METEOR

Modelling Exposure Through Earth Observation Routines

METEOR project

Modeling Exposure Through Earth Observation Routines

- Three-year project
- Funded by UK Space Agency
- Aims to develop innovative application of Earth Observation (EO) technologies to improve understanding of exposure
- Specific focus on pilot countries Nepal and Tanzania
- Consortium of eight organizations

funded by:

project consortium:

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METHODS FOR MODELLING MULTI-HAZARDS IN THE METEOR PROJECT

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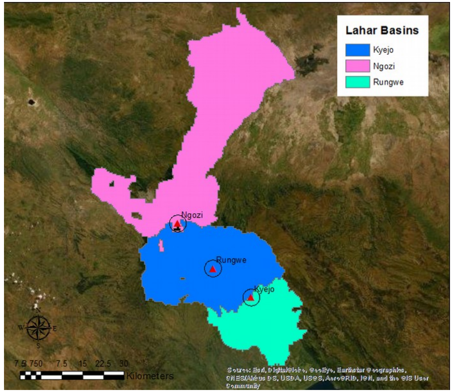
Methods for Modelling Multi-hazard in METEOR

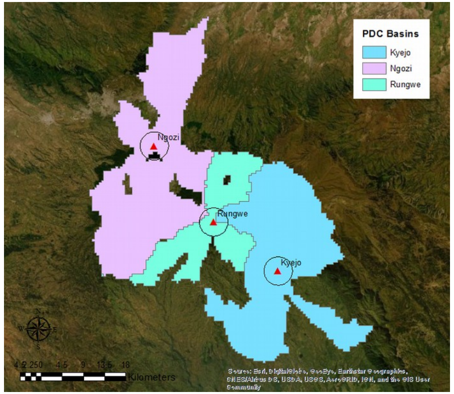
- Testing existing methodologies.
- The Greiving Model
- The Kappes Model
- Expert Elicitation and Weighting
- Developing protocols for modelling METEOR data
- Sensitivity testing

METEOR Hazard Outputs (Tanzania)

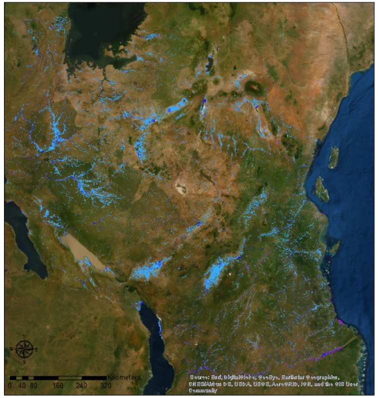
Volcanic hazard

Basin analysis for lahars and PDCs





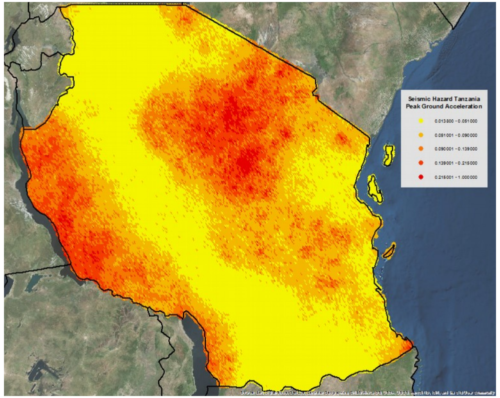
Flood hazard



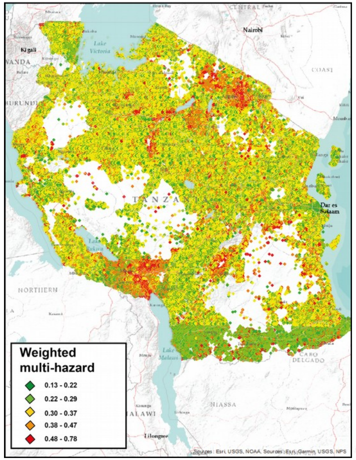
Fluvial and pluvial flood data for 1 in 5, 10, 20, 50, 75, 100, 200, 250, 500 and 1000 year return periods

Seismic hazard

PGA values due to earthquake ground shaking with 10% probability of exceedance in 50 years



Multi-hazard modelling



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Introduction to multi-hazards

Single hazards exhibit various characteristics such as: time of onset, duration and extent

Multi-hazard assessments are complicated by:

1. Hazards may be related to each other, and cumulative (cascades)
2. The impacts on elements at risk can be different for differing hazards and occasionally opposing
3. The differences between hazard characteristics and therefore the methods used to observe and monitor them
4. Any of the existing measures of hazard quantification need to be adapted to allow for comparison of multiple hazards

Testing methodologies

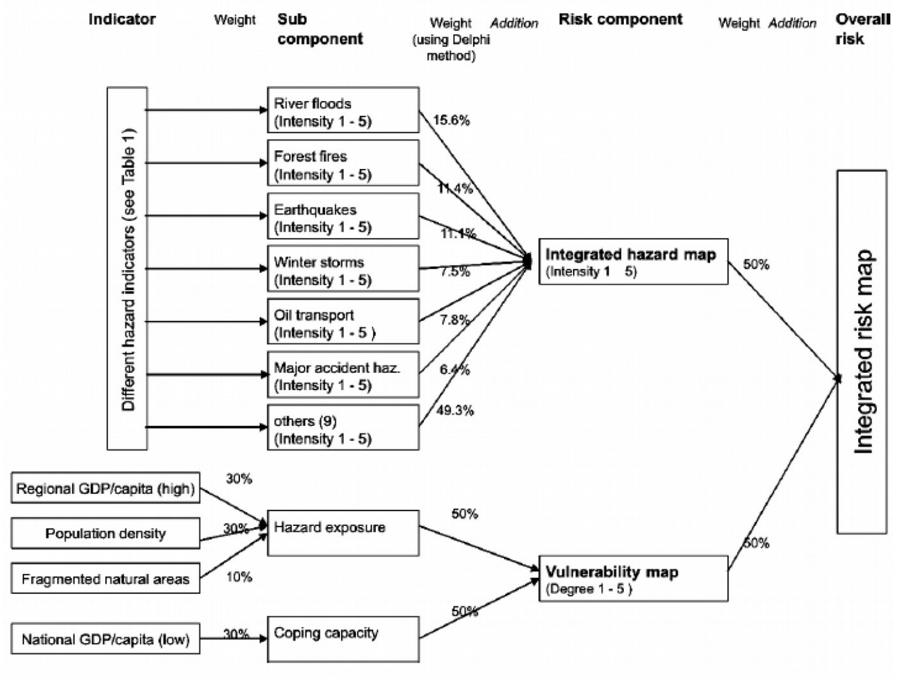
- Previous models have focused on: the frequency of events and use of historic dollar losses, as a proxy for infrastructure impact or exposure.
- In the METEOR project we don't have the baseline of data at a national level required for a for a fully quantitative model.
- Therefore selected a semi-quantitative model, including developing indicators
- Two methodologies selected to test data: Greiving (2006) and Kappes (2012)

The Greiving Model

Defines vulnerability as '*the degree of fragility of a system or community towards natural and technological hazards*'

Consider 3 types of hazard exposure:

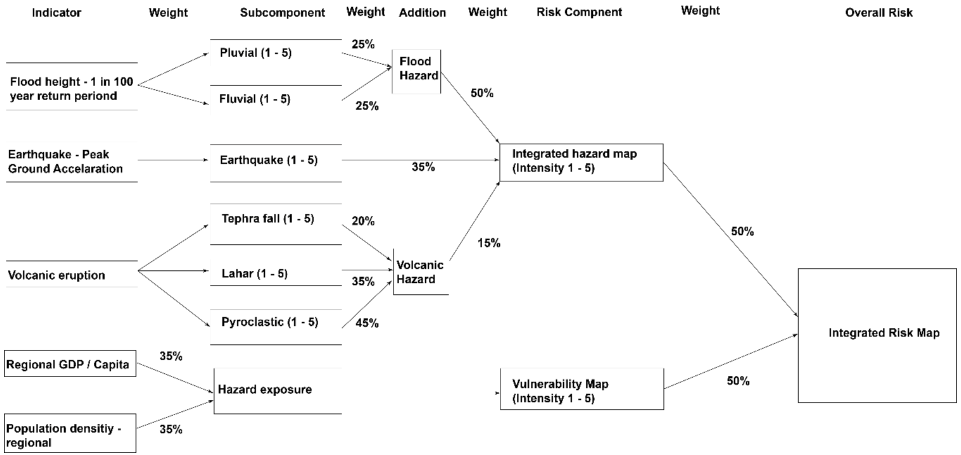
1) Economic
2) Social
3) Ecological



Calculation of integrated Risk. From: Greiving, 2006

The Greiving Model

1. Generate hazard maps – display the location and intensity of spatially relevant hazards.
2. Production of an integrated hazard map – Compile data into one map displaying overall hazard potential.
3. Create vulnerability map – collect social and economic vulnerability data to assess overall vulnerability of a region.
4. Compile Integrated risk map: Integrate hazard and vulnerability maps to show the overall vulnerability of each region.

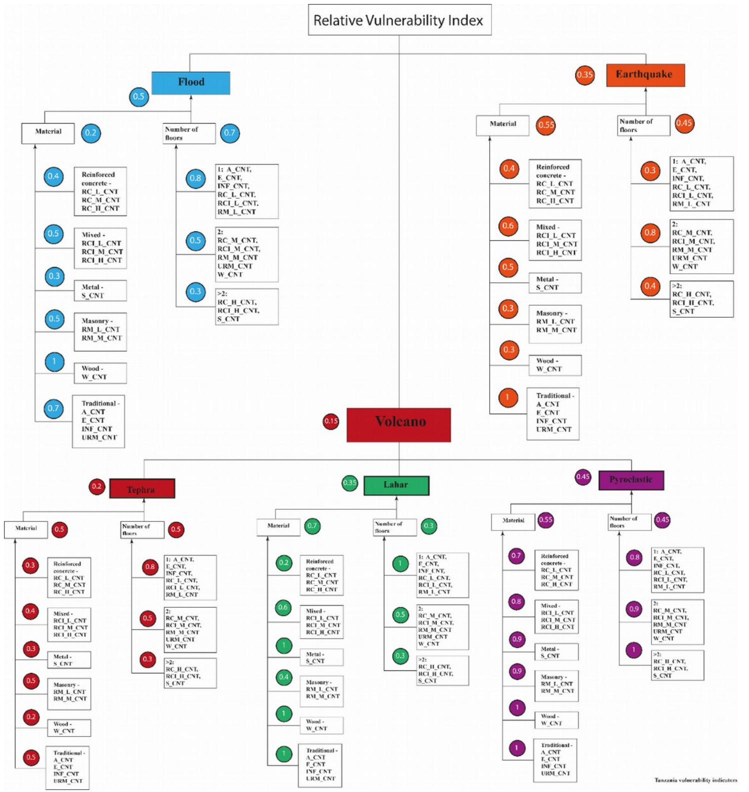


Network to apply the Greiving method to the METEOR data.

The Kappes Model

1. Identification of the inundation zone and inundation depth zones
2. Identification of factors that affect the vulnerability of buildings and people and collection of data
3. Calculation of the vulnerability of individual buildings within the inundation zone using a multi criteria evaluation method
4. Display of building vulnerability and human vulnerability

Indicator based vulnerability model



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Interacting hazards

Assess the inter-relationships between hazards by creating a hazard matrix.

Flooding (1.1)	Destabilisation of the subsurface due to increased water saturation and erosion is likely to change the response to an earthquake, increasing the potential for liquefaction. (1.2) (Alteration to the hazard / vulnerability)	No Interaction (1.3)
Cracks and damages from earthquakes may make structures more vulnerable to increased water volumes - specifically flood management infrastructure and dams. (2.1) (Alteration of vulnerability)	**Earthquake (2.2)**	(Fall) Cracks and structural damage caused by an earthquake may increase vulnerability to added pressures from ash falls (2.3a) (Alteration of vulnerability) (Flow) Cracks and structural damage may increase structures to a second impact (2.3b) (Alteration of vulnerability)
(Fall) No Interaction (3.1a) (Flow) Inundation of lahar and / or pyroclastic material may cause differences to river drainages, changing the areas of inundation from a flood event (3.1b) (Alteration of hazard)	(Fall) The addition of volcanic ash to the roofs of buildings may increase their vulnerability to shaking due to the increased weight on the structure (3.2a) (Alteration of vulnerability) (Flow) Structural damage from the impact of a volcanic flow is likely to increase a buildings vulnerabilty to further destabilisation (3.2b) (Alteration of vulnerability)	**Volcano (3.3)**

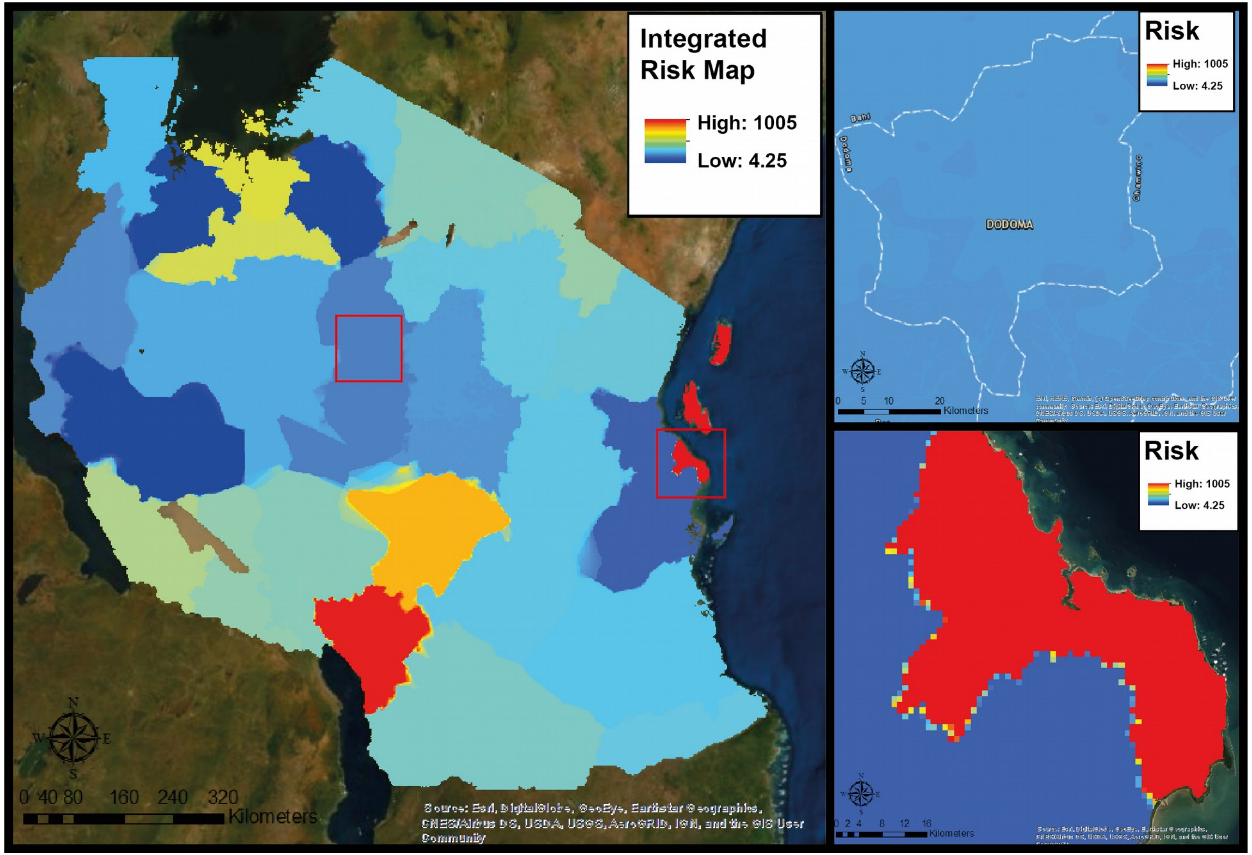
Expert Elicitation and Weighting

In both of the models tested, hazard and vulnerability indicators are weighted differently to reflect their relationships to each other.

Weights underpinned by fragility curve, inventories of data and expert elicitation.

Tanzania	Pluvial	Fluvial	Tephra	Lahar	Pyroclastic	Earthquake
Hazard Weight	0.25	0.25	0.03	0.0525	0.0675	0.35
CR/LFM/HBET:1,3 - Reinforced concrete moment frame (1-3 stories)	0.32	0.32	0.3	0.06	0.56	0.12
CR/LFM/HBET:4,7 - Reinforced concrete moment frame (4-7 stories)	0.2	0.2	0.15	0.1	0.63	0.32
CR/LFM/HBET:8,20 - Reinforced concrete moment frame (8-20 stories)	0.12	0.12	0.09	0.06	0.7	0.16
CR/LFINF+DNO/HBET:1,3 - Non-ductile reinforced concrete infilled frame (1-3 stories)	0.4	0.4	0.4	0.6	0.64	0.18
CR/LFINF+DNO/HBET:4,7 - Non-ductile reinforced concrete infilled frame (4-7 stories)	0.25	0.25	0.2	0.3	0.72	0.48
CR/LFINF+DNO/HBET:8,20 - Non-ductile reinforced concrete infilled frame (8-20 stories)	0.15	0.15	0.12	0.18	0.8	0.24
S - Steel	0.09	0.09	0.09	0.3	0.9	0.2
MUR+CB99/HBET:1,3 - Unreinforced concrete block masonry (1-3 stories)	0.4	0.4	0.5	0.4	0.72	0.09
MUR+CB99/HBET:4,7- Unreinforced concrete block masonry (4-7 stories)	0.25	0.25	0.25	0.2	0.81	0.24
W - Wood	0.8	0.8	0.2	1	0.8	0.09
MATO/LN - Informal constructions	0.56	0.56	0.6	1	0.8	0.3
MUR+ADO/HBET:1,3 - Unreinforced adobe masonry (1-3 stories)	0.56	0.56	0.6	1	0.8	0.3
MUR+CL99 - Unreinforced fired clay masonry	0.56	0.56	0.6	1	0.8	0.3
MUR+STRUB - Unreinforced rubble stone masonry	0.56	0.56	0.6	1	0.8	0.3
W+WWD - Wattle and Daub (Walls with bamboo/light timber log/reed mesh and post).	0.56	0.56	0.6	1	0.8	0.3

The Greiving Model: Results



Integrated risk map created by following the Greiving et al method – insert maps show risk in Dar es Salaam (high) and Dodoma (low)

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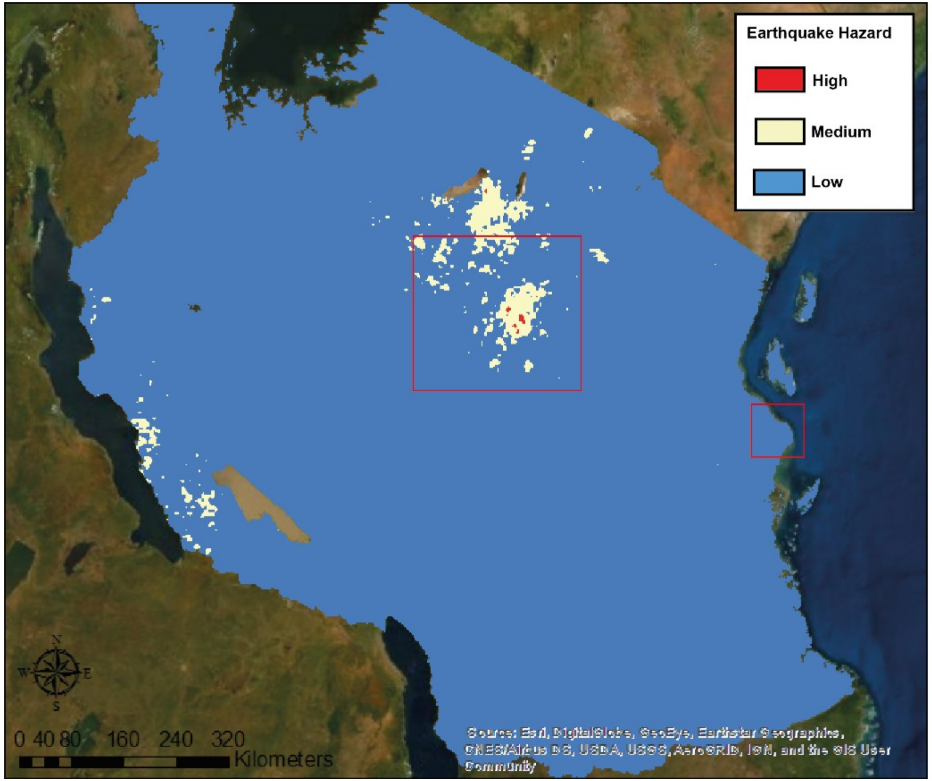
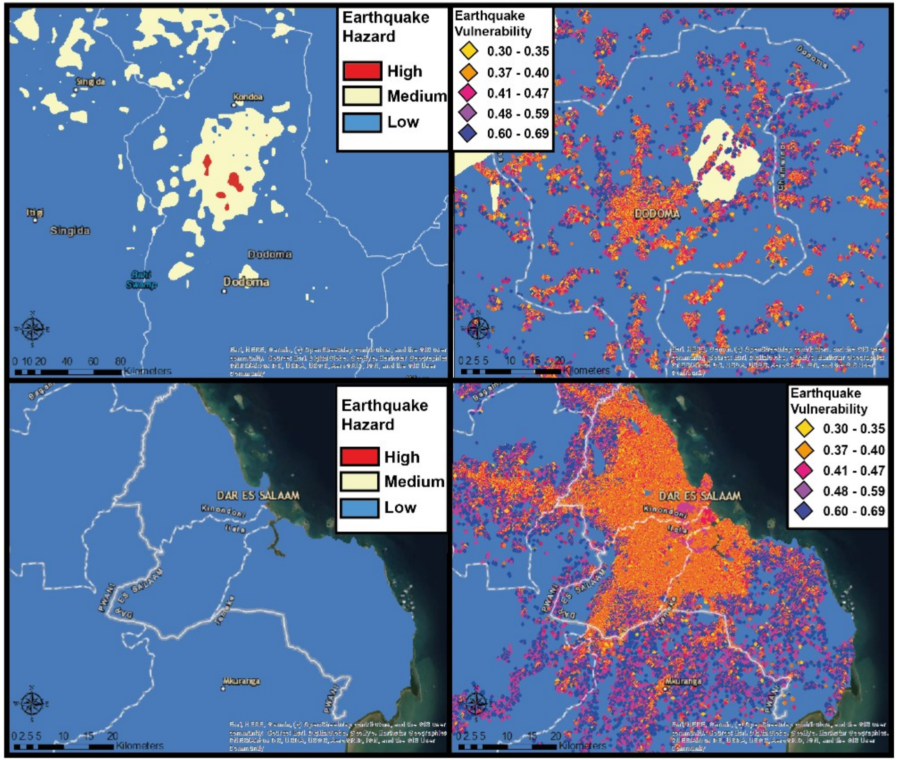
The Kappes Model: Results

Earthquake hazard and relative vulnerability index maps, created following the Kappes model





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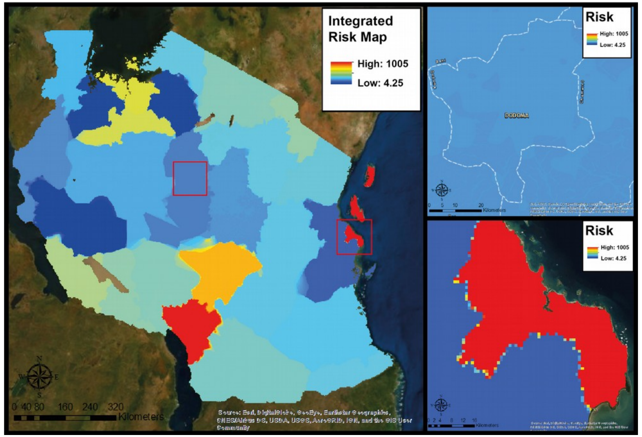
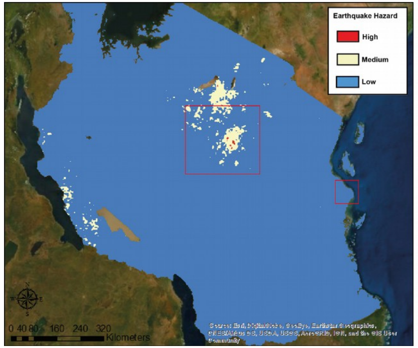
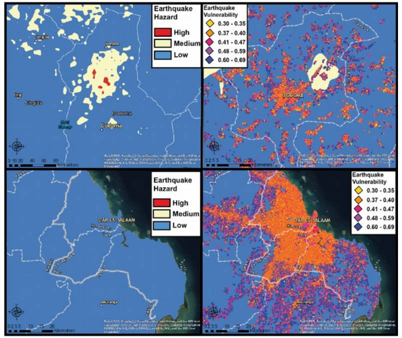
Testing methodologies

Greiving: National scale integrated risk with a regional resolution.



Kappes: Retains 90m resolution but generates unique outputs for each hazard.





METEOR model is therefore a hybrid of these models.

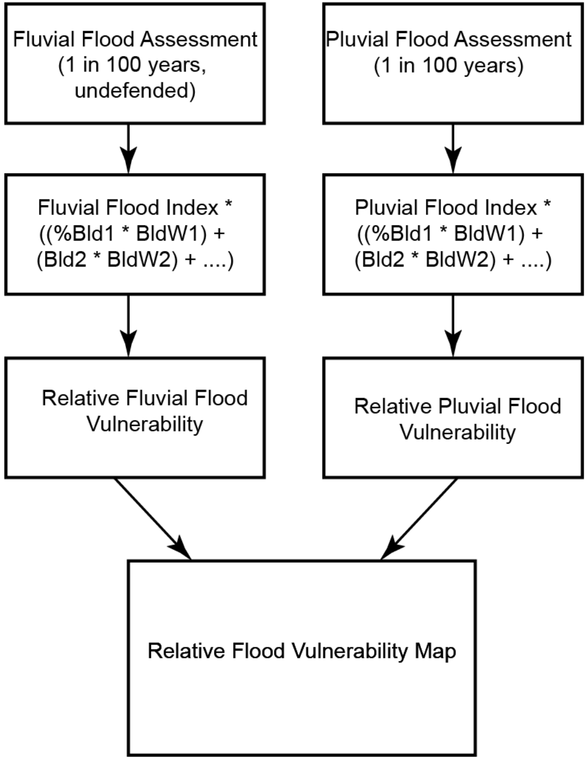
METEOR Protocols for modelling multi-hazards

Hazard Assessment

Exposure

Relative Vulnerability

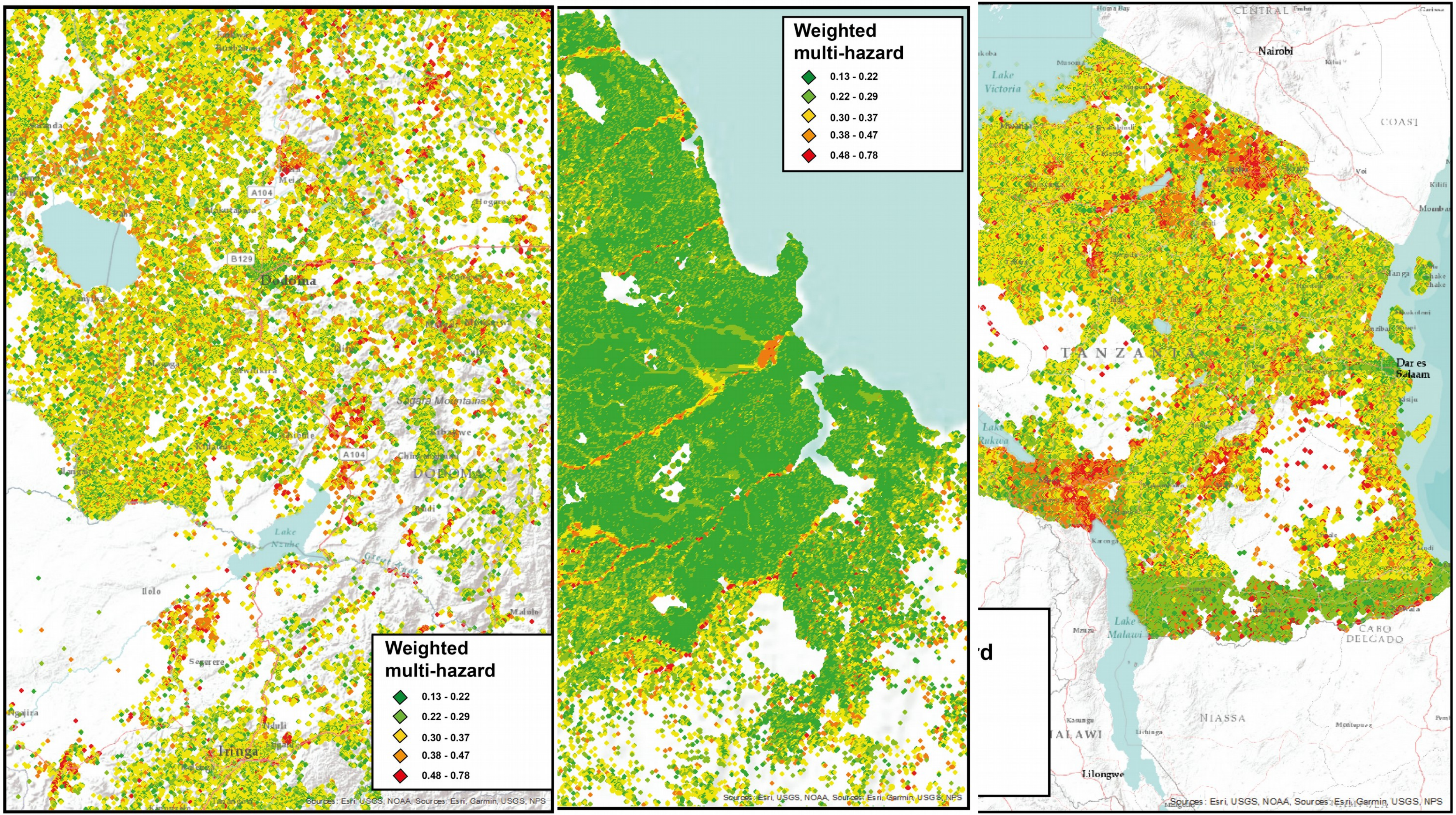
Part 1



Data is normalised and classified

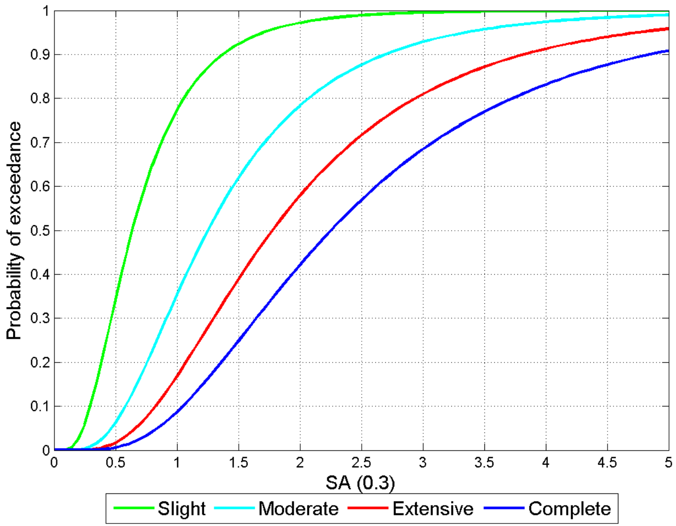
Develop Index
% of building types per pixel calculated
Weights defined for each building code - controlled by materials and number of floors

Can be weighted independantly if required



Weighted multi-hazard
0.13 - 0.22
0.22 - 0.29
0.30 - 0.37
0.38 - 0.47
0.48 - 0.78
Dodoma
A104
B129
Sagara Mountains
DODOMA
Lake Mtera
Iringa
Ilolo
Nduli
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS
Weighted multi-hazard
0.13 - 0.22
0.22 - 0.29
0.30 - 0.37
0.38 - 0.47
0.48 - 0.78
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS
Nairobi
CENTRAL
COAST
Lake Victoria
TANZANIA
Dar es Salaam
Lake Rukwa
Lake Malawi
MALAWI
Lilongwe
NIASSA
CABO DELGADO
rd
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS

Sensitivity Analysis



Summary

- The METEOR project has produced: single hazard assessments (earthquake, volcano and flood) and exposure data for Tanzania.
- We reviewed existing multi-hazard models and tested two differing models, using draft data from Tanzania.
- This models did not quite fit the needs of the METEOR project and so we have create a hybrid, semi-quantitative model that allows us to assess multi-hazards at a national scale, but with a resolution of c.90m.
- We are still in the final stages of sensitivity analysis to determine the effect of data uncertainty on these model outputs.

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