European Research Policy on Information and Communication Technologies for the Environment

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Abstract
Environmental management is a topic of worldwide concern. Being multidisciplinary in nature, it is a field having many facets that includes the advancement of thematic and applied research, the integration and deployment of new and existing technologies, the provision of usable services for the citizens, and the need to also adequately consider the social and economic dimensions of sustainable development. The European Commission (EC) is actively supporting environmental research through its multi-annual Framework Programmes for Research and Technological Development (RTD). In particular, current research in the field of environmental informatics is contributing to enhancing interoperability between geo-spatial information systems, improving collection integration and access to harmonised environmental data, and strengthening monitoring capacities through the integration of advanced sensor networks, and the development of decision support systems as an aid to sound environmental management.

1. Introduction
The overall aim of European research policy is to consolidate the European research community in order to promote scientific excellence and innovation to advance knowledge and understanding, and to support the implementation of related European policies. The European Commission (EC), and in particular, the Directorate-General for Research and the Directorate-General for Information Society and Media, have been supporting research on environment and sustainable development since the early 1980’s through the EC’s successive Framework Programs for Research and Technological Development (RTD).

Multinational and interdisciplinary research in this field has addressed thematic areas including climate change, biodiversity, natural and man-induced disasters, coastal and watershed management, environmental technologies, pollution emissions, just to name a few. European Union (EU) research has lead to the development of methods and technologies for improved environmental forecasting and monitoring; risk assessment, management and mitigation. In parallel, research efforts have also focused on the use of Information and Communication Technologies (ICT) in support of the environment, the objectives being to: improve access, integration and interoperability of data, models, tools and systems, harmonize geo-spatial information, collect and monitor environmental data through the integration of advanced sensor networks, and to develop decision support systems as an aid to sound environmental management.

2. The overarching EU policy context
In June 2001 the EU Sustainable Development Strategy² was adopted in Gothenburg. In 2005 it underwent a comprehensive review³ to take stock of the progress made since 2001, to sharpen the strategy’s objectives, and to set new milestones. The strategy addresses the most serious threats to sustainable development in Europe and the world; the so-called unsustainable trends. These are: climate change, public health, transport,

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landuse, management of natural resources, the challenges of an ageing society as well as poverty and social exclusion. Sound environmental management is hence one of the underlying pillars of sustainable development. At the international level, the strategy also considers our response to globalisation and how to effectively and equitably integrate the developing world into our economy; the promotion of good governance and financing for development, which also form part of the Millennium Development goals.

In parallel, this year the European Council judged that it was vital to re-launch the Lisbon Strategy\(^4\) to refocus priorities on growth and employment. The Lisbon Strategy adopted in 2000 outlines the goals to render Europe one of the world’s most dynamic and competitive economies, based on knowledge, sustainable development, employment, social cohesion, while respecting the environment. It, much like the sustainable development strategy, is based on three pillars: economy, society and environment. The Sustainable Development Strategy and the Lisbon Strategy ultimately share the same goal, namely to improve welfare and living conditions in a sustainable way for present and future generations. Both Strategies are mutually reinforcing. However, they focus on different actions and have different time frames.

The Sixth Environment Action Programme\(^5\) entitled “Environment 2010: Our future, our choice” covers the period 2001 to 2010. It defines the priorities and objectives of Community environmental policy up to 2010 and beyond, describes the measures to be taken to help implement the European Union's Sustainable Development Strategy.

The Action Programme makes it clear that meeting the challenges of today's environmental problems means looking beyond a strictly legislative approach and taking a strategic approach, using a whole range of instruments and measures to influence decisions made by business, consumers, policy planners and citizens. It proposes five priority avenues of strategic action: improving the implementation of existing legislation; integrating environmental concerns into other policies; working closer with the market; empowering people as private citizens and helping them to change behaviour; and taking account of the environment in land-use planning and management decisions. The Action Programme focuses on four priority areas for action:

- **Climate change**: to reduce greenhouse gases to a level that will not cause unnatural variations of the earth's climate.
- **Nature and biodiversity**: to protect and restore the structure and functioning of natural systems and halt the loss of biodiversity both in the European Union and on a global scale.
- **Environment and health**: to achieve a quality of the environment which does not give rise to significant impacts on, or risks to, human health.
- **Management of natural resources and waste**: to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment and to achieve a decoupling of resource use from economic growth through significantly improved resource efficiency and the reduction of waste. With regard to waste, the specific target is to reduce the quantity going to final disposal by 20% by 2010 and 50% by 2050.

The main objective of promoting research in the field of ICT for the environment\(^6\) is to support EU environment and sustainable development policies by providing decision makers with easy access to strategic environmental information and models in support of their environmental management decisions. This ICT sector is growing rapidly and is becoming an integral part of the European eco-industry whose turnover is estimated to be above 100 billion € annually with a growth rate of around 8%.

For the public sector, be it regional, national or European, ICT contributes to the improvement of a number of environmental policies from definition to monitoring and enforcement. It also helps to achieve

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\(^6\) See: http://www.cordis.lu/ist/environment/index.html
world-class environmental administrations in Europe by enhancing their efficiency, openness and accountability.

Apart from directly supporting the issue of environmental regulation, ICT is being used to make industry more competitive through better management and reducing environmental costs. Companies adopting environmental processes will have an advantage in the long term through being compliant with regulation, provided this compliance does not produce unreasonable costs. ICT can help industry become compliant at the lowest cost, and also the means to monitor, thereby ensuring compliance, transparency and accountability. In addition it also provides qualified jobs in an ICT-based economy, in line with the Lisbon agenda. For the citizen, it ensures appropriate information on the state of the environment in accordance with the Aarhus Convention.

3. Current European research and related initiatives

Multinational and interdisciplinary EU research in the field of environment has addressed numerous thematic areas including climate change, biodiversity, natural and man-induced disasters, coastal and watershed management, environmental technologies, pollution emissions, just to name a few. The aim of furthering research in the field of ICT for the environment is to support the development services for the citizen and the society through the new applied tools and technologies for improved:

- Ecological and natural resource management, mitigation and adaptation to long term environmental change (including global change and bio-diversity):
  - Pollution detection and monitoring of substances harmful to the environment and health (i.e.: including use of biosensors and nanotechnologies);
  - Management, decision support, optimisation and process control (i.e. adaptation to climate change, agriculture and rural development, waste treatment and waste water treatment sewage simulation, irrigation, etc.)
- Assessment of human exposure to environmental stresses (i.e.: in air, water, soil, industrial environment), in line with health/safety and environment policies.
- Disaster risk reduction and ensuring better protection of people, environment and property, in the event of natural and technological disasters (including industrial accidents) with multiple and systemic risks.

3.1 ICT for environmental management

Thematic areas where ICT have enabled environmental management activities directly contributing to EU environmental policy and directives:

- **Air quality and air pollution directives**: Urban traffic is a major source of noise and air pollution which strongly impacts the quality of life in European cities. The HEAVEN project has developed and demonstrated ICT-based management tools for municipal administrations in six European cities allowing them not only to monitor traffic conditions and levels of vehicle emissions, but also to simulate long-term traffic scenarios and establish dedicated Traffic Management Strategies. Hence, the project has contributed to the implementation of EU regulations on air and noise quality. It has provided solutions for meeting the required EU emissions standards for air and noise.

In the case of an observed or forecasted air pollution peak over a European city, it is primordial to inform the concerned citizens as widely and quickly as possible. The project APNEE-TU takes full benefit of the preferred, modern communication channels to disseminate safety warnings and relevant guidance to the citizens. Tested ICT equipments include the World-Wide-Web, SMS, MMS, WAP via mobile phones, PDAs, and smart phones, as well as voice servers...
and street information panels. APNEE-TU directly supports the implementation of several EC directives for the air-quality and the freedom/right of accessing air quality information.

- **Marine environment and Water Framework Directive**: Many heterogeneous data are being collected by local, regional and national actors to monitor the quality of our fresh water, rivers, reservoirs and lakes. However, reporting quality at European level of the so-called “Inland Waters” requires integrated access to numerous databases around the EU. EDEN IW provides such connectivity through what may be described as a virtual data warehouse, based on software agents which advertise, broker and retrieve data, thus allowing rapid and comprehensive answers to data queries. The EDEN IW data exchange prototype is a direct RTD contribution to the implementation of, for instance, the EU 6th Environmental Action Plan, the Water framework Directive of 2000, the Nitrate Directive of 1991, and the Drinking Water Directive of 1980.

- **International conventions on seas and coastal waters pollution**: From time to time, Europe is heavily affected by pollution crises in coastal and ocean regions (such as oil spills or harmful algal bloom events). DISMAR assists notably environmental agencies and civil protection authorities in their tasks of real-time monitoring and forecasting of the European marine environment by providing them with real time access to harmonised data input, and with the required integrated decision support system. Tested in six coastal zone and ocean areas in Europe, the DISMAR system builds upon internet and GIS technologies, open source software, international standards and a technical architecture meeting the requirements of the EU’s INSPIRE initiative. DISMAR is particularly relevant for International conventions on seas and coastal waters pollution to which the EU is a party.

- **Water quality related directives**: The I-MARQ project has develop service to deliver real-time information on coastal water quality into a variety of end-user markets, via a dynamic GIS-based system. The system support decision-making by various end-user groups: citizens concerned about environmental quality in recreational waters; local authorities seeking a quality tourism cachet and wishing to avoid hazard to public health; companies seeking to validate environmental performance and avoid liabilities from pollution incidents.

- **The urban environment and the Urban Waste Water Treatment Directive**: SEWING developed and tested a relatively cheap and generally accessible system for monitoring and early warning of water pollution regarding non-organic polluting ions. A prototype system based on CHEMFET/ISFET sensors (chemically-modified/ion sensitive field effect transistors), was implemented and verified in real field conditions by end users. When commercially developed, the system will permit real-time monitoring of various types of water resources and waste water in high-risk industrial regions, giving the possibility for early warning. The INTELCITY project produced a roadmap for RTD and ICT deployment for sustainable cities. It is taken up in the INTELCITIES Integrated Project in the eGovernment area.

- **Soil quality and the Nitrates Directive**: The GIMMI project has helped preventing abuse of pesticides and fertilizers in farming and agriculture and promoting eco-compatible practices.

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8 Directive 2000/60/EC: Water Framework

9 Directive 1991/676/EEC: Protection of waters against pollution caused by nitrates from agricultural sources


thanks to a number of tools allowing for better, more efficient planning of environmental controls and monitoring

- **The sustainable use of resources**: Marine and inland water pollution is of vital importance for the health, economy and the environment of coastal regions. In addition, oceans constitute biodiversity reservoirs and regulators of global climate changes. ICTs play an important role in the management and utilization of marine and coastal environment datasets, fusion and modeling techniques. SUMARE demonstrated the utility of intelligent sensors for environmental monitoring of marine resources and threats such as oil spills, thus permitting better information on pollution and algae incidents for marine environmental surveys and monitoring needs. The project contributed directly to the marine protection policy, and more specifically to the Water Framework Directive and the Directive on Quality of Bathing Water12.

According to the 1992 UNCED statement of principles, forests, with their complex ecological processes, are essential to economic development and the maintenance of all forms of life. FOREMMS integrated data from in-situ, airborne and satellite instruments, which are provided at different spatial resolution and frequency of coverage scales, and used a novel statistical data analysis method to link them in order to obtain an overview of the environmental situation of the forests in Europe. With this approach it is possible to detect small environmental changes in the European forests from one year to the next, and thus improve short- to medium-term monitoring capacity.

- **Directive on Environmental Noise**: The annual cost to the EU from lost productivity, accidents and health problems caused by lack of sleep and concentration due to noise, is estimated between 13 and 38 billion euro. According to the Directive on the Assessment and Management of Environmental Noise13, EU national and regional authorities will have to produce from 2007, strategic noise maps and abatement action plans detailing noise pollution near urban areas. Though for the first years, authorities’ own methods could be used, from 2012 onwards, a harmonized prediction method will have to be used for noise propagation estimation to permit accurate comparisons, method which has to be agreed. HARMONOISE developed a new noise assessment method from road and rail sources, decoupling propagation from source, thus allowing the effect of mitigation measures at the source to be assessed accurately and precisely. The project contributed thus directly towards the development of the highly-needed standard by the directive.

- **Land use policy and INSPIRE** (Infrastructure for Spatial Information in Europe): Harmonised environmental information across the EU will enable the EU and the Member States to better plan, implement and monitor environmental legislation. It will also reduce the cost of collecting data by optimising the cost of existing data. This is the objective of the INSPIRE regulation which requires the Member States to publish geographical information in a coordinated way. The ORCHESTRA project is developing an open information systems architecture to overcome the various challenges that hinder information exchange. This architecture is aimed at providing a first set of INSPIRE implementation rules. The proposed solution will benefit systems users, such as IT architects, system developers and integrators who create environmental applications. The adoption of this common architecture should in the medium term reduce the cost of building and maintaining environmental application by an order of magnitude.

3.2. ICT for improving Disaster Risk Reduction

In the area of disaster research advances have been made particularly in the areas of flood forecasting, the design of earthquake resistant structures, forest fire hazard mapping and suppression techniques, volcanic eruption monitoring, landslide and avalanche hazard assessment, and industrial process safety related to the implementation of the Seveso II Directive\textsuperscript{14}. Research has also addressed preparedness and response to major crises, and the improvement of safety of rescue teams, thereby reducing economic losses and the toll on human lives. On the crisis management side, research results have lead to the improvement of situational awareness, as well as better decision support tools in support of the whole command chain. Currently, all 25-member states of the EU have very different information systems, operational procedures and communication systems that do not talk to each other. Since 2000 significant RTD activities have addressed these issues and include the development of a software platform that improves interoperability between public sector information systems as well as enhancing contingency and continuity planning in the public and private sectors. The intention is to design, validate and demonstrate a generic integrated environmental risk management open system to support the whole chain of activities, from initial hazard assessment to post-disaster recovery. Special attention is given to operations of European civil protection organizations in the case of large-scale natural and industrial disasters across all 25 EU member states. The current research activities are divided into two sub-activities outlined below. The first one, entitled “disaster reduction” covering the hazard, vulnerability and risk assessment phases, including forecasting, preparedness and prevention. The second one entitled “crisis management operations: “dealing mainly with the alert and the emergency response phases.

- **Disaster Reduction**: Until recently, risk management components were developed independently by a vast range of institutions and organizations. In addition, the exchange of relevant information needed for dealing with risks is too often hindered by administrative and legal boundaries, as well as lack of interoperability on the technical side. The recently endorsed INSPIRE initiative aims at harmonizing geo-spatial information across the EU. This new Directive offers a unique opportunity for a major overhaul in environmental management and disaster prevention, contingency planning as well as community involvement in risk reduction. Current projects, including ORCHESTRA and WIN, are working on developing service architectures for risk management based on “open” standards. This approach should dramatically reduce the cost of building and maintaining environmental risk management applications, and it will also allow for the appropriate handling of multiple risks and environmental impacts.

- **Crisis Management Operations**: Initial investigations revealed that civil protection organizations appeared not to benefit as much as other professionals from the new developments in ICT. Many such public authorities are still poorly equipped, and since this market is rather small, providers companies are slow to invest in up-to-date and cost effective equipment and applications. This is one of the reasons why the EU ultimately decided to invest in this field. It was also perceived as an opportunity to improve equipment interoperability, in order to allow different emergency actors, possibly belonging to different regional or national European authorities, to work jointly in case of large scale and cross-boarder disasters. Crisis management operations are based on a three-level architecture concept: the “coordination and command centre” supported by “function- specific control rooms”, the “mobile command centres” and the “crew” in the field. The function-specific control rooms host the local management and interface with auxiliary functions (technical and scientific support, short term forecasting, meteorological office, emergency health care, public utilities, damage assessment, etc.). The reporting is made to the upper level, that is, the coordination centre, which is located

\textsuperscript{14} Directive 1996/82/EC: Seveso II
on the premises of the local, regional or national government authorities, depending on the size of the crisis, with a secure link to the crisis centre of the EC in case of major disaster. Several RTD projects, in particular the OASIS project, populated this concept with a full range of advanced applications and emergency management tools that were tested and validated by end-users. These elements are being integrated in Emergency Information Systems over a communication infrastructure supporting voice and data exchange through a robust messaging service.

A key objective of the current ICT projects is the creation of a civil crisis management methodology and an interoperable command and control infrastructure. The current approach is building on NATO experience and adapts successful methods initially developed for military applications to the needs of civil protection agencies. The projects will examine the effectiveness of an EU network of trans-national headquarters with the capability of dealing with more than one trans-regional crisis at any one time, and integrate applications into a full fledged C4I (Command Control Communication Computer and Intelligence) for Civil protection operations.

Future developments should address the need for better integration of the wide range public safety communications and evolve into a network-centric crisis management framework.

4. Related Initiatives

The EC is a co-founder of the Global Monitoring for Environment and Security initiative (GMES15), in co-operation with the European Space Agency (ESA). The objective of GMES is to build a European capacity for global monitoring of the environment and security by 2008. The initiative aims to integrate environmental observation data from all available sources, satellite and in situ, while taking account of EU policies and data standardization methods. GMES research activities support user-driven development of services targeted to provide reliable, timely and independent environmental information to European stakeholders. GMES is a major European contribution to the global ad-hoc Group on Earth Observation (GEO16), in which the EC continue to play a leading role. GEO’s primary task is to develop a 10-year Implementation Plan for a coordinated and sustainable Global Earth Observation System of Systems (GEOSS) presented at the global Earth Observation Summit in February 2005. GEOSS supports nine societal benefit areas related to sound environmental monitoring and management. European Research policy strongly supports both initiatives, GEO and GMES.

5. Conclusions

EU research policy on ICT for the Environment is committed to support the implementation of environment and sustainable development policies. In addition it will also contribute to providing better management tools and monitoring capacities, thereby reducing the costs of implementing such policies; generally incurred by industry and public institutions. Future research will promote more holistic approaches whereby ICT for environmental management is an integral part of a sustainable development strategy, hence linking environment with regional and urban planning, as well as considering the wider social and economic dimensions. Environmental management is a truly Europe-wide issue that needs to be addressed at a European scale, thus future research in this area will also have to enable us to effectively overcome problems of fragmentation, interoperability, language, and accessibility to information pertinent to the entire sustainable development chain.

15 GMES: http://www.gmes.info/
16 GEO: http://earthobservations.org/