Modelling Exposure Through Earth Observation Routines (METEOR)

a case study

https://meteor-project.org

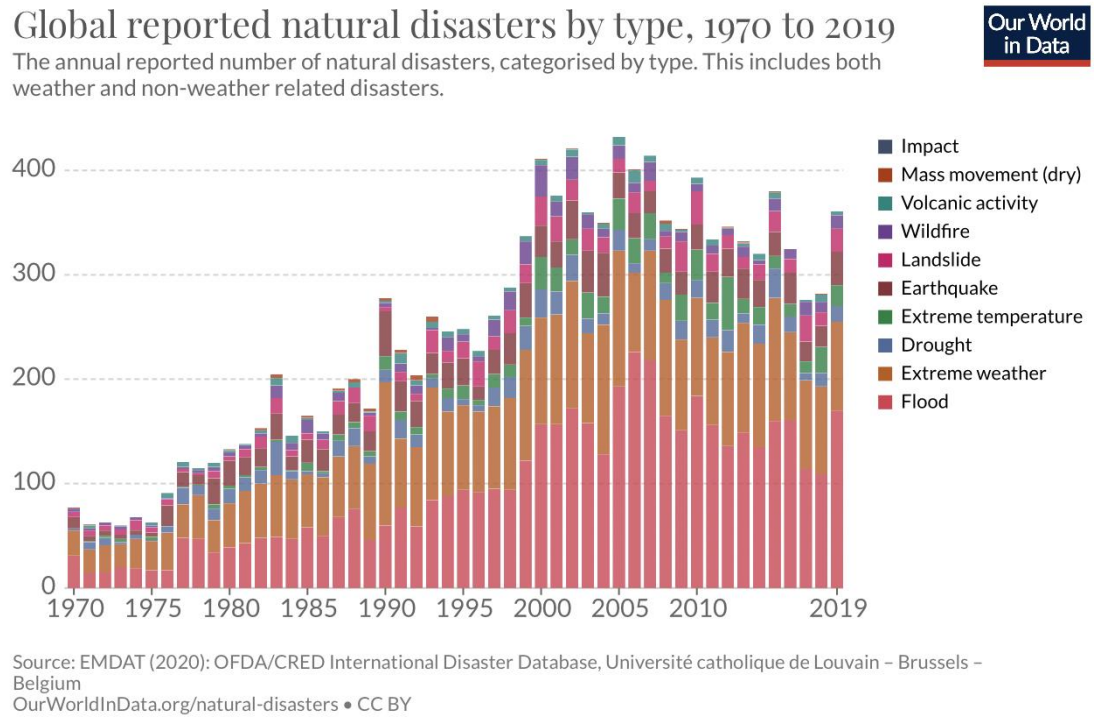
Acronyms

BGS	British Geological Survey
BIPAD	Building Information Platform Against Disaster, Nepal
DAC	Development Assistance Committee
DMD	Disaster Management Department, Prime Minister's Office of Tanzania
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EO	Earth Observation
GCRF	Global Challenges Research Fund
GEM	Global Earthquake Model Foundation
HDX	Humanitarian Data Exchange
HOT	Humanitarian OpenStreetMap Team
IDF	Insurance Development Forum
IPP	International Partnership Programme
KII	Key Informant Interview
KPI	Key Performance Indicator
METEOR	Modelling Exposure Through Earth Observation Routines
NDRRMA	National Disaster Risk Reduction and Management Authority, Nepal
NGO	Non-Governmental Organisation
NSET	National Society for Earthquake Technology, Nepal
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OPM	Oxford Policy Management
SDG	Sustainable Development Goal
SFDRR	Sendai Framework for Disaster Risk Reduction
UKSA	UK Space Agency
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
WB	World Bank

1. Project overview

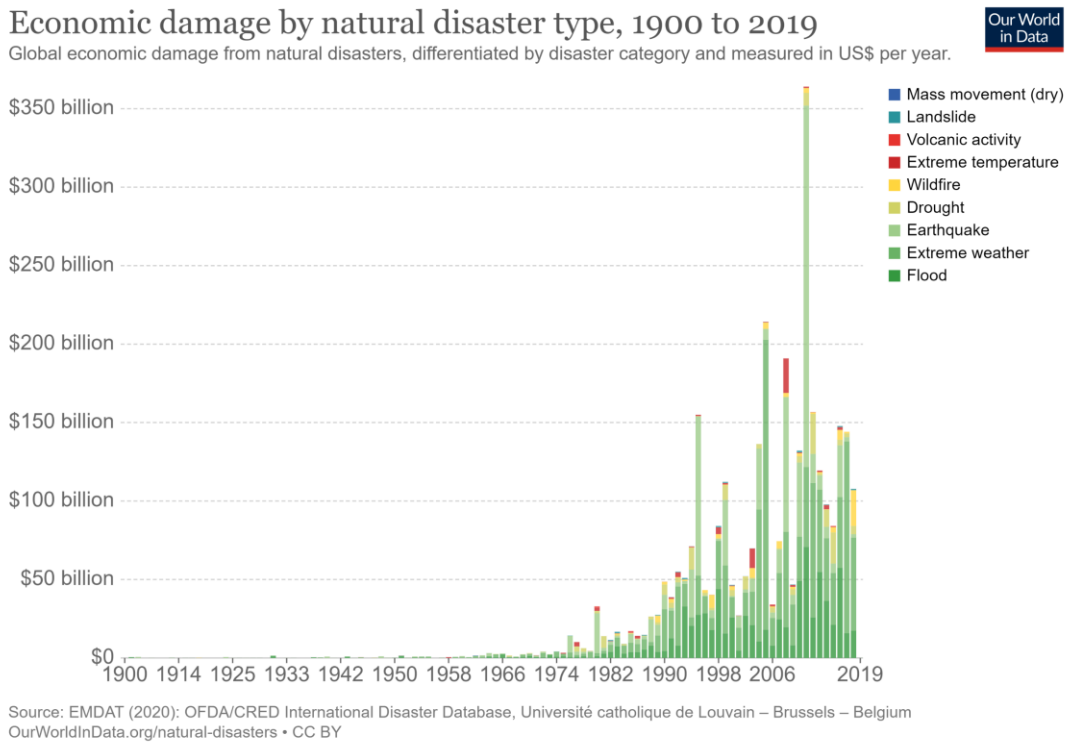
a) Project context

When a disaster (such as a flood, landslide, earthquake or volcanic eruption) occurs, triggering a loss of life and damage to infrastructure, it highlights the reality that our people and our assets are susceptible to such events, and that the impact varies according to the local environment. Disasters affect people who are vulnerable and people who live in poverty disproportionately. For example, in the ten years to 2018, 91% of storm-related fatalities were in low- and middle-income countries, even though these countries experienced just 32% of storms[1]. The graph below illustrates some of the history of disasters.



Since 1980, more than two million people have lost their lives due to disasters caused by natural hazards, and the financial cost of the total damages has increased more than sixfold, from $23 billion a year in the 1980s to $150 billion a year in the last decade[2]. The graph below shows this split by disaster type.

[1] https://www.worldbank.org/en/topic/disasterriskmanagement/overview
[2] https://www.emdat.be



World Bank (WB) data[3] show that almost 75% of the losses are attributable to extreme weather events, and climate change threatens to push an additional 100 million people into extreme poverty by 2030. These disasters have had large and long-lasting impacts on poverty. Such disasters can highlight the following in a community[4]:

- The geographical area where the community is settled is exposed to such a hazard;
- The society (including individuals) and its infrastructure, assets and other processes - as well as services which may have experienced damage or destruction - are vulnerable.

Population growth and rapid urbanisation are two of the factors driving the increase in disaster risks. The United Nations[5] estimates that more than two-thirds of the world's population will live in cities by 2050.

Mainstreaming Disaster Risk Management (DRM) into the planning systems of governments and large organisations can reverse this trend of rising cost from disasters in terms of death, damage and destruction. If countries act decisively, they can save both the lives of their citizens and their

[3] See WB reports including: *Shock Waves*, *Unbreakable*, *Investing in Urban Resilience*
[4] http://www.un-spider.org/risks-and-disasters/disaster-risk-management
[5] https://population.un.org/wup/Publications/Files/WUP2014-Report.pdf

assets such as hospitals, roads, reservoirs and public infrastructure. However, many developing countries lack the tools, expertise, and instruments to factor the potential risk of disasters into their investment decisions.

Definitions and Terminology[6]

Hazard is defined as "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation". Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterised by its "location, intensity or magnitude, frequency, and probability".

Exposure is defined as "the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas".

Vulnerability is defined as "the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards". Vulnerability is multi-dimensional in its nature. Some authors also include cultural and institutional factors. Examples include, but are not limited to, poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, high levels of poverty and education, limited official recognition of risks and preparedness measures, disregard for wise environmental management or weak institutions, and governance (including corruption etc.).

A major challenge when making DRM decisions is the lack of data on hazards leading to poor understanding of the distribution and character of exposure, particularly in low-income countries. Exposure needs to be mapped, monitored and modelled by Governments, Non-Governmental Organisations (NGOs), affected communities and businesses, so that they can minimise losses, and bolster resilience and recovery. Robust, quantitative methods are required to inform and underpin resilience decisions and risk mitigation. However, countries with the largest concentrations of citizens at risk are also often those countries where there is a lack of data and systems to use those data. This makes it difficult to make well-informed, good quality decisions on how to invest limited resources to protect the population and the infrastructure.

A further challenge relates to insurance against the risks of disasters. There is a significant gap between the level of insurance in place to cover global risks, and the actual cost to businesses and governments of rebuilding and recovering from major catastrophes. The leading insurance and reinsurance marketplace, Lloyd's of London, facilitates collective intelligence and risk-sharing expertise of the market's underwriters and brokers, working to anticipate and understand risk, and to develop relevant and new forms of insurance for customers globally. A recent report, which analysed all the latest non-life underinsurance and insurance penetration data for catastrophes for 43 countries across the globe, concluded that there is global underinsurance of $162.5bn as of 2018[7].

More and better data are needed to enable the insurance industry to develop and market appropriate insurances to enable business and government resilience and recovery. With this in place, further financial tools can be designed to free up finance for rebuilding and recovery.

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[6] ibid

[7] https://www.lloyds.com/news-and-risk-insight/risk-reports/library/understanding-risk/a-world-at-risk

b) The role of Earth Observation

Earth Observation (EO) is an ideal data source to improve this situation. EO is the collection, analysis and presentation of data in order to better understand the planet Earth[8]. Earth Observation data is fundamental to tackling many of today's issues relating to climate change and understanding the Earth's natural resources better. Data acquired from satellites can be used to monitor things like coastal erosion, atmospheric chemistry and land usage.

Some projects have aimed to map exposure with EO data using a range of approaches. However, the application of these in DRM has been greatly limited by the fact that many have been poorly calibrated, for instance by being based solely upon readily available data, or were designed only for a particular setting.

c) Our response

The METEOR project wanted to take a step-change in the application of EO exposure data by developing and delivering rigorous and open routines (protocols) and standards to allow quantitative assessment of exposure, with explicit uncertainties. In other words, to produce high quality data and models that can be used to improve decision-making in DRM. In particular we wanted to focus on countries with fewer resources available to meet the ever-rising risks and consequences of disasters. We chose to focus on countries receiving Official Development Assistance (ODA)[9], with deeper effort in Nepal and Tanzania, working closely with partners in those countries.

EO-based exposure data were produced for all 47 ODA countries, while the protocols and standards for developing locally calibrated exposure data were tested and validated in Nepal and Tanzania to ensure they are fit-for-purpose. The process of building capacity and co-delivering new, consistent, high quality data will promote welfare and economic development in these countries, and demonstrate the applicability of the techniques elsewhere.

d) Links with international frameworks

There are various global initiatives which are relevant to Disaster Risk Reduction (DRR). In particular, the United Nations has an important role to play. Founded in 1945, it is currently made up of 193 Member States. Its work is guided by its founding Charter and includes: maintaining international peace and security; developing friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples; and to achieve international co-operation in solving international economic and social problems, and in promoting and encouraging respect for human rights. As part of their work, the UN has grouped efforts around achieving specific goals. These are

[8] https://www.gov.uk/government/collections/earth-observation-eo

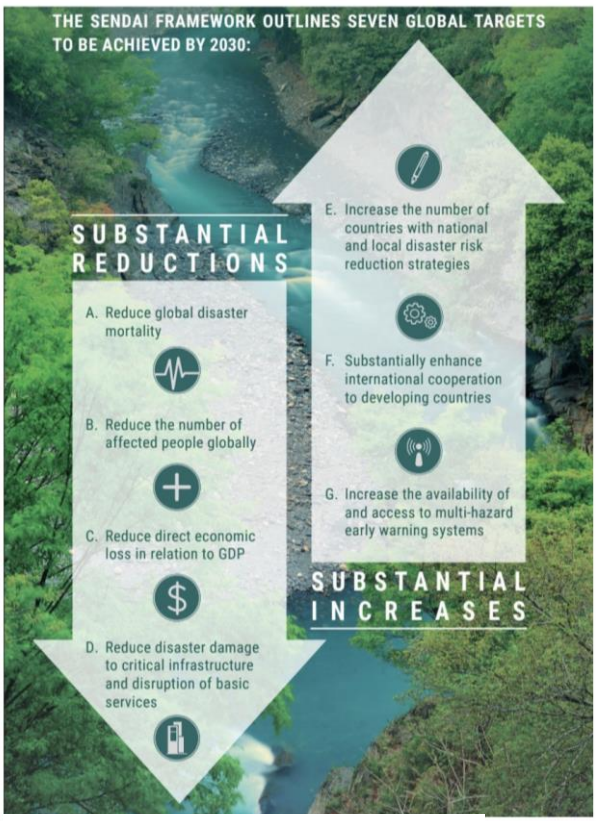
[9] ODA is a term coined by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD) to measure aid. The DAC first used the term in 1969. It is widely used as an indicator of international aid flow.

currently termed the Sustainable Development Goals (SDGs)[10]. The METEOR project is fully aligned with the UN SDGs, in particular, four of the seventeen goals, as shown on the previous page.

Furthermore, since the beginning of the 1990s, the United Nations has been promoting DRR efforts worldwide as a way to reduce the effects of natural hazards on vulnerable communities. To be effective in this, in 2015 the United Nations Office for Disaster Risk Reduction (UNDRR) facilitated the adoption of the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030[11]. This agreement provides Member States with concrete actions to protect development gains from the risk of disasters. The UNDRR is tasked with the support to the implementation, follow-up and review of the Sendai Framework.

The framework focuses on four priority areas:

1. **Understanding disaster risk**. Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.
2. **Strengthening disaster risk governance** to manage disaster risk. Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.
3. **Investing in disaster risk reduction for resilience**. Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.
4. **Enhancing disaster preparedness for effective response and in recovery, rehabilitation and reconstruction**. The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures.



Source: UNDRR's website

[10] https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[11] https://www.undrr.org/implementing-sendai-framework/what-sf

The METEOR project is also closely aligned with the Sendai Framework, contributing to its outcomes and priorities by:

- Increasing knowledge of exposure, multi-hazards and their impacts
- Co-producing baseline data to help stakeholders make informed decisions
- Enacting steps to help inform practice and policy
- Improving lives and livelihoods.

2. Project partners

The diagram on the following page shows the project partners and gives their organisational profiles.

The work is split into work packages coordinated by the British Geological Survey (BGS) which ensured communication, regular reporting and feedback on progress. BGS also led on multiple-hazard impacts on exposure and how they may be addressed in DRM by a range of stakeholders. Fathom generated flood hazard model input data to the multiple-hazard work. Oxford Policy Management (OPM) ensured that progress was monitored and that there was evidence to link activities and the desired outcome. ImageCat led on the EO-based data for exposure development, methods and protocols of classifying building patterns for stratified sampling of building characteristics, as well as sustainability and capacity-building, with the launch of the databases for Nepal and Tanzania while working with in-country experts. The Humanitarian OpenStreetMap Team (HOT) collected exposure data in Kathmandu and Dar es Salaam to help validate and calibrate the data derived from the classification of building patterns from EO-based imagery. The Global Earthquake Model (GEM) Foundation investigated how assumptions, limitations, scale and accuracy of exposure data, as well as decisions in data development process lead to modelled uncertainty. They also disseminated METEOR's products and results to the wider sectors through dedicated web-portals and use of relevant open databases. Key to the co-development of the datasets were our in-country partner organisations of National Society for Earthquake Technology (NSET) in Nepal and the Disaster Management Department (DMD) of the Prime Minister's Office of Tanzania.

The British Geological Survey has extensive experience in mapping and modelling multiple natural hazards and associated risks. It works globally, and has extensive experience in developing international agreements. It leads the Science and Technology Group for the UN Sendai Framework, and provides the Secretariat to the Global Volcano Model. The EO Team frequently responds to geohazard events including as project managers of the UN International Charter Space and Major Disasters.

ImageCat helps government agencies, research organisations, multi-lateral donors, and humanitarian organisations prepare for and respond to disasters including earthquakes, hurricanes, floods, and technological perils. It has helped UNICEF, governments, GFDRR, NGOs, and insurance clients, including UNITAR, Lloyd's of London, and USAID meet their exposure development and risk modelling needs. ImageCat is headquartered in the U.S. and has been trading in the UK since 2006.

The Global Earthquake Model Foundation is an NGO which calculates and communicates earthquake risk worldwide. It has developed exposure data and assessed human and economic losses, and its global risk modelling, now supports risk assessment for perils beyond earthquakes. GEM supports global capacity building in data collection and risk assessment and encourages sharing between public, private, and academic institutions.

National Society for Earthquake Technology is Nepal's foremost institution working on earthquake risk management, supporting science, engineering and technology to mitigate risk. It focuses on information dissemination, knowledge transfer, advocacy, networking, capacity building and institutionalisation.

The Disaster Management Department, part of the Prime Minister's Office of Tanzania, acts as the central planning, coordinating and monitoring institution for prevention, mitigation, preparedness, response and post-disaster recovery for all disaster risks. It formulates DRM policies and plans, and it is responsible for promoting education, knowledge and IT in disaster management for public awareness.

The Humanitarian OpenStreetMap Team has expertise in developing the OpenStreetMap data and community-led projects and has proven technical skills with open data platforms (Tasking Manager, Export Tool and OpenAerialMap). HOT works globally to build local mapping capacity; OSM is a great source of geospatial exposure baseline data for many cities, especially in poorly mapped emerging economies. HOT, has worked in many ODA countries and has a strong presence in Nepal and Tanzania.

Oxford Policy Management Limited helps policy makers design and implement sustainable reforms for reducing social and economic disadvantage in low-income countries. OPM's Monitoring and Evaluation team, includes experts in climate change and DRM. OPM has undertaken over 170 M&E projects in more than 50 countries, and has country offices in Nepal and Tanzania.

Fathom Provides innovative flood modelling and analytics, based on extensive flood risk research. Fathom flood products and expertise are targeted to meet client needs across the insurance, engineering, resource development and international aid sectors. Fathom-Global products have a 3-arc second resolution; their data cover fluvial (riverine) and pluvial (flash-flood) perils are provided both with and without flood defences.

3. Solution development/journey

METEOR is grant-funded by the UK Space Agency's International Partnership Programme (IPP), a >£150 million programme which is committed to using the UK's space sector research and innovation strengths to deliver sustainable economic, societal, and environmental benefit to those living in emerging and developing economies. IPP is funded from the Department for Business, Energy and Industrial Strategy's (BEIS) Global Challenges Research Fund (GCRF). This £1.5 billion Official Development Assistance (ODA) fund supports cutting-edge research and innovation on global issues affecting developing countries. ODA-funded activity focuses on outcomes that promote long-term sustainable development and growth in countries on the OECD Development Assistance Committee (DAC) list. IPP is ODA compliant, being delivered in alignment with UK Aid Strategy and the United Nations' (UN) Sustainable Development Goals (SDGs).

METEOR aimed to formulate an innovative methodology of creating exposure data through the use of EO-based imagery to identify development patterns throughout a country. Stratified sampling technique harnessing traditional land use interpretation methods, modified to characterise building patterns, can be combined with EO and in-field building characteristics to capture the distribution of building types. The associated protocols and standards were developed for broad application to ODA countries and tested and validated for both Nepal and Tanzania to assure they are fit-for-purpose.

Moreover, the project worked on: (i) developing and delivering national hazard footprints for Nepal and Tanzania; (ii) producing new vulnerability data for the impacts of hazards on exposure; and (iii) characterising how multi-hazards interact and impact upon exposure. The provision of METEOR's consistent data to governments, town planners and insurance providers will promote welfare and economic development and better enable them to respond to the hazards when they do occur.

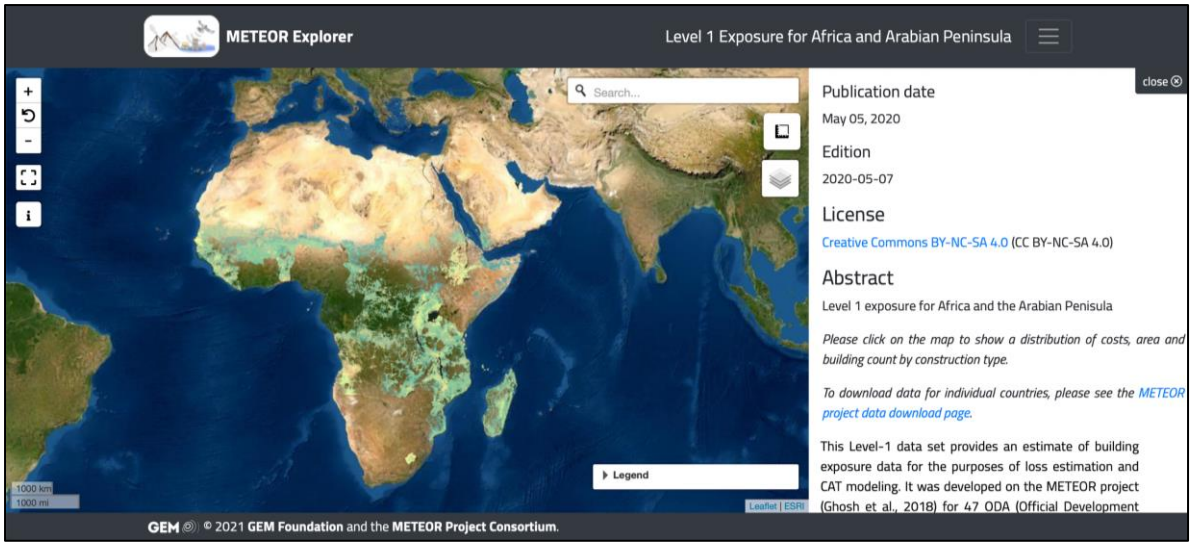
The METEOR project has delivered country-wide, openly-available "Level-1" exposure data for the 47 least developed ODA countries with calibrated exposure data for Nepal and Tanzania. The project created footprints of hazards of major importance for the specific countries of Nepal and Tanzania; created open protocols; developed critical exposure vulnerability information from EO data; and has undertaken capacity-building activities with local decision makers to apply data and assess hazard exposure.

The specific objectives of the project were:

I. Delivery and use of open-source national-scale exposure datasets for multi-hazard analysis by Nepalese, Tanzanian and global stakeholders;
II. Uptake of protocols to develop critical exposure information from EO data;
III. Uptake of sustainable business model for exposure application in DRM by stakeholders;
IV. Exposure data integrated into national DRM policy and planning (where possible in a three-year project);
V. Improved capacity for end users to utilise and understand hazard-exposure data;
VI. Creation of a network of stakeholders better placed to act as leaders of DRM in their geographic regions.

The "Level 1" data has been published and is available on multiple portals, including the project site: download: https://meteor-project.org/data/; visualisation: https://maps.meteor-project.org

An example of the Level 1 exposure for Africa and the Arabian Peninsula is shown on the next page.



Examples of how METEOR results can be used

In **planning:**

"Tell me which municipalities have high landslide susceptibility, and buildings that are highly susceptible to landslides." "What is likely to happen after: a 100-year flood? a large earthquake? a volcanic eruption?"

In **responding** to an event:

"There has been an earthquake; Where are the low hazard areas to which we can move people for their safety?" "Where are the biggest impacts likely to be?" "Where should we focus our retrofitting efforts?"

4. Sustainability model

The METEOR project aims to be sustainable through its work in:

- Supporting activities in DRR/DRM planning for Government and NGOs/International NGOs addressing the SDGs and Sendai Framework targets
- Helping the insurance industry develop products and markets for disaster risk insurance, catastrophe models for ODA countries
- Spurring future research and development funding for academic initiatives in hazards, exposure, vulnerability and risk
- Identifying networks and partnerships to position METEOR products for broader distribution and outreach with groups such as the Insurance Development Forum (IDF)[12], OASIS[13], the

[12] https://www.insdevforum.org
[13] https://oasislmf.org/

Humanitarian Data Exchange (HDX)[14], the PopGrid Data Collaborative[15] and the Group on Earth Observations[16].

The milestones to achieve and deliver results and deliverables as per the timeline included working with stakeholders to get their buy-in and use of results, conducting meetings including stakeholder workshops, insurance industry advisory meetings, learning events as planned, attending key conferences – national and international DRR/DRM and insurance, as well as training and capacity building workshops.

Minimum Leave Behind (if no additional funding)

Data and protocols that are Useful, Usable and Used

plus

People and organisations with the capacity and interest to use and build on what we have done

Improved resilience to disasters

Nepal and Tanzania as 'lighthouse' countries for the regions

Partnership of experts willing and able to continue working together

The strength and weaknesses of METEOR in terms of achieving the commercial end-game [as of today] are summarised below.

Strengths

- Experience and knowledge of consortium members
- Leverages EO and innovation in DRR/DRM
- In-country partnerships and products co-owned/ co-developed
- Includes protocols and standardised metadata along with significant resource allocation for training and capacity building
- Open data
- Supports the development of the insurance sector for ODA countries
- Positive feedback from stakeholders on need for the project outputs

Weaknesses

- Pricing standardisation may be difficult
- Sustainability and future development dependent on government budgets
- Outputs are appropriate for national scale assessments; for smaller sized countries, collection of site-specific footprints/point data are required
- Does not address critical infrastructure and agricultural sectors

[14] https://data.humdata.org
[15] https://www.popgrid.org
[16] http://www.earthobservations.org/index.php

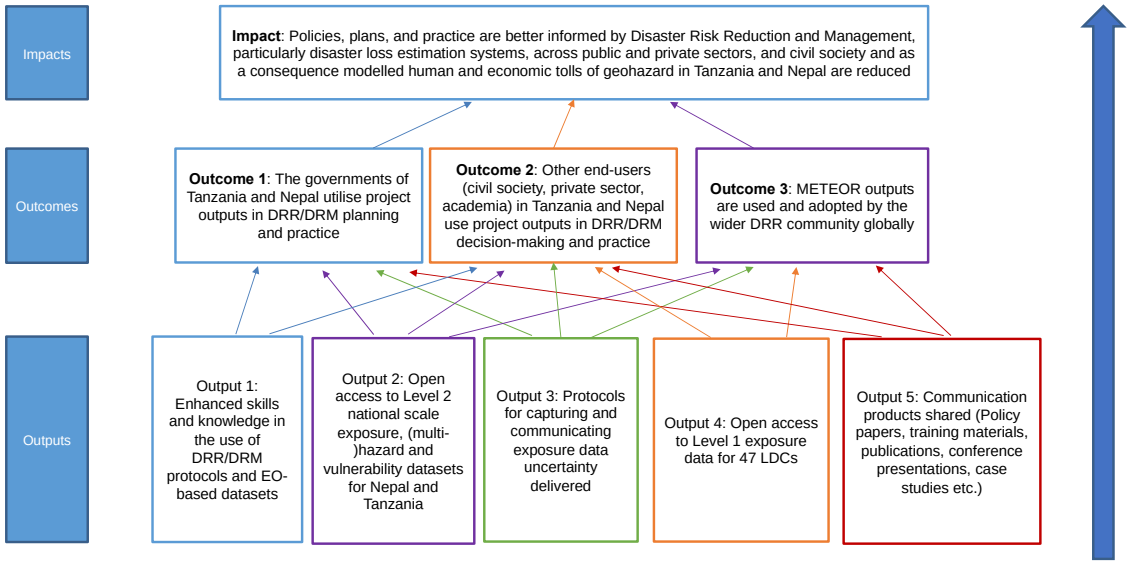
5. Project objectives and results

a) What the project intended to achieve

The pathway from the activities of METEOR to the ultimate impact is summarised in the diagram below. At the top level the objective is to ensure that good DRR and DRM practice is in place and resulting in fewer people dying and being injured, and less destruction of property, assets and resources. This is a long-term objective and will take many actions by many actors to be achieved: METEOR is seeking to make a positive contribution to that.

In the medium term, there are three objectives that METEOR worked towards, shown as outcomes in the diagram. The first deals specifically with Nepal and Tanzania, where the governments are using the data and protocols produced by METEOR. In the second outcome, it is other organisations and institutions such as universities, the Red Cross etc. that are using METEOR outputs. The third outcome seeks to have the outputs used widely across different countries, organisations and sectors.

The third row deals with the outputs, what METEOR actually delivered. The arrows show the outcomes that each output will contribute to, and on through to the impact. All outputs need to be delivered for all outcomes to be achieved.



b) How we have assessed these results

For each of the 3 levels of change sought, indicators to measure that change were agreed, and targets set to specify what progress is expected by when. The document that contains the objectives and indicators is called a logical framework or logframe, and it formed part of the Monitoring and Evaluation Plan which was drawn up and agreed at the start of project. It included details of how progress will be monitored on a regular basis, including through monthly calls and annual meetings in person.

That plan also laid out how the project would be evaluated. A baseline study was carried out in the early months of the project life, a midline evaluation carried out half-way through implementation and an endline evaluation completed in March 2021.

The endline combined an evaluation of the process of implementation which involved talking to key staff of the consortium partners. In addition, a formative evaluation used case studies for Nepal and Tanzania as well as a global case study to probe deeper into the project. For the last study, Key Informant Interviews (KIIs) were carried out with representatives from the METEOR Advisory Board. The methodology was shaped by the unusual nature of the pace of delivery for the project when most key deliverables' due dates are towards the end of the project.

c) The results

The table below summarises progress against the project's Key Performance Indicators (KIIs). Further details are contained in the full endline report (2021). The results (final column) are colour-coded: green for fully achieved; amber for partially achieved; red for not achieved.

	Indicator	Endline target	Achieved?
KPI 1	Outcome Indicator 1.2. Feedback from relevant Ministry (or decision-maker) on the usefulness of the project outputs for improving their national DRR/DRM.	METEOR datasets are hosted on official/government-led platforms in Nepal and Tanzania.	**NEPAL:** **Endline target achieved** as the METEOR data are hosted by **BIPAD: Building Information Platform Against Disaster (**https://bipadportal.gov.np/risk-info/#/hazard), the official disaster risk portal of the Government of Nepal. Furthermore, the National Disaster Risk Reduction and Management Authority (NDDRMA) has confirmed the usefulness of the METEOR data and protocols and their intention to use them in national assessments and planning.
			TANZANIA: **Endline target Achieved.** There seems to be too limited capability at the central government level to have a comprehensive online platform with national disaster risk data, like the one in Nepal. The consortium has identified the **Resilience Academy geonode platform** (https://geonode.resilienceacademy.ac.tz/), which is participated by the Government, as a viable option to have the data directly accessed by academia, practitioners, and potentially the Government. Therefore, the indicator target has been formally achieved. In terms of qualitative feedback from the Government on the usefulness of the project outputs, the KIIs and training feedback confirm the appreciation of the data by PMO-DMD. This is also evidenced by DMD requesting material from METEOR to inform the update of the national disaster risk policy.
KPI 2a.1	Percentage of Nepalese and Tanzanian territory covered by Level 2 exposure data (aligned with SFDRR Global Target g and Priority Area 1)	100%	**Endline target achieved** as the Level 2 Exposure data covering all Nepalese and Tanzanian territories have been published. (https://maps.meteor-project.org/)

<table>
<tr><th></th><th>Indicator</th><th>Endline target</th><th>Achieved?</th></tr>
<tr><td>KPI 2.a.2</td><td>Percentage of Nepalese and Tanzanian territory covered by Level 2 multi-hazard data (aligned with SFDRR Global Target g and Priority Area 1)</td><td>100%</td><td>Endline target achieved as the Level 2 Hazard maps covering all Nepalese and Tanzanian territories have been published. (https://maps.meteor-project.org/) Specifically:
Tanzania: Flood, Volcanic ash falls, Seismic hazards
Nepal: Flood, seismic, landslide hazards</td></tr>
<tr><td>KPI 2.b</td><td>Number of Level 1 datasets for LDCs uploaded on online platforms (aligned with SFDRR Global Target g and Priority Area 1)</td><td>47</td><td>Endline target achieved as the Level 1 Exposure data covering all 47 LDCs have been published. (https://maps.meteor-project.org/)</td></tr>
<tr><td>KPI 3</td><td>Percentage of professionals trained in Nepal and Tanzania reporting increased knowledge on the training topic (disaggregating males and females).</td><td>75%</td><td>Endline target achieved:

<table><tr><th></th><th>Trained</th><th>Increased knowledge</th><th>Percentage</th></tr><tr><td>Males</td><td>23</td><td>21</td><td>91%</td></tr><tr><td>Females</td><td>9</td><td>9</td><td>100%</td></tr><tr><td>Total</td><td>32</td><td>30</td><td>94%</td></tr></table></td></tr>
<tr><td>KPI 4</td><td>Qualitative indicator: Feedback from the global community (e.g. UNICEF, UNDRR, WB, GFDRR) in respect of usefulness of project outputs.</td><td>There is evidence of concrete plans that the organisations on the METEOR Advisory Board are going to use the METEOR outputs in supporting 1 DRRM activity in developing countries</td><td>Endline target achieved
At the moment, based on the feedback from the METEOR Advisory Board and meetings with the World Bank GFDRR and UNICEF, there is evidence that the METEOR products are highly relevant to the needs of the global DRRM community (hence useful), particularly the Level 1 Exposure data, because of their wide geographical coverage.
ImageCat has used the METEOR protocols to develop Level 1 Exposure data set funded by NASA for a project in Nigeria on flood risk management funded.
Furthermore, ImageCat was funded by the World Bank's Disaster Risk Financing and Insurance Program (DRFIP) to conduct a multi-hazard study for Tunisia using the METEOR protocols on exposure, and seismic and flood hazards. This study is likely to lead to a larger project funded by the GFDRR.</td></tr>
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Overall it is clear that the project was well-managed and communications were strong and appropriate. The consortium members reported good cooperation, excellent coordination by the project manager, and appreciation of the regular meetings, in particular those held in Nepal and Tanzania, in building relationships and effectiveness. The project worked hard at co-developing outputs, building partnerships and engendering ownership. However, COVID-19 and the resulting restrictions on travel have had an impact on the deliverables, affecting the training and capacity development aspects in particular. Despite this, training was held in Tanzania, with a plethora of new materials being developed so that the participants (some of whom were at the METEOR partner's office and some of whom were online) were able to be taken through the topics. These materials are a real resource and will remain available online. In Nepal a workshop was held to take the more senior officials through the materials. This was successful and a fuller rollout to more technical staff is planned.

6. Conclusions and lessons learnt

a) Conclusions

In terms of relevance, there is consistent and strong evidence that the METEOR products are needed and useful. Representatives of the insurance industry and development partners we're enthusiastic about the applicability of the data to their work. At the national level, key stakeholders highlighted the need for such data to inform policies plans and activities. Further evidence of the relevance of the products was given through requests for more of the data, at the sub national level in line with the delegation of responsibilities within government. The project is well aligned with other interventions in both Nepal and Tanzania and so demonstrates coherence.

In terms of efficiency the project outputs were delivered on time, and to a high standard. An analysis of cost effectiveness which compared METEOR's approach with two alternatives demonstrated the very clear cost effectiveness of the approach taken by the project.

In terms of effectiveness or whether the project met its objectives, all METEOR's KPIs were met. The project delivered well against ambitious targets. 100% of Nepal and Tanzania's territories are now covered by Level 2 exposure and multi-hazard data. In addition, the other 47 LDCs are now covered by Level 1 exposure data. In terms of training people to use the data, not all the planned courses were completed due to COVID-19. However for the training that was completed satisfaction is high.

All evidence points to the success of METEOR in producing useful, scientifically sound, accessible and cost-efficient data and protocols. The data produced by the project is available on multiple open access platforms and is publicly available. There is sustained interest from a range of development partners as well as representatives from the insurance industry. There is clear and sustained interest in using the data at the national level , although the development of capacity and Nepal and Tanzania for users to be able to model the data has not been completed as planned as at the end of the project.

b) Key lessons and learnings

METEOR achieved its main objectives of delivering datasets and protocols covering all ODA countries, with more detailed analyses for Nepal and Tanzania published and available as open data. The consortium consisted of a good mix of organisations who are key experts in their areas of science, they know their subject well and have a realistic idea of what they can deliver. To work on delivering the project objectives, the METEOR team invested in building joint ownership across the consortium with active, strong project management and continuous focus on delivering high quality products on time. The project team has flexed and adapted to changing circumstances, including new institutions such as the NDRRMA. The division of labour between the different partners was clear and logical and each of those partners brought their skills and experience to bear on working together efficiently and effectively. The result is a high quality, credible set of products that have the potential to inform policy and practice in DRM.

However, there is always more that could be done. In future projects, it would be useful to consider the balance of skills across the consortium. With METEOR, the focus was on organisations with credibility in delivering good quality science-based products. However, the ultimate aim of METEOR was to change the behaviour of policy makers and implementors. A partner with more experience of capacity development in ODA countries, and with expertise in behavioural change should be

considered. Such a partner could bring knowledge and the experience of conducting political economy analyses, could advise on building local political support and successful advocacy.

In order to be able to track the actual use of these data sets in policy making and practice, the project timeline would need to allow more time for post-production sharing and capacity development around the products. Ideally this would be accompanied by greater publicity and more political momentum, supported by a capacity development partner, as outlined above, and dedicated resources to result communication to policy-makers and the broader public, both nationally and internationally. Unfortunately, much of the planned face to face communication was hampered by the pandemic and an alternative approach to engagement ought to have been sought. In this regard, developing bespoke communication products to showcase the potential impact of data-driven DRR/DRM in non-technical terms (e.g. monetary savings, life loss reduction) could help generate broader political buy-in in developing country governments.

In terms of setting targets, there is a fine balance to be maintained between ambition and over-optimism. The process of setting targets should be participatory, strongly linked to the Theory of Change and based on a solid understanding of how change happens. It is also important to keep the pace of change in mind particularly given the constraint of the limited project life. In particular, co-development requires significant amounts of time, but increases the ownership of the final product by the people who are most likely to use it.