Global Assessment Report on Disaster Risk Reduction 2022
PART IV Chapter– Managing and governing systemic risks – emergent solutions Subchapter: 11.4 / 12.3

Integrating Indigenous knowledge and State-of-Art Earth Observation Solutions for the Sendai Framework implementation

Author(s):
Myrna Cunningham, FILAC, Bilwi, Puerto Cabezas, Nicaragua
Milind Pimprikar, CANEUS, Montreal, Canada
Shirish Ravan, United Nations Office for Outer Space Affairs, Vienna, Austria
Simon Lambert, University of Saskatchewan, Canada, Tuhoe/Ngāti Ruapani (Aotearoa NZ)

Keywords: Indigenous knowledge, Disaster Risk Reduction, Earth Observation, Eco-DRR, Sendai Framework, Nature-based Solutions, Inequality

ABSTRACT

Indigenous Peoples are the custodians of diverse knowledges on biodiversity, forests, wetlands, and resources which constitute historical significance and enable sustainable environmental management. This paper discusses potential of EO in providing simplistic and operational tools for the systemic risk analysis to complement Indigenous Knowledges covering nature-based solutions (NBS). This approach helps to address the techno-cultural complexities and provide robust baselines to meet the 2030 Sendai Framework Disaster Risk Reduction (DRR) targets. It describes relevant international frameworks and instruments in the context of role of Indigenous communities in building disaster resilience. The role of EO based tools and solutions is highlighted that have potential to contribute in achieving global targets of the Sendai Framework and providing nature-based solutions through the specific examples on the Ecosystem-based Disaster Risk Reduction (Eco-DRR) that has high relevance to complement the knowledges of Indigenous communities. The study addresses the inequity of access regarding space, and other technology by Indigenous Peoples and acknowledges the political, cultural, logistical, and other challenges to address this concern. The study also highlights the lessons learned during the Covid-19 pandemic by DRR community with reference to the

use of EO-based solutions which is relevant to Indigenous communities that are vulnerable due to climate extremes. The key messages and recommendations addressed the issues of inequalities relating to technological imbalance, language barriers and gender inclusion.

1.0 INTRODUCTION

The co-authors of this study paper CANEUS (Permanent Observer Member of the United Nations Committee on the Peaceful Uses of Outer Space, mandated to develop emerging EO technologies-based solutions to serve societal needs through Public-Private partnerships), FILAC (The Fund for the Development of Indigenous Peoples of Latin America and the. Caribbean, the only Indigenous "Inter-Governmental" organization with Permanent Observer representation at the United Nations, empowered to develop solutions to current challenges to serve the needs of Global Indigenous communities), UNOOSA (United Nations Office for Outer Space Affairs), and Canada's University of Saskatchewan - Indigenous Studies, were part of the consultation process that led to formulation of the Sendai Framework in 2015. CANEUS and UNOOSA had also partnered to conduct the workshop on "New Global Framework for Sharing of Space Technology and Data Standards to Serve Nation's Disaster Management Needs" at the "Third UN World Conference on Disaster Risk Reduction held at Sendai in March 2015"[1].

The progress from these activities were discussed and updated at the UN Secretary General's Indigenous Climate Action Summit held at UN-NY on Sept 21-22, 2019[2], and followed through a side event at UN-HLPF (UN High Level Political Forum) 2020 "Indigenous Peoples-led Use of Earth Observations"[3]. Indigenous knowledges are now

[1] https://caneus.org/undrr/, https://www.unisdr.org/preventionweb/files/46138_UN-WCDRR_CANEUS_Workshop_Report.pdf

[2] http://www.iipfcc.org/blog/2019/11/3/world-indigenous-peoples-present-climate-action-commitments-at-unsg-climate-action-summit

[3] http://www.caneus.org/unhlpf2020 https://caneus.org/Report_UN_HLPF_2020_Side_Event.pdf

seen to 'complement' and 'contribute' to disaster sciences[4]; how can EO empower Indigenous communities in the development of their own DRR strategies?

Therefore, the importance of Indigenous inclusion in the current efforts to meet the targets of the Sendai Framework for Disaster Risk Reduction 2015-30 (Sendai Framework) using emerging EO technologies. Targeted help for Indigenous communities to bridge the gap with technological equalities, specifically hands-on training, and capacity development, is necessary and relevant organizations already active in EO are ideally placed to provide the resources.

The study aims to help the Global Indigenous communities to implement workable and replicable EO solutions in pursuit of building disaster resilience.

2.0 THE VALUE OF INDIGENOUS KNOWLEDGE FOR DISASTER RISK REDUCTION:

Indigenous peoples are among those who have contributed least to the problem of environment and climate change, yet they are the ones suffering from its worst impacts. They are disproportionately vulnerable to environment and climate change because many of them depend on ecosystems that are particularly prone to the effects of extreme weather events such as floods, droughts, heatwaves, wildfires, and cyclones. Historical colonization and ongoing maginalization and oppression have undermined Indigenous efforts at mitigating their disaster vulnerabilities and exacerbated evolving environmental hazards, and cascading technological hazards[5].

Some of the most affected regions are small islands, high altitudes, humid tropics, coastal regions, deserts, and polar areas. Global warming increases the risk of disease, changes animal migration routes, reduces biodiversity, causes saltwater inundation of fresh water, destroys crops and results in food insecurity[6].

---

[4] Lambert, S. and Scott, J.C. (2019). International Disaster Risk Reduction Strategies and Indigenous Peoples. International Indigenous Policy Journal. Vol. 10(2) https://ir.lib.uwo.ca/iipj/vol10/iss2/2

[5] United Nations Human Rights Commission. 2014. Promotion and protection of the rights of indigenous peoples in disaster risk reduction, prevention and preparedness initiatives. Geneva: United Nations General Assembly. A/HRC/EMRIP/2014/2

[6] A/HRC/36/46 Report of the Special Rapporteur on the rights of Indigenous Peoples

Fig. 1 Schools destroyed by Hurricane Iota in Miskito Indigenous communities in Prinzapolka municipality, Northern Caribbean Coast of Nicaragua, November 2020

In November 2020, many Indigenous communities in Nicaragua, Honduras, Guatemala, Colombia, southern Mexico, and other territories of Abya Yala (America) were impacted by two category 4 and 5 hurricanes in less than 15 days, leaving dozens of deaths and countless material losses The Caribbean [coastal] Indigenous communities were hardest hit with strong winds and heavy flooding and houses destroyed. Prior to 2020, 8 storms did this in 169 years of recordkeeping. Three storms have done in two months, (Delta, Eta and Iota). In terms of pressure, Iota was the 20th most intense Atlantic hurricane on record[7].

Fig. 2 Miskito communities from the Waspam municipality, Nicaragua, evacuating before the arrival of Hurricane Theta, damages caused by Hurricane Iota in Bilwi, children affected by floods along the Wangky river after Hurricane Theta, both hurricanes affected Central America in November of 2020 (Source Waspam Local Government, Waspam Catholic Church).

Indigenous communities hold time-tested knowledge and coping practices developed through their intimate connection with their natural surroundings that make

[7] https://www.npr.org/2020/11/16/935422899/hurricane-iota-bears-down-on-already-battered-nations-of-central-america

them resilient to climate-related natural hazards and disasters. These knowledges remain a living practice for many communities which can adapt in response to changing circumstances. Indigenous Knowledges “includes an understanding of the relationships between Indigenous societies and nature, which have been tested by time and proven to be sustainable and successful in limiting the effects of hazards”[8].

Indigenous knowledge has a valuable role to play in disaster risk reduction and it should be recognized and protected accordingly. All too often, mainstream disaster management institutions have ignored Indigenous knowledge, and many successful local practices have disappeared because of non-Indigenous influence. At other times, Indigenous peoples’ practices have adapted to changing environments[9]. Complicating any engagement between EO and IK is the reality that Indigenous knowledges are diverse and dynamic, with location-specific relevance and accuracy. Indigenous Peoples now argue for data sovereignty, that is they seek control and ownership of data originating from their communities and territories (Kukutai and Taylor, 2016).

Fig. 3 Miskito Indigenous communities in the Northern Caribbean of Nicaragua, flooded after hurricanes Theta and Iota in November of 2020

Indigenous Peoples should therefore not simply be viewed as people who are vulnerable to climate change — they are also ecosystem peoples, with sound knowledge of and an intimate relationship with their environments that has evolved over generations to provide a level of resilience to environmental hazards. Indigenous peoples inhabit some of the most fragile ecosystems on the planet and have developed unique strategies

[8] (E/C.19/2013/14, para. 39)
[9] A/HRC/27/66 Promotion and protection of the rights of indigenous peoples in disaster risk reduction, prevention and preparedness initiatives

to cope with extreme variations of weather, such as altering land use and settlement patterns, and crop diversification, to minimize the risk of harvest failures.

Other coping strategies include (a) changes to hunting and gathering periods to adapt to changing animal migration and fruiting periods, (b) introduction of food banking and seed banking along with creation of community exchange networks, and (c) conservation of forests and watersheds, including the restoration of ecosystems[10].

The nature by itself embraces diversity which is undermined by modern agriculture by growing selective varieties. Merely reviving cultivation of indigenous grains, that are uniquely nutrient rich, is the key towards expanding biodiversity which is the most important instrument to build resilience. Fig. 4 illustrates importance of biodiversity in balancing ecosystem.

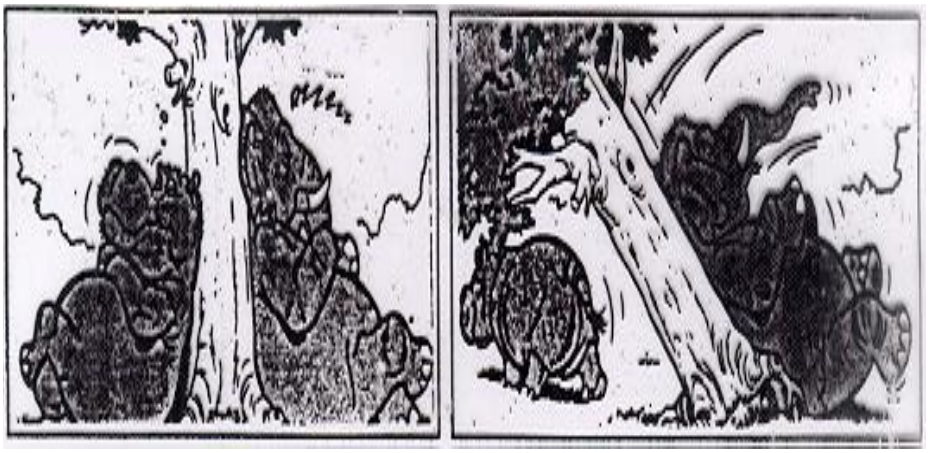


Fig.4 Illustration showing importance of biodiversity in balancing ecosystem

Source: Archives

Central America is the world's second most vulnerable region to natural hazards. But the region, rich in natural and cultural resources, can improve its climate resilience if the entire population, including its Indigenous Peoples, works together[11]. The Pan-American Health Organization (PAHO) is supporting an Indigenous Knowledge and Disaster Risk Reduction group that is coordinating and sharing information to advance

[10] A/HRC/ 27/ 66 Promotion and protection of the rights of indigenous peoples in disaster risk reduction, prevention and preparedness initiatives

[11] https://blogs.worldbank.org/latinamerica/how-integrate-indigenous-peoples-culture-and-traditions-disaster-risk-management

DRR, with an emphasis on health and resilience, in Indigenous communities in the Americas and Caribbean.[12] If the knowledge of Indigenous traditions is combined with modern technology, this can create opportunities to build a more resilient Central America.

This wealth of Indigenous Knowledges has not been well-recognized by the practitioners and policy makers of DRR[13], due to the predominance of technocratic thinking and due to lack of connections between mostly non-Indigenous officials and Indigenous population. Indigenous Peoples argue that recognizing their diverse knowledges, Indigenous rights, and traditional environmental management systems are all necessary in the processes of empowered emergency response, prevention, and reconstruction. In addition, they want events to be seen from the perspective of their Indigenous sciences and knowledges. They also want their own efforts in institutional and organizational strengthening, rights and safeguards, and voice and participation to be considered. Earth observation technologies, from this perspective, can be seen as an extension of traditional data gathering approaches that can enable more accurate insights into disaster contexts. Indigenous Peoples have never eschewed new technologies; they simply request the right to adopt and adapt these technologies according to cultural values and their own self-determined disaster risk reduction priorities and strategies. One of the solutions is to start a special drive through the existing capacity building centres to offer customized training programmes targeting youth and leaders of Indigenous community. The network of the Centres for Space, Science and Technology Education developed by UNOOSA are well positioned to undertake such task in collaboration with FILAC and other organisations that support development of Indigenous communities.

Therefore, the global disaster risk management (DRM) community need to take action to involve Indigenous Peoples as expert partners. The World Bank has proposed five strategic opportunities to include the perspective of Indigenous Peoples, derived from their culture and traditions, to address climate change: (a) Governance for DRM: Indigenous rights, and safeguards guarantee the respect, recognition, and exercise of

[12] https://www.indigenousdrr.org/index.php/en/the-network/background

[13] UNGA A/HRC/27/66, “Promotion and protection of the rights of Indigenous peoples in disaster risk reduction, prevention and preparedness initiatives”, Study by the Expert Mechanism on the Rights of Indigenous Peoples

Indigenous rights and safeguards in all DRM actions, (b) Risk knowledge: Develop and implement traditional and ancestral science, knowledge, and practice as part of DRM by providing timely access to climate and hydrological forecasts as well as the predictions of modern science, (c) Risk reduction and prevention: Develop cultural management processes for Indigenous territories as a mechanism for resilience and adaptation, e.g., communications in Indigenous languages as well as incorporating their perspective and traditional knowledge, (d) Emergencies: Carry out evacuations, rescues, and shipments of food and clothing with Indigenous authorities to install safe, dignified, and adequate shelters in line with their customs and norms, and (e) Recovery and reconstruction: Normalize the conditions of affected Indigenous Peoples by rebuilding after disasters in a culturally appropriate way.

3.0 INTERNATIONAL FRAMEWORKS AND UN INSTRUMENTS FOR INDIGENOUS DRR

A. International Legal Frameworks

Translation to Indigenous languages is important but is one of several strategies to embed Indigenous worldviews into modern disaster risk reduction. Definitions, concepts, and standards related to disaster risk reduction and response must reflect both Indigenous perspectives where relevant. The United Nations Declaration on the Rights of Indigenous Peoples (the declaration) is the most comprehensive instrument elaborating the rights of Indigenous peoples. Although it does not explicitly address disaster risk reduction, several of its provisions have related implications and can provide guidance for the design and implementation of sound disaster risk reduction strategies and interventions[14].

Similarly, International Labour Organization Convention No. 169 provisions are applicable in this context, e.g., Article 4 states that “special measures shall be adopted as appropriate for safeguarding persons, institutions, cultures and environment of those concerned.” Furthermore, the provision of Article 7, paragraph 1, affirms Indigenous peoples’ rights to decide their own priorities for development and

[14] A/HRC/27/66 Promotion and protection of the rights of Indigenous peoples in disaster risk reduction, prevention and preparedness initiatives

formulation, implementation, and evaluation of plans and programmes. Additionally, Article 16 addresses Indigenous peoples' right not to be removed from the lands they occupy and provides safeguards for relocation as an exceptional measure.

Among the many arguments that can be made for using traditional knowledge in disaster risk reduction, four are especially compelling: " (a) indigenous practices for DRR and mitigation can often be adapted for use by other communities in similar situations or environments, (b) use of community's traditional practices can encourage participation and empower the community to take lead in DRR initiatives, (c) traditional knowledge and practices can provide valuable information about the local context to project implementation partners, including government agencies working on DRR, and (d) non-formal dissemination of traditional knowledge can provide a model for awareness-raising and education on disaster risk reduction.

Today, Indigenous Peoples' traditional knowledges and cultural practices are increasingly considered to be important and necessary to the conservation of biodiversity and ecosystem based DRR. As stressed by the Permanent Forum on Indigenous Issues, maintenance of Indigenous peoples' cultural and spiritual relationships must be a key priority in effectively addressing environmental or food catastrophes. Recognition and respect of rights of Indigenous peoples to self-determination, lands, territories and resources, and protection of traditional knowledge, will have a positive impact on environment, and on DRR prevention, preparedness initiatives.

B. Relevant UN instruments

The Intergovernmental Panel on Climate Change[15] notes that Indigenous knowledge has been effective in developing measures to cope with climate hazards and has contributed to increased food security in many parts of the world. This view is also shared by the UN Climate Change Conference of Parties (COP), which has recognized that Indigenous Peoples are part of the solution to tackle climate change.

[15] A/HRC/36/46 Report of the Special Rapporteur on the rights of Indigenous peoples

At the COP25 in December 2019, two-year workplan of “Local Communities and Indigenous Peoples' Platform” (LCIPP)[16] had been adopted to formally recognize the values and roles of indigenous traditional knowledge and cultural practices. For example, Inuit knowledge of climate variability when hunting, the Inca traditions of crop diversification and knowledge of genetic diversity and, in the Sahel, the use of water-harvesting strategies and weather forecasting.

The Panel further confirmed Indigenous Peoples’ long-standing claim in relation to traditional knowledges based on their holistic interpretation of the relationships between communities and their environments Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation.

The International Indigenous Peoples’ Forum on Climate Change and UNEP have observed that Indigenous Peoples can contribute to numerous adaptation activities by drawing on their traditional knowledges, e.g., Furthermore, Indigenous Peoples can play a role in stopping deforestation by land titling, forest management and conservation and the strengthening of local governance. Indigenous approaches use extended historical insights, diverse recording and documentation formats, traditional weather and climate monitoring, and cultural fire management practices, rainwater harvesting, traditional sustainable agriculture and coastal marine management, and development of sustainable livelihoods. The totality of their disaster preparedness, response and early warning systems were articulated at the 2017UNDRR Global Platform by the Major Group on Indigenous DRR (2017).[17]

C. Experts’ Mechanism Advice No. 7 (2014): Promotion and protection of the rights of Indigenous Peoples in disaster risk reduction initiatives

Article # 18 of the “Expert Mechanism” stipulates that Indigenous Peoples should consider investing in training for youth on new technologies that are part of early warning and GIS (Geographic Information System) mapping applications, e.g., training by Elders on how to adapt traditional knowledge. It calls to (a) allocate funds

[16] (https://unfccc.int/LCIPP)

[17] Major Group on Indigenous DRR (2017). Indigenous Peoples Statement (Lambert, S., Scott, J., Redfern, M., Kuiack, T., Mark-Shadbolt, M., Partha, P., Ugarte, C.) Global Platform for DRR, May 13-17, Geneva.

for training to use technologies and technologies so that they are accessible to Indigenous Peoples, (b) operationalize incorporation of Indigenous traditional knowledge related to DRR within technological aspects, (c) draw up baselines of the disasters from 2015-2020 and compare them with that may occur in 2025-2030, and (d) incorporate recommendations for DRR in Indigenous territories within the FILAC Observatory on the Rights of Indigenous Peoples for their effective follow-up.

D. Global frameworks: Terms from Sendai Framework Article 69/283

The relevant terms from the Sendai Framework includes: (a) ensuring use of traditional, Indigenous, and local knowledge and practices, as appropriate, to complement scientific knowledge in disaster risk assessment and implementation of policies, strategies, and plans, (b) strengthening technical and scientific capacity to capitalize on and consolidate existing knowledge to develop and apply methodologies and models to assess disaster risks, vulnerabilities, and exposure to all hazards; and (c) promoting investments in innovation and technology development in long-term, multi-hazard and solution-driven research in disaster risk management to address gaps and obstacles.

4.0 EARTH OBSERATION, INDIGENOUS KNOWLEDGEs AND DRR

EO (space based) technologies have been already integrated in the Sendai framework. This section builds on these efforts and uniquely highlights possibility of complementing the state-of-the-art EO-based solutions with Indigenous knowledges adapted for generations in a coherent and logical way to live in harmony with nature. Representative examples from various regions were selected aimed to demonstrate how EO generates measurable long-term solutions, and how EO based tools and solutions helps expand the knowledge for Indigenous communities.

The goal is to examine and identify challenges and barriers for Indigenous communities to implement workable and replicable EO based solutions in pursuit of DRR. This will stimulate collaborations between disaster management authorities, EO (space) data providers and agencies, and the Indigenous communities in the interest of promoting nature-based solutions in DRR. Space-based services and technologies

are key in understanding the past and current situation of the land, oceans and environment and provide an understanding of climate change and related risks.

Space, especially EO satellites, have been used as a tool for humankind for over 50 years already and archives of the earth observation data provide valuable information to fill the data gap that exists in the countries that do not have well documented statistical data in past years. The global disaster community has been using the EO based solutions since the world's first successful weather satellite TIROS-1 (Television Infra-Red Observation Satellite) launched by NASA in 1960. CORONA, the first photoreconnaissance satellite imagery available from 1960 to 1984 provides an extension of monitoring ranges in comparison to later satellite data that are widely available today for change detection or assessment of natural hazard risk or even to understand baseline for strengthening DRR activities (Fekete, 2020).

The Sendai Framework has set a group of 38 indicators and four priorities for action with the aim of measuring global progress in its implementation. The potential of space technologies for supporting the Sendai Framework, and eventually the sustainable development goals (SDGs), is much wider with a direct link to several global targets of the Sendai Framework and SDGs. Indigenous Peoples are contributing to the SDGs but these contributions are rarely recognized by authorities and often not even known by Indigenous communities themselves. Earth Observation offers new opportunities to make use of geospatial information, to contribute to the quantitative measurement of some of these indicators established to track advances in the implementation of Sendai Framework.

Despite all these efforts, Indigenous communities have not benefitted enough from the advances in science and technology, including space-based technologies that provides contextual and time series information to understand how developmental activities around their area impacts their ecosystems and environment. This inequity of access regarding space, and other technology by Indigenous Peoples arise due to the political, cultural, logistical and other challenges and planned interventions are needed to address this concern.

The discussions in the following sections focus on the Earth observation (remote sensing and weather satellites) from space and its integration with location-

based services that relates to global navigation satellites and other frontier technologies such as big data, cloud computing and machine learning that enables analysis of complex datasets and derive meaningful information products.

5.0 INTERNATIONAL INITIATIVES AND MECHANISMS FOR INCLUSIVE EFFORTS TOWARDS DRR

The United Nations Office for Outer Space Affairs (UNOOSA) focuses on inclusiveness as an underlying factor in sustainable development while bringing benefits of space to humanity. It provides opportunities for emerging space nations to perceive space as a contributor to the inclusive growth of countries, in particular by serving as a catalyst for empowering people and ensuring inclusiveness and equality. The office addressed the topic related to involvement of Indigenous community at the twenty-seventh Workshop on Space Technology for Socioeconomic Benefits, on the theme “Ensuring inclusiveness through space-based applications and space exploration” jointly organised by UNOOSA and International Astronautical Federation in Washington DC, USA in 2019[18].

Initiatives such as UN-SPIDER ("United Nations Platform for Space-based Information for Disaster Management and Emergency Response"), a program of UNOOSA facilitates the use of space-based technologies for disaster management and emergency response offers broad range of services by assisting developing countries to use space-based information in the full disaster management cycle. While doing so, it has contributed to the “Hyogo Framework for Action 2005: Building the Resilience of Nations and Communities to Disasters” by engaging with the national disaster management agencies of United Nations Member States and other partners. Since the adoption of the Sendai Framework by Member States in 2015, UN-SPIDER has implemented concrete actions in collaboration with its network and in partnership with Member States. The services offered by UN-SPIDER include, but are not limited to, technical advisory services through technical advisory missions (TAM), capacity-building and fostering cooperation and knowledge management through the Knowledge Portal (www.un-spider.org). UN-SPIDER thus functions as a gateway to

[18] https://www.unoosa.org/oosa/oosadoc/data/documents/2019/aac.105/aac.1051218_0.html

space information for disaster management support, serves as a bridge between the disaster management and space communities, and acts as a facilitator of capacity-building and institutional strengthening.

Shared access to EO data and services for disaster management and emergency response is crucial given that only handful countries in the World have their own satellites. The EO-based tools developed by space agencies, industry sector, as well initiatives like SERVIR[19], and international mechanism that supports emergency response such as “International Charter Space and Major Disasters”, Sentinel Asia and Copernicus Emergency Management Services, amongst others to improve the full cycle of Disaster Risk Management (DRM) covering mitigation, preparedness, warning, response and recovery, thereby helping the global communities, specifically the vulnerable populations contributing to socio-economic indicators for societal and economic growth mandated by 2030 SDG’s.

Space technologies are integral components of the 4th industrial revolution technologies. Space technologies such as Earth observation, satellite navigation, satellite meteorology and satellite communication, integrated with emerging new technologies, provide critical inputs to the DRR sector, and thereby enables communities to be more resilient, sustainable and climate smart.

6.0 LESSONS LEARNED DURING COVID-19 PANDEMIC BY DRR COMMUNITY – EARTH OBSERVATION PERSPECTIVE:

Many organizations focused on the Covid-19 pandemic after its rapid spread and dramatic economic slowdown from March 2020. The UN-SPIDER organised a special conference in 2020 to reflect on the lessons learned from the Covid-19 pandemic and how space can contribute better during such situation[20]. These lessons are also important for the indigenous community as a preparedness in future to visualise scenarios of cascading risks. PAHO hosted several webinars in which Indigenous representatives discussed the impacts on their communities. Disaggregating

[19] https://www.nasa.gov/mission_pages/servir/index.html

[20] https://un-spider.org/news-and-events/events/un-international-conference-beijing-2020

Indigenous-relevant data is one of the many challenges of data management; EO and other spatially attuned remote-sensing technologies provide important technological advances for Indigenous communities to locate themselves and their territories in rapidly changing contexts such as a pandemic.

The year 2020 was a challenging time for World since intersection climate extremes, disasters and Covid-19 pandemic caused complex risks and cascading effects for which World is not prepared. This is crucial when extreme weather events are increasing frequency of floods, droughts and cyclones as experienced in many parts of Asia. Impact of climate change is also changing ocean currents, forest fires and probably act as a stimulant for outbreaks of a pandemic like Covid-19. This has a significant impact on economy, food security, health, education system and ecosystems and is a significant setback to World in achieving sustainable development goals (SDGs), especially its principle of 'leaving no one behind'. It is difficult to model and hard to monitor Covid-19 spread as it is influenced by the decision of the governance system and behaviour of people. The magnitude of such crisis go beyond humanitarian issue but awakens a notion of building a resilient society through resilient development. Disaster management community uniquely positioned to contribute to those challenges.

During flood and cyclone disasters in 2020, the additional challenge to the disaster managers and emergency responders was to follow social distancing norms during response efforts and avoid a spread of the virus by accommodating the lesser number of people in evacuation shelters. This means evacuations needed to be planned well in advance, more shelters were needed and these need to be sanitized frequently.

Information at various scale is needed to capture the systemic risk scenario and do predictive risk analysis for providing prescriptive analysis to help the decision-making process. Data on rates of infections among Indigenous Peoples are often not available as many states do not necessarily record health data by ethnicity. However, many reports revealed the number of confirmed cases across Indigenous communities; the outbreak in Navajo Nation saw an infection rate ten times higher than the general population of Arizona. Poor housing conditions and a lack of running

water were contributing factors.[21]In Canada, the health sector has been accused as a 'patchwork of service' for Indigenous communities stemming from colonialism.[22] Jurisdictional boundaries displaced and disrupted Indigenous governance over time. The deployment of EO, when centred on Indigenous communities in service of their sovereignty, offers a solution to lack of accurate and relevant data.

Power space technologies, big data, analytics, models can be very useful in building implementing scenario-based approaches. Earth observation can play important role in addressing systemic risks that are transboundary, stochastic, non-linear and uncertain. For Indigenous communities, relevant information delivered in a timely, culturally appropriate and location-specific format is necessary for successful adoption of ASTI. The deployment of EO takes place with the growing assertion of Indigenous voices within STI ecosystems. These voices will challenge funding bodies, ethics committees, universities, corporations, and governments in their strategies of empowered DRR.

[21] UN Department of Economic and Social Affairs. 2020. The Impact of COVID-19 on Indigenous Peoples; Policy Brief #70. New York: Department of Economic and Social Affairs.
[22] Yellowhead Institute/Skye, C.. 2020. Colonialism Of The Curve: Indigenous Communities & Bad Covid Data. https://yellowheadinstitute.org/2020/05/12/colonialism-of-the-curve-indigenous-communities-and-bad-covid-data/

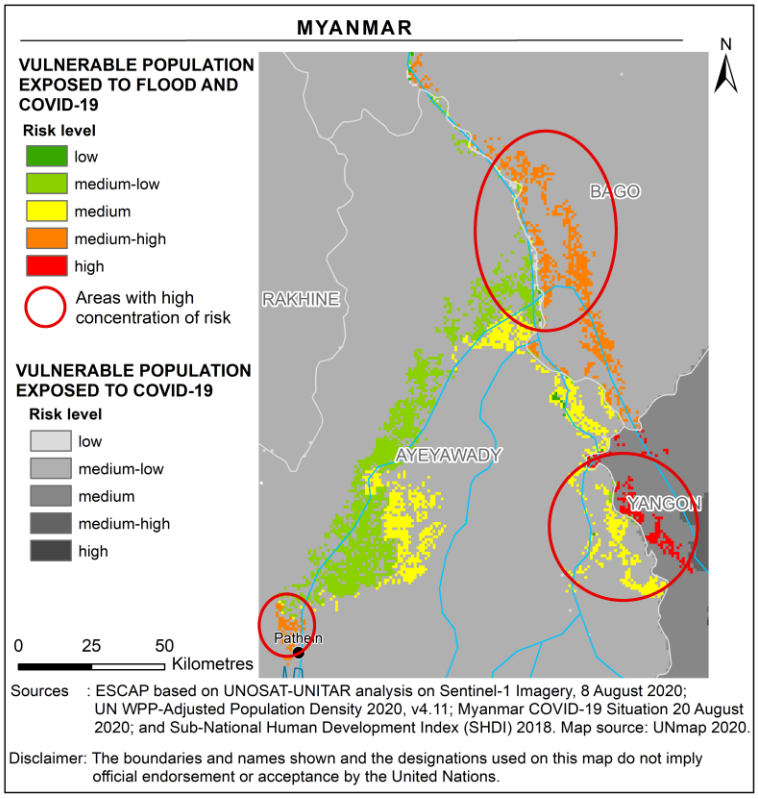


Fig. 5 Scenario-based risk analytics for managing cascading disasters - A pathway to manage risks and protect people in South Asia (Source: UN-ESCAP)

Space-based information should be used to influence the strategic process by identifying short-term, medium-term, and long-term needs, especially during this crucial pandemic situation. Space-based information shows people what they must to know about the risk and disasters. The spatial nature of the space-based information provides a better understanding of the scenario and influence the decision-making process to help research, policies, and programmes to align to evidence. This contributes to the notion that disaster management is too late and the right options are to reduce risk everywhere.

The concern is that there are many technologies, but these need to put to the use. This is where the role of a platform like UN-SPIDER is crucial as such platforms bring together all stakeholders including technical community, government officials, NGOs, industries, and people to learn from each other and help establish nexus from policy design to capacity building and institutional strengthening. Indigenous communities

should be central to these efforts to ensure that no one is left behind, and this has become possible due to the revolution in social media.

EO technologies provided great service during the disaster that overlaps with Covid-19 pandemic by narrowing down to the possible affected places and generate precise damage maps to assist local authorities in establishing evacuation plans. These damage maps contributed to mobilizing relief parties and supplies effectively under the mobility and distancing restrictions imposed by the COVID-19. Such information earned the lead time to respond to possible disasters which are particularly crucial under the COIVD-19 pandemic. Role of International Charter Space and Major Disasters, Sentinel Asia, and Copernicus EMS to share disaster information in near-real-time was crucial during the natural disasters occurred during the pandemic time.

7.0 RELEVANCE OF EO AND NATURE-BASED SOLUTIONS TO INDIGENOUS COMMUNITY

While EO based tools and solutions helps expand the knowledge for Indigenous communities, Indigenous knowledges also complements the EO technologies. For example, NASA is finding renewed interest in using the knowledge and mimicry of Nature to develop technology support new missions. George Studor, from NASA Engineering and Safety Center – NES, and the INCOSE Natural Systems Working Group (NSWG) have been exploring to broaden systems engineering processes to include consideration of both living and non-living natural systems[23].

UN-SPIDER is promoting nature-based solutions by incorporating ecosystem-based disaster risk reduction (Eco-DRR) in its activities. This approach shows possibility of incorporating Indigenous knowledges and lessons learned from Indigenous communities. However, some Indigenous knowledge holders have noted the pace of change in their environments outstrips the ability of their traditional knowledges to predict what is happening, particularly with weather and climate systems. Over time and at an increasing rate, external development practices are

[23] https://www.researchgate.net/publication/301704186_WHAT_IS_NASA'S_INTEREST_IN_NATURAL_SYSTEMS

adversely affecting the lands, waters, and resources of Indigenous Peoples, often making traditional knowledge irrelevant[24]. Indigenous knowledge holders are curious and engage in efforts to better understand their changing environments. EO networks can provide vital data in Indigenous decision-making.

Some of the efforts in this direction are the session on Ecosystem-based Disaster Risk Reduction in UN-SPIDER annual conference in Beijing, China, in 2018 that generated awareness among the DRR community about nature-based solution and the training programme organised by UN-SPIDER and Indian Institute of Technology- Roorkee, India in 2019 to provide guideline for urban planners to highlight the importance of space and geospatial data in developing 'blue and green infrastructure'.

The United Nations Environment Programme (UNEP) launched the Massive Online Open Course (MOOC) on Disasters and Ecosystems: Resilience in a Changing Climate in 2015 and relaunched in 2017[25] that offered a guided approach to Ecosystem-based disaster risk reduction and climate change adaption, planning tools for ecosystem-based disaster risk reduction and adaptation and approaches on how spatial data, GIS and remote sensing be used for Eco-DRR and ecosystem-based adaptation (EbA).

8.0 EO FOR COMPLEMENTING INDIGENOUS KNOWLEDGE - ECO-DRR APROACH

Ecosystem-based disaster risk reduction (Eco-DRR) is the sustainable management, conservation, and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development. Although indigenous communities have in-depth knowledge of the ecosystems they inhabit, the current scenario due to climate change and systemic risks calls for complementing to their knowledge based on scientific understanding of ecosystems.

Out of 4 priorities of the Sendai Framework, priorities 1 and 3 recognize the importance of ecosystems in DRR. It encourages the use of and strengthening of baseline and periodically assess disaster risks, vulnerability, capacity, exposure,

[24] Major Group on Indigenous DRR (2017). Indigenous Peoples Statement (Lambert, S., Scott, J., Redfern, M., Kuiack, T., Mark-Shadbolt, M., Partha, P., Ugarte, C.) Global Platform for DRR, May 13-17, Geneva.
[25] https://www.unep.org/resources/e-learning/disasters-and-ecosystems-resilience-changing-climate-mooc-2

hazard characteristics and their possible sequential effects at the relevant social and spatial scale on ecosystems in line with national circumstances. Well-managed ecosystems, such as wetlands, forests and coastal systems, act as natural infrastructure, reducing physical exposure to many hazards and increasing socio-economic resilience of people and communities by sustaining local livelihoods and providing essential natural resources such as food, water and building materials to the indigenous community.

For example, mountain forests protect human beings efficiently and cost-effectively against avalanches and rockfalls. Snow avalanches threaten human settlements and transportation lines in many mountainous regions throughout the world. Mountain forests reduce the probability of avalanche initiation and therefore are a valuable protective measure. WSL Institute for Snow and Avalanche Research SLF is investigating which properties of a forest determine the level of protection it provides and how this could be altered by climate change. The research is being carried in Chilean Andes, Nepal, and Swiss Alps[26].

The EO helps in analysing the indicators of the health of forest ecosystem such as extent and density of forest, its composition, biodiversity, biomass and carbon sequestration potential, which are illustrated below:

- Extent and density of the forest:

  The forest ecosystems that have larger extent and better density indicate good heath by offering well protected core area. EO helps investigating the forest extent and density in the most efficient way.

- Composition:

  The natural forest ecosystems that are considered robust are often diverse and composed of dominant tree species that are associated with strata of shrubs and herb. Multispectral and multi-resolution satellite data provides efficient way of mapping and monitoring forest cover and types and depicts composition of forest in time series.

[26] https://www.wsl.ch/de/projekte/epic-1.html

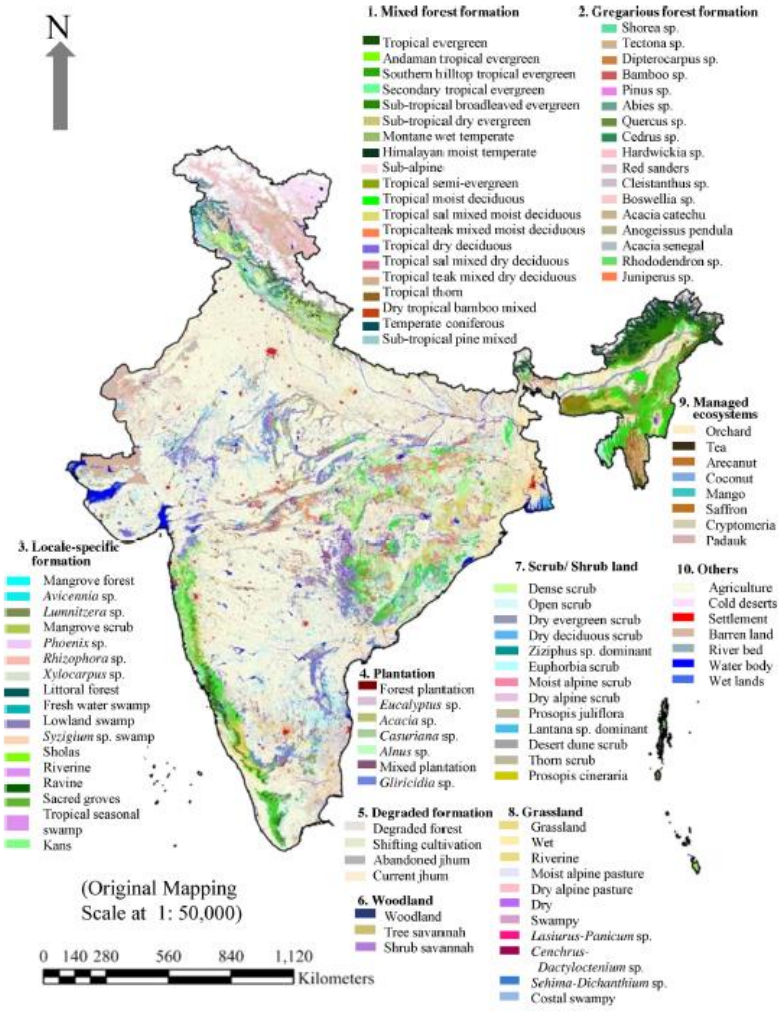


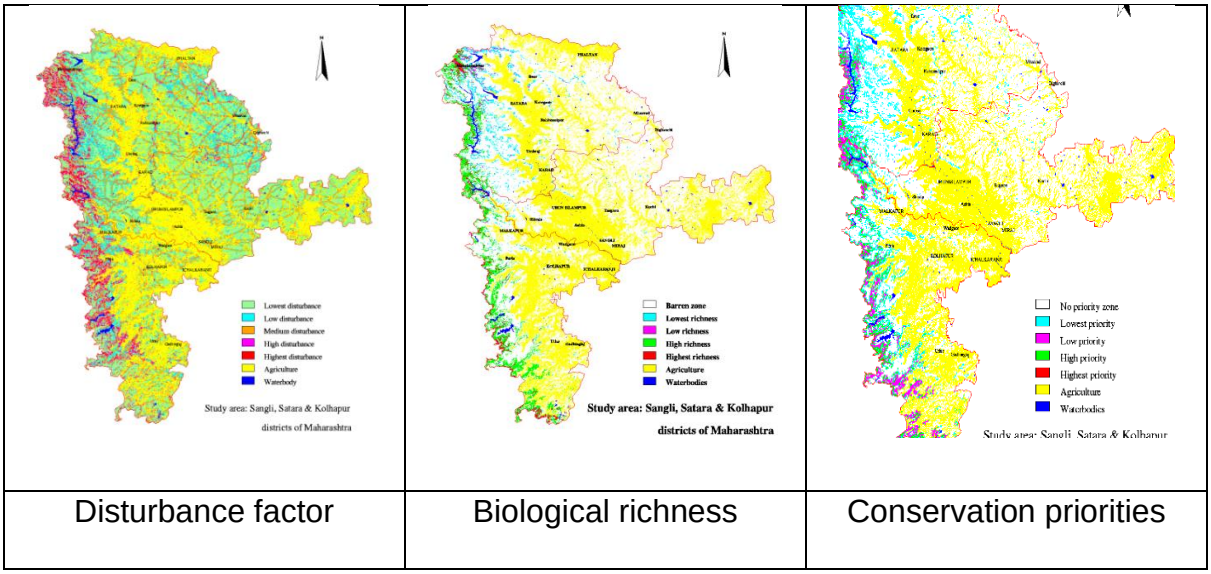
Fig 6 New vegetation type map of India prepared using satellite remote sensing: Comparison with global vegetation maps and utilities (Roy *et al,* 2015)

- Biodiversity:

  The EO data and research methodologies have provided a rapid way to monitor ecological status of forest through the landscape level biodiversity assessment. These approaches can be used to analyses long-term threats to the biodiversity thereby provides crucial inputs for ecosystem management.

  The below example from the western ghats of India, one of the World's biodiversity hotspot, shows that the vegetation map derived from satellite images can be modelled to understand ecological dynamics at landscape

level and prioritize conservation measures. Several indigenous communities inhabit this region of western ghats and their food system rely on ecosystems around them to as they collect non-timber forest products for their livelihood and the success of their indigenous crops depends on the health of the ecosystem.



Disturbance factor	Biological richness	Conservation priorities

Fig. 7 Analysis of the forested landscape in the biodiversity hotspot in Western Ghats of India – Analysis performed based on Ravan and Roy, 1997

- Biomass, productivity, and carbon sequestration potential:
  Multi spectral/hyperspectral satellite data provides efficient way of estimating and monitoring biomass. The changes in biomass of over the time series allows to estimate and net primary productivity of the forest ecosystem, which relates to understanding carbon sequestration potential of the ecosystem and provides valuable inputs to global issues such as global warming (Kale *et al, 2009)*. REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

These are the rapid ways of understanding robustness of forest ecosystems using EO data. Thus, EO provides evidence-based information on the indicators of

the health of the natural ecosystems (indicated by the net primary productivity and biodiversity) based on its biophysical parameters and through the models on eco-sensitive zoning, sustainable development, forest fire mitigation plans and bioresource utilization, it helps in efforts of restoring balance in the ecosystems, making them robust instrument for disaster risk reduction. The physical risk reduction capacity of ecosystems depends on their health and structure, and the intensity of the hazard event. Ecosystems can reduce physical exposure to common natural hazards, namely landslides, flooding, avalanches, storm surges, wildfires, and droughts, by serving as natural infrastructure, protective barriers, or buffers.

9.0 EO BASED TOOLS AND SOLUTIONS POTENTIALLY USEFUL FOR CATERING INDIGENOUS DRR NEEDS

Although no exclusive EO-based tools are developed for benefit of the Indigenous community in the context of DRR, there are several tools accessible that are relevant to integrate their knowledge and complement to the indigenous community. EO technologies are now becoming more affordable due to ample availability of open source satellite images, free and cloud-based software tools as well as free capacity building resources like recommended practices and MOOCs. One such MOOC titled “Geospatial Applications for Disaster Risk Management” is recently launched by UNOOSA as a free and self-paced learning programme[27].

In current scenario, Indigenous community, if enabled with decent internet linked to desktop/laptop, can effectively use EO solutions. In the Post-Covid-19 era, people have developed an aptitude of using online platforms for e-commerce, shopping, education and learning at all levels. This new normal paves a great way to transfer of technologies and capacity building. This vision is presented in the ‘Roadmap for Digital cooperation’ proposed by the UN Secretary-General in June 2020[28].

[27] https://un-spider.org/news-and-events/news/launch-phase-ii-mooc-%E2%80%9Cgeospatial-applications-disaster-risk-management%E2%80%9D
[28] https://www.un.org/techenvoy/content/roadmap-digital-cooperation

The study, however, suggests more efforts to develop customized tools/products in the interest of Indigenous community. Some of the tools that can be potentially used for benefit of Indigenous community are described below:

a. NASA Earth Applied Sciences Disasters Program: Indigenous Peoples Pilot[29]

NASA Tool for Disaster Readiness & Resilience Program promotes the use of Earth observations to inform disaster risk reduction activities on a global scale. The Program actively contributes to the Sendai Framework and its Global Risk Assessment Framework (GRAF), a United Nations initiative to help communities worldwide manage, mitigate and plan responses to a wide array of disasters. The NASA Indigenous Peoples Pilot (https://appliedsciences.nasa.gov/indigenous-peoples-pilot) engages with Indigenous communities to foster ethical and culturally relevant space for the use of Earth observations in monitoring, mapping, and managing natural and cultural resources.

b. European Space Agency Disaster Risk Reduction-EO4SD DRR

The ESA initiative, “Earth Observation for Sustainable Development (EO4SD)” with a focus area dedicated to disaster risk reduction (EO4SD DRR) promote development of EO services for supporting the implementation of DRR in International Financial Institutions’ (IFI) projects (targeted to Indigenous Peoples) with actionable information improved decision-making. Particularly, the lessons learned and future outlooks from the EO4SD DRR project (Alberto Lorenzo-Alonso, *et al*, 2019), offers important tools to support Indigenous led DRR efforts.

c. Emergent EO tools: Big Earth Data

The Indigenous community can benefit information derived from EO data and its modelling across spatiotemporal scales. In recent years, technological developments from other areas such as AI, machine learning have been transferred to the remote sensing world, producing a somewhat revolutionary effect across the spectrum of activities in DRR applications. To this cause, the work of UNOOSA and ESA on producing

[29] https://appliedsciences.nasa.gov/what-we-do/disasters/inside-disasters

a Space Solutions Compendium[30] may act as a practical tool for Indigenous communities to identify how space can support their efforts towards sustainable development. In particular, it will help developing countries incorporate space solutions in their strategies. UNOOSA and ESA will leverage their expert knowledge and networks to identify relevant space applications and show how these can be used in a variety of contexts.

The State-of-the-art “Earth data” technical solutions offer the potential for disruptive changes in Earth observation data management and analysis”. The surveillance of Indigenous Peoples has been a feature of colonization and has been particularly oppressive in the health sector. The expansion of modern digital technologies needs to be appropriate and transparent, with Indigenous engagement from the outset. The EO sector needs to be cognizant of such ethical challenges. Big Earth data with its emerging technologies and approaches may be an evolution of EO, but it also may allow us to revolutionise the way we use and apply EO in the various domains.

10.0 KEY MESSAGES AND RECOMMENDATIONS

The study findings contribute to bring attention to the most pressing real-world issues and Indigenous knowledge for DRR worldwide covering land, oceans, ecosystems, and societal transitions, and potential solutions offered by emerging EO based tools and techniques that offer evidence-based and efficient approaches to generate measurable long-term solutions. It also examines and identifies challenges and barriers for Indigenous communities to implement workable and replicable solutions in pursuit of building resilience.

Indigenous communities must have a voice in DRR. Their inclusion is justified as expression of Indigenous sovereignty articulated in the 2007 UN Declaration on the Rights of Indigenous Peoples. Imposing centralized solutions to local problems (many of which already have successful local solutions) can undermine a community’s capacity to reduce risk and save lives and property. The multilateral agreements have been consistent in demanding Indigenous Peoples must have opportunities to develop their own strategies as well as participate in the development of national and international policies. To track the Sendai Framework commitments, the UN has developed

[30] https://www.unoosa.org/oosa/en/informationfor/media/2019-unis-os-511.html

methodological guidance to establish baselines and assess progress across seven global targets for disaster risk reduction. There is a need to draw up baselines of the disasters that have affected Indigenous Peoples starting from 2015 to 2020 and the EO based tools and solutions to further attempt to compare them with the disasters that may occur in 2025 and 2030. Efforts are needed to derive simplified knowledge products that are outcome of research to create baselines and targets for Indigenous communities. These knowledge products will help the Indigenous communities to prevent the events from becoming disasters; keep the disaster fatality rate near zero; prevent people from being evacuated and avoid disaster economic losses; and protect significant sources of critical infrastructure from disruption.

The following key messages can be derived from the above discussion:

a. Promote real-time access to usable information products generated from EO data and in situ information through information and communications technologies (such as mobile phone) to enhance participation of Indigenous communities in DRR.
b. Enhance the knowledge of Indigenous stakeholders, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction.
c. Improve dialogue and cooperation among EO and Indigenous communities, other relevant stakeholders, and policymakers to facilitate their interface in effective use of EO products in DRR decision making.
d. Ensure use of traditional, indigenous, and local knowledge and practices, in combination with EO products to formulate DRR policies, strategies, plans and programs.
e. Strengthen technical capacity of indigenous communities to consolidate existing knowledge that may be useful to assess disaster risks, vulnerabilities, and exposure to all hazards.

The authors propose following recommendations:

a. A dedicated multi-year funded program for integrating EO and Indigenous Knowledge, as part of the efforts towards implementing the Sendai Stakeholder Engagement Mechanism (SEM) work plan.

b. Formulate consortium representing EO, disaster management and Indigenous communities to prepare and strengthen their work with climate and DRR for the timely implementation of Sendai Framework.

c. Empower Indigenous youths to use EO technologies driven DRR solutions with engagement through the institutions such as Indigenous Intercultural University to address the challenges with accelerated technological inequalities amongst the Indigenous Peoples.

   Introduction of “new” technologies, especially those as sophisticated and expensive as space-based EO (as well as GIS and others) present challenges to indigenous and other historically underserved communities. Communities and community-focused organizations with interests in DRR are in the best position to serve their populations when they can collect and maintain and visualize their own data.

   In the past, community-focused organizations would have to rely almost solely on partnerships with national or state agencies, or majority-institution partners to provide or engage in applications of EO and GIS mapping whose tools, historically, have been expensive to purchase and license. Training users was also a challenge because of the high skill levels associated with understanding and keeping up with commercial, proprietary hardware and software.

   Today’s environment is in a state of change. Hardware and software options are more varied and user-friendly. The tools are becoming available, particularly in the use of GIS where, now, workflow can be engaged by expert and novice users, with little budget resource. Introducing such workflows to communities can empower users to collect, analyze, display, and share their own spatial data.

d. Develop baselines of the disasters that have affected Indigenous Peoples starting from 2015 to 2020 and the EO based tools and solutions to further attempt to compare them with the disasters that may occur in 2025.

e. Address issues related to Indigenous community in the Space Solutions Compendium being developed by UNOOSA.

f. Prioritize DRR capacity development in local languages.

   Descriptions of research projects, consent forms, etc. should be adapted so they are culturally and linguistically appropriate in the local context, by participating communities and individuals (it’s not as simple as “language”). Members of communities who will be the focus of the research should be involved, also, up front, in the development of the research tools so that they can ensure relevance to community needs and that questions to be explored, and their implications, are understood in the local context.

g. Define and implement key role of women in the transfer of knowledge, especially through the Space4Women initiative of UNOOSA.

11.0 Draft Indigenous Workflow:

Timeline	Activities	Organizations
2021	• Ongoing networking of Indigenous support. • Launch of Itinerant Indigenous Chair – CII • Pilot project 1: Geo-mapping points of significance for select Indigenous communities. • Drafting of Indigenous engagement principles	CANEAUS Key global stakeholders e.g. PAHO
2022	• Indigenous session at virtual event - launch of Indigenous engagement principles; targeting select conferences for Indigenous sessions. • Pilot project 3: "Geo-fencing" Indigenous livestock and land management • Informing SDG indicators • Evaluation strategy and framework drafted. • Training Program: small-scale agricultural production • Draft ongoing Indigenous Capacity develop programs: Policy and Lab on Wheels; Indigenous STEM engagement	UNPFII UNDRR
2023	• UN Regional DRR/STI Platforms • Engagement with Pilot Project 2 • Training and Capacity development strategy drafted • Evaluation framework finalized and piloted. • Establishment of Indigenous Advisory Board	Key global stakeholders
2024	• Training and Capacity development strategy launched (DRR/EO conferences). • Indigenous STEM internships launched • Evaluation report.	Key global stakeholders
2025	• Symposia on Indigenous EO engagement • Program review • Future funding identified.	Key global stakeholders

12.0 CONCLUSIONS:

The study gives realization that the Indigenous community is vulnerable to the disasters and climate extremes. The knowledge possessed by Indigenous community is valuable and it can be further complemented by EO-based solutions. The EO solutions that focus on ecosystem and environment has a great relevance to needs of the

indigenous communities, however EO community needs to develop the perspective to integrate EO-based information products and knowledge of indigenous community. The study also underlines the gaps and practical barriers that impact the exchange between Indigenous and local community knowledge holders, and EO based tools and solutions developers and providers. The technological inequalities appear growing especially due to Covid-19 pandemic and it would be challenging to meet the indicators defined by the Sendai Framework for DRR 2015–2030.

ACKNOWLEDGEMENT

The study was benefitted by initiatives and programmes led by the UN Office for Outer Space Affairs that includes Access to Space for All, Space4Women, UN-SPIDER, Space Solutions Compendium and conferences promoting space for sustainable development.

We thank Members of the permanent representatives to the United Nations who contributed to this study and related research. Thanks, are also to several colleagues for providing research assistance.

REFERENCES

Lorenzo-Alonso Alberto, et al, 2019. Earth Observation Actionable Information Supporting Disaster Risk Reduction Efforts in a Sustainable Development Framework, MDPI journals - Remote Sensing, 11 (1), 49.

Kale Manish, et al, 2009. Patterns of Carbon Sequestration in Forests of Western Ghats and Study of Applicability of Remote Sensing in Generating Carbon Credits through Afforestation/Reforestation, J. Indian Soc. Remote Sens. 37 (457–471).

Kukutai, Tahu, and John Taylor, eds. 2016. Indigenous Data Sovereignty: Toward an agenda. Canberra: ANU Press.

Roy et al, 2015. New vegetation type map of India prepared using satellite remote sensing: Comparison with global vegetation maps and utilities, International Journal of Applied Earth Observation and Geoinformation, 39 (142-159)

Ravan Shirish, et al, 1997. Satellite remote sensing for ecological analysis of the forested landscape, Plant Ecology, 131 (129-141)

Scott Simon Lambert et al, 2017, Statement by the Major Group on Indigenous DRR at the 2017 Global Platform.

Pimprikar Milind, et al, 2019-2020, “A Global Initiative to improve living conditions for Indigenous Populations using earth observation data” UNFCCC COP25 “Earth Information Day 2019, and UN COPUOS STSC 2020 Session, Vienna,

Pimprikar Milind, et al, 2020 “Indigenous Peoples-led Use of Earth Observations”, UN-HLPF 2020 Side Event report, 24 pages.