MALSIS
A Soil Information System for the Maltese Islands
MALSIS: project inception, implementation and results

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Project Manager
Principal Scientific Officer

Ministry for Rural Affairs and the Environment
Project co-ordinates

- **MALSIS**: MALta Soil Information System is a project funded under the LIFE III (the financial instrument for the Environment) Third countries 2000 – 2004 programme.

- **Budget**:
  - Total cost: 639,950 Euro
  - EU LIFE contribution: 378,000 Euro

- **Project sponsors**:
  - European Commission (70%)
  - Ministry for Rural Affairs and the Environment

- **Project beneficiary**: MRAE

- **External Assistance**: Cranfield University - National Soil Resources Institute (NSRI)
Project team

**Project management:** National Soil Unit

**Project implementation:** National Soil Unit and team members from other entities

- **Project Director**
  - George E. Carbone

- **Technical Advisors**
  - NSRI Team

- **Project Manager**
  - Sonya J. Sammut

- **Project Administration**

- **Survey team**
  - Sub-manager
  - Sharlo Camilleri

- **Laboratory team**
  - Sub-manager
  - Moira bonello

- **Information systems team**
  - Sub-manager
  - Stefan Farrugia
Prior to MALSIS, the only soil survey information for Malta was 1:31,680 scale map and report by Lang (1960) showing the distribution of 13 mapping units.

The methods used to sample and describe soil properties and to characterise soil map units inadequate to understand spatial variation of such properties across Islands.
Motivation

- Until recently, Malta had no soil information system to:
  - underpin key policy requirements
  - interact with other national environmental datasets
  - harmonise with wider European Soils Information System (EUSIS)

- **Priority area:** Characterisation of soils for protection of groundwater to comply with Nitrate Directive, however, the implementation of other Directives also requires detailed information about the soil resources (Sewage sludge, waste, environmental assessment, habitats, pollution prevention, etc.).

- MALSIS was intended to store and provide easy access to baseline information to address a broad range of agro-environmental and land use and management issues.
Project objectives

- **Global objective**
  To create a soil information system for the Maltese Islands.

- **Specific objectives**
  1. To **identify** soil information data requirements and future needs of the user community.
  2. To **collect, analyse and map** the soil-related parameters relevant to agro-environmental quality.
  3. To **design and implement** a soil information system for Malta, MALSIS.
  4. To **develop** a forward security plan for a Maltese National Soil Unit.
Project phases of activities

- Implementation was divided in 6 phases:
  - 1 Primary data acquisition (soil survey)
  - 2 Soil laboratory analysis
  - 3 Hardware and software specification
  - 4 Implementation of information system
  - 5 Data entry and validation
  - 6 Construction of a Graphical User Interface
Phase 1: Primary data acquisition

- Objectives:
  - To carry out soil survey of Maltese Islands in 3 stages:
    - **Stage 1**: investigation and reconnaissance
    - **Stage 2**: national grid survey and limited “free” survey
    - **Stage 3**: local site investigations
Survey stage 1: Investigation and reconnaissance

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Identification of agronomic/ecological land use</td>
<td>✓ 16 land use types identified (11 agricultural and 5 non-agricultural)</td>
</tr>
<tr>
<td>➢ Reconnaissance survey</td>
<td>✓ 18 soil landscapes identified and described</td>
</tr>
<tr>
<td>➢ Review of existing soil information/maps</td>
<td>✓ Prototype soil classification scheme for Maltese soils based on FAO (1999)</td>
</tr>
<tr>
<td></td>
<td>✓ Prototype soil mineralogy and lithology scheme produced</td>
</tr>
<tr>
<td></td>
<td>✓ Soil maps/information reviewed</td>
</tr>
</tbody>
</table>
1. Flowcharts for soil classification

**FAO Soil Classification Flow chart**

1. Is there rock or rock rubble at 25 cm depth or less? Yes \rightarrow 0 to 4

2. Is there a Calcification present? Yes \rightarrow Pelagic Calcisol

3. Is there rock or rock rubble at 10 cm depth or less? Yes \rightarrow Calcaric Leptosol

4. Is there rock or rock rubble at 50 cm depth or less? Yes \rightarrow Calcaric Lithic Leptosol

5. Is there a Calcification present? Yes \rightarrow Calcaric Epelic Pedon

6. Is there a reddish clay subsoil over the rock rubble? Yes \rightarrow Ochric Epelic Pedon

7. Is the soil bedrock present? Yes \rightarrow Calcaric Epelic Cambisol

8. Is there a reddish clay subsoil over the rock rubble? Yes \rightarrow Calcaric Epelic Cambisol

9. Is the soil bedrock present? Yes \rightarrow Calcaric Anthric Regosol

10. Is the soil LL or 5 to 10 cm rock or rubble? Yes \rightarrow Calcaric Arenic Epelic Pedon

11. Is the soil (clay) starting at and extending below 25 cm depth? Yes \rightarrow Calcaric Leptosol

12. Is there rock or rock rubble at 100 cm depth or less? Yes \rightarrow 0 to 21

13. Is there a reddish clay subsoil directly below the topsoil? Yes \rightarrow Entelic Epelic Pedon

14. Is there a Calcification present? Yes \rightarrow 0 to 16
Survey stage 2a: National grid survey

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Identification of geo-referenced sites</td>
<td>✓ 331 geo-referenced sites identified</td>
</tr>
<tr>
<td>➢ Elaboration of field survey/sampling</td>
<td>✓ Field recording form and instruction manual.</td>
</tr>
<tr>
<td>protocols</td>
<td>✓ Field survey protocol.</td>
</tr>
<tr>
<td>➢ Grid survey at 1km x 1km interval</td>
<td>✓ Grid survey completed</td>
</tr>
</tbody>
</table>
Site Location & Description

Bulk / Topsoil sampling

Shallow pit

Sub-soil sampling

Soil profile description

Remove evidence of disturbance
Survey stage 3: Free survey

Free survey guided by pedological relationships. Investigates in detail small scale variability within a management unit.

Measurements include: depth, PSA, colour, stoniness and terrace height
Survey stage 2b: Limited free survey

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Identification, delineation of soil landscapes</td>
<td>✓ Soil landscapes map</td>
</tr>
<tr>
<td>➢ Derivation of free survey protocol</td>
<td>✓ Free survey protocol established</td>
</tr>
<tr>
<td>➢ Identification of potential sites and target sites</td>
<td>✓ 320 potential and 75 target sites identified</td>
</tr>
<tr>
<td>➢ Survey and sampling of target sites</td>
<td>✓ Survey at 75 target sites completed</td>
</tr>
</tbody>
</table>
Survey stage 3: Local sites investigations

- Objective: to conduct a detailed investigation of environmentally sensitive sites.
- Target sites
  - South east agricultural area irrigated with treated sewage effluent (25 sites)
  - Land based landfill at Maghtab (50 sites)

<table>
<thead>
<tr>
<th>Target area</th>
<th>Sampling programme</th>
<th>Soil samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>South east</td>
<td>Judgmental (depending on management and inputs)</td>
<td>Bulk topsoil (B) Subsoil (H2)</td>
</tr>
<tr>
<td>Maghtab</td>
<td>Systematic (5 line transects)</td>
<td>Bulk topsoil only</td>
</tr>
</tbody>
</table>
Phase 2: Soil laboratory analysis

- **Objectives:** To enable characterisation of certain properties of Maltese soils

- **Type of analysis:**
  - Mandatory parameters in Georeferenced Soil Database for Europe;
  - Heavy metals (Sewage Sludge Directive) to establish background levels in Maltese soils.

- **Target samples:**
  - Grid survey samples: B+H1+H2, app. 680.
  - Local sites investigations: B+H2, app. 100.
# Soil testing

<table>
<thead>
<tr>
<th>Survey stage</th>
<th>Type of soil sample</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a Grid survey</td>
<td>Bulk (B)</td>
<td>Bulk density, pH, EC, CEC, Org-C, Inorg-C, PSA, Pb, Cu, Cr, Cd, Zn, Ni, Hg</td>
</tr>
<tr>
<td></td>
<td>Topsoil (H1)</td>
<td>Bulk density, Org-C, PSA</td>
</tr>
<tr>
<td></td>
<td>Subsoil (H2)</td>
<td>Bulk density, pH, EC, CEC, Org-C, Inorg C, Pb, Cu, Cr, Cd, Zn, Ni, Hg</td>
</tr>
<tr>
<td>3 Local sites</td>
<td>Bulk topsoil (B)</td>
<td>EC, Pb, Cu, Cr, Cd, Zn, Ni, Hg</td>
</tr>
<tr>
<td>investigations</td>
<td>Subsoil (H2)</td>
<td>EC, Pb, Cu, Cr, Cd, Zn, Ni, Hg</td>
</tr>
</tbody>
</table>
Phases 3 and 4:
Information system design

- Information needs determined, constraints identified.
- Development stages:
  - Conceptual design
  - Detailed design: performance specifications, selection of computer environment to support client-server access via a relational database management system and geographical information system (GIS).
  - Software developed
Phase 5: Data entry and validation
Phase 6: Graphical User Interface

- The geographical information system used served as the platform for:
  - interpretative and display purposes providing a powerful dimension to data handling.

- Malsis database provides facility
  - To generate site report containing site description, site images and laboratory data.
  - To query such data and display outputs.
### Soil Analysis

#### Chemical Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Label</th>
<th>Depth</th>
<th>Test</th>
<th>Result</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>507560002</td>
<td>0.05</td>
<td>pH (5)</td>
<td>7.18</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>507560002</td>
<td>0.15</td>
<td>Electrical Conductivity (1.5)</td>
<td>276.115</td>
<td>μS-1</td>
</tr>
<tr>
<td>H2</td>
<td>507560002</td>
<td>0.50</td>
<td>H (1.5)</td>
<td>6.08</td>
<td></td>
</tr>
<tr>
<td>H2</td>
<td>507560002</td>
<td>0.75</td>
<td>Electrical Conductivity (1.5)</td>
<td>213.729</td>
<td>μS-1</td>
</tr>
</tbody>
</table>

#### Physical Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Label</th>
<th>Depth</th>
<th>Test</th>
<th>Result</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>507560002</td>
<td>0.05</td>
<td>Moisture</td>
<td>16.2907</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>507560002</td>
<td>0.15</td>
<td>Moisture</td>
<td>4.7843</td>
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</tr>
<tr>
<td>B</td>
<td>507560002</td>
<td>0.50</td>
<td>Carbonates</td>
<td>110.612</td>
<td>g/kg</td>
</tr>
<tr>
<td>H1</td>
<td>507560002</td>
<td>0.50</td>
<td>Bulk-density</td>
<td>1.1161</td>
<td>g/hr³</td>
</tr>
<tr>
<td>H1</td>
<td>507560002</td>
<td>0.75</td>
<td>Moisture</td>
<td>24.7807</td>
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</tr>
<tr>
<td>H1</td>
<td>507560002</td>
<td>0.75</td>
<td>Moisture</td>
<td>96.2140</td>
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<tr>
<td>H2</td>
<td>507560002</td>
<td>0.50</td>
<td>Bulk-density</td>
<td>1.233</td>
<td>g/hr³</td>
</tr>
<tr>
<td>H2</td>
<td>507560002</td>
<td>0.75</td>
<td>Moisture</td>
<td>5.1829</td>
<td></td>
</tr>
<tr>
<td>H2</td>
<td>507560002</td>
<td>0.75</td>
<td>Moisture</td>
<td>56.0278</td>
<td></td>
</tr>
<tr>
<td>H2</td>
<td>507560002</td>
<td>0.75</td>
<td>Carbonates</td>
<td>34.2425</td>
<td>g/kg</td>
</tr>
</tbody>
</table>

#### Heavy Metals
Project results

- MALSIS is a **result-oriented** project. The expected results were:
  - Digital soil-property maps of Malta
  - A computer-based information system to support environmental obligations of the *Acquis*.
  - A Maltese national soils office with trained staff.
  - A sound basis for on-going monitoring of soil quality indicators.
Digital soil property maps

MALSIS database has the facility to produce property maps showing:

1. Site information: e.g. land use, stoniness,

2. Soil profile information: e.g. depth to bedrock, structure

3. Soil chemical characteristics: electrical conductivity, organic carbon, metals

4. Derived maps: e.g. land suitability, limitations, etc.
Map Legend
Effective soil depth classes
- 7 - 10 cm
- 11 - 30 cm
- 31 - 50 cm
- 51 - 75 cm
- > 75 cm
The GIS platform provides facility to interpolate point data and produce a continuous surface.

It is also possible to produce ‘probability’ maps showing the probability that a threshold/legal limit has been exceeded.
Map Legend

Organic Carbon content in topsoil

- Very low (< 10 mg/kg)
- Low (10 - 20 mg/kg)
- Medium (20 - 60 mg/kg)
Capacity building

- MALSIS has ‘supplied’:
  - An information system that can be used to implement agro-environmental obligations of the Acquis

- A National Soil Unit that has:
  - Soil survey, laboratory soil analysis and soil archive facilities
  - Trained and dedicated team in these areas
  - Is the focal point for soil information at European level.
  - The national capacity to provide research-based policy-support and to implement forthcoming soil protection and soil monitoring Directives.

- Basis for on-going monitoring of soil quality indicator parameters
Already at this stage, NSU has established links with soil data users:
Next steps

- **Dissemination of project results:**
  - reports, technical monographs, scientific papers
  - participation in international conferences

- **Interpretation of results and further research:**
  - to support policy making process - implementation of code of good agricultural practice, agri-environment schemes (RDP), nitrate action programme, waste management
  - to bridge the knowledge gap and reach out to farmers – better guidelines in soil use and management at field scale
Reflections

- Pre-project planning and preparation started 5 years ago (1999), but project life cycle (24 months) was most intensive!
- Project implemented successfully and expected results achieved (or even exceeded)
- Advantage of project framework: problems that seem insurmountable bring minds together to make them dissolve.
- Looking back and comparing to the pre-MALSIS situation, very satisfied with what has been achieved: in terms of institutional capacity building and information; would have been difficult without the valuable input of our technical advisors
- Experience for project team: not only in soil survey, information systems, GIS and laboratory analysis, but also in project-based performing – capable team players and excellent direction
- These and others are reasons enough to motivate us to embark on post-MALSIS challenges…