AI for Natural Disaster Management

ITU Focus Group

FG-AI4NDM Report of the Working Group “AI for Effective Communications”

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AI for NDM Communications Report update summary

1. Last version review in AI4NDM focus group meeting in Athens in October 2022
2. Document size doubled with the inclusion of all available use case questionnaires
3. AI4NDM Communications is related to most use cases, especially the Multi-hazard topic group
4. Report added best practices summaries and insights from use cases
5. Added reference documents and updated bibliography for a more comprehensive state of the art overview
6. Added overall conclusion and identified emerging areas of research
7. Thank you for the guidance, support and many contributions from focus group and use case leaders

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- **Topic groups include** "AI for Multihazard Communications Technologies" or "AI for Wildfire Monitoring and Detection."

AI for NDM Focus Group Inputs and Outputs

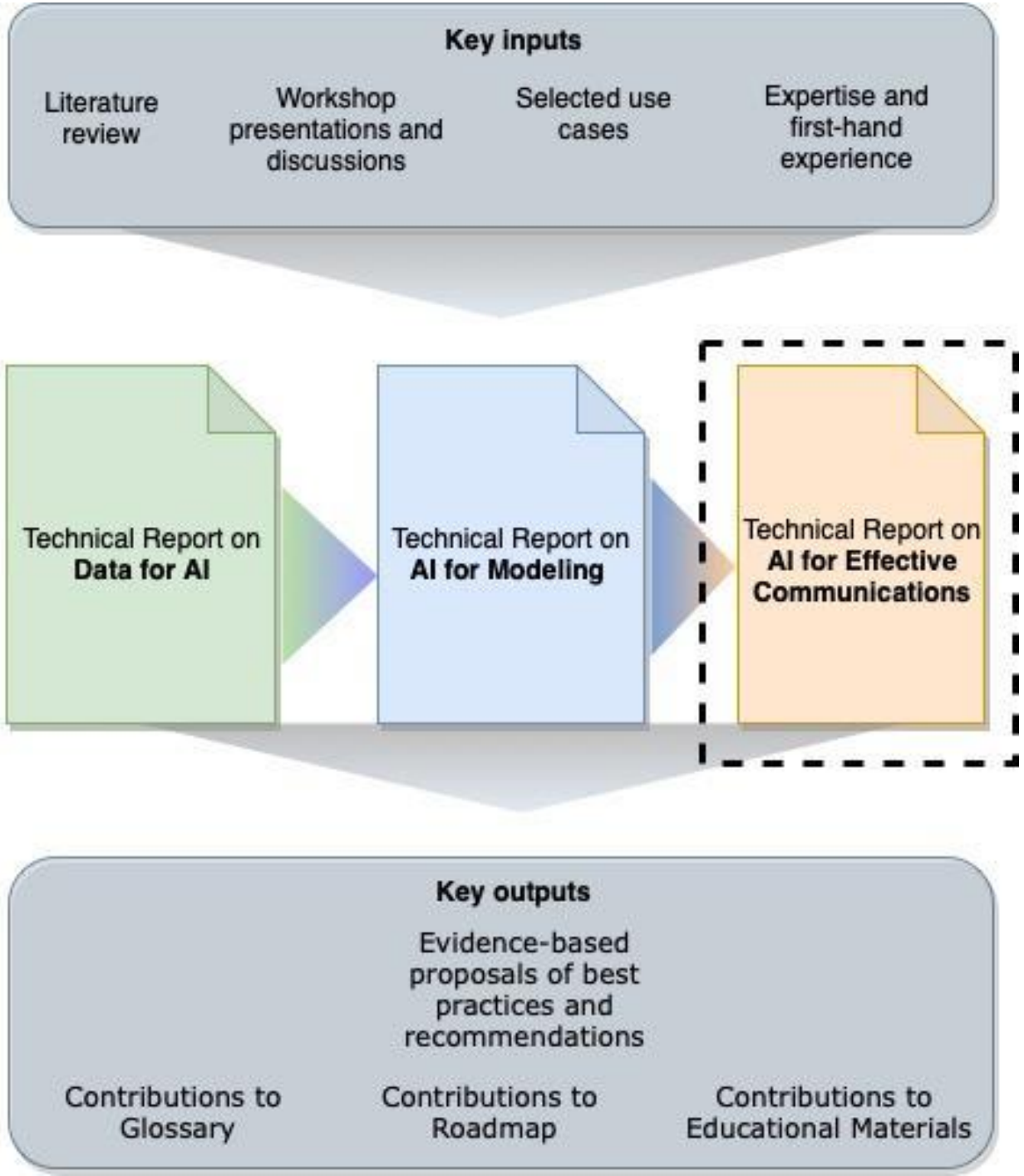


Figure 1a: Key inputs and outputs for the three technical reports.

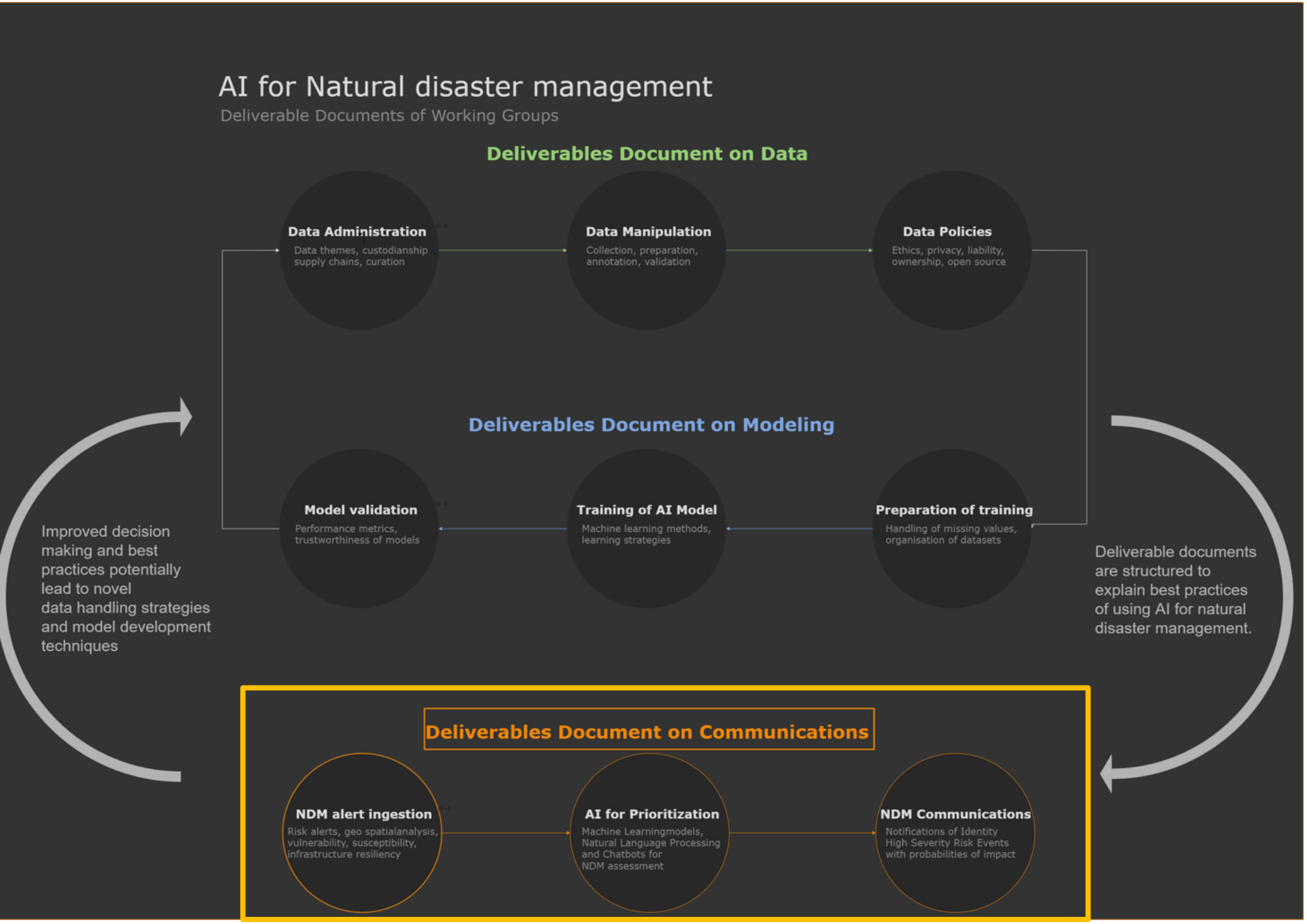


Figure 1b: Overview of topics in the three technical reports.

Primary Hazard types reported in literature review

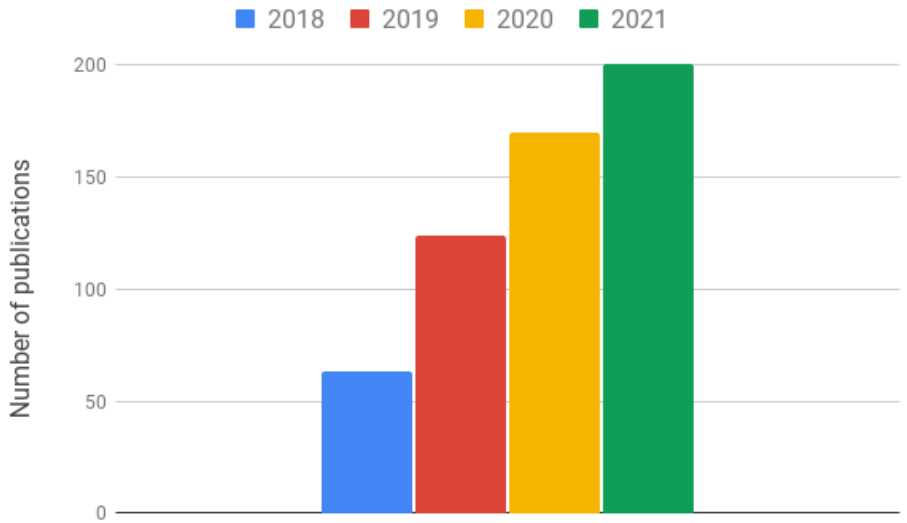


Figure 2: Number of articles published between 2018 and 2021.

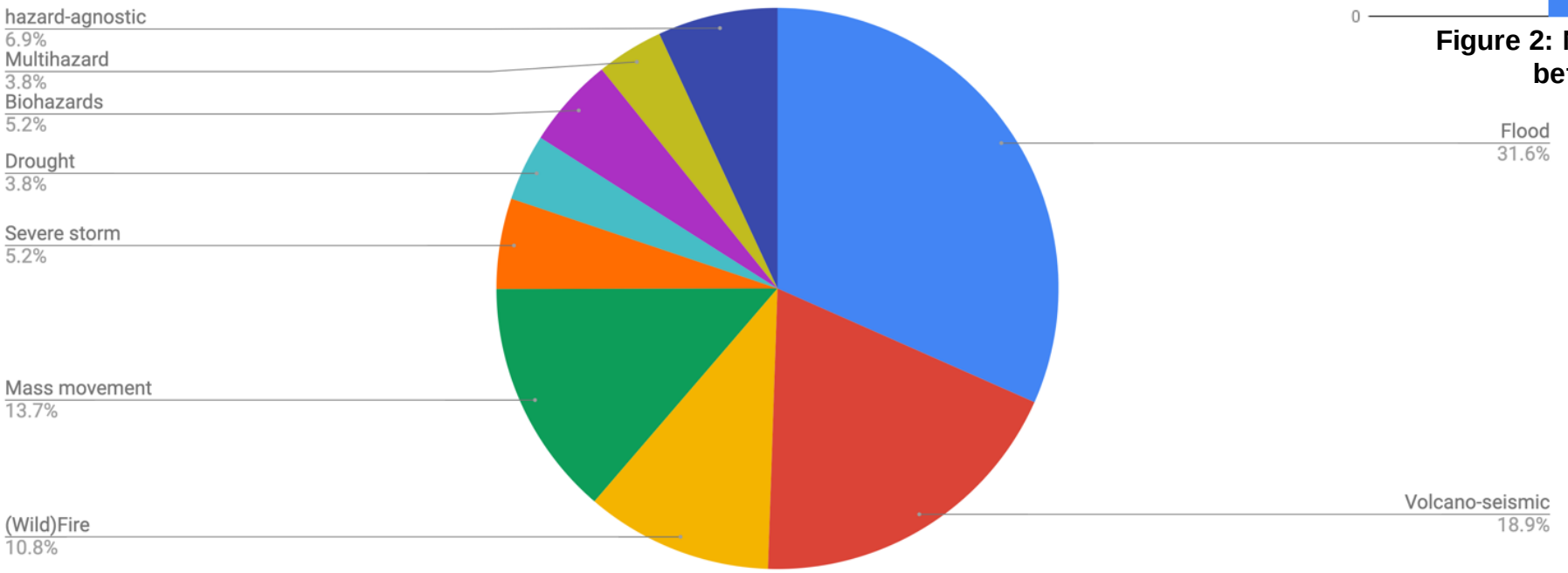


Figure 3: Hazard types targeted in application of AI for NDM with a focus on communication elements, derived from a preliminary literature survey covering articles published between 2018 and 2021.

Global Damage Relative Scale of NDM type from 2000 to 2017 was > $1T US$

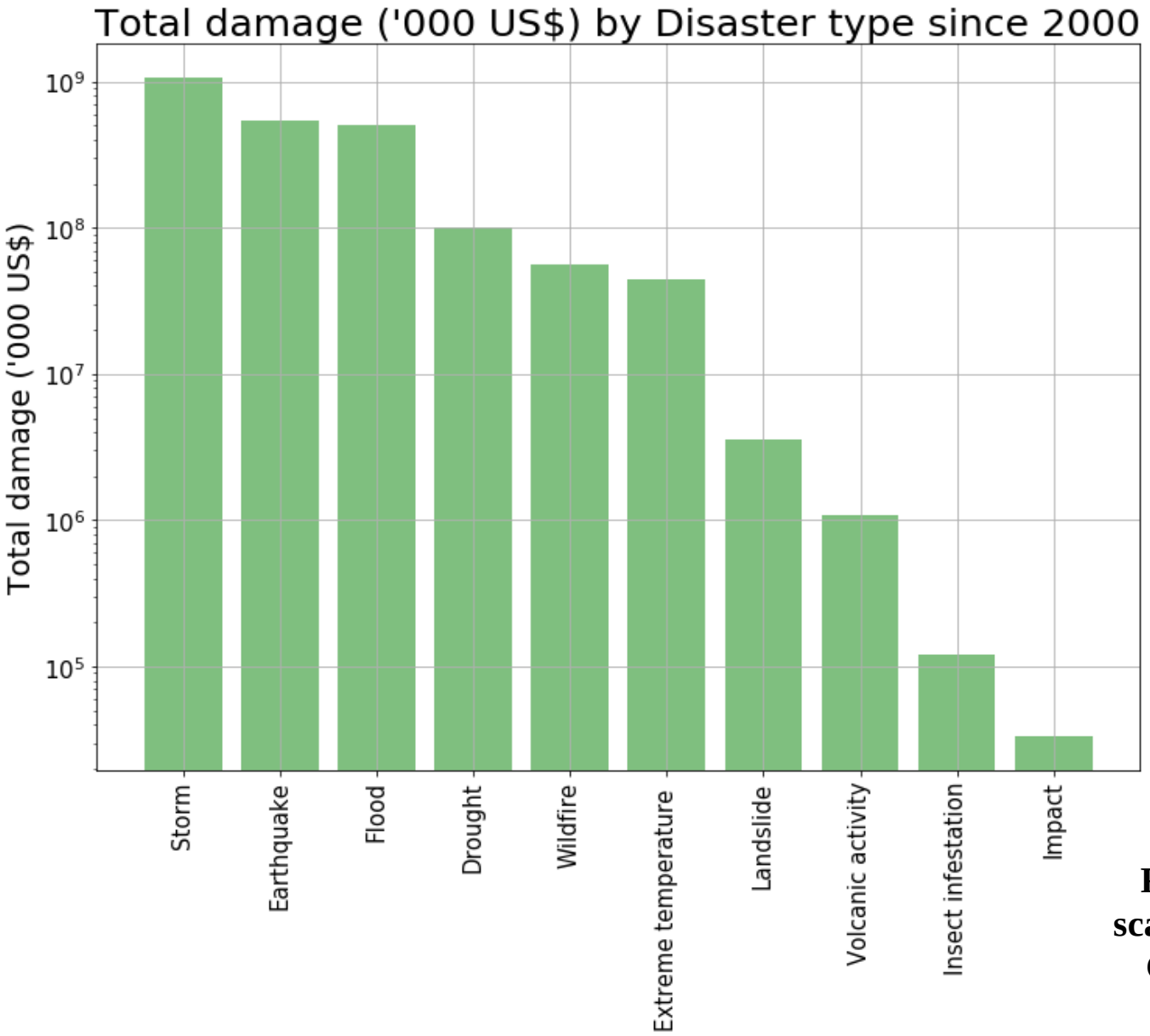


Figure 4: Total damage by disaster type on a log scale as per EM-DAT from 2000 to 2017 - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium.

Primary Communications Systems used in AI for NDM

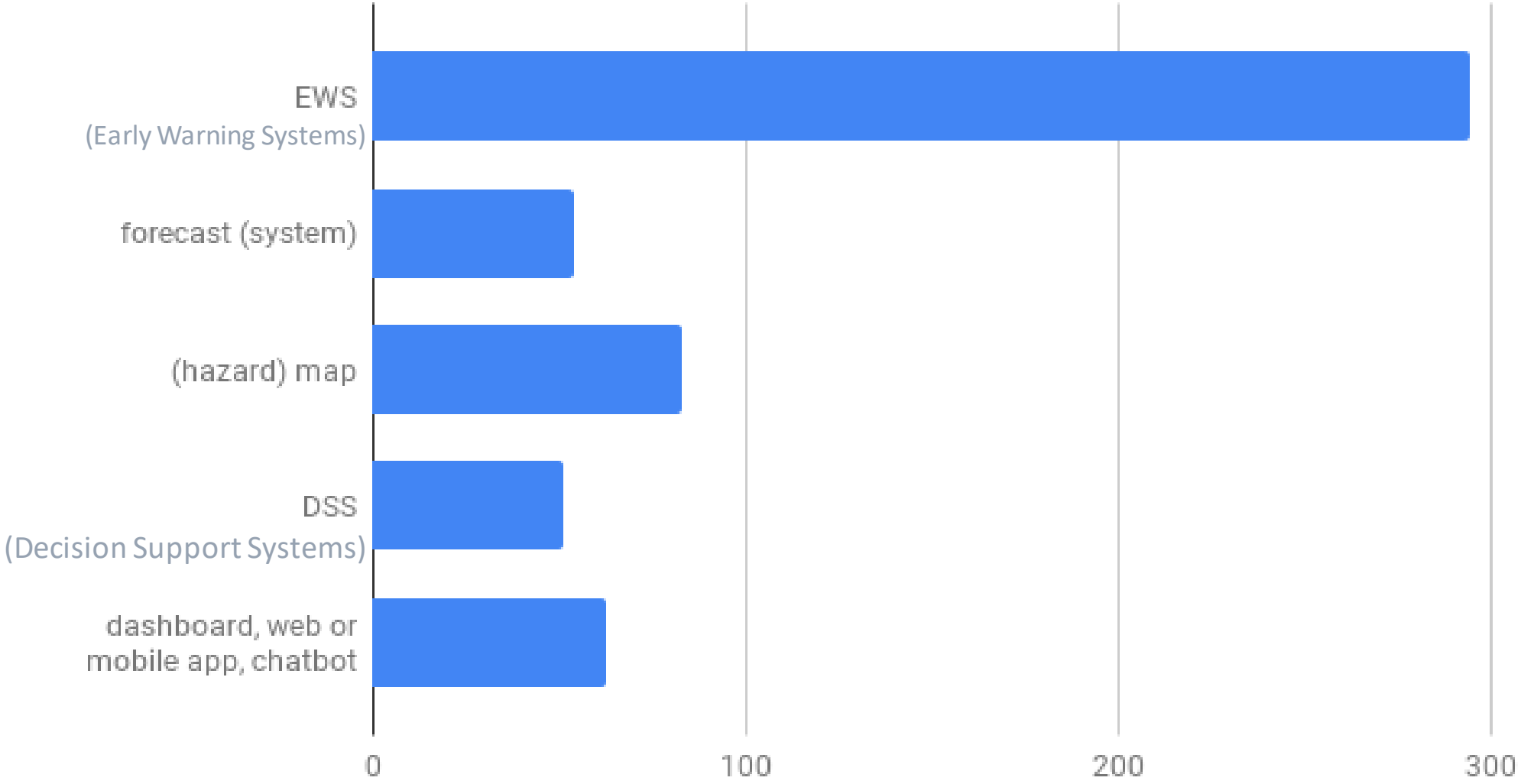
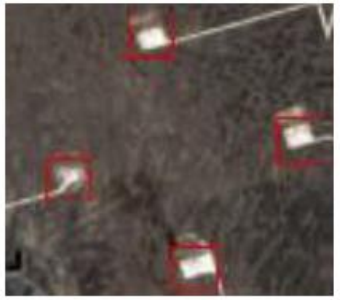


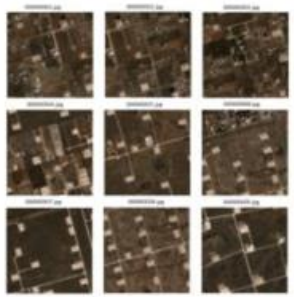
Figure 5: Communication systems or elements targeted in application of AI for NDM, derived from a preliminary literature survey covering articles published between 2018 and 2021.

Geospatial Information Systems (GIS) workflow used in AI for NDM

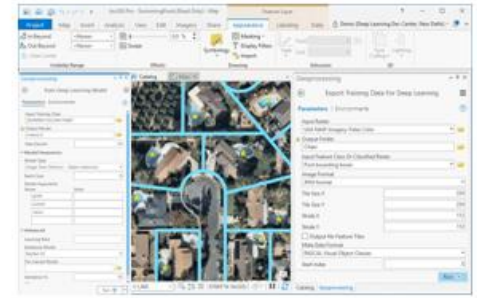
Spatio-temporal
Data Management



Labeling using
GIS tools

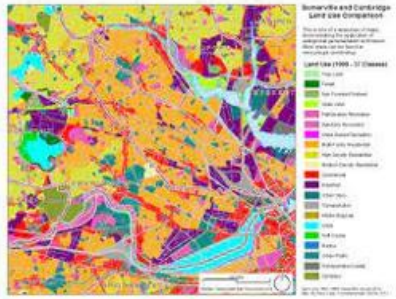


Training/Validation
Datasets Preparing

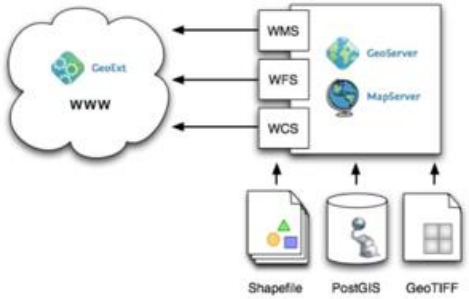


AI Model
Training/Validation

Geoinformation
Inferencing



Data Mapping
For End Users



Web Services
For End Users

Figure 6: GIS workflow using AI to visualize geoinformation.

Sample map visualization

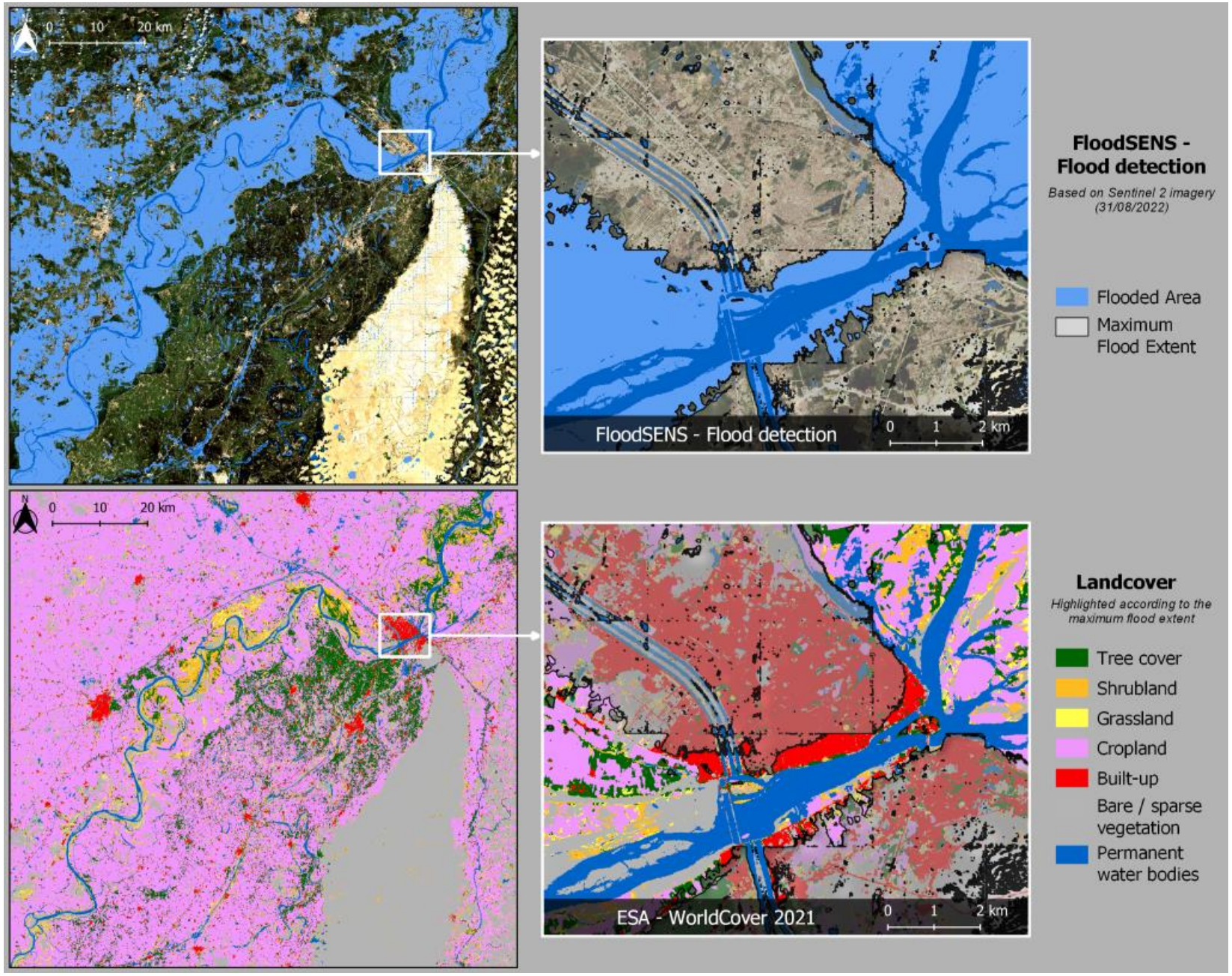


Figure 7: Map of the 2022 Pakistan Floods. Floods have been detected using the ML algorithm FloodSENS. The flood extent has been used to analyse land cover in the affected areas using the most recent ESA WorldCover classification.

Map example of AI for NDM Comms for Decision Support Systems

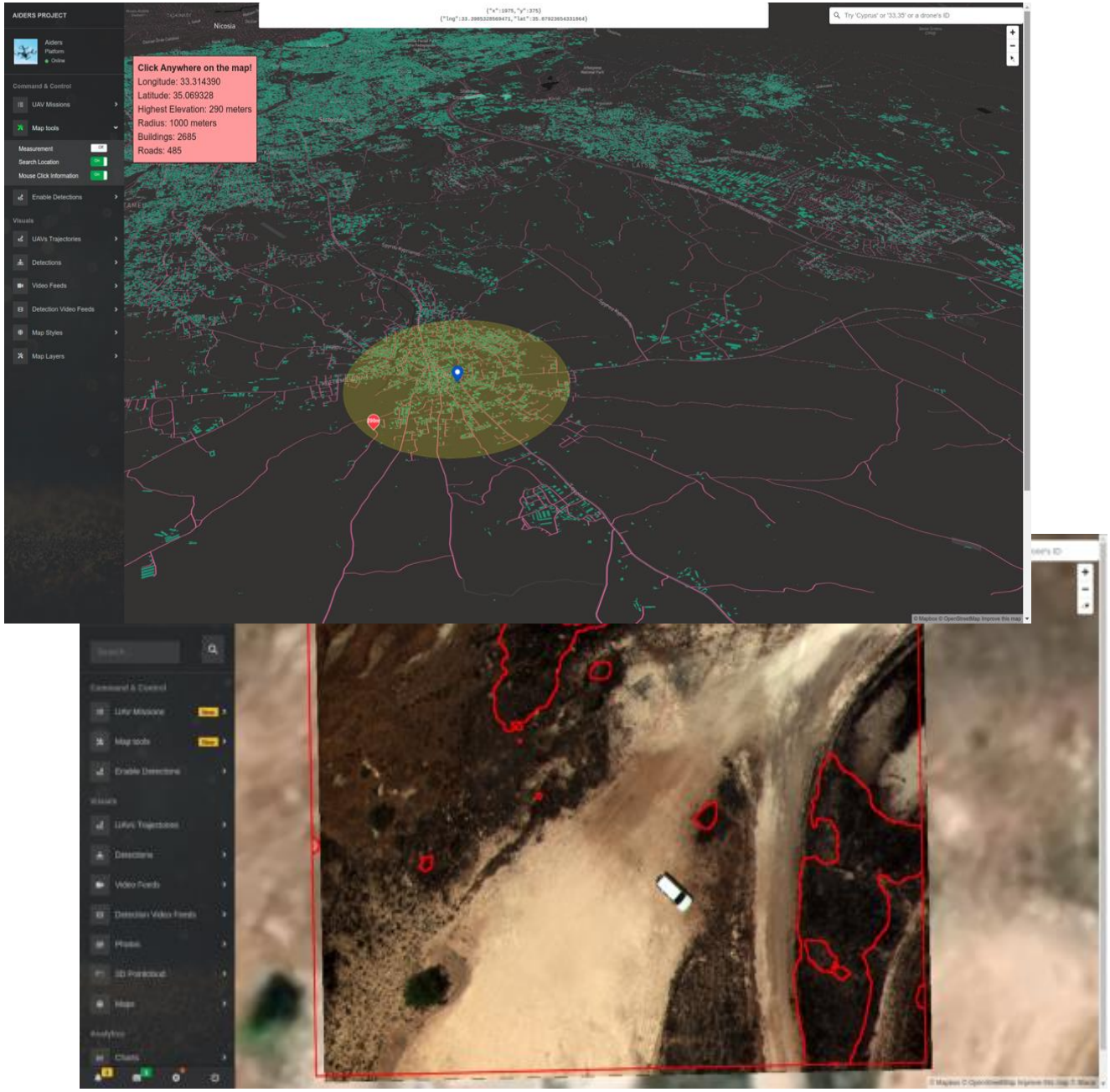


Figure 8: The AIDERS platform enables first responders to gain situational awareness during NDM. This example pertains to wildfire management.

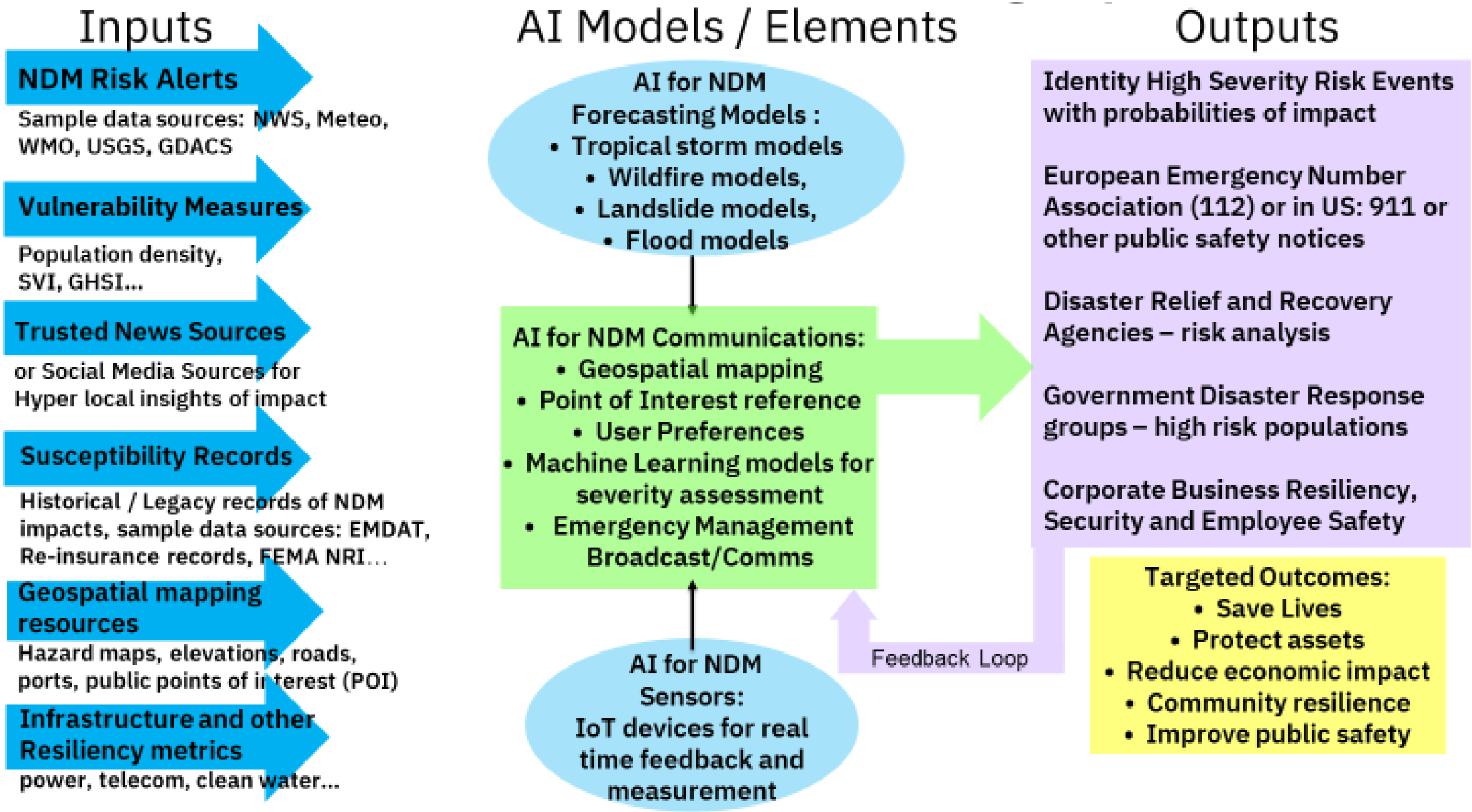


Figure 9: Suggested inputs, outputs, AI models and targeted outcomes when using AI in dashboards.

Sample Dashboards of AI for NDM communications

ORI Risk Level: 0.6

Region Risk Rating

Geolocation	(42.257,-74.238)
Location	New York Ulster County US.
Population Density	162.33 Person/Sq. Mile
Population	182.49 K
Social Vulnerability	Relatively Low (cdc.gov)
Annual Loss	Relatively Moderate (fema.gov)
Community Resilience	Very High (fema.gov)
Overall Risk*	Relatively Low (fema.gov)

Alert Hazard Level

category	orange
class	impacting
Alert Source	nws
Source Alert Level	watch

Alert Impact

IBM impacted locations: 40	Total impacted locations: 40
Alert Category was determined by ML. Contributing text:FLASH FLOOD WATCH	
*Overall Risk = Social Vulnerability + Annual Loss - Community Resilience	

Figure 10: ORI use case dashboard for risk alerting.

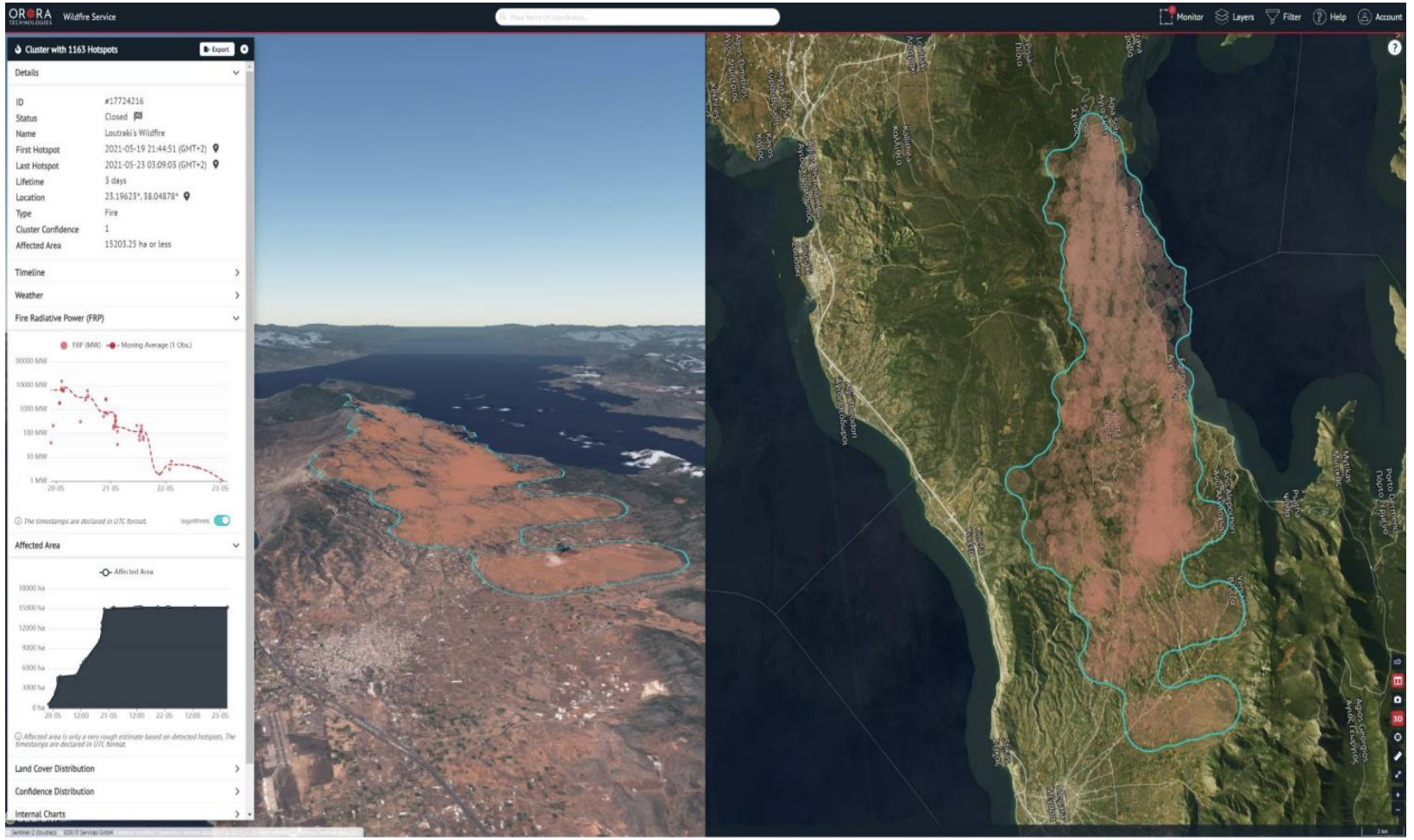


Figure 11: Loutraki's wildfire, Greece, May 2021 (source: OroraTech Wildfire Solution).

Global Health Security Index (GHSI) relative risk preparation level

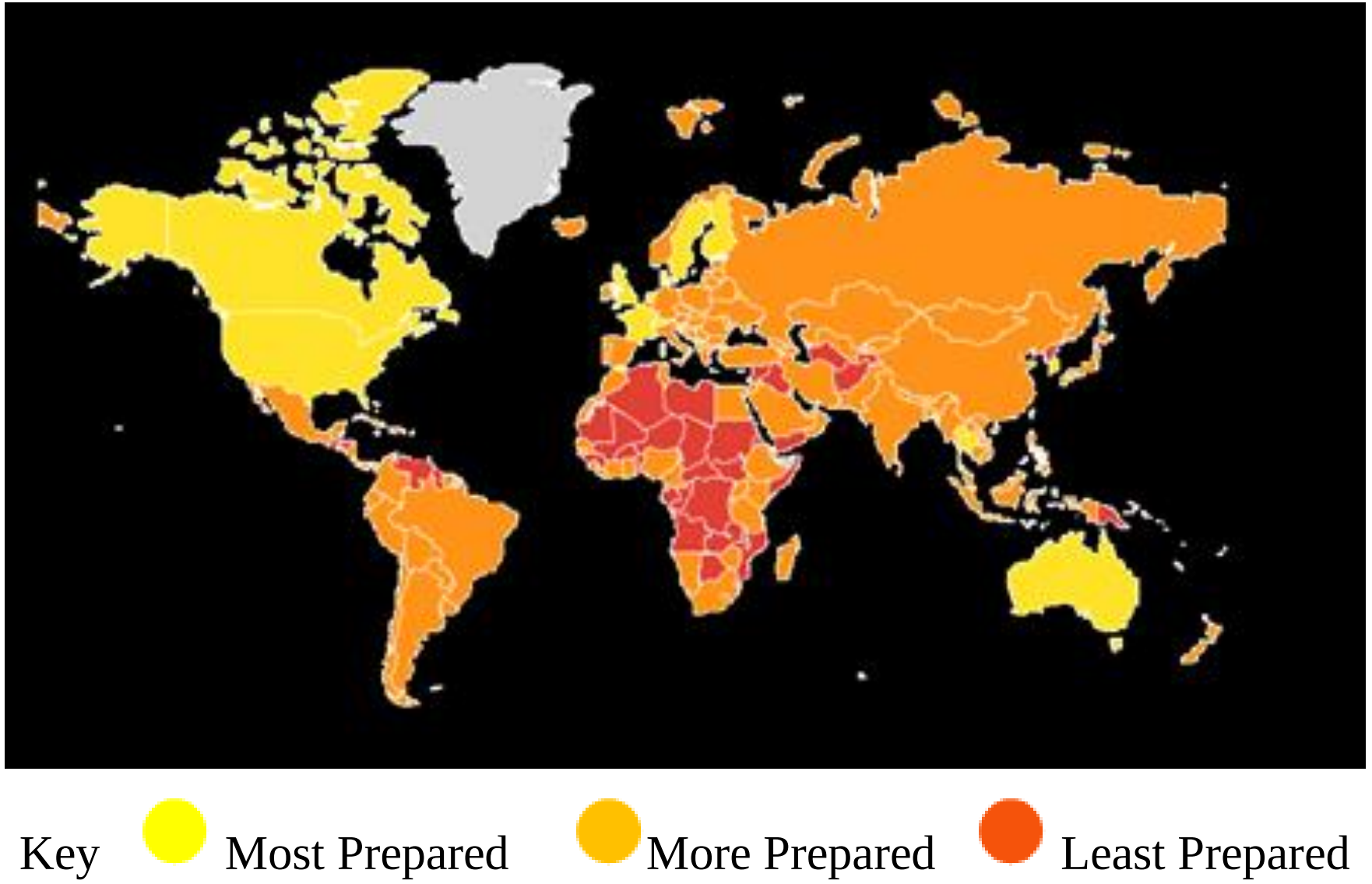


Figure 12: Vulnerability indicator of relative health security risk by country based on the Global Health Security Index (GHSI). Graphic provided by IBM.

Global Climate Risk Index (GCRI) relative risk preparation level

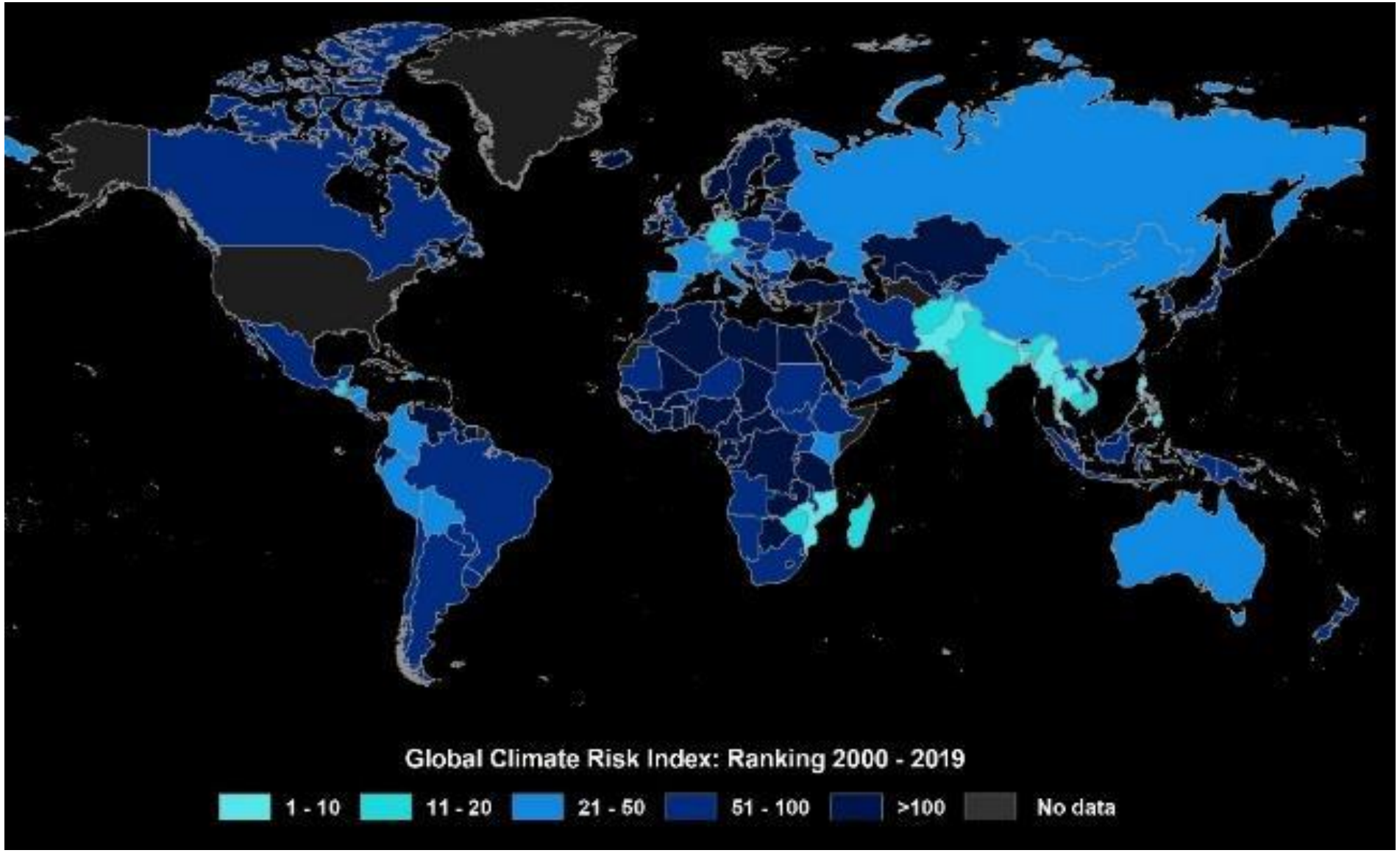


Figure 13: Susceptibility indicator of relative climate risk by country based on the Global Climate Risk Index (GCRI). Graphic provided by IBM.

AI for NDM Communications Best Practices Identified (1 of 3)

Best practices: For those using AI in alerts and EWS, it is suggested to:
Consider how AI will be integrated into the alert and EWS. When replacing traditional methods, new complexities and uncertainties may arise that need to be interpreted and communicated.

Best practices: For those using AI in forecasts, it is suggested to:
Use, establish, and enrich benchmark datasets. Constructing benchmarking datasets and complementing existing ones used for determining the generalisation capacity and robustness of AI pipelines for forecasting is the real touchstone of the disaster management collaborative efforts.

Best practices: For those using AI in forecasts, it is also suggested to:
Embody transfer learning and cross-domain capacities. It is very helpful to implement and include methodologies that enable transfer learning and fusion techniques in the spatial and temporal representations for disaster forecasting. In this way, AI-based solutions can be further tested and implemented in different parts of the world, while being subject and bench-tested to real-world diversity.

Best practices: For those using AI in hazard maps, it is suggested to:
Ensure a large enough database is available. Having a sufficiently large database is required to ensure adequate splitting between training and validation data.

Best practices: For those using AI in hazard maps, it is suggested to:
Ensure the final hazard map presented, using a GIS, adequately and accurately depicts the ML result, especially when showing uncertainties in mapping.

Best practices: For those using AI in decision support systems, it is also suggested to:
Enable seamless information sharing for understanding disaster dynamics with multi-stakeholder coordination. Real-time information sharing across entities from multiple sources form the constitutive part of intelligent decision making, requiring multi-agency coordination and cooperation.

Best practices: For those using AI in an alerting system, it is also suggested to:
Follow a standardized warning dissemination protocol. Standards such as the Common Alerting Protocol (CAP) provide a simple XML structure to convey key data and information about any kind of emergency.

Best practices: For those using AI in forecasts, it is also suggested to:
Promote transparency of forecasting information systems. As one of the most critical parts in forecasting is the reliable sharing and confirmation of information and forecast products, it is of very high importance that transparency and reproducibility is part of the overall solutions. In this way, AI biases, data gaps, and the very high potential for scientific and algorithmic improvement will not be hindered, but promoted between stakeholders, thus delivering more robust and evolving products.

Best practices: For those using AI in forecasts, it is also suggested to:
Incorporate climate change factors. Climate change has a significant impact on many natural disasters.

Best practices: For those using AI in hazard maps, it is suggested to:
Use accurate labelling representing a large variety of cases. Such a large variety of cases is crucial for achieving a well-trained supervised model.

Best practices: For those using AI in decision support systems, it is suggested to:
Identify communication channels and cater outgoing information (e.g., warning messages) to the targeted population. Depending on the targeted population, different types of communication channels can be appropriate. Furthermore, the outgoing information may or may not be accessible (due to, for example, local dialects).

Best practices: For those using AI in decision support systems, it is also suggested to:
Identify sources of information relevant to the target user when using AI to provide situational awareness. Depending on the target user, the type of situational awareness (and relevant information) can vary.

AI for NDM Communications Best Practices Identified (2 of 3)

Best practices: For those using AI in dashboards and apps, it is suggested to:
Consider the intended users and information that they could need. Depending on the user of a dashboard or app (whether it uses AI or not), the input data can vary.

Best practices: For those using AI in chatbots, it is also suggested to:
Consider adoption challenges. To facilitate adoption, consider chatbot implementation into already widely used (municipal) applications vs. development of a stand-alone system or app.

Best practices: For those using AI in communication systems for NDM, it is suggested to:
Consider the value added by AI. The value added by AI should outperform risks introduced by AI (if any).

Best practices: For those using AI in communication systems for NDM, it is also suggested to:
Proceed with caution. As AI-powered tools are not yet widely used in NDM, , lessons learned around unintended consequences are not readily available.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:
Share relevant information and to facilitate evaluation. Users, decision-makers, and the public should have access to the information necessary to evaluate the outcomes of a machine learning system and to understand the limits (when, where, and in which context) of system application.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Establish warning systems, oversight, and failsafes. There are many reasons that a communication system for NDM can fail, whether AI is implemented or not. Through failsafes, it is possible to protect against the most consequential threats that are (or are not) anticipated.

Best practices: For those using AI in chatbots, it is suggested to:
Evaluate the effectiveness of the device. Evaluating the effectiveness of a chatbot is recommended even if the device does not leverage AI. Through acquiring feedback from those using the chatbot, issues can be detected and managed early.

Best practices: For those using AI in chatbots, it is also suggested to:
Identify the target population. Check if high-quality NLP datasets and pre-trained algorithms for less commonly spoken languages exist or can be established.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:
Consider the challenges surrounding AI. An AI-powered system (as well as traditional technologies) relies on functioning infrastructure. Any failures can impact the integrity of the system.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:
Aim for transparency. In setting up a new system or tool, open-source and open-data approaches should be preferred where possible, alongside community capacity support in co-creation of machine learning projects.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Draw on effective principles from other domains such as ethics. Concerns around ethics and bias and examples of unintended consequences of AI applications in other domains can point to issues relevant for AI in NDM.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Identify and liaise with target audiences and stakeholders to cultivate a human-centric design. By clearly identifying the target user, it is possible to integrate them in the development of the AI-based communications tools and to ensure that the final product meets their needs.

AI for NDM Communications Best Practices Identified (3 of 3)

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Protect against unintended consequences of data-derived insights and biases. As the volume of data used in AI tools increases, so does the ability to draw insights into user behavior. This newfound level of awareness can be beneficial insofar as establishing more accurate patterns and predictions that can enhance disaster management. However, unintended consequences can occur due to underrepresentation of particular groups in datasets as well as targeted outcomes determined by AI models.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Develop the capacity of local communities. A community-based approach to NDM can enable local communities to take ownership of the proposed AI-based communications solutions.

Best practices: For those using AI in communication systems for NDM, it is suggested to:

Cultivate diverse, interdisciplinary, and local teams. AI-based algorithms are often developed by geoscience or ML experts in an academic setting, where development is not always tied to the inclusion of end user needs. Also, data scientists and machine learning practitioners may not have the necessary background or expertise to fully evaluate potential risks, while DRR practitioners are not necessarily experts on AI/ML.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Intentionally include intersectional considerations. Differences in cultures and societies around demographic information can greatly alter how tools are accessed and understood.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Consider social science aspects of communication. Effectively communicating with users during times of safety differs from times of risk [b-Gevaert]. Tools that do not communicate with the population at large will still have to consider cultural differences in how risk and crisis are managed around the world. Additionally, how that information is then interpreted and shared with the public in a manner that is perceived as trustworthy is also a consideration to be made and may even require a reworking of the current gold standard rather than its removal. The complexity of the tools, which may also be in a language different than the one practiced by the local communities, could undermine community engagement.

Best practices: For those using AI in communication systems for NDM, it is also suggested to:

Engage with young populations. The widespread adoption of social media platforms for communication among youth presents both challenges and opportunities for effective disaster communication to be considered.