Risk-informed Governance and Innovative Technology for Disaster Risk Reduction and Resilience

Module 2.4: Improving Data Analysis and the Presentation of Information

Contents

1. Big Data Analytics
2. Artificial Intelligence (AI) and Machine Learning
3. Virtual Reality (VR) and Augmented Reality (AR)

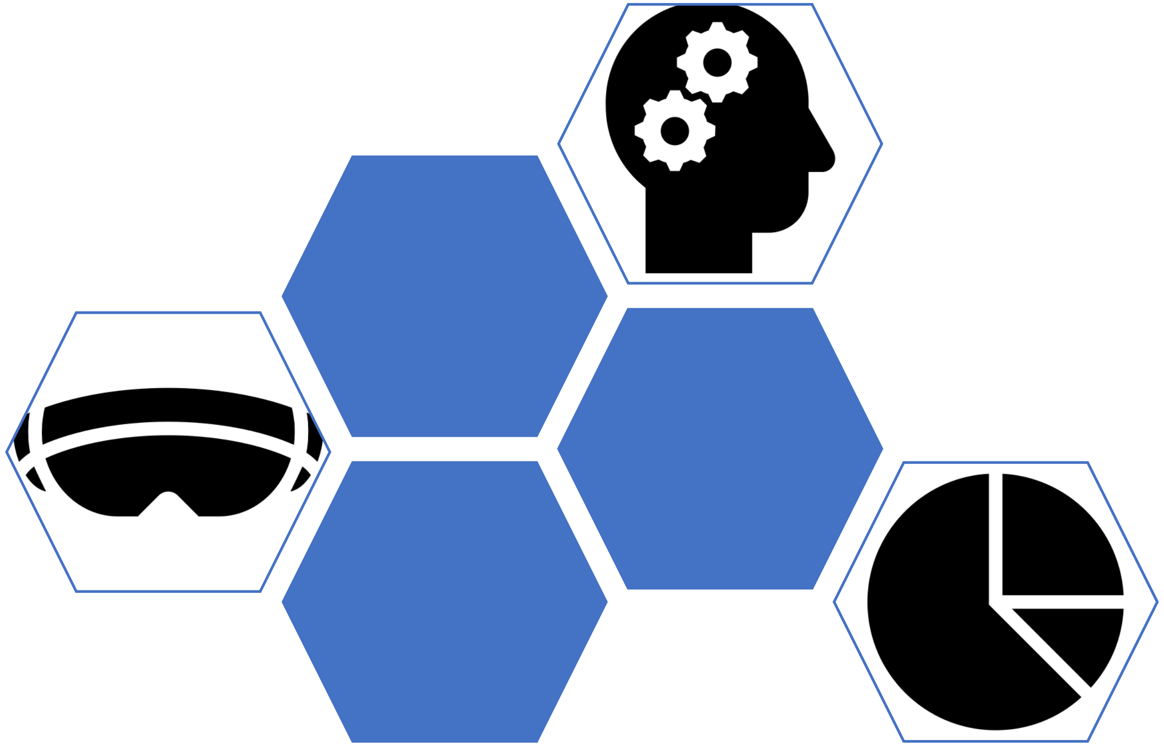
Learning Outcomes

At the conclusion of this Session, Participants will be able to:

- Incorporate existing big data analysis systems into planning and response
- Understand the range of big data that is being collected by different stakeholders, and the importance of data standards and open data policies to support its use in disaster risk management
- Understand what models are available to assist in both pre- and post-disaster planning efforts, and know how to access and use them

Introduction

- Big Data Analytics
- Artificial Intelligence (AI) and Machine Learning
- Virtual Reality (VR) and Augmented Reality (AR)



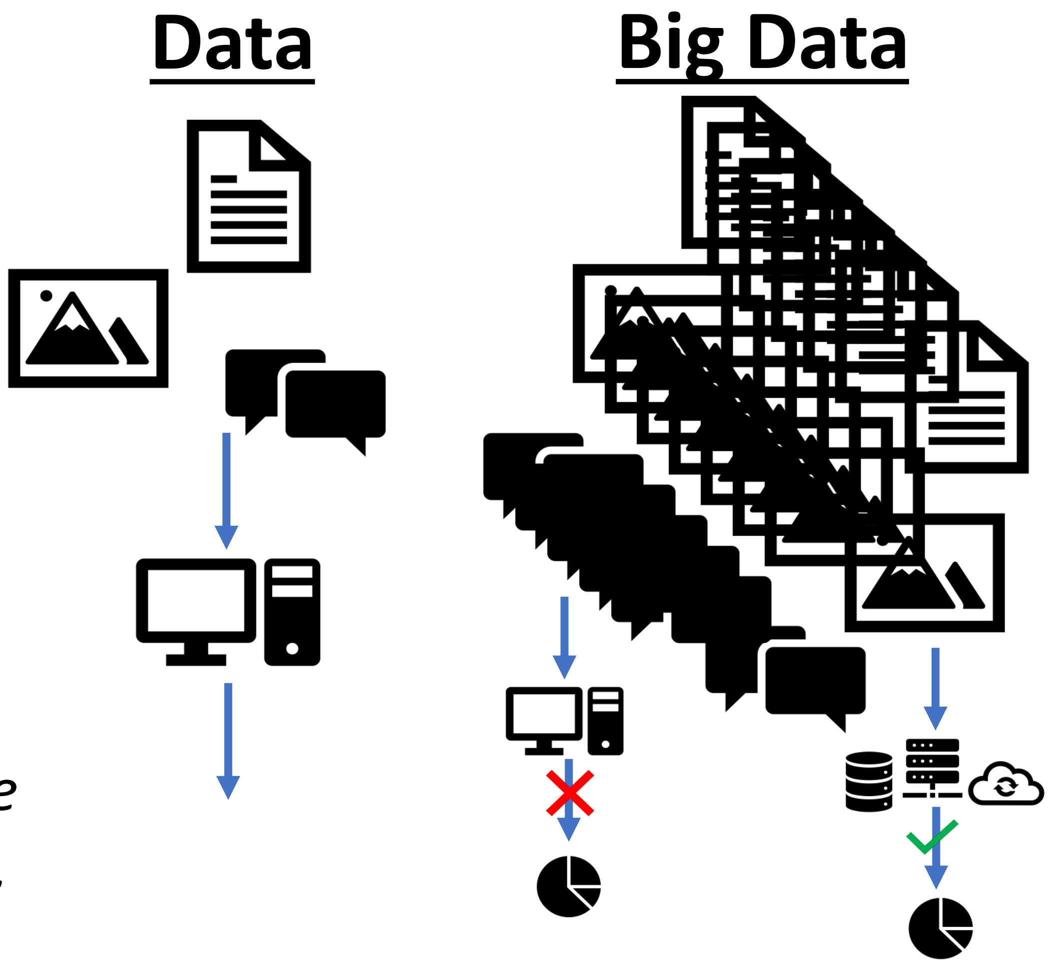
1. Big Data Analytics

- **Doug Laney (2001)**
  "[A] 3-dimensional data challenge of increasing data volume, velocity and variety."

- **Apache Hadoop (2010)**
  "Datasets which could not be captured, managed, and processed by general computers within an acceptable scope."

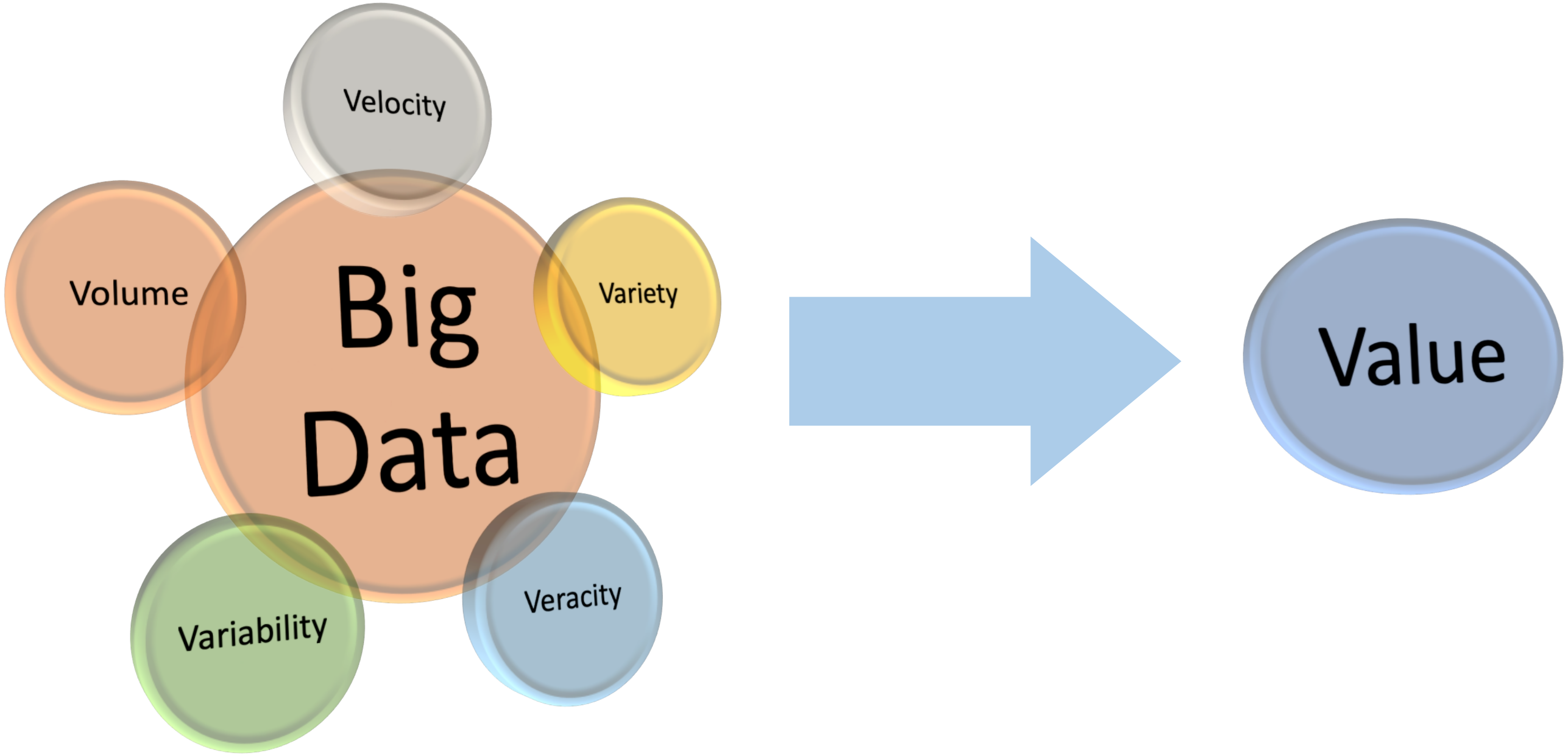
- **TechAmerica Foundation (n/d)**
  "[A] term that describes large volumes of high velocity, complex and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information."

▪ **Big Data**



1. Big Data Analytics

▪ The 'V's' of Big Data



1. Big Data Analytics

▪ Data Type Examples

- Satellite imagery
- LiDAR imagery
- UAV-based aerial imagery and video
- River/stream gauges
- Weather stations
- Social media
- Simulation Data
- Demographic data
- Traffic data / cameras
- Ocean data (temperature, wave height, currents)
- Doppler Radar
- Economic data
- Infrastructure

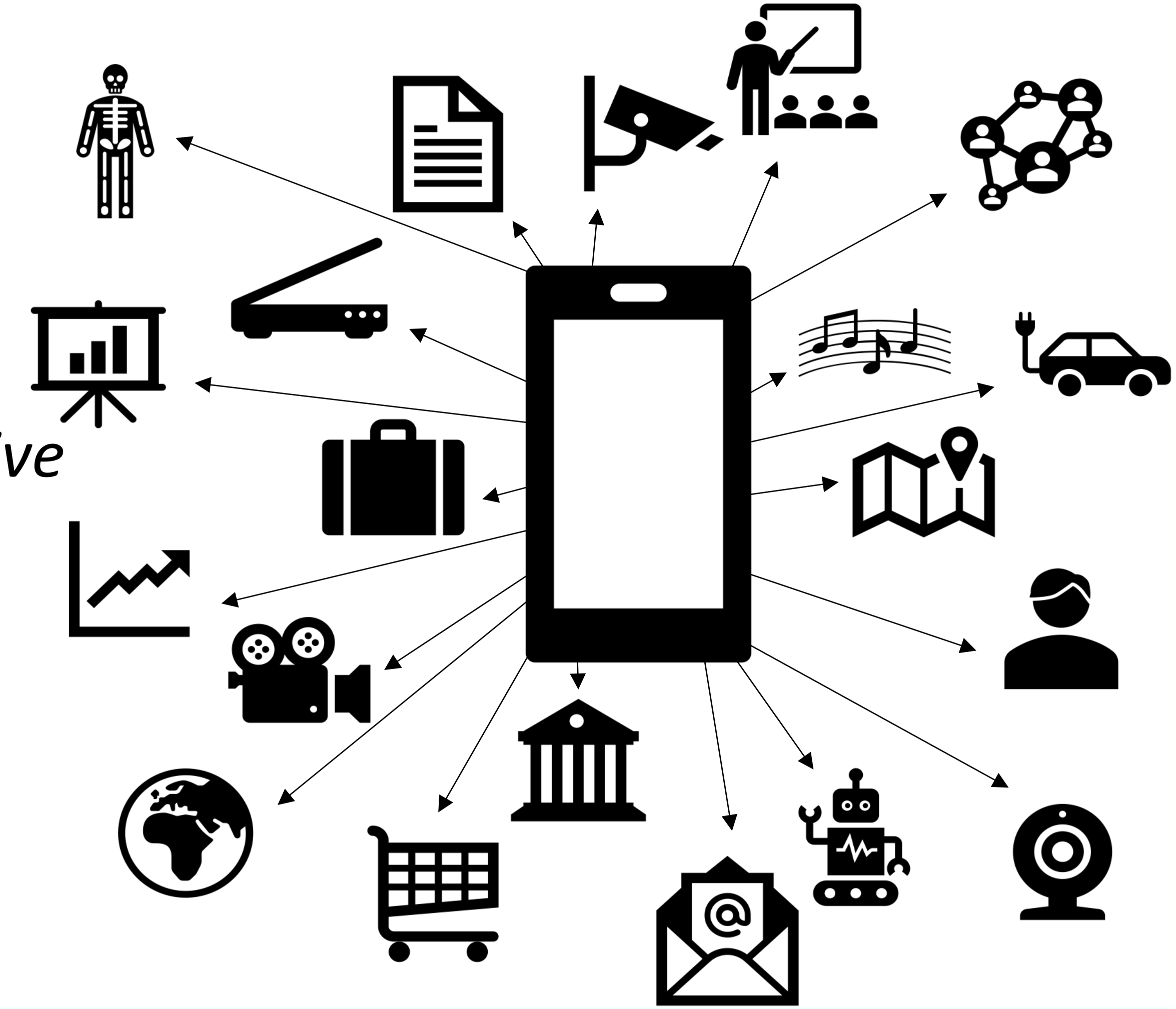
- Topographic data
- Soil data
- Vegetation data
- Land use data
- Agricultural data
- Education data
- Property values
- Tax base
- Infrastructure data
- Crime data
- Tourism data (‘visitors’)
- Epidemiological and public health data

1. Big Data Analytics

▪ Mobile Data Network

"In developing economies, Mobile Network Big Data (MNBD) currently represents the single most important source of Big Data for development purposes, due to its almost comprehensive coverage of the population. This makes citizens the sensors, and the resultant data derived from using their mobile phones – a useful source of insights for development policy."

- UNESCAP



1. Big Data Analytics

- **Big Data Stakeholders**

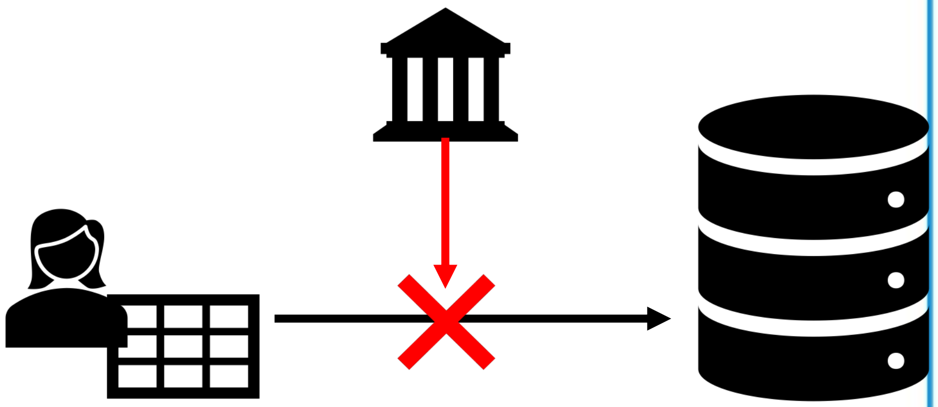
1. Big Data Analytics

▪ Case Study: Big Data for Social Good

Video Source: GSMA, 2018.

▪ Data Sharing Challenges

- The **political climate** may make data sharing difficult or even dangerous
- **Data quality** is poor.
- **Organizations** are prevented or discouraged from sharing data.
- **Organizational policies** are not set up to allow for data sharing.
- Others



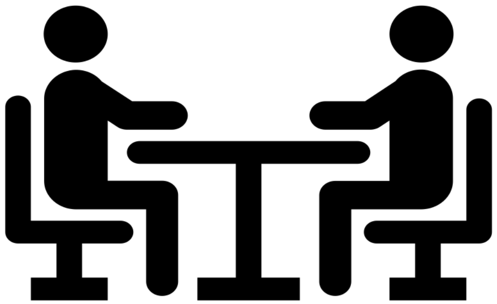
1. Big Data Analytics

▪ Case Study: Humanitarian Data Exchange

- **Problem**: There is a significant lack of disaggregated data on risk and resilience at the local and neighborhood level.
- **Need**: A mechanism to enable the sharing of data among the different organizations who collect and use it.
- **Obstacle**: There are several, including a lack of a common platform, a lack of advocacy for this need, a lack of assurance about how privacy will be protected, and more.
- **Solution**: A data sharing platform that promotes and enables responsible data sharing for development purposes.

Video: Making the Invisible Visible.
Source: UNOCHA, 2016.

Group Work and Activities



Group Work and Activities

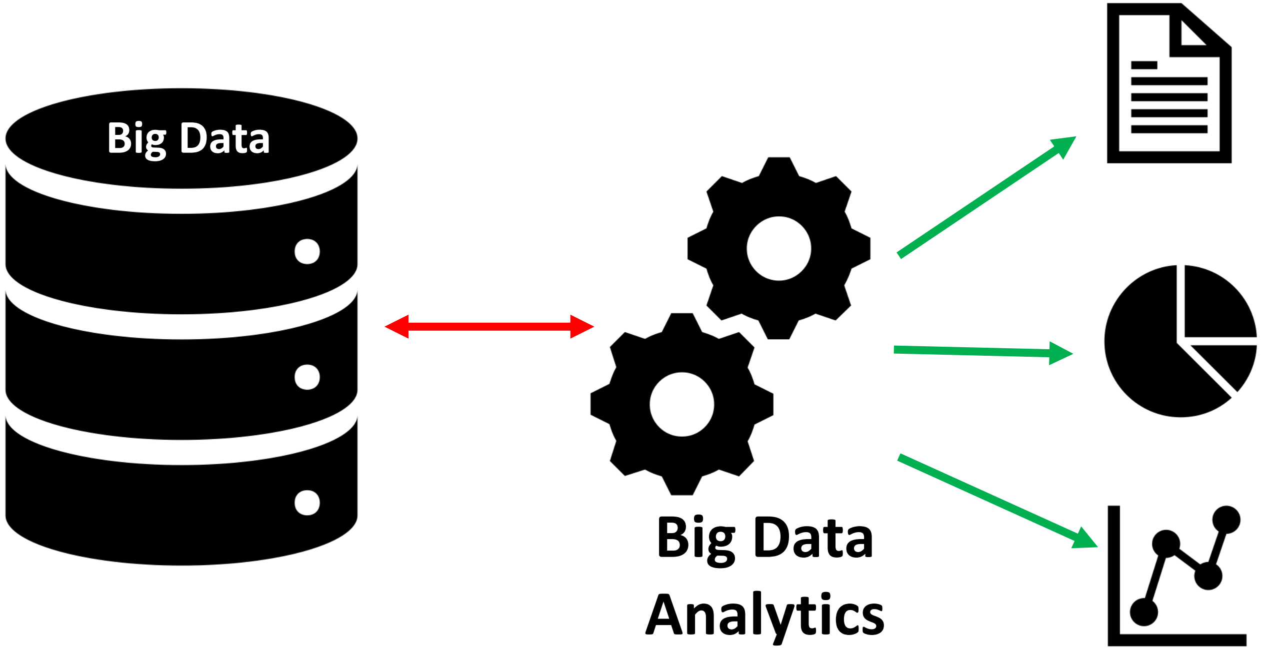
▪ Discussion 1: Data Sources and Stakeholders

- There are differences in each country with regards to who generates data and who owns or controls that data.
- **The Facilitator** can divide Participants into groups of 1 to 4 Participants.
- The Facilitator should provide for the participants the following list of data types (the Facilitator can add additional data types to this list)
- Each group should select five of these data types to consider in their own country (or countries). Questions to answer include:
    - What public, private, and/or nongovernmental sector organizations generate this type of data?
    - Who maintains this data?
    - Is access to this data limited or otherwise impacted by any laws?

1. Big Data Analytics

▪ Big Data Analytics

- Advanced form of data analytics
- Requires extraordinary computing power
- Coordination with data owners may be required



1. Big Data Analytics

- ## Aggregation and Disaggregation of Data

Image: Blind Monks Examining and Elephant. Source: Hanabusa Itcho, 1652-1724.

1. Big Data Analytics

▪ Data Visualization

- Reporting / presentation of data
- Maps and charts
- GIS is highly effective

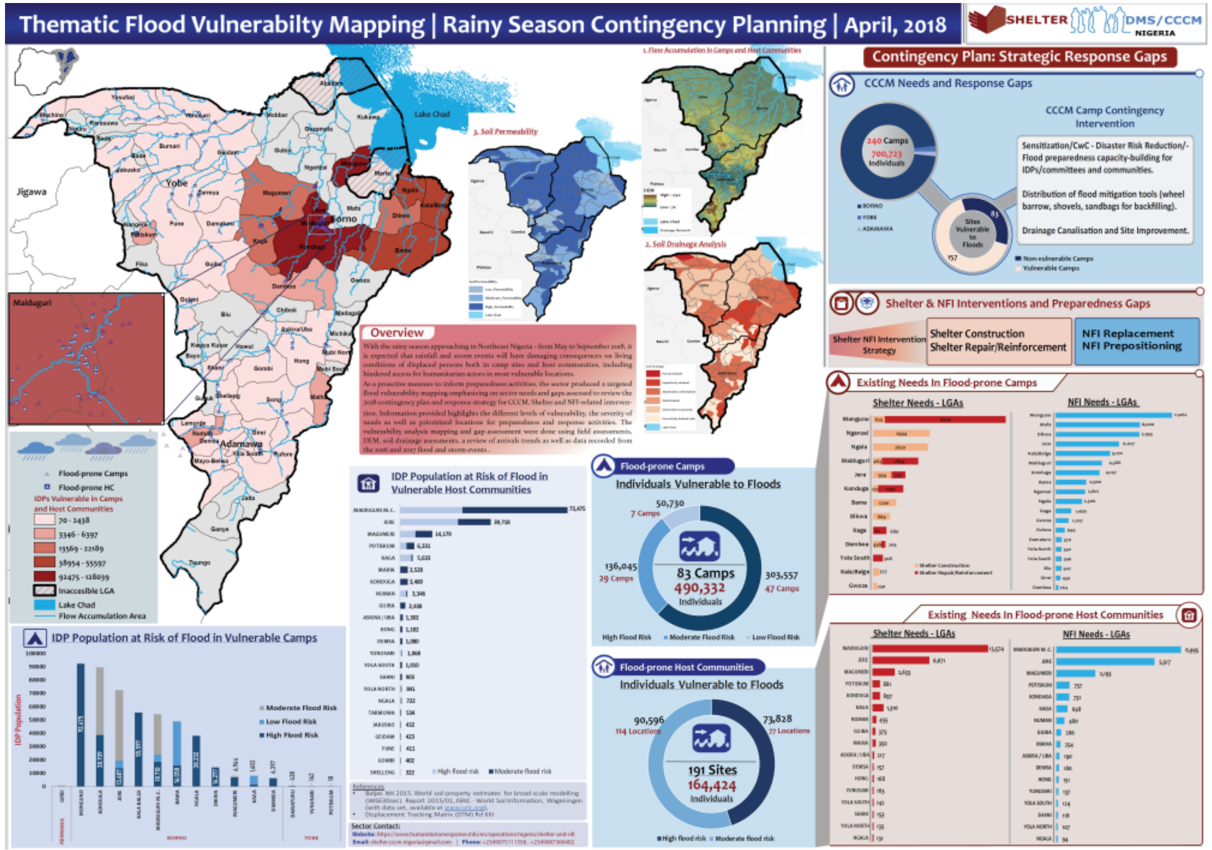


Image: Thematic Flood Vulnerability Mapping Product
Source: IOM, 2018.

1. Big Data Analytics

▪ GIS-Based Big Data Analytics

- Spatial information associated with data
- Presented on a map or satellite image
- Temporal data allows for trending analysis or projections
- High-impact visualization of Big Data analysis
- Supports pre- and post-disaster planning and analysis

Image: Tidal flood projections in a New York, USA community projected over a 15 year period. Source: First Street Foundation, 2020; http://bit.ly/2R3b0i4.

1. Big Data Analytics

Case Study: DisasterAWARE™

- **Problem**: A vast number of data sets with different sources and formats hinders data analytics capabilities.
- **Need**: Big Data Analytics capabilities tailored to the needs of a wide range of DRM practitioners.
- **Obstacle**: Big Data Analytics infrastructure is cost-prohibitive and necessary technical capabilities may not be available or may not exist.
- **Solution**: A user-friendly Big Data Analytics visualization system with customization capabilities.

Video: DisasterAWARE Reduces Disaster Risk, Saves Lives.
Source: PDC, 2017.

1. Big Data Analytics

Case Study: Haze Gazer

- **Problem**: Response to haze-related incidents is impacted by rapidly-changing conditions, and stale data is more of a liability than a help.
- **Need**: Incorporation of real-time data on hazard conditions, populations, and resources.
- **Obstacle**: No mechanism exists to quickly aggregate and process the streams of dynamic data that are generated.
- **Solution**: A Big Data incident management platform with a hazard-specific focus.

Video: Haze Gazer Platform.
Source: Pulse Labs Jakarta, 2017.

Case Study: CycloMon

- **Problem**: Response to cyclones is impacted by rapidly-changing conditions, and stale data is more of a liability than a help.
- **Need**: Incorporation of real-time data on hazard conditions, populations, and resources.
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Video: CycloMon Platform.
Source: Pulse Labs Jakarta, 2018.

1. Big Data Analytics

▪ Case Study: Coastal Inundation Dashboard

- **Problem**: Response to cyclones is impacted by rapidly-changing conditions, and stale data is more of a liability than a help.
- **Need**: Incorporation of real-time data on hazard conditions, populations, and resources.
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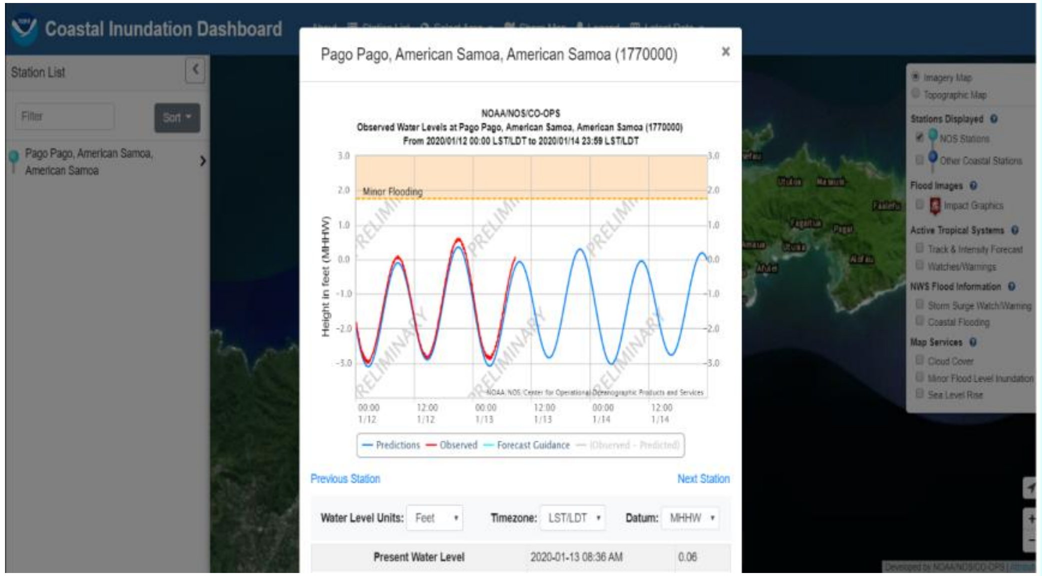
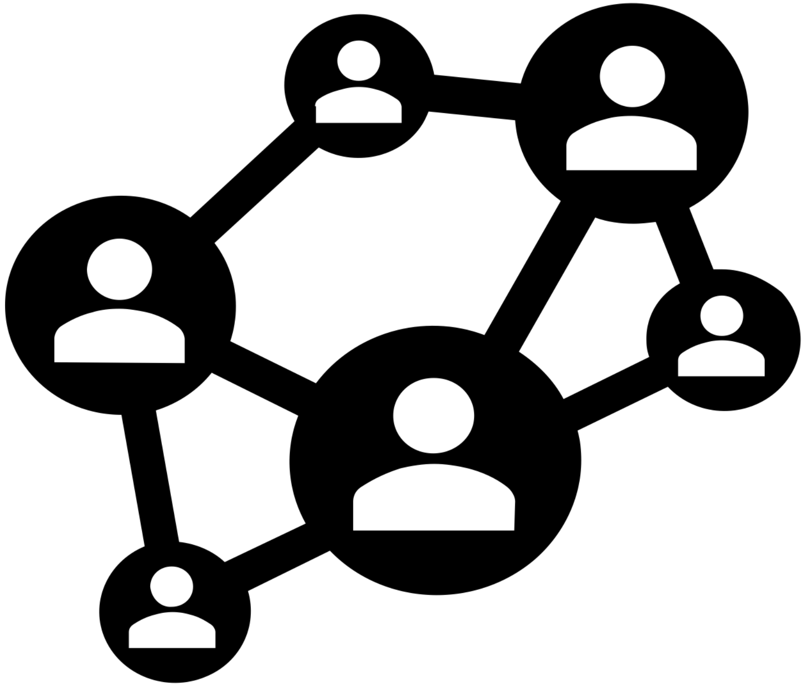


Image: US National Oceanographic and Atmospheric Administration.
Source: Pulse Labs Jakarta, 2018.

1. Big Data Analytics

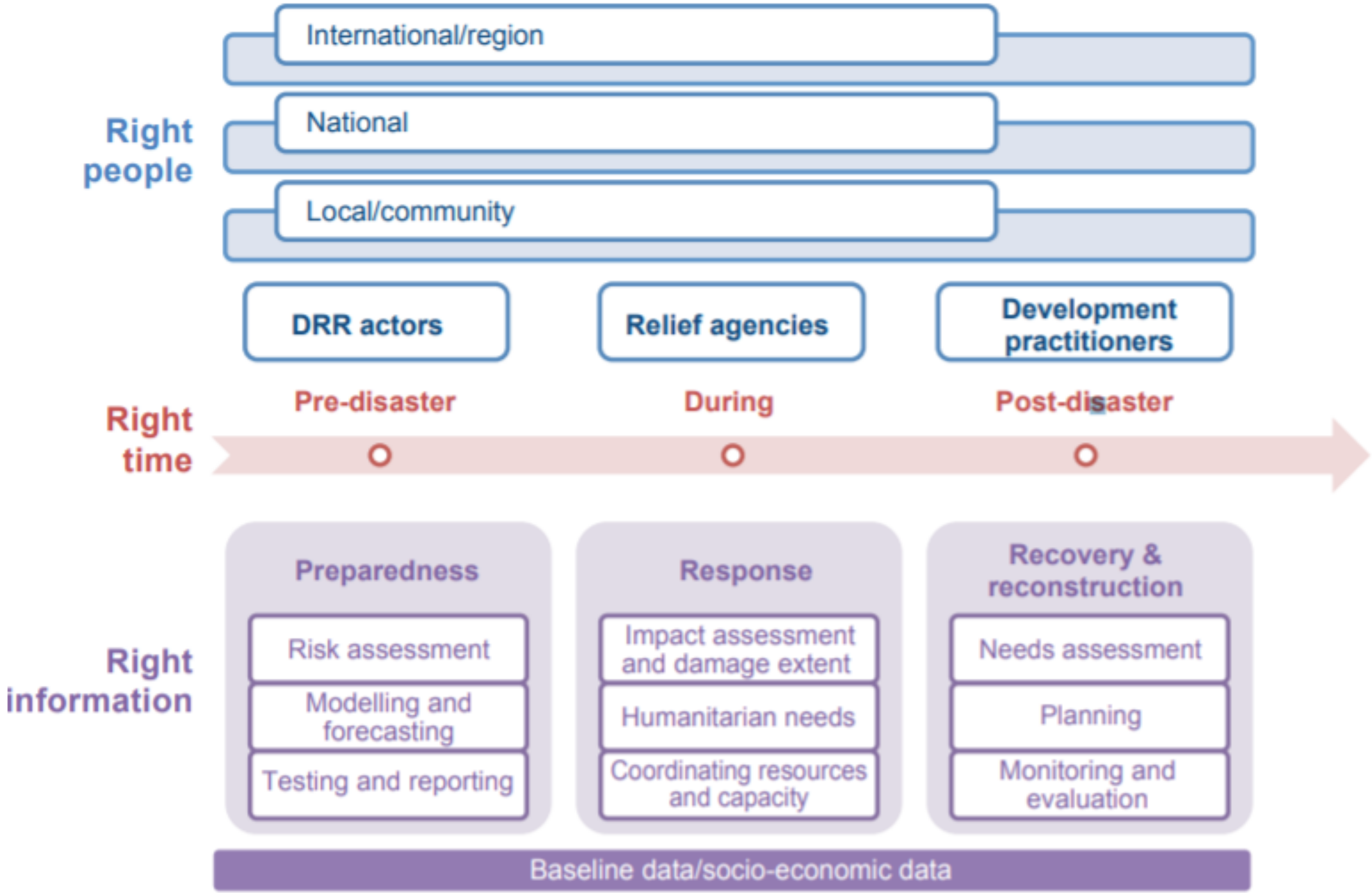
▪ Promoting Institutional Data Sharing

- EM organizations are not traditionally organized to utilize government-wide data resources (e.g., socio-economic data)
- Different agencies and departments often have different data policies, formats, systems, etc.
- Inter- and intra-governmental data sharing frameworks are required
- Open Government Data (OGD) is a philosophy



1. Big Data Analytics

▪ Right information, right people and right time

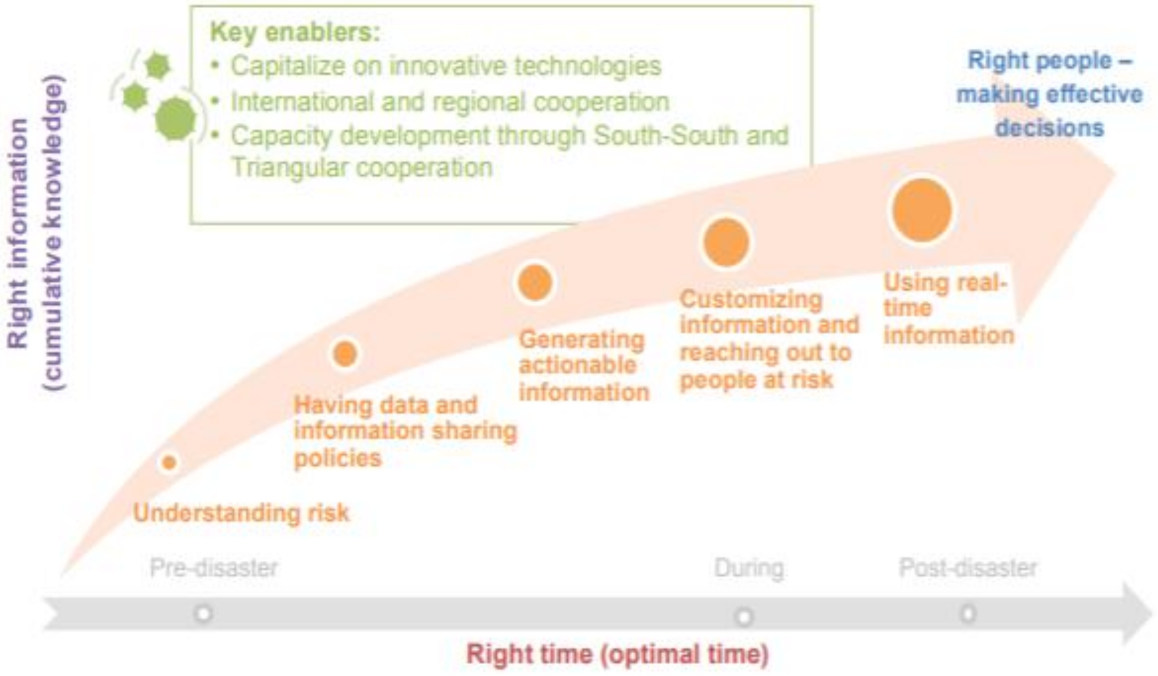


https://www.unescap.org/sites/default/files/apdr2015-ch4.pdf

▪ Roadmap to Effective and Resilient Information Management

Providing the right information to the right people at the right time, involves **five principal steps:**

1) understanding risk;
2) having data and information sharing policies;
3) generating actionable information;
4) customizing information and reaching out to people at risk; and
5) using real-time information.



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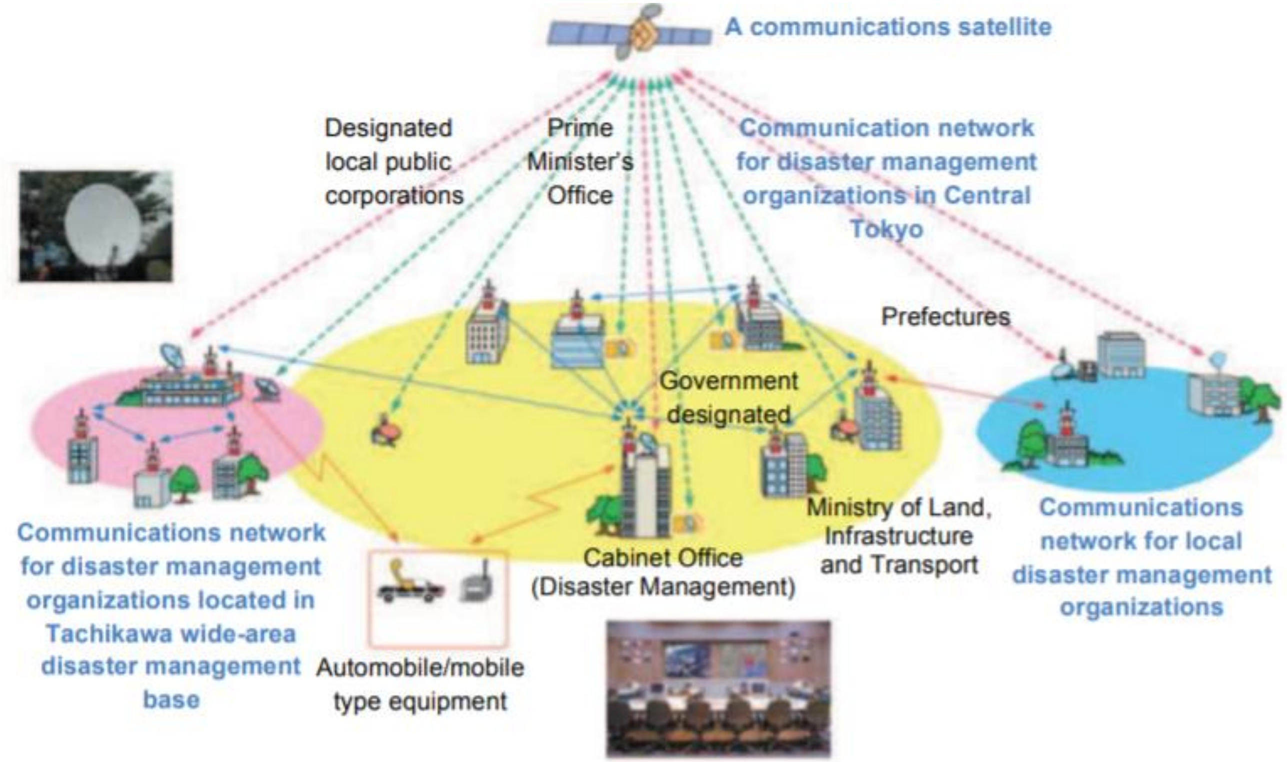
1. Big Data Analytics

▪ Central Disaster Management Radio Communications System in Japan



Source: Provided to ESCAP by Japan Aerospace Exploration Agency, 2014.

https://www.unescap.org/sites/default/files/apdr2015-ch4.pdf

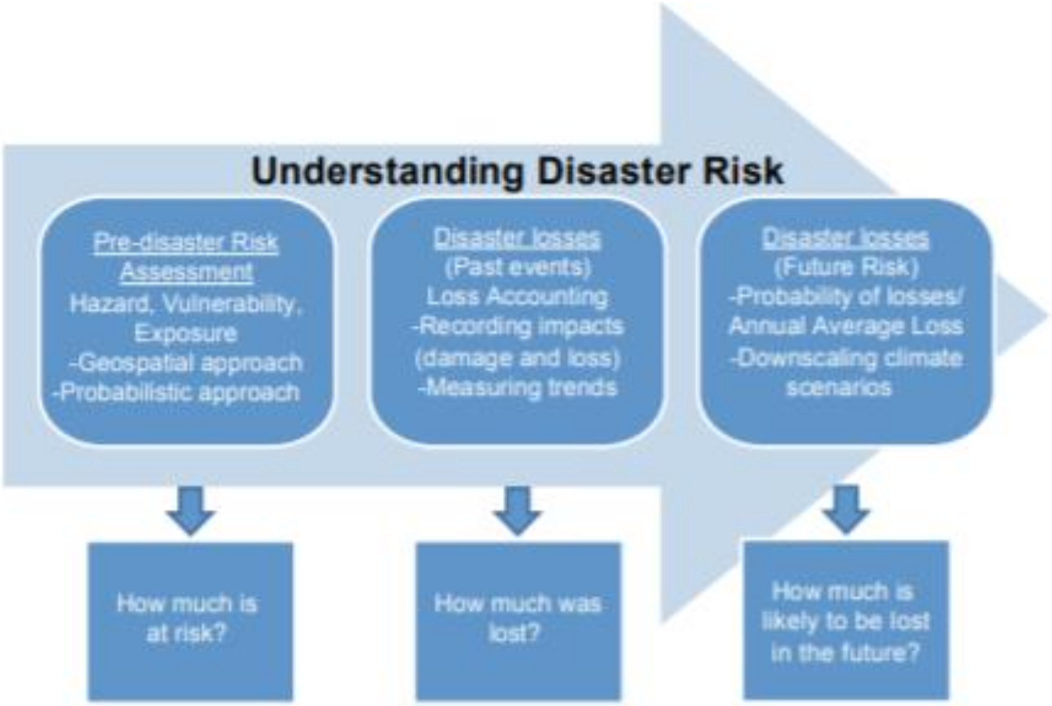
1. Big Data Analytics

- **Cloud to Street – Understanding Risk**

1. Big Data Analytics

▪ Information Management Practices for Understanding Disaster Risk

- Pre-disaster Risk Assessment
- Disaster Losses (Past Events)
- Disaster Losses (Future Risk)



https://www.unescap.org/sites/default/files/apdr2015-ch4.pdf

2. Artificial Intelligence (AI) and Machine Learning

- ## What is Artificial Intelligence (AI)

Video used with permission by Dr. Raj Ramesh, Top Sigma.

2. Artificial Intelligence (AI) and Machine Learning

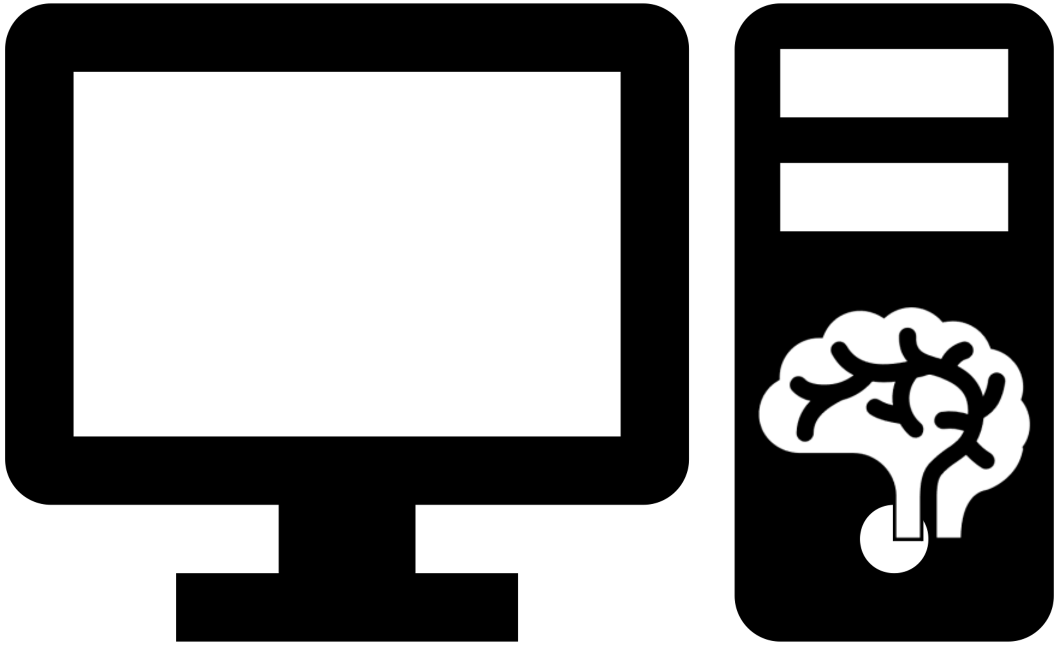
AI Definitions

- **Russell and Norvig**
  "The study of agents that receive percepts from the environment and perform actions"
- **Encyclopedia Britannica**
  "The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings"
- **Latanya Sweeney**
  "The study of ideas to bring into being machines that respond to stimulation consistent with traditional responses from humans, given the human capacity for contemplation, judgment and intention"
- **American Association for AI**
  "The scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines"
- **AI Depot**
  "A branch of science which deals with helping machines find solutions to complex problems in a more human-like fashion"
- **Raoul Smith**
  "A field of computer science that seeks to understand and implement computer-based technology that can simulate characteristics of human intelligence and human sensory capabilities"

2. Artificial Intelligence (AI) and Machine Learning

▪ AI Defining Characteristics

- Intentionality
- Intelligence
- Adaptability



2. Artificial Intelligence (AI) and Machine Learning

The Risks of AI

- Human Bias
- Human Tendencies
- Human Preconceptions
- Human Error

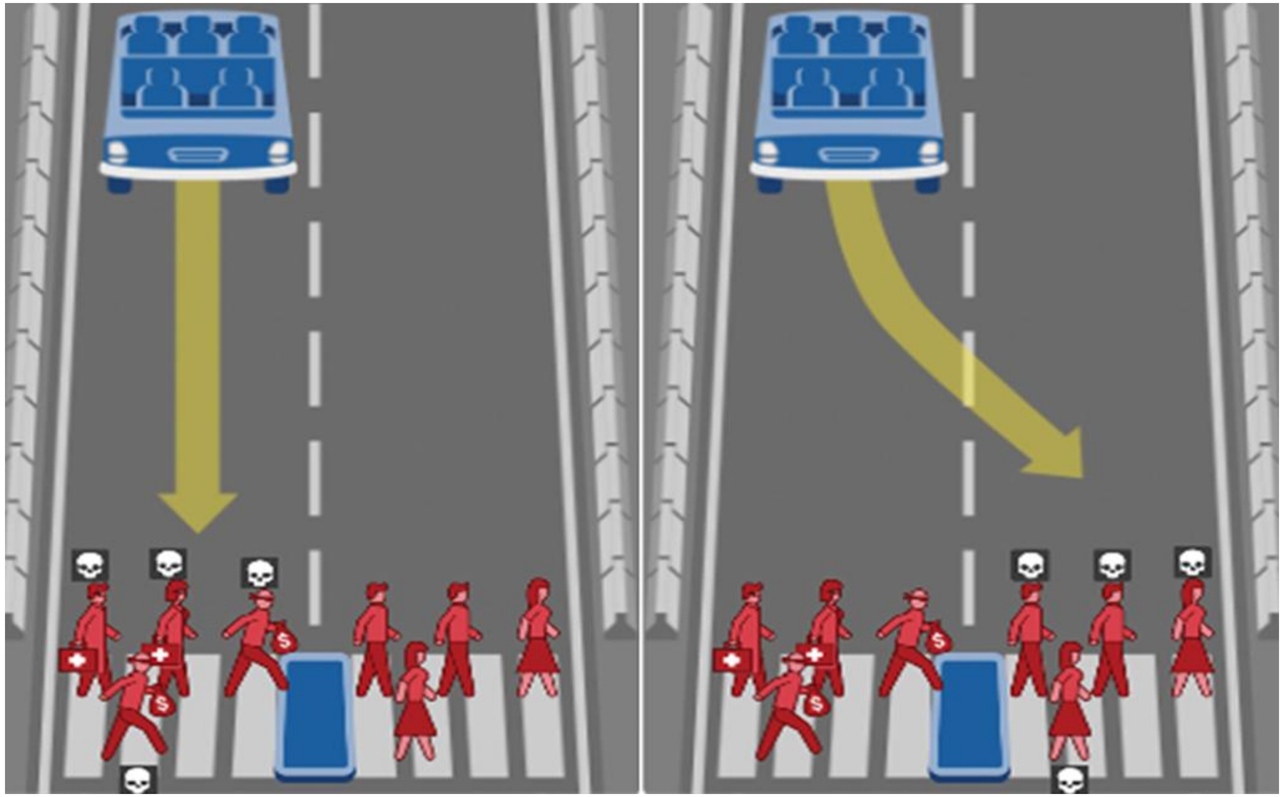


Image: Screenshot from the Moral Machine Survey. Image Source: MIT, 2020.

2. Artificial Intelligence (AI) and Machine Learning

▪ Case Study: Earthquake Smart Space App

- **Problem:** Building contents and configurations can increase or decrease seismic risk.
- **Need**: Citizens can become more resilient by mitigating high-risk arrangements and by learning what protection options are offered.
- **Obstacle**: Risk assessment of building contents requires a minimum level of technical expertise.
- **Solution**: Smartphone-based AI risk assessment system that uses the phone camera to identify risk.

Image: Sample screenshot of the Earthquake Smart Space App analyzing a living room space for seismic hazards.
Image Source: Earthquake Smart Space, 2020.

2. Artificial Intelligence (AI) and Machine Learning

Case Study: AI Analysis of Satellite Data to Predict Disasters

- **Problem**: Evacuation needs to be location specific to be efficient and effective.
- **Need**: Rapid decision support based on current data.
- **Obstacle**: Satellite data covering the wider impacted area exists, but analysis often takes too much time to effectively support evacuation.
- **Solution**: AI that combines satellite images with current weather data and data from ground-based sensors to recommend evacuation plans.

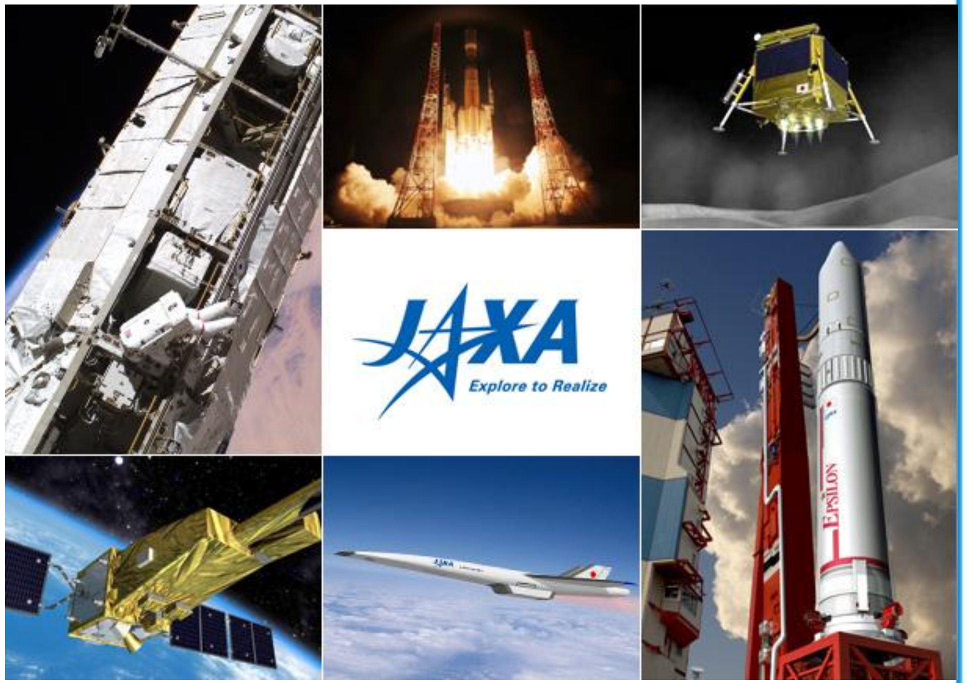
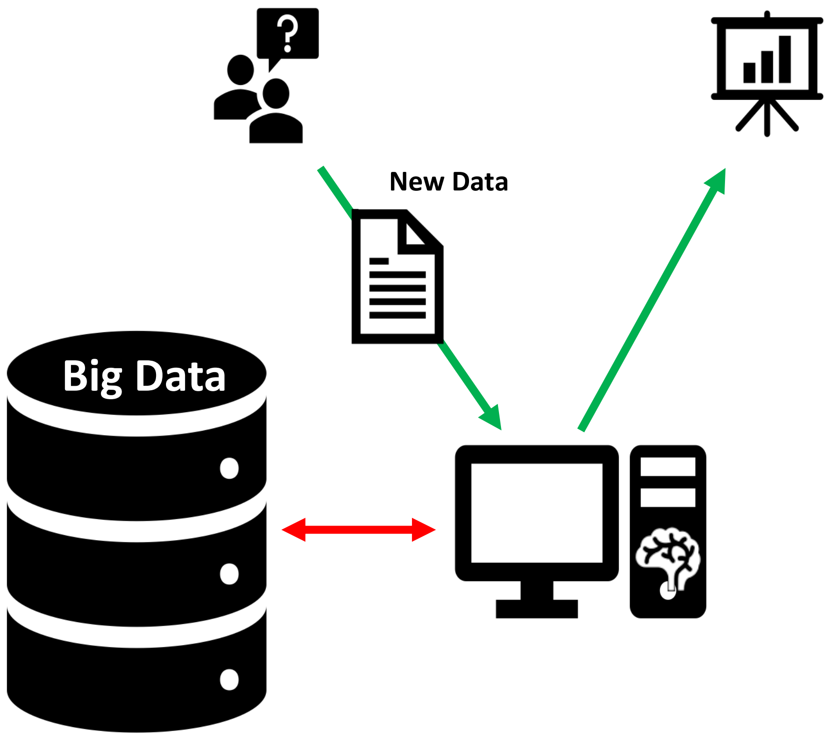


Image Source: JAXA, 2020.

2. Artificial Intelligence (AI) and Machine Learning

▪ Machine Learning

- **Machine learning**, at its most basic, is "using data to answer questions"
- **Machine learning** is 'trained' using data, and then approaches new data in light of training to identify underlying trends and make predictions
- It is able to eliminate unrelated data and can bring to light any important findings
- The focus is on understanding probability rather than performing reasoning
- In DRM, machine learning helps to make 'better' decisions



2. Artificial Intelligence (AI) and Machine Learning

▪ Machine Learning Applications

- Speech Recognition
- Text Recognition
- Image Recognition
- Robotics
- Reasoning

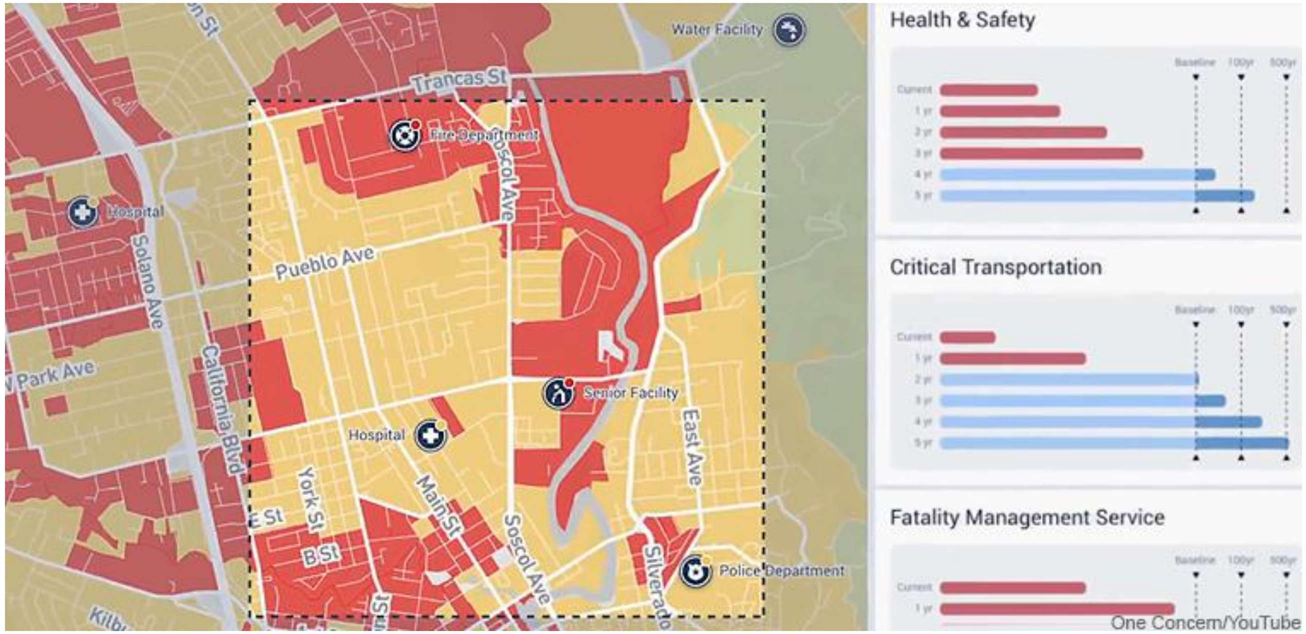


Image: Damage assessment report produced using machine learning AI application.
Image Source: One Concern, 2020.

2. Artificial Intelligence (AI) and Machine Learning

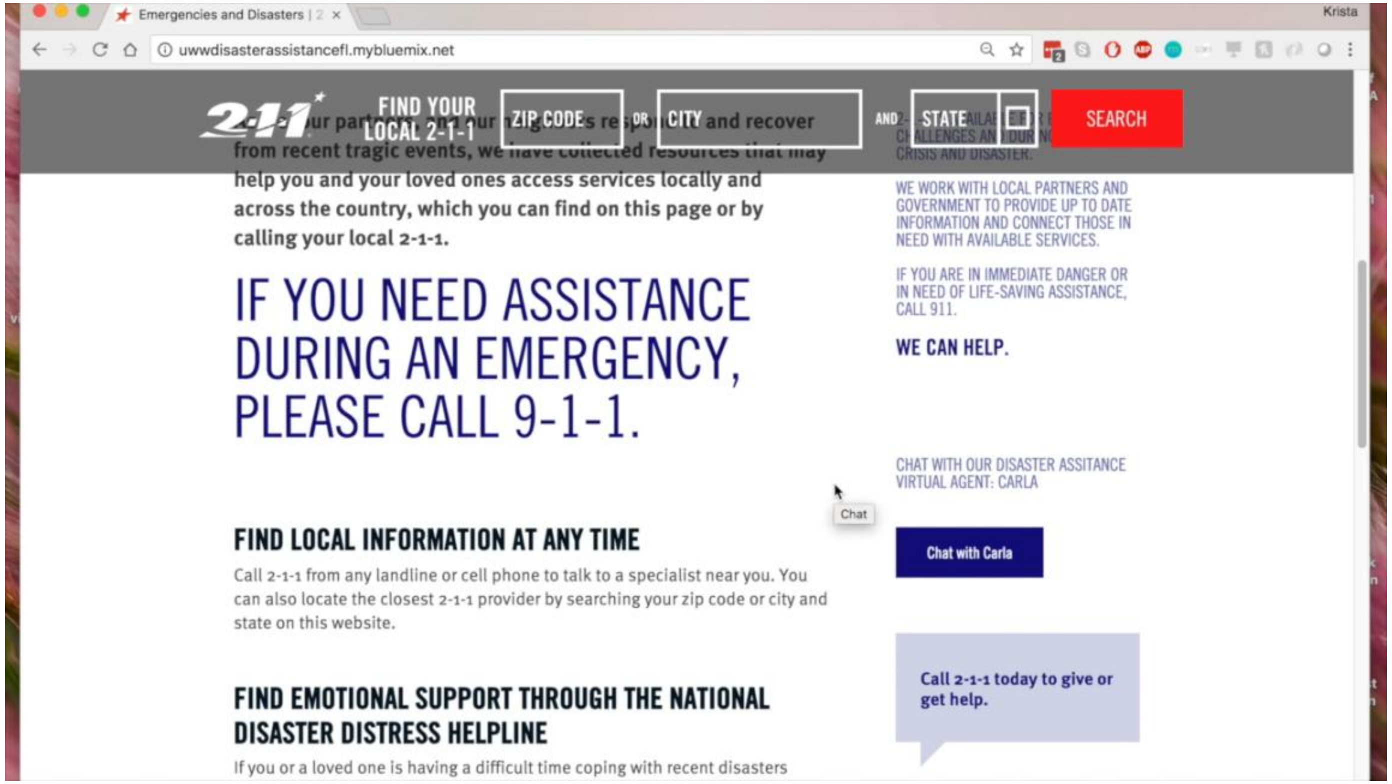
Case Study: IBM Cognitive Automated Response Learning Agent (CARLA)

- **Problem**: Victims have a range of needs for which they must reach out to local government.
- **Need**: Capacity to receive requests from disaster impacted people and provide appropriate information.
- **Obstacle**: Disaster response officials with the answers to most questions are often time-constrained when the public needs answers.
- **Solution**: Automated AI chat—based response system that can assess survivors' needs and provide appropriate information.

Video Source: IBM, 2019.

2. Artificial Intelligence (AI) and Machine Learning

▪ IBM CARLA Demonstration Video



Video Source: IBM, 2019.

2. Artificial Intelligence (AI) and Machine Learning

Case Study: Maxar Automatic Mapping

- **Problem**: Disaster risk reduction and disaster planning require a significant amount of spatial data.
- **Need**: Accurate data that informs vulnerability and risk assessments, such as settlement patterns, population movements, and commercial activities.
- **Obstacle**: Interpreting space imagery using people takes a lot of time.
- **Solution**: Machine learning system that can very quickly analyze remotely-sensed imagery and provide useful reports on that data.

Image: Before and after satellite photographs of the Palu Region affected by an earthquake and tsunami in 2018 as interpreted by the Maxar machine learning system.
Source: Maxar, 2020.

2. Artificial Intelligence (AI) and Machine Learning

Case Study: One Concern

- **Problem**: Disaster response staff need to make many decisions regarding the staffing of operations and dedication of resources in a relatively short amount of time.
- **Need**: Accurate information.
- **Obstacle**: Disaster assessments take time, often rely on old data or are based on past disasters and are not very flexible.
- **Solution**: Machine learning risk and disaster assessment platform that incorporates real-time risk information to make recommendations.

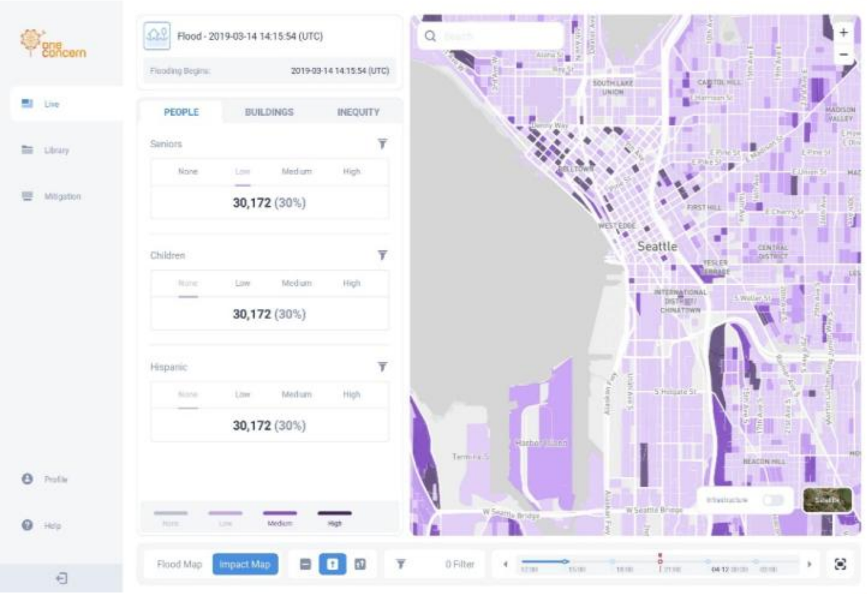


Image: One Concern Screenshot.
Source: One Concern, 2020.

2. Artificial Intelligence (AI) and Machine Learning

▪ Predictive Analysis

- We have no "crystal ball" for risk management
- Risk assessment seeks to reduce uncertainty, but some uncertainty always remains
- Predictive analysis identifies the most probable outcome, answer, or solution
- Dependence on accurate assumptions
- Uses regression analysis

"The technology is moving from descriptive analytics (what has happened) and diagnostic analytics (why it happened) to predictive analytics (what will happen). Data industry practitioners say the next wide-scale adoption will be prescriptive analytics, or data that can simulate the outcome of different tweaks to emergency response systems."

- Allen Young, 2017.

2. Artificial Intelligence (AI) and Machine Learning

Case Study: Optima Predict

- **Problem**: We often know disasters are happening before we understand what the response needs will be.
- **Need**: Ability to deploy response resources before requests are made for them.
- **Obstacle**: Human response personnel require time to process disaster data.
- **Solution**: AI predictive analytics system that can forecast likely needs and dedicate resources accordingly.

Video Source: Intermedix, 2014.

2. Artificial Intelligence (AI) and Machine Learning

▪ Case Study: Google Flood Prediction in India

- **Problem**: Floods can occur with little or no warning and affect an otherwise unprepared population.
- **Need**: Effective warning prior to a flood event.
- **Obstacle**: It can be very difficult to reach at-risk populations because there are so many different channels through which people receive their risk information.
- **Solution**: Identify at risk people by their internet use and provide them with hazard information when they are likely to be impacted.

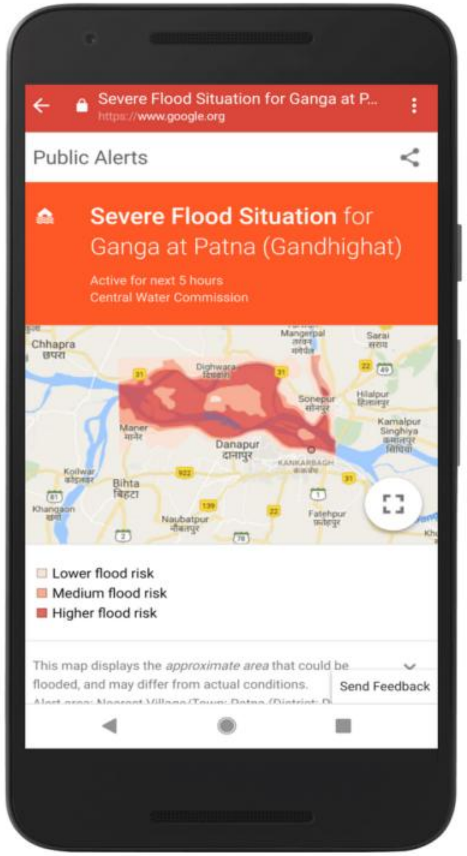


Image: Screen shot of Google-generated warning in India. Source: Google, 2018.

2. Artificial Intelligence (AI) and Machine Learning

▪ Case Study: Predicting Building Failure

- **Problem**: Some buildings are more prone to failure in an earthquake on account of their design, location, or construction materials.
- **Need**: Vulnerability assessment of all buildings to identify at-risk structures.
- **Obstacle**: Building inspections are time and resource intensive.
- **Solution**: AI system that can apply machine learning to identify at-risk buildings quickly and cost effectively.

Image: Report on building seismic vulnerability in Guatemala City
Source: World Bank GFDRR, 2018.

3. Virtual Reality (VR) and Augmented Reality (AR)

Virtual Reality (VR)

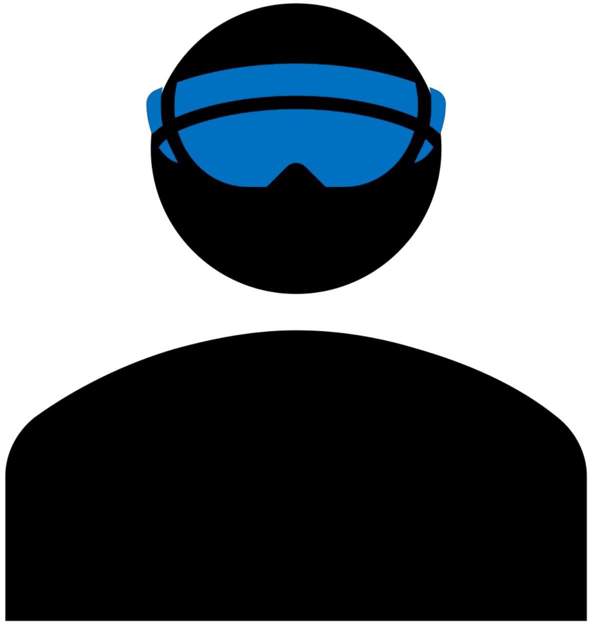
- A simulated situation or environment that someone can experience.
- Uses a combination of visual, audio, tactile, and other sensory tools.
- Nothing in the simulation is real.
- Applications:
    - Education
    - Training
    - Research
    - Therapy
    - Entertainment

Video Source: CGTN, 2019.

3. Virtual Reality (VR) and Augmented Reality (AR)

VR Advantages

1. Appeals to a variety of learning styles
2. Offers experiences that promote repetition and retention
3. Eliminates many risks / safety concerns
4. Can reduce training budgets and provide scalability
5. Can deliver results to a wide range of industries
6. Limits the need to schedule training at a certain time or in a particular place



3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Augmented Reality (AR)

- Applies artificial stimuli to the real world
- Typically uses digital enhancements
- Most smartphones are capable of running AR applications
- **Enhancements for**:
  - Planning
  - Preparedness
  - Mitigation
  - Alert and warning
  - Incident reporting
  - Response

Video: Demonstration of Disaster Scope augmented reality public disaster response training program.
Video Source: Tomoki Itamiya Laboratory, 2019.

3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Case Study: Augmented Training Systems

- **Problem:** Responders are not often familiar with equipment that is only used in disasters or major emergencies.
- **Need**: Training that provides familiarity with rarely used equipment.
- **Obstacle**: Training on actual equipment is not always practical due to costs or physical constraints.
- **Solution**: VR system that allows students to train from any location without requiring access to the actual equipment.

Video Source: Augmented Training Systems, 2019.

3. Virtual Reality (VR) and Augmented Reality (AR)

Case Study: AR-Supported River Flood Reporting in Indonesia

- **Problem:** Operational readiness is contingent on accurate and timely information about hazard conditions.
- **Need**: Reporting on flood river levels.
- **Obstacle**: Manual reporting is human resource intensive, and IoT systems can cost-prohibitive
- **Solution**: App-based AR system that allows citizens to easily measure and report river floo depth using smartphone cameras.

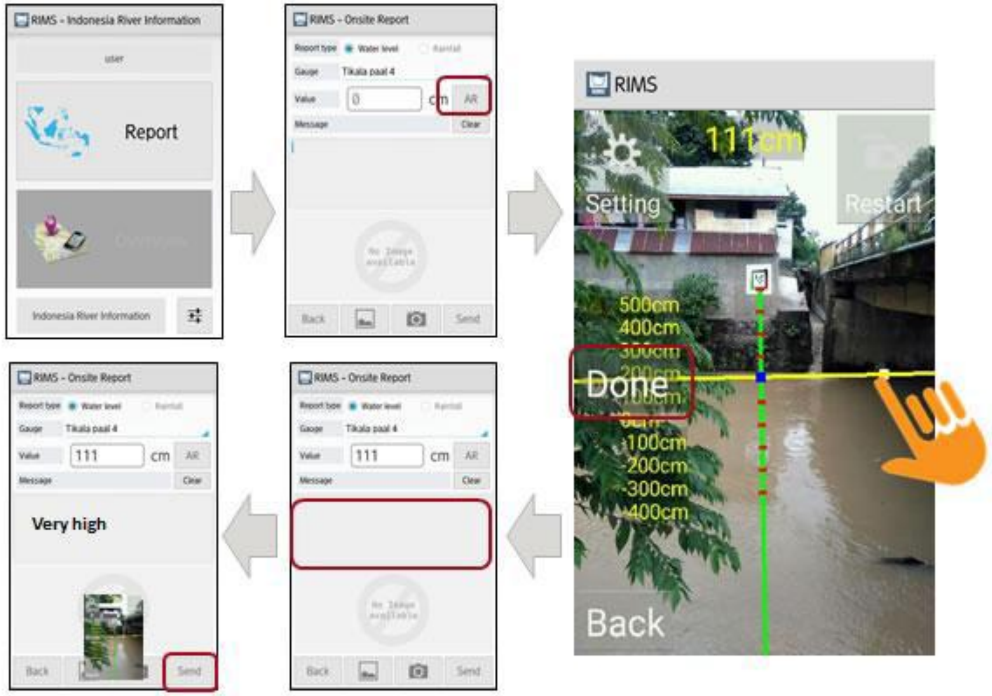


Image: Augmented reality system to report river flood depth in Indonesia.
Video Source: Fujitsu, 2016.

3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Case Study: AR Drone Footage Supports Response Operations

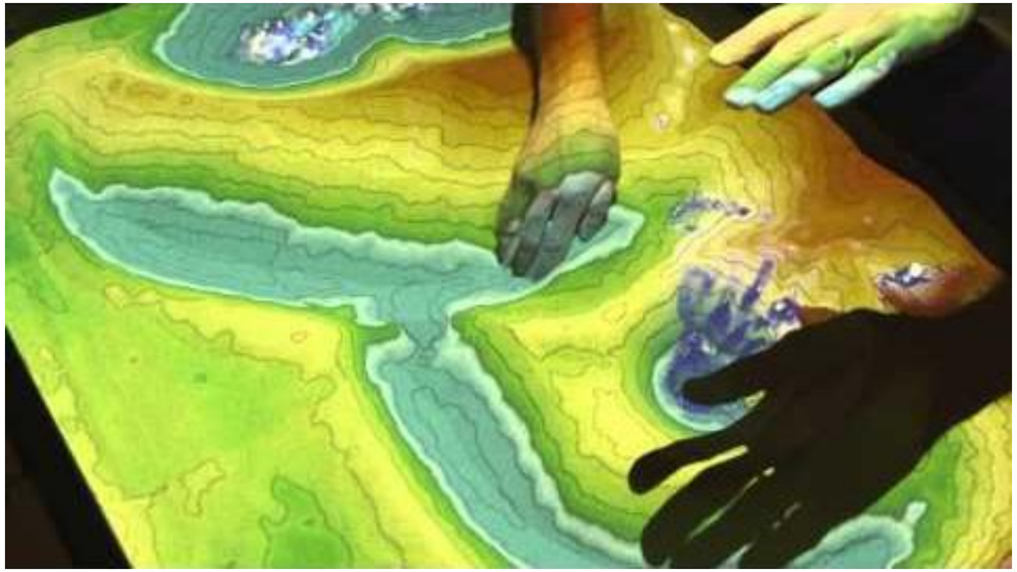
- **Problem:** Disasters often cover or otherwise hide physical features that responders use for reference; disaster operations are often location-specific.
- **Need**: Accurate information about the location of damages and needs.
- **Obstacle**: Damages make aerial and other imagery difficult to use because established reference points may be covered or destroyed.
- **Solution**: Software that can overlay map data and damage information over imagery.

Video: Augmented reality system to report river flood depth in Indonesia.
Image Source: Fujitsu, 2016.

3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Case Study: Augmented Reality Sandbox

- **Problem:** Hydrodynamics play a significant role in determining community risk, but the science behind the risk is difficult for many people to understand.
- **Need**: Increased public education about community flood risk.
- **Obstacle**: The topic is difficult to teach using standard teaching methods.
- **Solution**: Interactive AR-enabled system that allows learners to use multiple senses to learn about flood risk.



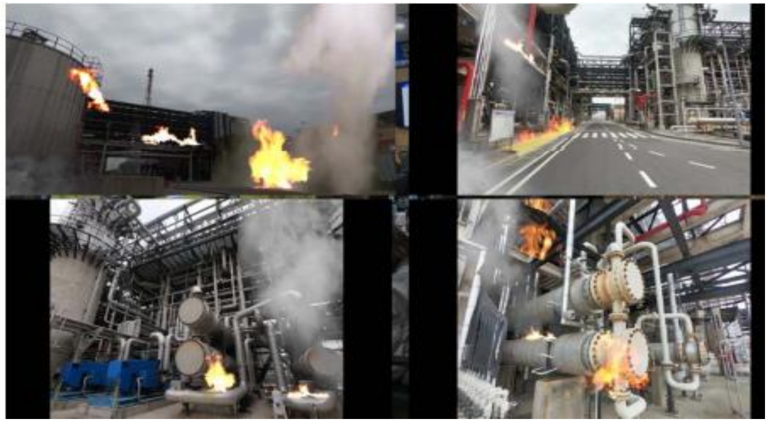
Video Source: University of California Davis, 2015.

3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Case Study: AR Emergency Disaster Response Training Simulator (AERTS)

AERTS System Description:

- **The AERTS system** developed by PI Prof. Jong-Moon Chung (Yonsei University) is an AI training system that uses AR, VR, big data etc.
- **The AERTS system generates** various disaster events on AR goggles and CCTV monitors for the purposes of disaster emergency training .
- **The AERTS system** has been used annually in the national Safe Korea training since 2018 .



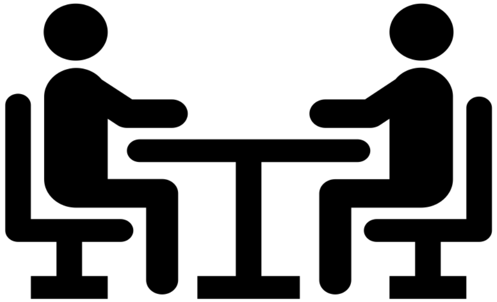
Images: Jong-Moon Chung, Yonsei University, Republic of Korea, 2020

3. Virtual Reality (VR) and Augmented Reality (AR)

▪ Case Study: Augmented Reality Emergency Simulator

Video Source: https://www.youtube.com/watch?v=ld7838I_D44

Group Work and Activities



Group Work and Activities

▪ Discussion 2: New Data for Disaster Risk Management Analysis

- **Disaster Risk Management analysis** is changing because the data used to inform it is expanding.
- For instance, **the analysis of social media communications** during disasters can help stakeholders to understand the nature of the disaster and the populations that are impacted. It can also help to understand what information and disinformation exists, what rumors are being spread, and what people might know that responders do not.
- Data on financial transactions during and after a disaster can help to inform DRM stakeholders of the types and extend of damages, or to understand where disasters are having a financial impact on populations.
- **Cellphone data** provides a treasure-trove of data for disaster-related analysis, including evacuation information, power outages, locations of those requiring rescue, and more.
- **The Facilitator** can lead a discussion with the participants to identify different types of data that are available to disaster risk managers that help to inform some aspect of pre- or post disaster risk management activities or needs.

Background Materials

Key Readings	• Global Facility for Disaster Risk and Reduction. 2018. Machine Learning for Disaster Risk Management. World Bank. Guidance Note. http://bit.ly/2oLonaW. • West, Darrell M. 2018. What is Artificial Intelligence? Brookings Institution. October 4. http://bit.ly/2AGL9Dm. • Yu, Manzhu, Chaowei Yang, and Yun Li. 2018. Big Data in Natural Disaster Management: A Review. Geosciences. George Mason University. http://bit.ly/2pBfUav. • Botha, Marc. 2019. The Limits of Artificial Intelligence. Medium. Towards Data Science. February 11. http://bit.ly/3aqfYwN. • Jain, S., & McLean, C. R. 2003. Modeling and simulation for emergency response: workshop report, standards and tools. US Department of Commerce, National Institute of Standards and Technology. https://www.govinfo.gov/content/pkg/GOVPUB-C13-bc62daf0582d06254b25f2535794242d/pdf/GOVPUB-C13-bc62daf0582d06254b25f2535794242d.pdf • United Nations. 2015. Asia Pacific Disaster Report. RIGHT INFORMATION, RIGHT PEOPLE, RIGHT TIME. https://www.unescap.org/sites/default/files/apdr2015-ch4.pdf


Thank you