On the predictability of flash floods and their impacts in North Malawi

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HS4.1.3/NH1.32 - Flash floods and associated hydro-geomorphic processes: observation, modelling and warning

BACKGROUND

Climate change and inequality in disaster impacts

Weather related hazards: Flash floods are the most deadly

Multiple root causes, Small temporal and spatial scale

Flash Flood Forecasting systems exist, but based on sophisticated model.

Developing countries : lack of monitoring, data, and resources.

Malawi- AFP

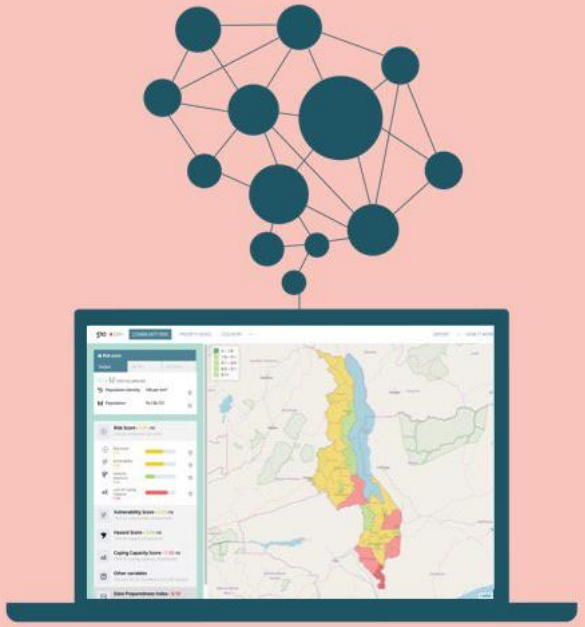
Lamalou-les-bains- France 3

HUMANITARIAN VISION

DATA PREPAREDNESS & FORECAST-BASED FINANCING

UNDERSTANDING RISK

- DATA COLLECTION
- DEVELOP RISK MODELS
- PREDICT VULNERABLE AREAS
- COMMUNITY RISK ASSESSMENT

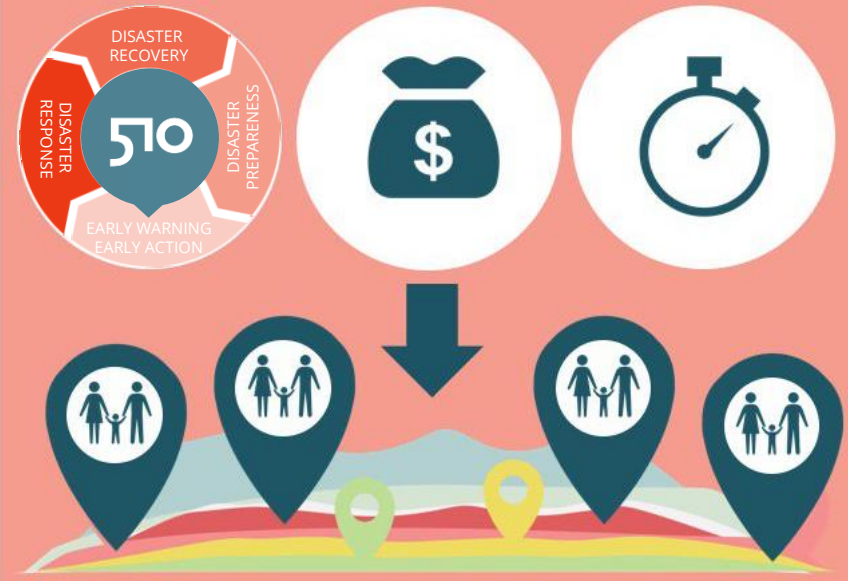


IDENTIFY DANGER

- HISTORICAL EVENTS DATA
- ANALYSIS & INSIGHTS
- IMPACT ON POPULATION
- IDENTIFY TRIGGER LEVELS

IMPACT FORECAST

- IDENTIFY VULNERABLE PEOPLE
- TRIGGER EARLY ACTION
- RELEASE FUNDS
- EXPEDITE FUNDS



OBJECTIVE

Bridging the gab between scientific and humanitarian world

Use **local knowledge,**
together with **catchment characteristics,**
and **global hydro-meteorological conditions,**
to understand spatio-temporal distribution of flash flood
and help to predict their occurrence and impacts

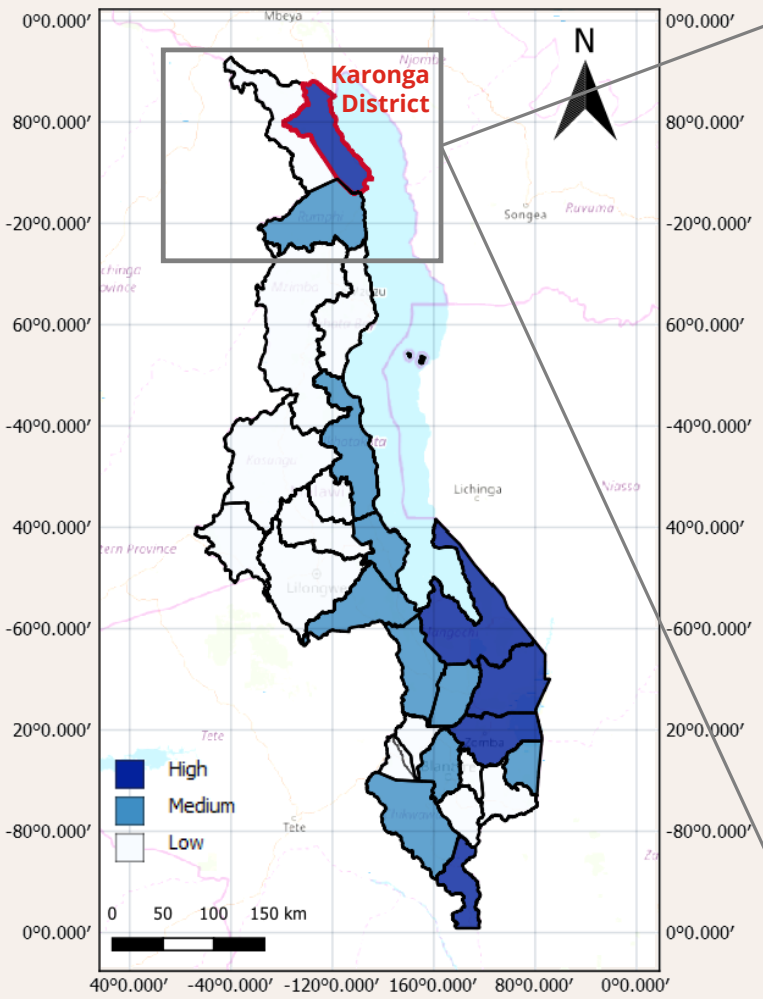
Understand flash flood risk

Identify factors leading to flash flood

Predicting flash flood

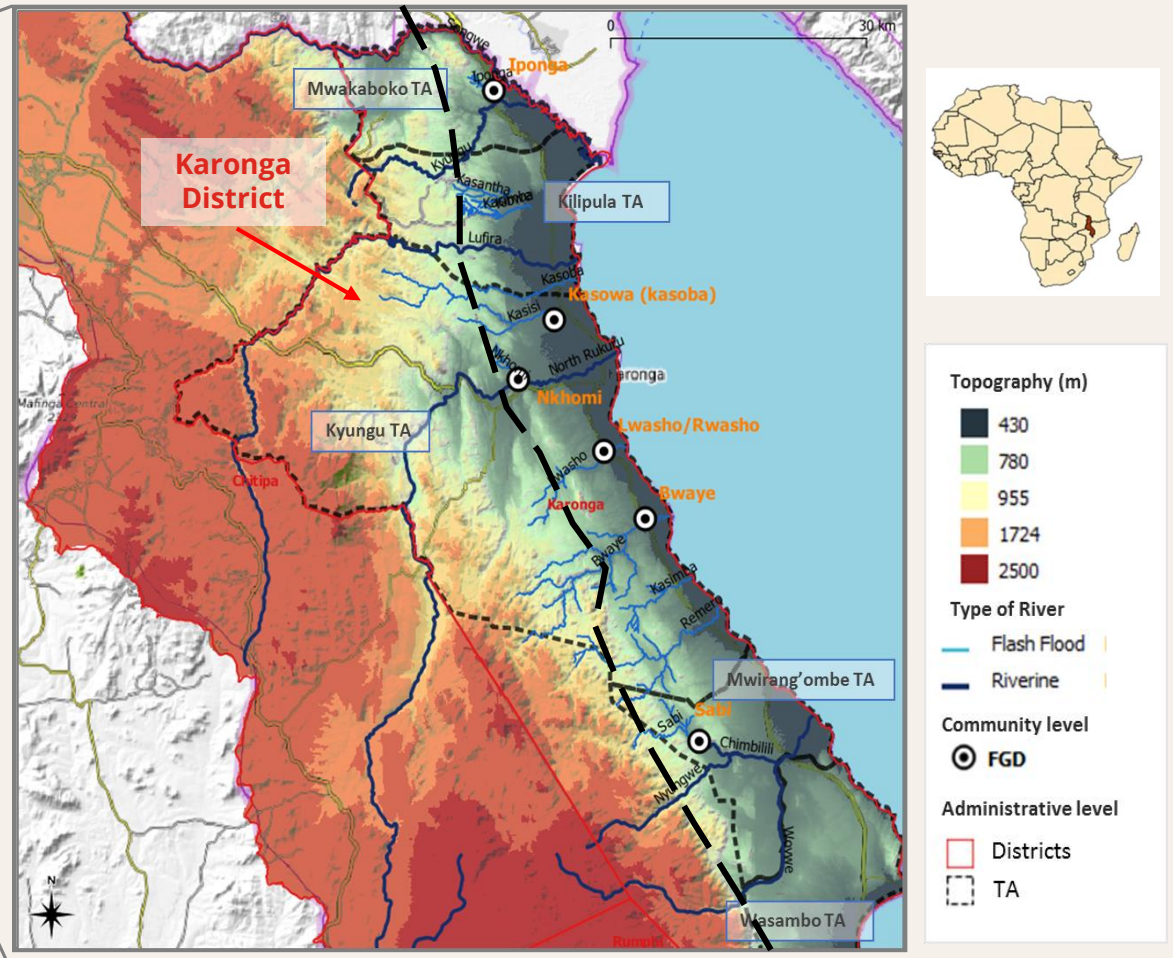
Northern Malawi Case Study

NORTHERN MALAWI



Flood frequency map
DoDMA (ICA 2015)

Rift escarpment



Topography (m)
- 430
- 780
- 955
- 1724
- 2500

Type of River
- Flash Flood
- Riverine

Community level
- FGD

Administrative level
- Districts
- TA

North Malawi Topography and Districts

UNDERSTAND RISK : DATA COLLECTION

Objective

Understand the spatial and temporal occurrence of flash floods and their impacts, and how are flash floods experienced by local communities

Methods

Secondary data collection
Online databases (EMDAT…) , humanitarian reports, online media..

Primary data collection
Semi-structured interviews

GVH | District and National

When
Where
Impacts

3 filters

District | TA | GVH

Flash flood occurrence and impacts

6 FGD

4 KII

Local knowledge

Outputs

Database of flash flood occurrence and impacts

Thematic analysis
- Flash flood definition
- Root causes
- Signs prior to FF

Outcomes

Spatial and temporal analysis

Impact severity classes

FF list at GVH level

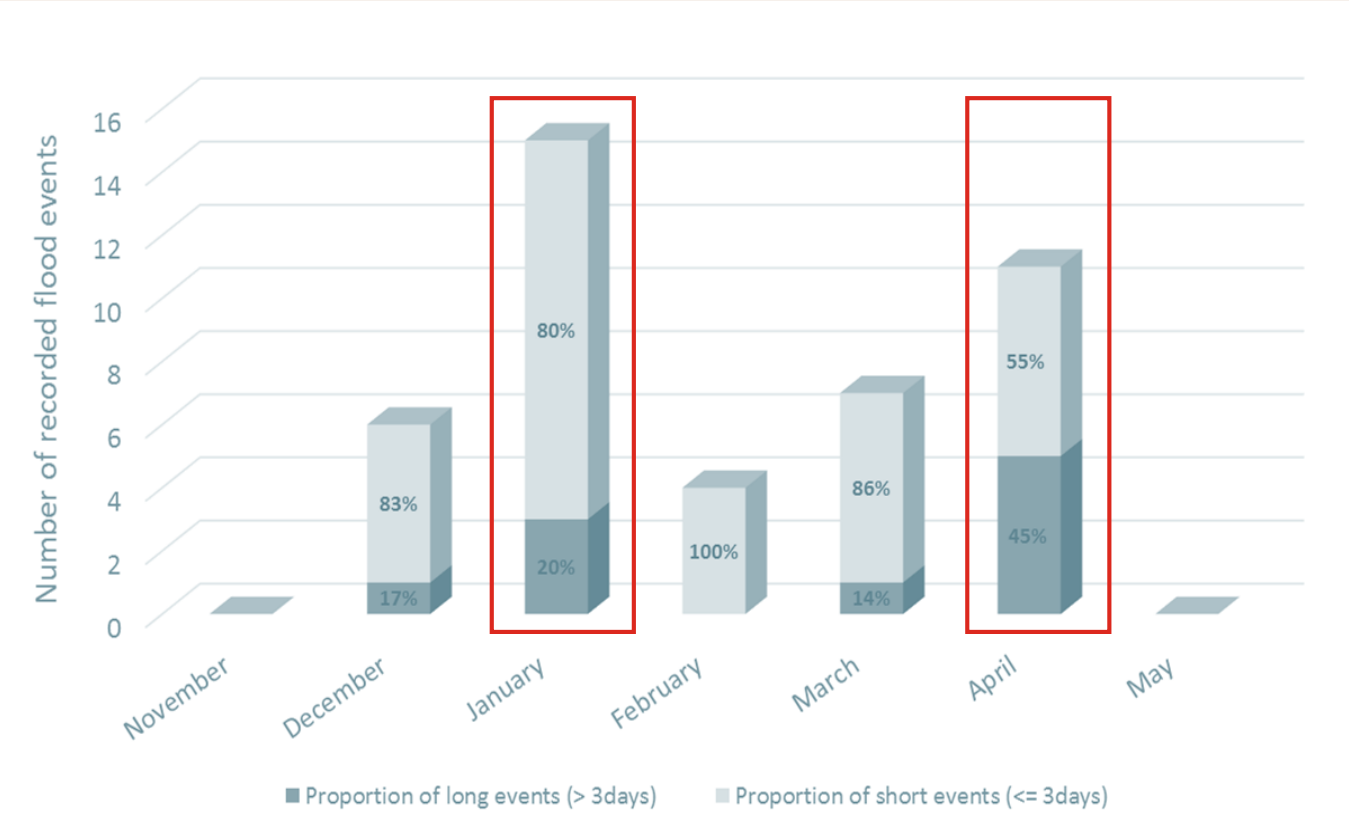
Community drawing

Transect walks

Focus Group Discussions

SPATIO-TEMPORAL FLOOD DISTRIBUTION

Flood occurrence and duration per month



Monthly flood events frequency based on 2000-2018 secondary data collection (43 recorded events), and associated proportion of short duration (<=3days) and long duration (>3days) recorded flood events.

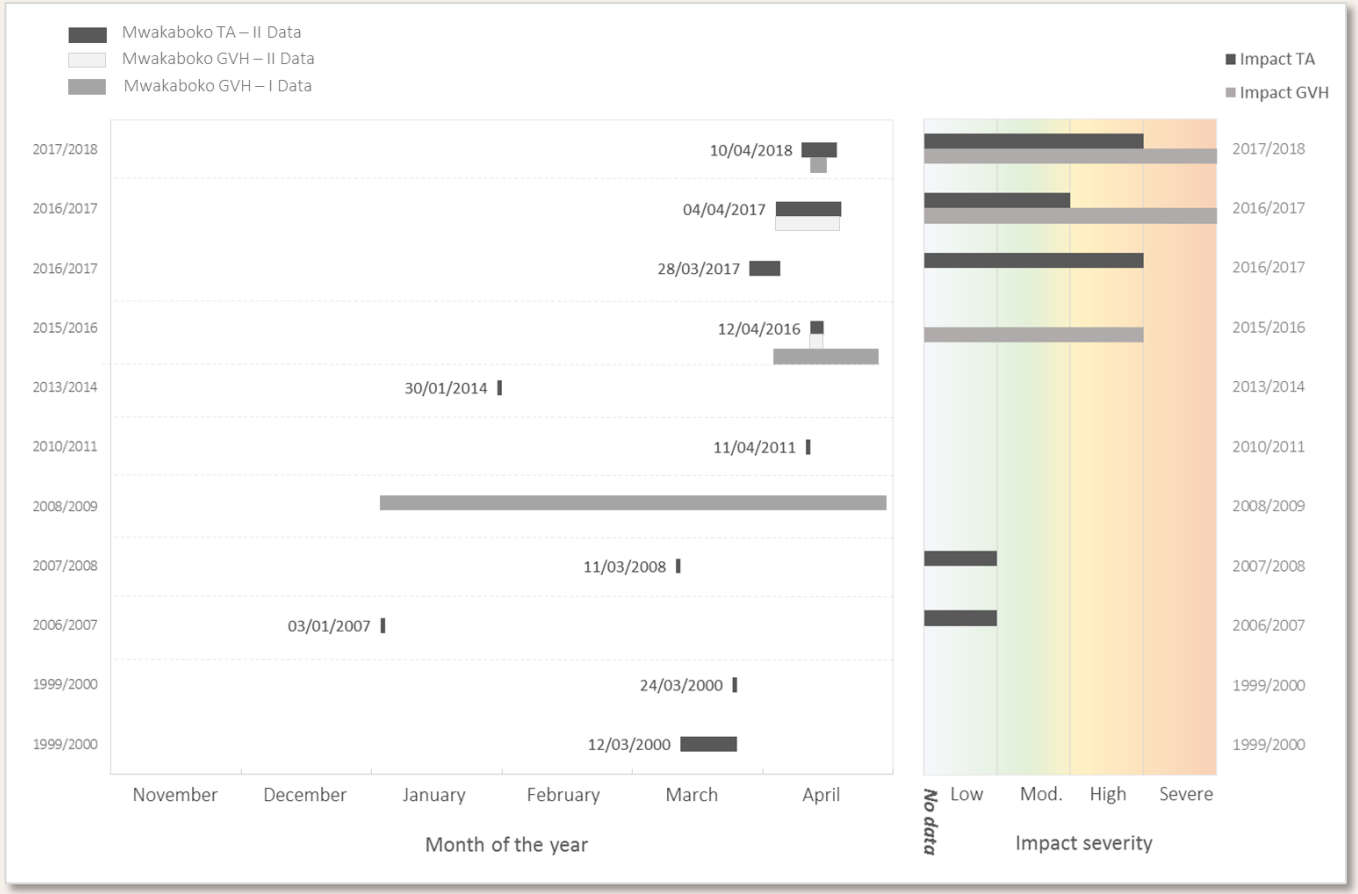
January
Smaller scale events in January.

Occurrence
Several time a year January/April

April
More events in the North than in the South

IMPACT OF FLOODS IN KARONGA

Timeline of flood occurrence and impacts



People: Number of fatalities, people injured, affected or displaced
Structural: Damaged Houses, collapsed houses, damaged toilets
Livelihood: Ha of crop damage & Livestock killed

Impact severity classes

Low
Moderate
High
Severe

Community
1 event can affect up to 400 ha and damage 200 households

North-South
Higher damage in the North (higher population)

For each community

IDENTIFY FACTORS : DATA EXTRACTION

From local to scientific knowledge

Identify factors that lead to an increased flash flood hazard.

Local Knowledge

Root causes, aggravating factors

Meteorological signs prior to flash flood

Data extraction

DEM → Catchment delineation

STATIC
1. Geomorphology: Surface and morphometric characteristics

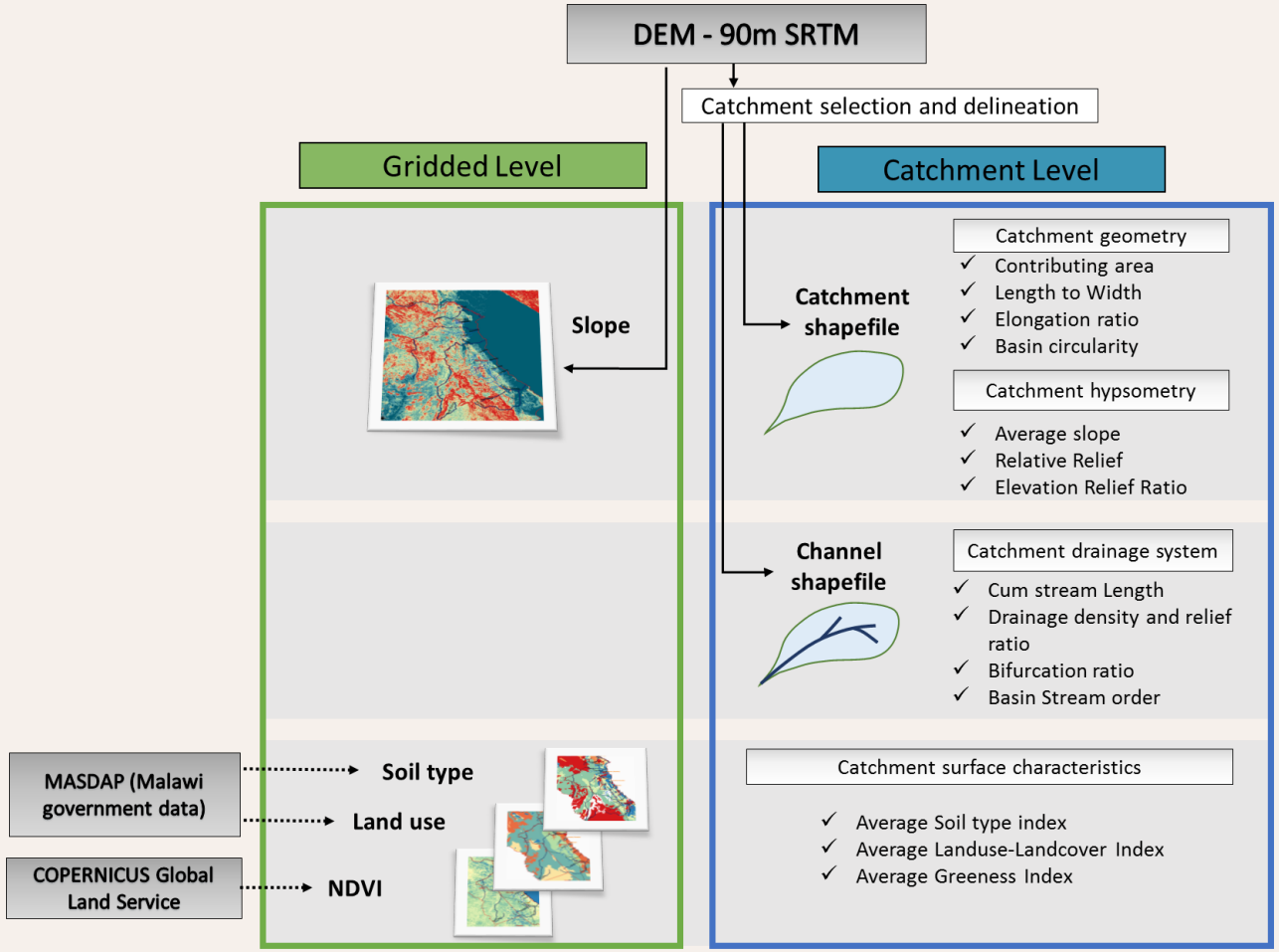
DYNAMIC
2. Precipitation
3. Large scale Hydro-Meteorological data

Root causes :
River sedimentation and deforestation
Proximity to escarpment
Soil type

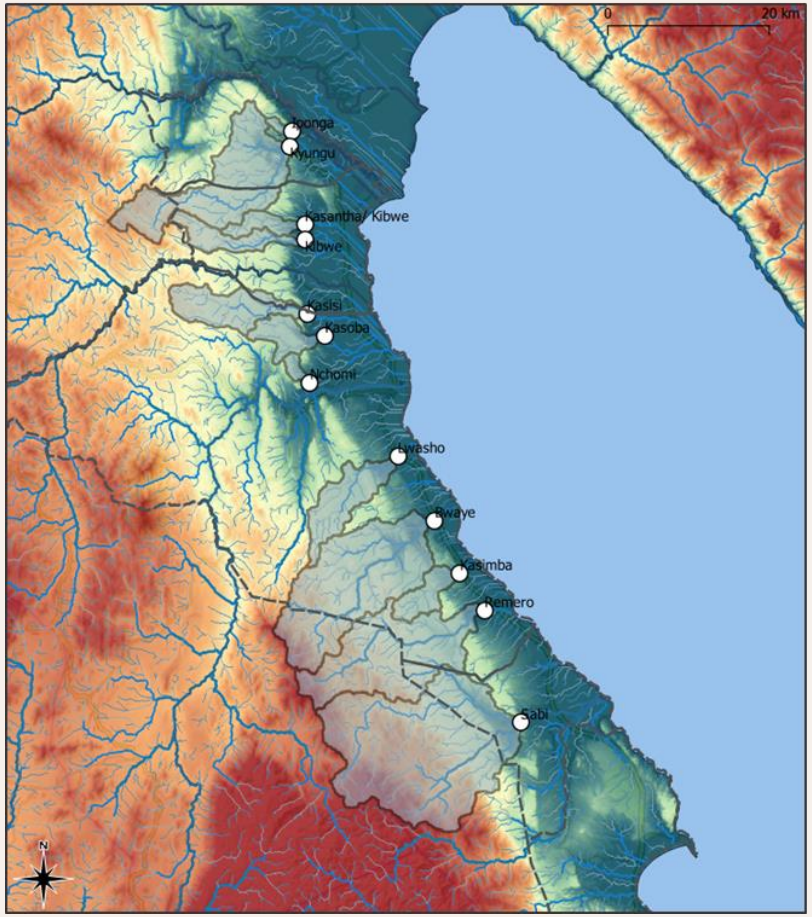
Meteorological signs :
Wind, cloud direction from South
Localized storm and thunders
Intense rainfall
Rise in temperature

RELATIVE CATCHMENT SUSCEPTIBILITY TO FLASH FLOODS

PCA for each catchment characteristic category

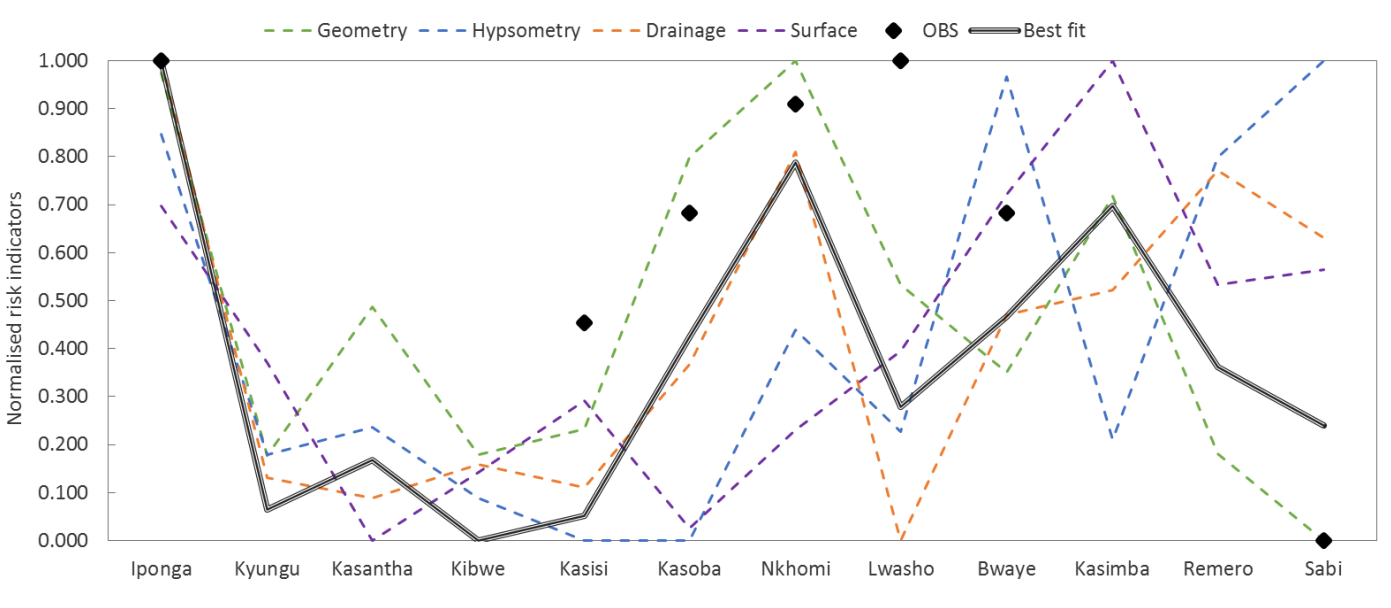


Delineation of 12 catchments in Karonga District



RELATIVE CATCHMENT SUSCEPTIBILITY TO FLASH FLOODS

Comparison with local knowledge using flash flood frequency



Catchment surface characteristics

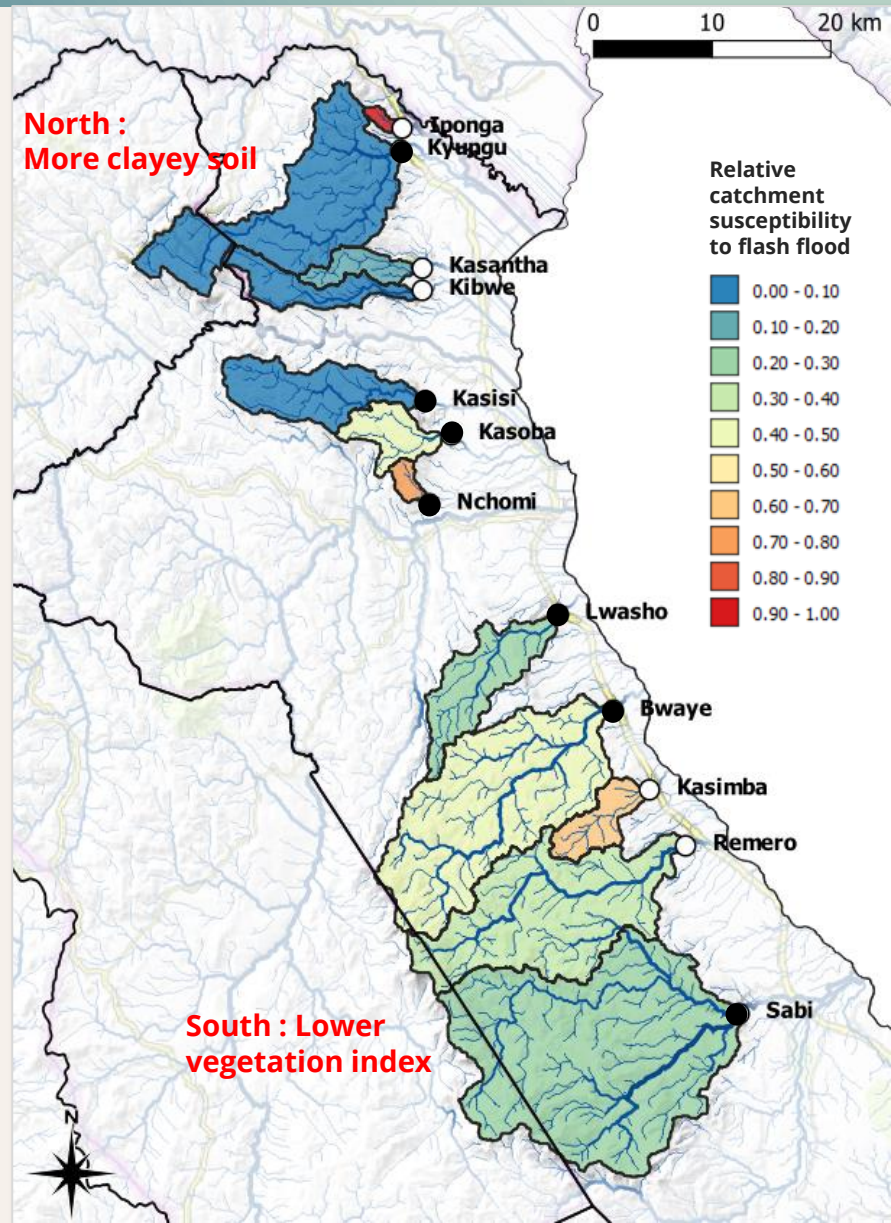
More clayey soil type in the North.

Bare vegetation in the South at the beginning of the wet season

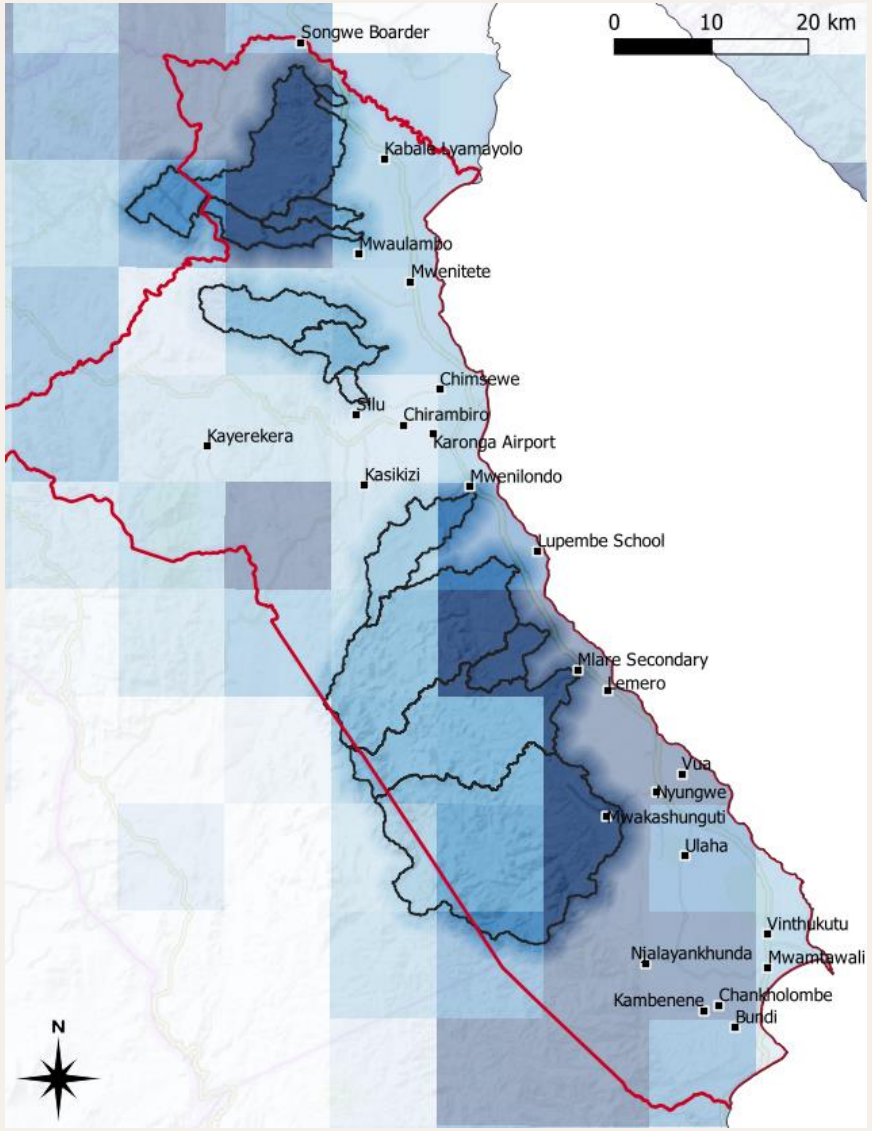
Catchment geometry

Smaller and more circular catchments have higher FF susceptibility.

Time of concentration: 40 minutes to 4 hours



HISTORIAL EXTREME RAINFALL ANALYSIS



Precipitation Dataset

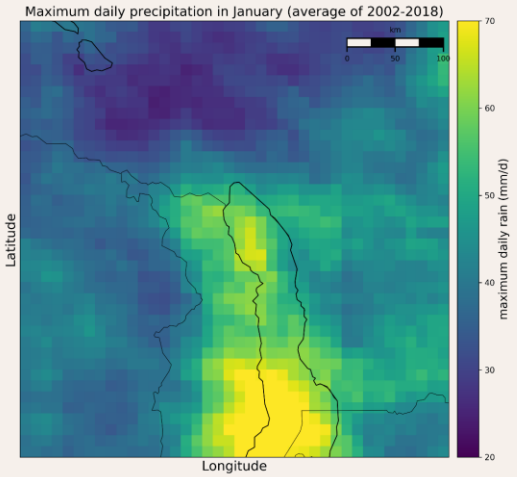
- raingauges
- GSMaP dataset
- Catchments
- Karonga District

GSMaP dataset (Global Satellite Mapping of Precipitation) : JST-CREST and the JAXA Precipitation Measuring Mission (PMM).

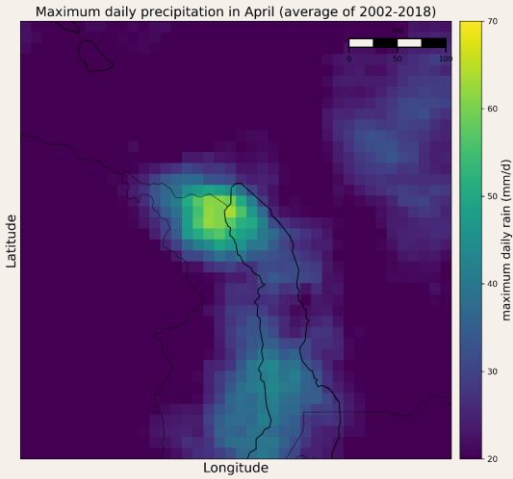
Hourly data

0.1°

January
Max daily rainfall



April
Max daily rainfall



January

More intense, frequent events in January

Smaller scale events

April

Mainly in the North

Larger scale longer duration

LARGE SCALE HYDRO-METEOROLOGICAL ANALYSIS

ECMWF ERA5

Climate Reanalysis model : 2000-2018

Resolution : 0.25°, hourly

Local Knowledge

Different Hydro-meteorological conditions beginning/end of the wet season

JANUARY :
Maximum atmospheric instability, high RH, weaker and variable winds
= risk for convective localized storm

APRIL :
Strong and constant wind pattern from the South
= Orographic rainfall in the North.

ERA5 standard daily average (2000-2018)

2m Air Temperature

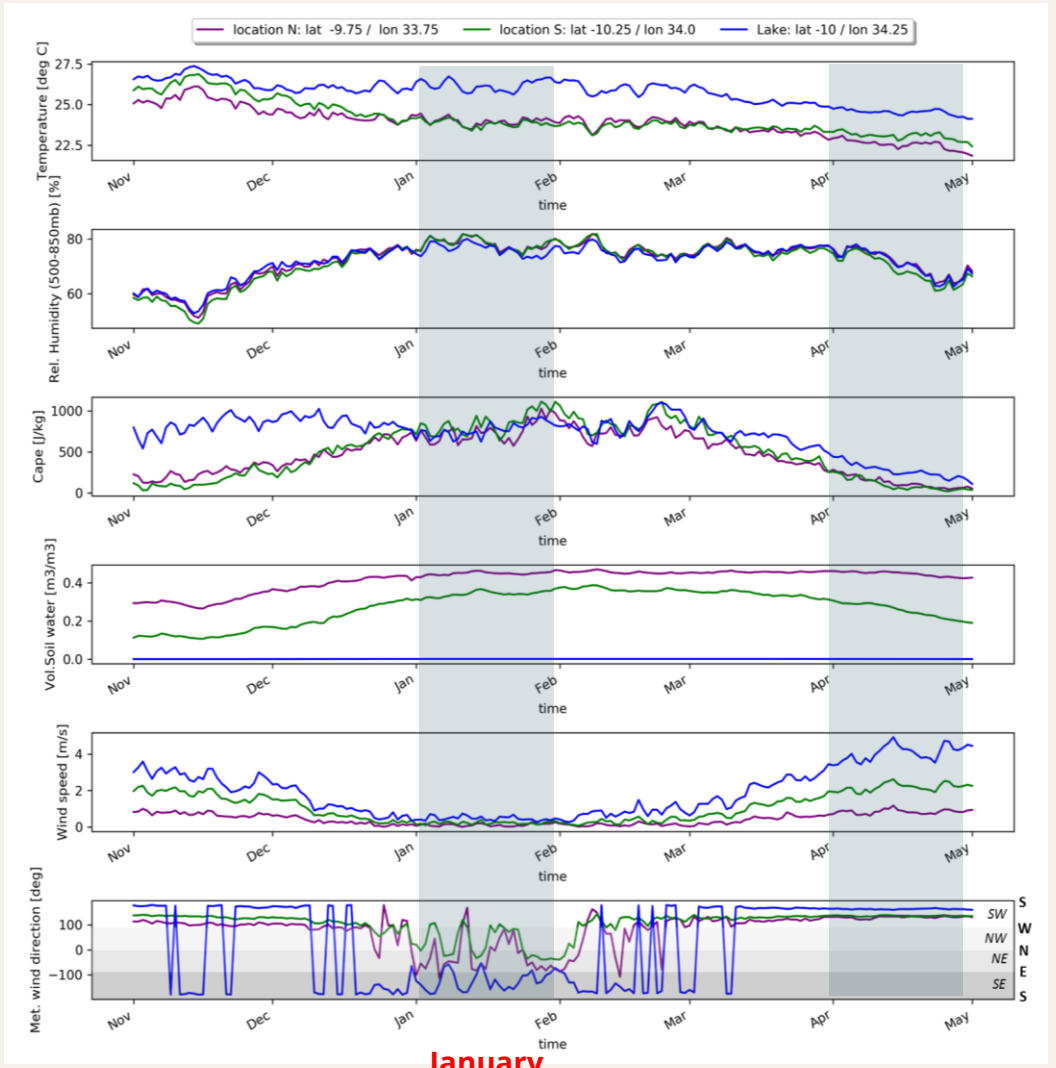
Relative humidity

CAPE

Volumetric Soil Water (top 7cm)

Wind speed

Wind direction



January
ITCZ above Malawi

HYDRO-METEOROLOGICAL PREDICTIVE INDICATORS

List of historical flash flood events

Most predictive Hydro-meteorological indicators

Time-series

Statistical extreme statistics

Rainfall indicators

- The maximum hourly rainfall during event
- Antecedent rainfall at the end of the wet season

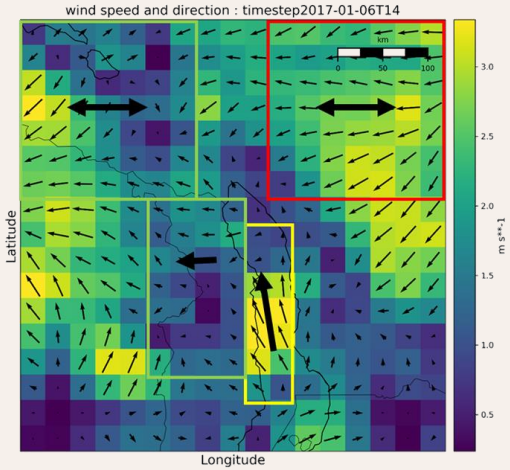
Large scale antecedent meteorological indicators

RH, CAPE and Wind for the early wet season.

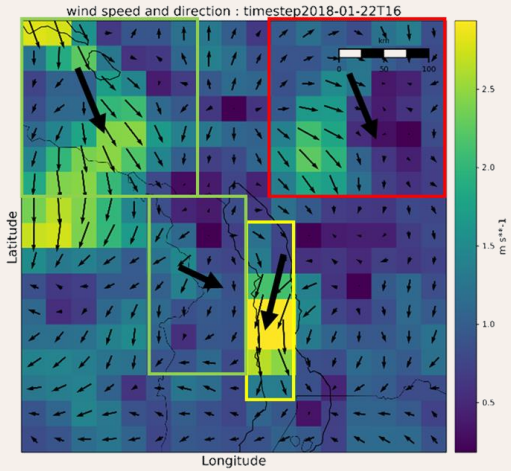
- 1 day RH
- 3 days CAPE
- Wind as a condition for spatial distribution

January FF events

Pattern for FF affecting the North

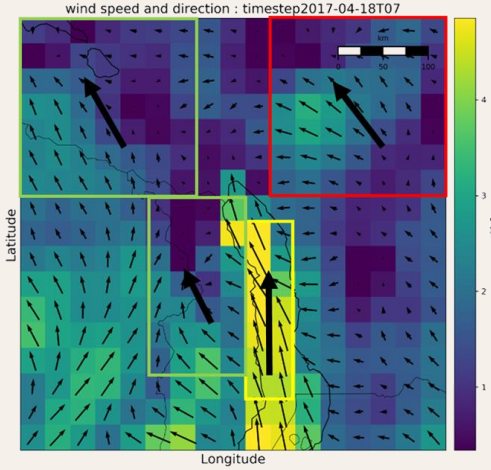


Pattern for FF affecting the South

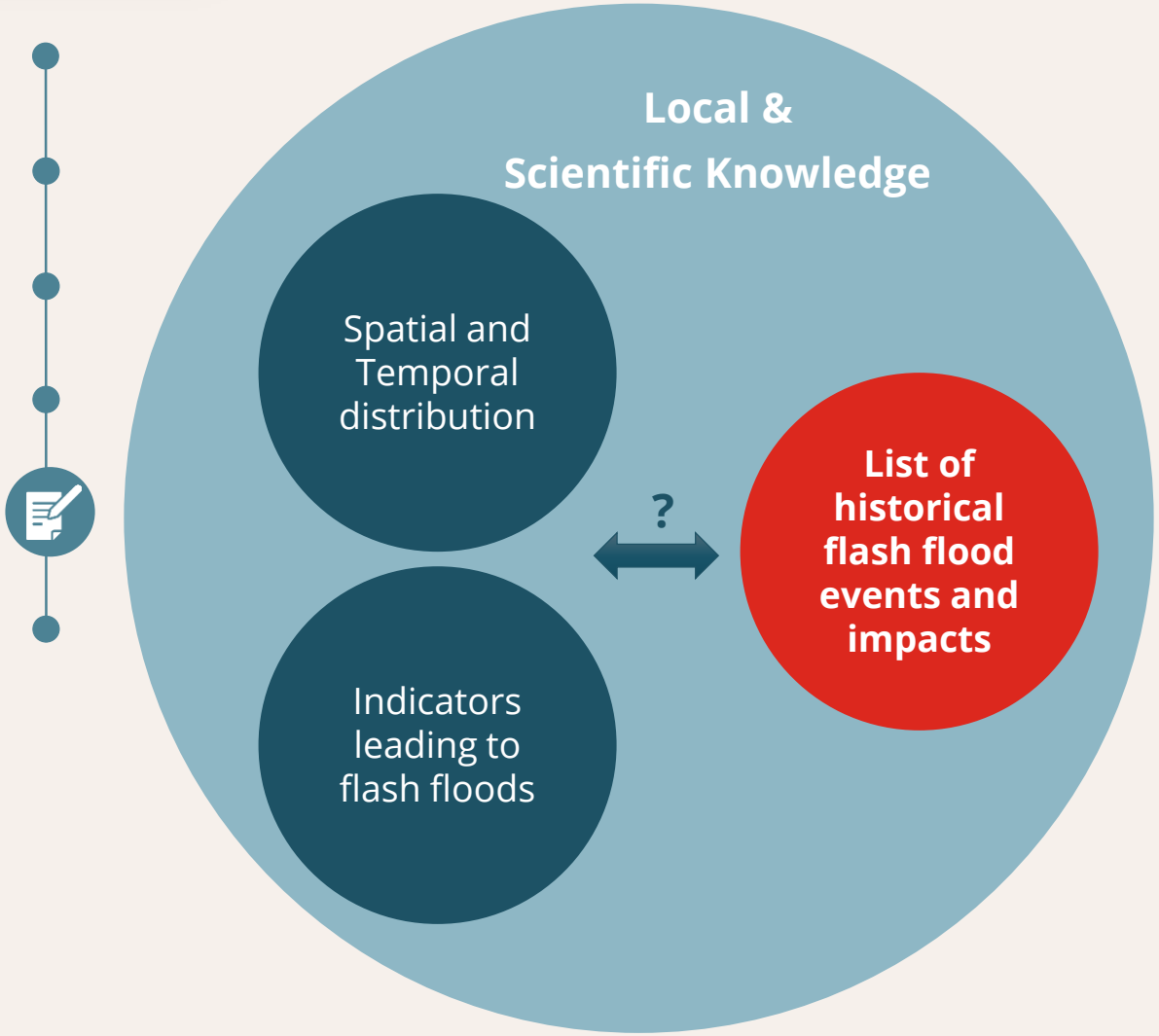


April FF events

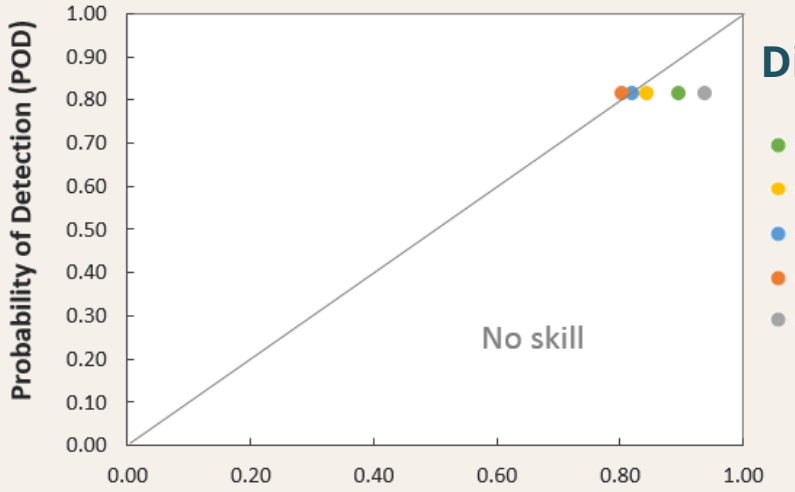
FF affecting the North only



PREDICTING FLASH FLOODS

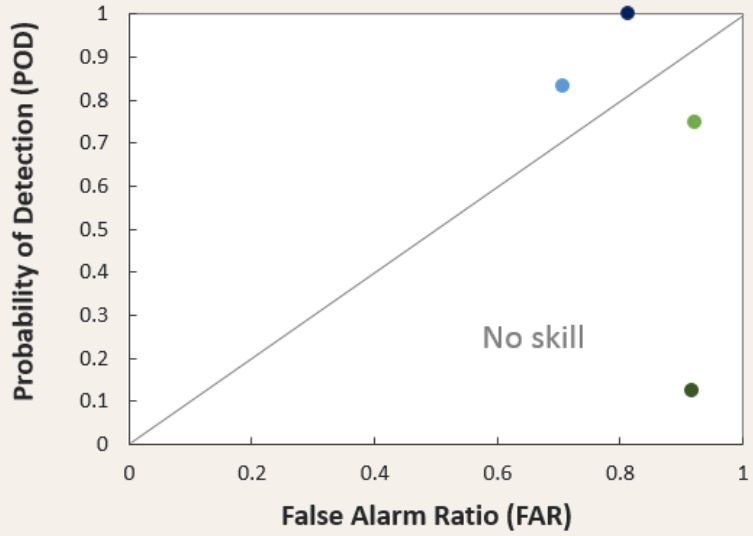


Simple skill score method
FAR, POD, POFD computed at different scales



District scale

- Case 1 : peak rain 16 mm/h
- Case 2 : adding antedent 1d rainfall
- Case 3 : adding antecedent 3d CAPE
- Case 4 : adding antecedent 1d RH
- Case 5 : antecedent only



North vs South

- Case 4 North
- Optimised North
- Case 4 South
- Optimised South

CONCLUSION

Local knowledge confirmed by geomorphological and hydro-meteorological diagnosis → valuable information for early warning

Characterization of flash flood risk:
Disaster data gap
Documenting local knowledge

Factors Increasing flash flood risk:
Spatial and temporal diagnosis using local & Scientific knowledge

Predictability of flash floods :
Spatial and temporal scale to consider for early warning

Further work :

Disaster data management

Work closely with meteorologists

- Extreme rainfall forecast
- Toward impact prediction
- How to apply this to FbF

Thank you for your attention

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