TRAINING ON

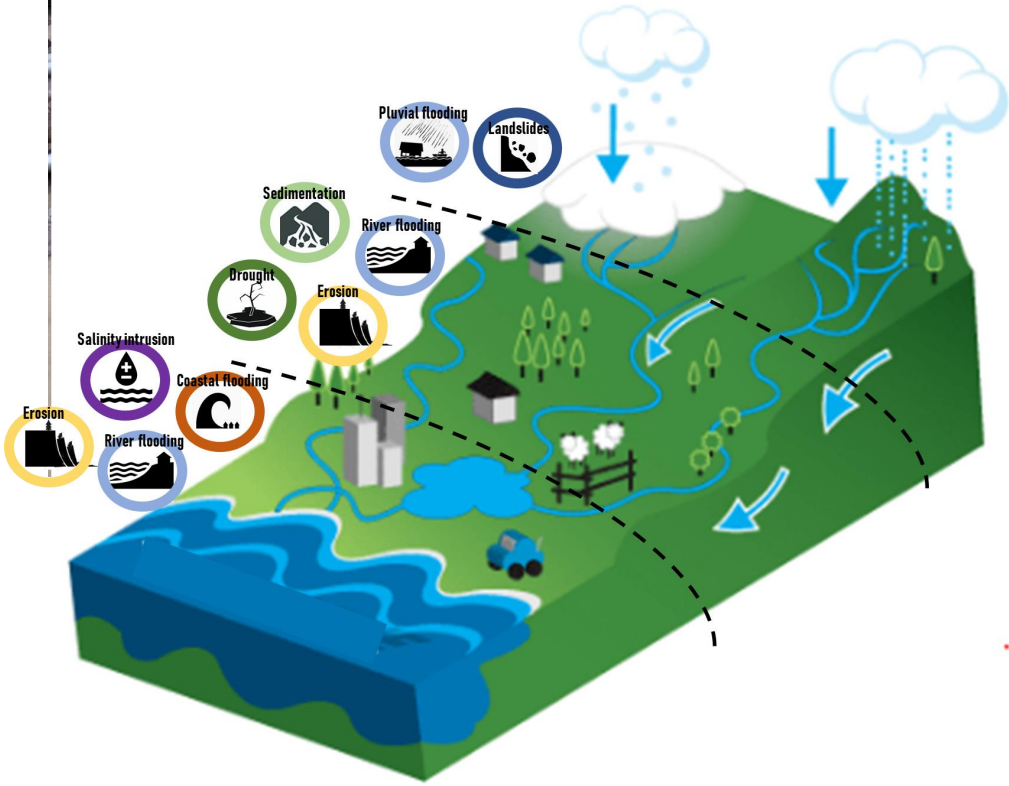
PREPARATION AND APPRAISAL OF INTEGRATED FLOOD RISK MANAGEMENT PROJECTS FOR NFPP-IV

26-28 MARCH 2024

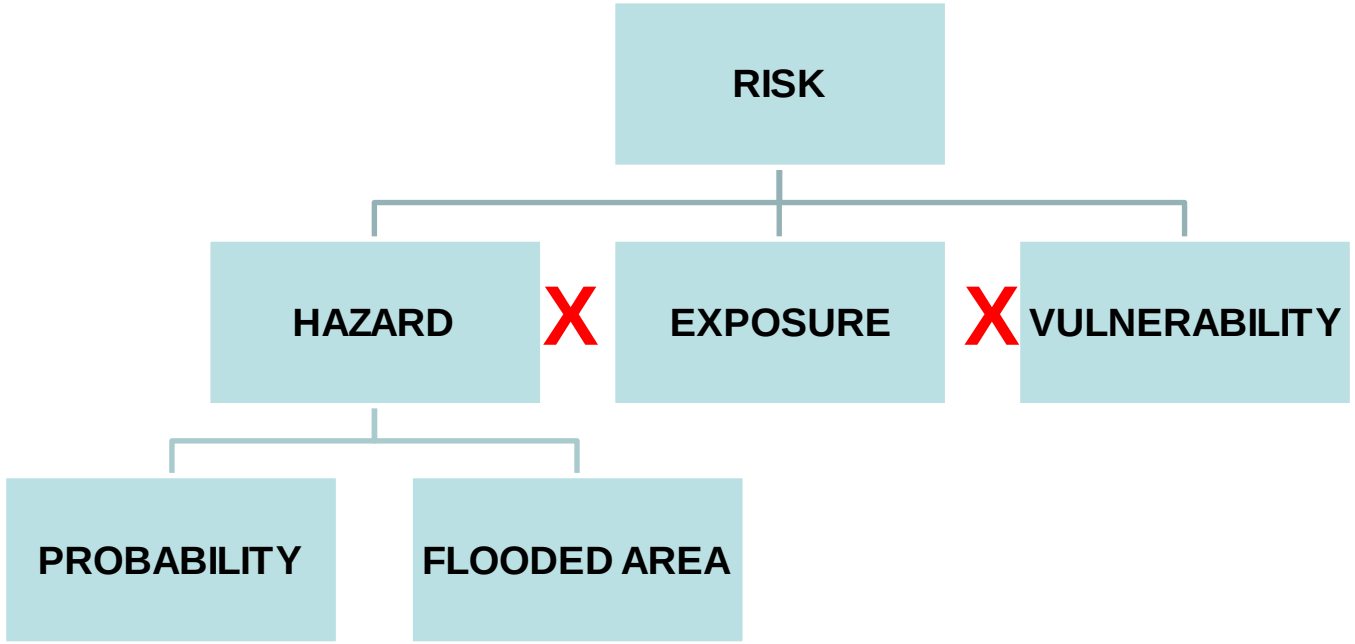
INTEGRATED FLOOD MANAGEMENT-HAZARD VULNERABLITY AND RISK MAPPING USING GIS/RS

IFRM

- Devastating impacts from recent flood events indicate a paradigm shift is needed
- IFRM provides more options to reduce flood risk compared to a strategy focusing mainly on flood protection
- IFRM will make projects more “bankable”
- IFRM reduces “lock-ins” where risk is increasing continuously and limitations in protection become more and more problematic
- There appears to be wide support for IFRM from federal and provincial agencies



Flood risk framework

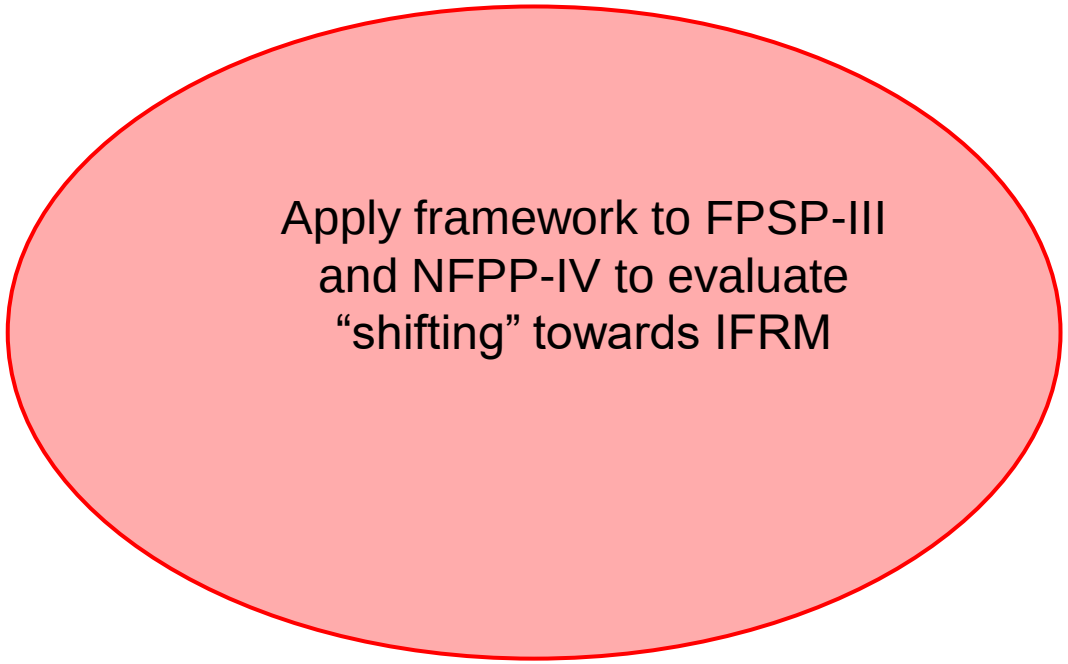


Hazard: Probability and magnitude of flood events

Exposure: Assets and population at risk particularly socially vulnerable groups

Vulnerability: Exposure losses if a flood event occurs

Integration dimension	FRAMEWORK FOR Integrated Flood Risk Management (IFRM)		
	Flood Hazard	Flood Exposure	Flood Vulnerability
• Basin level integration			
• Stakeholder integration			
• Vertical integration			
• Horizonal integration			
• Multi-sector integration			
• Temporal integration			



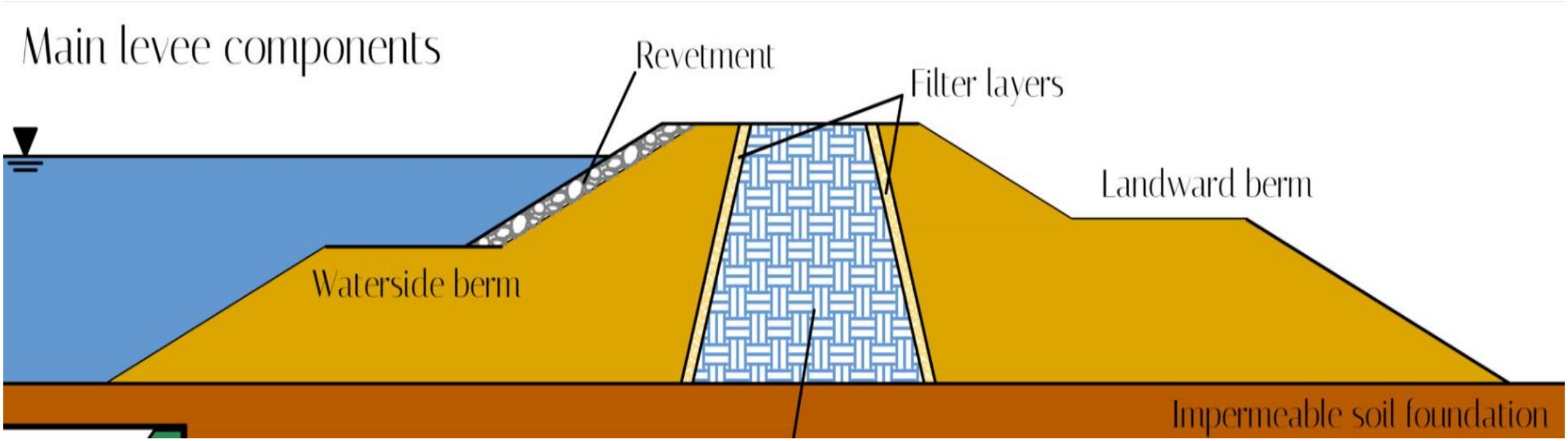
Expansion and enhancement of NFPP-IV's scope

1. More focus on non-riverine flooding:
    - Glacial lake outbursts
    - Flash floods in hill torrents
    - Coastal flooding
    - Pluvial&urban flooding
    - Tsunamis
2. Impacts of sea level rise and climate change
3. Land use change and planning in the context of population growth
4. Nature-based solutions

Objective flood frequency analysis

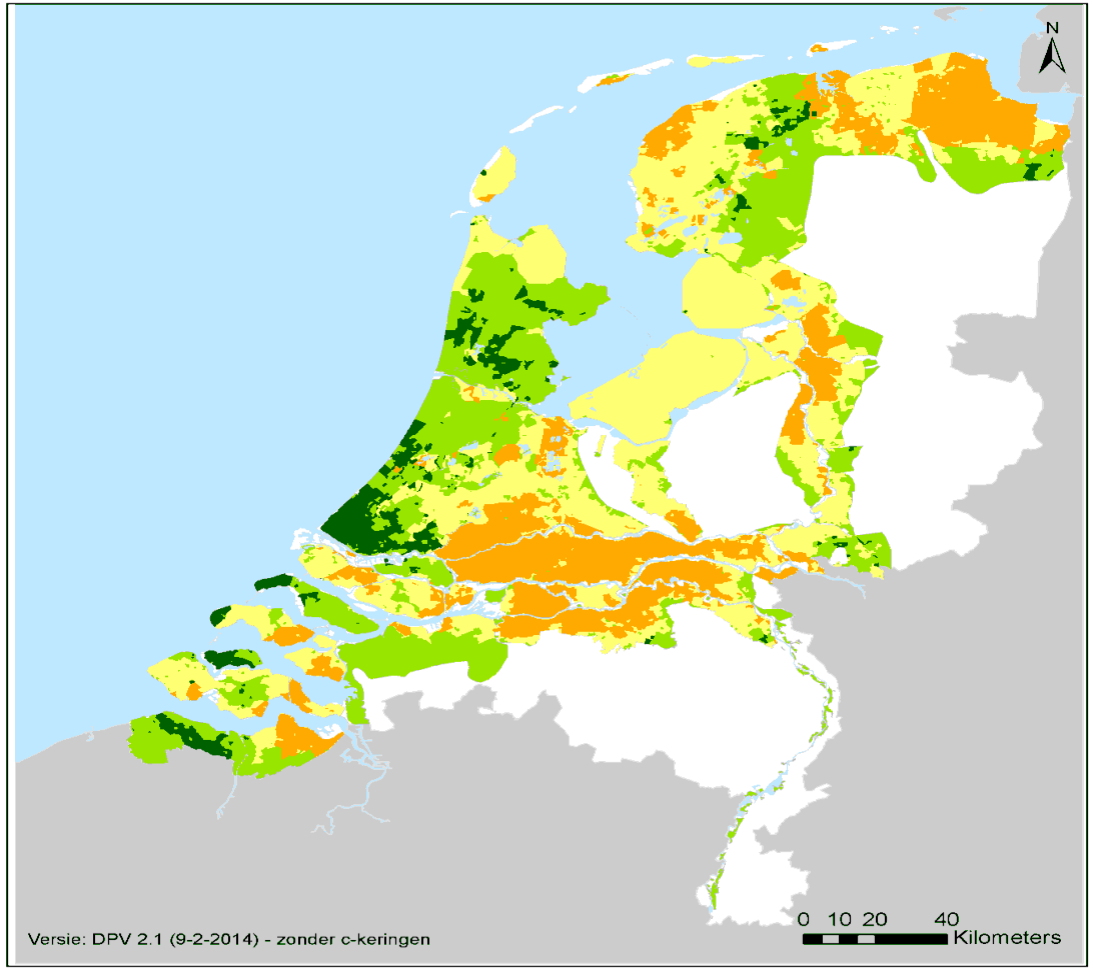
To derive probabilities (or return periods) of extreme river discharges rainfall needed for:

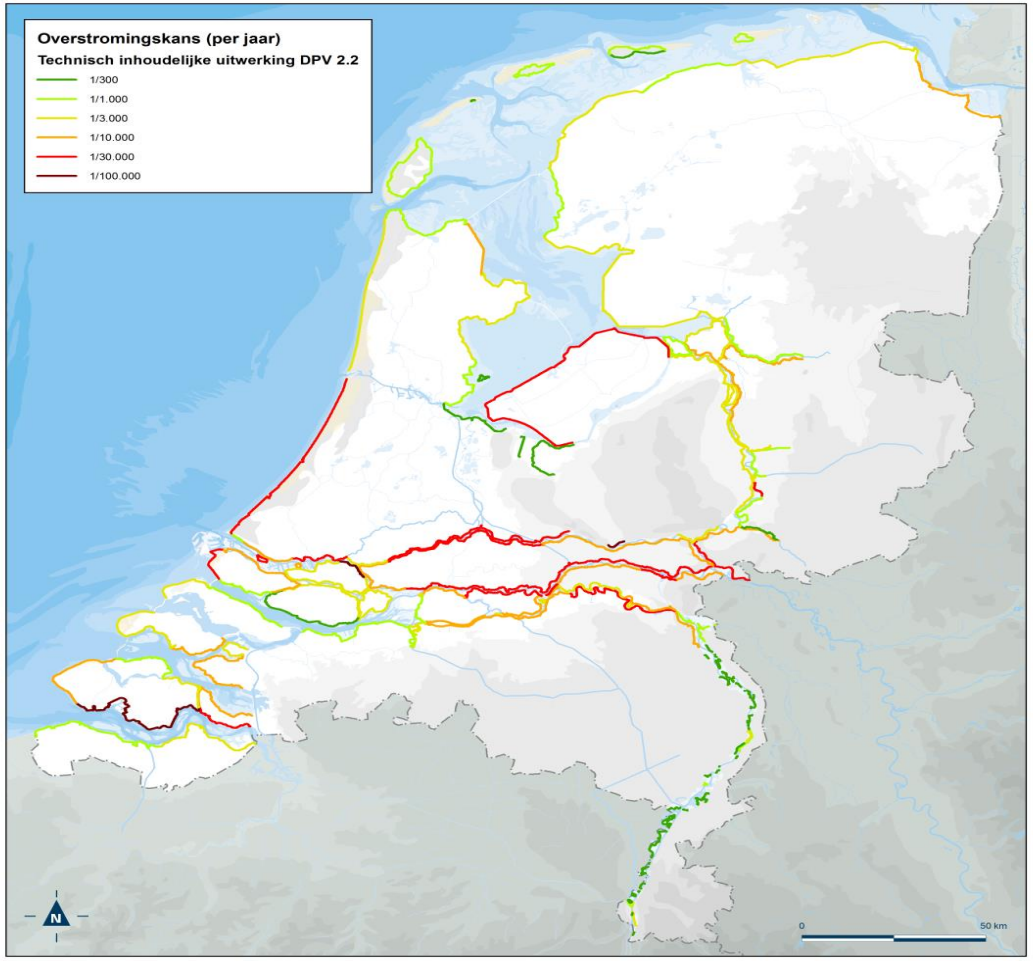
- Design of new structures
- Assessment of existing structures
- **Flood hazard and flood risk analysis of cities / communities**



Risk based safety standards

- Typically, the 100-year discharge is taken as the design event (safety standard)
- With risk in mind, the safety standard should depend on the potential impacts of a flood event





Ungauged catchments

Frequency analysis rainfall

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Hydrologic & hydraulic modelling

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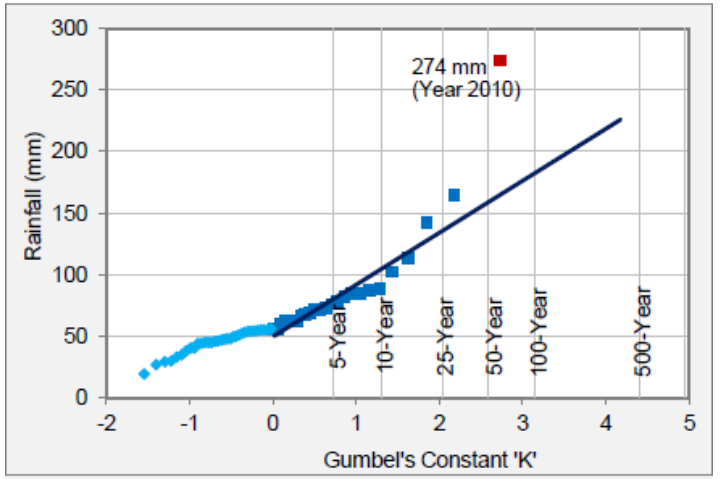
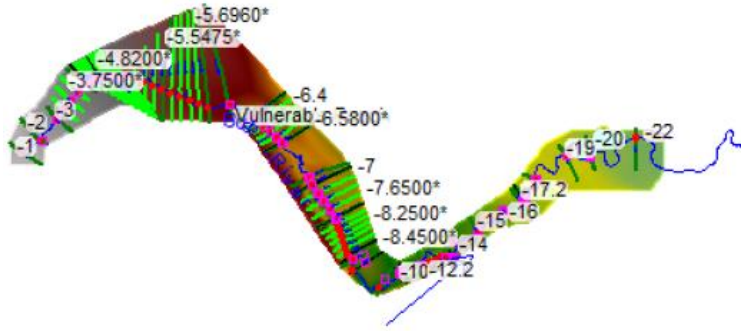
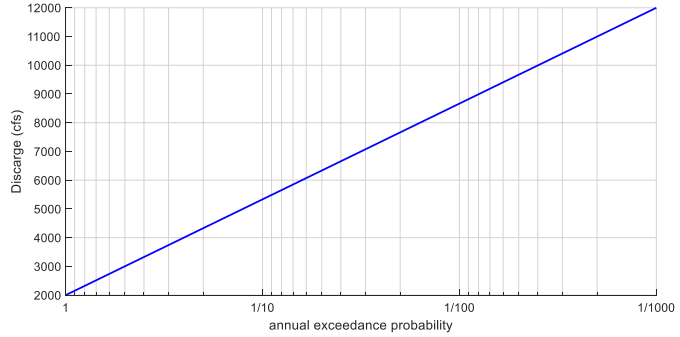
Frequency curve discharge







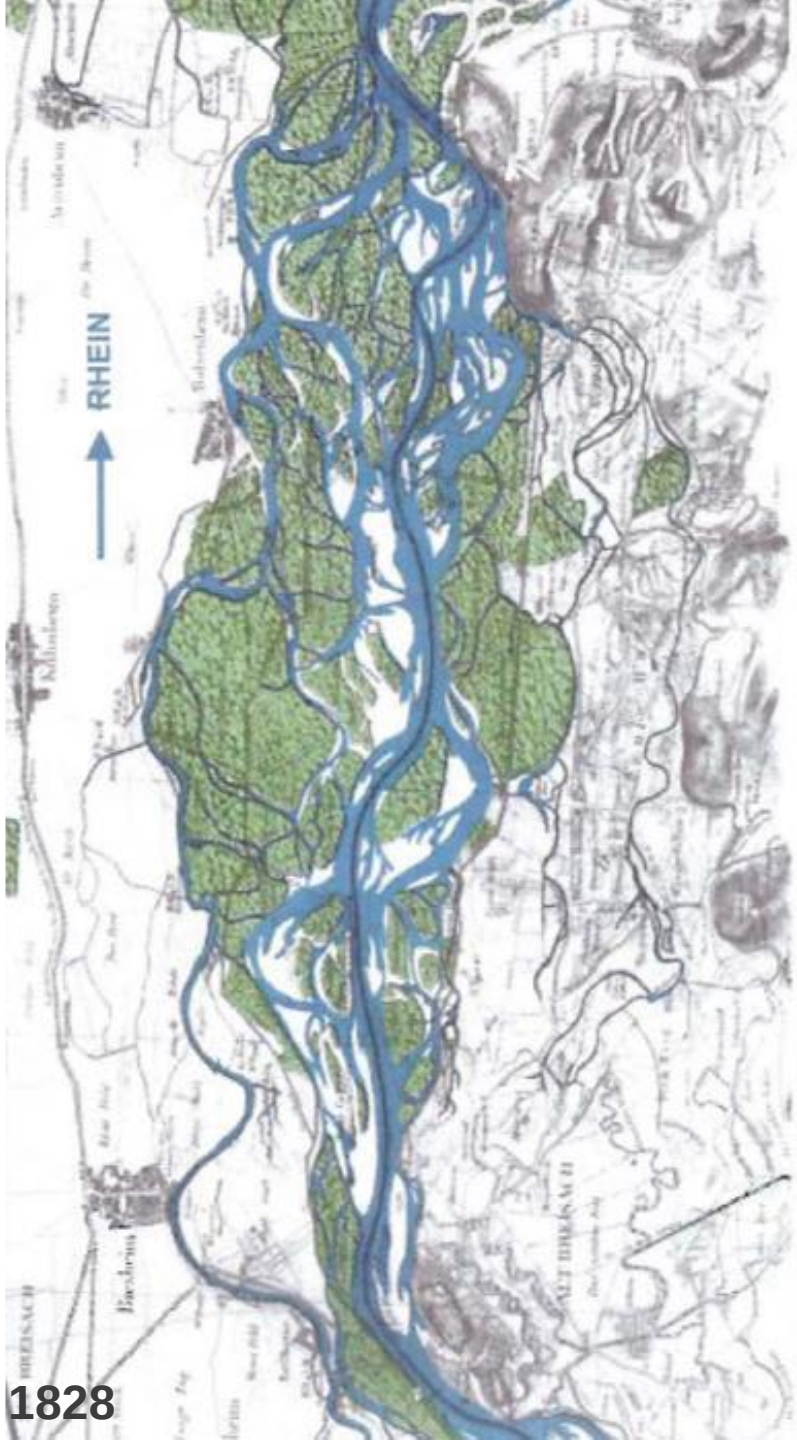
Rainfall-runoff approach

Rainfall analysis

- Daily rainfall -> hourly rainfall
- Orographic effects
- Station rainfall -> catchment rainfall
- Snow fall and snow melt

Runoff modelling

- Manning equation (uniform flow)
- Hydrologic modelling to estimate peak discharges



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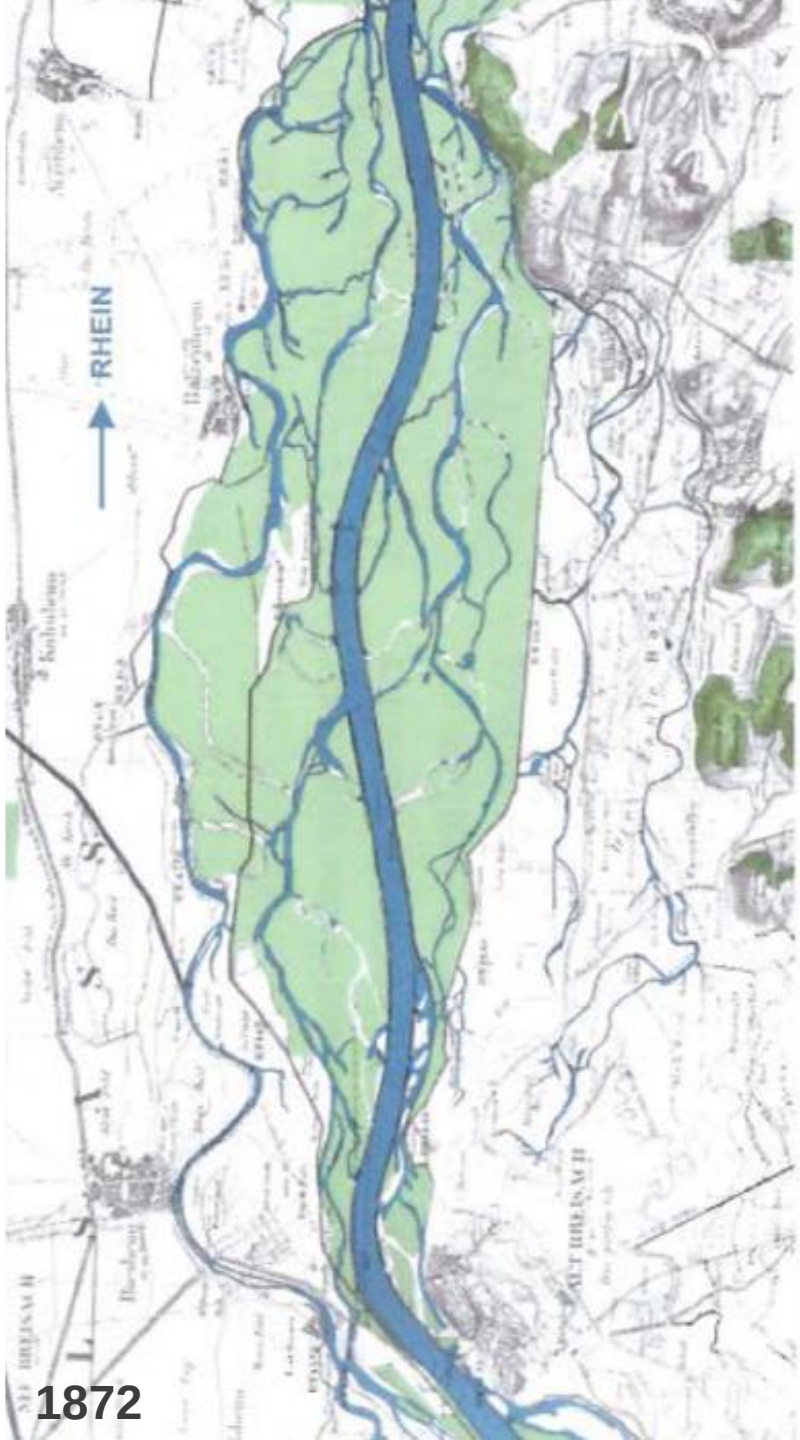

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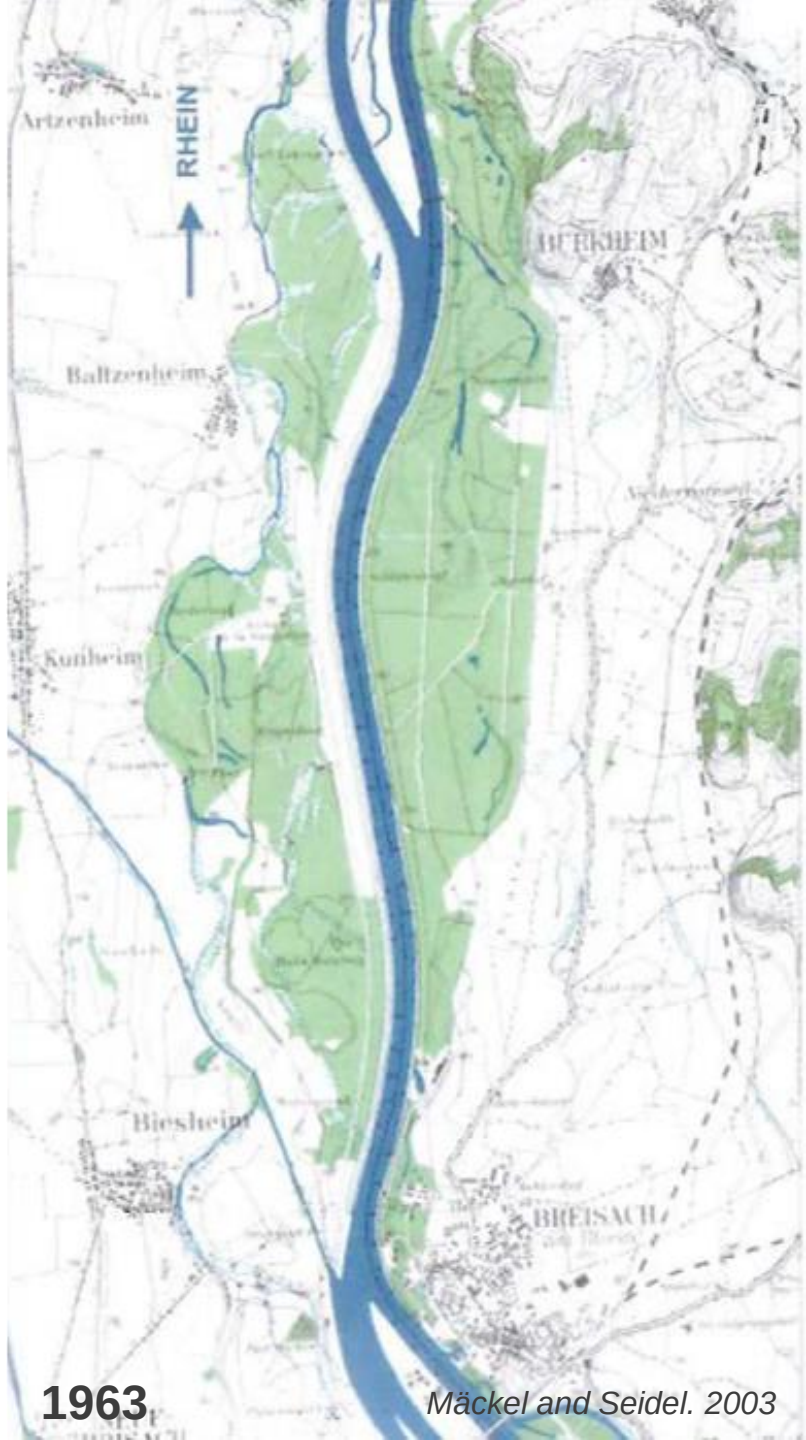

1963

Mäckel and Seidel. 2003

IFRM Framework

NRM APPROACH

Step 1: Definition of goals and objectives

Step 2: System analysis

Step 3: Selection of hotspot areas

Step 4: Selection of NbS

Step 5: Impact and economic analysis

Step 6: Prioritization of interventions

Step 7: Implementation

Step 8: Maintenance and monitoring

River function	Objective
Nature	• Ensure flows of freshwater and sediment to sustain downstream livelihoods, ecosystem services and biodiversity
Flood risk	• Decrease vulnerability of people to flooding through targeted, sustainable and long-term strategies per river section
Other functions	• Accommodate other functions but minimize interference with natural river behavior as much as possible

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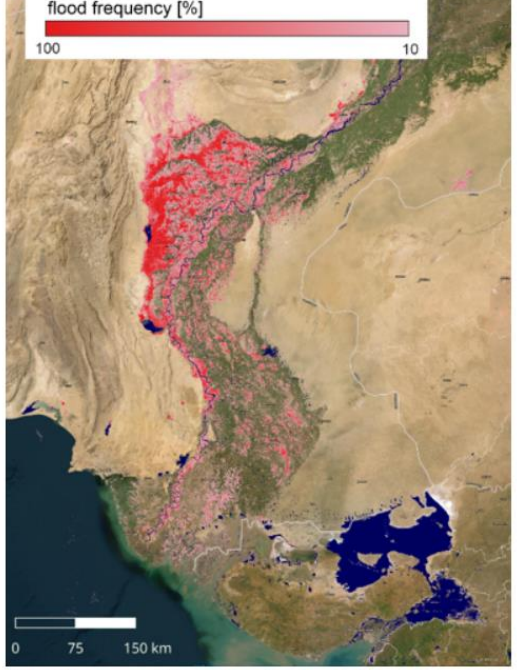
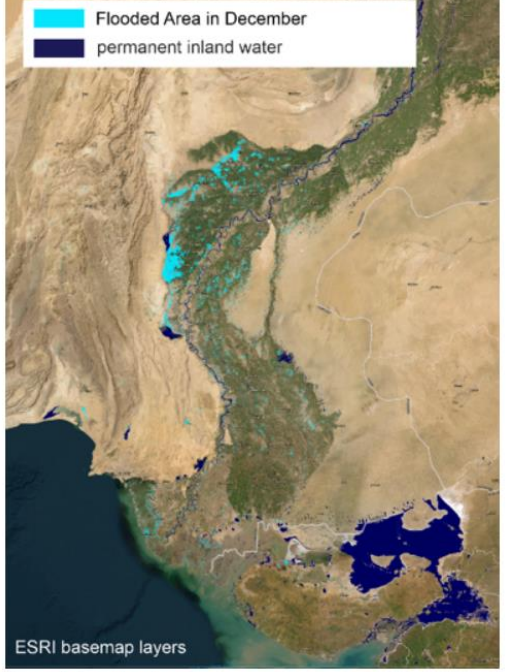


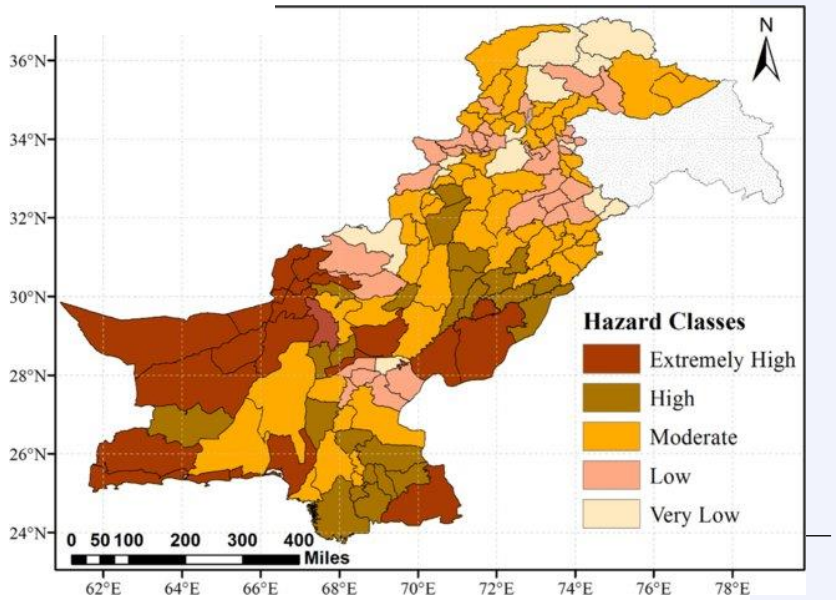
Flood frequency | Pakistan / Indus Valley.
Frequency of flood detection in period 18 August - 23 September 2022.



Remaining flood area.
Flood area remaining in period 1 December - 15 December 2022.

Source: https://www.eumetsat.int/features/towards-better-flood-and-drought-monitoring

Dynamics in space and time



Drought hazard map showing the vulnerability index for each district of Pakistan
Source Adnan&Ullah, 2020 https://link.springer.com/article/10.1007/s11069-020-04116-3

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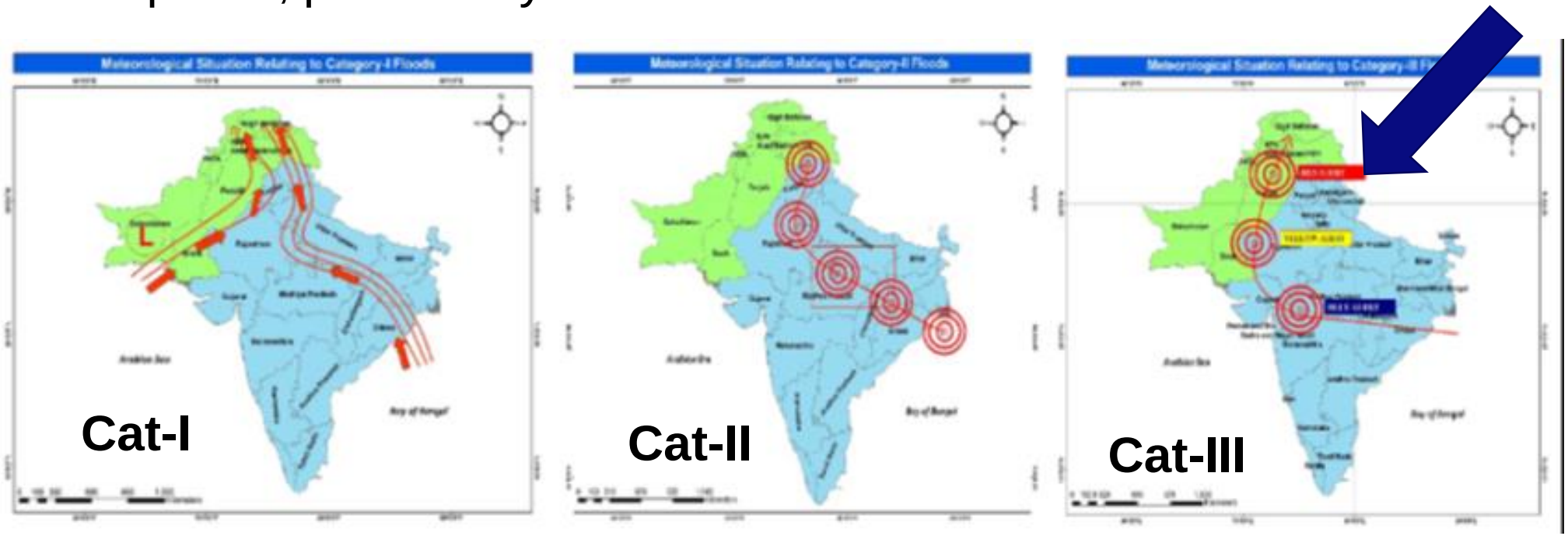
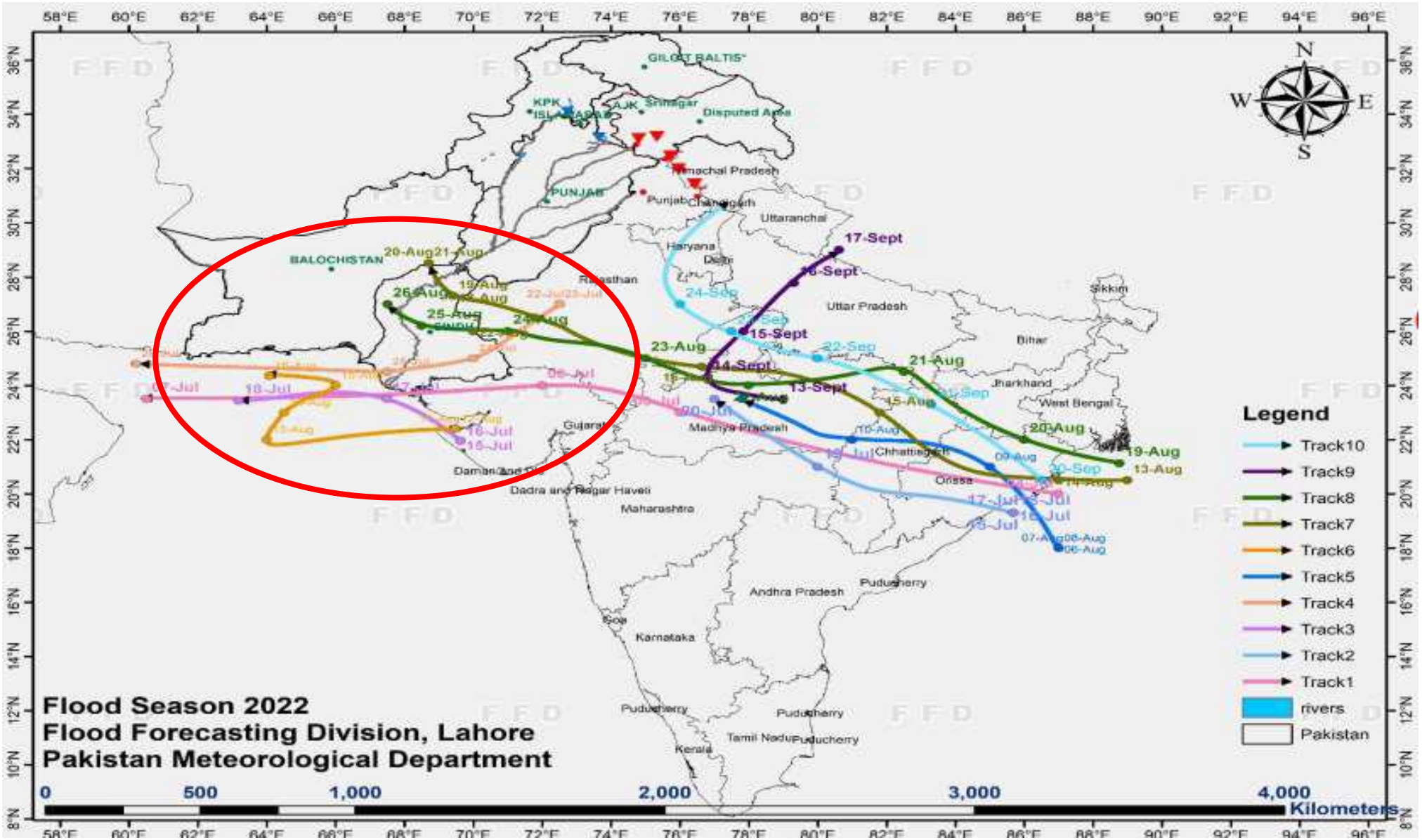
2022 flood mechanisms –Peculiarities of the 2022 flood event

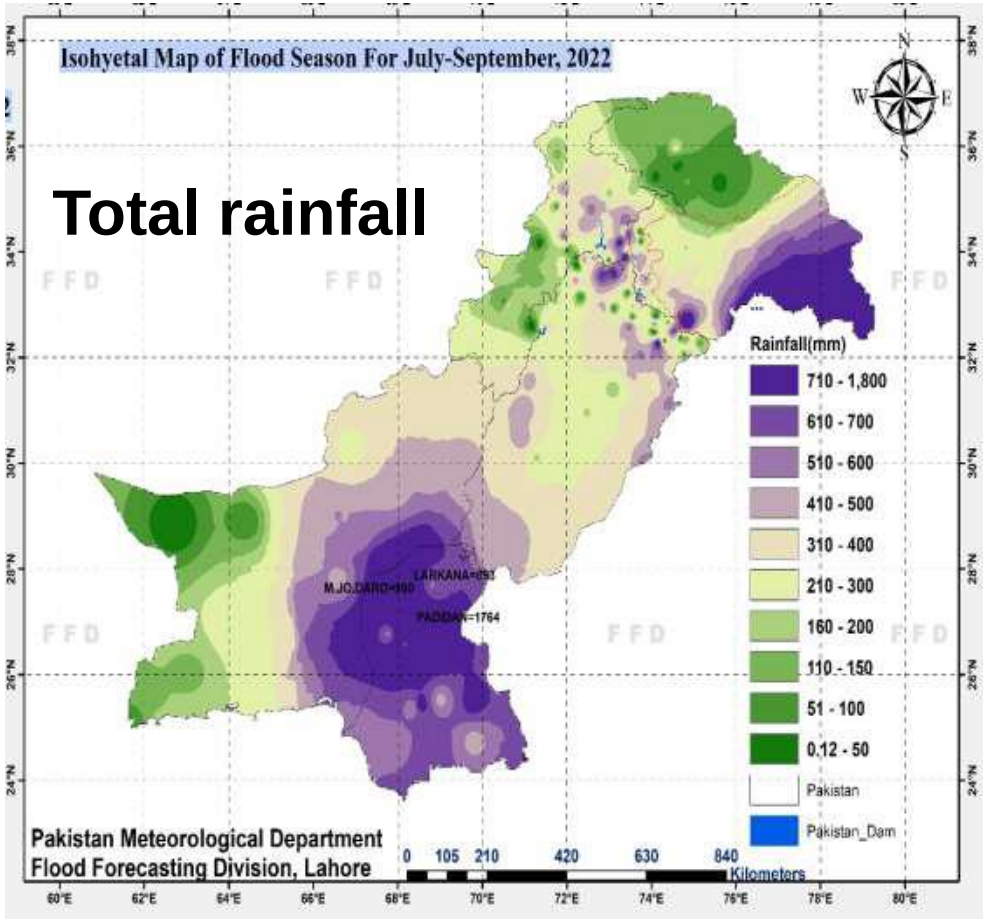
- Monsoon track typical “Category-III”, with unexpected western course of the storms, *but not an unknown type of monsoon track*
- Unusual high discharge from the hill torrents, and unusual high direct rainfall on the floodplains, particularly in Sindh and Balochistan

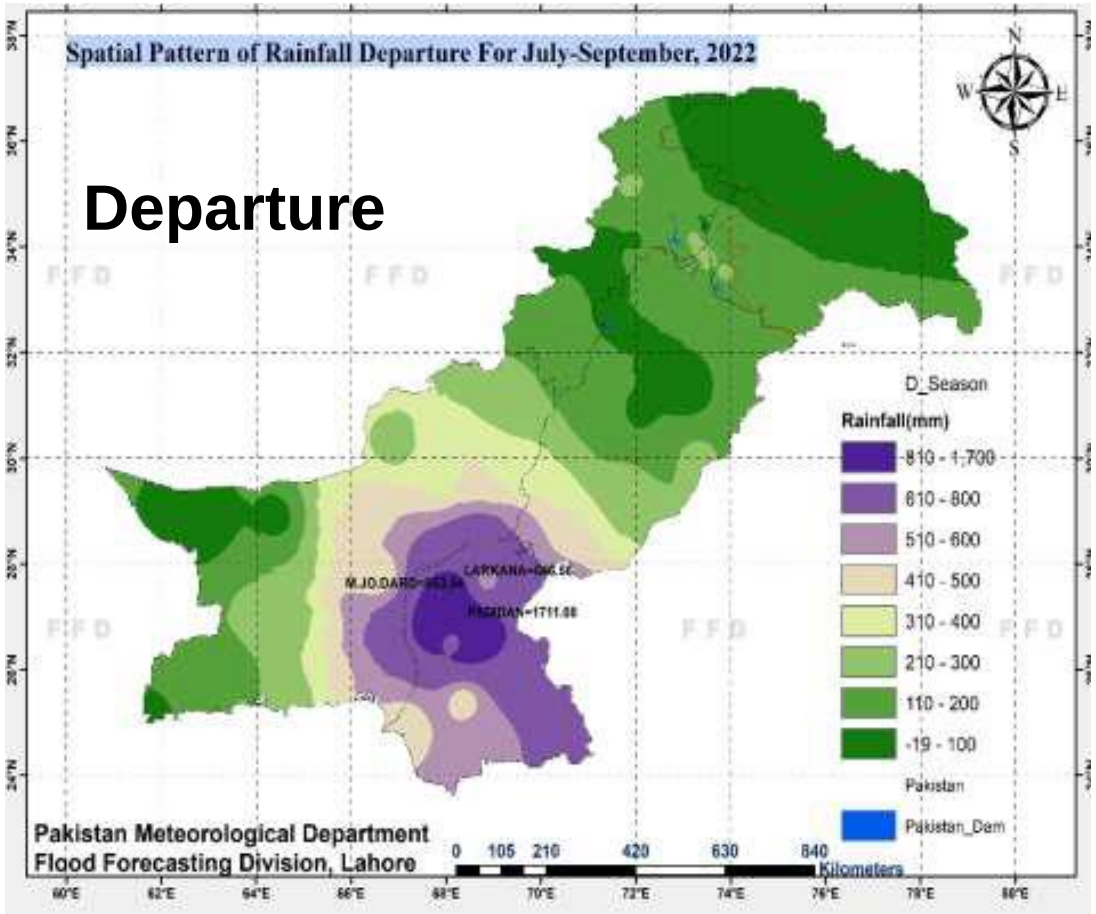


Movement of monsoon depressions in 2022



Total rainfall and rainfall departure (July – Sept. 2022)





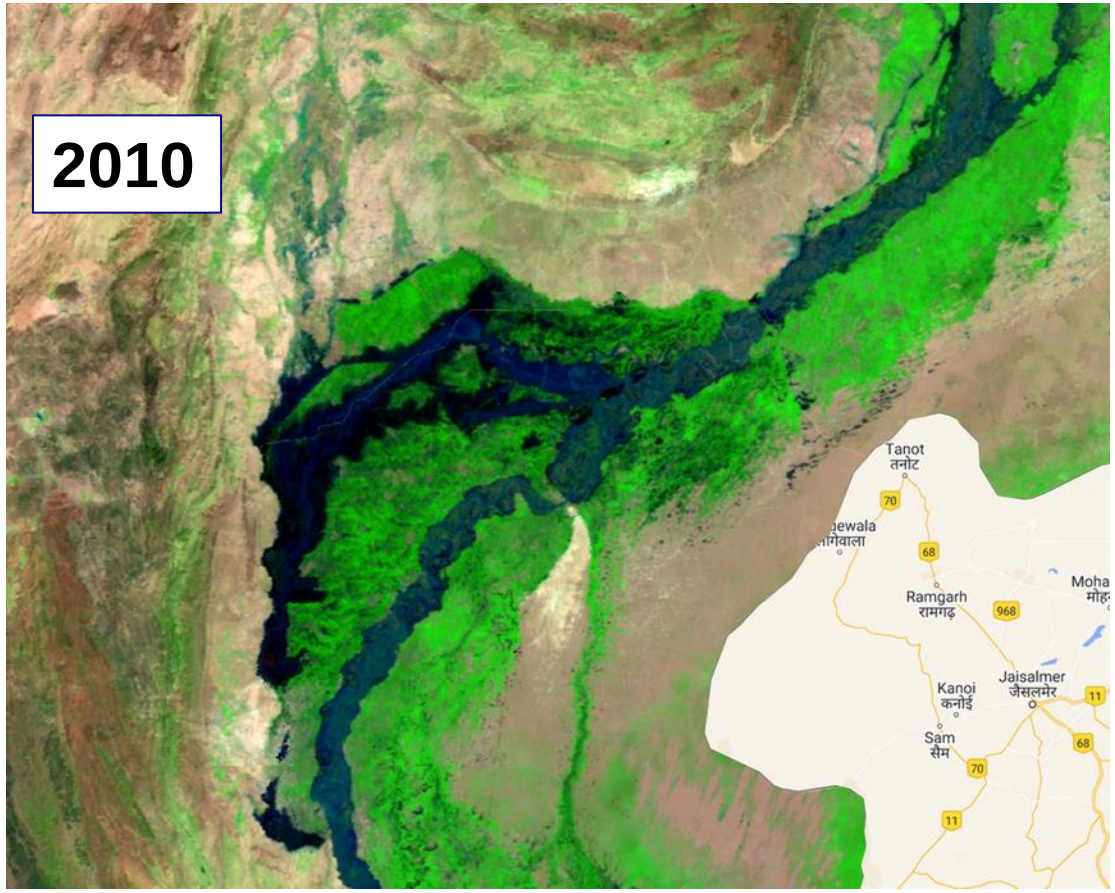
Max. discharge 2010 & 2022 floods compared to design capacity of barrages

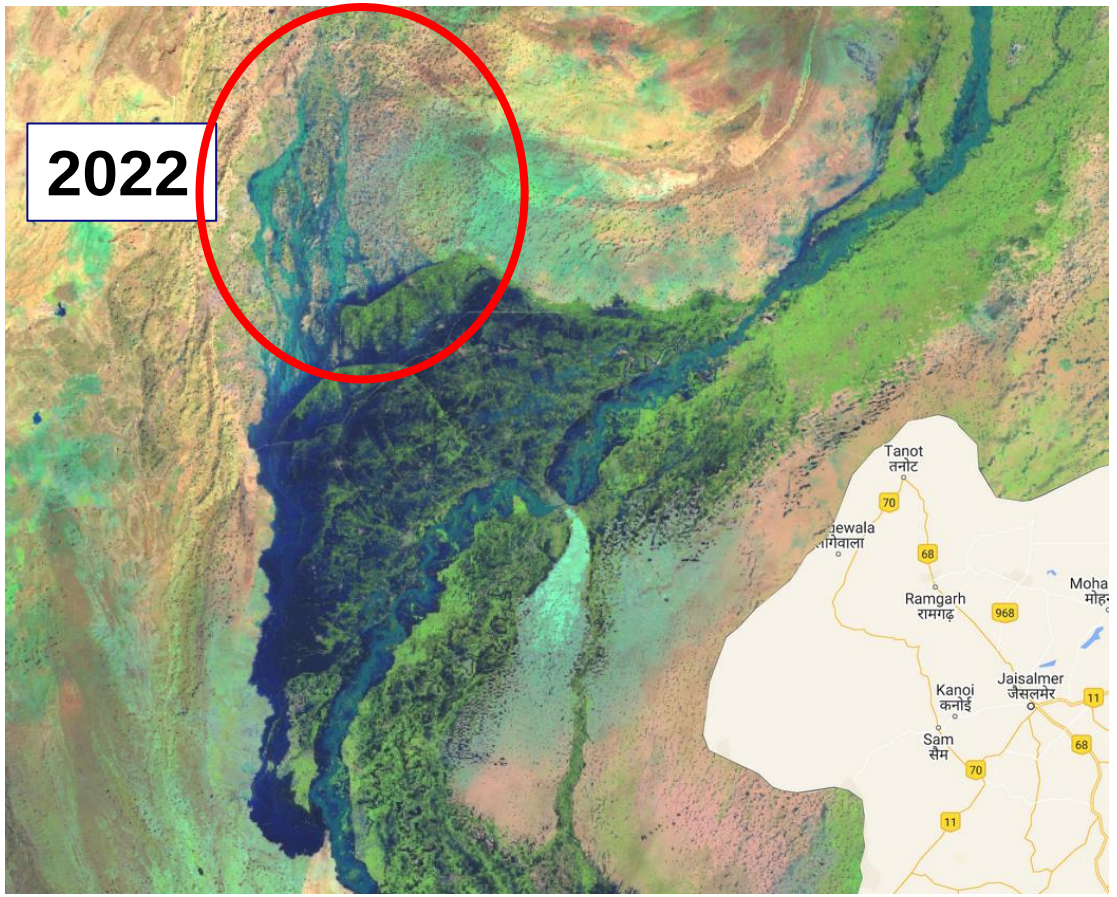
Site	Design capacity	Low	Med	High	V.high	Ex.high	*Max. 2010*	*Max. 2022*
Nowshera (Kabul river)	-	2124	2832	4248	5663	12743		**9019**
Tarbela	**42475**	7079	10619	14158	18406	22653	**17104**	**10616**
Chashma	**26901**	7079	10619	14158	18406	22653	**29356**	**14536**
Taunsa	**28317**	7079	10619	14158	18406	22653	**30724**	**17616**
Guddu	**33980**	5663	9911	14158	19822	25485	**32529**	**15807**
Sukkur	**25485**	5663	9911	14158	19822	25485	**32060**	**16417**
Kotri	**24069**	5663	8495	12743	18406	22653	**27323**	**16991**
Panjnad	**19822**	4248	5663	8495	12743	16990		**3187**

2010 **2022**

3187

Flood extent for 2010 and 2022 events (Sentinel-1)

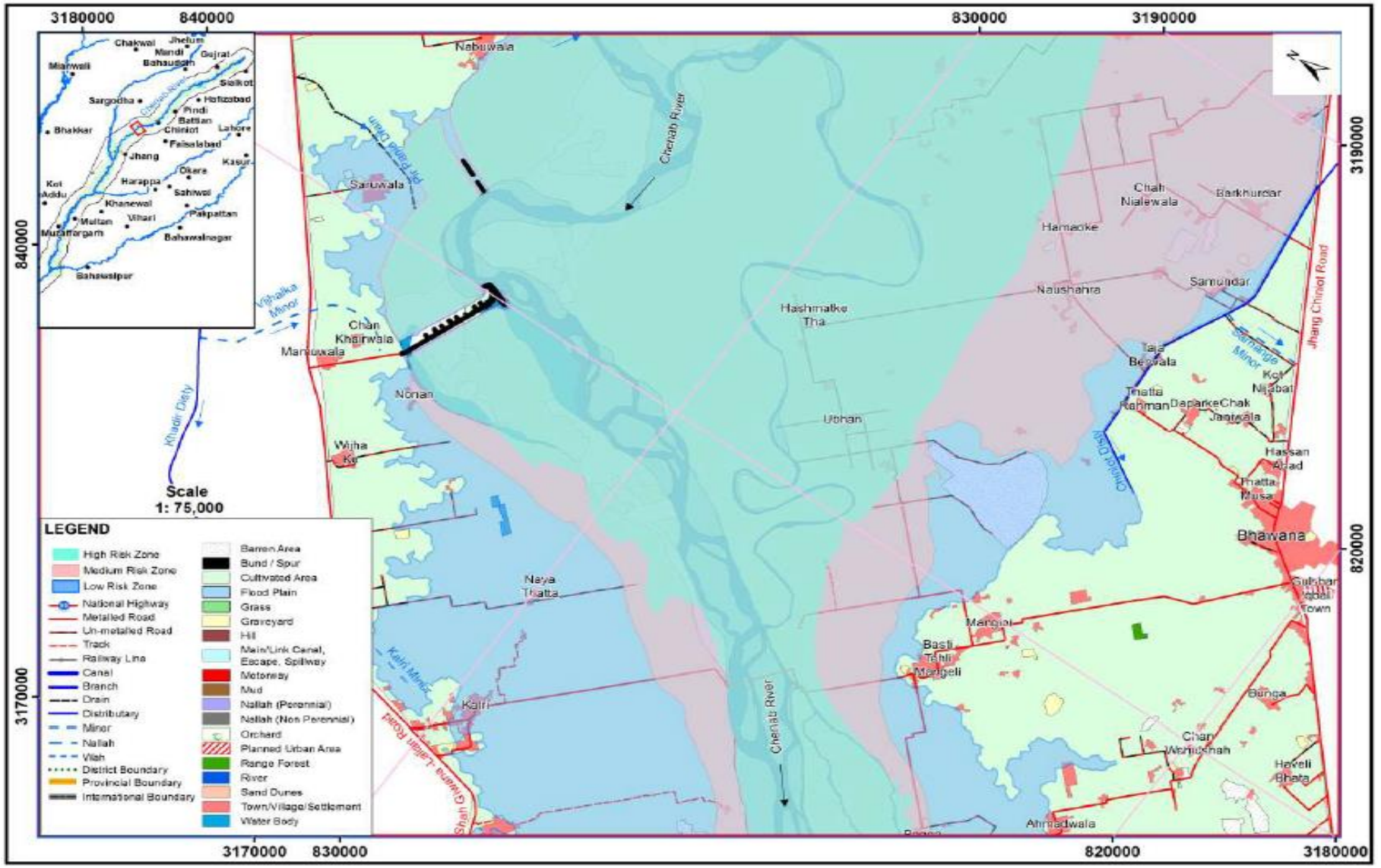




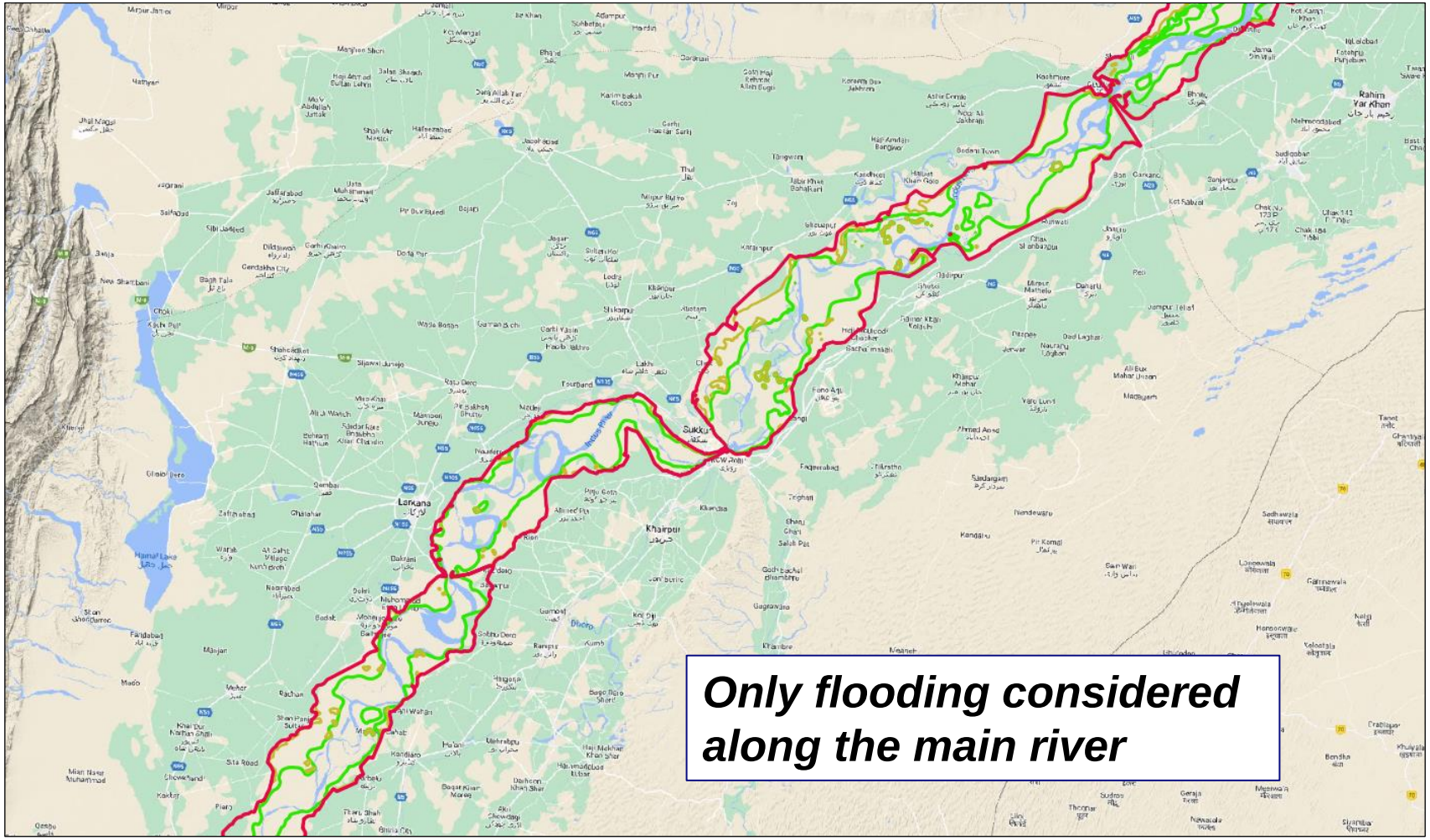
Flood hazard assessment

- Standard flood hazard maps developed as part of NFPP-IV by NESPAK / Deltares, based on 1-D (SOBEK) modelling for 5 & 50 years return period
- Only attention for riverine flood along Indus and major tributaries, including Swat & Kabul river
- Only flood extent for different return periods and historical floods, no flood exposure, vulnerability or risk assessment

Original flood hazard map from NFPP-IV (detailed example)



Original flood hazard map from NFPP-IV (Indus between Guddu and Sukkur)



Flood hazard assessment

- Urgent need for revision of the flood hazard maps
- Many studies and local projects, such as the *Multi-Hazard Vulnerability and Risk Assessment (MHVRA)* project, but no universal (nationwide) approach
- Urgent need for coordination of the various initiatives

New procedure towards flood exposure maps

- Approach that is described in ESCAP (2021)
- Entirely based on global data sets, and so nationwide
- Procedure in QGIS
- The following data are used:
  - Population data: *Humanitarian Data Exchange (HDX)(UN-OCHA)*
  - Global land cover data: *Copernicus Global Land Service*
  - Global flood hazard data: *Global Risk Data Platform (UN Environment Programme Global Resource Information Database (UNEP GRID))*
- Global flood hazard data from UNEP-GRID are available for return periods of 25, 50, 100, 200, 500 and 1000 years → *example made for 100 years*

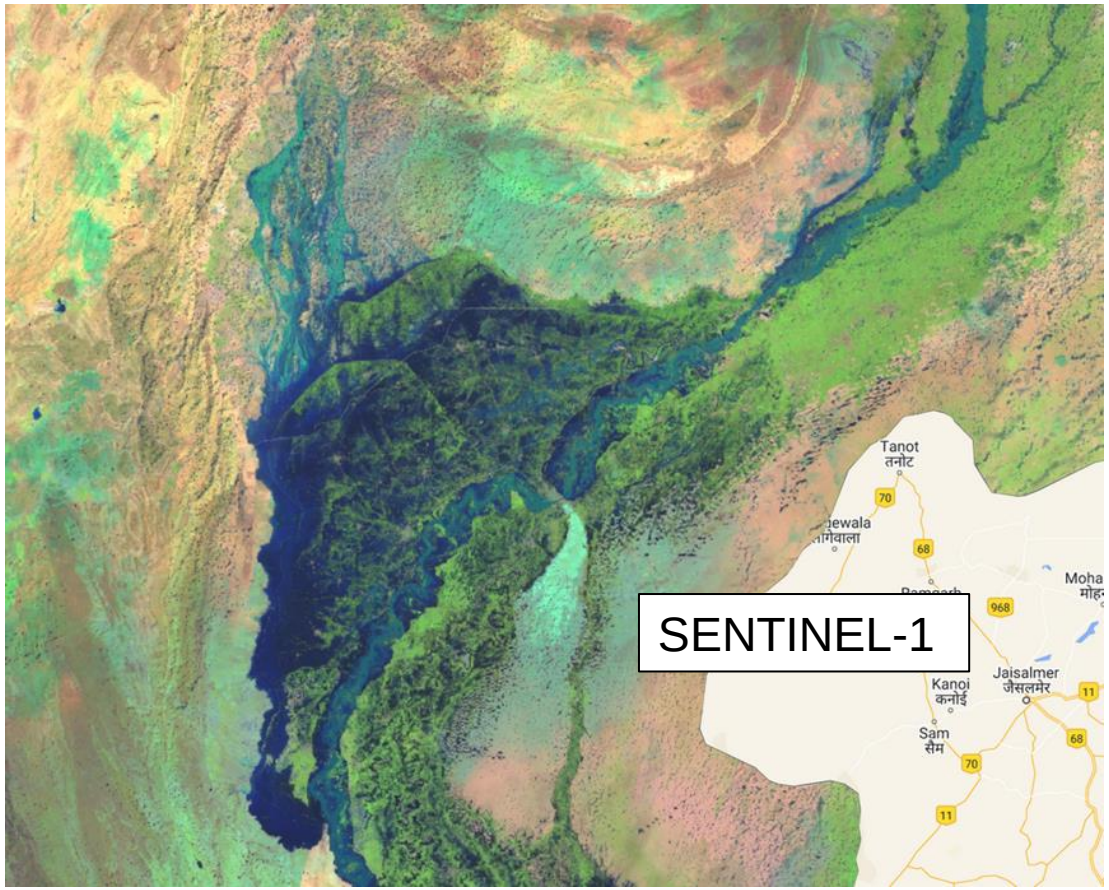
There are many other free global sources, though

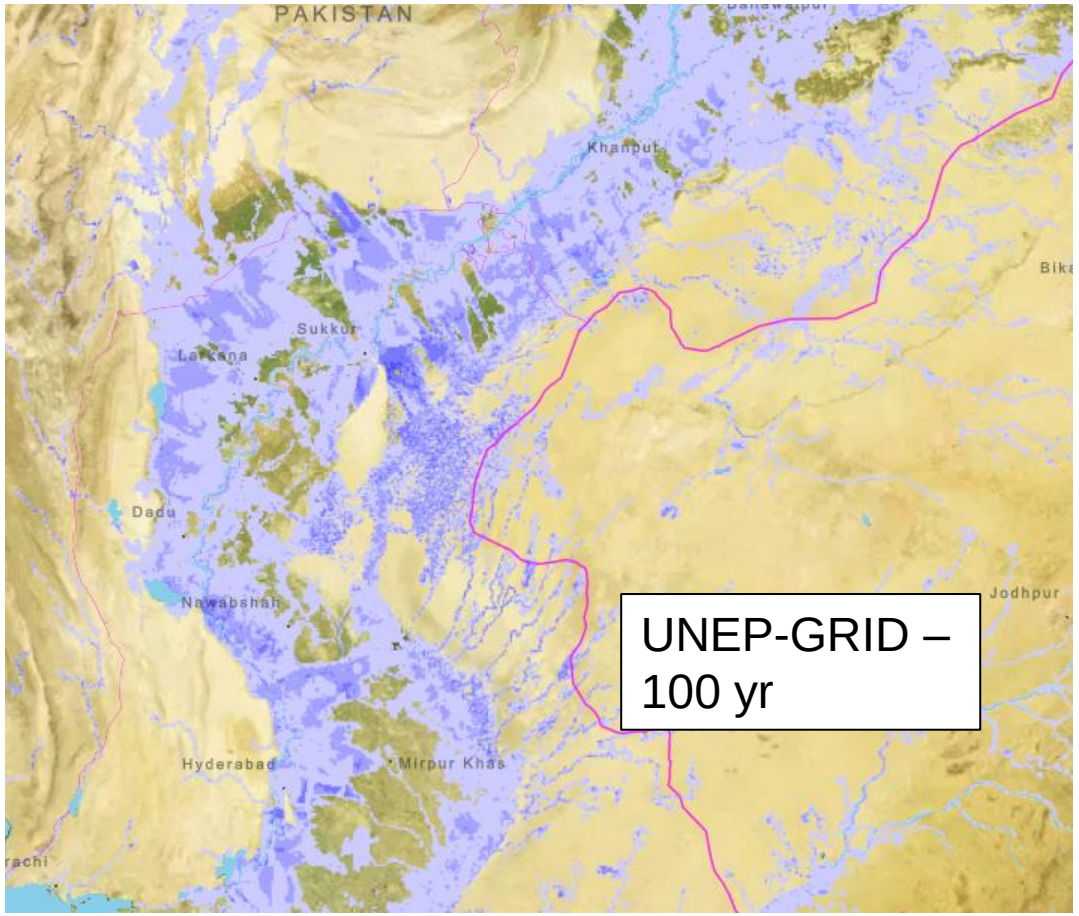
Name	Data Source
NRT Global Flood Mapping	https://floodmap.modaps.eosdis.nasa.gov/
Aqueduct Floods Hazard Maps	https://www.wri.org/data/aqueduct-floods-hazard-maps
The Flood Observatory	https://floodobservatory.colorado.edu/
DFO: Asia Flood information	https://diluvium.colorado.edu/
Global Risk Data Platform	https://preview.grid.unep.ch

NATCAT Risk Calculator : http://riskcalculator.sgs-suparco.gov.pk

In addition, commercial products exist, such as Fathom and JBA

Global flood map similar to actual situation in 2022

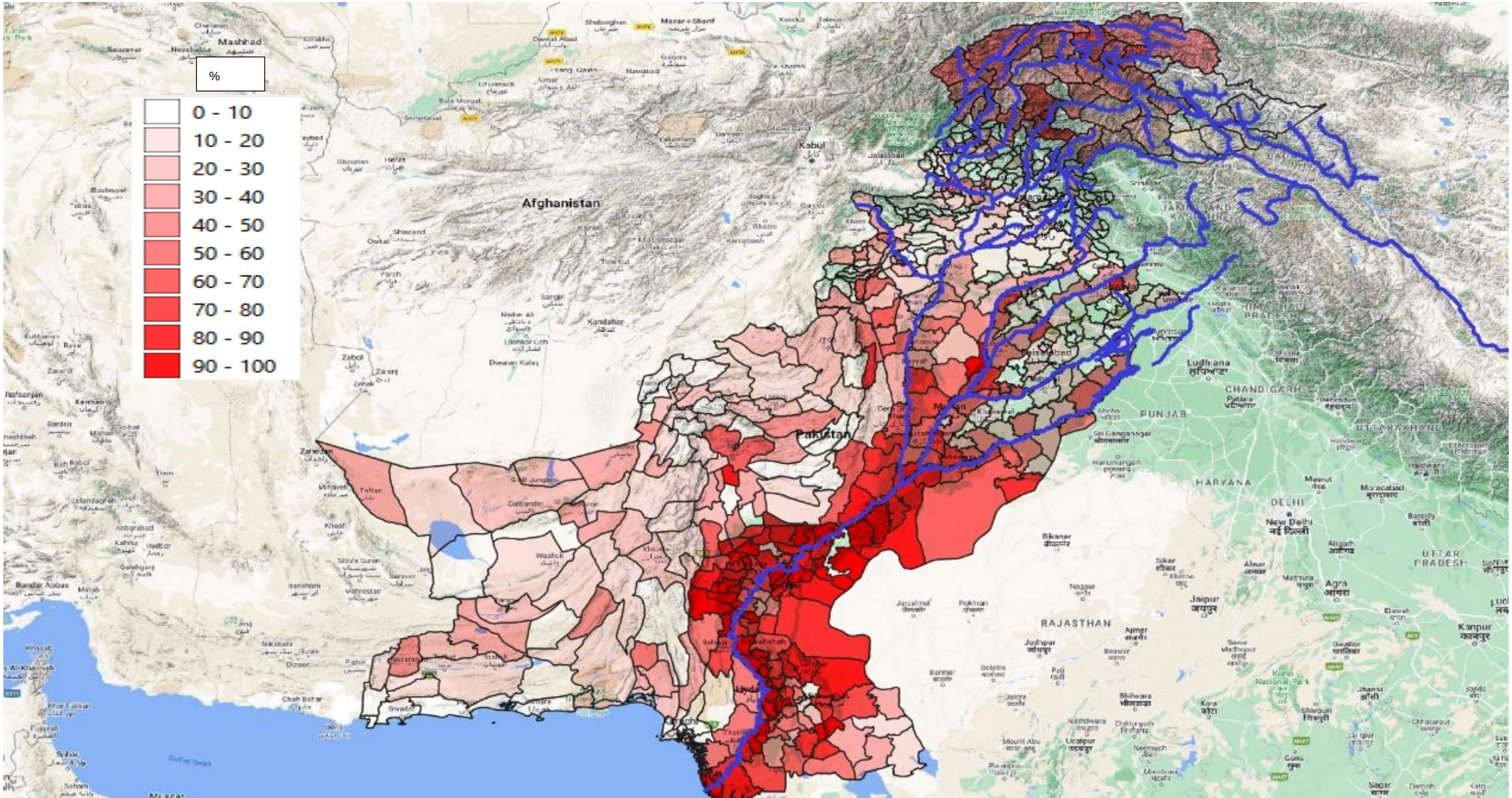




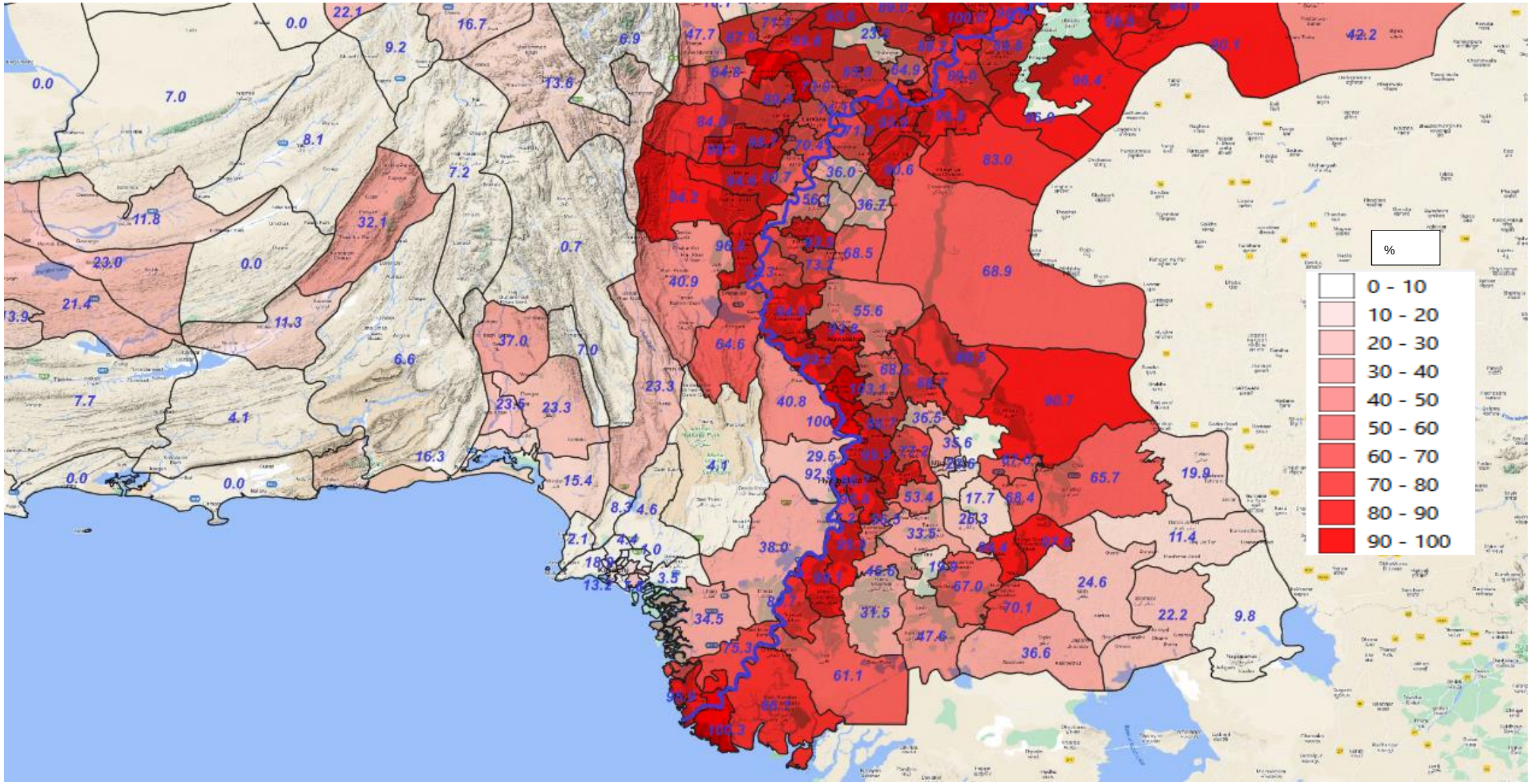
Procedure flood exposure maps

- Assessment of % of population exposed to flood hazard for a flood with 100 year return period
- Global map of population (in fact 2017 census) on Tehsil level
- Redistribution per tehsil based on build-up area from Copernicus database
- Overlay between population distribution and flood extent from UNEP-GRID flood map
- Calculation of % of population exposed to flooding

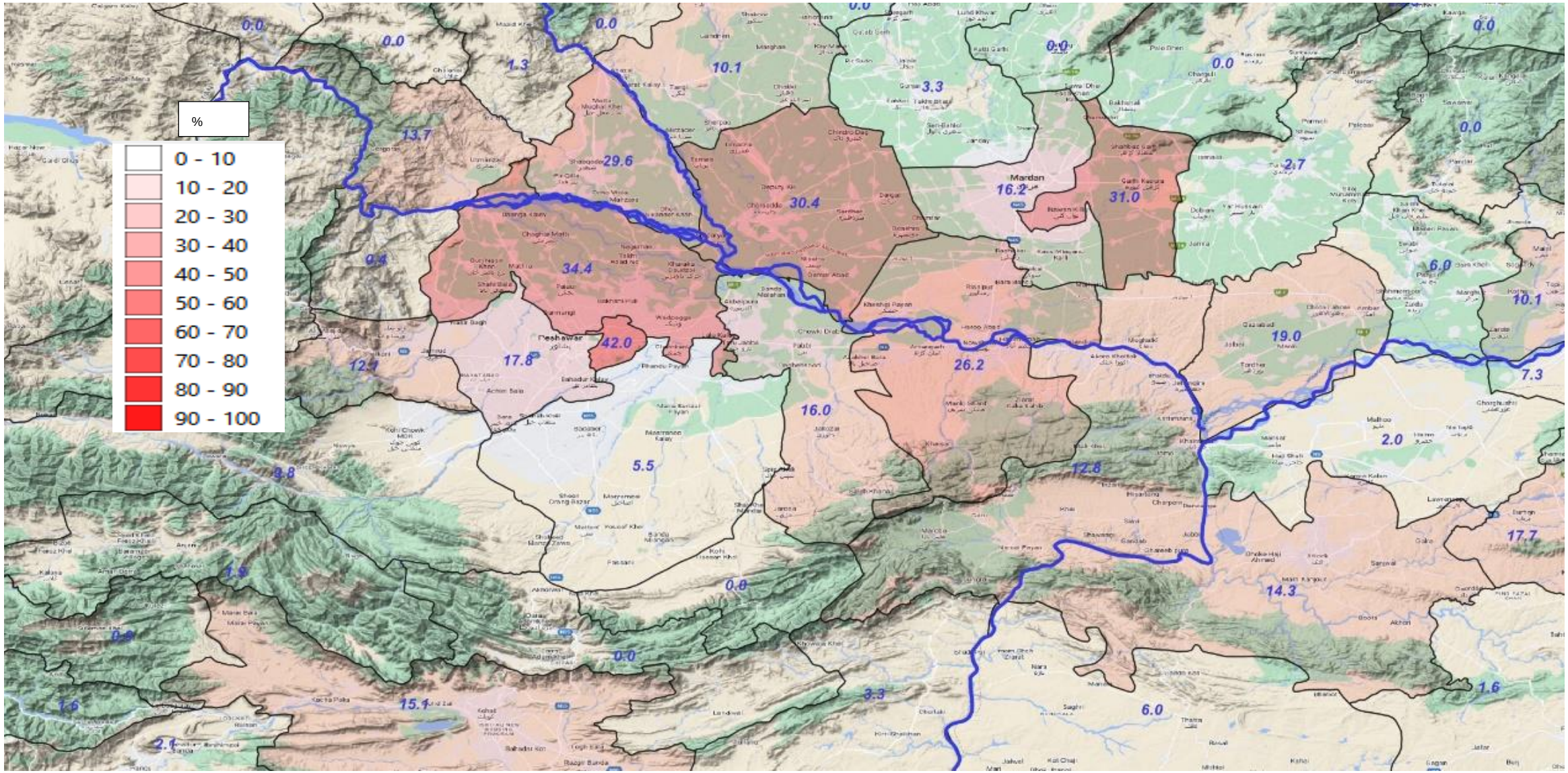
Nationwide % population exposed to flooding



Detail Lower Indus / Sindh



Detail Kabul river



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