

System (SEIS) and Development of a Web-Based GIS Interface

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Introduction

The Shared Environmental Information System (SEIS) is a collaborative initiative of the European Commission (EC) and the European Environment Agency (EEA) aimed to establish an integrated and shared EU-wide environmental information system together with the Member States.

SEIS presents the European vision on environmental information interoperability. It is a set of high-level principles & workflow-processes that organize the collection, exchange, and use of environmental data & information aimed to:

- Modernise the way in which information required by environmental legislation is made available to member states or EC instruments;
- Streamline reporting processes and repeal overlaps or obsolete reporting obligations;
- Stimulate similar developments at international conventions;
- Standardise according to INSPIRE when possible; and
- Introduce the SDI (spatial database infrastructure) principle EU-wide.

SEIS is a system and workflow of operations that offers technical capabilities geared to meet concept expectations. In that respect, SEIS shows the way and sets up the workflow effectively in a standardise way (e.g. INSPIRE) to:

- Collect Data from Spatial Databases, in situ sensors, statistical databases, earth observation readings (e.g., EOS, GMES), marine observation using standard data transfer protocols (ODBC, SOS, ftp, etc).
- Harmonise collected data (including data check/data integrity) according to best practices proven to perform well, according to the INSPIRE Directive 2007/2/EC (1) Annexes I: II: III: plus INSPIRE Implementation Rules for data not specified in abovementioned Annexes.

- Harmonise collected data according to WISE (Water Information System from Europe) or Ozone-web.
- Process, aggregate harmonise data so to extract information in a format understandable by wider audiences (e.g., Eurostat, enviro-indicators).
- Document information to fulfil national reporting obligations towards EU bodies (e.g., the JRC, EEA, DGENV, Eurostat)
- Store and publish information for authorised end-users (e.g., citizens, institutions).

This paper presents the development and integration of the SEIS-Malta Geoportals. The first section outlines EU Regulations on INSPIRE and Aarhus Directives. The second covers the architecture and the implementation of SEIS-Malta Geoportals. The third discusses the results and successful implementation of the Geoportals.

Regulatory Issues

The Aarhus Directive (Directive 2003/4/EC) (2) provides legal grounds for citizens to openly access environmental information held or produced by public authorities, including information on the state of the environment. In addition it provides people the right to inquire policies or measures taken on the state of human health and safety when this can be affected by the state of the environment.

Under this Directive, an applicant is entitled to obtain this information within one month of the request and without having to say why they require it, while in addition, public authorities are obliged to actively disseminate environmental information in their possession.

SEIS Malta makes data publicly available under interoperable services such as WMS, WFS and other, whilst providing access to reports on environmental status. For instance the data can be provided via map format accessible via the Geo-Portal from the official website of the national public authority maintaining the data.

By using open and interoperable service, the SEIS dataset can be made also available through mapping applications and thus directly accessible not only to citizens but also to the private sector, research organizations and institutes like universities or university departments.

In addition, SEIS-Malta sets a set of principles to be followed as discussed earlier in this text. A key step to the implementation of SEIS is the modernization and revision of the Standardised Reporting directive 91/692/EC (3) along the lines of SEIS principles. Although the current standardised reporting directive (SRD) applies only to relatively small proportion of reporting obligations in environmental legislation, the envisaged provisions in the revised directive is to modernise the way in which the information is made available could cover essentially all of the more than 100 existing environmental

reporting obligations.

During the development of SEIS-Malta several EU Directives were considered:

- Standardised Reporting Directive (SRD) (91/692/EEC): The purpose of this Directive is to rationalize and improve the provisions on the transmission of information and the publication of reports concerning certain Community Directives on the protection of the environment. This directive is mainly dealing with water protection and management, monitoring of atmospheric pollution and chemicals, industrial risk and biotechnology.
- INSPIRE Directive (2007/2/EC): INSPIRE is based on the infrastructures for spatial information established and operated by the 27 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative “regional” approach.
- European Environment Information and Observation Network (EIONET): EIONET is a partnership network of the European Environment Agency (EEA) aiming to provide timely and quality-assured data, information and expertise for assessing the state of the environment in Europe and the pressures acting upon it.

Architecture and Implementation

This section provides:

1. Overview of SEIS-Malta Architecture
2. Description of the SEIS-Malta services
3. Workflow for the creation of the INSPIRE geodatabase.

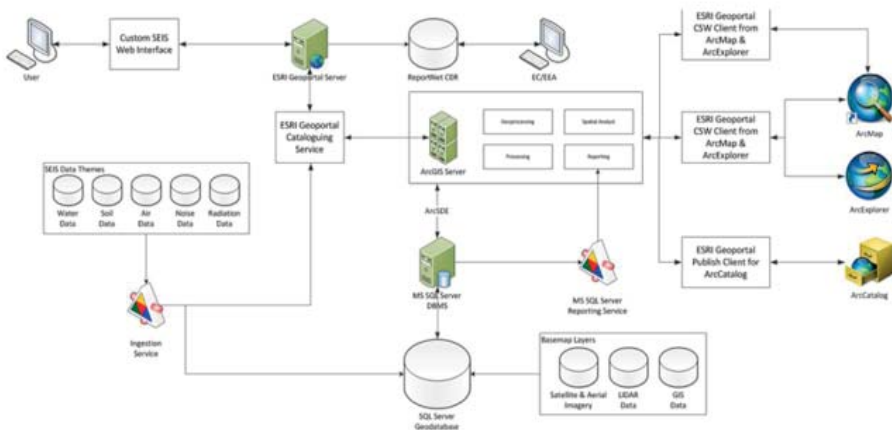
SEIS Architecture

Figure 1 provides an overview of the architecture and components of the SEIS-Malta. Details for each component follow.

Custom SEIS Web Interface

The Custom SEIS Web Interface is based on ESRI's Geoportal Technology. ESRI's Geoportal provides functionality that we can leverage not only to provide the users with a discovery portal (so users can find SEIS-based resources held by MEPA) visualisation, download, registry, and feedback services, as well as metadata harvesting functionality, we can also enhance it to provide a customisable web interface with a map viewer that is already standards-based and cross-browser compliant. ESRI's Geoportal proves that it is a solid choice for the development of the SEIS Portal. The Geoportal provides a highly tested codebase that can be deployed with minimum difficulties and with a great measure of confidence.

Figure 1: SEIS Architecture



ESRI's Geoportal follows a specific but fully customizable interface that we leveraged with additional functionality provided via a variety of ArcGIS Server 10 tools. Through this interface the user is able to:

- Search the SEIS database for environmental information regarding specific pollutants and/or conditions
- View such data on the embedded map
- Search and download reports as submitted to the Reportnet
- securely edit metadata
- query attribute data
- create thematic maps and charts
- download geospatial datasets (i.e. shp files) and reports
- securely edit data.

Types of Users

Five different types of users (user roles) are accommodated by the Geoportal:

Table 1: Types of Users

Role Functionality

Anonymous user	Not required to login to the Geoportal to use some of its key functions. This group of users can access the public functions of the Geoportal, including: search, view results, and view resources.
Registered user	Has access to the same functions as the anonymous user. In addition, a registered user can save searches and manage their user profile. To become a registered user, click the Register link at the top of the Geoportal screen and fill out the profile information.
Publisher	Can register, upload, and create resources using the Geoportal. Resources that a publisher publishes to the Geoportal must be approved by the Geoportal Administrator before they are discoverable through the Geoportal search interface. Publishers are responsible for keeping their own resources - and the data items and services referenced by them - current and accessible. A publisher will see the Administration tab in the Geoportal interface after logging in.
Editor	The Editor User has the same abilities as the Publisher User but with the added functionality of editing geospatial and attribute data.
Administrator	The gatekeeper of the Geoportal. Has access to the Administration tab on the Geoportal interface and through that tab is able to see all resources maintained in the Geoportal by all publishers. The Geoportal Administrator handles the following activities: <ul style="list-style-type: none"> • Review and approve posted resources • Notify the Geoportal security administrators if someone should be made a publisher

Data Themes for SEIS

Data Themes covering the requirements for SEIS are the:

- Air Data
- Water Data (Bathing Water, Transitional & Coastal Water)
- Soil Data
- Noise Data
- Radiation Data

Ingestion Services

The Ingestion Services obtain, import and process data into the MS SQL Server (4) SEIS database in near real-time as the data is delivered or produced by the sensors or other media. The Ingestion Service is an essential component of the infrastructure since it represents the main entry point for data ingestion.

The Ingestion Service is responsible for ingesting, pre-processing and storing data received from external sources of information, external stakeholders (users and services). Specifically, being an archiving and ingestion component, its responsibilities shall comprehend:

- Transparent retrieval of data from external sources;
- Transparent ingestion of the retrieved data.

The Ingestion Service additionally log all activities to allow the administrator to analyse the evolution of the various processing performed. The SEIS Ingestion Service is responsible for handling ingestion, cataloguing and archival of geospatial data by making use of relevant services provided by the infrastructure (chaining them properly) to perform the following functionalities:

- Data Pre-processing, responsible for performing various actions on the ingested data such as to collect data (from variable and configurable sources – like a spreadsheet, text file, xml or some other structured document source or live from the sensor network), get that data into the INSPIRE-based RDBMS schema for each data theme and through the business logic implemented in this service, monitor values for example and react on atypical values.

ESRI ArcGIS Server 10

SEIS is based on ESRI technologies; ArcGIS Server 10 (5) is used to serve the data and users of the SEIS Component, acting as a Web GIS Server. ArcGIS Server 10 is fully compatible to the requirements, specifications and standards of the Open Geospatial Consortium (6) regarding the implementation of:

- WMS – Web Map Service
- WFS – Web Feature Service
- WCS – Web Coverage Service
- WPS – Web Processing Service

For SEIS-Malta, WMS, WFS and WCS are used to implement the required functionality. Along these lines, ESRI's update for ArcGIS Server 10 is conformant to the specifications of INSPIRE. Customization for items not inherently supported by the software are provided (by the software development team) on a need-to-be-developed basis following the Hybrid software development technique described in MEPA's user requirements.

Figure 2: ArcGIS Server Overview (7)



ArcGIS Server 10 approach is service oriented following the SOA – Service Oriented Architecture to creating and managing GIS Web Services as the abovementioned. Additionally it can be deployed in cloud environment should MEPA choose to do so.

ESRI ArcSDE 10 - SDE

To connect to the RDBMS serving the data for SEIS, ArcGIS Server 10, ArcSDE 10 for Microsoft SQL Server is used. ArcSDE enables the usage of Relational Database Management Systems (RDBMS) for spatial data. The spatial data may then be used as part of a geodatabase.

Processing

Data processing for SEIS-Malta is completely based on the processing capabilities provided by ESRI ArcGIS Server 10. This software provides a wide range of processing and analysis tools as well as the ability for the user to develop and deploy his/her own tools and models.

SEIS-Malta used as a reporting obligations facilitation mechanism and an Environmental Data Dissemination tool according to the Aarhus and INSPIRE Directives. Data capturing procedures and methodologies are to be followed for each theme according to the current business processes of the authorities involved in data collection, processing and delivery.

These data is then to be acquired by the SEIS team of MEPA and through Data Ingestion Service to be uploaded to the Geoportal and made available to the public and to the registered users.

Reporting

The Reporting Service for SEIS is based upon MS SQL Server Reporting Services (SSRS). SSRS is a server-based report generation software system that can be used to prepare and deliver a variety of interactive and printed reports and is administered via a web interface. Reporting services features a web services interface to support the development of custom reporting applications.

With Reporting Services setup for SEIS, the MEPA side user is able to create interactive, tabular, graphical, or free-form reports from relational, multidimensional, or XML-based data sources. These reports can then be published in any format as mentioned above the user chooses. The user can also schedule the report processing or create and access reports on demand.

For example the person responsible for the air quality module can request from the Reporting Services a report with the collected data on air according to the standards set by the reporting obligations. Thus, he/she can create a report template where the Reporting Service will be based in order to query the database for the relevant data, fill the report with the appropriate values and deliver it at the requested time and with the requested file format i.e. Excel.

Especially used with XML-based data sources, the Reporting Services allow the user to query Web Services directly by parsing the XML structure of the SOAP (8) response.

Geoprocessing

Geoprocessing is performing through ArcGIS Server 10 thus supporting various data processing and tools/applications in a server/client based environment where the clients can be based on the power of the server for processing and serving.

Geoprocessing can be used to find spatially intersecting data, create buffers, create

spatial data unions, merge and dissolve spatial datasets thus creating basis for spatial queries and spatial analysis.

The MEPA-side user can use a Geoprocessing service to serve to the SEIS Geportal visitors a set of Geoprocessing tools which either was developed during the implementation of the project or was already available from the ArcGIS Server 10. Thus, the Geoprocessing service is executed on the server and the results are served over the web to the users and visitors.

Design INSPIRE Geodatabases

This sub-section presents the geodatabase model for each of the abovementioned data themes.

Air

The Air geodatabase is designed according to the following steps most of them being carried out in parallel:

- Analysis of the target Data Model (INSPIRE Environmental Monitoring Facilities Data Specifications v3.0rc3) (9);
- Analysis of the Source Data (MEPA website + sample data provided by MEPA);
- Conceptual design of the geodatabase according to INSPIRE EF Data Specification;
- Preparation and filling-in of the matching table;
- Creation of the geodatabase structure with ArcGIS Diagrammer;
- Import of the geodatabase in ArcGIS and SQLServer.

Water

The Bathing Water geodatabase is designed according to the following steps, most of them carried out in parallel:

- Analysis of the target Data Model (INSPIRE Environmental Monitoring Facilities Data Specifications v3.0rc3);
- Analysis of the Source Data (MEPA dataset xls + EIONET Data Dictionary Website – WISE - Bathing Water Quality Reporting under Directive 2006/7/EC) (10);
- Conceptual design of the geodatabase according to INSPIRE EF Data Specification;
- Preparation and filling-in of the matching table;
- Creation of the geodatabase structure with ArcGIS Diagrammer;
- Import of the geodatabase in ArcGIS and SQLServer.

The geodatabase for the Other Water themes is designed according to the steps:

- Analysis of the information provided by MEPA, which for the other Water sub-themes consisted of empty xls files corresponding to the EIONET reporting schemas uploaded

by the Maltese authorities into the EIONET data repository.

- Systematic research of all the applicable reporting schemas available in the EIONET Data Dictionary Website;
 - Thorough analysis of the most updated versions of the relevant reporting schemas available in the EIONET – Data Dictionary website and cross-check with the available uploaded Maltese datasets;
 - Development of the geodatabase structure with ArcCatalog – ArcInfo;
 - Import of the EIONET – Data Dictionary dataset template (in the respective geodatabase structure) using ArcCatalog – ArcInfoExport of geodatabase in XML Workspace Document using ArcCatalog – ArcInfo;
 - Development and analysis of UML geodatabase schemas using ENTERPRISE ARCHITECT;
 - Import of the geodatabases in SQLServer;
- All Water geodatabases follow the INSPIRE “compliant” structure designed on the INSPIRE Environmental Monitoring Facilities Data Specifications v3.0rc3.

Noise

The geodatabase for the Noise theme is designed according to the steps:

- Analysis of the information provided by MEPA, which for the Noise theme consisted of links to the corresponding reports uploaded by the Maltese authorities into the EIONET data repository;
- Systematic research of all the applicable reporting schemas available in the EIONET Data Dictionary Website;
- Thorough analysis of the most updated versions of the relevant reporting schemas available in the EIONET – Data Dictionary website and cross-check with the available uploaded Maltese datasets;
- Creation of the geodatabase structure with ArcCatalog – ArcInfo;
- Import of the EIONET – Data Dictionary dataset template (in the respective geodatabase structure) using ArcCatalog – ArcInfo;
- Export of geodatabase in XML Workspace Document using ArcCatalog – ArcInfo;
- Creation and analysis of UML geodatabase schemas using ENTERPRISE ARCHITECT.
- Import of the geodatabases in SQLServer.

Soil

The Soil theme geodatabase is designed in adherence to the INSPIRE SOIL Data Specification, according to the steps:

- Analysis of the target Data Model (INSPIRE SOIL Data Specification v3.0rc3);
- Conceptual design of the geodatabase structure according to INSPIRE SOIL Data

Specification;

- Preparation of the matching table;
- Creation of the SQLServer geodatabase with GoLoader (Snowflake Software);
- Export of geodatabase in XML Workspace Document using ArcCatalog – ArcInfo;
- Creation of the ESRI geodatabase using ArcCatalog – ArcInfo.

Radiation

The Radiation geodatabase is designed according to the following steps, most of them carried out in parallel:

- Analysis of the target Data Model (INSPIRE Environmental Monitoring Facilities Data Specifications v3.0rc3);
- Analysis of the Source Data (MEPA dataset, EURDEP format);
- Conceptual design of the geodatabase according to INSPIRE EF Data Specification;
- Preparation and filling-in of the matching table;
- Creation of the geodatabase structure with ArcGIS Diagrammer;
- Import of the geodatabase in ArcGIS and SQLServer.

Geodatabase Conversion

To convert the Geodatabase from the UML form to its MS SQL Server ArcGIS Geodatabase the “Publish” command is used from ArcGIS Diagrammer. This way it can be exported to an “XML Workspace Document” which is an ESRI proprietary file format that allows exchange and share geodatabase schemas.

The “XML Workspace Document” file can be loaded into new or existing geodatabase using ArcCatalog. It is also possible to load the geodatabase structure in a SQLServer database, using an ArcSDE connection in ArcCatalog.

Results

This final section presents the SEIS-Malta Geoportal available at www.seismalta.org.mt. For the SEIS–Malta Geoportal a new version of Geoportal has been developed taking into account the parameters like:

- User friendliness;
- Compliance and usage of MEPA’s infrastructure with regard to ESRI licenses and tools;
- Ability to easily extend the interface;
- Ability to easily add new databases or connect to different GIS servers and services;
- Addition of specific and extended WebGIS capabilities.

Data Ingestion from monitoring stations

Geoportal is able to collect environmental data in near real-time from various monitoring stations and locations. Specifically, these technologies are developed for the air (Figure 3) and bathing (Figure 4) water data themes. The air data model provides the possibility to use the same feature type to model objects at different levels with the possibility to take into account the hierarchy, as in the case of stations and sensors. One table for each monitored pollutant has been created for storing the information about measures.

Figure 3: Air monitoring stations

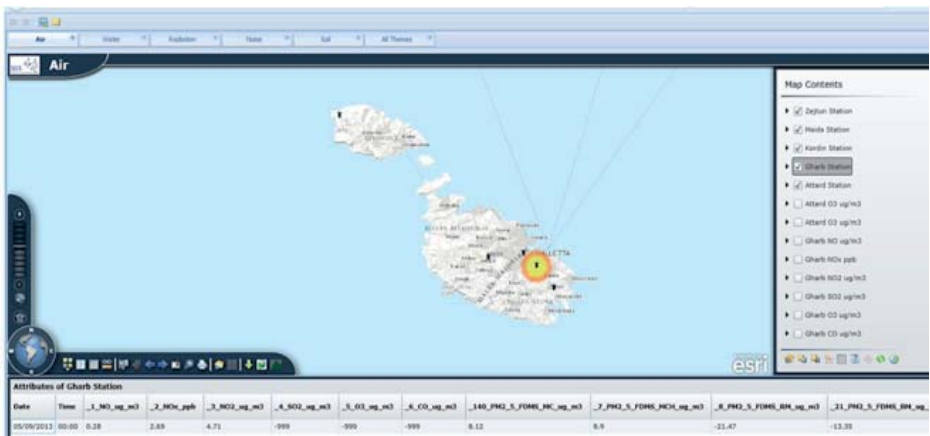
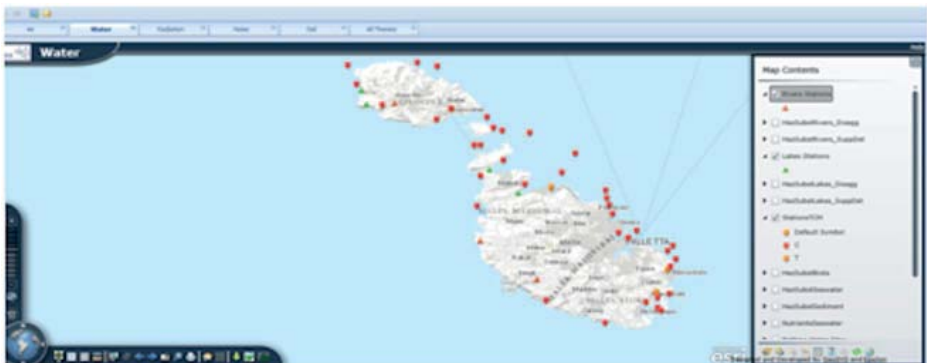


Figure 4: Bathing water monitoring stations



On-Line Data Editing

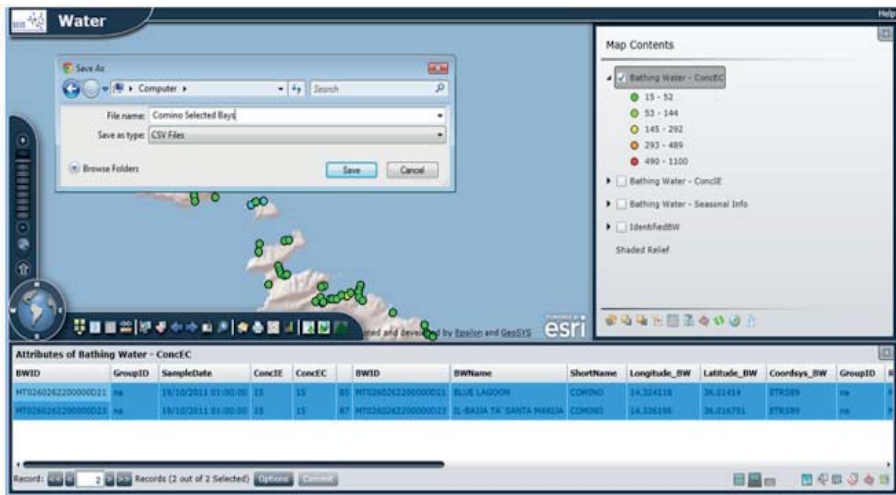
In the Bathing Water one table for each monitored pollutant has been created, for storing the information about the measures. All attributes and/or items with a multiplicity greater than one have been treated in separate tables, linkable to the feature type by means of joins using the unique ID.

As administrator, each theme expert of MEPA is able to perform online data editing via the editing tools provided through the MS SQL Server 2008 Management Studio as well as through the GIS interface provided via ArcGIS Desktop.

Data Export

The Geoportal contains an export tool which allows the user to export the selected data to CSV format (Figure 5).

Figure 5: Export Selection set



Metadata

For Metadata, a dedicated database is available according to the Geonetwork requirements in terms of supported RDBMS. The schema of the metadata database will adhere to the INSPIRE requirements on metadata for categories 1 and 3 and to EN-ISO 19115/19119 for categories 2, 4 and 5. In the occasions that metadata did not exist, it was create them from scratch. For the metadata editing the functionalities offered by Geonetwork are used, whilst existing metadata are harmonised according to the target schema following metadata harmonisation procedures that took place.

Reporting

One of the main objectives of SEIS is to be used as a reporting obligations facilitation mechanism and an Environmental Data Dissemination tool according to the Aarhus and INSPIRE Directives. During the project implementation almost all data themes of Geodatabase were structured according to the latest reporting schemas link to Eionet data Repository.

General Functionalities

The main interface of the application is fully customizable with regard to its size. The user will be greeted with the following interface when he/she initially links to the address of SEIS-Malta.

The SEIS Geoportal of Malta has multiple functionalities, such as:

- 2D thematic visualization interface and 3D viewer
- Feedback Services
- Navigation Tools
- GIS Tools and Functions: 13 Different Basemaps, Map Contents, Legend, Map contents Toolbox, Configure Layer, Filter & SQL Query, Configure the Auto-Updates (The user can select how often the application queries the databases or the selected layer for updated information), Show Attribute table, Filter Legends, Print, Timeline, Clustering data export (to csv format).

All the above capabilities are available for the Maltese citizens through SEIS-Malta Geoportal by providing state-of-the-art services. Further to this, within SEIS-Malta project our team produced a detailed user manual which will be released to the public.

Conclusion

The SEIS-Malta Geoportal goal achieved the provision of a system that is based on accessibility, easy data sharing and interoperability. The task was to maintain and improve the quality and availability of information required for environmental policy, in line with better regulation, while keeping the associated administrative burdens to a minimum, and finally to move away from a paper-based reporting to a system where information is managed as close as possible to its source and made available to users in open & transparent ways.

Figure 6: Spatial distribution of young males by Enumeration Area

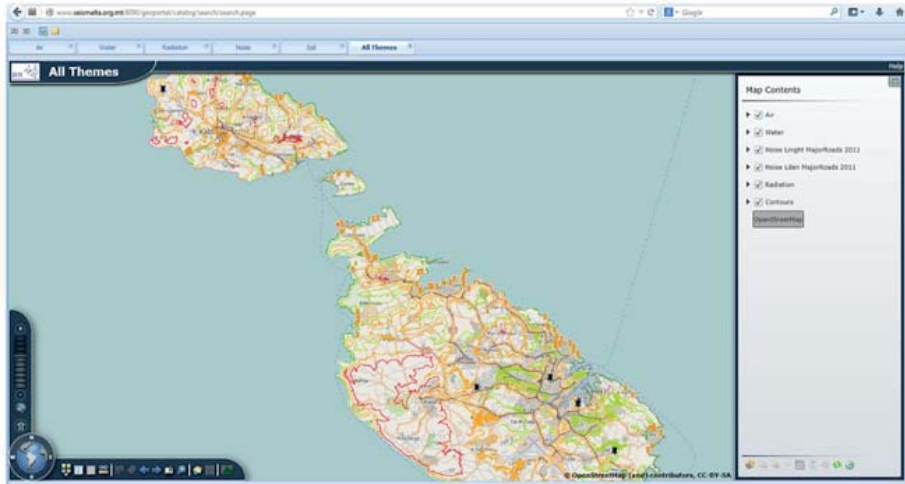


Figure 7: Navigation Tools Figure 8: GIS Tools and Functions



The future steps of SEIS-Malta are linked to improvement or extension and include the installation of new themes, geoportal optimization (based on users' feedback) and the implementation of SEIS technology in other countries.

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Chapter 5

Figure 1: Landslide Hazard Map for Malta (after Meli et al., 2013, Map 3.8)

