UNITED NATIONS
Office for Outer Space Affairs

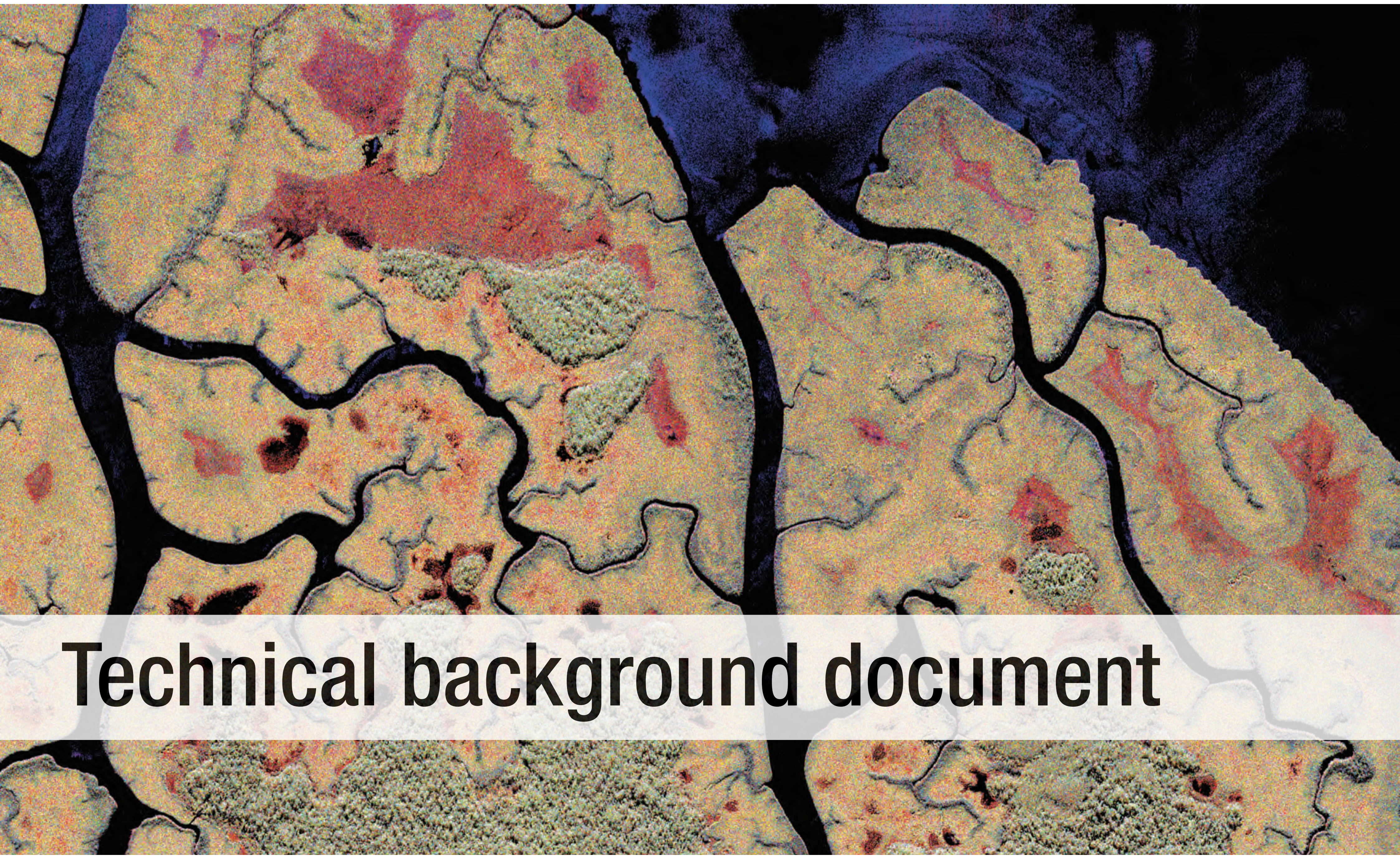
DLR

Federal Ministry
for Economic Affairs
and Energy

United Nations/Germany International Conference

International Cooperation Towards Low-Emission and Resilient Societies

22-24 November 2017, Bonn, Germany



Technical background document

with the support of

STADT.
CITY.
VILLE.
BONN.

Image: DLR

Contents

Setting the stage

In recent decades communities around the world began to experience foreseen and unforeseen manifestations of improperly planned development processes, uncontrolled urban expansion, population growth, political crises, rising inequalities within and among countries, and an improper management of the environment. Some of these are visible in terms of polluted rivers, lakes, and oceans; the degradation of the environment and the services it provides, sea level rise and global warming to name a few. Other manifestations can be seen in the impacts of natural hazards such as earthquakes, tsunamis and hydro-meteorological hazards exacerbated by climate change; pandemics such as those triggered by Ebola virus, and famines due to droughts. Those who are most vulnerable are relying on migration to developed nations to escape poverty or political unrest.

Recognizing the need to address these immense challenges and the root causes of those processes that area putting at risk the survival of many societies around the world and the biological and environmental support systems of the planet; leaders from nearly all countries of the world revamped the global development agenda in 2015 launching the Sendai Framework for Disaster Risk Reduction 2015-2030, the 2030 Agenda for Sustainable Development and the Paris Agreement.

The Sendai Framework calls for an improved understanding of disaster risk in all its dimensions of exposure, vulnerability and hazard characteristics to enhance the resilience of those societies that face such natural hazards. The aim is a "*substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries*." [1]

The Paris Agreement builds on the notion that "climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries". It calls on all Member States to conduct a variety of efforts to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels; and to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.[2]

Figure 1: The Third International Conference on Disaster Risk Reduction, Sendai, Japan, March 2015.

The 2030 Agenda[3] establishes an overarching plan of action for people, planet and prosperity with the aim of guiding global efforts towards sustainable development, marking a paradigm shift in how we approach development challenges. It calls for long-term thinking and an integrated approach, premised on cultivating inclusive partnerships where all relevant stakeholders' interests are heard and considered.

---

[1] UNISDR (2015): **Sendai Framework for Disaster Risk Reduction 2015-2030**. Available at <http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf>

[2] UNFCCC (2015): **Paris Agreement**. Available at < https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>

[3] United Nations General Assembly (2015): **Transforming our world: the 2030 Agenda for Sustainable Development.** Available at <http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E>

The three global agendas are geared to steer development trends worldwide to continue efforts towards sustainable development addressing the challenges posed by climate change and natural hazards. Structured in terms of goals or targets, the agendas refer to the need to achieve concrete results which can be monitored using indicators and to track progress using baselines.

Figure 2: Cities as engines of development worldwide.

Earth observation can contribute to track the status of our natural resources, the climate, our oceans and polar caps, land use patterns, the spatial evolution of cities, the expansion of the agricultural frontier, and other features of our planet. When incorporated in routine monitoring activities, Earth observation supports informed decision making at the local, national, regional and global level; helping us find ways to reduce disaster risks; identify different alternatives to plan our adaptation to climate change, prepare better for unavoidable losses and damages triggered by disasters, and contribute to monitor how well our efforts are leading to sustainable development; providing relevant information to align targets and indicators included in these global agreements; and can be used to develop harmonised national reporting systems.

Equally important is the use of satellite technologies to contribute to design of land-use planning norms or territorial ordainment policies to elude the impacts of natural hazards such as floods and landslides on critical infrastructure and settlements, and to elude the potential effects of sea-level rise in coastal areas. These technologies can also be used to contribute to the monitoring of natural hazards and vulnerable elements exposed to such hazards to improve early warning systems, to design insurance programmes in agriculture and livestock, as well as for forecast-based financing options.

Space technologies in disaster risk reduction, climate change and sustainable development

Since several decades ago, the space community has been developing, constructing and launching satellites into orbit to conduct systematic observations of the Earth, including of the land and water bodies, oceans, ice masses and the atmosphere. Satellite communications provide the backbone for the transmission of data generated by sensors such as buoys at sea and sensors deployed by scientists in remote areas. In recent years more and more applications are making use of the Global Positioning System (GPS) of the United States to assist in navigation, and the data from GPS is used to assess the magnitude of very large earthquakes, particularly when seismometers become saturated.

Figure 3: Sentinel 1a of the COPERNICUS programme of the European Commission (Courtesy of COPERNICUS).

Space technologies have a great potential to address global challenges such as climate change monitoring and mitigation, disaster risk reduction or sustainable development. All three types of space applications (i.e. Earth observation, satellite navigation and satellite communications) can help in various ways to monitor and help mitigate the negative effects of these global challenges as well as contribute to efforts in the field of sustainable development.

Earth observation satellites can not only provide up-to-date information on damages resulting from disasters (e.g. earthquakes, floods, hurricanes, etc.) but also monitor variables related to disaster hazards and risks, and deliver time series to identify significant changes of the environment and exposure of societies. They also help monitor essential climate variables and provide information to support ensuring compliance with international agreements, thereby contributing to the implementation of the Paris Agreement, the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals. In this regard, space data can be used as invaluable tools in the verification of the implementation of the treaties.

Communication satellites can ensure connectivity in regions where terrestrial infrastructure has been destroyed by natural or man-made disasters, mainly because their ground segment equipment is well suited for deployment in such areas. This allows real-time access to data, as well as the exchange of huge amounts of data between all stakeholders involved. Space-based telecommunication also allows providing communication services to areas deprived of terrestrial infrastructures.

Navigation satellites provide additional contributions, such as the “Search and rescue” service of the Galileo system.

Figure 4: SMALLGEO HISPASAT 36W-1. Courtesy of ESA.

The Space community remains committed to support global conventions such as the Paris Agreement, the Sendai Framework and the Sustainable Development Goals; and foresees the conduction of additional efforts to launch satellites to re-visit many regions of the Earth more frequently, with higher resolution, and expanding the range of the electromagnetic spectrum of its sensors to supply relevant data to understand the dynamic nature of the planet.

As a way to contribute to an improved understanding of the Earth system worldwide and to the implementation of these global frameworks, several space agencies began to implement open data policies in recent years that allow scientists in universities and research centres, staff in government agencies, non-government organisations and end-users to access satellite data free of charge. Examples include the open data policy of the European Commission concerning the Sentinel satellites of the COPERNICUS programme, the open data policy of the United States Geological Survey concerning satellite imagery of the Landsat satellites and the open data policy of the National Oceanographic and Air Administration concerning satellite data from environmental satellites.

Specific space agencies in many countries of the world, such as the German Aerospace Centre, contribute to the efforts of researchers addressing environmental issues including climate change through the donation of satellite data; and the European Space Agency has agreements with the World Bank to facilitate the use of satellite data to contribute to efforts related to development.

In a parallel fashion, several space agencies and the IT community have been developing open software to process such satellite data to facilitate the generation of relevant information in a timely basis. These two advances are allowing stakeholders in developing countries to generate timely information that can be used to track the status of the environment and to discover other applications of space-based information in disaster risk reduction, climate change and sustainable development.

In recent summits of Heads of Space Agencies, they recognised the usefulness of international cooperation and the pooling of resources to contribute to climate change, and reaffirmed their commitment to work together within a coordinated international framework including users, service providers and policymakers.[4,5]

Despite the efforts conducted by the space community, there are several needs that should be addressed to enhance the use of space technologies to achieve the goals and targets stipulated in the Paris Agreement, the Sendai Framework and the Sustainable Development Goals:

a) In the field of Earth observation, there exist several applications addressing disaster risk management and climate impact assessment and monitoring which have reached a level of maturity so that they could be used in a more systematic manner. However, the transition from scientifically-driven projects to operational utilisation in disaster risk reduction and climate adaption remains challenging. The conference could therefore discuss the involvement of new stakeholders and the establishment of new partnerships, namely between the private and the public sector, as well as new operational frameworks to allow this transition, including with the private sector;

b) In the field of communications, there exists a lack of coverage at high latitudes due to most communication satellites being stationed in GEO. Mega-constellations operating in LEO could, in contrast, provide coverage even at high latitudes, as most as them are placed on (or near) polar orbits. They could therefore establish broadband connectivity in regions which are not well served even by terrestrial infrastructure – regions which are at the same time particularly sensitive to climate change. However, as the feasibility of mega-constellations has yet to be demonstrated as well as their environmental pacific feasibility, there is still some uncertainty as to whether they will materialise. In the same vein, the ground/user segment is still unclear, i.e. what a user will need to invest to use mega-constellations for their connectivity needs.

In addition to these application-specific challenges, there is a more general necessity to strengthen international efforts and cooperation on phenomena such as climate change and disasters triggered by natural hazards. This requires common views as well as pooled efforts. Experience has shown that space-based emergency mapping as well as the provision of information required to address climate-related issues can be achieved effectively only in close cooperation with international mechanisms such as UN-SPIDER, the International Charter on Space and Major Disasters, the Committee on Earth Observation Satellites (CEOS) or the Global Climate Observing System (GCOS).

As such the following requirements could be addressed in a comprehensive manner in a view to support international cooperation to contribute to the implementation of the Agenda 2030 for sustainable development:

- Identify gaps in existing observational networks with focus on needs of developing countries, requirements derived from the Agenda 2030 for sustainable development, continuity of observations, development of in situ networks, and potential benefits of enhanced observing systems;

---

[4] International Academy of Astronautics (2015). Heads of Space Agencies Summit in Mexico City, Final Declaration, 18 Sept. 2015. Available at <https://iaaweb.org/iaa/Communication/pr1502.pdf>

[5] CNES, ISRO (2016) <https://in.ambafrance.org/Space-agency-heads-reaffirm-commitment-to-monitor-greenhouse-gases-emissions-13701>

- Promote and coordinate surface- and space-based observing systems to provide long-term continuous observations of all components of the Earth System;
- Ensure that the Earth and its physical processes are monitored globally across spatial and temporal scales;
- Advocate for improved collection of observations and dissemination of data, exploring also private public partnership models;
- Encourage improved utilization and uptake of space science, technology and innovation outcomes for development cooperation and to support implementation of the Agenda 2030 for sustainable development.

International Cooperation - the United Nations Committee on the Peaceful Uses of Outer Space.

In the context of international cooperation, the United Nations Committee on the Peaceful Uses of Outer Space[6] (COPUOS) has reiterated the usefulness of space technologies to address the challenges posed by climate change and natural hazards and consistently calls for the use of space technologies to generate useful information to address these challenges. In the year 2006, the Committee elevated to the General Assembly the usefulness of implementing a programme within the United Nations to enhance the use of space technologies in disaster risk reduction. Based on this recommendation, the General Assembly of the United Nations adopted its Resolution 61/110 establishing the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).[7]

Figure 5: COPUOS in session at the Vienna International Centre.

In the context of climate change, the Committee on the Peaceful Uses of Outer Space (COPUOS) incorporated the topic of Space and climate change during its fifty-second annual session in Vienna, Austria, in June 2009. In the report of its 2009 annual session[8], the Committee noted that "the adverse effects of climate change constituted a threat to communities worldwide and were manifested through a variety of processes – such as increasing global average temperature, sea-level rise and the fragmentation and melting of the polar caps". In addition,

---

[6] More information on COPUOS is available at < http://www.unoosa.org/oosa/en/ourwork/copuos/index.html>

[7] United Nations General Assembly (2006**): Resolution adopted by the General Assembly on the United Nations Platform for Space-based Information for Disaster Management and Emergency Response 61/110**. Available at <http://www.unoosa.org/pdf/gares/ARES_61_110E.pdf>

[8] COPUOS: Report of the Committee on the Peaceful Uses of Outer Space. A/64/20. Available at: <http://www.unoosa.org/pdf/gadocs/A_64_20E.pdf>

the Committee noted that space-based observations complemented by ground-based observations were well suited to monitoring the different manifestations of climate change and the factors contributing to it.

Taking into consideration the launch of the Sendai Framework for Disaster Risk Reduction 2015-2030, the Paris Agreement and the 2030 Agenda for Sustainable Development; the Committee incorporated in its deliberations the need to encompass the use of satellite technologies to contribute to the implementation of these three global agendas in the **Space 2030 Agenda** that the Committee will launch in June 2018. The next section describes this effort.

UNISPACE+50 and its preparatory process

Since decades ago, the United Nations recognised the potential of space technology for socio-economic development through three global conferences on the Exploration and Peaceful Uses of Outer Space (UNISPACE), the first of which took place in 1968. In 2015, the Committee on the Peaceful Uses of Outer Space (COPUOS) and the United Nations Office for Outer Space Affairs (UNOOSA) launched the UNISPACE+50 process to mark the fiftieth anniversary of the first UNISPACE conference and chart the future role of COPUOS, its subsidiary bodies and UNOOSA in line with the 2030 Agenda for Sustainable Development[9].

As an ambitious undertaking by the Committee, UNISPACE+50, to take place in 2018, will consider the status and chart the future role of the Committee, its subsidiary bodies and the Office for Outer Space Affairs as important players shaping global space governance.[10] The main outcome of UNISPACE+50 will be the SPACE 2030 Agenda. This agenda will include a Plan of Action containing decisions on agreed thematic priorities and related activities, directions for their implementation and expected time-bound results, including any additional or repositioned mandates of the Office for Outer Space Affairs and corresponding resources, to strengthen the delivery of adequate services in for the benefit of developing countries.

The preparatory work outlined by the Committee towards UNISPACE+50 includes a series of high level forums on “Space as a driver for socioeconomic sustainable development”, a series of United Nations international conferences and workshops hosted by Member States on the seven thematic priorities that have been defined by the Committee to steer this preparatory work, a UN-SPACE dedicated session in 2017 on UNISPACE+50 and a UNISPACE+50 exhibition in 2018.

The Thematic Priorities of UNISPACE+50

The thematic priorities of UNISPACE+50 and their long-term deliverables will clearly align with the 2030 Agenda for Sustainable Development, in the areas where stronger space governance and supporting structures are required to protect the space environment and secure the long-term

---

[9] COPUOS (2015): **Fiftieth anniversary of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space: theme of the sessions of the Committee on the Peaceful Uses of Outer Space, its Scientific and Technical Subcommittee and its Legal Subcommittee in 2018**. Available at: < http://www.unoosa.org/res/oosadoc/data/documents/2015/aac_105l/aac_105l_297_0_html/AC105_L297E.pdf>

[10] COPUOS (2016): **Fiftieth anniversary of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space: The Committee on the Peaceful Uses of Outer Space and global space governance**. Report A/AC.105/C.1/2016/CRP.4. Available at < http://www.unoosa.org/res/oosadoc/data/documents/2016/aac_105c_12016crp/aac_105c_12016crp_4_0_html/AC105_C1_2016_CRP04E.pdf>.

sustainability of outer space activities in order to ensure that benefits of this modern collaborative space governance strongly support nations in implementing the 2030 Agenda and reaching its goals. The seven thematic priorities are:

(1) Global partnership in space exploration and innovation;
(2) Legal regime of outer space and global space governance: current and future perspectives
(3) Enhanced information exchange on space objects and events
(4) International framework for space weather services
(5) Strengthened space cooperation for global health
(6) International cooperation towards low-emission and resilient societies
(7) Capacity-building for the twenty-first century

As outlined in figure 6, the thematic priorities will be used to shape the SPACE 2030 Agenda based on four pillars: space economy, space society, space accessibility and space diplomacy.

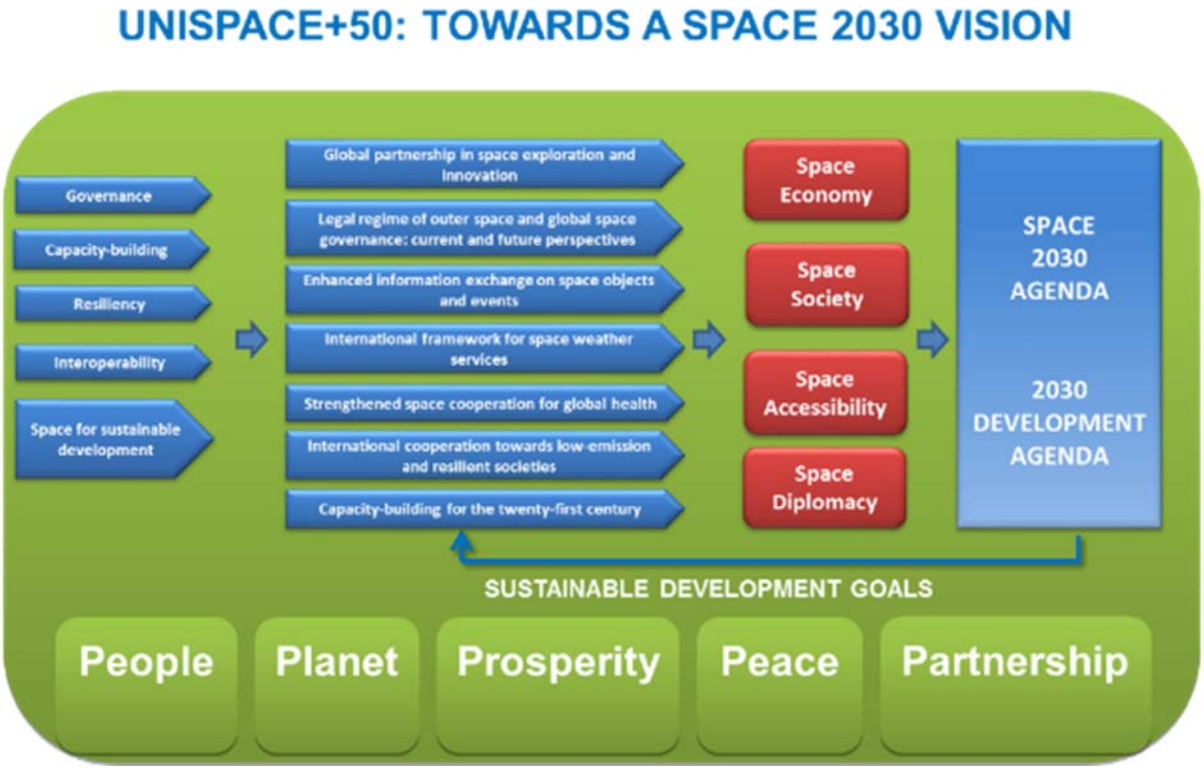


Figure *6*: The building blocks of UNISPACE+50.

Thematic Priority 6 addresses the topic of “International cooperation towards low-emission and resilient societies”. Through this Thematic Priority, the Committee envisions the following objectives:

- To define synergies between climate change mitigation efforts, disaster risk reduction and global development;
- To develop a road map for enhanced resiliency of space-based systems and the affiliation of existing and future Earth observation, global navigation satellite system and telecommunication constellations for disaster risk reduction and climate change monitoring and mitigation;

- To improve integrated space applications approaches and the interoperability of space-based systems and ground/in situ systems;
- To provide requirements to new developers for coverage in geographical areas not sufficiently monitored or applications that need further development; and
- To identify governance and cooperation mechanisms to support this objective.

The Committee tasked UNOOSA to undertake the work under this Thematic Priority and report regularly to the Committee and its Subcommittees on the work under this Thematic Priority. As a way to carry out this task, UNOOSA has conducted a variety of activities including the organisation of several international conferences and expert meetings, participation in selected conferences and events organised by United Nations organisations leading efforts in climate change, disaster risk reduction and sustainable development, and conducting a review of official publications and reports to extract relevant information on the current and foreseen use of space technologies in combination with in-situ information in disaster risk reduction, climate change and sustainable development efforts. The following international conferences, symposia and expert meetings were used to compile policy-relevant recommendations related to this Thematic Priority. Annex 1 presents those policy-relevant recommendations stemming from each one of these events. Figure 7 presents a timeline of these events.

Figure 7: Timeline of events conducted by UNOOSA to compile inputs for Thematic Priority 6.

Key recommendations linked to Thematic Priority 6

Between the fall of 2015 and the fall of 2017 staff from UNOOSA compiled key recommendations to be considered as part of Thematic Priority 6. Sources for these recommendations include:

- The international conferences, symposia, and regional expert meetings conducted by UNOOSA under the umbrella of the UNISPACE+50 process; and
- A review of the texts and means of implementation of the Sendai Framework, the Paris Agreement, the 2030 Agenda for Sustainable Development and the UN Convention to Combat Desertification.

As expected, there are two parallel tracks in which space technologies can be used when considering these three global agendas: to identify measures to be implemented to reach the goals and targets, and to monitor progress in achieving the goals through specific indicators defined by governments as part of these global agreements. Table 1 presents a summary of the types of possible contributions.

Table 1: Potential use of satellite technologies, in combination with in-situ data, in the implementation of the global frameworks and agendas

	Sendai Framework	**Paris Agreement**	**Sustainable Development**
Implementation	In applications to enhance an understanding of risks, design policies and measures to reduce existing risks and avoid the generation of new risks, improve disaster preparedness and build back better,	In on-going efforts targeting systematic observations of the climate and its manifestation; in mitigation, adaptation and loss and damage efforts	In the implementation of several of the sustainable development goals
Monitoring of implementation	In targets A (quantification of impacts due to disasters) and G (multi-hazard early warning systems and risk information	To contribute to define National Determined Contributions (NDCs) to be submitted to the Conference of Parties (CoP); As part of the Global Stocktake to be conducted as part of the climate change negotiations	To track progress in selected indicators defined as part of specific goals (goals 1, 2, 6, 9, 11, 14, and 15.)

Climate change

In the context of the three global agendas, it can be stated that it is in the climate change area where the space community has been more consistently engaged since the late 1990s. For example, to contribute to the climate change negotiations with scientific inputs, the International Panel on Climate Change (IPCC) and the World Research Programme on Climate (WCRP) heavily rely on systematic observations of the climate using space-based, aerial and in-situ instruments. The Global Climate Observing System (GCOS) has incorporated the Committee on Earth Observation Satellites (CEOS) to streamline the cooperative efforts of the space community to contribute to the continuous monitoring of the Essential Climate Variables (ECVs).

In parallel, several space agencies are also contributing to additional efforts to enhance the understanding of the concentrations of greenhouse emissions in the atmosphere like the GOSAT missions of the Japanese Aerospace Exploration Agency (JAXA), deployed to detect and track the concentrations of greenhouse gases in the atmosphere. Another example is the use of satellite technologies to monitor sea level rise by the National Centre for Space Studies of France (CNES). In addition, there are efforts by the European Space Agency (ESA) and other space agencies to track changes in sea ice and the melting of glaciers for example. Annex B contains a more detailed description and examples of the contributions of the space community to climate change efforts.

Recognising the need to migrate from experimental observations of the Earth using satellites to systematic, long-term observations of the ECVs, CEOS has developed an *Architecture to Monitor Climate from Space*[11]. The implementation of this architecture is coordinated by the joint CEOS/CGMS Working Group Climate (WGClimate) that was established in 2013. The architecture calls for a constellation of research and operational satellites, broad, open data-sharing policies and contingency planning. It includes agreements that are essential for bringing continuity to long-term and sustained climate observations that were established for weather observations.

When considering the Global Stock take contemplated in the Paris Agreement, it is important to clear in mind that Parties do not consider a global, satellite-based monitoring system of greenhouse gas emissions, but instead access to satellite data by each Party to generate its own reports as part of this Global Stock take.

Taking note of the efforts being conducted by the space community under the umbrella of CEOS to contribute to systematic observations of the ECVs, by the World Meteorological Organisation (WMO) to assess the climate, by the European Commission through its COPERNICUS programme, and other parallel efforts by different space agencies, an initial and key recommendation is for the Committee to endorse and support such efforts.

Another important key recommendation is for the Committee to encourage the space community and stakeholders to also conduct efforts to enhance the use of satellite technologies to contribute to adaptation efforts worldwide. For example:

- To contribute to the assessments of vulnerability as foreseen in the climate change negotiations as an input for Parties to elaborate their National Adaptation Plans;
- To systematise current land-use trends to find options to adapt to the different types of manifestation of climate change (sea level rise, areas exposed to more frequent floods or droughts, etc);
- Encourage a more systematic use of satellite technologies to assess the degree of melting of glaciers and to identify potential adaptation strategies.

UNOOSA could consider implementing a similar initiative to UN-SPIDER in the topic of climate change to promote the use of space technologies and in-situ data in climate change efforts, with a focus on developing countries.

Another key recommendation stemming from conferences and symposia conducted by UNOOSA and the German Aerospace Centre that is also highlighted in the Paris agreement and in the Sendai Framework is the need for the research community to continue its efforts regarding:

- The development of novel space-based sensors, and modelling techniques to contribute to improved monitoring of the climate and the manifestations of climate change worldwide;

---

[11] M. Dowell, P. Lecomte, R. Husband, J. Schulz, T. Mohr, Y. Tahara, R. Eckman, E. Lindstrom, C. Wooldridge, S. Hilding, J.Bates, B. Ryan, J. Lafeuille, and S. Bojinski, 2013: **Strategy Towards an Architecture for Climate Monitoring from Space**. Pp. 39. Available at: <www.ceos.org; www.wmo.int/sat; http://www.cgms-info.org/ GCOS, 2015: Status of the Global Observing System for Climate, GCOS-195, WMO, Geneva.>

- The conduction of research on the drivers and effects of climate change, using space and in-situ data, and models.

Taking into consideration the requirement stipulated in the Paris Agreement concerning the need for Parties to present their Nationally Determined Contributions (NDCs) to climate change, and the requirement for Parties to inform the Climate Change Convention regarding the year when such Parties may reach their peak in greenhouse gas emissions; a key recommendation is for the space agencies to facilitate access to data and services that Parties may use as a way to generate information to be used to elaborate their NDC, and subsequently in the Global Stock take efforts foreseen in the Paris agreement.

Disaster Risk Reduction

In the case of disaster risk reduction, satellite technologies have been used to contribute to the understanding of natural hazards, but the space community has congregated its efforts more in disaster response as opposed to disaster risk reduction. Several Space agencies have joined efforts to implement several mechanisms to contribute to disaster response efforts including the *International Charter Space and Major Disasters*, *Sentinel Asia*, and more recently, the *COPERNICUS Emergency Mapping Service*. However, the COPERNICUS Emergency Mapping Service can generate specific information on risks at the request of national government agencies and EU stakeholders.

Since a few years ago CEOS launched several pilot efforts to contribute to an improved understanding of several natural hazards including floods, volcanic eruptions and earthquakes.

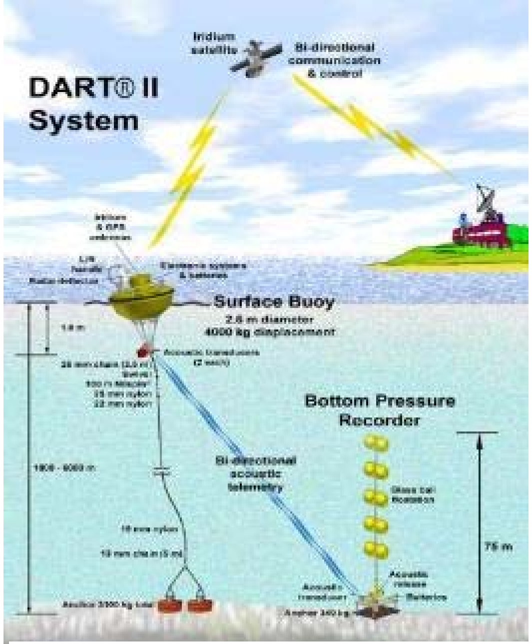


Figure 8: A diagram of the DART system including its satellite telecommunications segment. Courtesy of NOAA.

A type of application that is benefiting from the use of satellite telecommunications is early warning. Early warning systems rely on data regarding precursors that are transmitted via satellite from instruments deployed in remote areas to observatories using satellite telecommunications. Tsunami early warning systems are a case in point when it comes to satellite telecommunications, as these systems rely on data from specially designed Deep-ocean Assessment and Reporting of Tsunami (DART) buoys[12].   Buoys deployed at sea permanently.   The WMO satellite telecommunications system is used to transmit warning messages in case of tsunamis to meteorological offices or departments which then convey such warning information to civil protection agencies. Annex C contains additional information on the uses of space technologies in disaster risk reduction.

Earth observations are frequently used by meteorological offices or departments to track the temporal and spatial characteristics of bad weather in land and at sea, tropical storms, hurricanes, typhoons and cyclones.   A dedicated satellite mission was deployed to generate information on rainfall which allowed flood early warning systems.

---

[12] More information on DART buoys and tsunami early warning is available at: < http://itic.ioc-unesco.org/index.php?option=com_content&view=category&id=1343&Itemid=1343> and in < https://nctr.pmel.noaa.gov/Dart/#MainContent>

In the case of droughts, experts from the space community have developed indicators that track the effects of drought on vegetation. One of these, the Normalized Difference Vegetation Index, is used in some countries as a basis for insurance programmes targeting agriculture and livestock. The Food and Agriculture Organisation of the United Nations (FAO) has developed and uses the Vegetation Heath Index to elaborate its Agricultural Stress Index System (ASIS). ASIS makes use of the combination of archived and up-to-date information to generate information on geographical areas experiencing severe droughts, and provides a comparative view regarding the severity of specific droughts when compared with archived observations between 1980 and the present.

One key recommendation stemming from UNOOSA conferences is the promotion of the combined and complementary use of these satellite technologies, in combination with in-situ data to improve early warning systems in several ways:

- To collect information on exposure and complement this information with vulnerability to enhance warnings incorporating potential impacts linked to specific hazards that are being forecasted;
- To improve warning procedures making use of the most up-to-date information that Earth observation satellites provide (identification of evacuation routes and safe areas);
- To enhance the combined use of archived and up-to-date satellite imagery to provide a comparison on the effects of current events in comparison with the effects which took place in recent decades;
- To contribute to the implementation and improvement of multi-hazard early warning systems, including those targeting cascading effects.

A second recommendation stemming from efforts developed by the space community is the need to enhance the use of two products developed by the space community:

- Digital Elevation Models (DEMs) developed by space agencies such as the National Air and Space Administration of the United States (NASA) and DLR. These should be used to improve flood hazard and landslide risk assessments;
- Information on human settlements and land-use practices to characterize the level of exposure of vulnerable elements to natural hazards. Together with in-situ information, information on exposure can contribute to disaster risk assessment.

The Sendai Framework also incorporates explicitly a call for the use of satellite technologies in combination with in-situ data and other geospatial technologies to contribute to *Priority Area 1: Understanding Risk*.

Figure 9: Example of a Digital Elevation Model for a region of Kamchatka in the Russian Federation. Courtesy of DLR.

Recognising the usefulness of international partnerships, UNOOSA/UNSPIDER worked together with 17 partners including United Nations and other international and regional organisations, regional and national space agencies and national disaster risk reduction committees or agencies to design and launch a Global Partnership.

Figure 10: Launch of the GP-STAR during the Working Session on Earth Observations and High Technology to Reduce Risks at the World Conference on Disaster Risk Reduction in Sendai, Japan.

This *Global Partnership using Space-based Technology Applications for Disaster Risk Reduction* (GP-STAR)[13] aims to:

(a) Continue to facilitate the dialogue among stakeholders in Earth Observation, Satellite-based technologies and the global community of DRR experts and policy makers, including by the compilation and exchange of lessons learned regarding the use of such observations and technologies;

(b) Serve as a collective source and repository of information on efforts carried out worldwide by the EO and Satellite-based technology communities, including surveys and guidelines to improve the applications of existing and emerging technology to monitor hazards, exposure and risks;

(c) Generate policy-relevant advice to contribute to the integration of Earth Observation and satellite-based technologies into development processes and public policies relevant to DRR, including by facilitating the incorporation of research and technology advances in the activities of the DRR community;

(d) Facilitate the use of EO and related technology to monitor progress in the implementation of the post-2015 framework for DRR;

(e) Mobilise additional actors and stakeholders to contribute to efforts conducted by the partnership worldwide.

In a parallel fashion and under the umbrella of the Group on Earth Observations (GEO), CEOS launched the GEO-DARMA project[14] to contribute to the implementation of the Sendai Framework as well. GEO-DARMA aims to foster “the use of Earth observation (EO) data to support DRR, providing more accurate risk data for a better-informed decision making. These initiatives seek to raise the awareness within disaster risk management (DRM) communities of the benefits of using satellite EO in all phases of DRM”.

GEO-DARMA aims to support risk reduction activities through the implementation of end user priorities in line with the Sendai Framework on a trial basis in regions of the developing world. The main goal is to address critical issues related to Disaster Risk Reduction (DRR) affecting countries in three regions: South-East Asia, Latin America, the Caribbean, and Africa.

---

[13] More information on GP-STAR is available at: < http://kp.un-spider.org/network/post2015_drr>.

[14] More information on GEO-DARMA can be found in < http://ceos.org/ourwork/workinggroups/disasters/geo-darma/>

A third recommendation stemming from UNOOSA conferences is the need to strengthen UN-SPIDER and its networks, including the Network of Regional Support Offices and GP-STAR, so that the combined and complementary use of satellite technologies and in-situ information is enhanced during the period 2018-2030.

The usefulness of international cooperation is included explicitly in the Sendai Framework, in the Paris Agreement and in the Agenda 2030 for Sustainable Development. International cooperation is identified as extremely useful to support countries in their efforts to achieve the goals and targets that this agendas outline.

Equally important is the usefulness of establishing synergies among stakeholders from the public and private sectors, academia and the regional and international community to enhance the combined and complementary use of satellite technologies and in-situ data in the priority areas contemplated in the Sendai Framework.

Sustainable Development

The applications of satellite technologies in sustainable development can cover many topics from livelihoods to health to natural resources and the environment, including oceans and wildlife. As stated in the **Millennium Development Goals Report 2015**, the Millennium Development Goals (MDGs) helped "*to lift more than one billion people out of extreme poverty, to make inroads against hunger, to enable more girls to attend school than ever before and to protect our planet*". The results of this decade-long efforts led to sharp reductions in poverty worldwide, improved school enrolment rates, more girls enrolled in schools, more women taking jobs outside the agricultural sector and representing their communities or societies in national parliaments; reduced infant, children and maternal mortality; and led to a reduction in the number of deaths due to HIV, malaria and tuberculosis.

In the case of the environment, key successes include the virtual elimination of ozone-depleting substances, an increase in the size of terrestrial and marine protected areas in many regions; improved access to drinking water sources and improved sanitation; and a reduction in the urban population living in slums in the developing regions.

Interestingly, as of 2015, 95 per cent of the world's population was covered by a mobile-cellular signal. Internet penetration grew from just over 6 per cent of the world's population in 2000 to 43 per cent in 2015. As a result, 3.2 billion people were linked by 2015 to a global network of content and applications.

While these advances are notable, unfortunately the use of satellite technologies was very limited when monitoring the indicators that were defined to track progress. Established on precise goals and targets, the MDG campaign showed the immense value of setting ambitious goals. By putting people and their immediate needs at the forefront, the MDGs reshaped decision-making in developed and developing countries alike. One of the key lessons of the MDGs is that ***access to precise and accurate data is an indispensable element of the development agenda***. Using reliable data to monitor progress towards the MDGs allowed governments at national and subnational levels to effectively focus their development policies, programmes and interventions.

The MDGs energised efforts to increase the production and use of development data. Monitoring requirements drew attention to the need for strengthening statistical capacity and improving statistical methodologies and information systems at both national and international levels. However, the use of Earth observation technologies was limited in the case of the MDGs. Earth observation technologies could only be used in two of the sixty indicators.

7.1 Proportion of land area covered by forest
7.6 Proportion of terrestrial and marine areas protected

Nevertheless, the use of GPS is finding interesting applications when trying to combat outbreaks of viruses such as Ebola and Chagas. The use of geospatial data is considered as another key lesson learned: ***geospatial data can support monitoring in many aspects of development, from health care to natural resource management***.

As stated in the 2015 report on the outcomes of the MDGs, "knowing where people and things are and their relationship to each other is essential for informed decision-making. Comprehensive location-based information is helping Governments to develop strategic priorities, make decisions, and measure and monitor outcomes. Once the geospatial data are created, they can be used many times to support a multiplicity of applications. A geodetic reference frame allows precise observations and 'positioning' of anything on the Earth and can be used for many social, economic and environmental purposes, such as precision agriculture and monitoring changes in sea level rise".

Earth observation technologies offer a spatially consistent monitoring of the Earth with sufficient temporal repetition times. Space Technologies and space-based data and information can contribute to the efforts of national statistical offices' and the international community's ability to monitor the impacts of development programs and the SDGs. There are several applications for Earth observation data: harvest prediction, disaster response, and food security issues; monitoring geographic patterns and disease transmission corridors with geospatial determinants; measuring population density and the spread of new settlements; and mapping and planning transportation infrastructure. Annex D provides additional information on the potential use of space technologies to monitor progress using the indicators that have been established for this purpose.

The SDGs now cover the environment and disasters triggered by natural hazards as essential in the context of sustainable development. The continuous degradation of the environment and the increasing costs of recovery due to disasters are inhibiting developing countries from using resources to fuel progress for their citizens leading to long-term benefits.

By endorsing the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) in 2015, the world community reaffirmed its commitment to sustainable development, which is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

And adopting the notions of sustainable development implies the need to consider the fate of future generations in the decisions we are making today regarding the use of the natural resources in our planet and the services that the environment provides. Therefore, a key recommendation is for the tailoring and subsequent visualisation of the information generated combining satellite and in-situ data so that it can make decision makers aware of the potential impacts of the choices they make today on the livelihoods of future generations. This visualisation should allow decision makers to appreciate the five critical dimensions of the 2030 Agenda—people, prosperity, planet, partnership and peace, also known as the 5Ps.

Giving us a global perspective of critical issues such as climate change and natural hazards, and the information on current land-use trends around the world; satellite technologies, in combination with in-situ information, must contribute to the awareness of all the people around the world that our planet is limited in terms of its resources; that the environment is being degraded worldwide in many ways; and that sustainable development requires efforts from all societies that live in this planet.

The 2030 Agenda establishes an overarching framework to guide global efforts towards sustainable development, marking a paradigm shift in how we approach development challenges. It calls for long-term thinking and an integrated approach, premised on cultivating inclusive partnerships where all relevant stakeholders' interests are heard and considered. Through this Agenda, 193 Member States pledged to ensure sustained and inclusive economic growth, social inclusion, and environmental protection, fostering peaceful, just, and inclusive societies through a new global partnership. The 2030 Agenda is universal, transformative and rights-based, and encourages us to take bold and transformative steps, which are urgently needed to shift the world onto a sustainable and resilient path.

Therefore, another key recommendation in this context is to foster systematic spaces for cross-sectoral dialogue beyond the space and scientific community and partner diverse stakeholders to co-design contextual solutions. The SDGs force us to make conscious choices considering the trade-offs, synergies, and spin-offs of development interventions and allows all relevant actors to identify holistic solutions that engage all stakeholders and leave no one behind.

This implies the need to foster systematic spaces for cross-sectoral dialogue. Such spaces can uncover important interlinkages in challenges faced by the scientific, space, and wider development community, and provide opportunities for subject matter experts to co-design contextual solutions beyond technical assistance. These dialogues need to be convened in the spirit of transformative thinking and a desire for life-long learning, encouraging all relevant actors to break out of silos driven by technical approaches and join the dots between sectors. As such, it is crucial to raise awareness of and enhance public accessibility to space-based technologies and tools, and their applications to catalyse cross-fertilisation of ideas and action for sustainable development.

Finally, sustainable development calls for long-term thinking as well as policy coherence and coordination, and space-based systems and technologies have significant potential to inform policymakers in this regard. In terms of policy coherence and coordination, data retrieved through space-based technologies can be used for integrated policy approaches across the dimensions of sustainable development. For example, satellite data on changed environmental conditions may inform decision-makers in environmental ministries as well as in health ministries to facilitate better understanding of changing environmental conditions as trigger vectors for diseases.

Cross-cutting recommendations

The previous three sections addressed specific content and recommendations related to the three development agendas in a separate fashion. In addition, an integrated review of these three global agendas leads to the identification of cross-cutting recommendations which are presented in this segment.

Open Access and use of geospatial data;

The three agendas call for enhanced access to geospatial data, including data derived from satellite technologies. The obvious way is through the incorporation of open data policies. While several space agencies have introduced open data policies to facilitate access to the data that they generate; there is a need for government agencies, including those in developing countries, to also incorporate such open data policies, so that stakeholders are then able to combine the use of space-based and in-situ data as a way to generate relevant information to contribute to the identification of measures to be implemented as a way to implement these agendas, and to track progress through the indicators which have been already established by governments for this purpose.

To enhance the use of geospatial data in particular, countries should consider the design and implementation of National Spatial Data Infrastructures (NSDI). These infrastructures facilitate inter-institutional agreements on metadata, standards, and technologies to be used to facilitate access and exchange of geospatial data.

Therefore, it is important for the Committee to call on its Member States and the space community to implement open data policies as a way to facilitate access to geospatial data, and the incorporation of NSDIs as a way to streamline the sharing and use of such geospatial data.

Engagement with the private sector, including through private public partnerships;

Equally important is the need to facilitate the engagement of the private sector when considering the generation of data, either via satellite systems or ground-based systems; the processing of such data to generate relevant information; and ways to visualize the geospatial data and information that are generated.

Building on previous experiences, three interesting approaches can be mentioned:

- The joint conduction of case studies addressing the “Return of Investment” on the use of both open data as well as commercially available data to generate relevant information in a timely fashion. Along these lines it is equally important to compare the use of open software as well as commercial software to process raw data, and to visualize the results;
- The assessment of the usefulness of private-public partnerships to enhance the generation and use of geospatial information generated using space-based and in-situ data;
- The assessment of the potential roles of the private sector in terms of commercializing raw data to generate relevant information on a timely basis; and/or the provision of services that facilitate access to information to be generated on demand as part of the provision of a service.

Research; synergies between science and policy

The three global agendas note the need for science to provide guidance. The Paris Agreement calls for Parties “to undertake rapid reductions thereafter in accordance with best available science”, and that adaptation action should be “guided by the best available science”. The Sendai Framework reiterates that disaster risk reduction requires a multi-hazard approach and inclusive risk-informed decision-making based on “comprehensible, science-based, non-sensitive risk information, complemented by traditional knowledge”. Priority 1 of the Sendai Framework calls for a dialogue among scientific and technological communities, other relevant stakeholders and policymakers in order to facilitate a science-policy interface for effective decision-making” and “to enhance the development and dissemination of science-based methodologies and tools”.

The 2030 Agenda for Sustainable Development calls for contributions “to strengthen developing countries’ scientific, technological and innovative capacities to move towards more sustainable patterns of consumption and production”. Goal 9 of the SDGs calls for efforts to “enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending”. Goal 14 addresses the use of scientific cooperation to minimize and address the impacts of ocean acidification, and to use science-based management plans to restore fish stocks in the shortest time feasible and to conserve at least 10 percent of coastal and marine areas, on the best available scientific information.

The space community is fully aware of the need to conduct research to design and launch satellites capable of generating the data that is needed to generate the scientific knowledge required by these global agendas to contribute to their implementation.

Therefore, the Space 2030 Agenda should incorporate elements regarding the need to encourage the space community, research centres and universities to continue conducting research to contribute to the implementation of these global agendas. In addition, the Committee could consider a recommendation for UNOOSA to participate more actively in the scientific for a that the global agendas have implemented to pave the way for their implementation (the Scientific and Technical Advisory Group related to the Sendia Framework, the Subsidiary Body for Scientific and Technological Advice of the Climate Change Convention and the Technology Facilitation Mechanism established to support the SDGs).

Capacity building and institutional strengthening

Capacity-building and institutional strengthening are also essential to facilitate the implementation of the three global agendas and to achieve the proposed goals and targets. Since the 1970s, the Committee incorporated the Progamme on Space Applications as part of UNOOSA to carry out such capacity building and institutional strengthening efforts with a particular focus on developing countries. In a similar fashion, the UN-SPIDER programme was designed with the same aim as well.

Recognizing the need for capacity building and institutional strengthening efforts, the Committee included a specific Thematic Priority on this topic as part of the UNISPACE+50 process. This Thematic Priority has the label: Capacity Building for the 21st Century. Its goals are:

- Define new innovative and effective approaches to overall capacity building and development needs as a fundamental pillar of global space governance;
- Strengthen comprehensive capacity-building and outreach activities of the Office for Outer Space Affairs;
- Develop infrastructure for cross-sectoral and integrated applications, with combined scientific, technical, legal and policy outputs;
- Enhance existing partnerships and forge new ones to strengthen and deliver targeted capacity-building and technical advisory activities based on needs assessment; and
- Promote efforts to encourage science, technology, engineering and mathematics education, especially for women in developing countries.

Table 2 provides a summary of the key recommendations that have been outlined above.

Table 2: List of specific recommendations related to the three global agendas and cross-cutting recommendations.

Climate Change	Risk Reduction	Sustainable Development
Endorse and support efforts conducted by the space community under the umbrella of CEOS, by the WMO, the EC and space agencies.	Promotion of the combined and complementary use of satellite technologies, in combination with in-situ data, to improve early warning systems.	Tailoring and subsequent visualisation of the information generated combining satellite and in-situ data, in order to give to the policy makers a long-term vision on the impact of their choices on future generations.
Encourage the space community and different stakeholders to enhance the use of satellite technologies to contribute to adaptation efforts all over the world, taking as a model of implementation the systematic one of UN-SPIDER.	Enhance the use of: • Digital Elevation Models (DEMs); • Information on human settlements and land-use practices to characterise the level of exposure of vulnerable elements to natural hazards.	Foster systematic spaces for cross-sectoral dialogue beyond the space and scientific community and partner diverse stakeholders to co-design contextual solutions
Further enhance the efforts of the research community concerning: • The development of novel space-based sensors, and modelling techniques to contribute to improved monitoring of the climate and the manifestations of climate change worldwide; • The conduction of research on the drivers and effects of climate change, using space and in-situ data, and models.	Strengthen UN-SPIDER and its networks, including the Network of Regional Support Offices and GP-STAR.	
Encouragement from the space agencies of access to data and services, useful for the Parties in order to generate information then used to elaborate national NDC, and in the light of the Global Stock, take efforts foreseen in the Paris agreement.	Establish synergies among stakeholders from the public and private sectors, academia and the regional and international community.	
Cross-cutting recommendations: ➢ Access and use of geospatial data ➢ Engagement with the private sector, including the private and the public sector ➢ Research and synergies between science and policy ➢ Capacity building and institutional strengthening		

The United Nations/Germany International Conference on International Cooperation towards Low-Emission and Resilient Societies

The *United Nations/Germany International Conference on International Cooperation towards Low-Emission and Resilient Societies* constitutes the high point of a two-year-long process led by UNOOSA regarding Thematic Priority 6. The overall objective this International Conference is to compile and systematise inputs and suggestions from experts to structure inputs that the Committee can use to shape the corresponding segment in the SPACE2030 Agenda. The outcomes of the conference include recommendations on:

- Ways to improve existing international cooperation mechanisms to enhance the use of space-based technologies to address those elements that climate change, disaster risk reduction and global development have in common;
- Suggestions on the use of existing and future constellations of space infrastructure for Earth observation, global navigation and telecommunication in applications related to disaster risk reduction and climate change monitoring, mitigation, adaptation and assessing losses and damages;
- Ways to enhance the combined and complementary use of Earth observation, global navigation satellite system and telecommunication constellations for disaster risk reduction and climate change monitoring and mitigation;
- Approaches to enhance interoperability of space-based systems and ground/in-situ systems and requirements, e.g. for the provision of early warnings and support to better preparedness for disasters;
- Enhanced space applications to address the requirements of the three global frameworks, including their use to contribute to monitor progress in achieving the goals and targets;
- Governance and cooperation mechanisms to support these outcomes.

The conference has been structured in terms of high level panels, and sessions, which include plenary presentations and working groups sessions. The working sessions include ignite presentations and discussions geared to address key recommendations. Participants are requested to consider the recommendations that have been outlined in previous sections of this report in these discussion sessions.

The following paragraphs outline the content of the high-level panels and sessions to be conducted during the conference

High Level Panel of Space Agencies

This High-Level Panel brings together representatives from European, African, Asian and Latin American Space Agencies. They will provide views regarding on-going and planned efforts by the space community to contribute to the implementation of the Sendai Framework, the Paris Agreement and the Sustainable Development Goals.

Session 1: Role of Space Technology Applications for disaster risk reduction and climate change – quo vadis?

This session will start with four plenary presentations on Thematic Priority 6 of the UNISPACE+50 process, existing and future space technologies, as well as entry points to the use of satellite applications in disaster risk reduction and climate change. The session will then break into three working groups. Within each working group there will be three to four ignite presentations to be followed by groups discussions.

Working Group 1: Goals and Targets

The first working group will address the potential uses of space technologies in indicators that have been selected to measure progress in the relevant goals and targets. During the discussion session, participants may wish to take note of the following elements:

- In the context of disaster risk reduction, the Sendai Framework contemplates one set of indicators tracking impacts of disasters including losses. In the context of climate change there is an on-going effort in systematic observations to use satellite technologies to monitor several of the Essential Climate Variables.
- The Sendai Framework and the Paris Agreement call for Member States to report on progress in achieving the targets and highlight the usefulness of capacity building efforts and open data policies to access data and process it to generate information to be used in national reporting on progress related to the goals and targets.
- The SDGs contemplate a set of indicators that can benefit from the incorporation of the combined use of space- and in-situ-based data.

Working Group 2: Risk Reduction and Adaptation for Sustainable Development

The second working group will address the use of space technologies to contribute to disaster risk reduction, adaptation to climate change. During the discussion session, participants may wish to take note of the following elements:

- Satellite technologies could be used, in combination with in-situ information, to develop land-use planning norms to avoid the generation of new risks, to reduce the level of existing risks, and to design adaptation strategies;
- Satellite technologies could be used, in combination with in-situ information, to improve multi-hazard early warning systems. Particular areas where improvements could be useful are: ways to enhance warnings from impending hazards to potential impacts; identifying or updating evacuation routes and safe areas; forecast-based financing of measures to minimise losses, etc;
- There is a need to facilitate and speed-up the implementation of the regular use of procedures developed by the space community that are fairly well advanced in the scientific domain;
- There is a need to address via research the notion of cascading hazards, and the effects of climate change in exacerbating some of those cascading hazards (for example: storm surges in coastal areas, floods and landslides due to tropical storms and typhoons);
- There is a need to provide suggestions regarding how existing networks, associations, groups, platforms and partnerships could contribute to the implementation of the SPACE 2030 Agenda in this segment and what should be the appropriate forum where to promote such synergies.

Working Group 3: Understanding Climate and Disaster Risk

The third working group will address the use of satellite technologies to enhance our understanding of disaster and climate risks. During the discussion session, participants may wish to take note of the following elements:

- Satellite technologies are already contributing to an improved understanding of natural hazards and some of the ways in which climate change is manifesting itself in different regions of the world. The use of Earth observation to track the number of exposed elements is useful both in climate change as well as in disaster risk reduction. The combined use of archived and up-to-date satellite imagery is useful to track how exposure of vulnerable elements has changed in recent years.
- There is a need for vulnerability assessments as a way for developing countries to elaborate their National Adaptation Plans. Space technologies can be used in combination with in-situ information; but there is a need for procedures that can be presented in the context of the Climate Negotiations so that Parties may use them. This would require efforts from the research community.
- There is a need for decision makers and people around the world to understand the fact that the natural resources in the planet are limited, and that sustainable development implies a recognition that we only have this planet and must take care of it properly so that it can sustain life as we know it. There is a need to develop visual analytic procedures for decision makers and the people to become aware of the impacts of the solutions we implement today on the welfare of future generations. This would require efforts from the research community.

SESSION 2: Networks, Big data and integrated systems to support Agenda 2030

In September 2015, Heads of State adopted the Sustainable Development Goals (SDGs) as documented in the United Nations Resolution A/Res/70/1: "Transforming our world: the 2030 Agenda for Sustainable Development" (United Nations General Assembly Resolution A/Res/70/1: Transforming our world: the 2030 Agenda for Sustainable Development (2030 Agenda) , see http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.). Seventeen Sustainable Development Goals and associated targets and indicators anchor the 2030 Agenda. The 2030 Agenda specifically calls for new data acquisition and exploitation of a wide range of data sources to support implementation (Article 76), with a reference to Earth observation and geo-spatial information. The defined goals and targets need to be measured, monitored and evaluated. Taking into consideration the usefulness of space-based data and information, when combined with, modelling and in-situ information to generate objective and precise information worldwide, and taking into consideration the on-going efforts to develop appropriate indicators for the Sendai Framework and the necessities arising of the Paris Agreement, it is crucial to promote the incorporation of the use of space-based data and information to support the implementation of the 2030 Agenda.

Systematic observation and integrated assessments of the Earth system is indispensable for understanding, monitoring and evaluating the past, current and potential future states of Earth. Systematic observation requires appropriate sensor systems providing data to be fed into integrated assessment systems to turn data to information and knowledge contributing to evidence-based decision making. International efforts in developing and strengthening systematic observation and integrated systems are manifold. As examples to be mentioned in this context are the activities by Space Agencies and the Committee on earth Observing Satellites (CEOS), by the Group on Earth Observation implementing the Global Earth Observation System of Systems (GEOSS), the Global Climate Observing System (GCOS), integrated systems by WMO, FAO, UN Environment as well as by regional (e.g. European Union Copernicus programme) and national organisations. International networks and partnerships to be named as examples are the International Network of Multi-Hazard Early Warning Systems (IN-MHEWS), the Global Partnership using Space Technology Applications for Disaster Risk reduction (GP-STAR) or the Global Partnership for Sustainable Development Data.

This session addresses the UNISPACE+50 Thematic Priority 6 objective “To improve integrated space applications approaches and the interoperability of space-based systems and ground/in situ systems”. Specifically, this session aims at discussions and the suggestion of recommendations to attribute the following items:

- Ways to enhance the combined and complementary use of Earth observation, global navigation satellite system and telecommunication constellations for disaster risk reduction and climate change monitoring and mitigation;
- Approaches to enhance interoperability of space-based systems and ground/in-situ systems and requirements, e.g. for the provision of early warnings and support to better preparedness for disasters;
- Enhanced space applications to address the requirements of the three global frameworks, including their use to contribute to monitor progress in achieving the goals and targets;

In this session three plenary presentations will provide specific examples of space applications, integrated Earth observation applications in the frame of the Sustainable Development Goals (SDGs), Climate Change and the Paris Agreement as well as the Sendai Framework.

Working Group 1: Sustainable Development Goals

This working group will focus its discussion on the current and upcoming capabilities of Space Technology Applications (satellite remote sensing, satellite communication and navigation) and Earth observation to support the assessment and monitoring of the Sustainable Development Goals. Especially the complimentary and combined use of space-based data and information with statistical data will be discussed, data and knowledge gaps shall be identified. This working group will:

- Discuss requirements and gaps in the assessment and monitoring of SDGs
- Discuss current approaches, their applicability and potentials for improvements
- Elaborate on necessary enhancements of the interoperability of space-based and in-situ systems
- To identify gaps to be filled by further research and development efforts
- Foster systematic spaces for cross-sectoral dialogue beyond the space and scientific community and partner diverse stakeholders to co-design contextual solutions
- Adopt a holistic and integrated approach in applying space-based systems and technologies to identify synergies and address trade-offs between the five dimensions of sustainable development—People, Prosperity, Planet, Partnership, and Peace.

Working Group 2: Climate Change

The session will focus on requirements of the Paris agreement in the field of systematic observation, mitigation, adaptation, loss and damage with respect to Space technology applications and earth observation. In the field of mitigation, several activities working on monitoring Carbon and GHG can be recognised, e.g. the GEO Carbon and Greenhouse Gases Initiative promoting interoperability and providing integration across different parts of the system, the WMO's IG3IS (Integrated global greenhouse gas information system) effort, the GCOS implementation Plan 2016 and efforts by the European Union Copernicus programme. In the field of adaptation fewer activities can be recognised, but needs and opportunities for systematic observation to assess adaptation needs, monitor and evaluate adaptation strategies, contribute to requirements in the field of loss and damage can be stated.

Consequently, this working group will:

- Discuss requirements and gaps to support implementation of the Paris Agreement
- Discuss current approaches, their applicability and potentials for improvements
- Elaborate on necessary enhancements of the interoperability of space-based and in-situ systems
- To identify gaps to be filled by further research and development efforts

Working group 3: Disaster risk reduction

To guide efforts worldwide and at all levels (from local to global), the Sendai Framework includes seven global targets and four priorities for action that should allow Member States to achieve the proposed outcome and the proposed goal stated in this framework. Integrated systems are essential for the assessment of targets considering the set of defined indicators and are essential for the understanding of disaster risk and for Multi-Hazard Early Warning Systems. Effective reporting of progress toward the seven global targets of the Sendai Framework, using the agreed indicators, requires the use of multiple types of data, including: disaster loss accounting and statistical data sources, as well as the use of new sources of data – notably Earth observations (EO) and geospatial information (GI).

The working group will hence:

- Discuss requirements and gaps to support implementation of the Sendai Framework
- Discuss current approaches, their applicability and potentials for improvements
- Elaborate on necessary enhancements of the interoperability of space-based and in-situ systems
- To identify gaps to be filled by further research and development efforts

Background material:

Earth observation-derived monitoring and methodologies are being explored by the IAEG – Working Group on Geospatial Information (WGGI) and the UN custodian agencies

Sendai Framework data readiness review

GCOS implementation plan 2016

CEOS response to GCOS implementation plan

IN-MHEWS

GP-STAR

GEOSS

UNGGIM Expert Group on the Integration of Statistical and Geospatial Information

United Nations General Assembly Resolution A/Res/69/283: Sendai Framework for Disaster Risk Reduction 2015 – 2030, see http://www.unisdr.org/files/resolutions/N1516716.pdf

United Nations General Assembly Resolution A/Res/70/1: Transforming our world: the 2030 Agenda for Sustainable Development, see http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

GEO Initiative 18: Earth observation in service of the 2030 Agenda for Sustainable Development, see http://www.earthobservations.org/geo_sdgs.php

European Space Agency (ESA) and the 2030 Agenda, see : http://www.esa.int/Our_Activities/Preparing_for_the_Future/Space_for_Earth/ESA_and_the_Sustainable_Development_Goals

International Telecommunication Union and 2030 Agenda, see http://www.itu.int/en/ITU-D/Statistics/Pages/intlcoop/sdgs/default.aspx

SESSION 3: Space-based systems for resilient and low-emission societies: The way forward

The 2030 Agenda for sustainable development, as an outcome oriented development agenda, features defined goals, targets and indicators which have to be measured in a spatial explicitly manner. This includes the seven global targets as defined in the Sendai Framework. The Paris agreement requires more and more systematic observation to support mitigation and GHG accounting as well as adaptation, loss and damage assessment. More than 50% of the Essential Climate Variables are assessed from Space.

In order to ensure continuous and reliable data provision to support implementation of the 2030 Agenda, issues like space infrastructure resiliency, which includes identification and prevention of hazards to space infrastructures, robustness (to resist, absorb, accommodate, adapt to the hazards) and timely recovery. The Dubai Declaration adopted at the first UNISPACE+50 High Level Forum on 24 November 2016, notes the stronger interconnectedness between actions to enhance the safety, security and sustainability of outer space activities, including the protection of space assets, space systems and critical infrastructures.

This session aims to discuss current satellites missions and their usefulness to support requirements of the 2030 Agenda. Furthermore, current discussions on future missions and planned satellite constellations to support systematic observation demands will be presented and discussed. Additionally, the full requirements, feasibilities and capabilities of earth observing satellites or telecommunication, navigation and meteorological satellite constellations to support the 2030 Agenda needs to be systematically assessed. Hence demand driven requirement definition is essential for the Space community to elaborate on additional research and development issues and to plan future operational mission or satellite constellations appropriately.

Consequently, this session features three working groups:

Working Group 1: Satellite constellations for sustainable development

This working group focused on current available satellite constellations and their usefulness supporting the implementation of the 2030 Agenda. Current discussions and planning for future missions, their capabilities and future satellite constellations will be presented.

This working group will

- Showcase current space technology applications and will highlight lessons-learnt hereof
- elaborate on the usefulness of open data and open access policies
- discuss currently planned future missions and satellite constellations, including reflections space infrastructure resiliency as well as implications on long-term sustainability of space assets to support the 2030 Agenda, the Paris Agreement and the Sendai Framework
- discuss on ways and modalities to work towards long-term availability, accessibility and functionality of necessary space infrastructures and ground segments

Working Group 2: Requirements Agenda2030 and development cooperation

This working group focusses on the demands at national, regional and global level considering the 2030 Agenda including the Sendai Framework and the Paris Agreement. Current data and knowledge gaps which could potentially be filled by space-based data and information should be carved out. Additionally, the connection of Space technology applications for the 2030 Agenda and the integration of this domain into international development cooperation will be elaborated.

This working group will

- Work out requirements and demands from an implementation perspective
- Showcase and lay down current data and knowledge gaps
- Elaborate on the usefulness of space-based data and information for international development cooperation

Working Group 3: International groups, platforms and partnerships

Multi-stakeholder, international partnerships, platforms and groups are meanwhile essential to work in an international cooperation context jointly on the challenges we face. Cross-sectoral and trans-disciplinary approaches are necessary due to the complexity of the problems. This session will highlight examples of international cooperation efforts in this respect and aims to work out ways to improve and strengthen international cooperation.

Consequently, this working group will

- Discuss existing international partnerships, groups and platforms, their aims and work plan
- Elaborate on needs and required modalities to improve and strengthen international cooperation

High Level Panel: International cooperation towards low-emission and resilient societies

This High-Level Panel brings together representatives from United Nations organisations involved in climate change, disaster risk reduction, sustainable development, desertification, meteorology, and industrial development as well as from the donor community. The panel will be chaired by UNOOSA and will start with a statement on behalf of the Head of the Space Administration of DLR.

ANNEX A

Policy-relevant recommendations stemming from international conferences, symposia and expert meetings carried out by UNOOSA.

UN-SPIDER+10 ANNIVERSARY CONFERENCE; Vienna, Austria, 7 to 8 June 2016

The main recommendations stemming from this conference were:

(a) Consolidate the role of the UN-SPIDER network of Regional Support Offices and GP-STAR;

(b) Improve the UN-SPIDER Knowledge Portal making it more service-oriented via the implementation of online services;

(c) Encourage the incorporation of the use of space-based information in protocols and workflows used by disaster risk management and emergency response institutions;

(d) Enhance capacity building and institutional strengthening efforts incorporating a network of training institutions, the use of "training or trainer" approaches;

(e) Continue efforts in the area of early warning systems;

(f) Continue raising awareness efforts targeting the private sector, including insurance companies;

(g) Incorporate regional and trans-boundary approaches.

UN-SPIDER/DOMINICAN REPUBLIC REGIONAL EXPERT MEETING: USE OF SPACE-BASED INFORMATION IN EARLY WARNING SYSTEMS FOR DROUGHT; Santo Domingo, Dominican Republic, 18 to 19 July 2016

The main recommendations stemming from this expert meeting were:

(a) It is important for COPUOS and UNOOSA to continue supporting the use of space-based applications and information used in the SEWS-D project in national drought early warning systems as part of the national drought policies; including the strengthening of capacity of professionals and staff who are involved in the routine operation of these drought early warning systems and in the SEWS-D project;

(b) Taking into consideration the multiple, parallel efforts conducted to promote the use of space applications in drought related efforts at the international, regional and national levels, including drought monitoring; COPUOS and UNOOSA should consider the establishment of a global framework or platform to facilitate the coordination of efforts and to encourage international, regional and national organisations to join this framework or platform;

(c) In Latin America and the Caribbean there are many regional initiatives targeting climate change, disaster risk reduction and the sustainable development goals. COPUOS and UNOOSA should promote the use of space-based technologies these regional initiatives.

UN/AUSTRIA SYMPOSIUM ON "INTEGRATED SPACE TECHNOLOGY APPLICATIONS FOR CLIMATE CHANGE"; Graz, Austria, 12 to 14 September 2016

The main recommendations stemming from this symposium were:

(a) As a way to address the effects of climate change, it is important for COPUOS and UNOOSA to promote the use of data from the new Earth observation satellites;

(b) As a way to increase the understanding of the drivers of climate change, it is important for COPUOS and UNOOSA to support the efforts of the scientific community, which is focusing on the development of novel space-based sensors and modelling techniques;

(c) COPUOS should encourage the conducting of additional research on the drivers and effects of climate change, using space and in-situ data, as well as models;

(d) COPUOS should encourage international cooperation and outreach efforts concerning the open access and exchange of data, products and services.

United Nations/Germany International Expert Meeting on the Global Partnership on Space Technology Applications for Disaster Risk Reduction; Bonn, Germany, 1 to 2 December 2016

The main recommendation stemming from this expert meeting was stated as follows:

"As a way to contribute to the implementation of the Sendai Framework for Disaster Risk Reduction, the Committee on the Peaceful Uses of Outer Space should support efforts conducted by Global Partnership using Space-based Technology Applications for Disaster Risk Reduction (GP-STAR) as an example of international cooperation geared at achieving improved coordination among institutions dedicated to promoting the use of space technology applications, to increase the resilience of societies worldwide."

UN-SPIDER/ MEXICO REGIONAL EXPERT MEETING: "ENHANCING THE USE OF SPACE-BASED INFORMATION IN MULTI-HAZARD EARLY WARNING SYSTEMS"; Mexico City, Mexico, 11 to 13 July 2017

The main recommendations stemming from this expert meeting was stated as follows:

The Committee should encourage the use of satellite technologies in early warning systems via:

(a) The establishment of strategic alliances among the State, the private sector, academia, and international and national agencies as a way to promote the establishment and maintenance of the use of satellite technologies in such multi-hazard early warning systems;

(b) The use of regional virtual platforms to process satellite data to contribute to a more efficient use of such satellite data in a simultaneous fashion in Latin America and the Caribbean;

(c) The strengthening of UN-SPIDER so that this programme facilitates the use of satellite technologies in multi-hazard early warning systems, including through the modality of recommended practices and institutional strengthening of the agencies that operate such early warning systems;

(d) The conduction of hemispheric programmes and the strengthening of human resources focusing on decision-makers and technical staff in the public sector, academia, and the private sector regarding the use of novel satellite technologies and their applications in multi-hazard early warning systems.

ANNEX B

Earth observation technologies and climate change

In recent years, more and more experts indicate that climate change is a complex process which may deter sustainable development throughout the world. As a global phenomenon, climate change poses a threat to the economic, social, and environmental dimensions of sustainable development. But the impacts of climate change will be felt more severely in developing countries and Small Island Developing States, which are most vulnerable to disasters and to the impacts related to climate change. Unfortunately, these countries have limited capabilities when it comes to adaptation to the changing environment, and thus it is necessary to find mechanisms capable to targeting resources to help them in their efforts toward adaptation.


Figure 11: The Island of Tonga in the Pacific. Image courtesy of ESA.

Recognising no political boundaries, climate change is being addressed at the highest international level through the United Nations Framework Convention on Climate Change (UNFCCC). Based on the Assessment Reports elaborated by the network of scientists belonging to the International Panel on Climate Change; and taking into consideration scientific contributions from Parties, international and regional R&D organisations, the Conference of the Parties (CoP) launched in December 2015 *the Paris Climate Change Agreement*[15] with the aim "*to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:*

(a) *Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;*

(b) *Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and*

(c) *Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".*

The Paris climate change agreement reiterates the need to mitigate the efforts of climate change through considerable reduction activities and to conduct systematic observations to track changes in the climate and those factors that are affecting it. In a parallel fashion, the agreement recognises the need to adapt to the different types of manifestation of climate change and to consider losses and damages due to climate change in a more structured fashion.

---

[15] CoP (2015). Adoption of the Paris Climate Change Agreement. See: http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600008831

Satellite Earth observation efforts are finding their applications in climate change efforts in two parallel ways:

- In efforts conducted under the umbrella of the climate negotiations that are carried out by the Parties that are engaged in the United Nations Framework Convention on Climate Change (UNFCCC). **Systematic observations of essential climate variables** fall in this category;
- In efforts conducted by a variety of stakeholders worldwide to promote the use of such satellite technologies to contribute to climate change efforts. **Research & Development** efforts fall into this category for example.

In the context of the CoP, a dedicated *Subsidiary Body for Scientific and Technological Advice* (SBSTA)[16] was set up by the CoP in 1995 to provide timely information and advice on scientific and technological matters as they relate to the Convention or its Kyoto Protocol. This Subsidiary Body plays an important role as the link between the scientific information provided by expert sources such as the International Panel on Climate Change (IPCC) and other competent international bodies and programmes in areas related to scientific, methodological, technical, socio-economic and technological questions.

The need for systematic observations of the climate was recognised from the onset of the convention. Paragraph (g) of Article 4 of the Convention states explicitly that: "*All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall promote and cooperate in scientific, technological, technical, socio-economic and other research,* ***systematic observation*** *and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies*"[17].

The Committee on Earth Observation Satellites (CEOS), the Coordination Group on Meteorological Satellites (CGMS), the Global Climate Observing System (GCOS) and space agencies are leading efforts to promote the use of satellite technologies in this area of systematic observations. In 2016, GCOS launched the report entitled "The Global Observing System for Climate: Implementation Needs"[18]. As stated, the report "A system for global climate observations comprises a combination and integration of global, regional and national observing systems delivering climate data and products". The Implementation Plan outlined by GOCS in this report guides the development of such a system and sets out what is needed to meet increasing and more diverse needs for data and information, including for improved management of the impacts and consequences of climate variability and current and future climate change. As stated by GCOS, the implementation of this Plan will:

- Ensure that the climate system continues to be monitored;
- Improve global, regional and local long-term climate forecasts by: filling gaps in network coverage, refining ECV requirements, observing additional parameters identified by the scientific community;
- Improving techniques and addressing the global cycles more holistically;
- Support adaptation;
- Improve the provision of useful information to users;
- Improve the communication of the state of the climate.

---

[16] More information on SBSTA is available in the UNFCCC webpage: http://unfccc.int/bodies/body/6399.php

[17] For the original text of the convention, including Article 4, see: http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

[18] The report is available at: <https://library.wmo.int/opac/doc_num.php?explnum_id=3417>

Taking into consideration the needs identified in terms of systematic observations by GCOS and Parties, CEOS and the Coordination Group for Meteorological Satellites (CGMS), established the Joint CEOS/CGMS Working Group on Climate (WGClimate), and presented in 2017 the document entitled "Space Agency Response to GCOS Implementation Plan[19]. In this document CEOS and CGMS reiterated the fact that "*Space Agencies have continued to evolve their systematic observation of the climate system, now spanning several decades, strengthening scientific knowledge on climate, and supporting the provision of knowledge-based information to climate services to under-pin informed decision-making*". In their response, they refer to the on-going efforts to continue implementation the ***Strategy Towards an Architecture for Climate Monitoring from Space***[20], which was developed in 2013 by CEOS, CGMS and the World Meteorological Organisation (WMO).

Figure 12: Los Glaciares National Park in Argentina. Courtesy of ESA.

The proposed architecture "*calls for a constellation of research and operational satellites, broad, open data-sharing policies and contingency planning*". Through a concerted approach on behalf of relevant stakeholders from the space community, this constellation would provide the global, long-term capacity to monitor several ECVs from space that in combination with ground- and aerial-based data would allow scientists to develop improved climate models, and to downscale from global to more local observations of the climate in a systematic and sustained fashion.

Through this initiative, CEOS and CGMS call for a more international approach to pool the required resources to monitor climate from space, including observations of the coupled ocean, land, cryosphere and atmosphere. The proposed architecture calls for efforts to ensure accuracy and stability of measurements from space, making reference to the calibration of sensors and their metrological traceability to specific units in international metric systems used by National Meteorology Institutes and Observatories. The proposed strategy also incorporates the need to address issues related to data archiving, processing, documentation and distribution.

CEOS and ESA launched a special COP 21 document entitled **Satellite Earth Observations in support of climate information challenges[21]** that explains how satellite observations contribute to monitor the climate, to track forest carbon, to monitor sea-level, global atmospheric chemistry, glaciers and ice sheets, as well as extreme weather events. In this publication CEOS introduces the notion of four "building blocks" for climate monitoring from space.

---

[19] WGClimate. **Space Agency Response to GCOS Implementation Plan**. Available at: <http://unfccc.int/files/science/workstreams/systematic_observation/application/pdf/space_agency_response_to_gcos_ip_v0.111_execsummary-v0.30.pdf>

[20] CEOS, CGMS and WMO (2013): **Strategy Towards an Architecture for Climate Monitoring from Space.** Available at: <http://www.wmo.int/pages/prog/sat/documents/ARCH_strategy-climate-architecture-space.pdf>

[21] CEOS: http://ceos.org/about-ceos/publications-2/

Climate change has also been at the forefront of efforts conducted by the European Space Agency (ESA) for the last thirty years, contributing to the systematic monitoring of several ECVs required by the convention. ESA's goal is to provide stable, long-term, satellite-based ECV data products for climate researchers. Recently, ESA launched its **Climate Change Initiative**[22] to exploit robust long-term global records of ECVs, such as greenhouse-gas concentrations, sea-ice extent and thickness, and sea-surface temperature and salinity. Within this initiative, ESA makes use of satellites to contribute to observations to enhance our understanding of the dynamics of aerosols in the atmosphere, cloud dynamics; forests, forest fires and greenhouse gases; ice melting in Antarctic, Greenland and in glaciers; sea level rise, soil moisture and land-cover, and physical properties of the oceans.

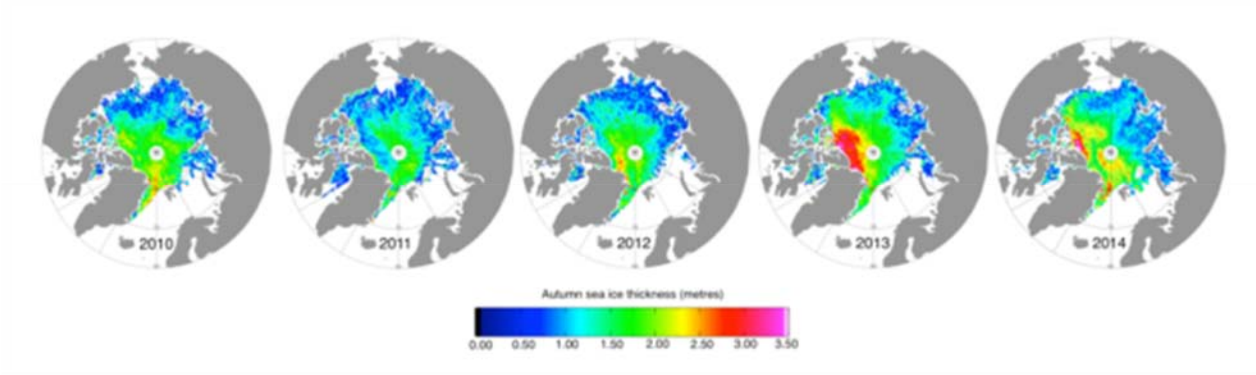


Figure 13: Autumn Arctic sea-ice thickness as measured by CryoSat between 2010 and 2014. Courtesy of ESA.

This ESA Climate Change Initiative is implemented through in two phases over a period of seven years through a series of projects. One of the features of this effort will be the establishment of an Open Data Portal that serves as a single port of entry to climate change data under this initiative. ESA collaborates with CEOS, EUMETSAT and CGMS in climate monitoring and is a strong supporter of the COPERNICUS Programme of the European Union.

Space agencies such as ESA, the National Centre for Space Studies of France (CNES) and the Japan Aerospace Exploration Agency (JAXA) are using satellites to monitor greenhouse gas concentrations in the atmosphere and track hotspots around the world, the changes of sea ice extent in the Artic and ice mass losses in Greenland and Antarctica, changes in the temperature in land and in the surface of oceans, sea-level rise and its variations in different regions of the world, glacier melting, changes in land-cover / land-use in urban and rural areas, and extreme events that trigger disasters.

Figure 14: Artist's conception of the Tandem-L mission. Courtesy of DLR.

The German Aerospace Center (DLR) is developing the space-based Tandem-L mission by which aims to contribute to monitor the environment from space, including forest biomass and its dynamics, surface moisture for water cycle research and glacial shifts and melting processes in polar regions.

---

[22] More information on the ESA Climate Change Initiative is available at: http://cci.esa.int/

Figure 15: The Merlin Satellite. Image courtesy of DLR.

DLR and CNES are also joining forces to launch the MERLIN mission[23] which aims to track methane gas concentrations in the atmosphere. The relevance of methane in the context of climate change cannot be overestimated. Methane is 25 times more potent than carbon dioxide. Its contribution is therefore significant. The goal of MERLIN is to learn more about the underlying processes of the methane cycle by characterising sources of the gas – both natural (wetlands, thawing permafrost, etc.) and anthropogenic (transport and burning of coal, natural gas and ruminant livestock, etc.).

---

[23] More information on the MERLIN mission is available at http://www.dlr.de/rd/Portaldata/28/Resources/dokumente/re/MERLIN_Datenblatt.pdf

ANNEX C

Earth observation technologies in disaster risk reduction

Earth observations are finding applications in several areas. The Tropical Rainfall Measuring Mission (TRMM)[24] of NASA and JAXA contributed to generate data on rainfall estimates from space during a period of 17 years. This mission ended in April 2015 and contributed to an improved understanding of the distribution and variability of precipitation within the tropics. The mission also allowed for an improved understanding of the interactions between water vapour, clouds, and precipitation that play a relevant role in the climate of the Earth. The data generated by TRRM was used by forecasters to predict floods, to monitor droughts and in applications in agriculture.

A continuing effort to TRRM is the Global Precipitation Measurement (GPM)[25] mission also launched by NASA, JAXA, EUMETSAT, NOAA, CNES, and ISRO in 2014. Combining the data from a constellation of satellites, GPM is able to improve precipitation measurements and enables for a global dataset of precipitation measurements. GPM's capabilities allow the mission to monitor rain and snow outside the tropic regions and will improve the capacity to monitor and predict hurricanes and other extreme weather events, as well as floods, landslides and droughts.

Two long-term missions that are contributing to environmental monitoring efforts in the air, land and sea are the Terra and Aqua satellites. These carry the Moderate Resolution Imaging Spectroradiometer (MODIS). These missions generate data on atmospheric parameters (aerosols, precipitable water, clouds), land parameters (land cover, vegetation indices, thermal anomalies useful for forest fire tracking, albedo, and water mask), cryosphere parameters (snow cover, sea ice and ice surface temperature) as well as ocean parameters (sea surface temperature, chlorophyll concentration, etc.).

Data on vegetation indexes such as the Normalised Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI)[26] are being used to monitor the effects of droughts on crops in different regions of the world. UN-SPIDER is promoting the use of these and other composite indices such as the Vegetation Condition Index (VCI) and the Standard Vegetation Index (SVI) in drought early warning systems. The aim is to complement existing information used by meteorological departments or offices concerning changes in weather and rainfall patters like the Standard Precipitation Index (SPI). From the point of view of efficient early warning systems, this introduction aims to incorporate information about vulnerable elements (crops and vegetation) into the drought early warning system as a way for the system to provide information not only on the meteorological characteristics of droughts, but also on its potential impacts on crops (agricultural drought). FAO is making use of the Vegetation Health Index in its Agricultural Stress Index System (ASIS)[27] to assess those areas that are experiencing severe droughts worldwide. FAO is developing a country version of its ASIS system to facilitate its use in developing countries.

---

[24] More information on the TRMM mission is available at: < https://pmm.nasa.gov/TRMM>

[25] More information on the GPM mission is available at: <https://www.nasa.gov/mission_pages/GPM/main/index.html>

[26] More information on these indices can be found in: < https://earthobservatory.nasa.gov/Features/MeasuringVegetation/>

[27] More information on ASIS is available at: < http://www.fao.org/resilience/news-events/detail/en/c/296089/>

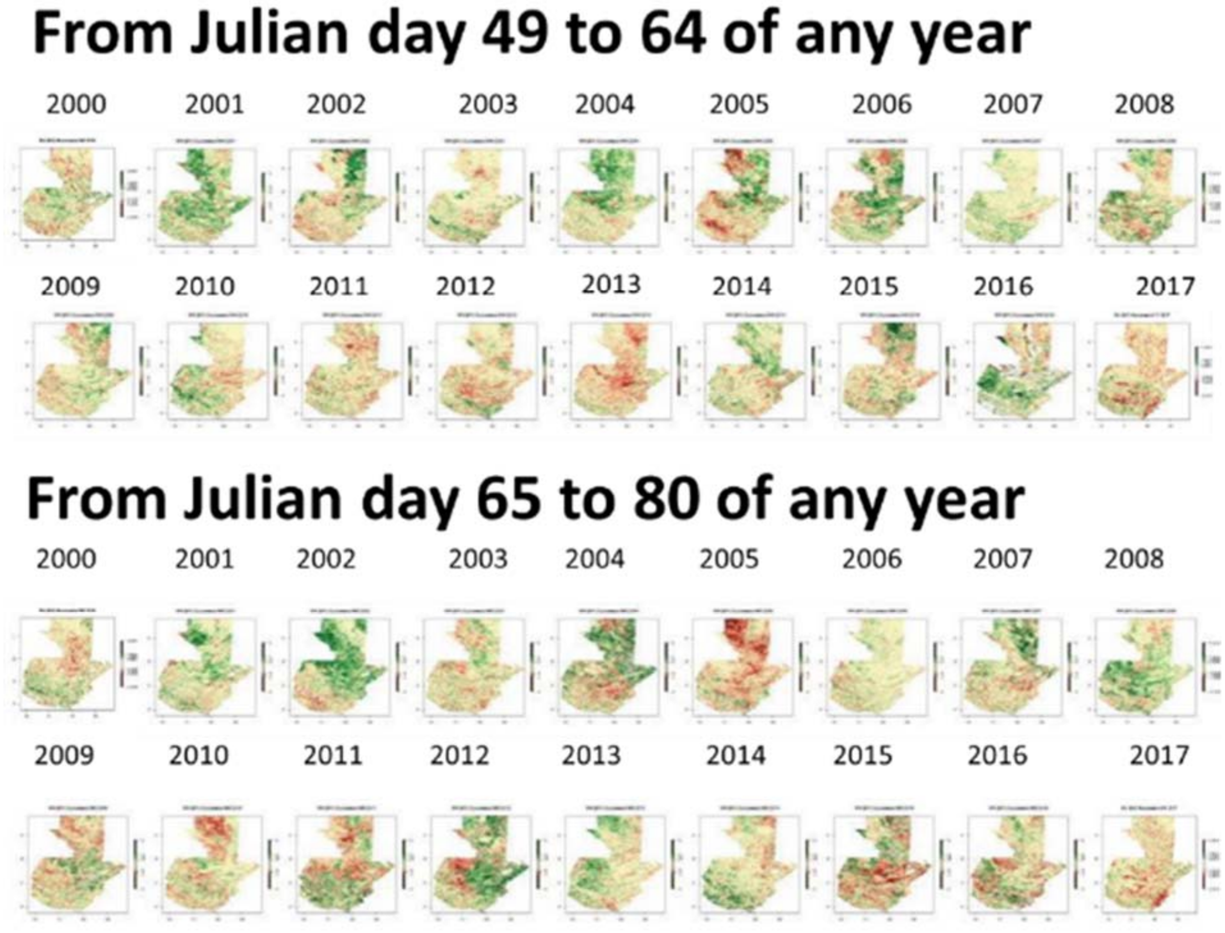


Figure 17: Example of the SVI for Guatemala for two consecutive periods (day 49 to 64, and day 65 to 80) spanning from the year 2000 to the year 2017. UN-SPIDER.

Earth observation satellites are finding applications in the case of volcanic activity in three ways. Some types of satellites are being used to track the ash clouds in the atmosphere so that air traffic controllers can warn military, commercial and private aircraft regarding the location of such ash clouds to avoid them. Another application is to use special satellites to see the cones of volcanoes, even below cloud cover, to detect the manifestation of magma. This procedure makes use of special satellites with active sensors operating in the microwave regime. The other application, still in experimental use, is to monitor the deformation of volcanic cones using a technique known as radar interferometry[28]. It allows for the comparison of two radar images of the same volcano on different days as a way to track deformations of the cone. Radar interferometry is also used to track landslides, subsidence, and the relative motion of tectonic plates due to earthquakes[29]. A complementary way to track the relative motion of tectonic plates is using Global Navigation Satellite Systems (GNSS) such as the United States Global Positioning System (GPS). Such observations are allowing seismologists to increase their understanding of these geologic hazards.

---

[28] More information on radar interferometry is available at: < http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10382/570_read-431/#/gallery/356>

[29] More information on the use of radar interferometry is available at: < http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10384/572_read-429/#/gallery/352>

Earth observation satellites are also being used in the case of forest fires. Initially Earth observations were used to track the geographical extent of forest fires. More recently, procedures have been developed to assess burn severity. In combination with in-situ information, satellite observations are allowing forest managers to design and operate forest fire early warning systems and to design strategies to combat such fires once they start considering meteorological conditions and other factors.

Natural hazards have been triggering disasters around the world for centuries. Some of the largest disasters during the last decade include the earthquakes that impacted Sichuan in China in 2008, Port Au Prince and much of Haiti in 2010, and the great Eastern earthquake and tsunami in Japan in 2011; several typhoons, hurricanes and cyclones including Hayan and Megi in the Philippines, Sandy and Irene in the west coast of the United States; the 2014-2016 El Niño event, major droughts in Asia, Africa and Latin America, as well as the eruption of Eyjafjallajökull volcano in Iceland to name a few.

The year 2017 will be remembered for hurricanes Harvey in the Gulf Coast of the United States, Irma and Maria in the Caribbean; the large monsoon floods in Bangladesh and India, the major landslides in Sierra Leone, debris flows in Colombia; and the earthquakes in Mexico.

But the impacts of such natural hazards are much worse in developing countries when compared with the impacts in developed countries. When analysing the root causes for this difference, it becomes clear that four major factors make the difference:

1. The implementation and enforcement of building codes that incorporate information regarding the geospatial extent of such natural hazards;
2. The implementation and enforcement of building codes incorporating the need for quality control of building materials and the proper structural design of infrastructure to minimize the impacts due to natural hazards;
3. The economic capacity of people in developed countries to be able to hire architects and engineers to build infrastructure;
4. The recognition of the need to adhere to the zoning laws and building codes.

Recognising the devastating impact that disasters provoke in communities around the world; the United Nations has carried out a sustained effort since 1990 to introduce changes in development frameworks used in many countries around the world so that when natural hazards such as typhoons or earthquakes manifest themselves, the impacts are lessened. The first effort began in 1990 with the International Decade for Natural Disaster Risk Reduction. In 2005, Member States met in Kobe, Japan, just a few weeks after the great Indian Ocean tsunami that provoked more than 250,000 fatalities in several countries, to agree on and to launch the Hyogo Framework for Action to steer efforts towards Disaster Risk Reduction (DRR). In March 2015, 187 Member States adopted the Sendai Framework for Disaster Risk Reduction 2015-2030 as a way to continue these efforts.

The main outcome of the Sendai Framework is *the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries*.

The framework incorporates seven targets and four Priorities for Action:

- Understanding disaster risk;
- Strengthening governance/institutional arrangements/organisational, legal and policy frameworks to manage disaster risk;
- Investing in disaster risk reduction for resilience; and
- Enhancing disaster preparedness for effective response, and to Build Back Better in recovery, rehabilitation and reconstruction.

The use of Earth observations, space-based applications, geographic information systems and remote sensing is included in three paragraphs related to Priority 1: Understanding Disaster Risk:

(a) At the national and local levels, paragraph 24(c) contains the following texts: “Develop, update periodically and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities at risk to disaster in an appropriate format by using, as applicable, geospatial information technology”; and “Promote real-time access to reliable data, make use of **space** and in situ information, including geographic innovations to enhance measurement tools and the collection, analysis and dissemination of data”;

(b) At the regional and international levels, paragraph 25(c) contains the following text: “Promote and enhance, through international cooperation, including technology transfer, access to and the sharing and use of non-sensitive data, information, as appropriate, communications and geospatial **and space-based technologies** and related services. Maintain and strengthen in situ and remotely-sensed Earth and climate observations. Strengthen the utilisation of media”.

The Sendai Framework also addresses the need to promote the conduction of comprehensive surveys on multi-hazard disaster risks and the development of regional disaster risk assessments and maps, including climate change scenarios; and the need to enhance the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems; and the need to support the development of local, national, regional and global user-friendly systems and services for the exchange of information on good practices, cost-effective and easy-to-use disaster risk reduction technologies and lessons learned on policies, plans and measures for disaster risk reduction.

To reach the goals stipulated in the framework, it calls for the to the application of science and technology, the conduction of capacity building and institutional strengthening efforts; the provision of technical advisory support, to facilitate flows of skill, knowledge, ideas, know-how and technology from developed to developing countries.

Recognising the usefulness of international partnerships, UNOOSA/UNSPIDER worked together with 17 partners including United Nations and other international and regional organisations, national space agencies and national disaster risk reduction committees or agencies to design and launch a Global Partnership. This Global Partnership using Space Technologies for Disaster Risk Reduction (GP-STAR) aims to:

(a) Continue to facilitate the dialogue among stakeholders in Earth Observation, Satellite-based technologies and the global community of DRR experts and policy makers, including by the compilation and exchange of lessons learned regarding the use of such observations and technologies;

(b) Serve as a collective source and repository of information on efforts carried out worldwide by the EO and Satellite-based technology communities, including surveys and guidelines to improve the applications of existing and emerging technology to monitor hazards, exposure and risks;

(c) Generate policy-relevant advice to contribute to the integration of Earth Observation and satellite-based technologies into development processes and public policies relevant to DRR, including by facilitating the incorporation of research and technology advances in the activities of the DRR community;

(d) Facilitate the use of EO and related technology to monitor progress in the implementation of the post-2015 framework for DRR;

(e) Mobilise additional actors and stakeholders to contribute to efforts conducted by the partnership worldwide.

As a way to contribute to efforts in disaster management, CEOS introduced a Working Group on Disasters (WGDisasters[30]) with the goal "to increase and strengthen satellite Earth observation contributions to the various Disaster Risk Management (DRM) phases and to inform politicians, decision-makers, and major stakeholders on the benefits of using satellite Earth Observations in each of those phases". As a way to reach this goal, the Working Group has:

- Defined a global satellite observation strategy for DRM (including a detailed assessment of needs, gaps, and satellite Earth observation requirements and the development of a strategy);
- Ensured the appropriate inclusion of satellite Earth observations in the "Sendai Framework for Disaster Risk Reduction 2015-2030";
- Supported DRM Outreach and Evaluation of DRM;
- Developed and strengthened relationships with stakeholder and end-users through a series of concrete actions addressing single-hazard Pilots projects (currently floods, volcanoes and seismic hazards), multi-hazards projects such as the Recovery Observatory and the GEO Geohazard Supersites and Natural Laboratories (GSNL), and through CEOS capacity building activities for disaster managers.

CEOS also launched a Disaster Risk Management Observation Strategy to respond to the observation requirements from the user community. The strategy is being implemented through thematic pilots:

- Flood pilot;
- Seismic hazards pilot;
- Volcano pilot;
- Recovery Observatory.

Under the umbrella of the Group on Earth Observations (GEO), CEOS launched the GEO-DARMA project[31], "aimed at fostering the use of Earth observation (EO) data to support DRR, providing more accurate risk data for a better-informed decision making. These initiatives seek to raise the awareness within disaster risk management (DRM) communities of the benefits of using satellite EO in all phases of DRM.

GEO-DARMA aims to support risk reduction activities through the implementation of end user priorities in line with the Sendai Framework on a trial basis in regions of the developing world. The main goal is to address critical issues related to Disaster Risk Reduction (DRR) affecting countries in three regions: South-East Asia, Latin America, the Caribbean, and Africa.

---

[30] More information on this working group can be found in < http://ceos.org/ourwork/workinggroups/disasters/>

[31] More information on GEO-DARMA can be found in < http://ceos.org/ourwork/workinggroups/disasters/geo-darma/>

ANNEX D

Earth observation technologies for the SDGs

The applications of satellite technologies in sustainable development can cover many topics from livelihoods to health to natural resources and the environment, including oceans and wildlife. As stated in the **Millennium Development Goals Report 2015**, those goals helped *"to lift more than one billion people out of extreme poverty, to make inroads against hunger, to enable more girls to attend school than ever before and to protect our planet"*. The results of this decade-long efforts can be summarised as follows:

Goal 1: Globally, the number of people living in extreme poverty has declined by more than half, falling from 1.9 billion in 1990 to 836 million in 2015. Most progress has occurred since 2000;

Goal 2: The primary school net enrolment rate in the developing regions has reached 91 per cent in 2015, up from 83 per cent in 2000. The number of out-of-school children of primary school age worldwide has fallen by almost half, to an estimated 57 million in 2015, down from 100 million in 2000;

Goal 3: Many more girls are now in school compared to 15 years ago. The developing regions as a whole have achieved the target to eliminate gender disparity in primary, secondary and tertiary education. Women now make up 41 per cent of paid workers outside the agricultural sector, an increase from 35 per cent in 1990. Women have gained ground in parliamentary representation in nearly 90 per cent of the 174 countries with data over the past 20 years;

Goal 4: The global under-five mortality rate has declined by more than half, dropping from 90 to 43 deaths per 1,000 live births between 1990 and 2015. Despite population growth in the developing regions, the number of deaths of children under five has declined from 12.7 million in 1990 to almost 6 million in 2015 globally;

Goal 5: Since 1990, the maternal mortality ratio has declined by 45 per cent worldwide, and most of the reduction has occurred since 2000;

Goal 6: New HIV infections fell by approximately 40 per cent between 2000 and 2013, from an estimated 3.5 million cases to 2.1 million. More than 900 million insecticide-treated mosquito nets were delivered to malaria-endemic countries in sub-Saharan Africa between 2004 and 2014. The tuberculosis mortality rate fell by 45 per cent and the prevalence rate by 41 per cent between 1990 and 2013;

Goal 7: Ozone-depleting substances have been virtually eliminated since 1990, and the ozone layer is expected to recover by the middle of this century. Terrestrial and marine protected areas in many regions have increased substantially since 1990. In 2015, 91 per cent of the global population is using an improved drinking water source, compared to 76 per cent in 1990. Globally, 147 countries have met the drinking water target, 95 countries have met the sanitation target and 77 countries have met both. Worldwide, 2.1 billion people have gained access to improved sanitation. The proportion of people practicing open defecation has fallen almost by half since 1990. The proportion of urban population living in slums in the developing regions fell from approximately 39.4 per cent in 2000 to 29.7 per cent in 2014;

Goal 8: Official development assistance from developed countries increased by 66 per cent in real terms between 2000 and 2014, reaching $135.2 billion. As of 2015, 95 per cent of the world's population is covered by a mobile-cellular signal. Internet penetration has grown from just over 6 per cent of the world's population in 2000 to 43 per cent in 2015. As a result, 3.2 billion people are linked to a global network of content and applications.

While these advances are notable, unfortunately the use of satellite technologies was very limited when monitoring the indicators that were defined to track progress.

This global initiative, established based on precise goals and targets, showed the immense value of setting ambitious goals. By putting people and their immediate needs at the forefront, the MDGs reshaped decision-making in developed and developing countries alike. One of the key lessons of the MDGs is that ***access to precise and accurate data is an indispensable element of the development agenda***. Using reliable data to monitor progress towards the MDGs allowed governments at national and subnational levels to effectively focus their development policies, programmes and interventions.

The MDGs energised efforts to increase the production and use of development data. Monitoring requirements drew attention to the need for strengthening statistical capacity and improving statistical methodologies and information systems at both national and international levels. However, the use of Earth observation technologies was limited in the case of the MDGs. Earth observation technologies could only be used in two of the sixty indicators:

7.1 Proportion of land area covered by forest
7.6 Proportion of terrestrial and marine areas protected

Nevertheless, the use of GPS is finding interesting applications when trying to combat outbreaks of viruses such as Ebola and Chagas. The use of geospatial data is considered as another key lesson learned: ***geospatial data can support monitoring in many aspects of development, from health care to natural resource management***.

As stated in the 2015 report on the outcomes of the MDGs, "knowing where people and things are and their relationship to each other is essential for informed decision-making. Comprehensive location-based information is helping Governments to develop strategic priorities, make decisions, and measure and monitor outcomes. Once the geospatial data are created, they can be used many times to support a multiplicity of applications. A geodetic reference frame allows precise observations and 'positioning' of anything on the Earth and can be used for many social, economic and environmental purposes, such as precision agriculture and monitoring changes in sea level rise".

Earth observation technologies offer a spatially consistent monitoring of the Earth with sufficient temporal repetition times. Space Technologies and space-based data and information can contribute to the efforts of national statistical offices' and the international community's ability to monitor the impacts of development programs and the SDGs. There are several applications for Earth observation data: harvest prediction, disaster response, and food security issues; monitoring geographic patterns and disease transmission corridors with geospatial determinants; measuring population density and the spread of new settlements; and mapping and planning transportation infrastructure.

Considering the current capabilities and upcoming potentials of space-based information, Table 1 provides a first overview on beneficial application areas related to the current and ongoing discussions on SDG and SFDRR indicators. Thereby synergies and interlinkages between the SDG and SFDRR indicator definition processes are considered. The potentials of space-based information are exemplified on the SDGs, associated targets and currently discussed corresponding indicators.

Thereby two classes are considered in the table to reflect the degree of technology and methods available to support measurement of SDG indicators:

1. Technological and methodological readiness
2. High potentials through further R&D efforts

Class 1 would require further resources for national / global level implementation as a service and for maintenance, as well related capacity development requirements. Class 2 would additionally require further Research and Development (R&D) efforts to demonstrate applicability.

Table 1: Potential of space-based data and information for the SDGs[32]

SDG	**Indicator**	**Description**	**Potential for the use of space based data** [a]
Goal 1 Poverty	1.5.2 (Sendai Framework)	Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)	2
Goal 2 **End hunger**	2.4.1	Proportion of agricultural area under productive and sustainable agriculture	2
Goal 6 Water	6.3.2	Proportion of bodies of water with good ambient water quality	2
	6.5.2	Proportion of transboundary basin area with an operational arrangement for water cooperation	2
Goal 9 Resilient infrastructure	9.1.1	Proportion of the rural population who live within 2 km of an all-season road	1, 2
Goal 11 Cities	11.1.1	% Urban population living in informal settlements	1
	11.3.1	Ratio land consumption to population growth	1, 2
	11.5.2	Direct economic loss in relation to global GDP,	1, 2

---

[32] The information on the indicators and their description is taken from the following link: <https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework_A.RES.71.313%20Annex.pdf>

		Damage to critical infrastructure and number of disruptions to basic services, attributed to disasters	
Goal 14 Life Below Water	14.1.1	Index of coastal eutrophication and floating plastic debris density	2
Goal 15 Terrestrial ecosystems, forests, land degradation	15.1.1	Forest area as a proportion of total land area	1, 2
	15.3.1	Proportion of land that is degraded over total Land area	2
	15.4.2	Mountain Green Cover Index	2

[a] Class 1 = Technological and methodological readiness, Class 2 = High potentials through further R&D efforts