THE POTENTIAL OF EARTH OBSERVATION, BIG DATA, ARTIFICIAL INTELLIGENCE, AND MACHINE LEARNING TO IMPROVE FINANCIAL RISK MANAGEMENT

World Bank Crisis Risk Finance Analytics Strategic Overview

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I. INTRODUCTION

ABOUT THIS DOCUMENT

This report presents a taxonomy on the potential of Earth Observation (EO), Big Data (BD), Artificial Intelligence (AI), and Machine Learning (ML) to improve financial risk management. First, the document explains the criteria used to develop this taxonomy and classifies the potential of the technologies to contribute to Disaster Risk Finance (DRF). Second, based on the analysis of several case studies, the most promising technologies and data sources are presented. Finally, the limitations, challenges, and ways forward are presented to ensure these solutions can be implemented and further strengthen the financial resilience of developing economies.

The most promising technologies and data sources outlined in this document correspond to Earth Observation, mobile and social media data. Their application is presented through the case studies below:

1 **Parametric insurance: Pan-African Flood Extent Depiction**

2 **Nature and biodiversity risk:**

a. Open asset-level databases for the cement and steel industries (ALD)
b. IPP CommonSensing Project Case Study

3 **Capacity-building: Geodata for upgrading smallholders' farming systems**

4 **Financial inclusion: FarmDrive Kenya**

5 **Early warning detection:**

a. Detecting climate adaptation with mobile network data in Bangladesh
b. Building resilience through crowdsourcing - Early flood detection for rapid humanitarian response

These use cases cover multiple facets of DRF, including hazard identification (through early detection), vulnerability reduction (through capacity building and financial inclusion) and financial products (such as parametric insurance).

CONTEXT

The escalation of natural and man-made disasters, exacerbated by climate change, has caused unprecedented social and economic losses for governments, businesses, and households around the world. Every year, natural disasters generate an average of US$152 billion in economic losses, directly impacting 200 million people.[1] In the absence of appropriate Disaster Risk Financing (DRF) and Management (DRM) solutions, fragile and vulnerable countries face significant financial losses through their contingent liability and emergency response efforts, as well as long-term recovery and reconstruction costs. In Haiti alone, the 2010 earthquake directly impacted approximately 15% of the population, with the damages estimated to exceed the national GDP in 2009[2]. In that same year, natural and man-made disasters generated US$440 billion dollars in losses.

DRF policies and instruments offer governments a potent tool to mitigate the large range of risks associated with natural and man-made disasters by improving financial preparedness and resilient recoveries through ex-ante financial planning.[3] DRF-powered analytics enable governments and policymakers to make risk-informed decisions to quantify, plan, and predict risks with more certainty, as well as to design adequate financial response mechanisms accordingly.[4]

New technologies play a significant role in enhancing DRF analytics. Big Data (BD) and Earth Observation (EO) technologies offer information with unprecedented resolution and comprehensive coverage. Machine Learning (ML) and Artificial Intelligence (AI) algorithms can help process these vast amounts of data and provide near-real-time risk information and more accurate assessments. This information can ultimately improve the timeliness and efficiency of better targeted financial response to affected communities, businesses, and industries.

1 The International Disasters Database (EM-DAT). Accessed October 27, 2021, https://www.emdat.be/. Found in "2020: The Non-COVID Year in Disasters - Global Trends and Perspectives - World," ReliefWeb, accessed October 27, 2021, https://reliefweb.int/report/world/2020-non-covid-year-disasters-global-trends-and-perspectives.

2 The damages were estimated at US $ 7.804 billion in 2010. Government of the Republic of Haiti, "Haiti Earthquake PDNA: Assessment of Damage, Losses, General and Sectoral Needs. Annex to the Action Plan for National Recovery and Development of Haiti," 2010, https://www.gfdrr.org/sites/default/files/GFDRR_Haiti_PDNA_2010_EN.pdf.

3 Understanding Risk (2021). Understanding Risk. Revolutionizing Disaster Risk Finance: Are You Up for The Challenge? Accessed October 27, 2021 https://understandrisk.org/disaster-risk-finance-challenge-fund-round-3/.

4 Disaster Risk Financing and Insurance Program, "Disaster Risk Finance Analytics: Supporting Countries to Manage the Cost of Disaster and Climate Shocks," 2017, https://www.gfdrr.org/sites/default/files/publication/Brochure%20Analytics.pdf.

THE WORK OF THE WORLD BANK CRISIS AND DISASTER RISK FINANCE TEAM

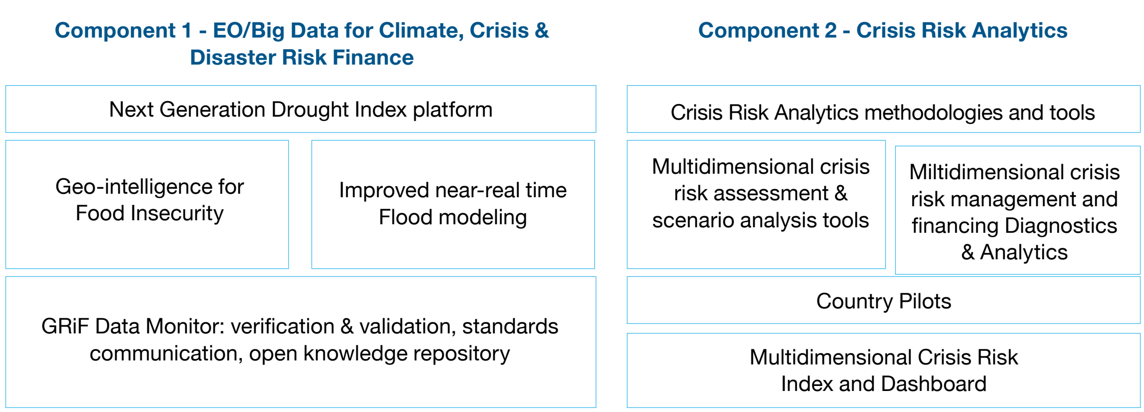
The high cost of natural disasters for nations and individuals is not necessarily a foregone conclusion. With appropriate policies and instruments in place, effective financial risk management can reduce the burden on governments and minimize the impact on livelihoods, development gains, and investments.

The World Bank Crisis and Disaster Risk Finance (CDRF) team supports governments through advisory services and risk financing solutions to strengthen their resilience to climate, crisis, and natural disaster shocks. The Crisis Risk Finance Analytics program (CRFA), founded in 2019, supports new and existing World Bank engagements related to innovative technology for improved risk finance applications. In particular, the program has integrated innovative data sources including EO and BD technologies, as well as analytical methods (e.g., parametric product design, image-processing, AI) to improve risk financing and management.

To that end, the World Bank CDRF team has established a partnership with the European Space Agency (ESA) to leverage such technological advances for improved pre-arranged financing. Established in 2019, the partnership focuses on leveraging remote sensing, online/social media/big data, and predictive analytics to support global level identification of risks, national/sectoral diagnostics, and project-specific activities to enable better informed and earlier financial response to crises. A core objective is the development of timely, reliable risk metrics and triggers as well as innovative approaches to assess overlapping risks in complex situations. As such, the joint partnership with ESA provides the missing link between technology and operations, by providing project-specific risk finance analytics. It focuses on supporting the CRFA program, whose ultimate objective lies in the scaling-up of risk financing operations in a sustainable, robust, and transparent manner.

The CRFA program is funded by the Global Risk Financing Facility (GRiF) and structured around two components as depicted in Figure 1.[5]

Figure 1. CRFA program structure



5 More information at: The World Bank, "Global Risk Financing Facility," World Bank, accessed October 27, 2021, https://www.worldbank.org/en/topic/disasterriskmanagement/brief/global-risk-financing-facility.

II. CRITERIA FOR TAXONOMY AND POTENTIAL CLASSIFICATION: EARTH OBSERVATION, BIG DATA, ARTIFICIAL INTELLIGENCE, MACHINE LEARNING FOR DISASTER RISK FINANCE

The taxonomy serves as a reference for policymakers and development partners to better know where and when to invest or deploy satellite and big data for DRF solutions. The technologies have been classified according to their application for one hazard or multiple hazards, the financial products that use these data sources, and the unit or level of application. This taxonomy is not intended to be exhaustive or definite, as the application of the technologies is expected to increase and change over time. The classification helps evaluate various technologies based on comprehensive criteria related to their capacity to enhance dynamic risk monitoring, provide objective data, scalability, sustainability, clients' buy-in, ownership, and benefit governments in their resilience efforts overall.

A. TAXONOMY

Hazard[6]: A Hazard is often referred to as a potential disaster and is a phenomenon that negatively impacts society, economy, and ecology. Hazards can be natural, anthropogenic, or socio-natural and are categorized by whether they are natural or technological. Natural hazards can be classified by their location or area they cover, duration, and magnitude or intensity. It is not possible to prevent natural hazards, but various strategies and actions can decrease their severity and harm. Hazards can be classified into droughts, floods, hurricanes, wildfires, landslides, tsunamis, and earthquakes.

Multi-Hazards[7]: The UN (2020) defines "Multi-hazard as (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may coincide, cascading or cumulatively over time, and taking into account the potential interrelated effects."

Ex-post or ex-ante risk management[8]: A technology serving disaster risk management can be implemented before or after the disaster. An ex-ante in financing instruments is the proactive planning of a national catastrophe risk management before a disaster. It is "the practice of recognizing the cost of public policy for disaster relief and recovery before a loss event." Ex-post management is a strategy that provides emergency response, recovery, or relief services in the aftermath of a disaster.

Type of financial and technical assistance products: The technologies are generally associated with financial and assistance products. Financial and assistance products may be a product or an instrument that helps mitigate financial risks such as:

a. Insurance: Sovereign insurance, micro-insurance, and sovereign risk transfer insurance.
b. Loans and credits: Contingent credit by development, microfinance, financial inclusion.
c. Savings: Transfer of funds.
d. Government budgets: Budget on reallocation or contingency budget, disaster reserve fund or contingent fund, tax increase, the credit risk of sovereign debt.
e. Information: Early warning systems, capacity, and awareness building.

6 UNDRR 2017, Terminology, https://www.preventionweb.net/understanding-disaster-risk/component-risk/hazard
7 UNDRR, 2020, Hazard definition and classification review https://www.undrr.org/publication/hazard-definition-and-classification-review
8 Justin Ram, Resilience building comprehensive disaster risk financing, https://www.cepal.org/sites/default/files/events/files/justin_ram_-_resilience_building_comprehensive_disaster_risk_financing.pdf

f. International aid and development assistance: A form of assistance provided by a country or a multilateral institution to support economic, social, environmental, and political development.[9]

g. Supply chain monitoring: Companies and organizations are often exposed to disruptions or scandals, causing financial and reputational damage. Spatial finance through "geospatial analysis can support the mapping and monitoring of supply chains, while ledger technologies such as blockchain allow for increased supply chain traceability".[10]

h. Addressing nature and biodiversity risk: Geospatial and earth observation datasets provide insights into economic actors or drivers of ecosystem degradation.

Level of implementation: Financial products derived from technologies are applied at the National, sub-national, sovereign, or individual levels.

Data source: Refers to the type of data being collected and used in the technology (e.g., table, database, photo, web, audio, social media, mobile, unstructured).

Table 1: Taxonomy & Examples of Big Data[11]

Types	Examples	Applications
Category 1: Exhaust data[12]		
Mobile-based	Call Detail Records (CDRs) GPS (Fleet tracking, Bus AVL).	Estimate population distribution and socioeconomic status in diverse places.
Financial transactions	Electronic ID, E-licenses (e.g., insurance), Transportation cards (including airplane fidelity cards), Credit/debit cards.	Provide critical information on population movements and behavioral response after a disaster.
Category 2: Digital Content		
Social media	Tweets (Twitter API), Check-ins (Foursquare), Facebook content, YouTube videos.	Provide early warning on threats ranging from disease outbreaks to food insecurity.
Crowd-sourced/ online content	Mapping (Open Street Map, Google Maps, Yelp), Monitoring/ Reporting (uReport).	Empower volunteers to add ground-level data that are useful notably for verification purpose.
Category 3: Sensing data		
Remote	Earth Observation: satellite imagery (ESA's Copernicus, NASA TRMM, LandSat) Unmanned Aerial Vehicles (UAVs).	Satellite images revealing changes in, for example, soil quality or water availability have been used to inform agricultural interventions in developing countries.

9 Lin Sabones (2015). What is international aid & why we should care. https://borgenproject.org/international-aid-care/

10 Spatial Finance Initiative (2021). STATE AND TRENDS OF SPATIAL FINANCE 2021: Next Generation Climate and Environmental Analytics for Resilient Finance https://www.cgfi.ac.uk/wp-content/uploads/2021/07/SpatialFinance_Report.pdf

11 Data-Pop Alliance (2015). "Big Data for Resilience: Realising the Benefits for Developing Countries". Synthesis report. https://datapopalliance.org/wp-content/uploads/2015/11/Big-Data-for-Resilience-2015-Report.pdf

12 Exhaust data is ambient data that is passively collected, with limited -or even zero- value to the original data collection partner. The data collector gathers it for a different purpose than its subsequent uses. New sources of value can be obtained from this data when combining it with other data sources. More information here: https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=5620&context=lkcsb_research

B. EVALUATION CRITERIA FOR ASSESSING THE POTENTIAL OF TECHNOLOGIES ASSOCIATED WITH DISASTER RISK FINANCE

Table 2. Evaluation Criteria

Criteria	Definition	Components	Research question
Dynamic risk monitoring	The continuous process of identifying hazards, assessing and working towards reducing and better responding to risks, and monitoring the rapidly changing circumstances. There are three major components: identify risks and sources of vulnerability, define risk appetite and decide on a risk response approach.	Hazard	Does the technology cover one or multiple shocks/stressors, and does it aim to prevent, reduce, or manage existing risk (ex-ante or ex-post risk management technology)?
		Frequency	How rapidly can the information coming from this technology (e.g., values of the indices) be made available (day/ monthly/weekly)?
		Coverage	What is the surface area of the globe that the satellite provider makes available? What is the temporal coverage of the historical imagery available?
Objective data	The observable and quantifiable data that is measured consistently.	Resolution	At what level of spatial resolution is data collected? And how reliable is it at estimating the impact on the ground?
		Complementarity	Is data used alone or in combination with other models (e.g., crop models)?
		Transparency	Is the data used free, transparent, open-source?
Scalability	Measures the ability of a system's increase and decrease in performance and the cost, which is subject to change, in application and system processing demands. Sustainability is the capacity to endure ongoing change.	Replicability	Is the technology easily scalable, and is the development process labor-intensive or automated?
		Capacity building	Is the development associated with in-house capacity building for replicability, and how complex is it to explain the product and its implementation to potential clients/users?
Benefits for financial resilience	Developing countries are developing financial protection strategies to secure the pre-arranged financing before any disaster or risk strikes, referred to as a governmental budget.	Direct benefits	Does the technology have direct benefits for government and other end-user applications in risk management and early warning?
Ownership	Refers to the methodology for creating financial products by checking whether it is proprietary or not and whether other countries or other agencies can adopt it within the country of operation.	Proprietary	Is the technology proprietary? If not, how challenging is its adoption by other users?
		Commercial protection	Is the technology commercially protected where it cannot be feasible to transfer the development of its indices to another country or company?
		Open source	Is the technology open source?

III. CASE STUDIES ANALYSIS

The following technologies have contributed to DRF applications by developing platforms, evaluation frameworks, and services. These technologies contribute to the development of assessments and financial instruments that can prevent high budgetary constraints for impacted countries and individuals and secure faster financial responses to beneficiaries on the ground. This section presents the most promising technologies according to the assessment criteria.

A. MOST PROMISING TECHNOLOGIES EMERGING FROM THE CASE STUDIES ANALYZED

EARTH OBSERVATION, MOBILE DATA, AND SOCIAL MEDIA-BASED TECHNOLOGIES

Earth observation (EO) represents the most promising application to improve preparedness before disasters. EO gathers information about the planet's physical, chemical, and biological systems using remote sensors, including satellites, balloons, and drones. This information allows for the monitoring of changes to the planet's composition across time and space. Hazards tend to happen after a combination of physical and environmental conditions occur. Once they happen, they also tend to change the physical and ecological needs of affected locations. For instance, some floods are caused by heavy rains. Once they take place, water occupies a space that used to be covered with land before. EO technologies allow us to monitor the triggers of hazards, like heavy rains, before they turn into hazards like floods. When stimuli are properly monitored through EO, they become inputs for models that help predict hazards in near-real-time. Most use cases relate to Satellite Imagery, because these images cover the entire globe, have a high-resolution[13], and revisit times of hours or days.[14] Regardless of its radar or image-based, satellite imagery can help monitor changes for a wide range of events. Several datasets are freely available, and, as will be exemplified by the following use-cases, these images allow decision-makers to better prepare in the face of natural and man-made disasters.

Mobile and social media-based technologies, often combined with EO data, represent the other promising technologies.

13 In sentinel-2 data, each pixel has a resolution between 10-60 meters. Covering the world's land area (from 56° S to 84° N). The European Space Agency. Sentinel online. Resolution and Swath. Spatial and Spectral Resolutions. Accessed on October 28, 2021. https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/instrument-payload/resolution-and-swath

14 The satellites in the Sentinel-2 constellation provide a revisit time of five days at the equator in cloud-free conditions. The European Space Agency. Sentinel online. Resolution and Swath. Spatial and Spectral Resolutions. Accessed on October 28, 2021. https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/instrument-payload/resolution-and-swath
NASA Landsat programme has a constellation of satellites that provide a revisit time of eight days. USGS, What are the acquisition schedules for the Landsat satellites? Accessed on October 28, 2021 https://www.usgs.gov/faqs/what-are-acquisition-schedules-landsat-satellites

Mobile-based or mobile-enabled technologies can become tools to deliver a wide variety of services that directly benefit users of climate risk mechanisms. Moreover, these technologies can create large-scale data issued from digital infrastructures, providing valuable inputs to transform climate finance and enable evidence-based decision-making. Four types of mobile and digital assets stand as enablers of solutions for climate mitigation, adaptation, and resilience:[15]

- "Mobile services: voice, SMS, USSD, interactive voice response (IVR), mobile apps
- Mobile payment services: mobile money, mobile money-enabled savings, mobile-enabled credit, mobile-enabled insurance
- Frontier technologies: Internet of Things (IoT), artificial intelligence (AI), blockchain, space technologies, Virtual and augmented realities, Drones and Robotics, and Big Data
- Data assets: customer data, big mobile data (commercial microwave links, call detail records, location data/location-based services, data through IoT services), etc."[16]

Although the benefits and applicability of each technology depend on the local context and the hazard, two main uses of these technologies in climate finance can be distinguished[17]:

1. Monitoring and measuring climate finance projects is a crucial -and often lacking- capability of climate financial mechanisms that can enable the measurement of impact and assure accountability.
2. Creating new business models for climate finance projects (i.e., reaching many beneficiaries in remote areas or deploying geographically dispersed programs).

Moreover, these technologies can be leveraged for multiple uses, from Early Warning Systems to monitoring displacement patterns in the aftermath of an event. For example, the latter could be analyzed through Call Detail Records (CRDs), as they can generate data related to location, movements, and environment, developing insight into mobility, social interaction, and even economic activity[18], allowing pre- and post-disaster comparison for better responses. In this vein, mobile phone data provides information on population behavior in areas where data was previously scarce, but that are no less affected by climate stress.[19]

Social media-based technologies and data can also enable critical insight for climate finance and risk management. According to the OECD (2013), social media may be categorized into: 1) Social networking media (i.e., Facebook); 2) Content sharing media (i.e., YouTube, Instagram); 3) Collaborating knowledge sharing (i.e., Wikis and podcasts); 4) Blogging and microblogging social media (Twitter) and 5) Volunteer technology communities (VTC) (which are social media platforms or modules specially created for risk and crisis communication).[20] The deluge of data produced by these technologies can be classified as "big data," and the process of retrieving, storing, processing, and visualizing it

15 Akanksha Sharma, GSMA (2021). The Role of Digital and Mobile-Enabled Solutions in Addressing Climate Change. 2021 GSM Association https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2021/03/The-Role-of-Digital-and-Mobile-Enabled-Solutions-in-Addressing-Climate-Change-Final..pdf

16 Ibid.

17 UN Global Pulse and the GSMA (2017). The State Of Mobile Data For Social Good Report. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2021/03/The-Role-of-Digital-and-Mobile-Enabled-Solutions-in-Addressing-Climate-Change-Final..pdf

18 Global pulse, GSMA, 2017, The state for mobile data for social good report https://www.unglobalpulse.org/wp-content/uploads/2017/06/Mobile_Data_for_Social_Good_Report.pdf .

19 Data-Pop Alliance (2015). "Big Data for Resilience: Realising the Benefits for Developing Countries". Synthesis report. https://datapopalliance.org/wp-content/uploads/2015/11/Big-Data-for-Resilience-2015-Report.pdf

20 Wendling, C., J. Radisch and S. Jacobzone (2013), "The Use of Social Media in Risk and Crisis Communication", OECD Working Papers on Public Governance, No. 24, OECD Publishing, Paris, https://doi.org/10.1787/5k3v01fskp9s-en.

as 'social media analytics' (Kumar et al., 2014).[21] The direct use of social media and its 'crumbs'[22] or 'big data', holds excellent potential for climate finance. Consequently, social media platforms[23] and crowdsourcing[24] (SMCS) strategies are becoming increasingly important in terms of climate risk and climate risk finance. Therefore, the main two uses relate to either the analysis of the existing data (passive) or the utilization of social media as communication channels (active). As portrayed in some case studies, each potential use can contribute to designing and implementing climate finance tools ex-ante, during, or in the event's aftermath.

B. APPLICATION OF MOST PROMISING TECHNOLOGIES IN THE CASE STUDIES ANALYZED

Earth Observation (EO) technologies have been widely incorporated into monitoring, preparedness, and response strategies, offering valuable information for emergency management decision-makers and long-term planning and response. The analysis of the case studies shows a broader application of EO technologies, ranging from insurance, early warning detection, financial inclusion, nature and biodiversity risk management, and international aid assistance.

- **Parametric insurance:** Earth Observation, particularly satellite imagery, is a versatile data source which helps identify the triggers of hazards, the vulnerability to a hazard, and its impact on people and infrastructure. It is also helpful to develop risk models to estimate associated costs. Satellite images provide ideal inputs to establish a large-scale mapping of exposure and vulnerability to different hazards. Using AI, the global coverage of satellite imagery and its granularity can be combined with data on assets on the ground, such as ownership, production type, productivity, and age, to produce asset-level data. Risk analyses can be made on specific assets, and the information can then be aggregated to create risk profiles for companies, portfolios, and countries. In turn, this

21 Habig, T., Lüke, R., Sauerland, T. & Tappe, D. (2020). DCT Knowledge Base – A consolidated understanding of Disaster Community Technologies for social media and crowdsourcing. Deliverable 4.1 of LINKS: Strengthening links between technologies and society for European disaster resilience, funded by the European Union's Horizon 2020 Research and Innovation Programme (No. 883490). Available at: http://links-project.eu/deliverables/

22 Letouzé E, "Big Data and Development: General Overview Primer." Data-Pop Alliance White Paper Series. Data-Pop Alliance, World Bank Group, Harvard Humanitarian Initiative. 03/2015.

23 "A group of Internet-based applications that build on the ideological and technological foundations of the Web 2.0 and that allow the creation and exchange -of user generated content (UGC). Web 2.0 is the Internet we are familiar with today in which people are not just consumers of information but producers of knowledge through social networking sites and services like Facebook, Twitter, and Instagram'' (Kaplan & Haenlein, 2010 in Habig, T., Lüke, R., Sauerland, T. & Tappe, D. (2020)).

24 "It describes a distributed problem-solving model where the task of solving a challenge or developing an idea gets 'outsourced' to a cloud. It implies tapping into 'the wisdom of the crowd'. In the context of LINKS, crowdsourcing involves using ICTs (Internet and Communication Technologies). For example: crowdsource mapping in crisis zones. Digital volunteers/communities offer free services by mapping critical information related to disaster-affected zones" (Howe, 2006in Habig, T., Lüke, R., Sauerland, T. & Tappe, D. (2020)).

information can be used to adopt insurance solutions before disasters happen, such as parametric insurance products, as in the case of the **Pan-African Flood Extent Depiction[25] or Kilimo Salama.[26]** These two case studies are an example of parametric or index insurance, triggered when specific variables or indices reach a certain threshold. By focusing on the trigger of a hazard, instead of its damages, this type of insurance provides payouts faster than traditional insurance schemes, thereby allowing for quicker responses and impact mitigation.

- **Official development assistance (ODA)** is government aid to promote the welfare of a developing country. The aid may be provided in several means according to the agency, donor, and recipient. Credits and loans of military purposes are not included, but such aids may consist of grants, soft loans (the grant element is equal to or more than 25% of the total), and provision of technical assistance.[27] GSMA's Mobile for Development case study shows how the mobile industry can provide different services, which donors have integrated into development aid projects to make them more effective. These services range from mobile money and digital solutions for small-holders to device information services, eSIM services, humanitarian assistance, and roaming services. The **European Spatial Agency (ESA) - Caribou[28]** case study highlights the importance of satellite data in ODA planning, mainly through its capacity to substantiate pressing challenges for development and support aid targeting. The contributions range from identifying land use and risks for food security to poverty mapping. The uniform global coverage of satellites, available for free in the Copernicus program, can help bring these applications to scale. It is also important to note that combining EO and mobile phone metadata can help improve model accuracy to predict population vulnerability. While satellite imagery is helpful for poverty predictions in rural areas, it is less accurate in densely populated areas. Adding mobile phone metadata from CDRs to machine learning models helps overcome this limitation and can enhance the capacity of governments to allocate ODA effectively.

- **Early warning systems and humanitarian responses** are an integrated system of hazard monitoring, disaster risk assessment, forecasting and prediction, preparedness activities systems, communication, and processes that enable governments, individuals, communities, businesses, and others to take timely action to reduce disaster risks in advance of hazardous events.[29] Technologies such as Earth Observation and satellite telecommunications have improved early warning systems and allowed countries to extend their hazards surveillance. Case studies such as **Building resilience through crowdsourcing and Detecting climate adaptation with mobile network data in Bangladesh[30]** demonstrate how the rapid dissemination of alerts and detection can easily enhance economic development, emergency response, and urban planning, among other development goals.

- **Capacity development** refers to an investment in practices, people, or institutions that enables countries to better achieve their development objectives. It is classified into three essential areas: upgrading skills, procedural improvements, and organizational strengthening.[31] The case study of

25 African risk Capacity (n.d.). River Flood. Accessed October 27, 2021 https://www.africanriskcapacity.org/product/river-flood/
26 Kilimo Salama. Since We Cannot Control the Weather. Accessed October 27, 2021, https://kilimosalama.wordpress.com/.
27 Official Development Assistance (ODA)," Text, accessed October 27, 2021, https://www.oecd-ilibrary.org/development/official-development-assistance-oda/indicator-group/english_5136f9ba-en.
28 European Space Agency (2018), Satellite Environmental information and development aid https://hobbydocbox.com/98486761-Art_and_Technology/Satellite-environmental-information-and-development-aid-an-analysrm-prospects.html
29 UNDRR, 2020, Hazard definition and classification review https://www.undrr.org/publication/hazard-definition-and-classification-review
30 Lu, X., Wrathall, D. J., Sundsøy, P. R., Nadiruzzaman, M., Wetter, E., Iqbal, A., ... & Bengtsson, L. (2016). Detecting climate adaptation with mobile network data in Bangladesh: anomalies in communication, mobility and consumption patterns during cyclone Mahasen. Climatic Change, 138(3), 505-519.
31 The World Bank. The World Bank Group - Capacity Enhancement. Accessed October 27, 2021 https://web.worldbank.org/archive/website00001/WEB/2DEFINIT.HTM

Crop Monitoring services- CROPMON[32] and G4INDO developed by G4AW shows how an affordable information service and insurance mechanisms may help farm management decisions and build resilience.

- **Supply chain monitoring:** Geospatial analysis adds value by enabling intuitive visualization of complex global supply chains, scalable risk assessments, and cost-effective tracking of compliance tools that can be measured against internal policies, legal frameworks, or (science-based) targets.[33] The case of Radar for Detecting Deforestation - **RADD[34]**, developed by Satelligence, highlights how providing improved, near real-time forest disturbance information, such as in the case of the **Congo Basin[35]**, can support a wide range of stakeholders in sustainable forest management and law enforcement. Monitoring deforestation in near real-time is a valuable instrument to incentivize engagement in deforestation-free supply chains. **ForestMind[36]** is another example of supply chain monitoring delivering actionable insight for food retailers and producers, providing them with the option to eliminate products that have caused deforestation from food supply chains and enabling them to stay within ecological boundaries, while also supporting inclusive economic progress through agricultural and sustainability specialists, Earth Observation data, and isotopic analysis.[37]

- **Nature and biodiversity risk:** The degradation of biodiversity and natural ecosystems is considered a source of financial risk. Geospatial and EO datasets provide insights into economic actors or drivers of ecosystem degradation. In particular, the case of **Open asset-level databases for the cement and steel industries (ALD)** illustrates how asset-level data provides granular information on specific facilities, which helps analysts and activists target and improve corporate engagements on emissions.

- **Financial inclusion** refers to enabling access to affordable services or financial products to suitably meet human and economic needs, which is translated into transactions, savings, payments, credits, and insurance. Financial inclusion plays a crucial role in building resilience to the impacts of disasters by recovering quickly, which shows the relation of climate change events or disasters to economic and social matters. The case study of **Farm Drive[38]** demonstrates how remote sensing used for financial product development reduces risk to financial institutions and enables them to make better lending decisions, increasing loans to farmers and agricultural production. The case of **GSMA's Mobile for Development** also shows how mobile money enables digital payments and transfers, creating universal access to a broad range of financial services and bridging the financial inclusion gap.

The case studies, the associated technologies, strengths, and weaknesses are discussed in the section below.

32 G4AW. CROPMON. Accessed October 27, 2021 https://g4aw.spaceoffice.nl/en/g4aw-projects/g4aw-projects/13/cropmon.html
33 Spatial Finance Initiative (2021). STATE AND TRENDS OF SPATIAL FINANCE 2021: Next Generation Climate and Environmental Analytics for Resilient Finance https://www.cgfi.ac.uk/wp-content/uploads/2021/07/SpatialFinance_Report.pdf
34 Satelligence. RADD. Accessed October 27, 2021 https://satelligence.com/radd
35 Ibid.
36 Satellite Applications Catapult. ForestMind. Accessed October 27, 2021, https://sa.catapult.org.uk/projects/forestmind/.
37 Spatial Finance Initiative (2021). STATE AND TRENDS OF SPATIAL FINANCE 2021: Next Generation Climate and Environmental Analytics for Resilient Finance https://www.cgfi.ac.uk/wp-content/uploads/2021/07/SpatialFinance_Report.pdf
38 FarmDrive. Alternative Credit Scoring for Smallholder Farmers. Accessed October 27, 2021, https://farmdrive.co.ke/.

C. ANALYSIS BY CASE STUDY: STRENGTHS AND WEAKNESSES

A. PARAMETRIC INSURANCE

CASE STUDY 1

PAN-AFRICAN FLOOD EXTENT DEPICTION

Hazard: Flood

Who? What? How?

The Pan-African Flood Extent Depiction (AFED) developed in 2016 by the African Risk Capacity (ARC)[39] uses Satellite-based Microwave Data, combined with Digital Elevation and Persistent Water Distribution, data to produce depictions of Non-persistent Surface Water, which represents the distribution of large-scale river flooding in Africa. In practice, AFED uses daily passive microwave remote sensing together with topographic downscaling using Digital Elevation Model (DEM) data. It detects long-lasting (>2-3 days) floods in wide (>2 km) flood plains, an approximate 90 m postings, over all of Africa daily, and it offers near real-time coverage from AMSR-2 and GMI sensors (the program has been active since 1998.) AFED data are managed and analyzed using the Africa RiskView Flood Data Explorer (FDE) software tool. This in-house ARC-developed tool allows for the extraction of flood depictions and derived data and automatically updates when new AFED data become available. Africa RiskView software is free, and users can request its access on the software page, which is subject to specific terms and conditions in the Software License Agreement. The Africa RiskView Support team grants access to prospective users.

Why?

AFED is used to underpin parametric flood insurance, analyzing the distribution of large-scale river flooding. In practice, it converts flood extent maps into an economic impact value in US dollars, creating an Africa RiskView flood index.

Where?

AFED is used in the African continent, 2016 it was tested in Gambia, Ghana, and Ivory Coast, but its application is wider.

Table 3: Technology Snapshot, case study 1

The African Flood Extent Depiction- AFED	
Frequency	Daily passive microwave remote sensing. Microwave sensors provide twice-daily measurements (day and night)

39 ARC is an agency of the African Union with the objective to help African governments improve their capacities to plan for, prepare for, and respond to extreme weather events and natural disasters. To meet this objective, ARC aims to price Africa's weather-related food security risk.

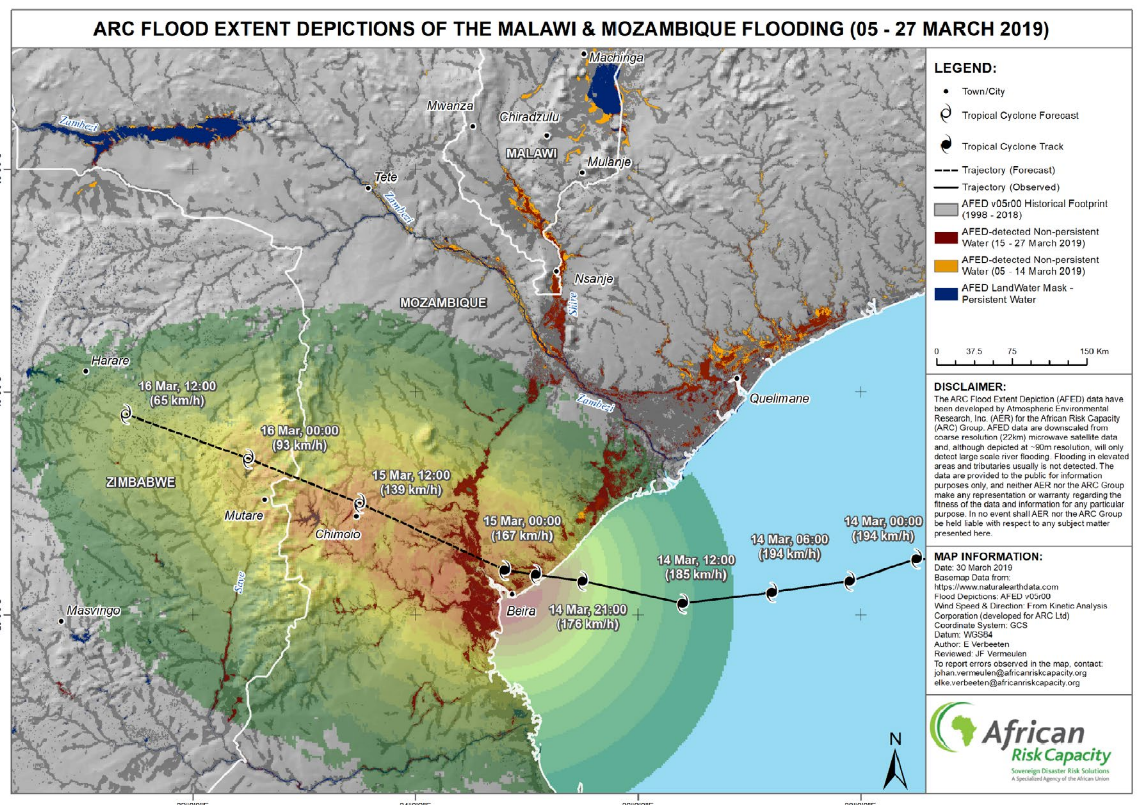
The African Flood Extent Depiction- AFED	
Resolution and modeling	• Satellite-based Microwave Data combined with Digital Elevation and Persistent Water Distribution data daily set of: georeferenced images tiling together to cover all Africa. Image pixel (3 arcseconds - about 90m x 90m) • Uses elevation data to downscale the microwave data and depict floods at a finer scale • Uses rainwater detection to produce flood depictions from the best quality data • Includes a land-water mask to exclude persistent open water
Coverage	It detects long-lasting (>2-3 days) floods in wide (>2 km) flood plains, an approximate 90 m postings, over all of Africa daily, and it offers near real-time coverage from AMSR-2 and GMI sensors since 1998.
Ownership	Owned by ARC, which is composed of two entities (Specialized Agency and ARC Company LTD)

Example of application

To evaluate the potential of this technology, Map 1 shows the extent of non-persistent surface water detected by the ARC Flood Extent Depiction (AFED) when the tropical cyclone Idai flooded Malawi and Mozambique in March 2019.

The area in orange shows the flooding detected during the period before Idai made landfall (5-14 March 2019), and the flooding caught post - Idai making landfall (15—27 March 2019) is marked in deep red.

Figure 2. Application of AFED technology



Source: African Risk Capacity[40]

40 African Risk Capacity (2019). ARC River Flood Model (AFM-R)., https://www.africanriskcapacity.org/wp-content/uploads/2019/06/ARC_AFMR_SouthernAfrica_FloodUpdate04_March2019_EN_20190330.pdf.

The depictions indicate flooding along the Zambezi river between Tete and the Shire-Zambezi confluence, along with the river Shire fl owing southwards towards the convergence before Idai making landfall. Detecting widespread flooding was during the post-landfall period and the Shire, the post-confluence stretch of the Zambezi, and the coastal areas north of the Zambezi. Flooding in and around Beira was initially not detected, possibly due to microwave sensors' inability to' see' through rain and/ or possible interference with the microwave signal from the ocean. However, widespread flooding was detected in AFED depictions from 18 March onward in the south of Beira, where the river Buzi flows into the Indian Ocean. Flooding was seen in Zimbabwe from 18 March onwards in Masvingo, Matabeleland, and Manicaland.

Strengths: How does Africa Flood Extent Depiction contribute (or can contribute) to improving disaster risk finance?

The information provided by AFED is used to develop a parametric insurance product that is an ex-ante risk management instrument that relies on flood indices and provides payouts in case of severe floods. As parametric insurance, it ensures a policyholder against an occurrence of a disaster event. The coverage is triggered when the disaster event meets specific thresholds—often a physical parameter such as water level, wind speed, precipitation amount, or earthquake magnitude. The main disadvantage of parametric insurance related to risk, i.e., the risk that the coverage is triggered when no loss is incurred or that the policy is not triggered when a loss has occurred. This insurance plays a critical role in the scope of disaster insurance, given the fact that it speeds up money transfer to policyholders, as it can be processed in weeks instead of months or years, compared to other indemnity contracts. The coverage can be underwritten based solely on the probability of an event that meets the thresholds for payout occurring at a given location, and claims payments are made exclusively based on the occurrence of the triggering event. As a result, the utilization of such insurance provides faster liquidity to cope with the shock.

The type of data and the big data analysis techniques applied in this insurance product development contributes to building financial resilience in different ways:

- **Accuracy in risk assessment:** Big data analytical techniques allow greater accuracy in risk assessment to reduce the potential of primary risk and therefore increase the probability that payouts are made when damages or losses are incurred.
- **Lowering the insurance cost:** Increasing availability of data and big data analytical techniques improve flood mapping and water level measures, optimizing the design of the insurance contract and lowering the cost of underwriting insurance coverage.
- **Coverage for more types of risk:** Increasing availability of data and the big data analytical techniques can provide a basis for developing parametric insurance coverage for more types of risks and with greater accuracy and therefore less potential for basis risk.

Further AFED technology is powerful in:

- **Planning:** AFED technology produces flood maps. Access to and use of detailed, up-to-date maps is fundamental in improving disaster planning and response in flood-prone areas and enhancing their capacity to cope with and adapt to the impacts of floods and other shocks and stressors. Providing decision-makers and communities with detailed maps of areas, roads, streams, floodplains to strengthen risk identification and awareness-raising about climate risk and uncertainty, while strengthening community and institutional coping capacities for disaster planning, prevention, and response. Furthermore, satellite-based flood risk indicators can help trigger early warnings for floods events much ahead of the expected harvest. For more accuracy and better planning, they can be combined with several measured indicators, such as temperature, precipitation, vegetation greenness, and soil moisture levels.

- **Capacity building:** Training and accompaniment are crucial to ensure actionability. Building local capacities and trust is vital to foster empowerment and continuity over time. The core mandate of ARC is to develop in-house capabilities for African governments to increase the effectiveness of climate and disaster risk management, which can be done through the introduction of tools and processes that are better able to provide services to local stakeholders.

Challenges:

- **Complex flood modeling:** The model focuses on a subset of flood risks, due to the complexity of flood modeling. During extensive river floods that last several days in duration, the insurance will target the largest of these events, which would have the most direct impact on people.

- **Insurance contracts quality standards:** As in all parametric insurance, the quality of the insurance contract is generally unobservable. The BASIS Markets, Risk and Resilience Innovation Lab—in collaboration with the Nairobi-based intergovernmental organization the Regional Centre for Mapping Resources for Development—are working with insurance companies and line ministries in East Africa to establish a facility to offer a quality certification (the Quality Index Insurance Certification program or "QUIIC").

B. NATURE AND BIODIVERSITY RISK

CASE STUDY 2

OPEN ASSET-LEVEL DATABASES FOR THE CEMENT AND STEEL INDUSTRIES (ALD)

Hazard: Multi-hazard

Who? What? How?

In collaboration with the Alan Turing Institute and the University of Oxford, Satellite Applications Catapult established the Spatial Finance Initiative (SFI) as part of the UK Centre for Greening Finance and Investment (CGFI). The initiative seeks to foster spatial finance applications and opportunities by using geospatial and asset-level data with data science, geospatial technologies, and finance capabilities. **Asset-level data** refers to physical and non-physical assets aggregated at the company, portfolio, regional, or global level. This type of data can be as detailed as to content type, geolocation, ownership structures, capacity, etc. (Foundational asset-level) and/or data on local conditions that frequently change and is typically collected through sensors, such as pollution, productivity, land cover, etc. (Observational asset-level).[41]

Through its GeoAsset project[42], Satellite Applications Catapult developed two open Asset-Level

41 Satellite Applications Catapult and Innovate UK (2021). Finance Use Cases for the Cement and Steel Sectors. https://sa.catapult.org.uk/wp-content/uploads/2021/07/Asset-level-Data-Use-Cases-for-the-Cement-and-Steel-Sectors.pdf

42 "[The] GeoAsset is a public goods endeavour focused on making accurate, comparable, and comprehensive asset-level data tied to ownership publicly available across all major sectors and geographies. The work of

Databases for the cement and steel industries (ALD) which included exact details on asset location, production process, and capacity utilization rate, and ownership. To build the ALDs, the project used both manual and machine learning techniques to analyze satellite, geospatial and web-based datasets that enable the extraction of asset-level information in a transparent and replicable manner.[43]

Why?

As cement and iron and steel production are considered "two of the most emissions-intensive industries in the world, with significant environmental impacts beyond carbon"[44]. The analysis of their impact through spatial finance tools becomes critical.

Where?

Worldwide

Table 4: Technology Snapshot, case study 2

Next Generation Climate and Environmental Development of Steel and Cement asset-level data	
Frequency	The satellites in the Sentinel-2 constellation will provide a revisit time of five days at the equator in cloud-free conditions
Resolution and modeling	• In Sentinel-2 data, each pixel has a resolution between 10-60 meters • Combining with other models allows aggregate asset-level data attributes and Environmental, Social, and Governance (ESG) scoring. Asset data depends on the extent to which actors publish information about the capacity, age, type, production, commodity, royalty holders, parent company, tickers, dates of an entity
Coverage	• Coverage of the world's land area (from 56° S to 84° N)
Ownership	ESA data is available for free • Transforming it into DRF products requires a highly technical and multidisciplinary team • Efforts to streamline its use and simplify its outputs to streamline benefits for decision-making

Example of application

The databases contain 3,117 cement plants and 1,598 production plants of Iron and Steel Production Assets with exact geolocation, ownership, production type, plant type, capacity, and production start year (where available). The assets include the tracking of all major steps in the production of the material[45].

As an example of applying this type of analysis, TransitionZero's financial analytics are leveraging observational and foundational asset-level data, combined with financial sector expertise to support zero-carbon transition decisions. They conducted valuable research on China's transition to clean energy using industrial production monitoring technology, to provide coal-fired power plant emission estimates, and -through a Risk Index System- assess and recommend the closure,

GeoAsset is a core part of SFI's mission to mainstream geospatial data and analysis into finance." Satellite Applications Catapult and Innovate UK (2021). Finance Use Cases for the Cement and Steel Sectors. https://sa.catapult.org.uk/wp-content/uploads/2021/07/Asset-level-Data-Use-Cases-for-the-Cement-and-Steel-Sectors.pdf

43 Satellite Applications Catapult and Innovate UK (2021). Finance Use Cases for the Cement and Steel Sectors. https://sa.catapult.org.uk/wp-content/uploads/2021/07/Asset-level-Data-Use-Cases-for-the-Cement-and-Steel-Sectors.pdf

44 Spatial Finance Initiative (2021). STATE AND TRENDS OF SPATIAL FINANCE 2021: Next Generation Climate and Environmental Analytics for Resilient Finance https://www.cgfi.ac.uk/wp-content/uploads/2021/07/SpatialFinance_Report.pdf

45 Spatial Finance Initiative. Retrieved from GEOASSET DATABASES https://www.cgfi.ac.uk/spatial-finance-initiative/geoasset-project/geoasset-databases/ on 24-10-2021

conversion, or reserve capacity of China's coal plants.[46] The report aimed at showcasing how plant or asset level production estimates can help to understand transition risk and opportunity.[47]

Figure 3. Example of a physical assessment as a use case of the ALDs

Source: Spatial Finance Initiative[48]

Strengths: How does ALD contribute (or can contribute) to improving disaster risk finance?

The outputs from spatial finance, in general, can contribute to disaster risk finance through critical insights for a wide range of instruments as:

- Physical climate risk assessments
- Carbon and emissions disclosure
- Multi-environmental, social, and governance risk and impact assessments

Thus, analysis issued from these asset-level datasets provides localized and target information on local population health, biodiversity, and climate change, which serves as input for various disaster risk finance and evidence for activists and NGOs to leverage engagement and outreach. Quantifying the necessities for industrial process technology transformation has the potential to drive sustainable dis/investment.

ALD asset-level reports can prompt dis- or re-investment driven by climate/transition risk or biodiversity impact, putting to the fore evidence on progress towards climate goals.[49] This was achieved in the Turning the Supertanker report through the measurement and ownership identification of Net generation

46 Matthew Gray (2021a). Turning the Supertanker. Tranzition Zero. https://www.transitionzero.org/insights/turning-the-supertanker
47 Matthew Gray (2021b). Turning the Supertanker. Tranzition Zero. https://www.transitionzero.org/data/turning-the-supertanker
48 Matthew McCarten (2021). Asset-Level Data for Cement and Iron & Steel Sectors. Spatial Finance Initiative. https://www.cgfi.ac.uk/wp-content/uploads/2021/07/SFI-Launch-ALD-Cement-and-Iron-Steel1.pdf
49 Satellite Applications Catapult and Innovate UK (2021). Finance Use Cases for the Cement and Steel Sectors. https://sa.catapult.org.uk/wp-content/uploads/2021/07/Asset-level-Data-Use-Cases-for-the-Cement-and-Steel-Sectors.pdf

(MWh) and Carbon emissions (MtCO2) but also the financial liabilities and risk exposure of the coal industry (i.e., Short and long-run marginal cost ($/MWh), Gross and net profitability ($/MWh), Risk index system (RIS) score (0-1)). The quantification and analysis of these impacts address a fundamental gap of information that can enable decision-makers to align capital and operational decisions with the Paris Agreement.[50] In short, the development of ALDs databases and analytics fosters realignment of funds to enable an industrial process technology transformation.

Challenges:

The main challenges are related to data. There is a lack of robust supply chain data worldwide, partially due to the difficulties in accurately assigning subsidiaries to parent companies and consistently matching parent companies across different systems.[51] Lastly, there is also a need to develop further benchmarking and scoring methodologies to better "define climate and environmental impact and risk across different industries".[52]

For ALD assets, classifying imagery for a specific class of "objects," such as heavy-carbon-emitting cement plants, is challenging as their characteristics vary significantly across geographies. Thus, current asset-level datasets for cement production are incomplete and only cover around 70% of global assets, with essential gaps in certain regions such as China. Moreover, the data is not only partial, but the information provided is not always applicable for all types of risk analyses.[53]

CASE STUDY 3

IPP COMMONSENSING PROJECT CASE STUDY

Hazard: Multi-hazard

Who? How? What?

The Satellite Applications Catapult[54] is a technology and innovation company that connects academia and industry to support the UK industry through satellite technologies and applications. Its three main activities include 1) Energizing the Market (i.e., unlocking new market sectors and customer demands); 2) Empowering Technology (i.e., support in bringing new technologies to markets) and 3) Enabling Business (i.e., brokering between business, investments, and markets).[55] Satellite Applications Catapult has played a crucial role in developing the satellite applications start-up ecosystem over the last decade as a critical focal point for the private sector, academia, and end-users.

The Satellite Applications Catapult is a crucial partner in the **IPP CommonSensing project** funded by the UK Space Agency's International Partnership Program. The project aims to foster satellite remote sensing capabilities to empower the Governments of Fiji, the Solomon Islands, and Vanuatu "in their efforts to build resilience to the devastating impacts of climate change and improve access to climate finance".[56]

50 Matthew Gray (2021b). Turning the Supertanker. Tranzition Zero. https://www.transitionzero.org/data/turning-the-supertanker
51 Patterson, D. J., Ariel, Y., Burks, B., Gratcheva, E. M., Hosking, J. S., Klein, N., ... & Wuebbles, D. J. (2020). Spatial finance: Challenges and opportunities in a changing world. https://documents1.worldbank.org/curated/en/850821606884753194/pdf/Spatial-Finance-Challenges-and-Opportunities-in-a-Changing-World.pdf
52 Ibid.
53 Dave Yoken (2021). Spatial Finance Initiative https://medium.com/astraeaearth/spatial-finance-initiative-816bb45e002e
54 Catapult Satellite Applications (2020). IPP CommonSensing Project Case Study. https://sa.catapult.org.uk/wp-content/uploads/2020/07/Common-Sensing-Case-Study.pdf
55 Catapult Satellite Applications. About us. Accessed on October 24, 2021. https://sa.catapult.org.uk/about-us/
56 Catapult Satellite Applications. Projects. Commonsensing. Accessed on October 24, 2021. https://sa.catapult.org.uk/

Why?

The goal of the project is to provide the necessary capabilities and infrastructure to help mitigate and adapt to climate change by improving access to climate finance, post-disaster risk reduction, and ensuring food security.

Where?

Fiji, the Solomon Islands, and Vanuatu

The goal of the project is to provide the necessary capabilities and infrastructure to help mitigate and adapt to climate change by improving access to climate finance, post-disaster risk reduction, and ensuring food security.[57]

The project deliverable structure consisted of several products:[58]

- A geospatial information portal (the IPP CommonSensing platform)
- Four web applications
  - Climate information app
  - Risk information app
  - Map explorer app
  - Decision support system
- Open Data Cube (ODC)
- Technical Training

Table 5: Technology Snapshot, case study 3

IPP CommonSensing Project Case Study-Fiji Mangrove Map	
Frequency	The satellites in the Sentinel-2 constellation will provide a revisit time of five days at the equator in cloud-free conditions
Resolution and modeling	In Sentinel-2 data, each pixel has a resolution between 10-60 meters. • UN-ASSIGN2 for Fiji Mangrove Map: It verifies the location of mangroves and then uploads geotagged photos onto UN-ASIGN2, a mobile application used to collect field data. These geotagged photos can then be displayed on UNOSAT's Live Map and other crowd-sourced images, allowing wider support invalidation.
Coverage	Depends on the use. Mangrove area in the Fiji case study
Ownership	IPP CommonSensing: Led by the United Nations Operational Satellite Applications program (UNOSAT) UNOSAT is the United Nations Institute for Training and Research (UNITAR). • It is a technology-intensive program active in applied research relating to satellite solutions, from earth observations to telecommunication, positioning, and navigation. • UNOSAT delivers satellite solutions, geographic information to organizations within and outside the UN system - To make a difference in the lives of communities exposed to poverty, hazards, and conflict or affected by humanitarian and other crises. • The Satellite Applications Catapult Ltd is responsible for: - The project management - User experience design - Data products and development - Infrastructure - Sustainability support - Communications for the IPP CommonSensing project

projects/commonsensing/

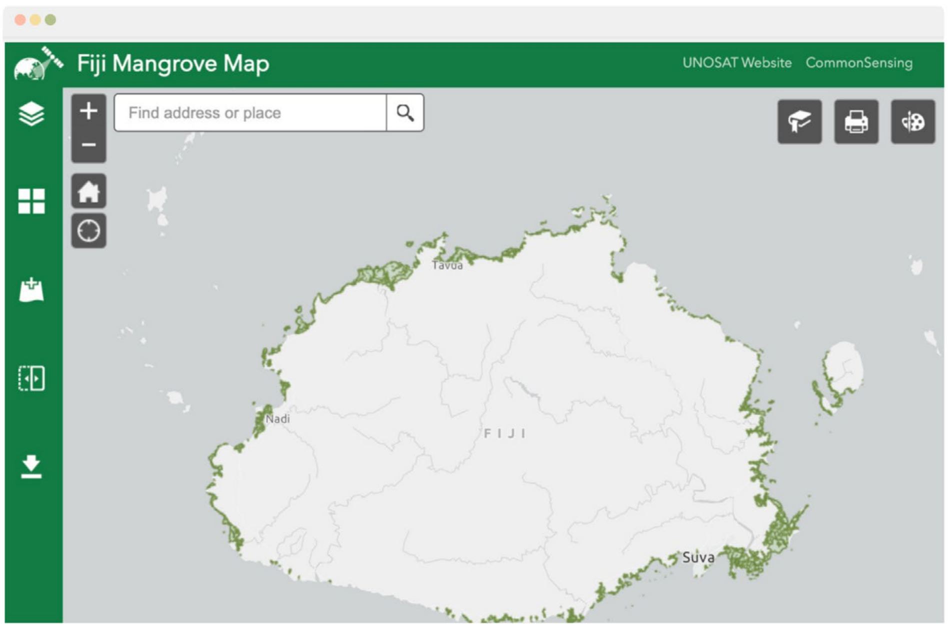
57 Catapult Satellite Applications (2020). IPP CommonSensing Project Case Study. https://sa.catapult.org.uk/wp-content/uploads/2020/07/Common-Sensing-Case-Study.pdf

58 Ibid.

Example of application:

Based on Fiji's Ministry of Forestry (MoF) request, UNOSAT created shapefiles and a web map to detect changes to mangroves between 2009 to 2019 using Sentinel-2 multispectral satellite imagery. The ministry and critical governmental authorities have recognized this input as crucial insight for evidence-based policies on the rehabilitation of forested areas, given the key roles of mangroves to protect dynamic habitats through preventing coastal erosion, harboring marine nurseries, and vitally sequestering carbon to aid in climate change mitigation.[59]

Figure 4. Fiji: Mangrove Map September 2020



Source: IPP CommonSensing Project[60]

Strengths: How does IPP CommonSensing contribute (or can contribute) to improving disaster risk finance?

- **Accuracy and coverage:** Commonsensing is providing timing, efficient access to Analysis Ready Data for Sentinel-1, Sentinel-2, Landsat-5, Landsat-7, Landsat-8, and SPOT 1-5 for 30 years (1990 – Present) via the Open Data Cube and a geospatial decision support system for the policymakers in the Small Island Developing States of the South Pacific.[61] The Analysis Ready Data (ARD) is prepared and hosted in the Open Data Cube (ODC), which refers to an Open Source Geospatial Data Management, Analysis Software project (Python libraries and PostgreSQL database. It helps to work with geospatial raster data) that "seeks to increase the value and impact of global Earth observation satellite data. This is done by providing an open and freely accessible exploitation architecture" overcoming barriers to achieve the use of EO data-s full potential and enabling its use by non-expert users.[62]

59 Catapult Satellite Applications (2020). IPP CommonSensing Project Case Study. https://sa.catapult.org.uk/wp-content/uploads/2020/07/Common-Sensing-Case-Study.pdf
60 Ibid.
61 Commonsensing. Solutions and Data. Accessed on October 24, 2021 https://www.commonsensing.org.uk/news/solutions-and-data
62 Ibid.

- **Capacity building:** the project provides technical solutions and the capacity to use the tools, as stakeholders have used the provided data, tools, and information to support decision-making processes on numerous programs and policies, including during emergencies.

- **Parametric insurance and financial response triggers:** by providing a risk quantification and near real time monitoring platform, this technology augments the quality of weather information with new insights, and paves the way for reliable response triggers. Which could ultimately be applied to parametric insurance products or to inform governments' contingency response plans.

Challenges:

- As a demand-driven service, only a few stakeholders in the line ministries had requested support in the first year of project implementation. By the second year, backstopping requests skyrocketed from 12 submissions in 2019 to 158 in 2020, owing to the quick mobilization of tailor-made support.[63]
- Maintaining and updating the different platforms, apps, and data systems after the full implementation of the project.

C. CAPACITY BUILDING

CASE STUDY 4

GEODATA FOR UPGRADING SMALLHOLDERS' FARMING SYSTEMS

Hazard: Droughts

Who? What? How?

In the year 2050, an estimated total of 9 billion people will need to be fed, and this challenge puts enormous pressure on the availability of water and fertile land. **The Geodata for Agriculture and Water (G4AW)** facility was born out of the belief that science and digital technology can play a significant role in fighting food insecurity. Since 2014, the program created by the Dutch Ministry of Foreign Affairs and executed by the Netherlands Space Office (NSO) aims to provide food producers with relevant information, advice, or financial products, such as insurance. G4AW aims to reduce poverty by strengthening sustainable economic growth and self-reliance in partner countries. The logic behind the program is that increasing awareness among farmers will bring a higher service uptake, use, and benefits. This program provides the correct information at the right time to the main actors in the food production chain: farmers, fishermen, and ranchers. Food producers can help improve and sustainably increase food production and thus ensure global food security.

Why?

The smallholder farming systems improvement program has the following objectives.

- **To improve the production and productivity of the agricultural sector** in partner countries by providing food producers with unprecedented information on the status of their production, advice for future harvests, and relevant financial products to respond to agricultural losses following a disaster.

63 Catapult Satellite Applications (2020). IPP CommonSensing Project Case Study. https://sa.catapult.org.uk/wp-content/uploads/2020/07/Common-Sensing-Case-Study.pdf

- **Achieve at least a 10% increase in sustainable food production** and/or an improvement in the financial situation of three million food producers.
- **Contribute to a 10% more efficient use of inputs for food production** (water, seeds, fertilizers, pesticides, etc.), focusing on sustainable improvement, increasing food production, and more efficient use of water in agriculture.

Where?

G4AW had 121 partners in 25 projects in 15 countries, primarily located in Southeast Asia and Africa.

Example of application: G4INDO

Initiated in 2014, the G4INDO project was commissioned by the Indonesian government, which wanted to integrate a crop insurance policy to support small-scale rice farmers in Java, generally with less than 2 hectares of land, and enhance food security. In this context, G4AW provides technical assistance to assess crop yield anomalies at the farm plot level. Processed satellite data, such as radar and optical ground observations, combined with weather monitoring, analysis and forecasting, crop models, and hydrological models, provide the necessary information. With the following services, the program offers crop insurance. The Indonesian Ministry of Agriculture and insurance companies use the information gathered to evaluate requests for service contracts, explicitly responding to farmers suffering crop losses due to a natural disaster. The project also supports the Ministry of Agriculture's crop calendar, telling 200,000 farmers whether a third rice crop is likely to receive sufficient rain.

Funding for this program limits its scope to self-sustaining services only after three years, once the number of insured has generated enough revenue to exceed operating costs. Implementation of the G4INDO service also requires investment in technology and knowledge transfer.

Strengths: How does G4AW contribute (or can contribute) to improving disaster risk finance?

This program illustrates the development and use of disaster-sensitive financing mechanisms and instruments for the agricultural sector. It is part of the larger project on Disaster Financing for Agriculture (DFA), as part of a comprehensive risk financing strategy. The G4AW facility leverages geodata, such as satellite and mobile data, to obtain specific information on climate change, weather, and hazards and even timely agricultural advice to:

- **Provide satellite-based drought index insurance** to small farms affected by a natural disaster, such as micro-insurances and/or microloans combined with information services that can help guarantee the continuity of food production and improve self-reliance.
- **Ex-ante risk management** builds and strengthens the technical capacity to empower food producers and stakeholders in developing countries to make better decisions based on data to ensure ownership, long-term sustainability, and technology adoption.
- **Ex-post risk management** increases farmer resilience by establishing response mechanisms, such as micro-insurance, which can avoid the need for harmful coping mechanisms and protect the welfare of rural households from the adverse effects of shocks.

Challenges:

The adoption of new agricultural technologies is a fundamental issue in the developing world. Many agricultural technologies, such as parametric insurance, are often adopted slowly in developing countries due to a lack of liquidity and credit constraints (Marr et al., 2016). Low take-up may also come from defects of the product itself, such as a probabilistic payout, or from other barriers such as high cost, liquidity constraints, lack of trust in the provider, difficulties in learning about a product that covers stochastic events, and behavioral specificities such as aversion to ambiguity and compound risks (Carter et al. 2017; Jensen and Barrett 2017). The products offered by G4AW should account for these adoption constraints to ensure endorsement, credibility, and adoption among decision-makers.

Table 6: Technology Snapshot, case study 4

Geodata for upgrading smallholders' farming systems -G4INDO	
Frequency	NA
Resolution and modeling	Radar and optical remote sensing technology combined with weather monitoring, analysis and forecasting, crop and hydrological models
Coverage	200.000 farmers
Ownership	The Indonesian Ministry of Agriculture and insurance companies will use this integrated information to assess claims from service contract holders experiencing harvest losses.

D. FINANCIAL INCLUSION

CASE STUDY 5

FARMDRIVE KENYA

Hazard: Multi-hazard, solvability

Who? What? How?

Founded by University of Nairobi students Rita Kimani and Peris Bosire, **FarmDrive** uses the Safaricom and M-Pesa platform to develop borrower profiles and credit scores for smallholder farmers. FarmDrive is a tool that leverages mobile technology, EO, and data analytics to obtain relevant information on the operations of smallholder farmers. It combines Geospatial data to predict crop yields (provided by Harvest Choice 2015) with satellite image data (supplied by Planet). Images were downloaded based on several dimensions; as a result, these images matched the areas of interest and linked directly to estimates of crop yields from the Harvest Choice data. Further, through short messaging services or a mobile app, farmers record their activities, effectively tracking their expenses and revenues. The gathered information is used to generate detailed credit profiles used to assess a farmer's creditworthiness.

Why?

Through the use of credit scores, financial institutions can develop small-scale agriculture loan products. Loans are disbursed and repaid through the M-PESA platform. The information about the farmer is also used to develop and send limited agricultural extension information designed to improve farm efficiency.

Where?

Kenya

Table 7: Technology Snapshot case study 5

FarmDrive	
Frequency	Planet provided daily satellite data Harvest Choice provided crop yield data up to 2005
Resolution and modeling	Combination of Geospatial data to predict crop yields (provided by Harvest Choice 2015) with satellite image data (supplied by Planet). • The Spatial Production Allocation Model produces estimates at a resolution of approximately 10 km x 10 km (Harvest Choice 2015) • Images were downloaded based on Timeframe—against predefined seasons • Area of interest—all of Kenya, wards in Kenya, and defined areas • Cloud cover—tiles were limited to those with less than 5 percent cloud cover • Asset type—testing both "visual" and "analytic" assets.
Coverage	All of Kenya, wards in Kenya, and defined areas.
Ownership	Satellite imagery was sourced from Planet, a commercial provider of satellite imagery.

Example of application:

FarmDrive currently relies on pilot programs and NGO projects as the initial mechanism for promoting and testing the product. No large-scale promotion strategy was available.

Strengths: How does FarmDrive contribute (or can contribute) to improving disaster risk finance?

- **Scalable and affordable financial products:** Remote sensing used for financial product development reduces risk to financial institutions and enables them to make better lending decisions, increasing loans to farmers and agricultural production.
- **Reduce marginal costs:** The financial providers can use models based on satellite images to estimate relevant metrics, such as timing and value of yields, at a low marginal cost.

Challenges:

- **Yield estimates:** Aggregated yield estimates referred to a relatively large area, and they could not efficiently assess the yield of individual farms.
- **Temporal coverage:** The ground truth yield data was disjointed temporally from the satellite imagery. The crop yield estimates were over ten years old (2005) compared with the imagery (2016), with computational constraints.
- **Resolution:** Even with cloud computing resources, the images are significantly scaled down from the native resolution provided by the imagery provider. The following enabled a large number of models to assess on lower-cost machines.

Despite the limitations encountered, the satellite model shows promise and helped to indicate where FarmDrive should invest more resources to build systems to better serve smallholder farmers. Ideally, the models may be created using objectively measured yield for target fields and a geographic shapefile that outlines the field's bounds in question. These two pieces of data collected at sufficient scale (say 10,000 examples) would allow the models to be much more effective.

E. EARLY WARNING DETECTION

CASE STUDY 6

DETECTING CLIMATE ADAPTATION WITH MOBILE NETWORK DATA IN BANGLADESH

Hazard: Cyclones and Earthquakes

Who? What? How?

Barisal and Chittagong, a team led by **Flowminder**,[64] a Swedish non-profit foundation, examined information from de-identified data, corresponding to five million phones in the Grameen phone network, during the wake of a cyclone. Since mobile phones in developing countries have proliferated, those methods may help evaluate the effectiveness of disaster response and assess the impacts of extreme events.

This case study sheds light on the usage of mobile networks in means of auditing the performance of early warning systems and programs.

Why?

The data had SIM movements, mobile recharges, and changes in call frequency, by which each finding suggested specific spikes. The interruption in network function can refer to infer damage to infrastructure power grids when towers are off; the points of call frequencies indicate an increase in communication of communities prepared to be impacted by the event. Despite having early warnings, the data showcased a lack of mass displacement in the preceding weeks and days from coastal areas.

Where?

Bangladesh (Barisal & Chittagong)

Table 8: Technology Snapshot, case study 6

Using mobile network data to understand actions, behaviors, and attitudes: Mobile network data and climate resilience-Bangladesh case study	
Frequency	Daily calling frequency six weeks before the landfall of the cyclone and six weeks after landfall.
Resolution and modeling	• Spatiotemporal comparison of calling frequency with rainfall data from NASA's Tropical Rainfall Measurement Mission (TRMM) • SIM movements, mobile recharges, interruption in network function. Call detail records (CDRs) for evacuation displacement and mitigation • Sigma-model to evaluate the stability of the observed sequence of activities extracted from customers' usage data in the mobile network.

64 Flowminder.org. Global Leaders in mobile operator data analytics for good. Accessed October 27, 2021 https://www.flowminder.org/about-us

Using mobile network data to understand actions, behaviors, and attitudes: Mobile network data and climate resilience-Bangladesh case study	
Coverage	Calling behavior from 5.1 million Grameenphone users in Barisal Division and Chittagong District, Bangladesh
Ownership	A collaboration between five organizations: • International center for climate change and development (ICCCAD)[65] • Flowminder[66] • Grameenphone[67] • Telenor Research[68] • United Nations University[69] Supported by the Bangladesh Ministry of Disaster Management and Relief[70]

Example of application:

The usage of mobile networks in this case study can detect multiple stressors before, during, and after the cyclone (6 weeks before the cyclone's landfall and six weeks after landfall). This application combines more than one technology, and the data is collected at a Spatio-temporal level along with anomalous patterns of phone usage, call frequency, de-identified data entries, SIM movements, mobile recharges, interruption in network function. CDRs for evacuation displacement and mitigation.

The cell phone metadata used is owned by mobile network operators , and even though this process may be automated in this project, algorithms have already been created to create relevant socioeconomic indicators based on CDRs. The operation of such technology is considered complex, and the cost of assessing the data may be more expensive. Still, this technology enables the government and end-users to monitor ex-post scenarios.

Strengths: How does it contribute (or can contribute) to improving disaster risk finance?

The detection of anomalous usage patterns using mobile network data is a promising approach that can provide research for human behavioral responses to associated impacts of climate change across a large spatiotemporal level. This technology may be an essential tool for assessing selected areas for a quick response following a cyclone.[71] While traditional surveys tend to lose track or miss individuals that move multiple times across vast areas, high rates of mobile phone data may provide a better data source on populations more vulnerable to climate change. By mapping data on a weekly, daily, or monthly basis, researchers can analyze the movements of a population in response to an event (e.g., Cyclone Mahasen).

Challenges

The limitations in this study are the representativeness of the data for the general population. In Mahasen, the maximum rainfall was 68 m/h, but despite that, it dissipated fastly. Therefore, with stroma and flooding that cause more significant destruction, findings cannot be generalized. Even though network data may assess important events, this does not deny that increased calling

65 International Center for Climate Change and Development (ICCCAD). Accessed October 27, 2021 https://www.icccad.net

66 Flowminder.org. Our Mission. To enable decision makers to access the data they need to transform the lives of vulnerable people, at scale. Accessed October 27, 2021 https://www.flowminder.org/

67 Grameenphone. Accessed October 27, 2021 https://www.grameenphone.com/

68 Telenor group. Accessed October 27, 2021 https://www.telenor.com/

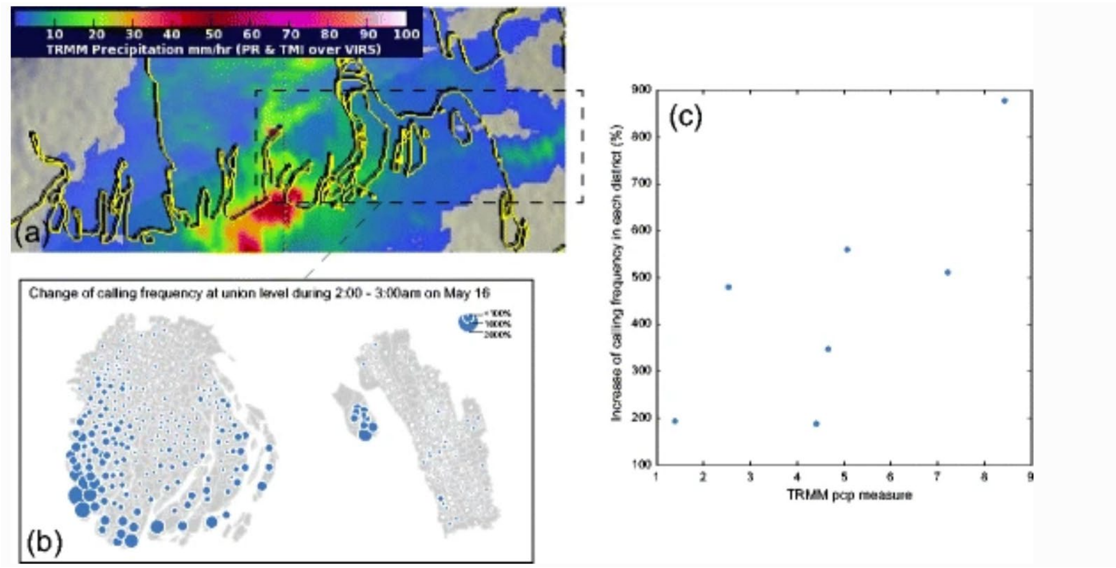
69 United Nations University. Accessed October 27, 2021 https://jp.unu.edu/

70 Ministry of Disaster Management and Relief. Accessed October 27, 2021 https://modmr.gov.bd/

71 Xin Lu et al., "Detecting Climate Adaptation with Mobile Network Data in Bangladesh: Anomalies in Communication, Mobility and Consumption Patterns during Cyclone Mahasen," Climatic Change 138, no. 3 (2016): 505–19, https://doi.org/10.1007/s10584-016-1753-7.

frequencies and mobility may be caused due to different causes rather than only indicating post-disaster assistance.

Figure 5a. Call anomalies and Rainfall 3:32 am

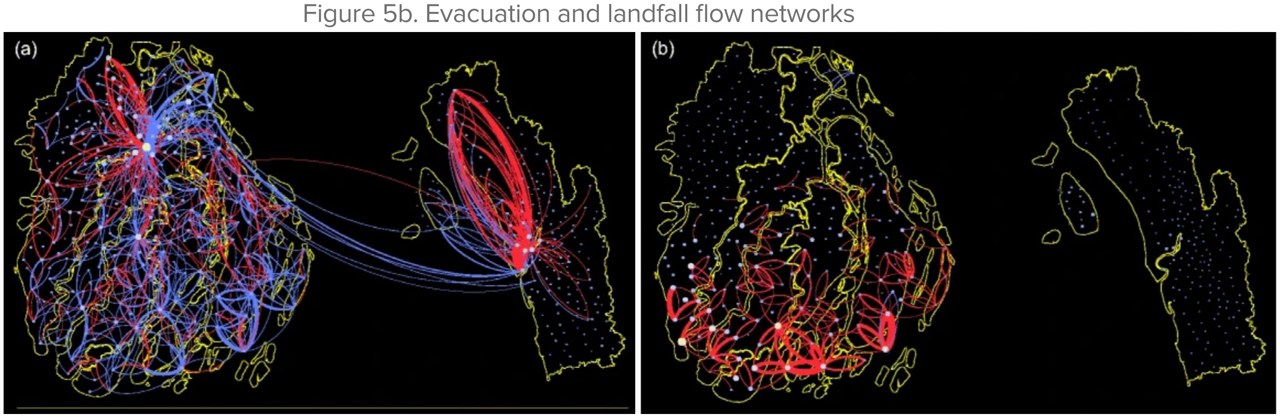


Source: Detecting climate adaptation with mobile network data in Bangladesh: anomalies in communication, mobility and consumption patterns during cyclone Mahasen[72]

Figure 5a: Call anomalies and Rainfall 3:32 am

a. The precipitation measurements were captured at 3:32 am from Nasa's Tropical Measurement Mission. This shows Rainfall distribution in the study area, reprinted from Gutro 3:00 march 2013, with permission from the authors.
b. May 16 - 3:00 am: The geographical distribution of call frequency
c. The Rainfall is plotted with calling frequency at the district level; the 10 correlation coefficient is 0.75, p = 0.05

Figure 5b. Evacuation and landfall flow networks



Source: Detecting climate adaptation with mobile network data in Bangladesh: anomalies in communication, mobility and consumption patterns during cyclone Mahasen[73]

72 Xin Lu et al., "Detecting Climate Adaptation with Mobile Network Data in Bangladesh: Anomalies in Communication, Mobility and Consumption Patterns during Cyclone Mahasen," Climatic Change 138, no. 3 (2016): 505–19, https://doi.org/10.1007/s10584-016-1753-7.

73 Xin Lu et al., "Detecting Climate Adaptation with Mobile Network Data in Bangladesh: Anomalies in Communication, Mobility and Consumption Patterns during Cyclone Mahasen," Climatic Change 138, no. 3 (2016): 505–19, https://doi.org/10.1007/s10584-016-1753-7.

Figure 5b: Evacuation and landfall flow networks

a. 15 May, one day before landfall compared with 24 April, three to ten weeks before the storm during the same hourly period.
The Positive flows are in red and indicate an increased flow on 15 May.
The Negative flows are in blue and indicate decreased flow on 15 May.

b. The thickness of the link represents the relative volume of flow. A user had to make at least two calls to appear in the flow network. Each SIM contributed only one movement (the first and last observed location). Links indicate areas where 10 or more movements were observed, the 00:00–6:00 am at distances greater than 10 km.

16 May, 00:00–6:00 a.m., is compared with 25 April (3 weeks prior during the same hourly period) the mobility network during landfall on Unusual mobility is observed in the affected area, where warnings were not concentrated

CASE STUDY 7

BUILDING RESILIENCE THROUGH CROWDSOURCING - EARLY FLOOD DETECTION FOR RAPID HUMANITARIAN RESPONSE

Hazard: Flood

Who? What? How?

Researchers from different organizations (Red Cross - The Netherlands, Institute for Environmental Studies, VU University Amsterdam, Floodtags, European Commission Joint Research Centre, Faculty of Geosciences, Utrecht University, International Research Institute for Climate and Society) assessed the effectiveness and usability of the near-real-time satellite and near-real-time Twitter data (i.e., social media data) for disaster response. They analyzed a range of flood events reported in Pakistan (September 2014) and the Philippines (80 reported flood incidents). They retrieved the geospatially explicit Global Flood Detection System (GFDS) that uses daily passive microwave satellite observations for rapidly identifying inundated areas. They capture the signal for seven days prior and seven days after the date of an event. Then, they used this data to analyze the signal development over time for the affected locations as specified by the disaster response data and national-level analytics. For social media data, they use the automated social media analytics platform Floodtags, which enables the filtering, visualization, and mapping of social media content based on location and keywords.

Why?

They gathered the information from disaster response organizations, the GFDS satellite signal, and Twitter activity in an analytical framework to produce three types of analyses:

- Location mapping (i.e., "where is the flood?")
- Early detection (i.e., "when can we know about the flooding?")
- Event understanding (i.e., "what do we know about the causes and effects?")

Where?

Philippines and Pakistan

Table 9: Technology Snapshot, case study 7

Building resilience through crowdsourcing - Early flood detection for rapid humanitarian response Philippines and Pakistan case study	
Frequency	• GFDS (GFDS) uses daily passive microwave satellite observations • Food tags platform captures Twitter signals that flag ongoing or upcoming flooding. These signals are regularly available.
Resolution and modeling	• GFDS: All data are available as global raster maps at a spatial resolution of 0.09° ×0.09° (~10 km at the equator). • GFDS in combination with Floodtags
Coverage	• GFDS data are published openly through a user-friendly web interface • Food tags can be used in agreement with Twitter terms and conditions
Ownership	• GFDS: it identifies riverine flood-induced water coverage from space within 24 hr. • Twitter: Flood-related social media activity

Example of application:

They analyzed a range of flood events reported in Pakistan (September 2014) and the Philippines (80 reported flood incidents). The results produced:

- Maps with GFDS and Twitter data; show the spatial intensity of tweets in a specific color scheme in a certain time interval (minutes, hours, days, months). To maintain consistency with GFDS data, which is available daily, they also derived daily heat maps in this study.
- GFDS signal agrees well with the detailed assessment that was produced weeks after the ending of the flooding.
- The GFDS maps highlight the detail on the spatial development of the flooding, i.e., the gradual change in inundated areas across the region can be tracked with a delay of less than a day.
- Floodtags platform shows a substantially different pattern from the GFDS data, highlighting that spatial information derived from social media is more complex to assess than satellite-based data.

Strenghts: How does it contribute (or can contribute) to improving disaster risk finance?

- **Early detection:**

  Early detection satellite signals provide a quantitative indication of a specific location and the possible magnitude of an ongoing event.

  Additionally, near-real-time data from social media platforms can provide qualitative insights about an ongoing situation on the ground. The following insights may include public discussions about risk prevention and evacuation measures (pre-emptive, forced, or voluntary evacuation). They may picture evidence of ongoing floods and requests for emergency aid.

- **Location mapping and disaster response:**

  Through the production of highly accurate maps of flood-prone areas, the initiative builds general awareness about food-related risks, fosters local responses and community-level action, and allows decision-makers to better plan for and respond to flood-related events, strengthening their capacity to cope with future disasters.

Challenges:

- **GFDS signal frequency:** Irrigation of measurements and comparison pixels affects the signal and causes a weakening in the performance. Further, the random and intermittent instrument noise produces intermittent positive spikes. Moreover, water and snow give similar signals since water is not filtered out in this version. Finally, by applying this methodology, the signal calculation may result in erroneous results in coastal areas by GFDS. GFDS and MODIS are the only daily public sources of satellite water detection; another promising alternative may be the global flood forecasting models such as GloFAS (Global Flood Awareness System) and GFMS (Global Flood Monitoring System).
- **The geographical allocation of Twitter messages:** The number of ambiguous words, including names of places, may cause a substantial share of messages that may not be accurately and confidently georeferenced. In addition to the repetition of names of locations within the same country, georeferencing messages that are exterior to the affected area is a crucial priority since most of the tweets may discuss second-hand information rather than observation.
- **The intensity of tweets:** Easily to find large numbers of tweets about (upcoming) floods only for densely populated areas, but possible false-alarm rates.
- **Selection of relevant tweets:** Challenges of selecting relevant tweets for the topic of discussion or issue at hand. Even though the results are already promising, the accuracy could improve when data processing is improved.
- **Social media penetration:** The penetration rate of social media is relatively low in Pakistan, at 4% of the population; in the Philippines, the penetration is higher at 29%.

IV. CHALLENGES AND RECOMMENDATIONS

To further leverage the potential of these technologies in enhancing financial resilience to disaster risk, the following challenges should be considered:

Consumer protection issues: Concerning the transfer security of mobile money, predatory lending for digital credit, and unobservable contract quality for index insurance. On these fronts, a variety of actors have made valuable efforts to address these concerns. For example, the GSMA has developed the Mobile Money Certification. In addition, BASIS has developed the Quality Index Insurance Certification (QUIIC), and the Center for Effective Global Action (CEGA) has developed the Digital Credit Observatory.

Building local capacities: To access and use Big Data is fundamental to avoid widening the digital divide between developed and developing economies. Capacity-building is also critical to ensure local ownership and scalability.

Collaboration and partnerships: Big Data approaches offer new engagement opportunities for stakeholders at the local, national, and international levels. As such, multi-scale networks and collaborations should be considered part of the design and implementation strategies of future initiatives in this field.

Validation: Technology can fail to predict outcomes correctly or can accentuate, rather than ameliorate, underlying inequalities in access to financial services.[74] Combining secondary and primary data sources is vital to ensure individuals fully benefit from these technologies.

Earth Observation and data transmission technologies (mobile and social media data) offer unique opportunities to improve the management of disaster and climate risks (before, during, and after disasters), and enhance the availability and affordability of financial protection, planning, and assistance tools. These technologies are utilized to improve risk assessment, reduce vulnerability, and build financial resilience through innovations for data collection (e.g., earth observation), data processing (e.g., artificial intelligence), and data transmission (e.g., social networks). The case studies analyzed show high potential for each technology in its broader applications. The analysis underlines how these technologies contribute to disaster risk management and financing, improved risk awareness, more effective planning and preparedness, and more inclusive risk transfer arrangements, through:

Enhancing the availability and affordability of insurance schemes: Offering 1) Financial protection against a number of different risks to economies, through parametric insurance combined with technology and innovation. 2) Risk reduction through improvements in the effectiveness of communications tools, combined with increased access to mobile-based technologies, providing new opportunities for insurance companies to support risk mitigation by their policyholders. 3) Lowering the cost of underwriting and speeding up the claim settings.

Managing public finance responses to climatic risks: Governments use reserve funds, contingent financing, borrowing, and risk-transfer to insurance markets to fund disaster-related costs. These varied funding approaches have different implications in terms of opportunity cost, timely access to funds, and funding cost. The emerging technologies allow governments to more accurately assess risk, providing them with the information necessary to better assess potential fiscal exposures.[75]

More efficient disaster response and recovery: Earth observation imagery from satellites and mobile- or social-based technologies can greatly increase speed and accuracy when producing damage assessments.

74 Benami, E., & Carter, M. R. (2020). Can digital technologies reshape rural microfinance? Implications for credit, insurance, and saving. Applied Economic Perspectives and Policy.

75 OECD (2020) Leveraging technology and innovation for disaster risk management and financing

Preparedness improvement: By using earth observations and mobile-based technologies, providing timely and accurate information on risk and likely impacts, thereby saving millions of lives in the event of a disaster.

More effective land use and spatial planning: The emerging technologies (described above) can also be utilized to address other challenges, such as land-use planning and risks stemming from rapid, unmanaged urbanization, thereby creating resilience-oriented land-use plans.

The success of these emerging technologies depends on the international community's ability to learn from each other during the integration of these technologies into disaster risk management and financing; the development of networks and mechanisms to transfer technical skills and knowledge; the sharing of experience regarding the development of regulatory frameworks that support the availability of data (including regulatory frameworks related to the commercial use of drones and privacy protection regulation, and insurance regulatory frameworks)[76]; the facilitation of coordination among stakeholders; the promotion and incentivisation of private sector involvement; investment in infrastructures, (for example, mobile phone networks in remote zones), and the synchronization of big data sources, such as mobile and social media data.

76 OECD (2020) Leveraging technology and innovation for disaster risk management and financing

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