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United Nations/Germany Expert Meeting on the Use of Space Based Information in Early Warning Systems

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UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, UNOOSA

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The United Nations Office for Outer Space Affairs (UNOOSA) implements the decisions of the General Assembly and of the Committee on the Peaceful Uses of Outer Space and its two Subcommittees, the Scientific and Technical Subcommittee and the Legal Subcommittee. The Office is responsible for promoting international cooperation in the peaceful uses of outer space, and assisting developing countries in using space science and technology. In resolution 61/110 of 14 December 2006 the United Nations General Assembly agreed to establish the "United Nations Platform for Space-based Information for Disaster Management and Emergency Response - UN-SPIDER" as a new United Nations programme to be implemented by UNOOSA. UN-SPIDER is the first programme of its kind to focus on the need to ensure access to and use of space-based solutions during all phases of the disaster management cycle, including the risk reduction phase which will significantly contribute to the reduction in the loss of lives and property.

REPORT

United Nations/Germany Expert Meeting on the Use of Space Based Information in Early Warning Systems

Organized by

The United Nations Office for Outer Space Affairs/ UN-SPIDER

and the

German Aerospace Center DLR

With the support of

Secure World Foundation

Federal Office of Civil Protection and Disaster Assistance (BBK)

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Acknowledgements

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I. Background

Taking into consideration the role of early warning systems in minimizing damages and losses in case of disasters through the provision of reliable information in a timely fashion; UN-SPIDER co-organized with the German Aerospace Centre (DLR) *the United Nations/Germany Expert Meeting on the Use of Space-based Information in Early Warning Systems* with the support from the Government of Germany, Secure World Foundation and the German Federal Office of Civil Protection and Disaster Assistance (BBK).

The expert meeting took place in Bonn, Germany, from 25 to 26 June 2013 and brought together 55 space technology, disaster-risk management and disaster management experts from 20 countries representing 42 national, regional and international organizations as well as internationally active private companies. The objectives of the expert meeting were to share experiences and lessons learned regarding the use of space-based information in early warning systems; to identify needs and to discuss knowledge management strategies to improve existing early warning systems through the incorporation of recent advances in space-based applications.

As stated by the International Strategy for Disaster Reduction of the United Nations (UNISDR), an Early Warning System is the “set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss”.

Space-based technologies, especially Earth Observation, provide valuable information on sudden-onset as well as on slow-onset hazards, including information on land cover and exposure of assets for risk assessment or to improve the warning service and response capability. A typical example is the use of imagery derived from satellites to track hurricanes and cyclones. In selected cases such as in the case of tsunamis, satellite telecommunications are the ideal mechanism to disseminate warnings across continents.

Taking into consideration UN-SPIDER’s mandate to serve as a bridge between the space community, the disaster-risk management and the emergency response communities and to serve as a gateway to space-based information for applications including early warning and disaster preparedness; this expert meeting aimed to gather elements to define an agenda of work as a way to contribute to the improvement of early warning and preparedness efforts through the use of space-based information.

The expert meeting brought together experts from different regions of the world who discussed ways in which space applications and geo-spatial information technologies can improve the functionality of early warning systems targeting a variety of hydrometeorological, geological and biological hazards. Several experts made presentations highlighting novel advances on the use of space applications in early warning systems and the discussion sessions focussed on the four main elements of early warning systems: **risk knowledge**, **monitoring and warning services, dissemination and communication**, as well as **response capability**. The role of remote sensing, global navigation systems and geographic information systems in early warning applications was discussed through the modality of breakout groups.

II. Experts

The expert meeting brought together 55 experts representing the following institutions:

United Nations organizations:

- The Food and Agriculture Organization (FAO);
- The United Nations Convention to Combat Desertification (UNCCD); and
- The United Nations University - Institute for Environment and Human Security (UNU-EHS).
- The United Nations Office for Outer Space Affairs (UNOOSA)

UN-SPIDER's Regional Support Offices:

- The Iranian Space Agency (ISA);
- The National Space Research and Development Agency (NSRDA);
- The Regional Centre for Mapping of Resources for Development (RCMRD); and
- The National Space Agency of Ukraine (NASU-NSAU).

Regional and International Organizations:

- The Secure World Foundation (SWF); and
- The Group on Earth Observations (GEO);
- The Space Generation Advisory Council (SGAC).

Government Ministries and National Agencies:

- The Federal Ministry of Economics and Technology of Germany (BMWi);
- The Canadian Forest Service (NRCan);
- The Economics Sub-Secretariat of Chile;
- The German Federal Office of Civil Protection and Disaster Assistance (BBK);
- The German Federal Institute for Geosciences and Natural Resources (BGR);
- The German Agency for International Cooperation (GIZ); and
- The National Institute of Rural Development, India.

Space agencies:

- The German Aerospace Center (DLR) ;
- The Mexican Space Agency (AEM); and
- The Space Research Center of the Polish Academy of Sciences (SRC);

Early warning centres and disaster-risk management organizations:

- The Burundi Disaster Risk Reduction Platform;
- The Disaster Management and Mitigation Unit (DMU);
- The German Committee for Disaster Reduction (DKKV); and
- The Indian Ocean Tsunami Early Warning System.

Universities and Research Centers:

- The Beuth University Berlin;

- The Bonn International Center for Conversion (BICC);
- The German Research Centre for Geosciences (GFZ);
- The Heidelberg University, Germany;
- The Institute of Environmental Geosciences (IEG) of the Russian Academy of Sciences (RAS);
- The University of Moratuwa; Sri Lanka
- The University of Bonn, Germany; and
- The Vienna University of Technology, Austria.

In addition, representatives from various private companies were present:

- BlueSky Regeneration;
- ESRI;
- GAF AG;
- HCP international (HCP);
- Industrieanlagen-Betriebsgesellschaft mbH (IABG);
- International Geospatial Services Institute GmbH; and
- T-Systems International GmbH.

III. Opening remarks

The expert meeting was opened by Ms. Agnieszka Lukaszczyk, Director of the Brussels Office of Secure World Foundation (SWF); Ms. Christiane Lechtenbörger, Strategy and International Relations Department of German Aerospace Center (DLR); and Mr. Juan Carlos Villagran de Leon, Head of the Bonn Office of UN-SPIDER.

Ms. Lukaszczyk welcomed the experts and gave a short introduction to the Secure World Foundation (SWF) stressing the fruitful cooperation with UN SPIDER and the progress made throughout the years. She pointed out that one of the strengths of UN-SPIDER workshops is to achieve concrete outcomes and subsequent follow up activities.

Ms. Lechtenbörger welcomed the experts on behalf of DLR and reminded them of the relevance of the use of space-based information in early warning systems by embedding the topic in the international debates on sustainable development, climate change and disaster risk reduction. She commented on the role of DLR in supporting the UN-SPIDER programme and assured the continuation of DLR’s engagement in research and development of satellite-based services and systems for disaster risk reduction, emergency response, and early warning.

Mr. Villagran de Leon gave a warm welcome to all experts coming from 20 different countries. He introduced the experts to the topic of the expert meeting giving illustrative examples on the importance of and challenges in early warning systems and stressing the potential of using space based information. Finally, he outlined the structure and objectives of the expert meeting.

IV. Session 1: Remote Sensing, Early Warning and Disaster Preparedness

Session 1 on remote sensing, early warning and disaster preparedness commenced with three keynote presentations.

Mr. Juan Carlos Villagran de Leon from UN-SPIDER gave an overview on the UN-SPIDER Programme and its role in early warning efforts stressing the importance of knowledge management. He gave examples on the use of space-based information in early warning systems like the identification of the location of critical infrastructure (e.g. schools), the use of time series of archived imagery to estimate how severe a current drought is in comparison to previous droughts and the transmission of warnings across continents using satellite telecommunications. The presentation is available for download at <http://www.un-spider.org/sites/default/files/JuanCarlosVillagran_UN-SPIDER_EarlyWarning.pdf>.

The second keynote presentation by Mr. Gunter Strunz from the German Aerospace Centre (DLR) provided a thorough overview of remote sensing applications for vulnerability and risk analysis, emergency response, and early warning systems. He highlighted mainly global operational monitoring services for floods, fires, severe weather including storms and drought. He then pointed out that these monitoring and forecasting services are not complete early warning systems. In the second part of his keynote address he presented the GITEWS project as an example of a full early warning system, which includes sensor system integration as well as situation assessment and decision support systems.

In her keynote presentation, Ms. Agnieszka Lukaszczyk from Secure World Foundation (SWF) focussed on early warning for Near Earth Objects (NEOs). She stressed that NEOs are the only natural hazard that could be completely prevented. NEO detection is possible by using optical telescopes, the warning may span from several years to decades, and the NEOs could be deflected, i.e. the orbit can be changed in a way that the NEO does not hit the earth. Ms. Lukaszczyk raised awareness on why NEOs are a concern and presented NEO governance issues and current activities like the recommendations of the Association of Space Explorers (ASE). The presentation is available for download at <http://www.un-spider.org/sites/default/files/AgnieszkaLukaszczyk_SWF_NEO_0.pdf >.

Discussion Session 1: Improving Early Warning Systems – Novel Space-based applications to monitor and forecast events

Many organizations operating at the global and regional levels are using space applications to derive information which can be incorporated into early warning systems operated at national and local levels. Therefore, there is a need to identify ways to enhance the flow of information from the international and regional levels to the national and local levels. Group discussions were conducted on how such information generated at the global and regional levels could:

- Widen the warning time;

- Enhance the warning message through additional, complementary information on the spatial extent of events which may trigger disasters.

Key issues discussed by the experts included:

- What novel sources of information at the global and regional levels can be used to improve the routine monitoring and forecasting capacities of existing early warning systems operated at the national and local levels?
- What are the key challenges to be addressed when promoting the use of geo-spatial information in monitoring and forecasting activities? What is the best way to approach such challenges?
- What strategies should we implement so that existing early warning systems complement the monitoring and forecasting phases of early warning systems through the use of novel geo-spatial IT technologies including the use of geo-viewers?
- How can we keep updated concerning recent advances in such types of novel sources of information?

Group 1: Hydrometeorological Hazards

The experts discussed which novel sources of information at the global and regional levels can be used to improve the routine monitoring and forecasting capacities of existing early warning systems operated at the national and local levels in the context of hazards such as floods and droughts. Among those sources of information which may be accessible free of charge, the experts identified the MODIS Aqua and Terra products, which can be accessed free of charge through online websites (<http://earthdata.nasa.gov/labs/worldview/>, http://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/realtime.cgi>, and <http://earthdata.nasa.gov/data/near-real-time-data/data/hazards-and-disasters>. They identified two new projects and initiatives that are relevant for drought forecasting.

First, a **global Agricultural Stress Index System (ASIS)** based on 10-day satellite data of vegetation and land surface temperature from METOP-AVHRR which is being developed by FAO-GIEWS as a tool to support food security early warning systems (<http://www.fao.org/climatechange/asis>); the objective is to detect agricultural areas with a high likelihood of water stress (drought) at global, regional or country level.

Second, a new **agriculture-climate observatory** that is being launched in Chile to allow decision makers, farmers, and scientists to access reliable and up-to-the-minute information on meteorological, hydrological, and agricultural conditions; and to provide the National Climate and Risk Management Agricultural Emergency Unit (UNEA) with tools to develop forecasts for upcoming seasons. The observatory is based on a highly flexible system that can integrate different data sources, both domestic and international, and allows information to be visualized and data to be exported in a suitable, accessible, and understandable form (<http://www.unesco.org/new/en/santiago/press-room/single-new/news/nuevo_observatorio_agroclimatico_en_chile_contribuira_a_la_alerta_temprana_ante_eventos_de_sequia/; the new system)>. The new system, which will be available online from the 8th of July 2013 (<http://www.climatedatalibrary.cl/UNEA/maproom/>), is part of a broader effort carried out in Latin America and the Caribbean for the management of water resources

(<http://www.cazalac.org/mwar_lac_test/>). UNCCD is in close contact with UNESCO regarding this new initiative.

The group discussed key challenges to be addressed when promoting the use of geo-spatial information in the monitoring and forecasting phases of early warning systems and which is the best way to approach such challenges.

Spatial resolution was identified as a constraint to many space-derived datasets. For example, the Metop ASCAT soil water index developed by researchers at the Vienna University of Technology has a coarse spatial resolution (25km). Consequently, the product can be used for global climate studies or drought applications, but it is limited when it comes to assessments of local flood risk. However, with the emerging of new satellite missions the spatial resolution will also improve. The Copernicus Sentinel satellites will allow for higher resolution soil moisture measurements (below 10km). The experts also commented that the TRMM data products are also too coarse for some local applications.

Another constraint related to information derived from satellite images is the **accuracy**. The objective should be to issue a warning only when the occurrence of an event is certain in order to avoid unnecessary evacuations. Experts agreed that it is difficult to communicate uncertainty to the end user.

Methodologically, **the definition of thresholds** was identified as a challenge when visualizing geodata. Soil moisture can be monitored from space, but the scientific community has not yet agreed on a standardized definition of thresholds to characterize the degree of soil wetness or dryness.

The experts also noted the challenge faced by space agencies to provide **large amounts of data free of charge,** which would be needed for disaster risk assessment, warning and preparedness.

An additional key challenge is **how to disseminate the right information to the local people and how to transform warning into right action**. In the Southern African Development Community (SADC) region, seasonal forecasting information (updated every three months) is used for contingency planning – based on the forecasts. A technical early warning committee (consisting of representatives of government, NGOs and the private sector) gives advice at the local level on suitable agricultural products for the particular season. In a complementary fashion, some regional initiatives facilitate access to accurate information. The European Centre for Medium-Range Weather Forecasts (ECMWF) provides accurate weather forecasts worldwide. However, **limited internet access** in some countries is the constraint to access such information.

The experts recognized the need to **raise awareness and enhance capacities** to ensure that people can take advantage of the information they receive. In some cases people do not perceive storms as dangerous and may not be prepared for the floods that such storms trigger.

The experts discussed strategies that should be implemented so that existing early warning systems complement the monitoring and forecasting phases through the use of novel geo-spatial information technologies including Geographic Information Systems (GIS), geo-visual analytic tools and geo-viewers. The group broke the question down to more specific questions: What are the different requirements for slow- and rapid-onset disasters? Who is authorized to disseminate the information? How are the public informed and which kind of information is used? Who are the actors and users of the early warning system? Who is taking part in the process of designing and implementing early warning systems? The experts highlighted three categories of stakeholders:

1. Data and service providers (space agencies, meteorological agencies) who are interested in data flows and services;
2. Decision-makers (local authorities) who may not possess a technical background;
3. Institutions that are in charge of communicating the data and information (civil protection).

All three categories are equally important. An effective early warning system has to clarify the roles of the stakeholders within the system.

The experts underscored the need to **differentiate between early warning and preventive information**. For dissemination of a warning message to the local level, SMS or public radio announcements are more suitable than online geo-viewers; SMS is useful for slow-onset disasters like droughts but it is also used for latest warnings like “tsunami coming”. In the Philippines public radio announcements proved to be more reliable than SMS for flood early warning. The private sector, i.e. mobile phone providers, needs to become involved in disseminating early warning messages. Geo-viewers are more suitable to convey information about risk than for about actual warning. Smartphone applications could link GPS information with risk information through a geo-viewer to make the user aware that he or she is entering a risk zone (e.g. 100 year or 10 year flood zone). Information for professional users would contain more technical details.

The experts stressed the need to **coordinate disaster risk reduction efforts** at various levels including at the international level. The CEOS initiative on disaster risk management, which is also part of the GEO workplan, was highlighted as a good example of how to better coordinate existing projects and feed them with additional space-based and in-situ information; three pilot projects focus on three main risks: earthquakes, volcanic activity, and floods.

Recognizing the difficulties that arise due to lack of funds to secure high resolution satellite data, the experts suggested finding ways to secure financial resources to purchase such data.

The experts also stressed the need for public **awareness, education, and training**, after all the best data is useless if people cannot interpret them.

The experts recognized the **advantages of web-based geoviewers** as powerful tools when it comes to making data products accessible – provided internet access is given. The ASCAT soil moisture product of the Technical University of Vienna is such an example. This soil-moisture product has been available since 2007 but the implementation of a geo-viewer two years ago has increased the use of the data immensely.

The discussion also focused on **crowd sourcing** as an additional useful source of information. CrowdRing was mentioned as an innovative approach, especially for areas with limited internet connectivity. The experts pointed out the great potential that crowd sourcing can provide in terms of useful information for the preparedness phase. The University of Heidelberg together with the University of Sao Paolo is involved in a research project on how to integrate crowd sourced information with satellite based information and data from terrestrial sensors for flood early warning in Brazil.

Group 2: Geological Hazards

Experts of Working Group 2 agreed to include earthquakes, volcanoes, and tsunamis in their discussion on geological hazards. They reiterated the conclusion of Mr. Strunz' (DLR) keynote presentation that many existing earth observation services are useful in the monitoring and forecasting phases and can also contribute to risk knowledge.

The group discussed what novel sources of information at the global and regional levels can be used to improve the routine monitoring and forecasting capacities of existing early warning systems and they streamlined the discussion around two major data sources. First, **freely available space-based data** hosted in various institutional websites such as the one operated by the National Air and Space Administration of the United States (NASA) for its Earth Observing System / Data and Information System EODIS at: http://earthdata.nasa.gov/data/near-real-time-data/data/hazards-and-disasters **.** With the opening of the Landsat archives and future missions with a similar data policy (e.g. future GMS satellites, Sentinels), researchers and disaster managers are now in the unique position to access abundant data for free. However, data access is still a major concern in developing countries. Experts suggested developing a central data pool to gather diverse space-based data, socioeconomic data and other possible geo-spatial data and then dispatching it on request to agencies in countries which need it. Such data pool may include representative applications, methods, and case study-or based practices.

Second, **crowd sourced and volunteered crisis data:** The experts made the point that crowd sourcing communities, e.g. Open Street Map, Ushahidi, and Crisis Mappers, provide free data that are useful for disaster-risk and disaster-response management. The advantages are that in some cases volunteered data provide a more complete and detailed data than administrative data. But the reliability of data and quality control is an issue. The experts also pointed out the need to discriminate between volunteered and structured crowdsourcing.

The experts recommended using web-based **GIS** and online geo-processing tools as a central platform where data and maps gathered by different communities at the global, regional, national and local levels are brought together as a way to allow stakeholders at different levels to cooperate and to conduct analysis with such data.

The group then addressed key challenges when promoting the use of geo-spatial information in the monitoring and forecasting phases of early warning systems and the best way to approach such challenges. As a way to streamline the dialogue, the group focused its discussion along four main areas: **access to data**, **access to tools and methods**, **improved interactions and networking** and the **need for capacity building**. In the context of **data** the experts identified as challenges the **limited access to the internet in many countries**; the time-gap between data acquisition and the availability of information, which is especially critical for fast events; and the **uncertainty of the data and related information** - if people do not trust the data, they will not use it. The experts also underscored that a major challenge is the **unwillingness** of many governments and agencies **to share** their **data**.

The experts stressed that efficient early warning systems can only be developed and implemented if the **different communities and stakeholders cooperate**. The experts suggested defining clearly the different communities that need to cooperate to develop efficient early warning systems. Dialogue between **science and politics** is essential for a successful development and implementation of methods for risk reduction like risk assessments, probabilistic earthquake modelling, tsunami hazards modelling, tsunami warning systems, or dissemination of information using GIS concepts. Equally important is the dialogue among **different scientific communities**, e.g. the remote sensing or engineering communities and the vulnerability community (which itself is heterogeneous consisting of social sciences, economists, and natural scientists).

In the context of **capacity building** the experts highlighted the need to ensure sustainability of efforts including maintaining face-to face relationships among the experts and those trained beyond the training. The experts suggested private-public-partnerships, community-based approaches, and train-the-trainer programmes as ways towards sustainable capacity building.

The group also discussed what strategies should be implemented so that existing early warning systems complement their monitoring and forecasting phases through the use of novel geo-spatial information technologies including the use of geo-viewers.

As a way to deal with the critical issues regarding access to data and the need to share it, the experts identified three complementary solutions:

1. To use volunteered geographic information to compensate for lack of access to official data.
2. To convince local and national governments to collect and share data including space-based and ground-based data. Data should be disseminated in a harmonized way on a joint platform, which requires a strong structure behind. UN-SPIDER, as an internationally known agency could play a role there providing policy-relevant advice on such spatial data infrastructures. The European INSPIRE directive was identified as a good example how to harmonize data coming from different sources.
3. To build on existing initiatives like the Open DRI initiative (<https://www.gfdrr.org/opendri)> of the Global Facility for Disaster Reduction and Recovery (GFDRR). OpenDRI builds on the World Bank's broader Open Data Initiative and implements the first policy recommendation of the joint World Bank / UN flagship report, "Natural Hazards, UnNatural Disasters, the Economics of Effective Prevention" (<https://www.gfdrr.org/NHUD-online>) which establishes the importance of data sharing to reduce vulnerability to disasters.

In the context of **access to tools and methods** to monitor and forecast potentially catastrophic events, and for risk assessment, the experts suggested the development of automated methods for value adding such as the extraction of an urban footprint. Baseline maps, including the location of schools and settlements as well as the delineation of disaster prone areas, were identified as an essential part of risk analysis. In many countries detailed cartography is lacking. The experts also stressed that technology for data sharing is available in form of GIS platforms but policies need to be set up to support it. Prioritization is needed to decide where to start with high resolution mapping, e.g. mapping hot spots in cities with large populations. In addition, experts recommend the use of applications such as Bing and Google Earth as a way to access data when access to commercial imagery is not feasible.

Social networks, media applications, SMS and smartphone messaging could also be used to facilitate the access to data. The group recommended creating a global charter to collaborate on sharing data for resilience. They also recommended establishing tight relationships with end users to develop guidelines on the usability of the data.

The group also discussed the need to promote early warning applications in the context of near earth objects following the presentation made by Ms. Lukaszczyk.

Group 3: Biological hazards

The experts in this working group began their discussion framing the field of biological hazards and deliberated on what can be addressed as biological hazards. According to the "2009 UNISDR Terminology on Disaster Risk Reduction"[1] publication, a biological hazard is: "a process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Examples of biological hazards include outbreaks of epidemic diseases, plant or animal contagion, insect or other animal plagues and infestations."

Since an exhaustive enumeration always bears the risk of gaps the following listing only mirrors the types of hazards which were mentioned during the discussion: Insect infestations (agricultural forestry), fire / forest fires, weed infestation, bush encroachment, diseases (vector borne diseases, water borne diseases, fungi, epidemics), sand and dust storms, extreme pollution (e.g. air pollution, industrial pollution), algae blooms, plant diseases, animal diseases, and industrial accidents.

The experts recognized the importance of space-based applications to support and improve early warning systems. Remote Sensing and monitoring application of e.g. the habitat of vectors or terrain and vegetation data could complement and support various kinds of early warning mechanisms. For an effective improvement in the context of early warning, the group identified the need to integrate baseline data (roads, rivers etc.), resource data bases (e.g. access to weather data), crowd-based data (e.g. report on diseases in the field), social science data (poverty indices, census data), and data on hazards using a variety of models.

The group discussed key challenges regarding the use of geo-spatial information which should be addressed when promoting the use of geo-spatial information in the monitoring and forecasting phases of early warning systems. **Interoperability, standardisation of data models, standardized terminology and vocabulary, quality and reliability of information** – especially of crowd-based / sourced information and an **existing research gap in the use of space-based information for early warning purposes**. Furthermore the group identified **barriers to open and free access to data** and the necessity of a multi-disciplinary approach.

To tackle these challenges the experts discussed the need for improvements at the institutional and technical levels. A leading organisation could set up a framework in relation to standards of data, vocabulary, methodologies or integration of data-sets. The need to make the appropriate technology

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[1] http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf

easy accessible, easy useable and easy to integrate in the respective working area was underlined. The experts also noted that capacity building approaches and technological transfers could be used to overcome the various gaps and challenges regarding the use of geo-spatial information in early warning systems. Finally the group mentioned the establishment of an expert group and communication forums as good approaches to keep updated on the various advances. The experts also recommended that researchers should use “plain” language in scientific papers, show best practices and formulate success stories to be able to better involve stakeholders or decision makers into the process and sell their ideas and scientific accomplishments. Institutions dedicated to applied sciences could be the most interesting partners to develop a network of experts, to establish an agency with a focus on operationalization and the connection of research and innovation in the field of early warning and space-based solutions.

V. Session 2: Enhancing the Early Warning Message: from warning about events to its potential impacts

This session began with three plenary presentations which paved the way for the subsequent discussion groups during this session which focused on ways to enhance the early warning message.

Mr. Erick Khamala from the Regional Centre for Mapping of Resources for Development (RCMRD) began with an introduction to RCMRD and its role in disaster management in Eastern and Southern Africa. He then proceeded to give an overview of existing activities in early warning for droughts, floods, landslides, and epidemic diseases as well as long-term early warning systems. He concluded his presentation with an example regarding how to enhance drought risk reduction using geospatial information gathered through a participatory approach. The presentation is available for download at <http://www.un-spider.org/sites/default/files/ErickKhamala_RCMRD_EarlyWarningEasternAfrica.pdf>

Mr. William J. de Groot from the Canadian Forest Service gave a presentation on behalf of Mr. Johann G. Goldammer and himself on the global early warning system for wildland fire. He started commenting that an area of the size of India burns every year and that the ultimate goal is to prevent or at least mitigate disasters provoked by fires through the implementation of fire monitoring, fire mapping, and fire modelling. Mr. de Groot explained the GOFC-GOLD Global Fire Early Warning System and showed recent developments in regional early warning and capacity building. He concluded his presentation making reference to future earth observation applications for fire early warning. The presentation is available for download: <http://www.un-spider.org/sites/default/files/BilldeGroot_NRC_WildlandFireEWS.pdf>.

In his presentation on the use of space based information in early warning systems, Mr. Samantha Hettiarachchi; Chair of the Working Group on Risk Assessment and Reduction, UNESCO/IOC/ICG/IOTWS presented the Indian Tsunami Warning System (IOTWS). He pointed out that risk is a function of hazard, vulnerability and deficiencies in preparedness and that Earth Observation can play a role in enhancing preparedness and in vulnerability assessment. While minimal tsunami warning systems include earthquake detection, a dissemination system and an educated population; standard systems also include tsunami detection and an advanced tsunami forecast system. The presentation is available for download at <http://www.un-spider.org/sites/default/files/SamHettiarachichi_UniMoratuwa_SBIforEarlyWarning.pdf>.

Discussion Session 2: Using Space-based information: from early warning to early response

Risk knowledge implies knowing which communities and assets are exposed to hazards, their degree of vulnerability and which deficiencies in disaster preparedness may accentuate losses in case an event manifests itself or may lead to slow and ineffective response. In the case of early warning systems, risk knowledge allows operators of early warning systems:

- To know the precise location and the degree of vulnerability of specific communities or vulnerable groups (children in schools, elderly in elderly homes, places that congregate a vast amount of people, etc.);
- To determine the need to issue specific warnings to such vulnerable groups ahead of time so that evacuation procedures can be conducted in a timely fashion;
- To determine the optimum evacuation routes for different vulnerable groups;
- To identify ways to minimize losses to critical assets as a way to facilitate business continuity in case an event manifests itself.

Key questions that experts discussed during the discussion session in this area of risk knowledge included:

- How can we use archived and up-to-date satellite imagery and satellite-assisted positioning to identify the location of vulnerable groups and assets?
- How can we use existing knowledge concerning the vulnerability of elements to assess potential effects in case an event manifests itself?
- How can we use geographic information tools to combine data derived from space applications with data and information derived from field surveys and expert knowledge and to display it to improve early warning systems?
- Which are the strategies that we should use to promote the use of geo-spatial and space-based information in early warning systems targeting a variety of hazards?

Group 1: Hydrometeorological Hazards

The group discussed how satellite imagery and satellite-assisted positioning can be used to identify the location of vulnerable groups and assets. The experts stressed that for information on the location of vulnerable groups, the most up-to-date data are needed. They remarked that the current approach to locate vulnerable groups and assets using satellite based information is too much top-down. Therefore they suggested approaching vulnerable groups and teaching them to access and to use the data. The experts shared their experiences and suggestions regarding the **use of satellite-assisted positioning**. Geo-coding of local houses in combination with survey data and maps of flood prone areas is used in the Philippines to calculate the number of people in a hazard prone areas. Using an interactive tool based on Google earth, inhabitants can display the position of their houses in the flood prone areas. Another suggestion is to equip pastoralists with GPS units to monitor their paths and to combine this information with satellite imagery in order to generate and make use of information on the vulnerability of this group. Regarding the use of **archived and up-to-date satellite imagery** they pointed out that satellite images are mostly used for **exposure** mapping, not for vulnerability mapping. Two challenges which were highlighted are: the integration of data acquired at different scales into one single database; and limited access to datasets due to their sensitivity, commercial or military interest. The experts stressed the importance of generating a database with a complete reference dataset – ideally aerial images -ready to be prepared and to update the data on buildings on a regular basis in such a database.

The group also discussed how geographic information tools can be used to combine data derived from space applications with data and information derived from field surveys and expert knowledge and to display it to improve early warning systems. The experts pointed out that GIS can serve as platforms to bring different data together. They underscored that satellite images are not sufficient to assess vulnerable groups and that vulnerability cannot be assessed without looking into socio-economic aspects.

The group discussed strategies to promote the use of geo-spatial and space-based information in early warning systems. In the case of droughts the experts suggested using information of past events to estimate the susceptibility of different crop types. In the case of floods they suggest the use of historic data and Google Earth to help local people to map the flood extent. The experts remarked that a clearing house is needed for the dissemination of information, including maps. When comparing the movies of flood modelling results that were presented by Mr. Hettiarachi with the static before and after images that were available some years ago, the experts pointed out the fast progress made in recent years. They suggested developing novel tools on smartphones to play around with aiming at increasing awareness and promoting the use of space based information. As a way to encourage the implementation of this recommendation, experts suggested the conduction of a GeoWiki contest to collect land-use information via mobile phones as an idea of a game approach to collect useful information. The drawback of such an idea is that there is no global coverage of smartphones, especially in rural areas in many developing countries where even access to electricity, internet, and mobile phones is still lacking. However, in this context it has to be mentioned that the African continent is currently the fastest growing mobile phone market. The experts highlighted the GEO task called GEONETCast as an approach to directly receive satellite data without internet access. This approach could be extended to deliver maps of affected areas to government agencies in countries with poor internet connectivity. Last but not least, the experts stressed the need to build on the experiences of current and past projects like GITEWS.

Group 2: Geological Hazards

During this discussion session on "using Space-based information: from early warning to early response" the experts of this group on geological hazards included also near earth objects (NEOs) and landslides in their discussions besides the three geological hazard types mentioned in discussion.

The experts discussed how archived and up-to date satellite imagery as well as satellite-assisted positioning can be used to identify the location of vulnerable groups and assets. In this context, they reported on the current FP7 SENSUM project (Framework to integrate Space-based and in-situ sENSing for dynamic vUlnerability and recovery Monitoring - <www.sensum-project.eu>), which includes the development of methodologies and software tools for dynamic, multi-resolution monitoring of pre-disaster vulnerability and preparedness, based on current and future space-based products and a novel approach to in-situ observations for data-rich and data-poor-countries. The experts suggested **prioritizing data collection**: first to collect free globally available space borne imagery, the continue with high resolution data, and finally complement the collection with archived local ground-based data (e.g. surveys). Data collection should be complemented with **information management tools**. In the case of data-poor-countries, tools need to be provided to exploit available data. The experts suggested searching for data and tools that can identify the triggering factors of geological hazards. They underlined that space-based imagery is an important source of information but it needs to be complemented with other data. Especially in the context of vulnerability, socioeconomic data, tools and methods are crucial. The group pointed out that a platform needs to be established to provide access to all relevant data in a harmonized way.

The group also discussed how to use existing knowledge concerning the vulnerability of elements to assess potential effects in case an event manifests itself. The experts stated that vulnerability, exposure, and risk are different concepts which are often confused. They identified local knowledge, experience of the people, crowd sourced information, and scientific knowledge as sources of existing information for vulnerability assessments. The group stressed that **harmonization of collected data** is necessary. The OpenQuake suite of open software of the global earthquake model (GEM - www.globalquakemodel.org) was introduced as a good example of a harmonized platform. In addition, they mentioned QuakeSim (<http://quakesim.org>) as a good example of a geographic web-service for earthquake forecasting.

Furthermore the experts discussed how geographic information tools can be used to combine data derived from space applications with data and information derived from field surveys and expert knowledge and to display it to improve early warning systems. The experts recommended to consider **OGC compliant geographic web-services** and to establish **an open platform** as a way to combine data from different sources, i.e. space-based and field data. The group underscored the importance of **education and training** to enhance the capacity of potential users so that they understand the processes behind the tools and data products.

Last but not least, the group discussed possible strategies to promote the use of geo-spatial and space-based information in early warning systems. The experts formulated recommendations for the UN-SPIDER programme. UN-SPIDER with its network of Regional Support Offices should serve as a vehicle to promote the proper use of space-based applications especially among end users and decision makers who are not experts as follows:

- **Facilitating Educational activities** aimed at deepening the understanding of advantages and limitations of datasets, data products and tools. Such activities should describe what happens in black boxes of software tools or how a data product was derived;
- **Facilitating access to ready-to-use data** and information (like the Charter maps) through web-services so that people can use them in their own applications;
- **Facilitating the visualization of data** in the Knowledge Portal;
- Establishing a **network of focal points** to promote the use of space-based information for early warning; the UNISDR national platforms would be suitable focal points; use the UN-SPIDER knowledge portal to get these networks together and to showcase best practices;

- Building stronger **links to other organizations** and advertise what UN-SPIDER has to offer; the cooperation regarding the UNESCO-IOC guidelines is a positive example where this was already done;
- Filling the **Space Application Matrix by collaborating with other agencies** showing that these are cross-cutting topics;
- Providing a **tool package** that does not only include space-based applications but also additional tools like meteorological tools.

Group 3: Biological hazards

The experts discussed various fields where archived imagery could be an asset:

- Integration of historical and up-to-date climate change and vegetation data for **resilience estimates** (e.g. TRMM datasets, National Centre for Atmospheric Research datasets);
- Collection of infrastructure data sets for research on historical disease occurrences and to track the **diffusion of Malaria or Dengue**;
- Correlation of the data on the impact of a disaster with historical hazard data to build **predictive models and simulation of disasters**;
- Revision of historical data to address the question regarding which crop or plant is more vulnerable to certain biological disasters than others. Historic data could be used to research which type cultivation, land-use planning and management practices reduce vulnerability.

The experts mentioned the importance of **adding value and prices to data derived from space applications**. Decision makers can more easily draw conclusions on values from numbers and react to the value of data.

The group also stressed the value of **outreach, capacity building and training** efforts and the transfer of know-how and technology to promote the use of geo-spatial and space-based information in early warning systems.

Finally the group recommended the conduction of research using archived imagery to extract a wealth of information which could then be used to build convincing **scenarios of possible impacts** to convince decision makers to implement important actions. The development of **danger scales** similar to the already existing scale of forest fire was mentioned as an important tool to promote risk knowledge efforts.

VI. Session 3: Enhancing links in the early warning chain

As in the case of the two previous sessions, this session began with three plenary presentations. In their joint presentation Mr. Olaf Neussner from the German Agency for International Cooperation (GIZ) and Mr. Johannes Anhorn from Heidelberg University presented a case study from the Philippines on linking regional, national and local levels in flood early warning. Data from river gauges are processed in an operation centre that issues the warnings to the communities. Global earth observation data products - like TRMM rainfall estimations and ASTER global digital elevation model – and flood masks derived from SAR data contribute to improved risk knowledge as well as to the monitoring and warning element of flood early warning systems. The presentation is available for download at <http://www.un-spider.org/sites/default/files/NeussnerAnhorn_GIZUniHeidelberg_PhilippinesFloodEW.pdf>.

The second presentation by Mr. Oscar Rojas from the Food and Agriculture Organization of the United Nations (FAO) dealt with the FAO Agricultural Stress Index System (ASIS), which is based on 10-day satellite data of vegetation and land surface temperature from the METOP-AVHRR sensor at 1km resolution. Mr. Rojas pointed out that ASIS extends the classical approach of using anomalies of vegetation indices by incorporating agricultural information like the JRC global crop mask and information on the stage in the agricultural cycle. He completed his presentation showing the global agricultural stress index for each year from 1984 till 2011. The presentation is available for download at <http://www.un-spider.org/sites/default/files/OscarRojas_FAO_ASIS.pdf>.

The third plenary presentation was given by Mr. Emanuele Gennai of Esri on "Sharing value – The GIS platform for disaster management". Mr. Gennai commented on the role of GIS as a platform with the potential to combine and synthesize information from many sources, integrating disciplines and cultures, and facilitating communication and collaboration. He also informed the audience about Esri's disaster management programme. The presentation is available for download at <http://www.un-spider.org/sites/default/files/EmanueleGennai_Esri_GISPlatform.pdf>.

Discussion Session 3: Enhancing links in the early warning chain

There are novel advances regarding the use of space applications to monitor the dynamics of natural hazards (spatial and temporal dynamics). Yet, some of these have not found their place in the day-to-day operation of early warning systems. There are also novel efforts regarding the combination of archived and up-to-date imagery which could support early warning operations at the national and local levels, but synergies need to be built. Finally, technologies such as satellite-assisted positioning and navigation could be used in early warning. Key issues discussed among experts in this context of enhancing links included:

- What are the key challenges to be addressed when promoting the use of geo-spatial information generated at the global, regional and national levels in early warning systems operated at local levels? What is the best way to approach such challenges?
- How can we complement the operating of early warning systems through the use of information derived from archived and up-to-date satellite imagery?
- What is the best way to promote the use of remote sensing and satellite-assisted navigation and positioning in early warning systems?
- How should such information be presented in portals such as the UN-SPIDER Knowledge Portal so that it can be used routinely by early warning systems around the world?
- What strategies can we think of to transmit global knowledge to local communities who operate and rely on early warning systems?

Group 1: Linking global, national and local efforts

The experts in this group identified various key challenges which need to be addressed and kept in mind when promoting early warning systems. **Language barriers, limited access to the internet, bureaucracy** within a country itself and at the international, national and regional levels; **incompatibility of the various systems**, **weak identification of the needs** of the end users, **limited**

access to data, **limited opportunities for training and education**, **few approaches to transfer from raw data into useful information**, **lack of funds**, **weak communication among the respective institutions**, **differences in the source of data** (commercial data, military information, open data), **lack of awareness** about what is possible and what is in place already (case studies / best practices) which have been mentioned as main topics in previous discussion sessions that need to be addressed.

Capacity building and outreach activities should be the first approach to overcome these challenges and the United Nations System and its various institutions could offer a good opportunity to promote the use of remote sensing applications in early warning systems. The efforts and the network of UN-SPIDER were underlined as an excellent tool for the **dissemination of information and promotion of the advancements of satellite-based technologies**. Technical Advisory Missions (TAMs), the Knowledge Portal and the UN-SPIDER network of Regional Support Offices (RSOs) offer a great possibility to support these efforts. Furthermore the formation of collaborative platforms on local levels, networks of local scientists and the strengthening of local institutions could offer an additional asset.

Experts commented that it is essential to know the target audience to be able to provide **tools which are simple, useable and adaptable to different formats and languages**. It was noted that these efforts should be complemented with a solid education in schools and universities to make sure that all graduates have a reasonable understanding of the topic as a way to promote the use of space-based information in early warning systems.

The group discussed that the **dissemination of simple and interesting case studies** could support the efforts and enhance the knowledge of stakeholders as the translation of technical words into simple language would portrait the success better. These efforts can as well be complemented by the **publication of small booklets on success stories, methodologies, guidelines, information sources or involved stakeholders and parties**.

Group 2: Combining archived and up to date imagery

The group discussed how the operation of early warning systems can be complemented through the use of information derived from archived and up-to-date imagery. The experts stressed the importance of archived imagery to understand and learn from previous events. Archived data allow experts to model what could happen in the future. Image archives are building up daily; there are records for more than 30 years (e.g. Landsat, NOAA-AVHRR). The experts exchanged views on examples where archived imagery has been used:

- The calculation of some indices like the **vegetation health index (VHI)**, which is not feasible without long time series of data (cf. presentation of Oscar Rojas, FAO).
- Another example for the use of archived imagery is the Namibia flood project where the UN-SPIDER Regional Support Office NASU-NSAU used time series of more than 100 archived Landsat scenes to produce **flood extent maps**, and to conduct **frequency and extreme events analysis**. In combination with dwelling information, such **hazard maps** can be integrated in early warning systems in order to define regions that are most exposed to floods. Limitations of this approach are the timing of data acquisition as it is not always possible to capture the maximum extent of the flooded areas due to the revisit time of the

satellite and due to cloud coverage. The experts also suggested integrating TRMM data which are dating back to 1997 and the MODIS imagery with its broad range of products that can be developed in near real time.

- Land-use and land-cover change detection can also be used **to update hazard maps**.
- Crowd sourcing like in the case of the mapping of Port au Prince/ Haiti is also done on the basis of archived images.

The experts emphasized that real time data are the last pieces of information that are included in a GIS for Early Warning. A **GIS database** including baseline data and archived images needs to be prepared before a disaster strikes. Having **archived reference maps ready at hand** eases the estimation of the impact of a disaster. However, there is no global solution to build up such a data infrastructure as the access to national databases is very different from country to country. The experts suggested preparing **map templates** indicating which data are needed to successfully feed early warning systems for specific hazard types, together with a standardized legend, and the file format of the maps. Furthermore **standard operational procedures** are needed, which clearly define responsibilities. This should be done in cooperation with experienced partners.

The experts made the following suggestions regarding how such information can be presented in portals such as the UN-SPIDER Knowledge Portal so that it can be used routinely by early warning systems around the world:

- The Knowledge Portal should contain **baseline maps and examples of images before and after an event**.
- The Knowledge Portal could serve as a **data hub where data relevant for early warning systems are compiled and easily accessible**. Such a compilation of data should not only include space-based data but also complementary datasets like crowd sourced data, socio-economic data, or data about where people are located. There should be a link to the UN data page (<http://data.un.org/>). The experts suggested that UN-SPIDER should consider broadening its focus to datasets and developing case-based models and applications other than on only space-based data.
- The Knowledge Portal should **promote methodologies developed everywhere** around the globe. Rather than prescribing certain methods using a top-down approach; UN-SPIDER should follow a bottom-up approach **showcasing examples from specific countries** and then see if it can be applied in different regions. The recommended practices are one step in that direction. Thereafter, through a top-down approach the methods and applications can be recommended to certain national agencies in countries as a way to tackle disasters.
- Methods and datasets in the Knowledge Portal should contain an indication on their position in the disaster management cycle.
- The Knowledge Portal should also contain more **links to case studies** which showcase how early warning systems use archived images.

Another recommendation made by the experts was that UN-SPIDER should become more involved in **bridging the gap among different stakeholders** in countries like the national government institutions, the disaster managers, end-users, and researchers at universities.

The group also discussed strategies to **transmit global knowledge to local communities** who operate and rely on early warning systems and identified the main challenges. The experts recognized that global datasets like TRMM data products are impressive but for applications on the local scale the spatial resolution is often too coarse. Research has to focus more on how to **downscale global datasets to the local level**. Another challenge is to choose the right technology for dissemination – in many countries internet and smartphones are not widely available. The experts underlined the importance to include telecommunication companies in technical advisory missions. Especially for fast events like flash floods, timeliness of data and warning dissemination is crucial. UN-SPIDER could play a role in transmitting the information via its network. A suggested strategy was to define clear roles for the stakeholders in early warning systems, i.e. who acquires the data, who is the value adder, who receives the data products and who receives a plain warning message.

Group 3: The role of RS, GNSS and GIS in Early Warning applications

This group focused on the role and relevance of Remote Sensing (RS), Global Navigation Satellite System (GNSS), and Geographic Information System (GIS) in early warning applications. As experts suggested, the use of telecommunication applications was also included within the discussion. Experts were also asked to define critical issues and to share their experiences related to the integration of these systems with disaster management considering their expertise. During the discussion the experts raised several points that should be taken into consideration and they highlighted the importance of a sustainable platform to carry on the capacity building efforts and to address these issues periodically. The most relevant are:

- The implementation of policies on which to establish and institutionalize early warning efforts;
- The estimation of the monetary gain of using geo-spatial information as a way to convince policy makers;
- The establishment of a **process management system** with well-defined actors and their stated responsibilities to sustain the flow of information and experiences;
- The incorporation of the private sector into government-NGO-INGO partnerships since funding is critical to sustain such an effort; and
- The need to encourage **institutions to share their data, as** access to free data is still an issue particularly in developing countries.

From this point on several tasks should be conducted;

- To promote the use of commercial images in addition to freely available imagery including high resolution and archived imagery;
- To identify capacity building needs; to conduct training workshops targeting those stakeholders involved in early warning efforts;
- **To digitize baseline data** to link them with other datasets;
- **To standardize the quality of the data**;
- To establish and institutionalize the use of **spatial data infrastructures** with all the relevant data;
- To promote the **use of disaster scenarios**.

The experts agreed on the point that UN- SPIDER has the unique advantage of being an objective initiator to serve as a **common platform both to share data and the knowledge** and to promote the use of these tools and applications in early warning systems. For this purpose the UN-SPIDER Knowledge Portal should be harmonized and advertised. The following recommendations were made:

- **To use the 16 Regional Support Offices to disseminate capacity building efforts**;
- **To establish connections between developed countries and developing countries;**
- **To add case studies** to the Knowledge Portal and to incorporate an online-open forum to share the ideas and experiences.

The main emphasis of the discussion group was on setting priorities in collecting and disseminating data. **Capacity building** was also identified as a key issue as well as encouraging authorities to start establishing spatial data infrastructures for early warning systems.

VII. Session 4: The way forward

Taking note of the comments and recommendations made by experts during the meeting, it can be concluded that space based information and geo-spatial technologies can indeed be used to improve early warning systems that target a variety of hazards. However, experts did stress that no early warning system can be operated using space-based information exclusively.

The experts manifested that earth observation techniques using the most up-to-date sensors can improve the determination of the temporal and spatial evolution of events capable of provoking disasters. They also reiterated that the combination of ground-based data, ground-based and satellite-based techniques and satellite-assisted positioning can be used to increase the warning time, to define more precisely warning strategies, and to suggest potential impacts of events based on the use of archived data including archived satellite imagery. Experts made several general recommendations:

- To identify, systematize and promote applications, case studies and success stories on the use of space-based information and geo-spatial information technologies to improve the functionality of EWS;
- To raise awareness concerning the most recent advances regarding space-based applications in early warning systems and disaster preparedness;
- To incorporate efforts targeting early warning in the case of near-earth objects.
- To become aware of needs at the national and local levels: in particular whether the need is for data or for information;
- To implement knowledge management strategies as a way to encourage the sharing and use of data, including through the incorporation of data standards;
- To conduct training activities and to transfer technical know-how to facilitate access to and use of space-based information in early warning systems, including simulations and exercises;
- To identify ways in which Voluntary Technical Communities (Crowd-source efforts) and local stakeholders can be involved in the generation of data and information to be used in EWS;

- To contribute to the efforts conducted worldwide in the area of early warning through the establishment of technical groups that focus on the development of tools and methods; as well as through improved dialogue among all stakeholders involved in early warning efforts;
- To identify and implement ways in which the private sector should become involved.

In the specific area of **data and information**, the experts made the following recommendations:

- The **establishment of geospatial databases** containing reference data as way to improve the assessment of risks and potential impacts, as well as to improve warning strategies;
- **The combination of space and ground-based data** through novel applications, including through the use of Volunteer Technical Communities;
- The conduction of efforts to **encourage data sharing** including through platforms that invite people to upload their data and a clearing house to **control data quality**.

In the area of **knowledge management**, the experts recommended three parallel approaches: capacity building, networking efforts and the UN-SPIDER Knowledge Portal.

Capacity building: Experts proposed the elaborations of three specific products:

- A **curriculum** which should include modules on how to access, process and disseminate geospatial data, and modules on the different roles of stakeholders in the early warning systems. An overall objective should be improving the capabilities to think in geospatial ways;
- **Training material for three different target groups** : technicians and professionals, decision makers, and the general public including students;
- **A handbook with all available resources including recommendations** on the applicability of the resources.

In addition, the experts recommended exploring innovative ways for capacity building, training, and awareness raising like simulation exercises. For example:

- Cooperating with existing capacity building institutions;
- Providing access to online trainings via e-learning approaches including the virtual campus operated by Esri.

Knowledge management efforts should also target:

- The continuous update of novel sources of data and methodologies developed in all regions of the world that make use of space-based applications in early warning systems; which should be subsequently disseminated among stakeholders;
- The development of **guidelines on standardized data products** as a way to encourage the harmonization of products;
- The use of **existing mapping standards** like OGC that cover standards of data, vocabulary, methodologies or integration of data-sets.

Networking: Experts recommended facilitating synergies among stakeholders through several ways, including:

- Establishing a virtual communications platform such as **an online open forum** to facilitate communication among stakeholders;
- Establishing **a community of practice** focusing on the use of space-based applications in early warning that could focus its efforts on the development of web-based geospatial platforms, methods to downscale global datasets to make them useful at national and local levels and training material; and which could serve as a basis for collaboration in project-like approaches; and
- **Facilitating the dialogue** among the scientific community, decision makers and the operators and beneficiaries of early warning systems.

UN-SPIDER Knowledge Portal: The experts discussed ways to enhance the content of the UN-SPIDER Knowledge Portal through various options including:

- **The creation of new content by experts** including best practices and interesting articles to be fed in the corresponding sections of the portal like the Space Applications Matrix;
- The systematization and incorporation of several **data sources**, **software tools** and **sources for early warning purposes**;
- The incorporation of a **web-based GIS platform** to make data from different sources available (like the Namibia SensorWeb). Such a platform could also provide a common geospatial data infrastructure and serve to provide baseline data to facilitate preparedness;
- The **dissemination of capacity building programmes**
- The promotion of the Knowledge Portal as an **information broker** linking to resources and institutions.
- The incorporation of a specific **section on Early Warning**.

In addition, experts reiterated that such knowledge management efforts must take into consideration and address challenges including:

- Language barriers;
- Limited access to the internet;
- Bureaucracy;
- Incompatibility of the various systems;
- Limited access to data and training opportunities;
- Lack of financial resources;

VIII. Key results and outcomes

The UN-SPIDER expert meeting on the use of space-based information in early warning systems provided a fruitful platform for discussions among the experts. It permitted UN-SPIDER to achieve several outcomes. From the experts' perspective, the expert meeting allowed them:

- To become aware of recent advances regarding the use of space-based information in early warning systems and disaster preparedness;
- To become aware of UN-SPIDER's role in early warning efforts and to identify ways and means to become engaged in such activities;

- To network with representatives a variety of countries and regional and international institutions and to bridge the gap between the space and early warning communities;
- To share their experiences and to provide their suggestions and recommendations regarding the use of space-based information in early warning systems and disaster preparedness;

In the context of UN-SPIDER, the expert meeting allowed the programme:

- To contribute to bridge the space, the disaster-risk management and the emergency response communities;
- To establish contact with experts from many institutions involved in tasks that are related to early warning;
- To collect a variety of suggestions and recommendations from experts regarding the use of space-based information in early warning systems;
- To compile experiences and lessons learned from existing early warning systems that already make use of space-based information;
- To identify and systematize areas where space-based information can improve the functionality of existing early warning systems;
- To identify knowledge management strategies that can facilitate access to and use of space-based information in early warning and disaster preparedness;
- To identify strategies or procedures to facilitate or improve the transition between early warning and emergency response efforts;
- To identify strategies to enhance synergies between the space community and those members of the disaster-risk management and emergency response communities involved in early warning and disaster preparedness.
- To collect a variety of suggestions and recommendations from experts in the area of knowledge management, and in particular on ways to improve the usability of its Knowledge Portal.

IX. Steps ahead

Having completed the expert meeting, UN-SPIDER will systematize the recommendations gathered during this event, prioritize them in line with the UN-SPIDER workplan, and define an agenda of work involving experts and stakeholders as a way to contribute to the improvement of early warning and preparedness efforts through the use of space-based information.

X. ANNEX 1 – Programme of activities

TUESDAY, 25 June 2013

TIME	ACTIVITY	Lead / Moderation
8:30 - 09:00	**Registration of Participants**	
09:00 – 09:30	**OPENING REMARKS** Secure World Foundation German Aerospace Center UNOOSA / UN-SPIDER	Moderator: UN-SPIDER
09:30 - 10:30	**SESSION 1: RS, EW and DP** UN-SPIDER and early warning efforts. Early Warning Systems for Natural Disasters. Early Warning in the case of Near Earth Objects	 UN-SPIDER DLR SWF
10:30 – 11:00	**Coffee break**	
11:00 – 12:30	**DISCUSSION SESSION 1: Improving Early Warning Systems: Novel Space-based applications to monitor and forecast events** Group 1:Hydrometeorological hazards Group 2: Geological Hazards Group 3: Biological hazards	All participants Discussion sessions chaired and facilitated by selected participants
12:30 – 13:00	**Plenary Session: Group presentations**	Rapporteurs of groups
13:00 - 14:00	**Lunch Break**	
14:00 - 15:00	**SESSION 2: Enhancing the Early Warning Message: from warning about events to its potential impacts** Remote sensing applications in case of floods Forest Fires and EW - soils, forests, population Risk assessment and Tsunami early warning	Moderator: UN-SPIDER RCMRD CFS IO-TEWS / Sri Lanka
15:00 - 15:30	**Coffee Break**	
15:30 - 17:00	**DISCUSSION SESSION 2: Using Space-based information: from early warning to early response** Group 1: Hydrometeorological hazards Group 2: Geological Hazards Group 3: Biological hazards	All participants Discussion sessions chaired and facilitated by selected participants
17:00 - 17:30	**Plenary Session: Group presentations**	Rapporteurs of groups
17:30	**End of the First Day of the Expert Meeting**	

WEDNESDAY, 26 June 2013

TIME	ACTIVITY	Lead/Moderator
08:30 – 09:30	**SESSION 3: Enhancing links in the early warning chain** Flood early warning: linking regional, national and local levels The "Agriculture Stress Index System" (ASIS) Combining RS, GNSS and GIS	Moderator: UN-SPIDER GIZ FAO Esri
09:30 - 10:00	**Coffee Break**	
10:00 - 12:00	**DISCUSSION SESSION 3: Enhancing links in the early warning chain** Group 1: Linking global, national and local efforts Group 2: Combining archived and up to date imagery; Group 3: The role of RS, GNSS and GIS in Early Warning applications.	All participants Discussion sessions to be chaired and facilitated by selected participants
12:00 - 12:30	**Plenary Session: Group presentations**	Rapporteurs of groups
12:30 - 14:00	**Lunch Break**	
14:00 - 15:30	**SESSION 4: THE WAY FORWARD** Plenary discussion: Strategic Directions - the road ahead Synergies and networks Knowledge Management: The KP: a virtual platform for collaboration, enhancing the use of novel applications; tracking efforts Sustaining the efforts at the local level	Moderator: UN-SPIDER
15:30 - 16:00	**Coffee Break**	
16:00 - 16:30	**Wrap up and Farewell**	Organizing Committee
16:30	**End of the Expert Meeting**	