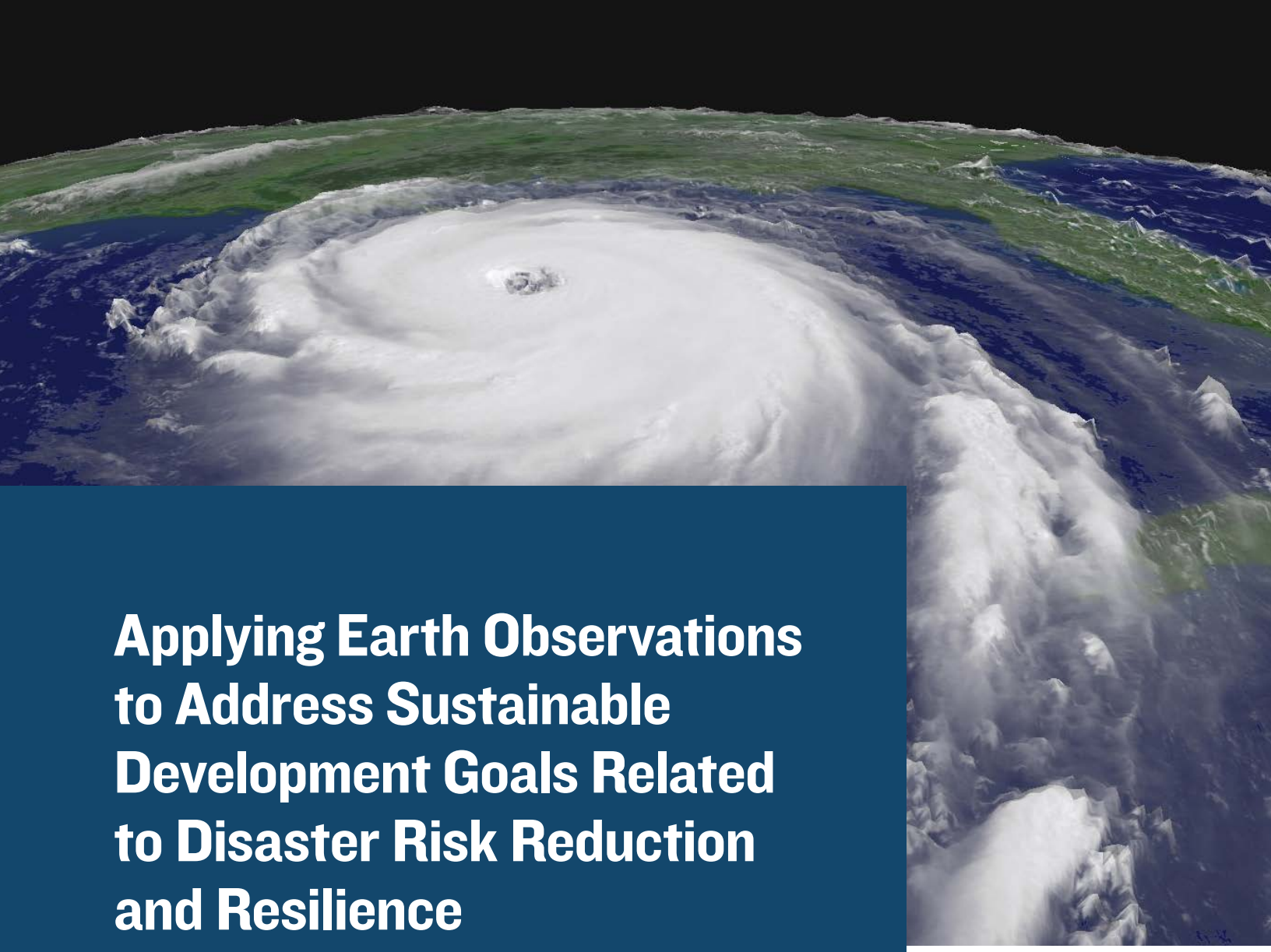

Applying Earth Observations to Address Sustainable Development Goals Related to Disaster Risk Reduction and Resilience

Gertrude Pavur

EARTH OBSERVATIONS FOR THE SUSTAINABLE DEVELOPMENT GOALS

GEO GROUP ON EARTH OBSERVATIONS

Abstract

Earth observations from satellites are essential tools for solving complex societal challenges and for promoting sustainable development within communities around the world. Satellite-based data aids efforts to achieve the United Nations Sustainable Development Goals (SDGs), helping countries address the social, economic, and environmental effects of disasters across the globe. With the support of ground-based and other forms of Earth observations, satellite data provides community leaders with improved information about disasters. This can significantly decrease the loss of life and economic burdens disasters place on society, as well as better represent poor and vulnerable community members. Included in this report are two case studies about creative uses of remote sensing data to promote resilience and reduce risks related to disasters in Puerto Rico and Bangladesh.

Introduction

Disasters, such as hurricanes, floods, droughts, and storms, have extensive effects on communities across the globe. From decimated infrastructure to significant loss of life, disasters cause major social, economic, and environmental setbacks for a nation. To combat and prevent the aftermath of disasters, countries must strategically reduce vulnerability and improve resilience.

The United Nations 2030 Agenda for Sustainable Development encourages countries to tackle ambitious goals related to disaster risk reduction and resilience. At global, regional, national, and sub-national levels, processes to achieve sustainable development need to include risk information in order to achieve sustainability, resilience, poverty eradication, and inclusion of vulnerable communities. Because of the cross-cutting nature of disasters, many of the SDGs directly relate to improving the social, economic, and environmental impacts of disasters.

This report focuses on SDG 11 and the related Target 11.5. SDG 11 challenges countries "to make cities and human settlements inclusive, safe, resilient, and sustainable." Target 11.5, a subset of this Goal, focuses on reducing the social, economic, and environmental impacts of disasters. Through timely preparation, improved predictions, and continual monitoring, communities can significantly improve their disaster preparedness and resilience. There is also a call to focus on protecting under-represented communities, including the poor and those in vulnerable situations.

The use of satellites to provide Earth observations and geospatial data is valuable and necessary for achieving disaster preparedness and sustainable cities and communities. A flood forecasting system in Bangladesh and the use of nightlight satellite imagery to aid with emergency response efforts in Puerto Rico after Hurricane Maria showcase the innovative use of Earth observations to enable disaster risk reduction and preparedness.

Figure 1. NASA Black Marble composite images for year 2016 provide full-hemisphere views of Earth at night. Natural surfaces, clouds, and sun glint—added here for aesthetic effect—are derived from the MODIS Blue Marble Next Generation imagery products. Credit: NASA / Román et al.

Sustainable Development Goals Related to Disaster Preparedness

Disaster risk reduction and sustainable development have a strong, interconnected relationship. The following SDGs relate to disaster preparedness:

- Goal 2, Zero Hunger,
- Goal 3, Good health and well-being,
- Goal 6, Clean water and sanitation,
- Goal 7, Affordable and clean energy,
- Goal 9, Industry, innovation, and infrastructure,
- Goal 11, Sustainable cities and communities,
- Goal 12, Responsible consumption and production,
- Goal 13, Climate action,
- Goal 14, Life below water,
- Goal 15, Life on land, and,
- Goal 17, Partnership for all the Goals.

Light on Puerto Rico:

How Satellite Data supported Emergency Response Efforts after Hurricane Maria

155 mile per hour winds. Record flooding. An entire island without power. September 20, 2017 is a day Puerto Rico will remember. It marks the landfall of Hurricane Maria: the strongest storm to hit Puerto Rico in the past 85 years. In less than 18 hours, the storm evolved from a Category 1 to a Category 5 hurricane, leaving little time for the Caribbean island to sufficiently prepare. According to the National Oceanic and Atmospheric Administration (NOAA) National Hurricane Center, Hurricane Maria caused estimated damages of $90 billion in Puerto Rico, making it the third costliest tropical cyclone in United States history.

With extensive flooding, uprooted trees, landslides, and power outages, first responders faced significant challenges while providing aid in Puerto Rico immediately after Hurricane Maria. Knowing the importance of timely and efficient response to disasters, researchers at NASA informed the National Guard and the Federal Emergency Management Agency (FEMA) about a remote sensing tool they developed called Black Marble.

Figure 2. Satellite image of Hurricane Maria on September 20, 2017 in the Caribbean. Credit: NASA

This satellite-based tool identifies areas on Earth with electricity at night, and can be used to provide more information to emergency first responders to help them decide where to direct their efforts.

Two Earth observing satellites, Suomi-National Polar-Orbiting Partnership (S-NPP) and Joint Polar Satellite System (JPSS), have sensors that capture nighttime light patterns across the globe. These sensors, called Black Marble, were developed by researchers at NASA Goddard Space Flight Center and Marshall Space Flight Center. To accurately identify areas on Earth with electricity at night, Black Marble uses complex algorithms to account for non-electric light sources and cloud cover.

Black Marble captured the nighttime lighting of Puerto Rico before and after Hurricane Maria. As power was gradually restored to the island, response teams monitored the areas to continually identify locations in need of assistance, including areas with hospitals but lacking power.

Satellite imaging provided information about Puerto Rican communities in distress in ways that ground observations alone could not. This saved time assessing the situation directly after Hurricane Maria, and prompted government agencies to quickly direct efforts towards areas in need. The use of Black Marble and remote sensing tools provided more information, enhancing government and non-government agencies' efforts to efficiently assist Puerto Rico after one of the most traumatic hurricanes in United States history.

Puerto Rico in September vs. Puerto Rico in December:

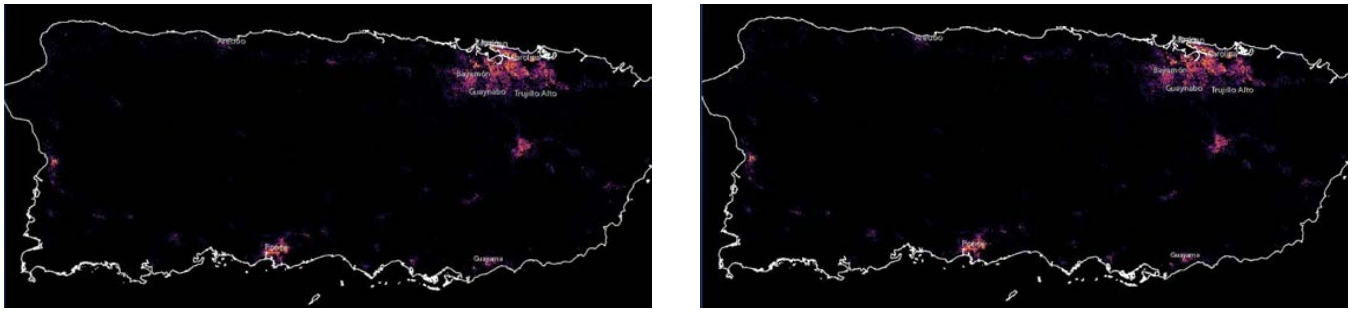

Figure 3: Black Marble satellite images of Puerto Rico in September (left) and December (right). Credit: NASA / Román et al

Figure 4: Flooded house south of Dhaka, Bangladesh. Credit: Yann Arthus-Bertrand

Forecasting Floods in Bangladesh

In South Asia, Bangladesh faces the burden of living downstream from one of the world's largest and most dynamic river delta systems. Major flooding events cause significant pressures on the social, economic, and environmental aspects of Bangladesh. For political reasons, in-situ water data is not reliably shared between the neighboring countries of this watershed, leaving Bangladesh with little time to prepare for the floods. Through a collaboration between various local and international organizations, NASA Earth observations were used to create an eight-day flood forecast warning system to improve flood risk and resilience in Bangladesh.

Because Bangladesh sits at the delta of three major rivers—the Ganges, Brahmaputra, and Meghna Rivers—it is prone to frequent and major flooding events. During monsoon season, the rivers can swell up to twenty times their normal state. The water also originates as rainwater from Bhutan, China, India, and Nepal, and as snowmelt in the Himalayas. Unfortunately, the poorest people of Bangladesh typically live in the most flood-prone areas, making them the most vulnerable and at-risk communities.

> **"If we knew earlier that the flood was coming, then we would have tied down the jute in a safe place and we would not have to lose it. The drowned jute rotted completely."**
>
> **- Community leader from the village of Char Bozra**

SERVIR, a joint venture between NASA and the U.S. Agency for International Development (USAID), collaborated with local organizations to create an eight-day flood prediction system by using NASA Earth observations. Satellite data allows Bangladesh to overcome challenges of sharing ground data between countries, which helps them obtain regional hydrological information. The satellite-based, flood forecasts validate ground data and support three-day flood predictions. The further-out prediction system allows more time for Bangladesh communities to prepare for an incoming flood, including moving livestock, tying down crops to prevent them from washing away, and even evacuating the area.

"Countries have boundaries, Earth observations don't."

– Barbara Ryan, Director, Group on Earth Observations (GEO) Secretariat (2012-2018)

A recent evaluation of this eight-day flood forecasting warning system found that a large portion of Bangladesh's population never actually received the flood information. "Only 11% of people living in the most dangerous, risk-prone areas of the country ever got the government issued warnings. That is abysmally low," said SERVIR project scientist Ashutosh Limaye.

In an effort to increase the dispersion of the flood warning information, SERVIR is aligning their efforts with the Red Cross to create a forecast-based, financing program. This initiative involves the Red Cross distributing small amounts of money to incentivize those living in areas at risk to evacuate when the flood forecasting tool predicts a major flood. "It's a preventative action," said SERVIR Director Daniel Irwin. "This approach is millions of dollars cheaper than responding with emergency aid after a major flood."

While Bangladesh still faces significant challenges concerning the social, economic, and environmental burdens of floods, this eight-day flood forecasting tool provides the opportunity to issue early warnings, allowing more time for people to prepare. The Red Cross forecast-based financing program strives to incentivize people to evacuate areas with significant flood risk and also to be more aware of government-issued flood warnings. The innovative collaboration of SERVIR and Red Cross's forecast-based financing program supports Bangladesh's efforts of making significant progress towards reducing disaster risk and becoming more resilient.

Conclusion

Earth observations and remote sensing data are valuable tools for achieving Sustainable Development Goals related to disaster risk and resilience. This technology has the potential to address complex social, economic, and environmental challenges of disasters across the globe. As in Puerto Rico after Hurricane Maria and in Bangladesh following major flooding events, the use of Earth observations can support efforts to decrease the loss of life, the economic burdens placed on society, and the vulnerability of the poorest communities. While Earth observations cannot solve every problem, the data can be used to support best uses of in situ monitoring resources to provide community leaders with a more holistic understanding of disasters. This can help countries make significant progress towards decreasing disaster risk, improving resilience, and developing sustainably.

Acknowledgements

I would like to acknowledge Daniel Irwin, SERVIR, Ashutosh Limaye, SERVIR, Elena Lobo, Catapult UK, Shanna McClain, NASA HQ, and Africa Flores, SERVIR, for providing insights, knowledge, and time for interviews. I would also like to acknowledge my mentor, Argyro Kavvada, NASA HQ, for her guidance and support throughout this project. Finally, I would like to thank Auset Taylor, Princeton University, for her assistance with this report.

References

Alfieri, Lorenzo, et al. "A Global Network for Operational Flood Risk Reduction." *Environmental Science and Policy*, vol. 84, June 2018.

Anderson, Katherine, et al. "Earth observation in service of the 2030 Agenda for Sustainable Development." *Geo-spatial Information Science*, vol. 20, no. 2, June 2017.

"Bangladesh Flood Forecasting and Warning Center adopts satellite-based flood forecasting system developed by SERVIR." *SERVIR Global*, SERVIR, 25 June 2014, https://servirglobal.net/Global/Articles/Article/1320/bangladesh-flood-forecasting-and-warning-center-adopts-satellite-based-flood-fo.

"Costliest U.S. Tropical Cyclones Tables Updated." *National Hurricane Center*, NOAA, www.nhc.noaa.gov/news/UpdatedCostliest.pdf. Accessed 8 Aug. 2018.

"Hurricane Maria Lashes Puerto Rico." *NASA Earth Observatory*, NASA, https://earthobservatory.nasa.gov/images/91004/hurricane-maria-lashes-puerto-rico. Accessed 8 Aug. 2018.

"NASA Black Marble HD: Hurricane Maria." *NASA Earth Science Disasters Program*, NASA, www.arcgis.com/apps/MapSeries/index.html?appid=6135434f7ffe4b13b815afc6dd052eb3. Accessed 8 Aug. 2018.

"Puerto Rico Goes Dark." *Visible Earth: A catalog of NASA images and animations of our home planet*, NASA, https://visibleearth.nasa.gov/view.php?id=88796. Accessed 8 Aug. 2018.

"Quick Facts: Hurricane Maria's Effect on Puerto Rico." *Mercy Corps*, 6 June 2018, www.mercycorps.org/articles/united-states/quick-facts-hurricane-marias-effect-puerto-rico.

Ramage, Steven, et al. "Earth observations for climate-resilient cities at ICLEI's Resilient Cities 2018 congress." *Earth Observations for Sustainable Development Goals*, Group on Earth Observations, https://eo4sdg.org/takeaways-from-icleis-2018-resilient-cities-congress/. Accessed 8 Aug. 2018.

"Sendai Framework for Disaster Risk Reduction 2015-2030." *Sustainable Development Knowledge Platform*, United Nations Office for Disaster Risk Reduction (UNISDR), https://www.unisdr.org/we/coordinate/sendai-framework. Accessed 8 Aug. 2018.

Voiland, Adam. "Pinpointing Where the Lights Went Out in Puerto Rico." *Earth Observatory*, NASA, https://earthobservatory.nasa.gov/images/91044/pinpointing-where-the-lights-went-out-in-puerto rico. Accessed 8 Aug. 2018.

Wang, Z., et al. "Monitoring Disaster-Related Power Outages Using NASA Black Marble Nighttime Light Product." *International Society for Photogrammetry and Remote Sensing*, vol. XLII, no. 3.

Prepared by:

Gertrude Pavur, Georgia Institute of Technology (NASA 2018 Summer Intern)

Designed by:

Steve Fultz, CHIEF

Earth Observations for the Sustainable Development Goals (EO4SDG)

EO4SDG Secretariat
NASA Headquarters
300 E Street SW
Washington, DC 20024-3210
http://eo4sdg.org