relation to caves by the access roads to Lake Nemi (fig. 35), and problematic vandalism have only been recorded in Romitorio di S. Michele. The latter regards overpainting carried out possibly several decades ago.
Fig. 34: Map of objects assessed with regard to the presence of garbage/litter and vandalism. As can be seen from the map, garbage is only a problem along the access roads from Genzano down to Lake Nemi.

Fig. 35: One of the few places with much garbage: By the Cisterna and Grotta along the road from Genzano down to Lake Nemi on the west side of the basin.
Initial risk assessment

On average, the risk of decay and occurrence of damaging hazards has been assessed at less than medium (3) ("substantial damage may happen within the next 50 years or so") (fig. 36). As with the initial condition assessment, the distribution of risks within the Nemi basin is dependent on type of object, its location and several other factors. For example, the risk of decay (weathering, roots, erosion by rain/moisture etc.) is higher than the risk of damage by natural hazards (landslide, rock fall, earthquake) on the terraced plains close to Lake Nemi (the Roman vila area, the Diana temple). In the steep slope below Nemi town, natural hazards, especially earthquake, which may trigger rock fall, is estimated as being as important as decay (fig. 37, 38). Figs. 39-42 shows typical risks of damage.

Fig. 36: Average decay risk (red) and hazard risk (yellow) of the investigated objects. The uppermost column in each category shows the overall average.

Fig. 37: The distribution of decay risk and hazard risk with regard to investigated objects in the Nemi basin. The decay risk outweighs the hazard risk in the Diana temple area and the Roman villa area, whereas these two risk are more evenly distributed in the steep slope below Nemi town.
Fig. 38: The estimated risk of damaging earthquake at objects in the Nemi basin. Five objects are particularly vulnerable, either because of their rather ruined state and stability problems (Exedra, Le Mole 1 & 2 and Ambienti Voltati/Le Grotte close to the Museum) or because of their location (Romitorio). High risk means that “substantial damage may happen within less than 50 years”.

Fig. 39: Romitorio S. Michele has been affected by previous earthquakes, possibly as late as in 1927. It is likely that large rockfalls (indicated by arrows) followed one of the most recent earthquakes. See also table 2. There is a high risk that further rockfalls and possibly collapse will happen during a new earthquake. Photo 2004. A full interpretation of the earthquake damages in the Romitorio will be given by Bionda et al. (forthcoming)

Fig. 40: Typical risk of damage by roots (arrow) in a recently restored (newly plastered) part of the Diana temple area (section QR). The damaged new plaster is probably weathering also because of moisture (hygric dilatation) and salts present in the masonry. Photo 2003
Fig. 41: Typical risk of damage because of moisture — in this case rainwater heavily eroding a recently excavated part of the Roman villa area (the north wing). It can be seen that the vulnerable Roman masonry is literally flushed away upon heavy rain, as in February 2004. Photo 2004. Similar damages are bound to take place after most excavations in the Nemi basin because of the "soft" nature of Roman masonry having been buried below the volcanic soil for nearly two millennia. Thus, it is extremely important to protect such masonry by roofs (or by re-covering) after excavations. Photo 2004.

Fig. 42: The risk of moisture damages may also take the form of water leaks or water infiltration, as in the eastern part of the interior of Romitorio S. Michele (cf. fig. 39). The July 2001 picture shows the dry summer conditions in the chapel, whereas the February 2004 image gives an idea of the wet state of the walls after two days with very heavy rain. Obviously, the risk of weathering, especially because of salts, but possibly also due to hygric dilatation and frost, is very high when such amounts of water can infiltrate through cracks and openings.

**Initial recommendations**

In fig. 43 our initial recommendations for the investigated objects have been presented. The recommendations are also summarised in table 4, and further described by fig. 43-45.

<table>
<thead>
<tr>
<th>Tab. 4: Summary of recommendations related to the investigated objects in the Nemi basin.</th>
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</thead>
<tbody>
<tr>
<td><strong>Vegetation management</strong></td>
</tr>
<tr>
<td>Smaller repairs and security measures</td>
</tr>
<tr>
<td>Conservation + smaller repairs and security measures</td>
</tr>
<tr>
<td>Restoration + smaller repairs and security measures</td>
</tr>
<tr>
<td>Full restoration/conservation</td>
</tr>
<tr>
<td>Installing protective roofs</td>
</tr>
<tr>
<td>Scientific investigations (for drawing up sound restoration/conservation concepts)</td>
</tr>
</tbody>
</table>
Fig. 43: Overview of recommendations for the various investigated objects in the Nemi basin. **Full restoration/conservation is recommended for:**
- Romitorio S. Michele
- Le Mole 1 & 2
- The central Peristyle in the Diana temple area

**Restoration, especially related to stability measures is recommended for:**
- The Exedra
- The Cistern in the Roman villa area
- Tempio K in the Diana temple area

**Conservation measures should be carried out at:**
- The north wing of the Roman villa
- Muro e collonato (Section QR) in the Diana temple

Fig. 44: Overview of objects at which protective roofs should be considered. For the north wing of the Roman villa and the central peristyle in the Diana temple area an option may also be to cover the structures.
Retrospective monitoring

Wherever possible, retrospective monitoring has been carried out by comparing available historic photos with photos taken during the project period. Overview photos were available for 17 of the investigated objects, most of them were, however, taken during the 1990s, some in the 1970s and a only a few during the first half of the 20th century. Historic detail photos were only available for five objects, particularly important were those taken in the 1970s of the interior of Romitorio S. Michele. Fig. 46 gives an overview of the results of the retrospective monitoring, whereas figs. 47 and 48 shows two important examples.
Fig. 47: The state of the Diana temple area in the 1970s and 2003. After abandonment of agriculture, the temple terrace has been left to nature and is slowly becoming overgrown with trees and bushes. Photo from the 1970s after Devoti 1980.

Fig. 48: Romitorio S. Michele: Medieval mural painting on the west side of the presbytery, detail showing the face of the Virgin Mary. Although the image from c. 1970 is of relatively poor quality, it seems that very few new damages have occurred until 2002-2003. This is astonishing, given the very poor state of the interior of the Romitorio. 1970s-image from Anon. 1982. Note that the 2003-picture gives the impression that the mural is in better condition than before. This is due to the fact that the picture was taken on a day with heavy condensation on the walls, thus the thin veil of gypsum or calcite on the surface became transparent and the underlying colour could be seen. On the 2002-picture the lack of transparency can particularly be seen in the whitish areas. Generally, the pictures show how important it is to consider the conditions during photography when comparing historical photos with the present state.
Diagnostic monitoring throughout the project period – discussion of results

Some of the diagnostic monitoring results, especially related to moisture/erosion, have already been mentioned in the section on initial risk assessment. Focusing on nine objects, diagnostic monitoring throughout the project period included the following themes:

- Changes in the immediate surroundings of the objects, especially related to vegetation development
- Larger changes related to the substance of the objects, documented by overview photography
- Changes related to details and decorated surfaces, documented by close-up photography
- Climate and salt activity (only Romitorio S. Michele)
- Development of cracks and fissures at various objects

![Fig. 49: Map of changes to the objects and their surroundings as monitored during the project period (2001-2004). 9 objects were monitored, and it can be seen from the map that rather large changes have taken place in the Roman villa area and the Diana temple area – especially at places, which have recently been archaeologically excavated.]

The most important finding is related to the **extreme vulnerability of objects immediately after archaeological excavation**. This is especially true for the north wing of the Roman villa area (fig. 41, 50), but also at several places in the Diana temple area (fig. 40). In the north wing it seems that erosion during heavy rainfall accounts for the most severe damages, but also vegetation (moss, grass, smaller plants) are of importance. Clearly, installing protective roofs as soon as possible after excavation will reduce the weathering rate, but, as examples in the Diana temple area show, this will not prevent rather rapid weathering by vegetation, salts and other factors (fig. 40, 51); It can only prevent from the most extreme rainwater erosion and vegetation. Thus, protecting the objects by re-covering should in some cases be seriously considered. If, for various reasons, such as the wish to present newly excavated sites to the public, objects cannot be re-covered, one must allow for very active maintenance and regular
"re-conservation". This of course demands a well-functioning organisation of the work, as well as proper funding.

Fig. 50: Structure in the north wing of the Roman villa area, an example of very rapid weathering after the archaeological excavation, which was finished in 2001. Rainwater erosion of the soft joint mortars (which have lost most of their binding force after nearly two millennia below the ground) initiates the weathering, which is followed by loss of e.g. pieces of brick. In the winter of 2002-2003 there was evidence of some frost damages, and the weathering proceeded further throughout 2003 and 2004. However, it may well be that the growth of moss (2004) may contribute to a certain stabilisation of the situation, at least until larger bushes and trees get a foothold and root bursting can take place.

Fig. 51: Tempio di Diana, Central peristyle, Section M, room D (June 2003 and during heavy rain in February 2004). The mural paintings on the wall are only partially protected by the roof – water infiltration cannot be avoided. Although maintenance and active conservation might help, the murals will sooner or later be lost if not re-covered.
The extreme vulnerability of newly excavated archaeological sites is generally well known. After centuries or millennia below the ground, objects will often reach some sort of "equilibrium" with their surroundings – an "equilibrium", which is drastically disturbed by excavation. It may take decades and centuries before a new "equilibrium" above ground is reached – but then the objects may have disintegrated to heaps of rubble…

An intriguing question is related to the fact that some of the Roman (lime) mortars appear to be in a very poor state upon excavation (cf. fig. 50). Many seem to have completely lost their binding properties. This is not spectacular, as it happens with buried mortars also in other environments, but one may still wonder whether the special volcanic soil in the Nemi basin contributes to the "dissolution" of lime. An indication of the "aggressiveness" of the soil is also related to the state of excavated marble fragments in the Roman villa during the 1990s. Many fragments, especially from Carrara marble, but also from other marbles, were in an utterly poor state upon excavation. However, given that the pH of the soil is around 7, it has been difficult to reach a consistent conclusion as to why this has taken place. One possibility might be very local acidic soils (by for example roots), or soils not saturated with respect to calcium carbonate, another might be related to the history of the Roman edifices, especially the possibility of violent fires (see further discussion in Storemyr 2001b).

For objects that have remained above ground since the Roman period, or later periods, respectively, we could hardly detect significant changes in fabric/substance throughout the monitoring period (2001/2003-2004). The most obvious reason is that the monitoring period was too short, but it is also possible that we were simply not able to detect all sorts of small changes due to the limited time for fieldwork. Our limited repeated measurements of crack evolution at a couple of objects (Exedra, Diana temple and Romitorio di Michele) neither showed significant changes. However, there is some evidence of very little loss of paint fragments at the murals in the Romitorio, investigations that have not yet been properly evaluated.

With regard to the Romitorio, the most significant findings were related to the varying climatic conditions, especially extreme (and probably long-lasting) condensation events in winter/spring/early summer (fig. 52). Such condensation occurs when mild and/or humid weather affects the cold walls of the chapel. For rock cut structures this is of course nothing spectacular, but of vital importance for understanding the weathering of the murals/walls of the chapel: Despite the frequently very moist conditions, also due to extreme water infiltration, which could be observed in February 2004 (fig. 42), the murals are in a rather good condition. It is likely that the moist conditions prevent heavy salt weathering in the innermost part of the chapel, whereas close to the opening/door there is ample evidence for such weathering taking place because the microclimate is frequently drier here and thus facilitating salt crystallisation.

Fig. 52: Extreme condensation on mural in Romitorio S. Michele, June 2003.
We were very lucky to undertake some of our monitoring on very rainy days in February 2004. This rainfall event enabled us not only to verify the importance of water infiltration and erosion (see figs. 41 and 42); it also gave us an idea of the instability of the loose pyroclastic rocks when they are thoroughly wet. One example is the cliff above Sepolcreto_1 along the path from Nemi lake to Nemi town (fig. 53). Several rather large pieces fell down from the cliff under these conditions, obviously because of expansion of the rock fabric upon moisture uptake.

Since 2001 we have been able to follow how vegetation changes throughout the seasons. Although a major problem, especially with regard to root bursting of masonry and the problem of keeping it down along paths and at sites that are supposed to be visited, the problem may sometimes appear larger than it really is. The best example can be found in the Exedra by the Roman villa area, which was cleared by the Nordic excavation group for investigation purposes in 2001. Since then the Exedra has again become completely overgrown, mainly by elder, with the largest trees/bushes now measuring 4-5 m (fig. 55). However, there is no evidence that this new growth has actually damaged the fabric of the Exedra, which has remained above ground since the Roman period. Rather than destroying, this new vegetation is mainly preventing accessibility, and thus it might for the occasional visitor appear very problematic.

Instead, as also previously mentioned, the main problem with vegetation in the Nemi is the quick growth at newly excavated sites and root bursting by older trees in all types of masonry (fig. 54). Clearly, for the latter phenomenon, it may be very difficult to decide whether to cut/remove the trees/roots or not, as the roots in many cases contribute to the stabilisation of the masonry.

Throughout the monitoring period, various types of management measures were also recorded. In the Diana temple area, new vegetation was kept reasonably well down, and a new and better protective
roof was installed above the murals in the Central peristyle, Section M, room D (cf. fig. 51 and 56). Otherwise, few management measures were observed over the monitoring period.

Fig. 55: The Exedra by the Roman villa area. The panorama pictures show the evolution of the vegetation from the clearing in 2001 to February 2004. The latter panorama picture was taken during heavy rain; note that large parts of the masonry are nevertheless rather dry.

Fig. 56: Diana temple, Central peristyle, Section M, room D. A new protective roof was installed after the summer of 2003.
PART 3: PROPOSALS FOR LONG-TERM MONITORING IN THE NEMI BASIN – INDICATOR DEVELOPMENT

The investigations undertaken in the Nemi area can be considered a basis, upon which further, long-term diagnostic and systematic monitoring can be carried out. Although the Nemi basin is small and the number of monuments is limited, in order to facilitate further systematic monitoring, we have below evaluated the most promising indicators that can be elaborated from the results obtained so far. Moreover, we have given some recommendations with regard to following up the diagnostic monitoring already carried out in the project. Finally, the whole work is briefly discussed, especially in terms of challenges related to cultural heritage monitoring on object/monument level.

Indicator framework for systematic monitoring – physical condition

Systematic monitoring, as defined in this work and as applied to the Nemi basin, is carried out mainly for local/regional management purposes. This implies that the aim of the monitoring is not to address specific causes of damage and decay, but rather to obtain an overview of the general trends and threats in a defined area over time. Generally, if they are properly selected, evaluated and related to thresholds and goals, indicators can be an important aid in such monitoring. Moreover, the use of indicators forces one to think in terms of comparative assessment-strategies and measurements over time. Without enabling comparative assessment, it is not possible to carry out valid long-term monitoring. As discussed in part 1, this is a great challenge in cultural heritage monitoring, especially as the assessment of condition and risk inevitably will be rather subjective. Thus in the proposal below, we have included "hard facts" (quantitative measurements/counting), such as numbers of objects with special properties (e.g. whether they have been excavated and restored or not), as well as qualitative assessments. The latter must generally be regarded supplementary to the quantitative measurements/counting, facilitating the interpretation of monitoring results.

The elaborated proposal relies on the much used framework of condition, pressure and response within environmental monitoring, and many ideas have been gathered from Pearson et. al (1998) and their work on indicators for cultural heritage monitoring/reporting in Australia. As far as we know, this is the only comprehensive attempt at developing indicators for systematic cultural heritage monitoring at the site and object level worldwide.

Our task in the DEMOTEC-A project was to conduct investigations related to the physical condition of the cultural heritage in the Nemi basin (on the object and detailed level). Thus, our proposal for indicators mainly deals with this issue. This means that we have not worked on indicators emerging from studies at the landscape level (a task to be performed by NIKU/NINA), e.g. related to the evolution of vegetation and infrastructure. We have neither included issues such as values and

46 We have searched the Internet for initiatives related to systematic cultural heritage monitoring at the site and object level using indicators. Also in the "Compendium – a global directory to indicator initiatives", published by the International Institute for Sustainable Development (see www.iisd.org) there seems to be no work matching the Australian approach.
significance of the cultural heritage, nor issues related to knowledge/education and funding. Such issues constitute a central part of the Australian approach to monitoring using indicators.

In brief, our proposal is based on a framework including a) status of monitoring in the Nemi basin, b) condition of the objects, c) risks to the objects, d) issues related to excavation and conservation and e) management and legal matters. Table 5 gives an overview of this framework, which is generated from an evaluation of the issues included in our database for Nemi (see part 1 of this report) and supplemented with a few indicators that are not yet part of the database. Below, we will discuss the selected indicators in more detail, as well as how they are assessed.

Tab. 5: Proposal for indicator framework for long-term, systematic monitoring related to the physical status of objects in the Nemi basin, and based on information related to single objects (and not to the landscape level)

<table>
<thead>
<tr>
<th>STATUS OF MONITORING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Investigation – Number of objects investigated</td>
</tr>
<tr>
<td>2. Diagnostic Monitoring – Number of objects diagnostically monitored</td>
</tr>
<tr>
<td>3. Systematic monitoring – Number of objects systematically monitored</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. General physical condition – Number of objects assessed as being in poor or very poor physical condition</td>
</tr>
<tr>
<td>5. Ruins – Number of ruined objects</td>
</tr>
<tr>
<td>6. Loss of fabric – Average percentage of loss of fabric at objects (since last assessment)</td>
</tr>
<tr>
<td>7. Loss of fabric/decoration – Average percentage of loss of fabric at mural paintings (or other decorations) (since last assessment)</td>
</tr>
<tr>
<td>8. Visibility 1 – Number of objects assessed as being poorly and very poorly visible</td>
</tr>
<tr>
<td>9. Visibility 2 – Number of objects visible from defined viewpoints</td>
</tr>
<tr>
<td>10. Vandalism – Number of objects being subject to much or very much vandalism</td>
</tr>
<tr>
<td>11. Garbage – Number of objects with much or very much garbage in the close surroundings</td>
</tr>
<tr>
<td>12. Risk for people – Number of objects assessed as being at high or very high risk for people</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Hazard risk 1 – Number of objects assessed as being at high or very high risk towards (natural) hazards</td>
</tr>
<tr>
<td>14. Hazard risk 2 – Number of objects having been strongly or very strongly destroyed by (natural) hazards (since last assessment)</td>
</tr>
<tr>
<td>15. Decay risk – Number of objects assessed as being at high or very high risk towards (natural) decay</td>
</tr>
<tr>
<td>16. Anthropogenic risk 1 – Number of objects assessed as being at high or very high risk towards anthropogenic threats</td>
</tr>
<tr>
<td>17. Anthropogenic risk 2 – Number of objects having been strongly or very strongly destroyed by anthropogenic development (since last assessment)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXCAVATION AND CONSERVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. Conservation – Number of objects not conserved</td>
</tr>
<tr>
<td>19. Excavation – Number of objects excavated</td>
</tr>
<tr>
<td>20. Protective roofs – Number of objects with protective roofs</td>
</tr>
<tr>
<td>21. Reburial – Number of objects reburied after excavation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MANAGEMENT AND LEGAL MATTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Legal protection – Number of objects having legal protection</td>
</tr>
<tr>
<td>23. Private property – Number of objects belonging to private owners</td>
</tr>
<tr>
<td>24. Public access – Number of objects assessed as not having adapted public access</td>
</tr>
<tr>
<td>25. Management – Number of objects assessed as having poor or very poor management</td>
</tr>
<tr>
<td>26. Management plan – Number of objects with specific management plan</td>
</tr>
</tbody>
</table>
Explanation and discussion of the selected indicators

In table 6 all indicators are listed with a short description and discussion. In addition, results from the Nemi basin investigations have been included where applicable. The explanation of the fields in the table is as follows:

**Short name/indicator**: The short name of the indicator as well as the indicator itself, as also used in table 5.

**Condition, Pressure and/or Response (C, P, R)**: A suggestion for where the various indicators belong within the general framework of condition, pressure and response.

**Comments**: Brief comments and discussion of the indicator selected, as well as a few proposals for additional indicators along the line of the indicator in question.

**Specific baseline information required?** In order to compare the development over time using indicators, one of course need baseline information, usually from a specific study carried out in a specific year. In addition, some indicators require specific baseline information, or a "datum point", e.g. related to measurements of loss of fabric. It does not give meaning to measure/assess loss of fabric as compared to an imaginary condition in the past; one has to set a zero and start from there. In many cases, photos or other material from our investigations can be used for specific baseline information.

**Qualitative Assessment/quantitative Measurement (A, M)**: Much of the information in the database is based on qualitative assessments using the scale 1 ("very good") to 5 ("very poor") as described in part 1 of this report. Generally, for the indicator development, we propose to use 2 ("good") and 1 ("excellent") as (hopefully) significant assessments. The idea is that, upon conservation measures and other interventions, the number of objects with good rates will increase. Since qualitative assessment is inevitably subjective, we also propose a range of more objective indicators, generally based on measurements or counting. The idea behind such indicators is that they may point towards obvious (and less obvious) flaws in the management of the objects and the area. A simple example may be the number of objects that actually have some kind of management plan. Generally, such indicators will, however, tell next to nothing about the quality of the management plan or other phenomena assessed.

**Nemi results**: Number means the actual number of objects fulfilling the criteria of the indicator. This information has been collected from the database developed (see part 1 and volume 2). N=23 means the actual number of objects we have investigated during our investigations in the Nemi basin. As previously mentioned, we have investigated most of the large and important objects. The database currently contains information on 59 objects, but for the calculation of percentage of objects fulfilling the criteria of a specific indicator, we have used the investigated objects (23). Generally, this information is given in order to ensure correct interpretation in the future, as more objects in the area may become investigated and assessed. A rather personal, subjective evaluation of the results in the Nemi basin is given under the heading status:

😊 Indicates that the results of the investigations are positive.

😊 Indicates that the results are quite OK, but that there are many things that could become better. This face is also used when the results cannot be evaluated other than "neutral", as e.g. in connection with natural hazards (earthquake etc.).

😢 Indicates that the results of the investigation are rather negative, and that there is a lot to do in order to improve the situation.
Tab. 6: Proposed set of indicators for the cultural heritage in the Nemi basin. See explanation for the various columns in the text. The basis for the Nemi results are our own investigations described in this report.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pressure and/or Response</th>
<th>Short name / indicator</th>
<th>Comments</th>
<th>Specific baseline information required?</th>
<th>Qualitative Assessment/ Quantitative Measurement</th>
<th>Nemi results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Number (N=23)</td>
<td>%</td>
</tr>
<tr>
<td>ISSUE: STATUS OF MONITORING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Investigation</td>
<td>Number of objects investigated</td>
<td>Indicates the number of objects investigated and recorded in a database, as related to the total number of defined objects in the area.</td>
<td>No</td>
<td>M</td>
<td>23 of 59</td>
</tr>
<tr>
<td>P, C, R</td>
<td>Diagnostic Monitoring</td>
<td>Number of objects diagnostically monitored</td>
<td>Indicates the number of objects diagnostically monitored for various purposes, such as finding the causes of decay.</td>
<td>No</td>
<td>M</td>
<td>9 of 59</td>
</tr>
<tr>
<td>R</td>
<td>Systematic monitoring</td>
<td>Number of objects systematically monitored</td>
<td>Indicates the number of objects systematically monitored as part of an overall management and monitoring plan, the results being recorded in a database.</td>
<td>No</td>
<td>M</td>
<td>0 of 59</td>
</tr>
<tr>
<td>ISSUE: CONDITION</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>C</td>
<td>General physical condition</td>
<td>Number of objects assessed as being in good (2) and/or excellent physical condition (1)</td>
<td>Indicates the general physical condition of the objects in the area. One could also have used the individual condition issues (with static stability as the most critical issue).</td>
<td>No</td>
<td>A</td>
<td>9</td>
</tr>
<tr>
<td>C</td>
<td>Ruins</td>
<td>Number of ruined objects</td>
<td>Indicates the total number of ruins in the area. This can be a good indicator of the development of some areas over long time spans. However, in an area like the Nemi basin, where all potential ruins are in fact ruins, it will not tell much.</td>
<td>No</td>
<td>M</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>Loss of fabric</td>
<td>Average percentage of loss of fabric at objects (since last assessment)</td>
<td>Percentage of obvious loss measured at each object since last assessment. Requires a developed measuring methodology, e.g. based on photos. Can be a good general indicator for physical condition, especially for architectural assets and ruins with well-defined “boundaries”, but it is difficult to apply to less defined ruins. An alternative, similar indicator could be “number of objects having lost more than X% of the fabric”. The problem with these indicators is that loss of fabric (or addition of fabric) may also take place during deliberate interventions.</td>
<td>Yes</td>
<td>M</td>
<td>Considered, can be applied during subsequent survey (using photos from our survey)</td>
</tr>
<tr>
<td>Condition, Pressure and/or Response</td>
<td>Short name / indicator</td>
<td>Comments</td>
<td>Specific baseline information required?</td>
<td>Qualitative Assessment/Quantitative Measurement Number (N=23)</td>
<td>Nemi results</td>
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<td></td>
<td>%</td>
<td>Status</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Loss of fabric - decoration</td>
<td>Average percentage of loss of fabric at mural paintings (or other decorations) (since last assessment)</td>
<td>Percentage of loss measured at each defined mural painting since last assessment. Requires a developed measuring methodology, e.g. based on photos. Can also be applied for other defined decorations. An alternative, similar indicator could be &quot;number of murals having lost more than X% of the fabric&quot;. The problem with these indicators is that loss of fabric (or addition of fabric) may also take place during interventions.</td>
<td>Yes</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>C, P</td>
<td>Visibility 1</td>
<td>Number of objects with visibility assessed as good (2) and/or excellent (1)</td>
<td>Indicates the state of the vegetation cover (or in some cases nearby infrastructure), and how it develops over time. It does not tell anything about the management, as many sites may, for various reasons, be deliberately left covered with vegetation.</td>
<td>No</td>
<td>A</td>
<td>12</td>
</tr>
<tr>
<td>C, P</td>
<td>Visibility 2</td>
<td>Number of objects visible from defined viewpoints</td>
<td>This is an alternative indicator for visibility based on quantitative measurements of the extent of vegetation at an object, as seen from a defined perspective.</td>
<td>No</td>
<td>M</td>
<td>Considered, but not applied</td>
</tr>
<tr>
<td>C, P</td>
<td>Vandalism</td>
<td>Number of objects being subject to little (2) and/or very little (1) vandalism</td>
<td>Indicates whether vandalism is a great problem or not (and whether there is/has been a presence of &quot;vandals&quot;)</td>
<td>No</td>
<td>A</td>
<td>22</td>
</tr>
<tr>
<td>C, P</td>
<td>Garbage</td>
<td>Number of objects with little (2) and/or very little garbage (1) in the close surroundings</td>
<td>Indicates whether garbage/littering is a great problem or not (and whether there is/has been a presence of people/institutions that make a litter)</td>
<td>No</td>
<td>A</td>
<td>18</td>
</tr>
<tr>
<td>C</td>
<td>Risk for people</td>
<td>Number of objects assessed as being at low (2) and/or very low (1) risk for people</td>
<td>An indicator for the security of people accessing the objects in the area. However, a better, similar indicator would be the actual numbers of injuries occurring over defined time spans.</td>
<td>No</td>
<td>A</td>
<td>18</td>
</tr>
</tbody>
</table>

The indicators "Loss of fabric" and "Loss of fabric – decoration" may call for additional description. Requiring specific baseline information, these indicators are based on the assumption that it is possible to detect material lost from the objects using photos from a previous assessment. The material lost can be masonry parts, whole stones or bricks or part of such materials, or, for mural paintings, paint flakes or other fragments. It is important to note that the indicators do not consider the value of the material lost; part of a face in a mural painting and e.g. the background sky in the same painting will thus be treated similarly. If put into use, a practical way of assessing the material lost may be to develop classes based on percentage lost, e.g. >1%, 1-5% etc.
<table>
<thead>
<tr>
<th>Condition, Pressure and/or Response</th>
<th>Short name / indicator</th>
<th>Comments</th>
<th>Specific baseline information required?</th>
<th>Qualitative Assessment/Quantitative Measurement</th>
<th>Nemi results</th>
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<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hazard risk 1</strong></td>
<td>Number of objects assessed as being at low (2) and/or very low (1) risk towards (natural) hazards</td>
<td>Indicates the risk of destruction by natural hazards. One could also have used individual hazard risks (earthquake, rockslide, landslide, bushfire)</td>
<td>No</td>
<td>A</td>
<td>17</td>
</tr>
<tr>
<td><strong>Hazard risk 2</strong></td>
<td>Number of objects having been strongly (4) and/or very strongly (5) destroyed by (natural) hazards (since last assessment)</td>
<td>This indicator possibly provides a more objective assessment of the actual hazard risks in the area (as compared to Hazard risk 1). However, it requires a rather intimate knowledge of events having taken place. The best would perhaps be to use the individual risks (earthquake, landslide, etc.)</td>
<td>Yes</td>
<td>A (M)</td>
<td>Considered, can be applied during subsequent survey (using photos from our survey)</td>
</tr>
<tr>
<td><strong>Decay risk</strong></td>
<td>Number of objects assessed as being at low (2) and/or very low (1) risk towards (natural) decay</td>
<td>Indicates the risk of destruction by (natural) decay, regardless of cause. One could also have used the individual decay risks (collapse, weathering, roots and moisture)</td>
<td>No</td>
<td>A</td>
<td>9</td>
</tr>
<tr>
<td><strong>Anthropogenic risk 1</strong></td>
<td>Number of objects assessed as being at low (1) and/or very low (5) risk towards anthropogenic threats</td>
<td>Indicates the risk of destruction by agriculture, urban expansion, deliberate demolition etc. One could also have used the individual risks. Due to difficulties described elsewhere in the report, this risk was not assessed.</td>
<td>No</td>
<td>A</td>
<td>Considered, but not applied</td>
</tr>
<tr>
<td><strong>Anthropogenic risk 2</strong></td>
<td>Number of objects having been strongly (4) and/or very strongly (5) destroyed by anthropogenic development (since last assessment)</td>
<td>This indicator provides a more objective assessment of the actual anthropogenic risks in the area (as compared to Anthropogenic risk 1). It requires a rather intimate knowledge of events having taken place. The best would perhaps be to use the individual risks (agriculture, urban expansion/house building, deliberate demolition etc.)</td>
<td>Yes</td>
<td>A (M)</td>
<td>Considered, can be applied during subsequent survey (using photos from our survey)</td>
</tr>
<tr>
<td>Condition, Pressure and/or Response</td>
<td>Short name / indicator</td>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
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<td>----------</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Nemi results</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specific baseline information required?</td>
<td>Qualitative Assessment/ Quantitative Measurement</td>
<td>Number (N=23)</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>M</td>
<td>4</td>
<td>17%</td>
</tr>
<tr>
<td>R, C</td>
<td>Conservation</td>
<td>Indicates the number of objects restored or significantly repaired/conserved in the area (taken from the <em>restoration</em> field in the database). This is an important indicator of the interest taken by authorities and owners – and/or whether there are funds available for restoration activities. It does not give information on the quality of the restorations, neither if they were necessary.</td>
<td>No</td>
<td>M</td>
<td>4</td>
</tr>
<tr>
<td>C, R</td>
<td>Excavation</td>
<td>Indicates the number of objects archaeologically excavated in the area. This is an important indication of the archaeological activity and thus the general scientific interest. It does not give information on the quality of the excavations.</td>
<td>No</td>
<td>M</td>
<td>6</td>
</tr>
<tr>
<td>R, C</td>
<td>Protective roofs</td>
<td>Indicates the number of objects with protective roofs, e.g. to protect excavation areas. This indicator also tells about the interest taken by authorities and owners – and/or whether there are funds available for installing protective roofs. It does not give information on the quality of the roofs, neither whether they were necessary or not. Instead of relating the indicator to all objects in the area, it could have made more sense to relate it to the number of excavation areas.</td>
<td>No</td>
<td>M</td>
<td>2</td>
</tr>
<tr>
<td>R, C</td>
<td>Reburial</td>
<td>Indicates the number of objects having been reburied after archaeological excavation. <em>Note to the Nemi results:</em> Parts of the Roman villa area, as well as by Tempio K and in the Theatre in the Diana temple area were reburied after archaeological excavation. This information is not included in our database. Instead of relating the indicator to all objects in the area, it would perhaps have made more sense to relate it to the number of excavation areas.</td>
<td>No</td>
<td>M</td>
<td>0 (3)</td>
</tr>
<tr>
<td>R, C</td>
<td>Legal protection</td>
<td>Indicates the number of objects enjoying legal cultural heritage protection (could also include the status of the legal protection). This is a good indicator of the state of the cultural heritage management in an area. For Nemi we got information on this aspect too late to include it in our database. The number included to the right is thus from the ESA GIS-material (2004).</td>
<td>No</td>
<td>M</td>
<td>15</td>
</tr>
<tr>
<td>Condition, Pressure and/or Response</td>
<td>Short name / indicator</td>
<td>Comments</td>
<td>Specific baseline information required?</td>
<td>Qualitative Assessment: Quantitative Measurement</td>
<td>Nemi results</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>C, R</td>
<td>Private property</td>
<td>Indicates the number of objects belonging to private owners. This indicator gives an idea of the general state of the cultural heritage management in an area. One could also have used type of ownership as an indicator. It was not possible to apply the indicator in the Nemi basin, since we did not have the necessary information.</td>
<td>No</td>
<td>M</td>
<td>Considered, but not applied</td>
</tr>
</tbody>
</table>
| R, C                              | Public access                           | Indicates whether or not the objects have an access adapted to the general public/visitors. This may at first glance seem a very subjective indicator, but it merely gives information on whether it is difficult to access the objects or not. The reasons for difficult access can be fences, dense vegetation, lacking information signs etc. Thus, it does not give information on why the access is difficult or whether the objects are intended for access by the general visitor. | No                                      | A (M)                                         | 4 17%   

Brief evaluation of the indicator results

Below, we have attempted at representing graphically the results of the Nemi investigations through a core set of indicators (fig. 57). We have selected 10 indicators, most of which are based on qualitative assessments, since this is the best we can come up with at the moment.

Despite the fact that most indicators are based on qualitative assessments, we believe fig. 57 gives a rather good picture of the general state of the cultural heritage in the Nemi basin at the moment, as seen from the object level.

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Fig. 57: General state of the cultural heritage in the Nemi basin (2004), as seen from the object level, and represented by a core set of 10 indicators. The axis shows percentage of objects (of the 23 investigated objects in the area) fulfilling the criteria of the various indicators.

As can be seen from the figure, the problem areas are related to physical condition, decay risk, public access, conservation measures and management. Following the analyses in part 2 of this report, this of course does not come as a great surprise. Several objects are in a poor state, some have serious stability problems or are weathering fast, especially those having recently been excavated, and there are few objects having been subjected to conservation measures. Moreover, very few objects have an adapted public access and some are completely overgrown and poorly visible. Whether such objects should be "opened" for the public is another matter and dependent on the goals set for the management and presentation of the whole area. Thus, the low rate given for the management must be seen in relation to the possibility that not all objects should in fact receive management, for instance with regard to regular trimming of vegetation. The state of legal protection is rather good – it is mainly the numerous caves and the stone quarry (le cave storiche di pietra sperone) that are not legally protected with the archaeological authorities (SAL). The Romitorio S. Michele appears to be protected by the architectural cultural heritage authorities.47

The indicators selected generally show numbers of objects, which are in a "good or very good state". It would have been possible also to show those in a "poor or very poor state" to get a better picture of the situation. However, in a small area like Nemi, such matters can be shown and interpreted as in part 2 of this report, using GIS-based maps of the individual results from the database, as well as the database itself. The indicators are mainly meant for quickly getting an overview and for setting up management goals, as well as to be able to check whether the goals have been achieved or not. Moreover, the indicators can be a vital aid in communicating the general state of the cultural heritage towards the general public, authorities and politicians – and, not least, in arguing for funds.

Clearly, the current state could have been represented more securely by putting more objective indicators at work. Thus, in the future we would recommend taking indicators such as "loss of fabric" (indicating decay) and "management plan" (indicating the state of the management) into account. Moreover, the picture emerging from the indicators is by no means complete, especially since the landscape level and the management of the landscape have not been considered, but also because we have not investigated all objects in the basin.

**Putting the indicators at work – a local/regional management issue**

Whether good or poor, secure or doubtful, indicators can only be put sensibly at work within a larger local/regional management framework. In this connection it may be useful to evaluate the suggested indicators using a model proposed in a EU-project called "PASTILLE" (FP5), the so-called "PASTILLE-test".  

Tabs 7: The "PASTILLE-test" as applied to the proposed indicators on the object level for the Nemi basin. Test from: www.lse.ac.uk/Depts/geography/Pastille/news.htm#PTest

<table>
<thead>
<tr>
<th>Questions</th>
<th>Yes</th>
<th>Probably so</th>
<th>Not sure</th>
<th>Probably not</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are the indicators easy to understand for your target group?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2. Is it possible to collect the data on a regular basis?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>3. Are the indicators relevant to the local circumstances?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>4. Are the indicators producing meaningful messages for the target audience?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>5. Are the key stakeholders involved in the use of indicators familiar with measurement and the role of indicators?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>6. In general, do key stakeholders perceive indicators as useful from past experience or current knowledge?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>7. Do the values, routines and attitudes of key stakeholders work in favour of the use of indicators and provide a supportive environment?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>8. Are there enough resources available for data collection and communication of indicator findings?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>9. Do the people involved in data collection and communication of indicator findings have the appropriate skills and training?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>10. Are the indicators based on a clear vision of sustainable development which is shared by key stakeholders?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>11. Are the responsibilities for data collection and communication of findings clarified and agreed among key stakeholders?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>12. Are the indicators and those who are running them trusted by key stakeholders?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>13. Are the key stakeholders cooperating effectively with each other and without major conflict?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>14. Are there any arrangements on how to deal with conflicts about the interpretation and use of indicators?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>15. Are the findings of the indicators communicated in a timely way to all relevant stakeholders – especially to those who should act upon them?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>16. Are your indicators easily adapted to changing circumstances? Are examples of changing circumstances identified in relation to your indicators?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>17. Are the indicators integrated in formal decision-making processes or procedures?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>18. Are the indicators linked to any targets or thresholds, which are agreed among key stakeholders?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>19. Are there any arrangements on how the indicator findings will be used to inform decision-making?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>21. Is there administrative and political support?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

48 The "PASTILLE" project (Promoting Action for Sustainability Through Indicators at the Local Level in Europe) finished in 2002 and dealt with local sustainability indicators. See www.lse.ac.uk/Depts/geography/Pastille/ for a description and for downloading reports and the test.

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Although several of the questions in tab. 7 may not be particularly relevant in the Nemi case, or cannot really be properly answered at the moment, the table clearly shows that there are a lot of management questions to sort out until the proposed indicators, or other sets of indicators, can be put sensibly and effectively at work. However, the discussion of management and planning issues are beyond the scope of our work. These issues are strongly dependent on how the whole Nemi area should be generally treated in the future, the decisions for which are in the hands of the responsible authorities.

Thus, we come back to the values and significance of the sites and objects in the basin, the presentation of the archaeology, the future use of the basin in terms of agriculture, infrastructure and vegetation management – and not least to Giuseppina Ghini’s (SAL) statement that the idea is not to create a trimmed park landscape, but rather to preserve the "spirit of the place" by small and purposeful interventions. In any case, the use of indicators can be an important aid to show agreed goals, and subsequently to monitor the development over time, for instance every 5 years or so, in order to check whether the goals have been achieved or not (see also fig. 58).

Fig. 58: Imaginary example of setting up goals for the cultural heritage management of the objects in the Nemi basin, using the same core set of indicators as in fig. 57 (the orange area shows the current situation). The red dots show targets to be achieved over a, say, 10-15 year period. As can be seen, we have generally chosen 75% as a target, but taken into account that it is not necessary to undertake larger conservation measures, including restoration, for so many objects. The reduction of the decay risk at the remaining objects must thus be achieved through management measures, including regular trimming of vegetation, small, targeted repairs and general maintenance (the latter should of course be carried out wherever necessary!). For detailed recommendations regarding types of measures at the objects investigated, see page 50-52.

49 As an important part of cultural heritage management, the relationship between management and monitoring was discussed during project workshops. Adaptive models such as AEAM (Adaptive Environmental Assessment and Management) were a focal point of interest. For more information on AEAM, see "Adaptive Management Practitioners' Network", http://www.iatp.org/AEAM/

50 See page 40 in this report.
Brief note on future diagnostic monitoring in Nemi

Having selected an object in order “to do something”, not yet knowing exactly what kind of measures to undertake, whether passive or active conservation, a larger restoration or other types of interventions, we enter the realms of thorough scientific investigations and diagnostic monitoring. Investigations strategies, using detailed surveys, detailed mapping, historic analysis etc. are reasonably well known and will not be repeated here.  

Diagnostic monitoring is, as exemplified in part 2 of this report, undertaken on a much more detailed level than the systematic monitoring described above. The primary aim is not to show general trends and threats, but to understand and explain the risks and causes of damage and decay in order to draw up sound conservation plans. Moreover, the diagnostic monitoring tools, intervals and duration must be selected according to the type of problem to be solved and the assumed causes of damage and decay. It is not enough to monitor the condition, say, every 5 years. Thus, one of the most important challenges in diagnostic monitoring is to select intervals and times of observation that enable detection of the real risks.  

A good example is how heavy rain actually influences an object: In order to understand this, one simply has to inspect the object on a rainy day (as we were lucky to achieve in Nemi in February 2004). Another example is the importance of taking a look at the objects just after earthquakes, for instance in order to observe whether smaller or larger parts seem to have collapsed during the event.

Otherwise, the tools put at work for diagnostic monitoring in Nemi, can well be carried out in future conservation projects in the area:

<table>
<thead>
<tr>
<th>Monitoring tool</th>
<th>Typical intervals (best practice, not necessarily the intervals put at work in Nemi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Visual inspection of various damage and decay phenomena at whole objects, parts of objects and their details and decorations. Documentation should be carried out by photography.</td>
<td>Seasonally and after known natural hazards and other dramatic events, such as strong rainfall, bushfire etc.</td>
</tr>
<tr>
<td>• Logging of indoor climate (with electronic loggers; Romitorio)</td>
<td>Hourly, or even more frequently if the aim e.g. is to investigate how visitors influence the climate</td>
</tr>
<tr>
<td>• Salt crystallisation activity (including analysis of salt species)</td>
<td>Seasonally, or even more frequently if the salts are suspected to crystallise/dissolve in other periods.</td>
</tr>
<tr>
<td>• Crack development (with simple hand measurements, as we have done in Nemi, and/or electronic logging and/or gypsum/mortar seals)</td>
<td>Seasonally, in order to understand whether crack development is climate dependent. Crack development should also be related to information on earthquake activity.</td>
</tr>
</tbody>
</table>

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If necessary, many other diagnostic monitoring tools can of course be put at work in the Nemi basin. From the perspective of damage processes, some of the more useful tools could be:

- **Infrared thermography**: This gives a good picture of wall temperature distribution. It could be a valuable tool for a better understanding of salt activity and condensation events/periods in the Romitorio, and probably also at other objects, if put at work seasonally.

- **Microbiological activity**: Many objects are subject not only to large-scale vegetation, but also to microbiology (e.g. fungi, algae and lichen). Understanding their activity and damage potential can be undertaken by combined microbiological analysis and following the evolution of the damages in affected areas.

- **Root bursting observation**: Since larger (and sometimes smaller) roots are very important damage factors in the Nemi basin, it would be a good idea to select some areas with assumed root bursting and follow the evolution carefully.

- **Video/web camera**: This could be a good general tool for following up objects at high risk. However, it is very important to clarify regulations concerning use of data/pictures in areas where people/visitors may be affected by such monitoring.

Essentially a diagnostic tool, retrospective monitoring should also be more carefully considered before conservation measures are undertaken. In our work we have quite clearly not found all relevant old photos and descriptions available, simply because we have not searched public archives. Thus, these, as well as private collections, may constitute very valuable sources for interpretation of causes and rates of decay (and the general evolution of the area).

In part 2, we have given an overview of objects at which scientific investigation is recommended before undertaking conservation measures (Exedra, parts of the Diana temple area, Le Mole 1+2 and the Romitorio). These, as well as objects recently excavated and those with stability problems, should be the main focus for diagnostic monitoring in the years ahead.

The question of indicator development on the basis of diagnostic monitoring has not been considered in our work. However, it may well be that reasonable indicators may emerge as more data may become available. One should in particular keep an eye on crack development and possible collapse at various objects as related to earthquake activity. Perhaps interesting results can be obtained from such a study? Moreover, it would generally seem that indoor climate and its influence on weathering and especially weathering of decorative details, such as mural paintings, constitutes a promising area for indicator development. This is especially so because of the frequent importance of keeping the climate within fixed limits. Thus, indicators catching the essential climatic characteristics over long time spans could be a considerable aid in explaining and preventing damages resulting from a not adapted indoor climate.
Concluding remarks

We believe the investigations described in this report and which work methods are summarised in tab. 9 have given a rather good picture of the current state of the archaeological sites and objects in the Nemi basin. Moreover, on the basis of the surveys, the diagnostic monitoring, as well as the indicators developed and suggested for future systematic monitoring, it should be possible to follow up the work for the responsible authorities. Our investigations can thus be regarded as a "2004 baseline", from which future management, including conservation measures and monitoring can be carried out. We also hope that the work methods, especially the suggestions for diagnostic and systematic monitoring can give ideas to people working with similar problems in other areas and cultural landscapes.

The practical results of our work in the Nemi basin have been discussed at some length in the previous sections. Here it will suffice with a brief summary of what we believe are the most important issues:

- There is very rapid decay/erosion of recently excavated archaeological sites/objects, this implying that, in some cases, re-covering should...

Tab. 9: The work process roughly followed in the Nemi basin. Text in brackets indicate activities that we have not undertaken (measures)

<table>
<thead>
<tr>
<th>Archaeology and environmental history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits and literature survey</td>
</tr>
<tr>
<td>(Definition of aims and resources)</td>
</tr>
<tr>
<td>Selection of sites/objects for recording</td>
</tr>
<tr>
<td>Retrospective monitoring</td>
</tr>
<tr>
<td>Initial recording of sites/objects</td>
</tr>
<tr>
<td>Condition assessment</td>
</tr>
<tr>
<td>Risk assessment</td>
</tr>
<tr>
<td>Recommendations</td>
</tr>
<tr>
<td><em>(Undertake obvious measures)</em></td>
</tr>
<tr>
<td>Selection of sites/objects for diagnostic monitoring</td>
</tr>
<tr>
<td>Diagnostic monitoring</td>
</tr>
<tr>
<td>Testing – confirmation/deviation related to condition, risks and recommendations</td>
</tr>
<tr>
<td>Production of report – an atlas – with interpretations and recommended indicators for further systematic monitoring at e.g. 5 year intervals</td>
</tr>
<tr>
<td><em>(Undertake obvious measures)</em></td>
</tr>
<tr>
<td><em>(Further systematic and diagnostic monitoring dependent on overall management decisions and planning by responsible authorities)</em></td>
</tr>
</tbody>
</table>
be strongly considered.

- Vegetation poses a basic threat to most objects (root bursting, but also microbiology). However, roots may also keep masonry in place, implying that extreme care is required upon removal and trimming. Vegetation is, however, often a larger problem in terms of accessibility to the sites, as compared to the actual damage it causes.

- Earthquake and associated threats, such as rock falls and landslides, probably constitute, in the very long run, the greatest risk to objects with substantial structures above the ground. There is ample evidence of earthquake damages in the past, such as collapse and heavy cracking of objects.

- Heavy rainfall may clearly trigger smaller landslides and rock falls (and perhaps also more substantial ones), but the current tree cover prevents the most dramatic erosion. Thus, future vegetation management strongly ought to consider this aspect.

- Weathering and decay of objects and their decorative details generally seem to proceed quite rapidly, but one may also be fooled by first impressions of "poor state", i.e. damages that happened long ago, are no longer active or now proceed very slowly. In e.g. the rock cut chapel of Romitorio S. Michele, it is astonishing to observe that the condition of the mural paintings have changed little throughout the last 30 years. This must, however, not be confused with the potential risk of future damage, which may be high although the current situation seem rather stable.

- Management of the sites and objects, including regular trimming of vegetation and accessibility for visitors, is very difficult, and not yet properly solved for the overwhelming majority of sites in the Nemi basin. Our suggestions for systematic monitoring using indicators may hopefully become an important aid in the future management, especially since it enables control of whether goals and targets resulting from planning procedures are reached or not.

- Likewise, conservation activities, including restoration, conservation of decorative details, smaller repairs and security measures, may be aided using systematic monitoring. However, for the actual planning of sound measures at the objects proposed on page 50-52, diagnostic monitoring is the essential aid when the causes of damage and decay are not properly known.

It should be strongly underlined that our investigations were carried out mainly at the object level, and do not address the cultural landscape as a "whole". Landscape investigations carried out by other DEMOTEC-A project partners (NIKU, NINA, ESA) are thus supplementary to our work (and vice versa).

The most important lessons we have learnt from the work in the Nemi basin can be summarised like this:

- Understanding the general history, archaeology and environment is of utmost importance when setting up monitoring programmes in an area comprising larger number of objects. Otherwise it is difficult or impossible to really understand the essential threats and thus address these in the monitoring, be it systematic or diagnostic. Without addressing the essential threats, a monitoring programme runs the risk of not aiding its main purpose – to become an important tool for preventive conservation.

- Likewise, it is indispensable to get a grip on area regulations, ownership and private management of sites, as well as possible plans related to these. Since we were not able to get hold of essential information, we had great trouble assessing the anthropogenic risks to the objects included in our surveys.
Having a clear idea of indicators and their potential use is also essential before embarking on a survey that should end up in development of sound indicators for future use/comparisons. One example is visibility of objects, which in our approach was assessed from a rather general, subjective perspective. It would have been little time consuming to additionally assess the same phenomenon from selected, fixed viewpoints, thus possibly achieving a better indicator for the future. However, the problem of defining the actual viewpoint still remains, this being dependent on value perspectives and in the end ideas of how the objects in their landscape context should actually be presented.

For future systematic monitoring we believe one has to think in terms of both "hard" indicators, i.e. indicators based on quantitative measurements and counting, and "soft" indicators based on qualitative assessments. It does not make sense to reduce all problems and challenges to what can be actually measured and counted, since this implies a danger of missing out the qualitative aspects of cultural heritage, its damage, decay and management. Thus, building indicator frameworks from both perspectives, these supplementing each other for the interpretation and reporting, would be our general recommendation.

This is not to say that for the qualitative assessment one should not strive for strategies enabling comparative judgement in time and space. Certainly one should, based on sets of criteria for the assessment as for example proposed in this work (part 1). In this connection it would have been very interesting to test the qualitative assessment methods by asking different teams to undertake the same work as we have done, following the methods described in this report, in the Nemi basin. Perhaps this is a work that ought to be considered in the future?

Generally, we certainly hope that monitoring can be continued in the basin, following our or other methods. For example, comparing different monitoring strategies could make a great contribution to this young field of study within cultural heritage. One obvious proposal would be to put the Italian Risk Map at work in the basin and see whether the results are comparable to ours (the systematic monitoring/indicator development part). This ought to be particularly interesting, as our method is based on a rather profound knowledge of the area and assessment of all phenomena "on the spot". On the contrary, the Italian Risk Map is based on more rigid, semi-quantitative assessment of condition and vulnerability, which is analysed within a territorial, rather "coarse-grained" hazard framework, in order to statistically determine individual risks at an object/site/building level.

The Nemi basin is not only a beautiful landscape with an extraordinarily rich heritage – it is also an ideal "laboratory" – a microcosm – for developing sound methods for cultural heritage management, risk assessment and monitoring. Hopefully this work can be continued to the best of the landscape and the archaeological sites – and to the people in the area and the scientific community.

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53 The forthcoming work of NIKU on the landscape level in the Nemi basin will include further discussions on the use of fixed viewpoints.
54 See brief description in part 1 of this report. Preliminary discussions on the feasibility of putting the Italian Risk map at work in the Nemi basin have been undertaken with Giorgio Accardo, the main responsible for the Risk map.
**Bibliography**

The following bibliography is only applicable to the Nemi basin. Other literature used in this report is referred to in footnotes (especially Part 1).

### Archaeological/historical overviews

<table>
<thead>
<tr>
<th>Source</th>
<th>Title</th>
<th>Publisher/Editor</th>
</tr>
</thead>
</table>

### Archaeological and environmental plans

<table>
<thead>
<tr>
<th>Source</th>
<th>Title</th>
<th>Publisher/Editor</th>
</tr>
</thead>
</table>

### Geographical Information Systems (GIS)

<table>
<thead>
<tr>
<th>Source</th>
<th>Title</th>
<th>Publisher/Editor</th>
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<tbody>
<tr>
<td>European Space Agency (ESA):</td>
<td>GIS-model of the Nemi area. Shapefiles and images provided by Emmanuel Loret and others.</td>
<td></td>
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<tr>
<td>Loret, E. &amp; Testana, C. (2003):</td>
<td>A GIS-model for cultural heritage analyses. <em>Presentation at DEMOTEC-A Workshop</em> in Genzano di Roma, 30.5-1.6 2003 [Presentation of the existing GIS-model of the Castelli Romani Park, worked out in the <em>Primavera</em> EU-Project, this GIS material constituted the basis for the GIS maps presented in the current report] (Power-Point presentation, unpublished.)</td>
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</table>
Tempio di Diana ("Area Sacra") - archaeology and restoration


Loc. S. Maria (the Roman villa/Villa Imperiale - archaeology


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**Emissario (and the Roman ships)**

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**Romitorio di S. Michele**

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**Palizzate e bancina (Roman embankment)**

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**Lake Nemi**

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**Geology and earthquake**

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### DEMOTEC-A reports/publications (Export-Center für Denkmalpflege)


Bionda, D. et al. (forthcoming): Weathering of Romitorio di S. Michele, Nemi, Italy

### Websites

- [www.parks.it/parco.castelli.romani/Eindex.html](http://www.parks.it/parco.castelli.romani/Eindex.html)
  About the Castelli Romani Park, of which Nemi is part.

- [www.eduspace.esa.int/eduspace/Background/default.asp?document=228](http://www.eduspace.esa.int/eduspace/Background/default.asp?document=228)
  GIS training package related to the Castelli Romani Park and the Nemi basin

- [www.dkinst-rom.dk/nemi](http://www.dkinst-rom.dk/nemi)
  The Colli Albani and Nemi Villa Projects 1998-2002

- [www.hum.au.dk/klasark/klasark/nemi.htm](http://www.hum.au.dk/klasark/klasark/nemi.htm)
  Reports from the excavations of loc. S. Maria.

- [www.comunedinemi.it/index.html](http://www.comunedinemi.it/index.html)
  Official website of Nemi with description of its history and several archaeological sites

- [www.villadiana.dk/nemi.htm](http://www.villadiana.dk/nemi.htm)
  Good site in Danish with information about several sites in the Nemi basin.

- [http://nemiship.multiservers.com/](http://nemiship.multiservers.com/)
  Site dedicated to the reconstruction of the Nemi ships. See also:
<table>
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<tr>
<th><a href="http://www.abc.se/~m10354/mar/nemships.htm">www.abc.se/~m10354/mar/nemships.htm</a></th>
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<tr>
<td><a href="http://www.bartleby.com/196/">www.bartleby.com/196/</a></td>
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<tr>
<td>Frazer's &quot;Golden Bough&quot;</td>
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<tr>
<td><a href="http://80.117.141.2/cft/">http://80.117.141.2/cft/</a></td>
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<tr>
<td>Catalogue of Strong Italian Earthquakes from 461 BC to 1990. [With detailed information on the effects of major earthquakes]</td>
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<td><a href="http://www.ingv.it/~roma/SITOINGLESE/activities/seismology/sismologiavulca/testo.html">www.ingv.it/~roma/SITOINGLESE/activities/seismology/sismologiavulca/testo.html</a></td>
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<tr>
<td>Earthquakes, crustal structure, and deformation of the Alban Hills [More intense activity every 30 years, about GPS-network for prediction of activity, good figure, takes the 1989-1990 seismic swarm as the basis]</td>
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<tr>
<td><a href="http://www.ingv.it/~roma/attivita/geodesia/retivulcani/rete_albani/albani.html">www.ingv.it/~roma/attivita/geodesia/retivulcani/rete_albani/albani.html</a></td>
</tr>
<tr>
<td>La rete GPS dei Colli Albani (Roma) [About the GPS-network for earthquake prediction]</td>
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<tr>
<td><a href="http://www.iris.edu/seismon/">http://www.iris.edu/seismon/</a></td>
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<tr>
<td>Echtzeit-&quot;Seismisches Monitor&quot;</td>
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<tr>
<td><a href="http://gndt.ingv.it/">http://gndt.ingv.it/</a></td>
</tr>
<tr>
<td>Gruppo Nazionale per la Difesa dai Terremoti (Rubrik Banche Dati anschauen)</td>
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<tr>
<td><a href="http://io.ingrm.it/terremoti/terremoti.html">http://io.ingrm.it/terremoti/terremoti.html</a></td>
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<td>Istituto Nazionale di Geofisica e Vulcanologia, Aktuelle Erdbeben</td>
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<td><a href="http://io.ingrm.it/banchedati/banche.html">http://io.ingrm.it/banchedati/banche.html</a></td>
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