Soaring Spaces – The Development of an Integrated Terrestrial and Bathymetric Information System for the Maltese Islands

Saviour FORMOSA

1 Introduction

In a rapidly developing world where the introduction of massive online information systems has enabled both the scientist and the general public to interact with remotely-located data from across the globe, the reality of access to data and eventually to information is slowly bringing forth the realisation that decades-old barriers to access to data still need to be overcome. Data availability suffers from a plethora of scourges that have left entire countries with a dearth of reliable baseline information, particularly small states which have limited human capacity to manage the whole datacycle in the physical, social and environmental domains. The main limitations include the fact that there are few homogeneous structures in operation, which governance situation has rendered data gathering agencies as a series of independent hoarding kingdoms, where data 'ownership' is seen as a private not as a corporate or a national affair thus the main users instead of being custodians transform themselves as the private owners of such data.

Other more technical issues include the fact that there are too many standards to follow, data is not dynamic (gathered ad hoc as a one-off and not real-time), data is not quality assured/controlled, queries are not organised and recorded, data is not secured – ('illegal' use of storage on personal storage devices and other digital media) and that versioning is not practiced. In addition, even where the data is available, there is an upsurge in requests for access to such data which has increased drastically since TIM BERNERS-LEE'S (1989) world wide web (WWW) proposal changed society as never before. The WWW changed a medium that was at best techno-centric to one that is now essentially socio-technic. Increasing requirements for bandwidth has resulted in a need for a reanalysis of DAHRENDORFF's (1990) access issue in contemporary worlds, both real and virtual, where not all society has access to the information through on-line services.

The other most important issue relates to the access to standardised processes for information-creation which is being tackled from various legislative loci such as the Data Protection Act (OJ 1995), the Århus Convention (OJ 2003a, OJ 2003b), the Freedom of Information Act (OJ 2003c) and the INSPIRE Directive (OJ 2007), the SEIS initiative, as well as other guidance documents that are targeted to enable the smooth and free flow of effective information.

In this paper, the Malta case study is brought to the fore with an analysis of the approaches taken to ensure that despite the limitations imposed on a small country, access is being made to the diverse users of data ranging from data in the physical and social domains through the fruition of a decades-long drive that culminates in the dissemination of environmental and 3D data to users for free. This following situation as analysed in 2006

where most datasets were not inter-connected, basemaps had a time-tag of 1988, environmental data capture was ad hoc and data dissemination was available through a mapserver with a date tag of 2000, whilst actual data could be requested by the public on a ad hoc basis (CONCHIN et al. 2010).

The need was felt to acquire a comprehensive set of new baseline information, through nation-wide digital terrain and bathymetric scanning, acquisition and analysis of environmental and spatial data within an interactive medium and the free dissemination of all information through an INSPIRE compliant online tool. This scope was targeted to ensure project integrativity and the need to ensure compliance with the legislative requirements (MALTA ENVIRONMENT & PLANNING AUTHORITY 2009).

2 State of Affairs: a 20-Year Approach

2.1 Laying the Structural and Academic Foundations

The need for change has been felt for some time since the mid-1990s when a review was carried out on the GIS legacy that had been acquired since 1964, which experienced rapid changes in visualization and data transfer (GATT & STOTHERS 1996). With major changes experienced in geographic information systems (GIS) from 1985 onwards, two main phases were identified, those related to Digital Mapping/data collection phase and those related to the application of GIS in an operational context (Figure 1). The process entailed the setting up of a national mapping agency (NMA) in 1988, a transition to a fully digital scenario between 1994 and 1998 which also saw the introduction of GIS, and the launch of the mapserver in 2000 (MEPA 2000).

This drive identified several hardware restrictions and high storage costs, which caused the NMA to truncate all the spatial data (Malta falls within 1 zone on the UTM projection) by removing part of the northings and eastings which were the same within all the national datasets. Whilst such a decision was aimed to ease the rolling-out costs, it has obstructed all the EU/EEA data reporting to the various agencies, since such datas need to be reconverted to the original full UTM. In order to reconvert all the resultant 20-year data legacy as required for convergence, costs are estimated to have overtaken any savings made over the decades; a situation that requires immediate action.

A new wave of data creation initiatives brought about by EU membership gave a boost to the drive to give birth to a phase through creation of baseline datasets against which all new information would be gauged against. This process was tested for its potential through the creation of datasets such as Corine Landcover 1990-2000-2006 and the relative change analysis, elevation maps, environmental protection maps (EEA CDDA, Natura 2000, SAC)[1] and in 2011, a Land use/cover area frame survey (LUCAS) field survey[2].

[1] European Environment Agency, Common Data Repository. Available online: http://cdr.eionet.europa.eu/mt (accessed on 29 February 2012).

[2] European Commission, Land use/cover area frame survey (LUCAS) Decision 1445/2000/EC. Available online: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Land_use/cover_area_frame_survey_(LUCAS) (accessed on 29 February 2012).

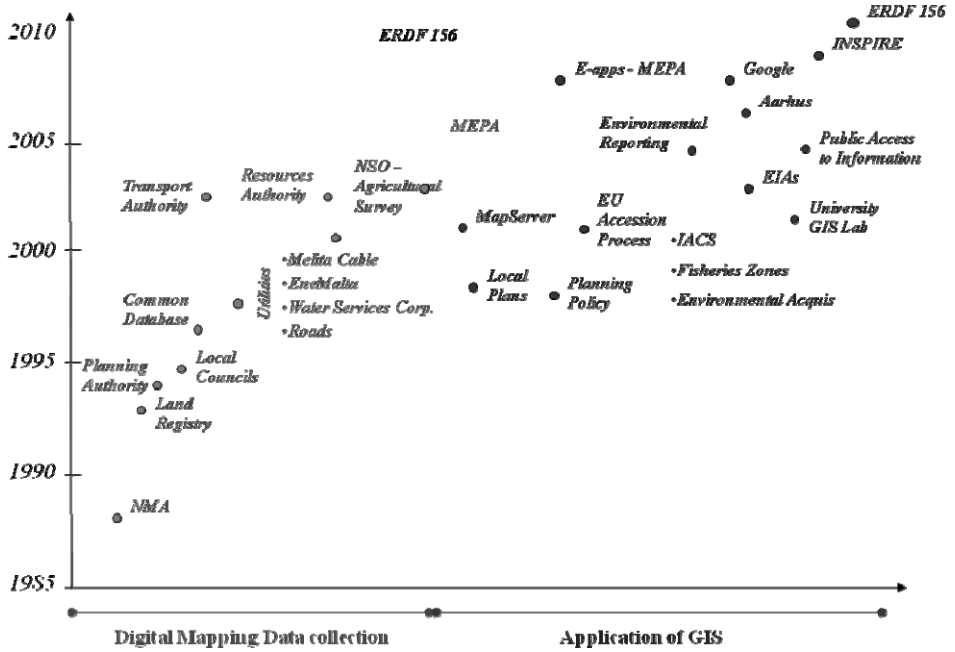

Fig 1: The GIS data process

On the academic side, various research initiatives were initiated. These included studies on organisational change (GATT et al 1996), remote sensing (TABONE ADAMI 1998), census web-mapping (FORMOSA 2000), environmental-landuse (TABONE ADAMI 2001), GML-related (AGUIS 2003), ethics in GIS (VALENTINO 2004), 3D GIS for spatial planning (CONCHIN 2005), environmental (FARRUGIA 2006), quality improvement cycle (RIZZO NAUDI 2007), through to socio-technical approaches to GIS (FORMOSA et al. 2011). The iterative studies have helped to consolidate the GIS-based data and operation structure which eventually shaped the foundation for a national geographic information data structure which culminated in the ERDF project discussed in this paper.

A number of projects in the spatial planning and environmental domains resulted in the launching of a comprehensive strategy based on the data cycle; such projects included Structural Funds 2007-13, EAFRD 2007-13, Transition Facility Programme for Malta, Pre-Accession Funds, and other programmes3. Having laid out the groundwork, the next step identified the need for the integration of the environmental domain with the spatial development domain through the implementation of information resources and information technology infrastructure in line with the Aarhus, INSPIRE and SEIS requirements as well as the outcomes of such projects as Plan4all (BEYER & WASSERBURGER 2009).

[3] Internationally Funded Projects at MEPA. Available online: http://www.mepa.org.mt/internationally-funded-projectsatmepa (accessed on 29 February 2012).

2.2 The Engine to Be: ERDF

The project that emanated from this exercise is co-financed by the European Regional Development Fund under Operational Programme 1 – Cohesion Policy 2007-2013 – Investing in Competitiveness for a Better Quality of Life. The authors are implementing the project through the Malta Environment and Planning Authority (MEPA) in collaboration with the Malta Resources Authority (MRA), the Department of Environmental Health, the National Statistics Office (NSO) and the University of Malta.

The project will result in the procurement of equipment, information management systems, environmental baseline surveys, training of staff, and the enhancement of the national monitoring programmes in the environmental themes of air, water, noise, radiation and soil.

The following outputs will be delivered:

- Comprehensive assessment of the environmental monitoring requirements in the areas of air, water, radiation, noise and soil, an environmental monitoring strategy and detailed monitoring programmes will be designed and drawn up by Q2 of 2013 to cover all monitoring requirements;
- Installation of air, noise and radiation equipment, information resources systems and infrastructure procured, installed, tested and commissioned, and relevant staff trained in their operation by the Q4 of 2012;
- Baseline studies with 100% scan coverage of the Maltese Islands conducted in the areas of water, radiation, noise and soil, together with terrestrial spatial surveys and bathymetric surveys of coastal waters within 1 nautical mile by Q2 of 2013;
- A Shared Environmental Information System (SEIS) designed and implemented by Q2 of 2013; The results of the latter will raise public awareness of environmental issues, which participation and enhanced policy decisions.

3 Acquisition and Access

The initial status research was initiated in 2006, which study highlighted the need to enhance the national monitoring programmes in the five environmental themes through the identification of information gaps in monitoring processes and filling data gaps, carrying out environmental baseline surveys and through the procurement of monitoring equipment & information management systems and finally the training of staff.

The project will result in the integration of the requirements for EU environmental reporting through the employment of the INSPIRE Directive for the spatial component, the use of the Aarhus Convention as the conveyor for the dataflow and ultimately the employment of a tool pertaining to the SEIS requirements for the eventual online dissemination. The latter will employ standards comprising; OGC WMS, OGC WMS-T, OGC WFS, OGC WCS, ANSI SQL, INSPIRE, Z39.50 and CSW.

The project outcomes can be structured into 4 sectors: Environmental Acquisition, Spatial Constructs, Dissemination Media and Access as per Table 1.

This review ensured that a new baseline is created from which to launch Malta's new data capturing exercises across the different themes. Terrestrial and bathymetric data would be available at higher resolutions suitable for environmental modelling and EU reporting

Environmental Acquisition	**Spatial Constructs**
(1) Air Strategy and Baseline Study (2) Water Strategy and Baseline Study (3) Noise and Radiation Strategy (4) Soil Strategy (degradation processes and contamination in diffuse sources)	(1) Full LIDAR Scan: Terrestrial and Bathymetric (2) Ground truthing for sea substrate type (3) Oblique aerial & satellite imagery (4) An address point dataset
Dissemination Media	**Access**
(1) Online information service (2) Online mapservice – SEIS (3) Statistical backing for experts – inc. spatial stats	(1) All Data are to be disseminated for FREE

Table 1: The 4 Project Outcomes

purposes. As the non availability of high quality 3D spatial data hinders comprehensive land use planning, environmental monitoringthe project will deliver a series of scans using different technologies in order to provide a comprehensive seemless dataset. The delivery includes high resolution 3D terrestrial data coverage for the Maltese Islands using a combination of oblique aerial imagery (Figures 2 a-b)and Light Detection and Ranging (LIDAR) data (Figure 2c), as well as through a bathymetric survey of coastal waters within 1 nautical mile (nm) radius off the baseline coastline, using a combination of aerial LIDAR surveys, acoustic scans and a physical grab sampling survey as well as GIS-based noise maps (Figures 2d). These technologies, as well as other fieldwork technologies, has equipped the researchers with a launching pad for the diverse physical, environmental and social studies that are undertaken in relation to social and environmental health.

The outputs from the project include the following services and supply shows Table 2.

Fig. 2a: Oblique Imagery Valletta 2011

Fig. 2b: Oblique Imagery Fort Manoel 2011

Fig. 2c: LIDAR Scanning Exercise 2012

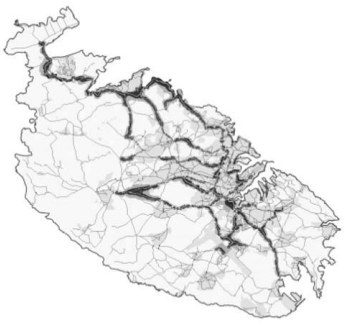

Fig. 2d: Noise Mapping Exercise MEPA 2011

Services	Supply
(1) LIDAR Scan: Terrestrial (Topographic Light Detection and Ranging (LiDAR)) Digital Surface Model (DSM) and Digital Terrain Model (DTM) (316 km.sq) – Figure 3a (2) Bathymetric LIDAR aerial survey – depths of 0m to 15m within 1 nautical mile from the Maltese coastline (38km.sq) – Figure 3b (3) Bathymetric Scan: Acoustic (side scan sonar) Digital Surface Model and an acoustic information map of sea bed (361 km.sq) – Figure 3c (4) High resolution oblique aerial imagery and derived orthophoto mosaic and tiled imagery of the Maltese Islands (316km.sq) (5) Satellite imagery (6) A complete address point database	(7) Remote GPS Cameras (Remote capture GPS receiver) (8) 3D scanner (9) GIS Handhelds (10) Global Navigation Satellite System Station and geodetic receivers Figure 4 outlines the remotely-sensed, aerial and in situ data capture data capture processes employed in the project.

Table 2: Project Outputs

Fig. 3a: Maltese Islands coast inclusive of 1 nautical mile boundary from the baseline coastline

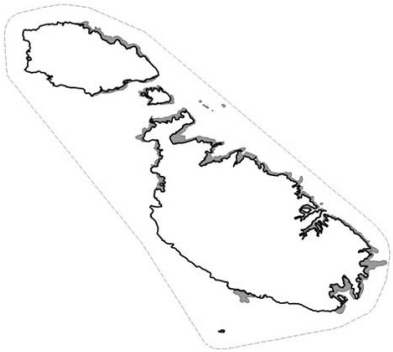

Fig. 3b: Maltese Islands showing coastal water area with depths of 0m to 15m within 1 nautical mile from the Maltese baseline coastline

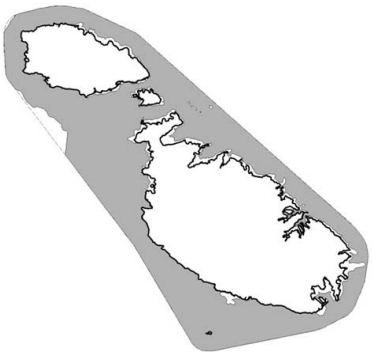

Fig. 3c: Maltese Islands showing coastal water area with depths of 15m to 200m within 1 nautical mile from the Maltese baseline coastline

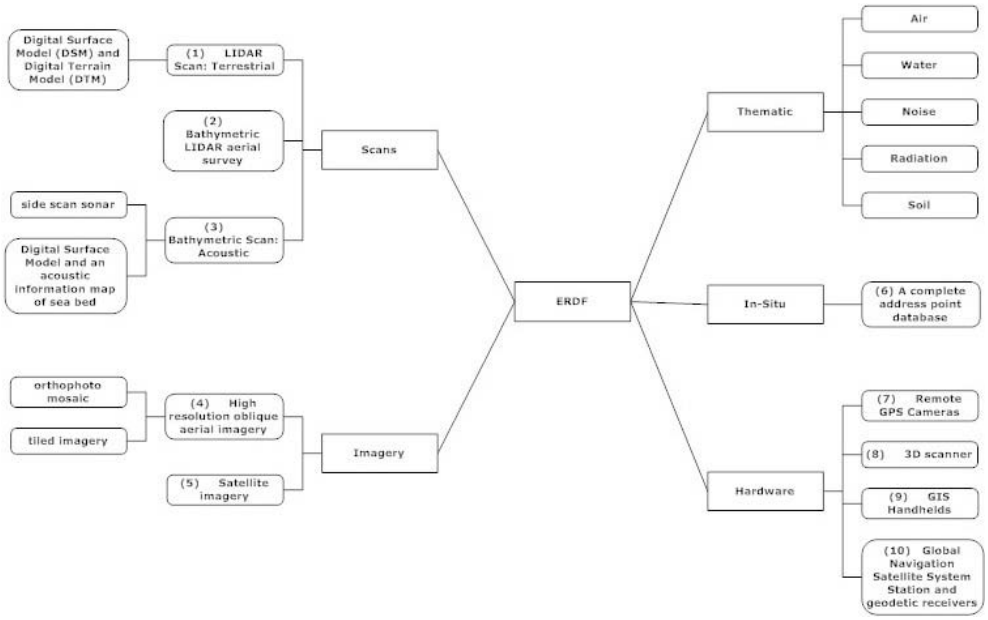

Fig. 4: Remotely-Sensed, Aerial and In-situ Data Capture Components

4 Taking the Project to the Masses

The data dissemination phase will be based on a SEIS-based strategy and implementation through an online tool. The tool was planned to develop and implement the requirements outlined by SEIS, which outputs will include a dedicated geoportal based on ArcGIS geodatabase design as based on ArcGIS server architecture.

The phase is aimed to review the state of play of the current developments with respect to the Shared Environmental Information System (SEIS), including the following:

- EU Directives supporting the EU's SEIS initiative and any proposed recommendations of the EEA, JRC, EUROSTAT;
- Commission's Communication COM (2008) 46 Final "Towards a Shared Environmental Information System";
- SEIS developments by the European Environment Agency (EEA);
- Overview and updates on the SEIS-BASIS (Shared Environmental Information System Baseline and Evolution Study) project which aims to provide guidance on how to improve the comparability and quality of environmental data, as required by SEIS;
- The outputs of the NESIS project and roadmap developments on how to move from the current information systems of EU's environment agencies towards an INPSIRE-SEIS based system. To include relevant results for the NESIS State of Play study on examples of best practice as a source of guidelines for MEPA' s proposed SEIS as informed by recent developments;

- Relevance of the INSPIRE Directive (Directive 2007/2/EC) and the Aarhus Convention to the EU's SEIS;
- Linking of an integrated reporting system is required in line with the EEA Reportnet initiative and its CDR (Common Data Repository) structure to SEIS;
- An analysis of the existing Maltese information management systems and platforms, as well as an assessment of the present institutional capacity necessary for the operation of the Maltese component of the SEIS;
- New or emerging reporting standards currently being adapted, such as XML-related standards, to which the SEIS should conform.

The proposal was to design a geodatabase data model that is flexible, caters for potential expansion, easily adaptable by the environmental agency and supports migration from current data structures. In order to improve the development of the geodatabase schema the project entailed; the identification of data sources and key data themes; development of representation specifications and relationships of the geodatabases; data capture definition procedures; geodatabase design documentation and; the employment of ArcSDE in order to to manage the underlying geospatial data that will be stored in Microsoft's SQL Server RDBMS (Figure 5) (BONOZOUNTAS & KARAMPOURNIOTIS 2012).

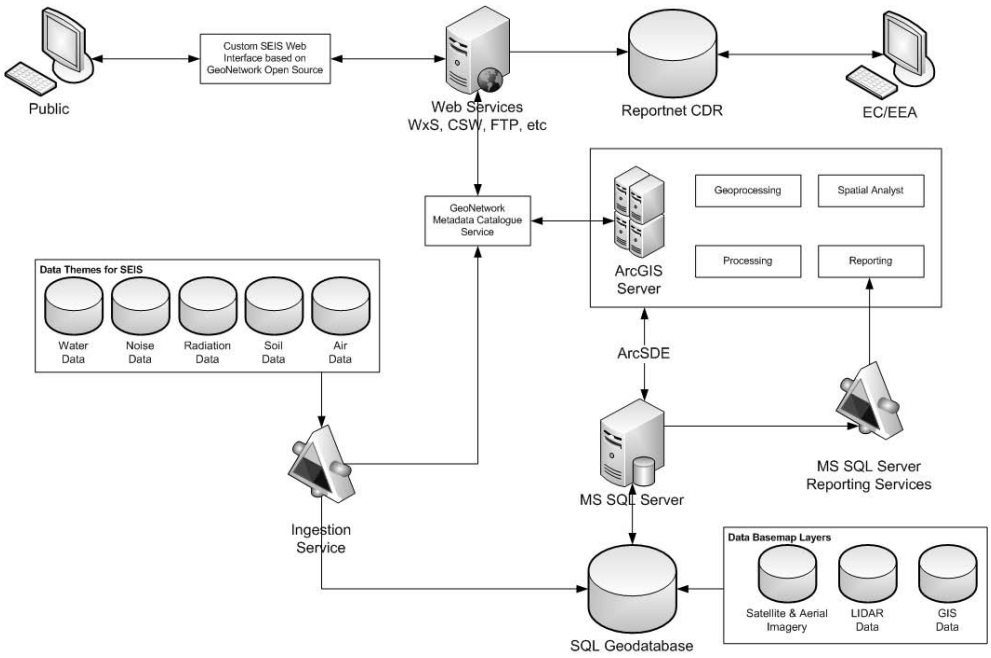

Fig. 5: Malta-SEIS Architecture: Source: BONAZOUNTAS & KARAMPOURNIOTIS (2012, 17)

The project datacycle, from data capture, analysis, reporting and dissemination, outlines a structure that conforms to the Aarhus, INSPIRE and SEIS requirements. The main functions cover in sequence: Web interfacing and security (allowing the viewing, data

querying, reporting and analysis of all spatial datasets identified in the five themes and the information resources datasets); Front end flexibility (allowing for increasing levels of geospatial data within a changing and dynamic environment); Discovery services/functions (provision of access to resources via product-neutral visualization and downloading services; Geoportal (linked to the National Spatial Data Infrastructure (SDI) and eventually to the EU SDI under development; Spatial dataset standards (to conform to the INSPIRE Directive (Directive 2007/2/EC) standards and; Spatial data transfer (ensuring available processes are thoroughly understood and depicted into the model with a target to establish a coherent data integration system that will allow the further transmission through the online portal).

The final leap will be to integrate all these systems with others linked to domains not normally taken up by the physical domains, those pertaining to the social disciplines. The system will further strive to understand physical-social dataset integration as identified in the Plan4all Malta case study (FORMOSA et al. 2011). The study investigated the potential for an INSPIRE-based system aimed at integrating information from the physical, social, criminological, psychological and health domains. The studies of the impacts of environmental factors on social and health issues are expected to lead to public participation and knowledge gain in the Maltese Islands as people become more aware of readily-available realtime information irrespective of their location.

5 Conclusion

In conclusion, the Maltese Islands, whilst having a legacy of data creation, have taken the bold step to create baseline data for integrative future analysis. The project took on a challenging aspect in that it covered the whole state, which in the economies of scale was an ambitious one. The processes undertaken ensured that the information gain was an integrated one as it conceptualises a nation-wide strategy targeting access to data employing various Directives and Conventions. The employment of the Arhus and INSPIRE Directives, as well as the SEIS initiative ensured that the various components governing spatial and thematic information come together into one freely-available location.

References

Aguis, C. (2003), *Using GML to represent Spatial Environmental Information.* Unpublished MSc GIS thesis, University of Huddersfield, Huddersfield.

Berners-Lee, T. (1989), *Information Management: A Proposal.* Available online: http://www.w3.org/History/1989/proposal.html (accessed on 29 February 2012).

Beyer, C. & Wasserburger, W. (2009), *Plan4all Deliverable 2.2. Analysis of innovative challenges.*

Bonozountas, M. & Karampourniotis, I. (2012), *MALTA-SEIS: Deliverable D2.1 Report of Analysis and Detailed Proposal for SEIS.* CT3067/2010 – 02, Malta.

Conchin, S., (2005), *Investigating the development of 3D GIS technologies for Spatial Planning: A Malta study*. Unpublished MSc GIS & Environment thesis, Manchester Metropolitan University, Manchester.

Conchin, S., Agius, C., Formosa, S. Rizzo Naudi, A.(2010), *Does visualisation of digital landscapes serve itself? How topographic, planning, environmental and other thematic information is integrated and disseminated via web GIS.* In: Buhmann, E. et al. (Eds.), Peer Reviewed Proceedings of Digital Landscape Architecture 2010, Anhalt University of Applied Sciences. Berlin/Offenbach, Wichmann. ISBN 978-3-87907-491-4.

Dahrendorff, R., (1990), *The Modern Social Conflict: An Essay on the Politics of Liberty*. Berkeley, CA, University of California Press.

European Commission, *Land use/cover area frame survey (LUCAS) Decision 1445/2000/EC*. Available online: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Land_use/cover_area_frame_survey_(LUCAS) (accessed on 29 February 2012).

European Environment Agency, *Common Data Repository*. Available online: http://cdr.eionet.europa.eu/mt (accessed on 29 February 2012).

Farrugia A. (2006), *Implications of EU Accession on Environmental Spatial Data: a Malta Case Study.* Unpublished MSc GIS Science thesis, Manchester Metropolitan University, Manchester.

Formosa, S. (2000), *Coming of Age: Investigating the Conception of a Census Web-Mapping Service for the Maltese Islands*. Unpublished MSc thesis Geographical Information Systems. University of Huddersfield, United Kingdom. Available online: http://www.tcnseurope.org/census/1995/index.htm (accessed on 29 February 2012).

Formosa, S., Magri, V., Neuschmid, J. & Schrenk, M. (2011), *Sharing integrated spatial and thematic data: the CRISOLA case for Malta and the European project Plan4all process.* In: Future Internet 2011, 3 (4), 344-361, doi:10.3390/fi3040344.

Gatt, M. & Stothers, N. (1996), *The Implementation and Application of GIS in the Planning Authority of Malta.* Geographical Information, Second Joint European Conference and Exhibition on Geographical Information, Barcelona, Spain, ISBN 90-5199-268-8 (IOS Press), ISBN 4-274-90098-3 (OHMSHA).

Internationally Funded Projects at MEPA. Available online: http://www.mepa.org.mt/internationally-funded-projectsatmepa (accessed on 29 February 2012).

MEPA mapserver (2000), Available online: http://www.mepa.org.mt/mepa-mapserver (accessed on 29 February 2012).

Malta Environment & Planning Authority (2009), *Developing National Environmental Monitoring Infrastructure and Capacity.* MEPA, Floriana, Malta.

Malta Environment & Planning Authority (May 2011), *Data Flow 7 Supplementary report Noise Action Plan (Summary).* MEPA, Floriana, Malta.

Official Journal of the European Union (24 October 1995), *Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data.* L 281 , 23/11/1995.

Official Journal of the European Union (28 January 2003a), *Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC.* L 041, 14/02/2003.

Official Journal of the European Union (26 May 2003b), *Directive 2003/35/EC of the European Parliament and of the Council of 26 May 2003 providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC – Statement by the Commission.* L 156, 25/06/2003.

Official Journal of the European Union (17 November 2003c), *Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information.* L 345, 31/12/2003.

Official Journal of the European Union (25 April 2007), *Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE.*, L108, Vol. 50

Rizzo Naudi, A. (2007), *A Continuous Quality Improvement Cycle for Geographic Information Systems within the Malta Environment & Planning Authority* (MEPA). Unpublished M. Sc. dissertation, Manchester Metropolitan University, Manchester.

Shared Environmental Information System. Available online: http://ec.europa.eu/environment/seis/ (accessed on 29 February 2012).

Tabone Adami, E. (1998), *Corrections for the estimation of chlorophyll concentrations in coastal waters from remotely sensed data*, MPhil thesis. University of Cambridge, Cambridge.

Tabone Adami, E. (2001), *Integrated modeling of nutrient transfers from land-based sources for eutrophication assessment of Maltese coastal waters.* PhD thesis, University of Cambridge, Cambridge.

Valentino, C. (2004), *Developing a Coherent Approach to Ethical Use of Geographical Information in Malta.* Unpublished MSc GIS & Management thesis, Manchester Metropolitan University, Manchester.