Committee of Experts on
Global Geospatial Information Management

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Contribution of the Committee to Rio+20 –
United Nations Conference on Sustainable
Development – and implications of the outcomes of Rio+20

Monitoring Sustainable Development: Contribution of Geospatial Information to the Rio+20 Processes

Background Document Prepared by the Secretariat

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Background Document

Contribution of Geospatial Information to Rio+20 Processes

Executive Summary

This paper provides background on the advancement of geospatial policies, practices, and technologies since Rio+10. This paper is provided in preparation for the Rio+20 UN Conference on Sustainable Development and suggests a central role for the United Nations Committee of Experts on Global Geospatial Information Management in the deliberations of that conference and in the implementation of subsequent actions determined at the conference.

As the world population continues to grow, the pressure on the earth to sustain and provide for this growth increases even more rapidly. Available resources – both non-renewable and renewable – are under increasing stress. As never before, global environmental issues such as deforestation, desertification, climate change, and soil loss require not just local responses but global coordination and collaboration to address and ameliorate the environmental degradation that is impacting our ability to ensure sustainable development for all nations and communities. At the same time, with more individuals and communities affected, the impacts of natural disasters are unprecedented. The ability of the global community to respond to and provide aid after a disaster is being stressed as never before. This problem is exacerbated given the unequal infrastructure of the global economy.

All of the issues impacting sustainable development can be analyzed, mapped, discussed and/or modeled within a geographic context. Whether collecting and analyzing satellite images or developing geopolitical policy, geography can provide the integrative framework necessary for global collaboration and consensus decision making. Ten years ago, the vast majority of spatial data infrastructure activity was focused on providing digital maps via web portal applications which were usually focused on national needs. The data provided was typically maintained by one or two national agencies. There was no ability to easily integrate other spatial data sources. Regional or international collaboration was discussed but not implemented. Neither the policies nor the standards were in place to provide for global spatial data infrastructures designed for local, national, regional, or international collaboration. From a technical perspective, ten years ago many key technologies such as social networking, cloud computing, and smart phones did not exist. Cellular technology was just beginning to permeate the developing world.

In the last ten years, this situation has dramatically changed. There are now numerous regional and international activities that demonstrate the architectures and policy frameworks necessary to design, build, and deploy geospatially enabled IT infrastructures that meet the requirements for collaboration for decision support, policy discussions, and modeling required by the sustainable development community and policy makers. Examples include national spatial data infrastructure activities such as the Canada Geospatial Data Infrastructure[1], the Spain NSDI[2], and the Malaysian SDI[3]. At the regional level, the European INSPIRE initiative has defined the policy, governance, and technical guidance for a pan-European standards based spatial data infrastructure. At the global level, OneGeology, Global Map and

[1]http://geodiscover.cgdi.ca/
[2]http://www.gsdi.org/gsdiconf/gsdi11/papers/pdf/161.pdf
[3]http://ijsdir.jrc.ec.europa.eu/index.php/ijsdir/article/view/175/228

GEOSS are examples of how SDI concepts can successfully be deployed as a global asset. There is now discussion of a Global Network of Networks. Each of the examples above has the following characteristics:

- Commitment at executive levels;
- Strong governance – but governance that does not hinder the use of new technologies or consideration of new ideas and approaches;
- Generally accepted content models;
- Strong commitment to best use of standards, including best practice guidance;
- Ability to easily integrate new sources of geospatial data and services into the infrastructure;
- Policy support;

Perhaps most importantly, there is a strong belief that geography provides the integrative framework necessary to support the requirements of multiple information communities in a timely and effective manner – providing the right data at the right time to the right place. The same geospatial content, re-purposed, can support applications ranging from agricultural management, to emergency planning and response, to scientific collaboration on climate change, to transportation planning. All of these applications have implications for sustainable development and livability.

Within this context, this paper makes several recommendations. The UN Committee of Experts on Global Geospatial Information Management is in a unique position to implement these recommendations and to provide guidance on how geospatial information can be effectively used to help deliver sustainable development. (Additional technology specific recommendations are contained in section 4).

The recommendations include:

- Continued consideration and development of geography as an integrative framework for sustainable development applications, decision support, and policy development.
- Identification of new and emerging technologies and how these technologies can enhance our ability to better respond to sustainable development issues.
- Consideration of legal and ethical issues such as privacy, security, intellectual property and liability (www.spatiallaw.com)
- Engagement with the scientific and research community in the development of sustainability science (ICSU, 2010)
- Provide guidance and a discussion framework for how the numerous regional and global remote sensing portals and dissemination networks can be integrated to create a network of networks. Providing guidance on geospatial standards best practice
- Facilitating cooperation among the major players involved with geospatial information at the global level

Section 2 of this paper provides policy background as related to geospatial data and services infrastructures. Section 3 provides a discussion of the current and emerging trends in institutional policy. Section 4 discusses technology trends that are reshaping how geospatial data content and services are designed, accessed, deployed, and managed and section 5 provides a brief conclusion.

1. Introduction and Context

1.1 The initial United Nations Conference on Environment and Development was held in Rio de Janeiro in 1992. This gathering was also known as the Earth Summit. One of the Summit's outcomes was the action program known as Agenda 21. The conference adopted the paradigm of sustainable development as defined by the Bruntland Commission (1987) as "…development which meets the needs of the present without compromising the ability of future generations to meet their own needs." Chapter 40 of Agenda 21, which deals with Information for Decision Making, recognized the critical importance of authoritative information on sustainable development issues in meeting the challenges of sustainable development. From the outset, the community recognized that sustainable development had three pillars - environmental, social and economic – each with its own information needs. The value of geographical information was acknowledged but primarily in the field of environmental information (UN Committee of Experts on Global Geographical Information Management (E/c.20/2011/4).

1.2 World Summit on Sustainable Development Rio+20

A follow-up World Summit on Sustainable Development (WSSD) was held in Johannesburg (Rio+10) ten years later. Again, the value of geographic information was recognized (UN Committee of Experts (Ec/.20/2011/4). Global mapping was mentioned both in the political declaration in paragraphs 132 and 133 and in the implementation document where the International Steering Committee for Global Mapping was recognized as an implementing agency. A case in point is Global Map, which was created in response to Agenda 21 and provides spatial information, vital to facilitating the monitoring of changes occurring in the global environment. (www.iscgm.org).

The significance and importance of geographic information for sustainable development featured prominently at a number of side events held in conjunction with the main conference program. One of the most significant was that organized by the National Research Council of the United States around the publication of a comprehensive report entitled "Down to Earth: Geographic Information on Sustainable Development in Africa". This publication was the result of a year-long study by the Mapping Science Committee of the NRC Board on Earth Sciences and Resources and included input by senior scholars from Africa. The publication described the technical and institutional geospatial platforms that were available at that time to support sustainable development using a number of case studies from Africa to illustrate this.

1.3 The Need for an Integrated Information Platform

Both the Earth Summit in 1992 and the World Summit on Sustainable Development held a decade later recognized the need for the integration of very different types of information on the environment and both social and economic development into a common framework but both the technical and institutional challenges to achieve this have proven to be very difficult to overcome. The institutional challenges have proven to be particularly recalcitrant although significant progress has been made in technology. A strong case was made for geography as an integrating mechanism for both data and information relating to the challenges of sustainable development. This built on the vision of a "Digital Earth" outlined by Vice-President Gore of the United States in 1999 (Gore, 1999). Gore presented compelling arguments for the application of geospatial information to the challenges to sustainable development which leant heavily on the use of location to link environmental information.

1.4 Integrated Information for Rio+20: The Power of Location

As we approach the 2012 United Nations Conference on Sustainable Development (Rio+20) both the recent technical and institutional advances in geographic information processing now make it more possible to provide an operational integrative framework for the management of the wide variety of information required to support sustainable development. The promise of geography and location as an integrating factor has long been recognized as Gore's 'Digital Earth' and the documentation of both the original Rio meeting and the Rio+10 meeting illustrate, but the facts show that although some progress was made, that promise has not yet been fully realized. There are some parallels here with GIS technology which did not deliver on its early promise for several decades until the Web enabled deployment of geo-enabled applications accessible by millions of users. The current consensus as outlined by Max Craglia et.al. (2012) is that the rapid and continuing advance of technology supported by the availability of increasing volumes of data of all types (McKinsey Global Institute, 2010) makes the implementation of Gore's vision a very real possibility although institutional challenges still remain. This integration and the effective management and application of geospatial information will make a major contribution to meeting the challenges of sustainable development.

1.5 The Central Purpose of the Paper

The central purpose of this paper is to demonstrate that both the technology and the institutional frameworks have reached a level of maturity where location-based policies and the effective use of geospatial information can be powerful drivers for sustainable development. The paper will describe a range of these developments. It is argued that the United Nations Committee of Experts of Global Geospatial Information Management can make a significant contribution to Rio+20. As Prime Minister Kim Hwang-Sik of the Republic of Korea has recently argued "Geospatial information is the most fundamental tool to support the planet's joint efforts in resolving global issues. By interconnecting information on natural disasters, poverty and the environment though location data, global issues such as sustainable development and poverty eradication can be effectively managed" (http://ggim.un.org/seminar_24Oct2011.html). The contribution of the Expert Group will be both technical and institutional with the latter being of special importance. There are a number of global initiatives in the geospatial management field (e.g. GEOSS, Global Map, EyeOnEarth, OneGeology); the Expert Group provides an institutional mechanism which could help to link these into a distributed "system of systems" as suggested by Max Craglia et. al. (2012) and facilitate the use of geographic information to deliver effective sustainable development.

2. Some Recent Institutional Developments

2.1 The United Nations Committee of Experts on Global Geospatial Information Management

In August 2011 the Economic and Social Council of the United Nations passed a resolution formally establishing the UN Committee of Experts on Global Geospatial Information Management (Resolution 2011/24). This was an important step in creating an institutional framework to help implement the potential contribution of geographic information to the challenges of sustainable development (http://ggim.un.org).

2.2 The High Level Forum on Global Geospatial Information Management

The first High Level Forum on Global Geospatial Information Management was held in Seoul, Republic of Korea from October 24 to 26, 2011 and brought together 350 participants from 90 countries, 22 representatives from different UN agencies and 37 representatives from institutional organizations and the private sector. An important component of this meeting was the Ministerial Session where ministers from eight countries (Finland, Chile, India, Korea, Malaysia, Mongolia, Namibia and Niger) participated (http://ggim.un.org/seminar).

2.3 The Seoul Declaration

The meeting adopted the Seoul Declaration on Global Geospatial Information Management on October 26, 2011 which reads in part:

“We therefore resolve,

- To express our support for the initiative of the United Nations to foster geospatial information management among UN Member States, international organizations and the private sector; and in this regard:
  - to take actions to foster and strengthen national, regional and global cooperation with the aim of developing an interconnected global community of practice on geospatial information under the umbrella of the United Nations;
  - to devise effective processes for jointly and collaboratively promoting common frameworks and standards, as well as harmonized definitions and methods for the treatment of national geospatial data in order to enhance geospatial information management at the national, regional and global level;
  - to share experience in policy-making, supporting legislation, and funding strategies, to encourage and develop best practices in geospatial information management (ie. collection, storage, maintenance and documentation) at all levels, including integration of spatial data and thematic data from other sources, and to facilitate and promote capacity development in the developing countries.” http://ggim.un.org/seminar_26Oct2011.html

There were a number of significant institutional achievements at the Forum.

2.4 High Level Government Recognition

For the first time senior government representatives in the presence of eight cabinet members explicitly recognized the importance of geospatial information to the solution of national, regional and global development problems including environment and sustainable development. The opening address to the Forum was made by the Prime Minister of the Republic of Korea. This explicit recognition marks a significant political statement of the importance of Global Geospatial Information Management and its importance to sustainable development.

2.5 Institutional Models for Geospatial Data Management

A comprehensive presentation and discussion of the institutional models which are being used to manage and integrate information using location as a key tool took place. This included presentations by Brazil, Chile, Canada, China, Korea, Malaysia and Indonesia. Several nations (e.g. Brazil) reported on the establishment of these infrastructures by legislation whereas others are being created by innovative voluntary partnerships (e.g. Canada).

The concept of a Spatial Data Infrastructure (SDI) emerged in the early 1990s (Masser, 2005). This was defined by the US Office of Management and Budget Circular A16 of 1992 as "…the technology, policies, standards, human resources and related activities to acquire, process, distribute, use, maintain and preserve spatial data".

The discussion demonstrated that SDIs at the national, regional and global levels have evolved with increasing resolve and commitment and a number of excellent examples were given. At the national level the examples of Korea, China, Singapore and Malaysia represent good examples as do those of Chile, Brazil, Canada, Australia and Spain. (http://ggim.un.org/seminar). At the regional level the INSPIRE (www.inspire.geoportal.eu) program of the European Union and the emerging Arctic Spatial Data Infrastructure under construction by the Arctic Council and ten pan-Arctic nations were worthy of note (asdi.arcticportal.org) and at the global level both Global Map (http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi) and OneGeology (www.onegeology.org) illustrate how location-based information can be used for geospatial discovery, access, and management at a world scale. These broadly supported and deployed applications rely heavily on the use of international standards.

The discussion also pointed out that geospatial data management must include the areas which are particularly important for sustainable development. The role of the International Hydrographic Organization (IHO) is of special importance in this respect (www.iho.nt) and in integrating data for sustainable development decision making there is a need to integrate maritime data with terrestrial data to give a more complete picture of the earth's realities. This is of special importance to small island states such as those of the Pacific Islands where 95% of their sovereign territory is ocean (Howorth, 2011). Sixteen Pacific Island states created Pacific Oceanscape in 2011 to integrate marine conservation and sustainable management over 40 million square kilometers and in November 2011 the Cook Islands entered into a partnership with the commercial sector to create a one million square kilometer marine park (Geoinformatics Newsletter, week 52, 2011).

Also at the international level is the increasing importance of international standards for enabling geospatial content and service interoperability. These standards, developed by the Open Geospatial Consortium (OGC) and ISO TC 211 (Geomatics), have reached a level of maturity and global implementation that is having significant impacts on the successful deployment and delivery of SDI portals and applications. Further, during the last few years the specification for the use of specific versions of these standards as part of national policy and/or procurement language has been dramatically increasing.

Sustainable development requires information and databases which are integrated, linked, and interoperable. A large and growing number of environmental, climate, land use, and socio-economic databases exist at a variety of different scales and the technology to link these is now in place as will be outlined later in this paper. The emergence of new institutional models, such as the SDI, is of particular importance if this information is to be useful for sustainable development and that is why the efforts of UN-GGIM are of such great significance.

2.6 Weaknesses of Existing SDI Models

Some of the weaknesses of the existing SDI models from an operational perspective were also discussed. Many of the SDIs are predominately supply, rather than demand, event driven and are rarely designed to respond directly to high priority policy issues (Jackson et. al, 2009). To more effectively respond to the issue of sustainable development a very clear definition of the problem and the design of an integrated infrastructure to address that problem at the national, regional or global scale is required. In many cases, an SDI community assumes that the infrastructure being created will provide the information to respond to any situation simply by the provision of comprehensive data layers at the appropriate scale. Comprehensive data layers have value in their own right but a more targeted approach is of greater utility to decision makers (Jackson et. al., 2009; Taylor, D. R. F., 2010). Canada's Geospatial Data Infrastructure is a good example of such an approach. Further, many SDI's do not consider the policies, governance, or technology for leveraging the value of volunteered geographic information or social media.

Many SDIs are being created by national mapping organizations and their creation is seen as an extension of the institutional model of providing comprehensive map coverage for the nation. Authoritative and accurate location data are necessary but not sufficient for the effective management of geospatial information. In addition, many SDIs do not include adequate social-economic data yet these data are critical if SDIs are to act as integrating infrastructures to meet the needs of sustainable development. Many SDIs are isolated from mainstream scientific collaboration which is carried out by many agencies other than the national mapping organization and often are not part of the institutional arrangements for the creation of an SDI. An example of this was the development and evolution of the One Geology project (http://www.onegeology.org/). The One Geology project is now supported by 165 organizations in 117 countries. Fortunately, while One Geology was developed and the portal application deployed independent of any national SDI policy, the portal and data exchange capabilities are standards based. Therefore, minimal effort is required to access and integrate One Geology services and content with other SDI portals and applications or global collaboration tools such as those provided in GEOSS. Many SDIs also do not include participatory frameworks, modeling capabilities and policy response scenarios (Max Craglia et. al. (2012).

The potential of social networks and Volunteered Geographic Information to supplement and complement information of value to sustainable development is considerable. But at present this potential is not being fully developed. Citizens of affected areas are in an unique position to provide information on the impact of climate change and global warming. They can also provide crucial information in disaster situations such as the earthquake in Haiti where detailed street maps were created through Open Street Map in the absence of authoritative information. Real time information in geospatial form can be vital to the success of mitigation efforts in disaster situations and locally reference mobile devices such as cell phones are ubiquitous.

2.7 Integration of Statistical and Geospatial Information

The national statistical organizations are of central importance in achieving an integrated approach. At the Forum, a parallel Seminar on the Integration of Statistical and Geospatial Information was held. This seminar was organized by Statistics Korean, the US Bureau of the Census and the Statistics Division of the UN Department of Economic and Social Affairs (UN-DESA).The seminar considered the importance of geography to statistical information and the challenges of integrating statistical and geospatial information. The US Bureau of the Census model and that of Brazil were of special interest in this respect. In Brazil the statistical and geospatial responsibilities at the federal level are met by one institution (Brazilian Institute of Geography and Statistics (IBGE)); (Taylor, 2010). It is clear that the integration of statistical datasets with geospatial ones, as well as data from other thematic sources, is of value to the analysis and evidence-based decision making so important for sustainable development (http://ggim.un.org/seminar_27oct2011.htm/). This trend of increased integration of statistical analysis and modeling into traditional SDI applications is further supported by increased activity in the standards community to define best practices and standards for accessing and integrating statistical processes into existing SDI portals and application suites. An example is the availability of an OGC Web Processing Service (WPS) interface to the "R - a package of statistical algorithms" (*ifgi.uni-muenster.de/~epebe_01/pebesma_etal.pdf*)

Sustainable development is above all a human problem and can best be addressed by integrating socio-economic information with spatial and environmental information. The institutional process of linking census with mapping agencies taking place through UN-GGIM is an important institutional process in this respect.

2.8 Conceptual Shift in Managing Geospatial Information

The community recognized that if the promise of geography and location as an integrating infrastructure is to be realized, then there has to be a conceptual shift from the management of geospatial information to the management of all information geospatially, including a change in existing institutional structures to facilitate this. An outstanding example of the implementation of such an approach is that of the Republic of Korea through the Smart Korea program in which location is the key integrating factor for a wide range of information of all types. Korea leads the world in this respect and provides an institutional model for other nations to emulate. A clear political decision at the highest level has been taken to make location central to information integration and substantial investments have been made to implement this decision (http://ggim.un.org/seminar).

Another conceptual shift that needs to take place is to ensure that as much government collected geospatial data as possible is made as widely accessible and available in a timely manner at minimum cost. At present, too often access is restricted or the data are available for a fee. This situation is changing. For example, the European Commission has launched an Open Data Strategy for Europe, which is expected to deliver a €40 billion boost to the EU's economy each year. In the developing world India is an excellent example of a state which moved from a high restrictive policy on the availability of geospatial data to a much more open one. Access to data is a critical policy issue and must take into account a variety of issues such as security, privacy, confidentiality, and what has been called "legal interoperability". UN-GGIM has a key role to play because without effect policies to share data at the local, regional and international scale the contribution of geospatial information to sustainable development will be much reduced.

2.9 The Role of the Private Sector

The Forum also marked an institutional innovation by providing an opportunity for the private sector to make input on both technological and management issues relating to Global Geographic Information Management. The private sector is a key player in the effective development, communication, and deployment of geospatial technology and data. A dynamic new “geoweb” is emerging as part of a location-based ubiquitous computing environment and the private sector, through numerous private sector companies, many of which are not familiar to the GIS practitioner, is actively involved. These companies are driving the developments of a rapidly growing location enabled series of social networks, location enabled internet standards, location enabled infrastructure, and so forth.

The private sector, through organizations such as the Open Geospatial Consortium (OGC), is also playing a key role in the development of standards and specifications that are central to the interoperability and sharing of data which will be discussed later in this paper.

In advance of the Forum, a one-day meeting entitled, An Exchange with the Geospatial Industry for the United Nations Initiative on Global Geospatial Information Management was attended by senior representatives of 29 of the world’s leading geospatial industries and representatives of over 35 national mapping organizations (http://ggim.un.org). Industry has a major role to play in more effective integration of information for sustainable development and new institutional relationships and partnerships are required. Industry is not simply a supplier of goods and services to governments and other public sector agencies. It is a key player in building new institutional structures. This was recognized in the Report of the Chairman of the UN High Level Forum.

“The Forum recognized that the geospatial industry is a key player in the global geospatial information community. The dialogue with industry partners noted the importance of continuing the dialogue between governments and industry under the umbrella of UN-GGIM. The private sector could respond faster to the market place and identify appropriate technological solutions, as we move from a paradigm of management of geospatial information to the management of all kinds of information.” (http://ggim.un.org/seminar_26Oct2011.html) UN-GGIM is providing an important institutional mechanism to include the private sector in the application of geospatial information to meet the challenges of sustainable development.

2.10 International Geospatial Information Societies

The Forum also recognized the important role of international geospatial information societies. At the Forum the ten members of the Joint Board of the Geospatial Information Societies (JB-GIS) presented a joint paper for the first time. The Joint Board is a coalition of the leading international geospatial societies that speaks on behalf of the geospatial profession at the international level (http://www.fig.net/jbgis). The Joint Board includes the following organizations:

- Global Spatial Data Infrastructure (GSDI) Association
- IEE Geoscience and Remote Sensing Society (IEEE-GRSS)
- International Association of Geodesy (IAG)
- International Cartographic Society (ICA)

- International Federation of Surveyors (FIG)
- International Geographical Union (IGU)
- International Hydrographic Organization (IHO)
- International Map Trade Association (IMTA)
- International Society of Photogrammetry and Remote Sensing (ISPRS)
- International Steering Committee for Global Mapping (ISCGM)

For the first time these professional societies spoke with a united voice "…aligning strategies and endeavors to collectively present a strong response to global needs" (JB-GIS, 2011). This is an important step in creating a strong community of professional practice which is required to ensure the integration of information sources required to respond to the needs of sustainable development and also to help to give geospatial input to the major challenges of global sustainability research as identified by the International Council of Sciences (ICSU, 2010)(http://www.icsu .org).

3. Technological Trends Impacting Geospatial Technology and Sustainability

Over the last decade, information and computing technology have undergone significant changes. Ten years ago, there were no social media applications, no concept of cloud computing, very few deployed geospatial standards, GPS smart phones were just appearing. These dramatic technology advancements and shifts have significant implications for the procurement, deployment and use of geospatial technology. Further, they have even more significant implications for providing sustainable information infrastructures AND enhancing our ability to have positive impacts on sustainable development and economies.

3.1 Joint Board of Geospatial Information Societies presentation

The keynote presentation by the Joint Board of Geospatial Information Societies covered a number of characteristics of Spatial Data Infrastructures, including governance, data sharing, discovery, access, and interoperability.

The presentation touched on a variety of requirements for access to key geospatial data sources, data sharing, interoperability, and the need for international coordination on global geospatial information management. The report suggested that for so many situations (disaster relief, sustainability, better decision making, etc.) it is critical to have the right data, at the right time, displayed logically, in order to respond and take appropriate action.

At the recent UN High Level Forum on Global Geospatial Information Management it was acknowledged that the technology trends have occurred and this was documented in the Report of the Secretary-General, "Contribution of the Committee to the United Nations Conference on Sustainable Development (Rio+20)".

In all of these documents and presentations, statements are made regarding the evolution of technology and the potential positive impacts on sustainable development and economies, especially in developing nations. This section specifies the new and emerging technologies presented in the context of the SDI and governance framework as defined in the JB-GIS report. Further, the issues related to access, knowledge transfer, and technology sustainability are also discussed.

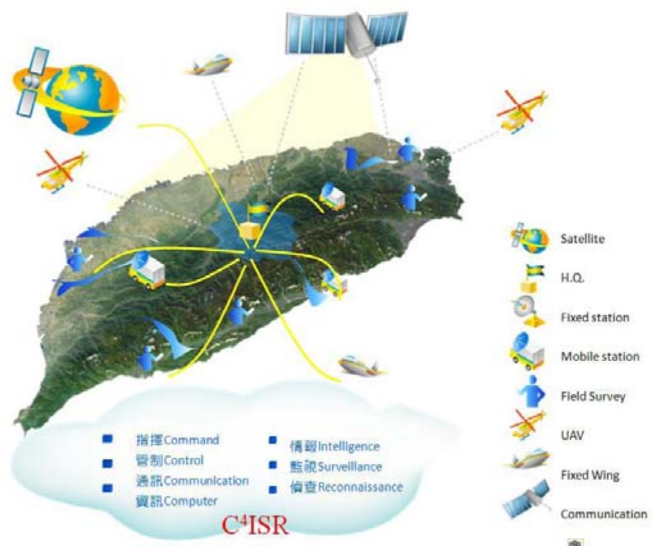
The following topics are suggested areas for further study as the basis for recommendations and presentation at Rio 2012.

3.2 An example of geospatially enabled decision support – the future is today

Debris flows are a major issue in many nations, especially mountainous island nations, such as Chinese Taipei, that experience sudden and intense precipitation events. Some nations have experienced significant loss of life due to debris flows. A combination of real time sensor data fused with other geospatial data content and modeled via debris flow simulation models can provide a viable solution.

A debris flow is a fast moving mass of unconsolidated, saturated debris that looks like flowing concrete. The difference between a debris flow and a mudflow is expressed in terms of the viscosity of the flow. Flows can carry debris ranging in size from clay particles to very large boulders. A debris flow can be extremely destructive to life and property.

In a debris flow warning system, advanced monitoring sensors include rain gauges, wire sensors, geophones, stress gauges, and CCD cameras. A rain gauge is used to record on-site rainfall. The warning model for the debris flow alert uses rainfall intensity and accumulated precipitation as warning indexes to determine whether rainfall has reached the threshold and thereby the application provides timely red and yellow alerts to high risk areas where debris flows are likely to occur. Alerts are sent to cell phones and to radio and TV stations. As the debris flow moves down the channel, the flow breaks wire sensors placed in the spillway of diversion dams, hence indicating the occurrence of debris flow and issues additional warnings.



The ability to share geospatial and sensor data and perform multi-int fusion for situational awareness and decision support is achieved using a standards based framework coupled with access to a private cloud that provides an elastic computing platform. Since many citizens do not have internet access or televisions, but they do have cell phones, alerts are provided using a location enabled SMS messaging system. Once the event is over, first responders have access to all of the real time information collected during the event. They also have internet access to a global spatial data infrastructure that provides them the most recent imagery of the impacted area. At the same time, wireless mobile devices are used to collect real time data of missing persons, damaged buildings, bridges destroyed and so forth. The data collection is performed by both emergency responders as well as citizens. The new, volunteered data are constantly shared in near real time with all responders via a standards based geosyncronization service. The geospatial and response computing and application environment is a combination of proprietary and commercial open source products. Everyone has the right information at the right time at the right location.

These technologies are being very effectively used today in Chinese Taipei (Chou, J. 2011). Although these technologies collect real time information on a particular environmental disaster situation it is clear that this operational technology has much wider application in other situations dealing with the environment and sustainable development. The question becomes how will these technologies evolve over the next ten years and how can we ensure that all governments and citizens in all countries can benefit from having the right geospatial data available in a timely manner at the right place.

3.3 Service provision (access, capacity building, governance, standards, technology transfer)

Ten years ago, most geospatial technology was deployed via networked desktop computers and PCs or by providing limited functionality through web portals. For decades, this has been the traditional technology transfer and deployment strategy for SDI and GSDI. In the mid to late 1990's the Web began to change how geospatial technology was deployed and accessed. However, most of those early Web portal deployments only provided simple query and access. They were one way information exchange portals. While valuable, there was little concept of allowing citizens to provide content, add services, and so forth. Further, too often these web applications were available to only a fraction of the population.

Over the last 5 or 6 years, technologies have emerged that are radically changing how geospatial data and services are deployed and accessed. Technologies such as geo-enabled mobile devices, increased bandwidth, mature geospatial standards, the "cloud", social networking, and broadly used open source tools have all emerged as significant changes. Further, these new technologies are providing access to geospatially enabled capabilities on a scale never imagined a decade ago. These new technologies have significant implications related to sustainable development activities in all nations but especially in developing nations where both the smart phone and the Cloud can be seen as "leap frog" technologies.

3.4 The Cloud

One of the issues identified by the JB-GIS concerns technology deployment and sustainability. Too often, GIS hardware and software systems have been developed, demonstrated, and then left in an organization in a developing nation organization with no ongoing support. Without continued support financially and educationally, these systems are often not properly utilized. Given the known financial, knowledge transfer, and infrastructure constraints, the UN community should consider the implications of using the Cloud for deployments of geospatial technology and access to geospatial assets. For areas with little or no traditional internet access, mobile device access via cellular networks could provide a solution as indicated in 4.3 above.

What is the “cloud” and what is “cloud computing”? The US National Institute for Standards and Technology provides the following definition:

> Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

This cloud model promotes availability and is composed of five essential characteristics**,** three service models, and four deployment models. These are fully described in the NIST report[4].

The essential characteristics are: On-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service.

All of these cloud characteristics can also provide strong benefits to traditional SDI/GIS deployments in any organization or nation. For example, elasticity means that in time of intense need, the computing resources are available. Broad network access means that the services and related content are available anytime, anywhere via a connected device, such as a tablet or cellular telephone. Further, the cloud provides a sustainable infrastructure for geo-technology applications and content. Any network connected device can access cloud deployed applications, obviating the need for expensive to maintain larger computer assets, such as desktop computers or mainframes. As long as there is phone and/or internet access, cloud deployed applications can be accessed and used. From a cost perspective, cloud based services can be procured only when operationally required and so can be funded from Operational Expenditure rather than Capital Expenditure making procurement a much less painful process (DGI Conference, 2012). On the environmental impact side of the sustainability equation, “Organizations choosing to run Microsoft’s BPOS can reduce carbon emissions by 30 to 90 percent for major business applications. Cloud computing drives energy reductions in four related ways: reducing excess capacity, flattening peak loads, using large-scale "virtualization" SW, and improving datacenter design. Less than 4 percent of the energy going into a data center is used to process something. [Winston, 2011].

A number of geospatial technology providers already provide access to GIS functionality using the cloud either as software as a service or as a computing platform

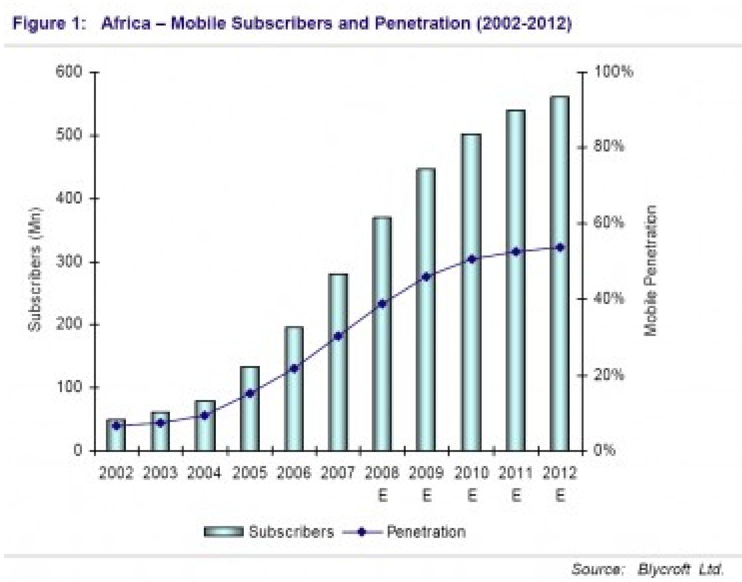
Recommendation: The UN needs to consider guidance (best practice) and governance of the use of the cloud as a key platform for providing access to geospatial content and services, especially in developing nations as a contribution to sustainable development.

3.5 Mobile devices and smart phones

Internet access and therefore access to geospatial services and content that support sustainability, emergency response, and so forth is still an issue in many developing nations as well as rural areas in developed nations. Mobile devices may provide a solution to the internet access problem. Cell phone penetration in Africa, for example, is approaching 50%. Already, numerous mobile phones are being used to access internet deployed applications. As another example, IBM predicts that 80% of the world's population will have a mobile phone

[4]http://www.nist.gov/itl/csd/cloud-102511.cfm

within five years. "As it becomes cheaper to own a mobile phone, people without a lot of spending power will be able to do much more than they can today,"[5].



Source: http://www.w3.org/2008/MW4D/wiki/images/9/9c/FrontPage$Africa_Mobile_Fact_Book_2008.pdf

Mobile phone service is increasing by leaps and bounds in Africa. Indeed, so many Africans have subscribed to wireless service that the continent is now the second-largest market in the world – having supplanted Latin America -- and behind only Asia, the top market[6].

Further, there is a technology trend to deploy geo-enabled environmental information using the mobile device as the platform. As an example, there is a new conference "Building Innovation Through Partnerships: Apps for the Environment Forum" that will commemorate the US Environmental Protection Agency's Apps for the Environment Challenge and present a vision for the future of environmental apps and mobile technology (http://www.epa.gov/appsfortheenvironment/forum.html)

Finally, the impact of mobile, internet connected technologies does not suggest the need for expensive, high-bandwidth smart phones or tablets. Other ways in which the mobile phone plays a vital role in enhancing the economic and social well-being of mobile users and their families in the emerging markets, are directly related to SMS [short message service] messaging. The ability for citizens to SMS (text) each other and the authorities in time of crisis has huge benefits. As another example, farmers can use their phones to receive weather reports, harvest prices, information about fertilizers all by SMS. With this valuable information at hand, they can plan better and increase their crop yields. Mobile phones and SMS also play a vital role in improving peoples' lives in the emerging markets, by giving patients access to valuable medical information. For example, mPedigree in Ghana offers an SMS authentication service to verify prescribed medications (e.g., malaria treatments) and

[5] Information Week, December 2011. Innovations IBM Says Will Change Your Life. http://www.informationweek.com/news/software/info_management/232300803?cid=nl_IW_btl_2011-12-21_html&elq=cdc8e107ac6b49a095fe8b1efb5164c2

[6]http://www.ibtimes.com/articles/251484/20111117/africa-mobile-phone-sms-service-rural-south.htm. International Business Times, November 17, 2011

fight the plague of counterfeit drugs. It reaches up to 50 percent of current usage with significant economic and social impact.

A final comment on mobile phones, specifically smart phones, is about how the on-board sensors can be utilized to enhance the ability to obtain real time sensor observations for use in existing or planned location enabled applications for sustainable development. Most everyone is familiar with the fact that all new phones have a GPS chip. What is less know is that many new phones – especially smart phones – have as many as 5 other on-board sensors, including accelerometer, microphone, digital compass, GPS, gyroscope, camera, light sensor. Inputs from these sensors can be used to enhance user experience as well as provide additional data for multi-source integration and fusion activities. Kronos (with input from the OGC) is working on a low level API for consistent access to these onboard sensors[7]. "The new API will support a general-purpose framework for consistently handling advanced sensors such as depth cameras, touch screens and motion and orientation sensors as well as traditional input devices".

Recommendation: The UN community needs to explore how to leverage the cell phone infrastructure and the small device footprint to bring geospatial decision support to citizens in developing nations, citizens in rural areas, or other areas in which traditional internet access does not work. Further, cell phones can play a key role in alerting and warning applications, volunteered data, and other applications that have significant implications for livability and sustainability.

3.6 Disconnected, field deployable units

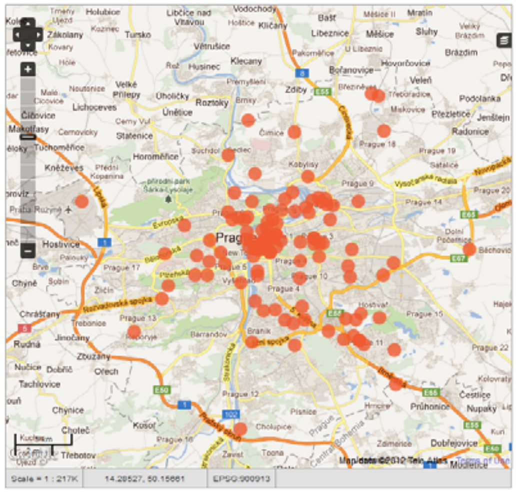
Despite the increasing use of cell phones in developing nations as well as increased availability of internet connectivity, there are still many regions of the world that have little or no communications connectivity. In these cases, mobile, disconnected field mapping units need to be considered. For example, GPS enabled tablets that support simple map data capture tools are readily available. Some vendors already provide comprehensive GIS analysis capability for tablets, although providing such full functionality obviates simplicity and the learning curve associated with simple map capture tools, such as those used by the crisis mapping community. Disconnected units can be used to map infrastructure, location of villages, perform census activities, log endangered species observations, capture geological information, update the location of medical and food supplies, and dozens of other applications. Further, citizens can be trained to use these disconnected devices and therefore make significant contributions to the spatial data infrastructure of their country or region.

Related to the use of disconnected field units is the ability to upload and download geospatial content to ensure that all data repositories are synchronized and provide the same content. The OGC community has been developing projects and standards that enable this form of "geosynchronization".

When geospatial data from field deployed disconnected tablets and from GPS enabled smart phones are combined, then the crowd sourcing applications such as those used and available from Sahana and Ushahidi have incredible value for emergency response, election monitoring, local knowledge collection, asset management and situational awareness. All of these applications have implications for enhanced sustainability and quality of life in a region or country.

[7] http://www.khronos.org/

The following map is from the Ushahidi Praguewatch (based on CrowdMap), which is an internet guide to Prague's controversial cases of urban planning, big development projects, parks and allotments under threat and alleged cases of corruption and cronyism.



Kauzy (podle data zařazení na mapu)

NÁZEV	POLOHA	DATUM
Pěší zóna na Smetanově nábřeží	Smetanovo nábřeží	19.1.2012
Z úřední desky: Žižkov - Parukářka klink...	Parukářka, Praha 3 - Žižkov	14.1.2012
Z úřední desky: Holešovice - nové výškové...	Tusarova, Praha	14.1.2012
Z úřední desky: Michle - rozsáhlé kácení...	Ohradní, Praha	14.1.2012
Z úřední desky: Nákladové nádraží Žižkov...	Nákladové nádraží Žižkov	18.12.2011
Z úřední desky: Trojmezí - Obytný soubor...	ul. Klapálkova, Čenětická, Blažimská-Chodov, Záběhlice	18.12.2011
Z úřední desky: Smíchovské železniční nádraží...	Smíchovské železniční nádraží	18.12.2011
Z úřední desky: Holešovice - nový bytový...	ulice U vody, Jankovcova a Varhulíkové, Praha 7 - Holešovice	28.11.2011
Z úřední desky: Florenc - přestavba vnitrobloku...	vnitroblok mezi ulicemi Na Poříčí a Na Florenci	28.11.2011

Recommendation: The UN community needs to explore technologies and standards that enable the ability to "geosyncronize" geodata collected in the field with data contained in spatial databases maintained by national mapping agencies, open data projects, and other SDI data holdings.

3.7 Satellite Remote Sensing (access, discovery, data sharing, interoperability)

The following sections describe a number of satellite and other sensor based applications and activities that have evolved or emerged in the last 10years. Satellite and other sensor data will provide the majority of the location based content need to address numerous sustainability issues, such as climate, oceans, agriculture and natural disasters, and to allow enhanced decision support and policy definition.

Satellite data has always been a key data source for change detection, emergency and disaster planning response, peace keeping, and a variety of other applications that are aspects of sustainable economies and development.

As pointed out in E/C.20/2011/4, an increasing amount of geospatial data are being generated and captured in almost real time through the use of high resolution satellite imagery and other data collection techniques at a variety of scales from the local to the global level. There is an incredible wealth of satellite assets. However, unless there are easy mechanisms to discover and access this content when and where needed, the value of these satellite resources is diminished. Therefore, we need to evaluate:

- The ability to describe the satellites in a standardized way;
- The ability to easily discover satellite resources when needed (a global registry?);
- The ability to provide an internet global infrastructure for discovery and access. GEOSS has been suggested as such a framework;

- The ability to easily access satellite imagery archives in a consistent manner;
- The ability and mechanisms to communicate satellite imagery in limited bandwidth environments; and
- New satellite assets that were not available 10 years ago.

An example of both the promise and the challenges of utilizing remote sensing data as outlined above is provided by the South Pacific region. The region has been utilizing remote sensing for at least two decades under the South Pacific Applied Geoscience Commission (SOPAC).

Since 2006, all remotely sensed imagery for the Pacific region has been purchased through SOPAC and all image data pre-processing is done through SOPAC. SOPAC currently supports its member countries by providing technical support services in a number of areas including remote sensing. These services are offered via three core programmes administered by SOPAC, namely the *Ocean and Islands Programme* (provides applied ocean, island and coastal geoscience services to govern and develop natural resources, increase resilience to hazards and facilitates data-based approaches to adaption), *the Water and Sanitation Programme* (capacity building, awareness and advocacy related to the management of water resources and the provision of water supply and sanitation services), and the *Disaster Reduction Programme* (technical and policy advice and support to strengthen disaster risk management practice).

As a regional organisation, SOPAC aims to be proactive in responding to the development needs of its member countries. In its 2011-2015 Strategic Plan, SOPAC states that its purpose it to ensure that Pacific Island Countries and Territories are able to (i) monitor and assess natural resources, systems and processes, (ii) develop, manage and govern their natural resources, and (iii) manage vulnerability and risks in their countries. Within its mandate and expertise, SOPAC endeavours to contribute to Sustainable Development (SD) in the region by addressing three fundamental development issues: (i) the high dependence on the direct utilisation of natural resources and degradation of the natural environment, (ii)the extreme vulnerability of the communities and the environment, and (iii) the limited access to water, sanitation, energy, and information and technology for development.

SOPAC makes extensive use of earth-observing imagery, for regional programmes such as the three mentioned previously, as well as for local programmes aimed at specific events such as natural disasters in particular member states and this has been a critical part of its work for two decades. Remote sensing has made a significant contribution to sustainable development in the region, but as Horowath (2011) points out, there are many challenges.

> **"**The generally small islands, surrounded by a vast ocean area, makes it uneconomic to record image data by default. Clouds build up fast on the high volcanic islands, resulting in relief related atmospheric anomalies. There are sensor problems to adapt to different reflections of water and land.
>
> Then there is the tyranny of distance, including long distances to transport sensors to islands. Airborne based sensors such as for aerial photography or LiDAR imagery have very high mobilisation costs.
>
> There is no satellite imagery ground receiving station in the Pacific islands region.

On the positive side, Horowath notes that "There are new data capture options with improved accuracy/resolution. Modern satellites such as GeoEye and WorldView-2 have enhanced GPS location recording capacity during data capture and an enhanced star tracker which allows more precise geo-accuracy.

Last year, the TanDEM-X satellite was launched, a radar satellite flying in close proximity to the TerraSAR-X satellite which had already delivered data for flood mapping in Fiji. Both satellites together now deliver data enabling DTMs with about two metre contour lines, which is good but still in my view not sufficient resolution for DTMs of low-lying islands. But it will be a huge step ahead for the DTM requirements for atmospheric correction and ortho-rectification.

New satellites will continue to be launched. For example, next month Pleiades a system with two satellites in space capable of providing 50 cm resolution on the ground in colour, and stereo images for DTM generation."

He also gives some specific examples of how remote sensing is contributing to sustainable development.

"

- For the first time in the Pacific, data of the Thailand owned satellite THEOS will be utilised for shallow water bathymetry, as for example we have recently carried out in French Polynesia.
- Coconut palm resource assessment for example in Kiribati and Tuvalu is now making use of advanced GIS tools to count the number of palms per hectare from VHR image data.
- A very recent image of shipping vessels in Suva harbour demonstrates the potential of 1 metre resolution radar data for vessel monitoring, an issue of particular importance in monitoring the exploitation of the tuna resources throughout the region.
- The delineation of maritime boundaries utilises increasingly VHR image data of high geo-accuracy to establish base lines, as is currently being used by Kiribati and Cook Islands in regard to their shared boundary.
- Deforestation monitoring has attracted the Agriculture Department of Fiji to now map the non-forest areas with 10m resolution ALOS image data at SOPAC.
- The support for Pacific utilities continues and now includes assets management for example in the. Fiji's Election Office, or at Airports Fiji where new applications will be developed for flight security and search and rescue at sea."

Horowath's overall conclusion is, however, a sobering one.

"Next year in June the world convenes in Brazil for the Rio +20 Meeting for the Third World Conference on Sustainable Development. In Rio in 1992 the small island developing states were acknowledged to be a "special case' in development. Last year, in 2010, for our region the Pacific Small Island Developing States five-year review of the Mauritius Strategy for Further Implementation of the 1994 Barbados Programme of Action for Sustainable Development of SIDS (MSI+5) found that since the Rio Meeting in 1992 our vulnerability has increased whilst our capacity to cope has not. This has been due in no small part to the additional pressures of climate change, climate variability and sea-level rise which have been compounded by the international fuel, food and financial crises. These new pressures have exacerbated those that were identified in 1992."

3.7.1 Global Earth Observation System of Systems

The Group on Earth Observations was established to help implement the contribution of earth observation data to the UN Millennium Development Goals (www.geo.org) many of which are directly related to sustainable development. This is a voluntary effort involving 85 countries and 58 organizations including several members of the Joint Board of the Geospatial Information Societies. The Group held its Eighth Plenary Session, GEO VIII, in Istanbul, Turkey in November 2011 (GEO, 2011a). Of special interest to Global Geospatial Information Management is the work relating to the creation of GEOSS, the Global Earth Observation System of Systems and in particular the work on the GEO Common Infrastructure – including the interoperability architecture (AIP, see below) and the work of the GEOSS Data Sharing Task Force. At the recent GEO there were discussions, presentations, and other mechanisms related to access and discovery of geospatial data assets available through the GEO Common Infrastructure. Significant progress was made on the GEOSS Common Infrastructure (GCI) through a "Sprint" to the Plenary. Using the GEO Web Portal, users and applications have the ability to discover and access close to 29 million data resources. This was accomplished by using the CNR (Italian National Research Council) Discovery Broker which maps vocabularies for distributed search and by including the Committee on Earth Observation Satellites (CEOS) CEOS WGISS Integrated Catalog (CWIC) catalog that allows inventory level data search of CEOS catalogues, e.g., NASA ECHO. All of this capability uses standard interfaces based on the OGC Catalogue Service-Web and common metadata.

Both the technical and the institutional challenges of data sharing are fundamental to the effective management of geospatial information at all scales (Taylor, 2010). Without effective and timely sharing and access to data the potential of geospatial data management as an integrating mechanism to create data infrastructures for sustainable development would be severely constrained. The work of the GEOSS Data Sharing Task Force in addressing the key policy issues involved has made a major contribution to addressing data sharing issues and concerns (GEO, 2011b). The Report of the Data Sharing Task Force also includes the identification of a substantial number of datasets already available in the GEOSS Data-CORE (Data Collection of Open Resources for Everyone) which appears as Appendix A of the Report. The Report also includes two other appendices of special interest: Appendix B on "Legal Options for the Exchange of Data through the GEOSS Data-CORE" and Appendix C on "Liability Issues in the Global Earth Observation System of Systems". The Report discusses the important topic of "legal interoperability" and points out that "legal interoperability of data made available through GEOSS Data-CORE is essential for the effective sharing of data in GEOSS" (GEO, 2011b Appendix B, 2.1). Although the issues discussed relate to satellite and remotely sensed data they apply equally to all geospatial data.

The GEOSS Architecture Implementation Pilot (AIP) can provide many valuable lessons about how to define and implement national, regional, and global infrastructures that support numerous application domains as defined by the GEOSS "Information for Societal Benefits" categories. See http://www.ogcnetwork.net/AIpilot for extensive information on the multi-year AIP and related demonstrations.

The goal for GEOSS is to achieve sustained operation, continuity and interoperability of existing and new systems that provide essential environmental observations and information, including the GEOSS Common Infrastructure (GCI) that facilitates access to, and use of, these observations and information. Specifically, GEOSS is focused on nine domains of "information for societal benefits", such as climate, energy, water, and biodiversity - all of which are key sustainability topics. These societal benefits align almost exactly with those specified by the UN in the 2001 report, "Indicators of Sustainable Development: Indicators and Methodologies".

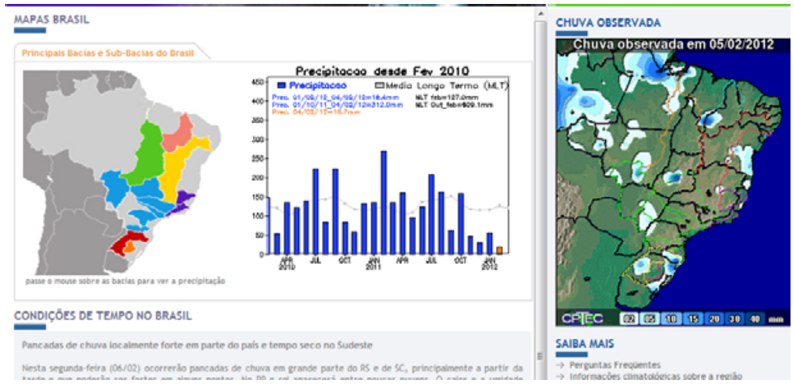
Recommendation: Satellite data will remain a critical data resource for many UN applications as well as for meeting the RIO objectives. However, the data needs to be 1.) "discoverable", 2.) described in a consistent manner, 3) accessible in a timely manner, and 4) provided to the end user or application in one or more standard encodings. Standard metadata, cataloguing, and access interface mechanisms are key to achieving the full value and use of satellite data. Therefore, GEOSS should be evaluated and integrated into UN and partner applications, portals, and SDI applications and can make a major contribution to sustainable development.

3.7.2 GEONETCast

Another example of a global satellite dissemination system is GEONETCast (http://www.earthobservations.org/geonetcast.shtml). Developed in support of GEOSS, GEONETCast is a near real time, global network of satellite-based data dissemination systems designed to distribute space-based, air-borne and in situ data, metadata and products to diverse communities. GEONETCast is a Task in the GEO Work Plan and is led by EUMETSAT, the United States, China, and the World Meteorological Organization (WMO). Many GEO Members and Participating Organizations contribute to this GEONETCast activity.

The system consists of three regional broadcasts: EUMETCast (operated by the European Organisation for the Exploitation of Meteorological Satellites [EUMETSAT], covering Europe, Africa, and parts of Asia and the Americas), CMACast (operated by the China Meteorological Administration [CMA], covering Asia and parts of the Pacific), and GEONETCast Americas (operated by the U.S. National Oceanic and Atmospheric Administration [NOAA], covering North, Central, and South America and the Caribbean). The GEONETCast system uses the Digital Video Broadcast-Satellite (DVB-S) or Digital Video Broadcasting–Satellite–Second Generation (DVB-S2) standard over commercial communications satellites and low-cost, off-the-shelf technology to widen the access of new user groups to Earth observation information. The dissemination system as deployed implements numerous existing OGC and ISO standards.

One goal of EONETCast to provide affordable and sustainable access to satellite data via low cost ground stations. This user-driven, user-friendly and low-cost information dissemination service aims to provide global information as a basis for sound decision-making in a number of critical areas, including public health, energy, agriculture, weather, water, climate, natural disasters and eco-systems. Accessing and sharing such a range of vital data will yield societal benefits through improved human health and well-being, environment management and economic growth.



GEONETCast applications and catalogues provide information and access to thousands of resources, such as climate information for South America (above).

GEONETCast receiving technology is based on using widespread and off-the-shelf components allowing for widespread adoption of the service at low cost. An entire receiving station can be purchased and installed for $2,000–3,000.

Finally, there is the GEONETCAst project "GEONETCast for and by Developing Countries (DevCoCast)". This project involves Developing Countries more closely in the GEONETCast initiative.[8] This includes activities such as training African trainers on the applications and use of the available content and building regional applications in western and southern Africa.

Many Developing Countries face serious environmental risks and need adequate Earth Observation (EO) data and derived environmental information for their sustainable development.

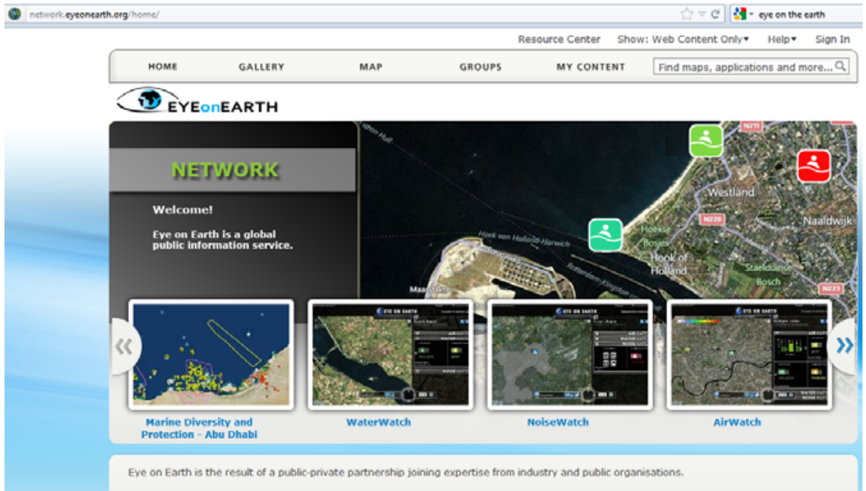
Recommendation: The UN community needs to assess how these low cost and open capabilities can be deployed and used in developing nations where there are critical sustainability issues.

3.7.3 Eye on Earth

Eye on Earth (http://network.eyeonearth.org/home/) is a two-way communication platform on the environment which brings together scientific information with feedback and observations of millions of ordinary people. It is the result of a partnership between Microsoft and the European Environment Agency (EEA). (Not to be confused with NASA's Eyes on the Earth! - http://climate.nasa.gov/Eyes/eyes.html).

Eye on Earth is a 'social data website' for creating and sharing environmental information. Examples of the wide range of potential users include policy makers, environmental organizations, emergency responders, GIS professionals, communities and citizens. All are invited to participate in the new and dynamic online 'environmental community' facilitated by EEA, technology leaders, cutting-edge innovations and cloud technology.

[8] http://www.devcocast.eu/ViewContent.do;jsessionid=F3766A75084AB20092CB353CB716C6D5?pageId=1



Currently, Eye on the Earth includes information on the water quality for more than 22,000 bathing sites throughout Europe, air quality for more than 1000 air quality monitoring stations throughout Europe, noise monitoring, and other key sustainability topic areas. Additionally, an air quality model enables viewing of the air pollution situation in between the air quality monitoring stations. For water sites, the portal presents historical data over several years and for some, the latest 2009 data is also available.

3.7.4 UAVs (capacity building, multi-source integration or fusion)

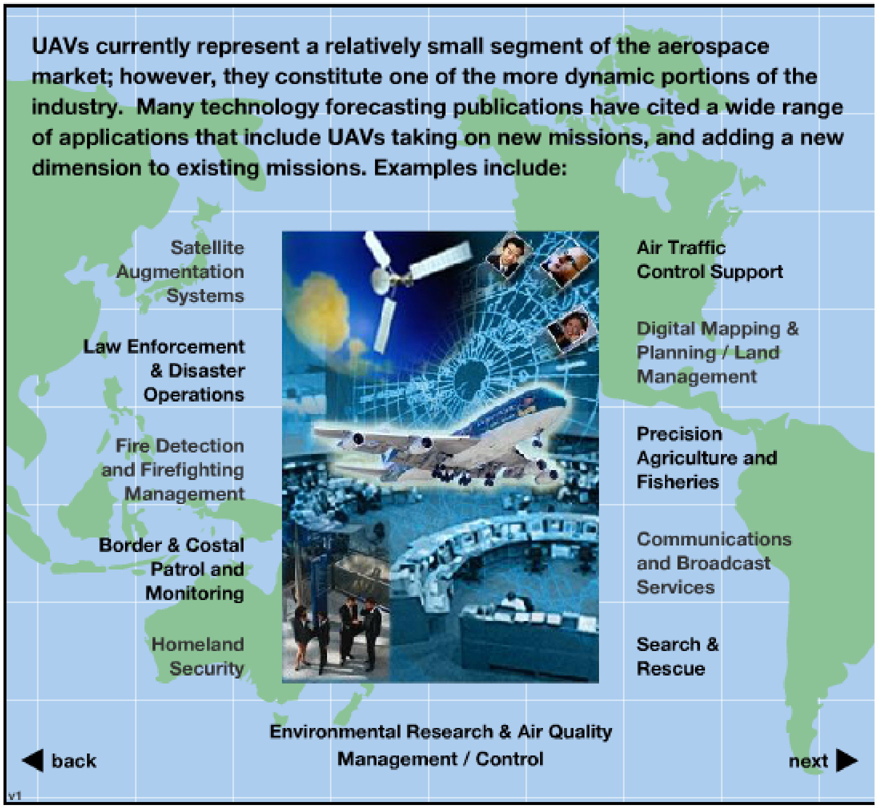
A major new potential source of geospatial data is from Unmanned Aerial Vehicles (UAVs). Until recently, the use and availability of such assets were expensive and difficult to procure. However, there is now a new generation of small, easily transported UAV platforms that can carry high resolution digital cameras and other sensor assets. Additional UAV remote sensing functions include electromagnetic spectrum sensors, gamma ray sensors, biological sensors, and chemical sensors. A UAV's electromagnetic sensors typically include visual spectrum, infrared, or near infrared cameras as well as radar systems. Other electromagnetic wave detectors such as microwave and ultraviolet spectrum sensors may also be used, but are uncommon. Biological sensors are sensors capable of detecting the airborne presence of various microorganisms and other biological factors. Chemical sensors use laser spectroscopy to analyze the concentrations of each element in the air.

Aerial surveillance of large areas is made possible with low cost UAV systems. Surveillance applications include: livestock monitoring, wildfire mapping, pipeline security, home security, road patrol and anti-piracy. The use of UAV technology in commercial aerial surveillance is expanding rapidly.

These UAVs are also well designed for high detail, small area coverage such as for urban areas, areas of recent disaster, crop inventory, and counter-terrorism activities. An individual UAV can also cost less that US 10,000 per unit including the camera. See http://cropcam.com/ as an example. Two examples of the effective use of UAVs are the use of UAVs for wildfire monitoring and logistical support[9] and for peacekeeping

[9] http://www.nasa.gov/centers/dryden/news/Features/2007/wildfire_socal_10_07.html

support. Below is a diagram from NASA showing the functional areas that UAV assets can be used to support. Many of these functional areas are strongly related to sustainable communities, sustainable development, and livability.



http://www.nasa.gov/centers/dryden/research/civuav/index.html

Recommendation: The UN Expert Committee on GGIM should explore the ability to use UAV assets and to integrate the geospatial content into SDI frameworks. UAVs can also provide real time imagery and other sensed data. Therefore, the UN community needs to explore how such low cost, sensor based data can be quickly and effectively integrated and/or fused with other information assets to enhance decision support and situational awareness.

3.7.5 Full motion video (capacity building, data sharing, multi-source data integration, interoperability)

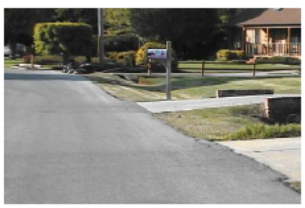
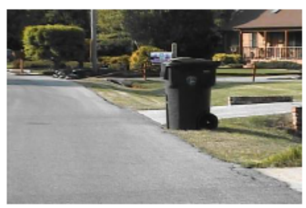
Over the last few years, the need (and the ability) to collect, analyze, and integrate full motion video assets into decision support and situational awareness applications have escalated. A key requirement for using full motion video is change detection. However, a much more standards based approach is required.

The world community faces growing challenges from the proliferation of various types of data sources. This is especially true for motion video. Although the high volume of video data is beneficial, it creates a number of data management and analytical challenges. Detecting changes from imagery over time has been a vital intelligence function for decades. But with the increased use of video, new and more efficient tools are required.

Analysts cannot be expected to detect small changes over very large geographical areas using only the naked eye. Thus the need for a processing service to perform an automated comparison of video streams over the same geographical area that identifies small changes is critical to handling these large data volumes.

For example, a video of a street view taken from a ground based vehicle or an aerial view taken from a UAV is recorded and cataloged. A few weeks later, another ground based vehicle or UAV is recording the same street view or aerial view. This live video stream can be compared to the one recorded weeks earlier to identify new rock or garbage piles on the side of the road as potential hiding locations for IEDs. This identification will allow convoys to avoid the area until it can be investigated.

The OGC community has been investigating the ability to use standard interfaces, models, and encodings to better utilize the rich content contained in comparing full motion video for the same geographic area. The following images are from an OGC testbed that demonstrated the ability to perform real time change detection between archived motion video and a new video stream.

Video1	Video2	Change
		

Such capabilities can be used not just for homeland security and public safety applications but also emergency response, land use monitoring, building compliance, and many other applications.

Recommendation: Many sustainable development applications require change detection, such as crop analysis, security, environmental monitoring, forest inventory modeling, and many more. The UN community needs to explore and understand how full motion video, especially standards based change detection, can be integrated into existing and planned applications. They may also explore how FMV can be integrated into SDI applications.

3.8 Social Media (capacity building, governance, multi-source integration, interoperability)

The power of social media applications such as Twitter and Facebook to provide real time updates on events has the potential to reshape how human gathered "intelligence" (HumInt) is gathered and processed. There are real opportunities to enhance the ability to respond to crisis situations by tapping the information flow in social media applications.

The following is an excerpt from a recent event in the US:

> Yesterday morning, I was alarmed to find out via my Facebook newsfeed that a gunman carrying an assault rifle had been reported at East Carolina University, causing a lockdown across the campus. I was reminded of the horrific April 2007

> Virginia Tech Massacre in which a gunman killed 32 people and injured many others. Many of my terrified Facebook friends were posting real-time updates from locked-down areas around campus including classrooms, office buildings, and the athletic department. Despite my efforts to find "official" sources of information via the news media or local public safety officials, my Facebook network proved to be the most reliable source of information, as even the most credible news sources were only reporting the most basic details. http://www.awareforum.org/2011/11/eastern-carolina-universitys-gunman-scare-shows-power-of-social-media/#more-1916

The article later states that there was no such attack and that one individual started the entire event by reporting what they thought was a man with a rifle on campus.

This event demonstrates both the strength and weakness of using social media as an information asset in any application including SDIs. That said, most social media companies now provide a location API. This allows Facebook events or Twitter tweets to be tagged with a simple point location. The addition of location elements to social media has serious implications for the ability to utilize vast amounts of citizen provided, location enabled content in times of need.

AT the DGI 2012 Conference, Major General Jerry Thomas provided insight into the changing world of intelligence in which Social media provides over 80% of the intelligence in the public domain available in chat rooms, Twitter, Facebook etc. The problem is making sense of all this data. This is where 'the' geo-int buzz word comes in: Geo-int all about 'Fusion' (multi-int Fusion to be precise). It's no good gathering all this information, it needs to be broken down and re-assembled in order for it to be meaningful, much like baking a cake - the ingredients on their own taste awful but baked in the right way you have a good end result.

Recommendation: The UN community needs to consider how location enabled social media can be used to enhance decision support in a variety of application areas, such as emergency response, security, and agriculture. However, a good governance structure will be required as well as a means of assessing the accuracy and quality of the data being provided.

3.9 Crowd Sourced Data and Volunteered Geographic Information (data sharing, governance, interoperability, capacity building)

Traditionally geographic data have been captured by well-trained specialist using state of the art technology. Recent developments like Web 2.0 platforms, GPS enabled cell phones and sensor technology make capturing of geographic data no longer the exclusive domain of well trained professionals, but opens new possibilities for involvement of citizens. Every human is able to capture geographic information about social and environmental phenomena. The Internet provides the means to upload those observations and share it with other users. Information about places of interests, bird species, GPS tracking of bike and hiking routes are examples of this user generated content. The term "Volunteered Geographic Information" (VGI) is used to describe user generated geographic information.

Crowd sourced data and VGI is becoming an extremely valuable source of geospatial content. OpenStreetMap has demonstrated over and over the ability to collect and maintain geospatial content in developing nations, especially in times of critical need. Another excellent example of VGI is EyeOnEarth (http://www.eyeonearth.eu/). Collection of geospatial content via VGI and crowd sourced data is needs based, completely open to anyone to contribute content, and unrestricted in terms of use. The UN community needs to explore how crowd sourced and VGI content can be leveraged and integrated into existing or emerging SDI frameworks.

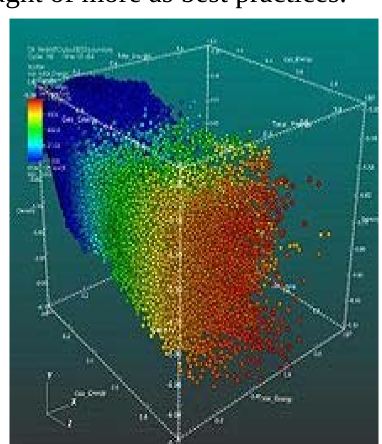
Volunteered noise data in Eye on the Earth

For many countries, VGI may provide the necessary (free and open) geodata for decision support related to environmental and sustainable living and economies. VGI has definitely proved its worth in support of an emergency response. One of the key aspects of VGI is that the user does not need to be a trained geospatial expert or trained GIS user. Often working across increasingly artificial boundaries of sector, organization, and country -and sometimes bending or breaking "The Rules" – we have learned new lessons about how large scale mapping efforts interact with the local legal systems and existing mapping activities. This issue of governance is critical to the effective use of VGI.

There are now numerous research articles and presentations on the relationship of SDI and VGI. An excellent position paper by Coleman titled "Volunteered Geographic Information in Spatial Data Infrastructure: An Early Look At Opportunities And Constraints" was presented at GSDI 12.

Recommendation: The effective use of crowd sourced and VGI geospatial data needs to be explored by the UN community. However, the proper policies and governance infrastructure needs to be documented and provided. These policies and governance requirements should not be prohibitive or bureaucratic. They should instead be thought of more as best practices.

3.10 Big Data



All of the above identified data sources (social media, crowd sourcing, UAVs, satellites, sensors, and so forth) generate massive amounts of data, what has been termed "Big Data".

Currently, over 1.5 zetabytes[10] of big data are collected each year and the rate is increasing. If 80 percent of these data are location enabled, then we are faced with an overwhelming amount of geospatially referenced data that currently remains an untapped intelligence and decision support resource in today's SDI deployments. At a recent meeting of Emergency Management/EM GIS specialists, the audience was asked if they had any experience or plans to utilize existing big data business and location intelligence tools. Only a few in the audience responded in a positive way. Big data can be used as the basis for defining trends, providing critical inputs into predictive modeling such as drought forecasting, climate modeling, crop analysis), providing enhanced emergency services and logistics support, reducing risk, and providing for accurate warnings and alerts.

However, most of today's GIS professionals have little or any experience with big data. Further, today's geospatial technology for the most part is not designed to manage or analyze big data. Unfamiliar technologies such as Hadoop, Map Reduce, NoSQL, and PIG need to be understood and recommendations provided as to now these technologies can enhance the situational awareness and decision support activities required to meet RIO objectives. Another issue is that much of these data are unstructured and GIS professionals tend to deal with very structured data. Using Big Data requires "new" thinking about geospatial data sources, processing, storage, and analytics.

There is now movement by early adopters in several geospatially related domains to utilize the power of big data. For example, a recent O'Reilly Conference titled, "Big Data, Emergency Management and Business Continuity" (September 2011) and the FAA's recent procurement where MarkLogic was selected to power the FAA's emergency response and severe weather tracking system with big data solutions (October 2011).

3.11 Big Science

Traditionally, "Big Science" implies one or more of these specific characteristics: big money, big staffs, big laboratories, and/or big machines. We contend that a new form of Big Science is emerging: the ability for a very large global community of scientists and researchers to virtually collaborate and to define and develop a globally accessible framework of data and services. The ability to effectively research and develop potential solutions to sustainable development – for issues ranging from local to national to global – requires global scientific collaboration. The vast majority of scientific data collected by scientists working on environmental, climate, agricultural, and other sustainable development areas of focus is geographically based. Therefore, the ability to share, re-purpose, and generate and share value added data within the science and research community is critical. There are numerous examples of this evolution, such as GEOSS and OneGeology. Another example is the increasing domain focus of standards work, such as the Hydrology, Oceans, and Meteorology work in the OGC. The integration of the Big Science collaboration and tools into a global sustainable decision support framework has tremendous value but has been an area often underutilized.

In order to properly address many sustainability issues, the world of big science needs to be fused with the SDI and Earth Observation communities. Some of this collaboration and fusion is happening in the Open Geospatial Consortium in the Meteorology, Hydrology, and Emergency and Disaster Management Working Groups. These working groups are defining

[10] A zetabyte= 1 billion terrabytes

best practices for integrating domain specific observations, modeling, and scientific research into current and future information infrastructures using existing standards

3.12 Linked Data

Related to Big Data, and other newer sources if geospatial content, is “linked data”. Linked data is a concept related to the semantic web. From W3C, “The Semantic Web isn't just about putting data on the web. It is about making links, so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data.” Wikipedia defines Linked Data as "a term used to describe a recommended best practice for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF."

Tim Berners-Lee outlined four principles of linked data in his Design Issues: Linked Data note, paraphrased along the following lines:(http://www.w3.org/DesignIssues/LinkedData)

1. Use URIs to identify things.
2. Use HTTP URIs so that these things can be referred to and looked up ("dereferenced") by people and user agents.
3. Provide useful information about the thing when its URI is de-referenced, using standard formats such as RDF/XML.
4. Include links to other, related URIs in the exposed data to improve discovery of other related information on the Web.

There is an increasing interest and work related to using linked data in the geospatial community. For example, the Ordnance Survey (UK) has made a major commitment to linked data. OS OpenData is the opening up of Ordnance Survey data as part of the drive to increase innovation and support the "Making Public Data Public" initiative. As part of this initiative Ordnance Survey has published a number of its products as Linked Data. Linked Data is a growing part of the Web where data is published on the Web and then linked to other published data in much the same way that web pages are interlinked using hypertext.http://data.ordnancesurvey.co.uk/

Recommendation: Linked data provides the ability to link and navigate geospatial content in ways not available ever a few years ago. The UN community needs to consider how linked data will help achieve the Rio objectives and how linked data can enhance existing and planned SDI applications.

3.13 Open Source (capacity building, technology transfer)

Software technology costs (licensing) can be a real barrier to the use of geospatial data and services in developing nations. Open source geospatial technology has dramatically improved over the last ten years and is now the basis of numerous deployed applications for such applications as emergency and disaster management, crisis mapping, and other key applications. The UN already has a commitment to both proprietary and open source geospatial technology. Therefore, the UN needs to explore how open source solutions can properly fit into existing and emerging SDI applications, how governance is handled, and how open source solutions can leverage the value of existing installed proprietary systems. The issue of licensing options in this respect has been explored by the GEOSS Data Sharing Task Force as mentioned earlier (GEO2011b). How does open source related to sustainability?

Open Source provides a cost effective alternative to proprietary software. Open source brings in more flexibility for an organization to modify the software to reach their business goals. And, you can have multiple vendors supporting the software solution.

Sustainability provides a new strategic lens for communities to leverage greater value for the dollars invested, create new revenue options, and enable greater citizen participation. It provides a way for organizations to create new products, manage their processes better and reach new consumers for their goods and services.

In the current financial crisis facing the world, both open source and sustainability will make a great combination as strategic tools to create a better organization and better decisions and related policy.

3.14 Registries – Discovery and shared access of distributed spatial data

In order for any user or application to be truly effective, there is a requirement to quickly find and utilize the appropriate geospatial content. There are two aspects to this problem: Discovery and metadata (Section 4.17). Discovery of resources for internet and web applications or users that are internet connected is typically accomplished by using one or more registries. A registry contains information about a resource (service, geodata, symbology, etc) and how to access that resource. An example of service and data registries can be found as part of the GEOSS infrastructure. In preparing this proposal, we discovered that there are extensive data assets for data for Africa. However, these assets are distributed between numerous portal and other applications. A single (can be virtual) registry could provide extensive new capabilities for users to find the right data and services when they need them. This requirement needs to be explored further.

3.15 Metadata (capacity building, data sharing, interoperability)

Data and services cannot be discovered without consistent (standardized) metadata. We know that the UN community has a strong commitment to capturing and maintaining metadata. The UN needs to explore how this investment can be leveraged via the use of registries of resources as well as what additional elements may be required to ensure proper utilization of existing and planned SDI deployments. Further, if the UN determines that VGI and other sources of location enabled content are critical to achieving the RIO objectives, then a clear policy and related governance needs to be defined for VGI metadata.

3.16 Geospatial Data Integration and Fusion

Many of the RIO related reports and documents speak to the requirement for data integration. The UN community has many similar fusion and data integration requirements as seen in other communities, such as emergency services, the military, aviation, and health care. For the last several years, the OGC community has invested considerable time and effort into learning about and testing various approaches to fusion and data integration.

From the OGC perspective, "*"Fusion is the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one's capability (or provide a new capability) for detection, identification, or characterization of that entity*". Developing new or exploiting current capabilities for fusing information from multiple sensors, from multiple sources, and from multiple INTs in ways that dramatically improve the ability to detect, identify, locate, and track objects. Current research addresses fusing information from different sensors of the same modality, fusing information from IMINT sensors of different modalities (e.g. fusing LIDAR, hyperspectral, and OPIR), fusing information from different INTs (e.g. fusing IMINT and SIGINT), fusing disparate GEOINT data types, developing new ways to reason and make decisions from fused information, and providing fusion-based solutions to hard problems in a net-centric environment. The research also addresses measurements and databases for fused and composite signatures of targets of interest, conflation of multi-sensor, multi-modality data, and development of automated fusion exploitation algorithms for hard problems.

Categories of fusion depend on the processing stage or semantic level at which fusion takes place. Fusion processes are often categorized as shown in the figure below. Sensor Fusion combines several sources of raw data to produce new data that is expected to be more informative and synthetic than the inputs. This kind of fusion requires a precise (pixel-level) registration of the available images, as well as perhaps synchronization of dynamic observations. In the intermediate category - Object or Feature Fusion - attributes or elements of geographic features are combined into new features and that may then be used by further processes. Creating associations between features that were not previously associated should also be considered. Decision Fusion supports near-real-time manipulation and sharing of massive amounts of increasingly complex information collected and fused from diverse data sources to support collaborative decision making.

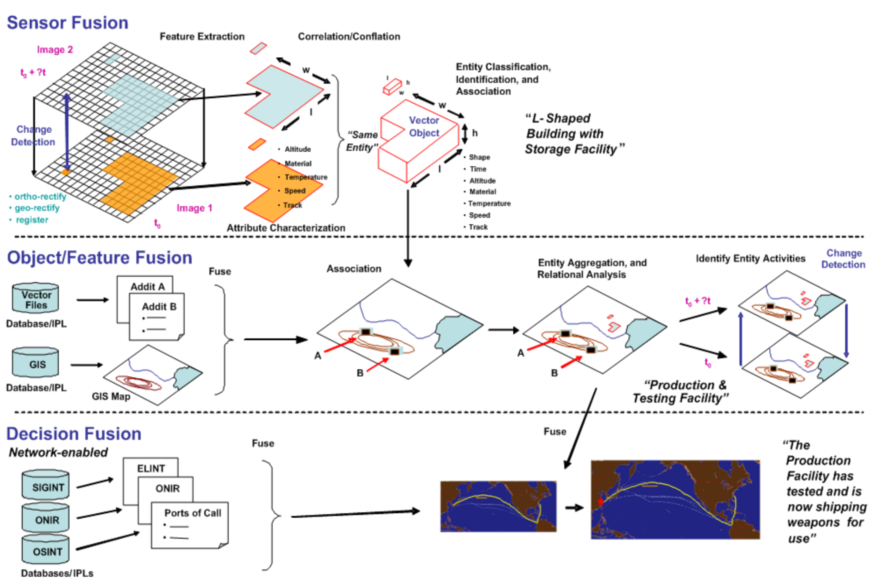


Figure: Categories of Fusion. Source: OGC, 2010

Recommendation: The UN needs to explore how the work of the OGC and other communities can help the UN community achieve their stated goals for data integration and fusion.

3.17 Standards and data sharing, common services interfaces, and access

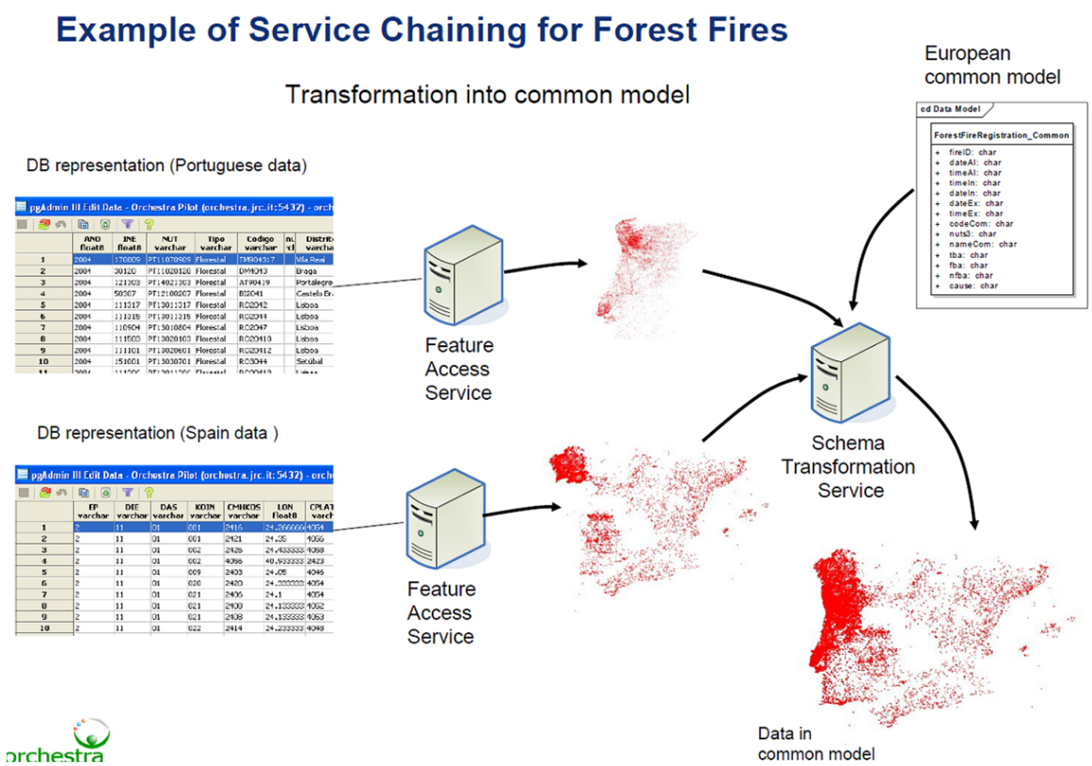
In the DOWN TO EARTH report there is the statement, “Data sharing, facilitated by all users adopting the same software, data formats, and file directory structure, and a metadata database has resulted in cost savings”. Using modern web service technology coupled with standards obviates the requirement to standardize on single hardware and software platforms. Standards when properly implemented enable plug and play, protection of legacy systems and data, lower risk, lower life cycle maintenance costs, and more. In the various reports, there is a consistent message of interoperability and a requirement for data sharing. However, the value of standards in achieving those visions is never stated. We need to explore how the effective use of OGC and ISO standards can enhance the deployment and accessibility of geospatial resources into the UN community and Member nations. Further, there needs to be discussion and policy statements formulated that guide the use and procurement of standards based geospatial technology products by UN organizations.

3.18 Content Models (data sharing, interoperability)

Content models can fulfill many of the requirements for data sharing in standards based technologies. Content models represent community agreements on the vocabulary, semantics, and elements, and their relationships for a given geospatial theme, such as land cover. There are many examples of content models, such as the new ISO Land Cover model, GeoSciML (geology), WaterML (hydrology), and the 34 theme content models being developed for INSPIRE. These content models provide the ability to share information between and among many communities. This is because a common semantic understanding has been agreed upon.

If there is an accepted content model, then from a technical viewpoint there is the ability to map content from multiple geospatial repositories into the common model. These transformations can happen “on the fly”. As such, there is no need for all stakeholders to use the same database model or the same software.

The following diagram depicts how these transformations occur. Each country has their data holdings for a specific theme, such as forest inventory data, stored in web accessible but independent distributed databases using their own structures and software. Each repository is accessed by a Web Feature Service and the received content is then mapped using a schema transformation service into the common model. The common model is then used for all subsequent processing.



The UN needs to explore how existing or emerging content models can help the UN community help achieve its goals of data sharing and a sustainable environment.

3.19 Augmented Reality

Augmented Reality (AR) was originally defined in the 1990's. AR is now a "hot" topic in mobile technology research and development. Augmented reality is a term for a live direct or indirect view of a physical, real-world environment whose elements are *augmented* by computer-generated sensory input such as sound, video, graphics or GPS data[11].

Any use case must meet the three basic criteria of augmented reality first cited in A Survey of Augmented Reality[12]:

- combine the real and the virtual (digital) worlds
- permit real time interactivity and
- be registered and aligned in three dimensions.

Most use cases postulated today are either entirely within one of these categories or a blending of two or more use cases within these three. For purpose of sharing these use cases and for inviting feedback and discussion, each is described in simple terms and, we anticipate they will be depicted graphically.

There is a very active community collaborating on a common and consistent definition and development of a standards framework for AR applications

[11] Wikipedia
[12] Azuma 1997

(http://www.perey.com/ARStandards/). There are an increasing number of professional articles and development activities aimed at using AR for a variety of non-consumer applications that could support sustainability and livability. For example, a very recent 2011 paper, “Cross-Organizational Collaboration Supported by Augmented Reality” describes how (AR) technology has been used as a tool for supporting collaboration between rescue services, the police and military personnel in a crisis management scenario.

There are also existing examples of the use of augmented reality for sustainable development and maintenance. For example, the UK JIST has funded a project at Exeter University. The project aims to create a campus-based Augmented Reality environment in which Smartphone users will be able to access scientific data collected about flora and fauna (biodiversity) in a creative and accessible way. This approach to environmental interpretation will reveal a hidden curriculum to a wide range of formal and informal learning communities and promote engagement with the Education for Sustainable Development (ESD) agenda. An Augmented reality Toolkit and associated advice, guidance and workshops will enable others to adopt the technology and underpinning pedagogies to develop their own applications which enable interactions to take place between the physical and virtual worlds.

3.20 Internet of Things

At a very high level of abstraction is the concept known as the “Internet of Things”. The Internet of Things refers to uniquely identifiable objects (things) and their virtual representations in an Internet-like structure[13]. The term Internet of Things was first used by Kevin Ashton in 1999.

Recently, the Open Geospatial Consortium has been exploring how the internet of things and the relation to the geospatial web (GeoWeb). (http://www.ogcnetwork.net/COMGeoWorkshop) There was a special workshop during COM.Geo 2011 that discussed connecting our world with accessible networks scaling to trillions of everyday objects. The Internet will be augmented with mobile machine-to-machine communications and ad-hoc local network technologies. At the network nodes, information about objects will come from barcodes, RFIDs, and sensors. The location of all objects will be known. The workshop explored the role of location in expanding GeoWeb to an Internet of Things.

The IoT conceptually combines many of the technology trends identified above. The question then becomes how does the UN community leverage the content, services, and sensor systems that will be accessible via the IoT.

3.21 Internet Apps

A Focus On The App Internet

Mobility used to be simple: Support the BlackBerry. But smart phones and tablets from Apple, Google, and other platform providers besides RIM have redefined expectations for executives and employees. For IT, there are now myriad mobiles apps in the development queue that are aimed at reaching customers and business partners. Device-resident apps that rely on cloud services will continue their ascent. That's in direct contrast to the browser-based

[13] Wikipedia.

Web model that dominated the PC world for 10 years. At Forrester, we call it the "app Internet."

Devices will always advance technologically, but the greatest change in mobility in 2012 will be around this app Internet. Companies will get more serious about the leadership, governance, and processes needed to deliver effective apps. The largest companies will appoint someone as the leader of a mobility council, responsible for the portfolio of employee, partner, and customer apps.

And companies will start creating their own app stores. At most, these app stores will remain in planning stage next year. But eventually, employees will able to download preapproved apps they need and charge them back to their business unit, or they'll let managers sign off on employee app downloads just like they do a travel expense. Expect these app catalogs to support multiple device platforms.

How will you manage and secure those mobile devices and applications?

http://www.informationweek.com/news/global-cio/interviews/232300728?pgno=2

3.22 Standards – again

Standards have been mentioned in numerous points in this position paper. Ten years ago, there were very few mature standards available for use by the either the geo or the broader ICT communities. This situation has radically changed in the last ten years. The OGC and ISO have defined a robust, mature standards baseline for enabling geospatial interoperability and for integrating geospatial data and content into any application or software environment. These standards are now broadly implemented in proprietary, open source and commercial open source software and applications. For example, there are over 3,500 active OGC Web Map Service interface instances in the European community (http://ijsdir.jrc.ec.europa.eu/index.php/ijsdir/article/viewFile/233/299). The UN has also implemented a number of these standards in a variety of deployed applications. Relief Web is an example.

However, the UN does not have a consistent policy and set of governance best practices for the use of OGC and ISO standards. The result can be a significant lack of interoperability even when implementations of are for the same version of a standard. There are a number of examples of best practice guidance and policies related to the use of OGC and ISO standards for SDI and other enterprise applications. These include The Canada Geospatial Data Infrastructure and the INSPIRE directives in Europe.

In terms of sustainability, there are numerous reasons for a strong commitment to standards. The Institute for Trade, Standards, and Sustainable Development states, “To achieve this paradigm (Sustainable Development), we emphasize the importance of economic growth, free markets, the rule of law, strong intellectual property rights, scientific discovery, technological innovation, and the establishment of balanced, science-based and cost-effective national regulatory and standards systems”. They go onto to say that when are not scientifically, technically and economically justified and are not developed in an open, inclusive and transparent manner, there is a real danger that standards may be utilized without accountability for ideological political purposes, as disguised protectionist barriers to trade and innovation, and as instruments of social change designed to circumvent the rule of law and to deny individuals their constitutional liberties and right to due process of law.

Recommendation: The UN community needs to define best practice guidance and develop the governance infrastructure for a UN geospatial standards platform. Any standards considered by the UN need to have been developedin an open, consensus process.

3.23 Communication with Decision Makers and the Public

We need to effectively communicate to both decision makers and to the general public the results of the application of geospatial information processing and analyses to aspects of sustainable development. In discussing the future of the web Tim Berners-Lee identified the importance of linked data as reported earlier in this paper but he also stressed the importance of more innovative display and communication of online information as an important facet of the Web 3.0 era. (www.TED.com/talks/Tim_Berners_Lee_on_the_next_web.html) The map has for centuries been an important communication and analytical mechanism and new forms of visualization and interactive multimedia and multisensory mapping continue to emerge. The work of the International Cartographic Association Commissions on Visualization and Mapping for the Internet provide many examples (www.ica.org). These are important analytical and communication techniques and include new ways of capturing and displaying community narratives on the impact of environmental change such as those of the Inuit communities of northern Canada (Aporta, Laidler and Taylor, 2011). Many of the new maps are being designed for smart phones and other mobile devices.

Recommendation: UN-GGIM should provide examples of best practice on how these new cartographic developments can be applied in helping decision makes and the general public both analyze and understand the complex topic of sustainable development and enable communities to contribute their own descriptions of the impact of environmental change.

4. Conclusion

The central argument of this paper is that since the last RIO+10 Conference the potential of location referenced information has rapidly advanced and has now reached a level of maturity that allows this information to make a central contribution to the integration of information for the purposes of sustainable development. These advances have been documented using concrete examples. The work of the United Nations Expert Group on Global Geospatial Information Management will continue to explore both the institutional and technological developments to make a major contribution to the implementation agenda of Rio+20. The Expert Group has a special role to play in helping to coordinate and link existing and emerging attempts to create location-based information at the global level. UN-GGIM is an important vehicle to facilitate development, coordination, management and use or geospatial information which will be central to the effective delivery of sustainable development

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Appendix A Data-CORE Master List
Appendix B Legal Options for the Exchange of Data through the GEOSS Data-CORE
Appendix C GEOSS Liability Issues in the Global Earth Observation System of Systems

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