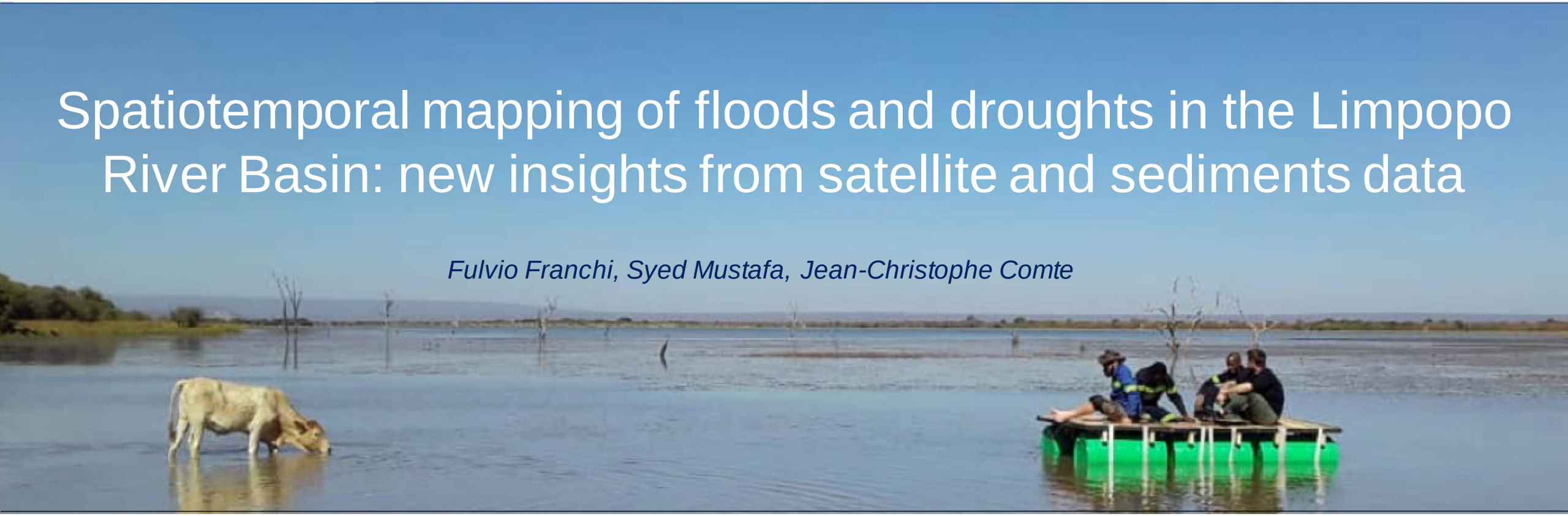
Connect 4
WATER RESILIENCE

Connecting water resources, communities, drought and flood hazards, and governance across 4 countries in the Limpopo basin

Spatiotemporal mapping of floods and droughts in the Limpopo River Basin: new insights from satellite and sediments data

Fulvio Franchi, Syed Mustafa, Jean-Christophe Comte



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Limpopo River Basin is highly vulnerable to floods & droughts

Feb 2021
Flash floods in South Africa and Zimbabwe
20 deaths

Feb 2017
Flood in Botswana, South Africa and Zimbabwe
246 deaths
Cost: $100m

2015-2016
Drought in Southern Africa
22 million people under food insecurity

2018-2020
Drought in Southern Africa

2014
Flood in Mozambique and Zimbabwe
408,711 people affected (Mz)
68,000 people displaced (Mz)

2014
Flood in South Africa
30 deaths
700 households

2000
Flood in Mozambique/Botswana/ South Africa/Zimbabwe
220,000 people displaced (Mz)
150 deaths (Mz)

2002-2003
Drought in Mozambique
520,000 people facing food insecurity

March 2003
Flood in Zimbabwe and Mozambique

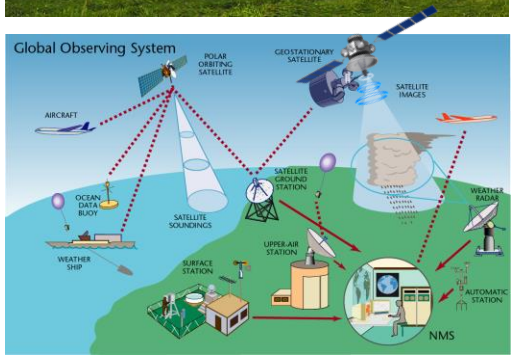
2013
Flood in Mozambique and Botswana
150,000 people displaced
100 deaths (Mz)

2005
Drought in Zimbabwe, Mozambique and South Africa

2011
Flood in Mozambique

What are the issues

- Traditionally floods and droughts are managed separately
- Surface and groundwater resources are treated as separate entities
- Limited interaction/consultation between water managers and water users
- In situ gauging stations are sparse and not readily available in real-time, particularly in the southern African region
- RS provides a promising way to measure hydrometeorological data at high spatial resolution and in near real time
- RS data can be used to pinpoint past events in the sedimentological



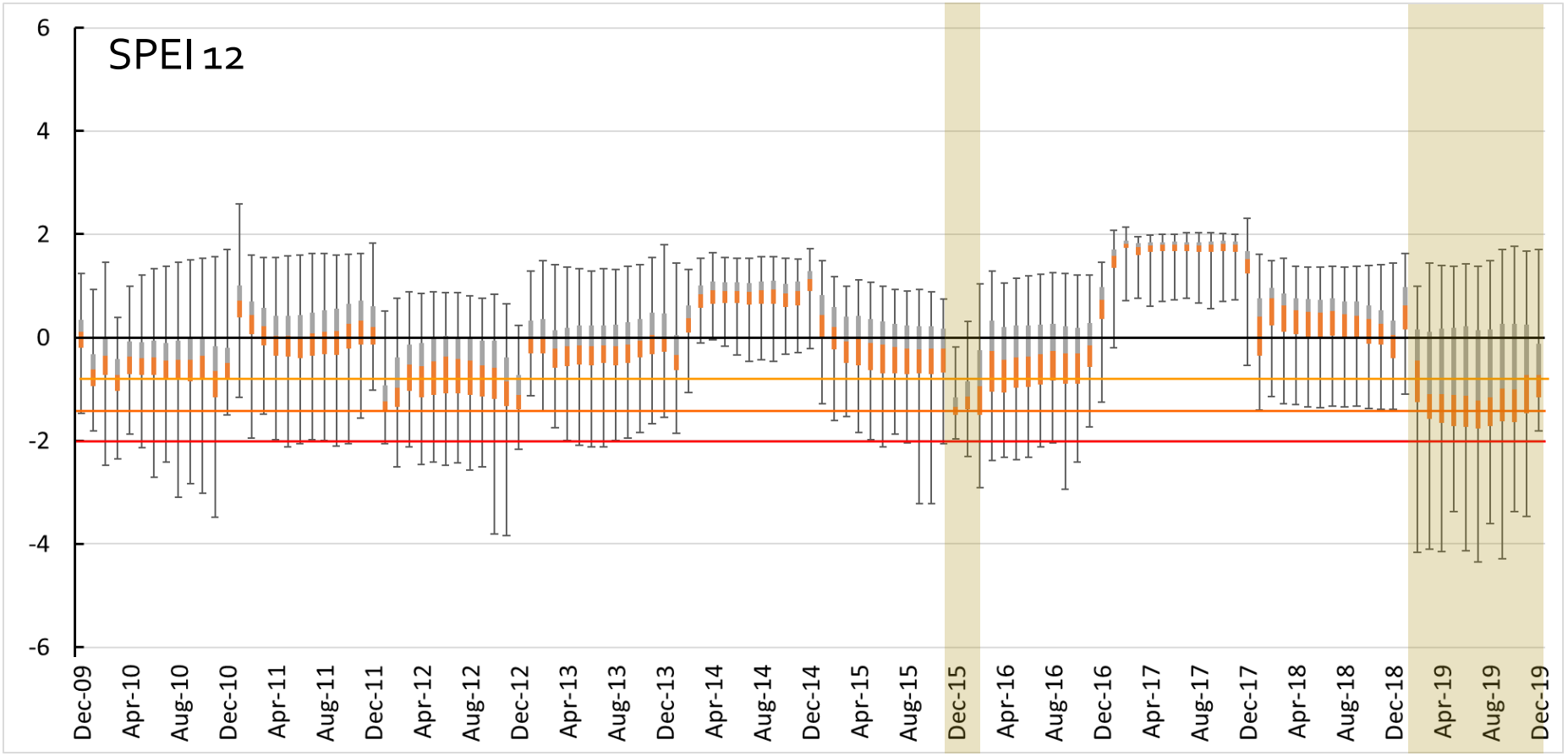
RS data have been used in improving monitoring and management of hydrological extremes (flood & drought)

- The Climate Hazards Group InfraRed Precipitation with Station data (CHIRP) data set
- NASA's Shuttle Radar Topography Mission (SRTM)
- European Space Agency's Sentinel-2A (satellite)
- Climate Forecast System Reanalysis (CFSR) data
- FAO Water Productivity Open-access portal (WaPOR) remote sensing data
- United States Geological Survey data from USGS Global Visualization Viewer
- NASA Socioeconomic Data
- SATELLITE IMAGES

Source: Adopted EC Copernicus

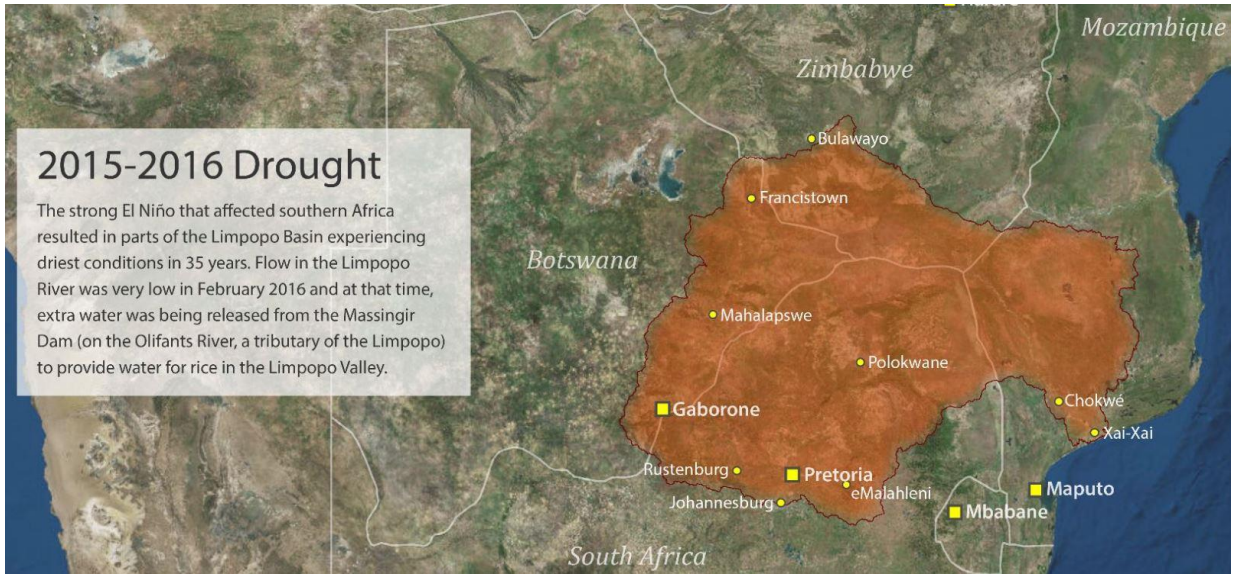
The frequency and intensity of extreme drought events are on the rise

Considering 25000 grid points across the LRB

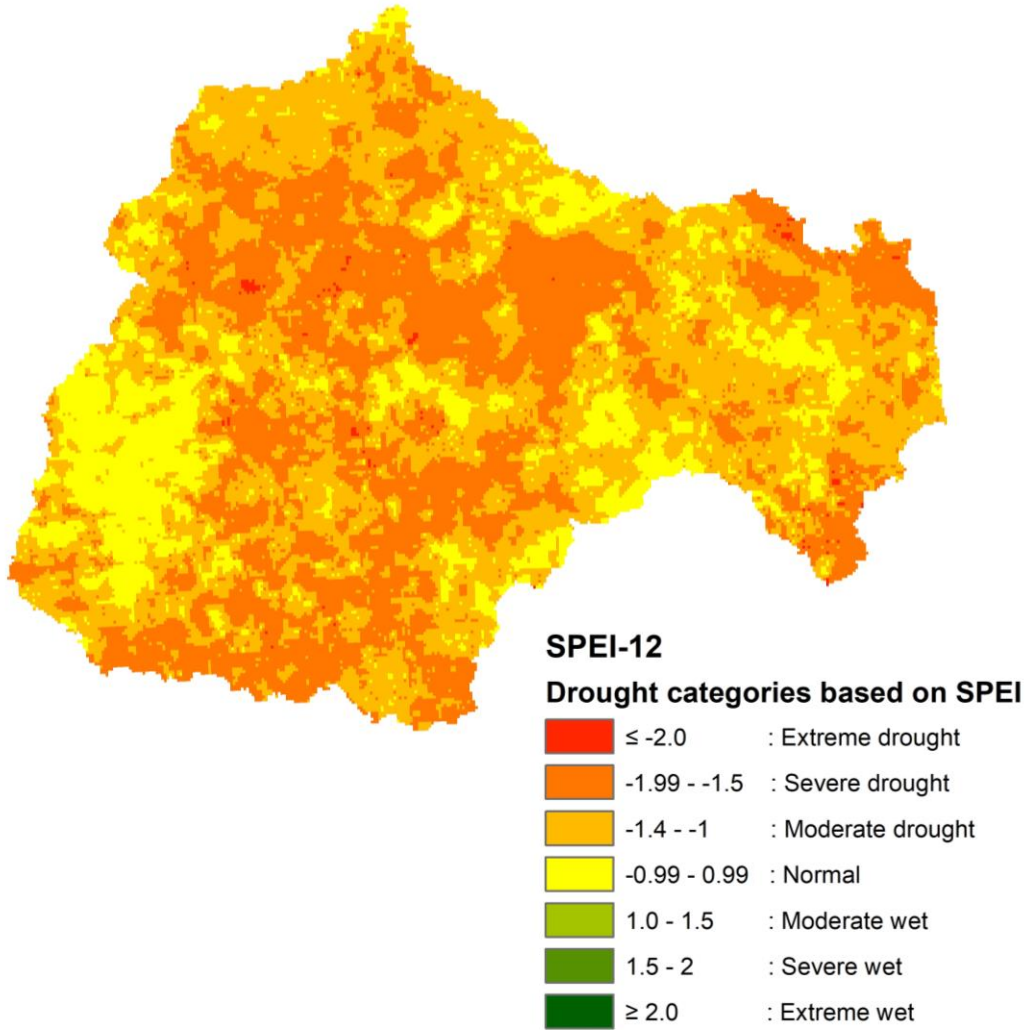


Standardized Precipitation Evapotranspiration Index (SPEI) - timescales of 12-month

Satellite observation-based index is able to simulate spatio-temporal drought



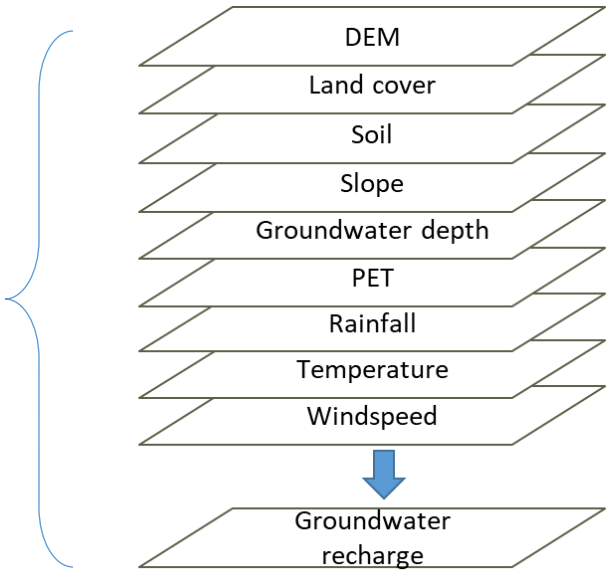
Data source: U. S. Geological Survey

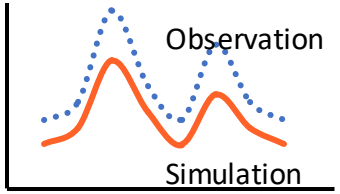


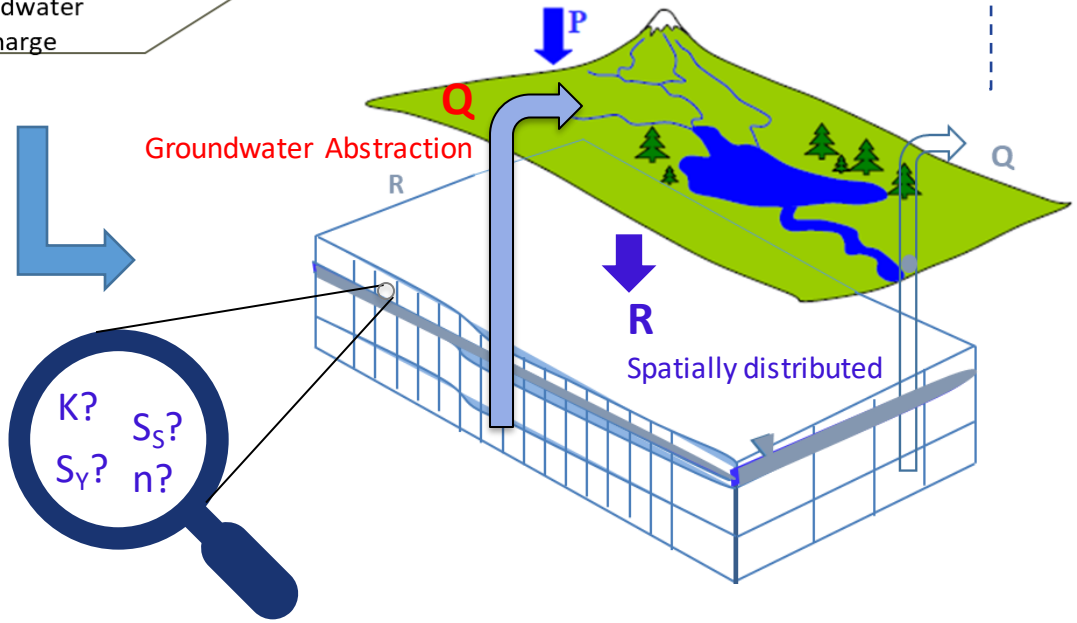
Source: Story Map compiled by Elsa Lindevall

Hydrological modelling

WetSpass
(spatially distributed water balance model)







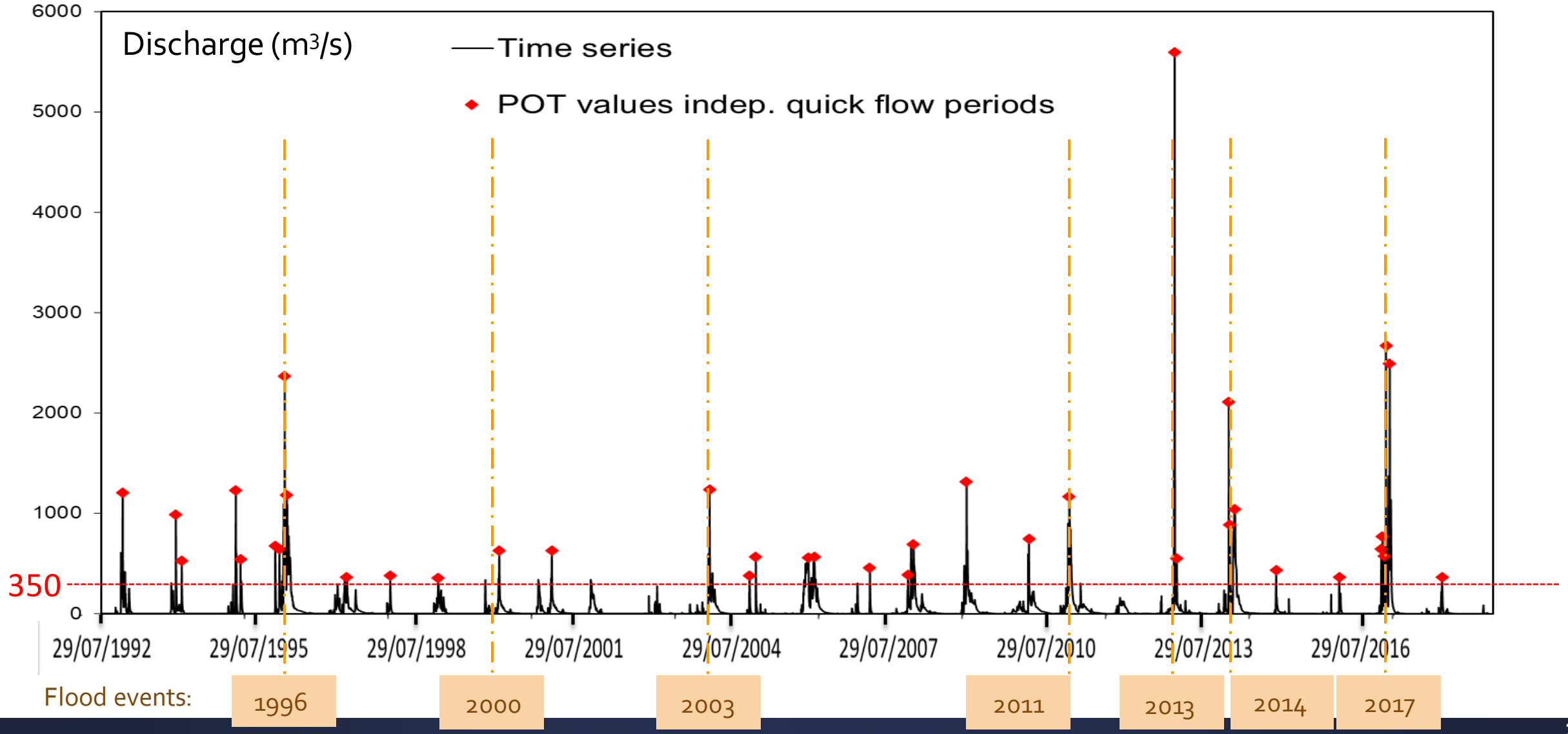
MODFLOW

(WetSpass, Batelaan & De Smedt, 2007)

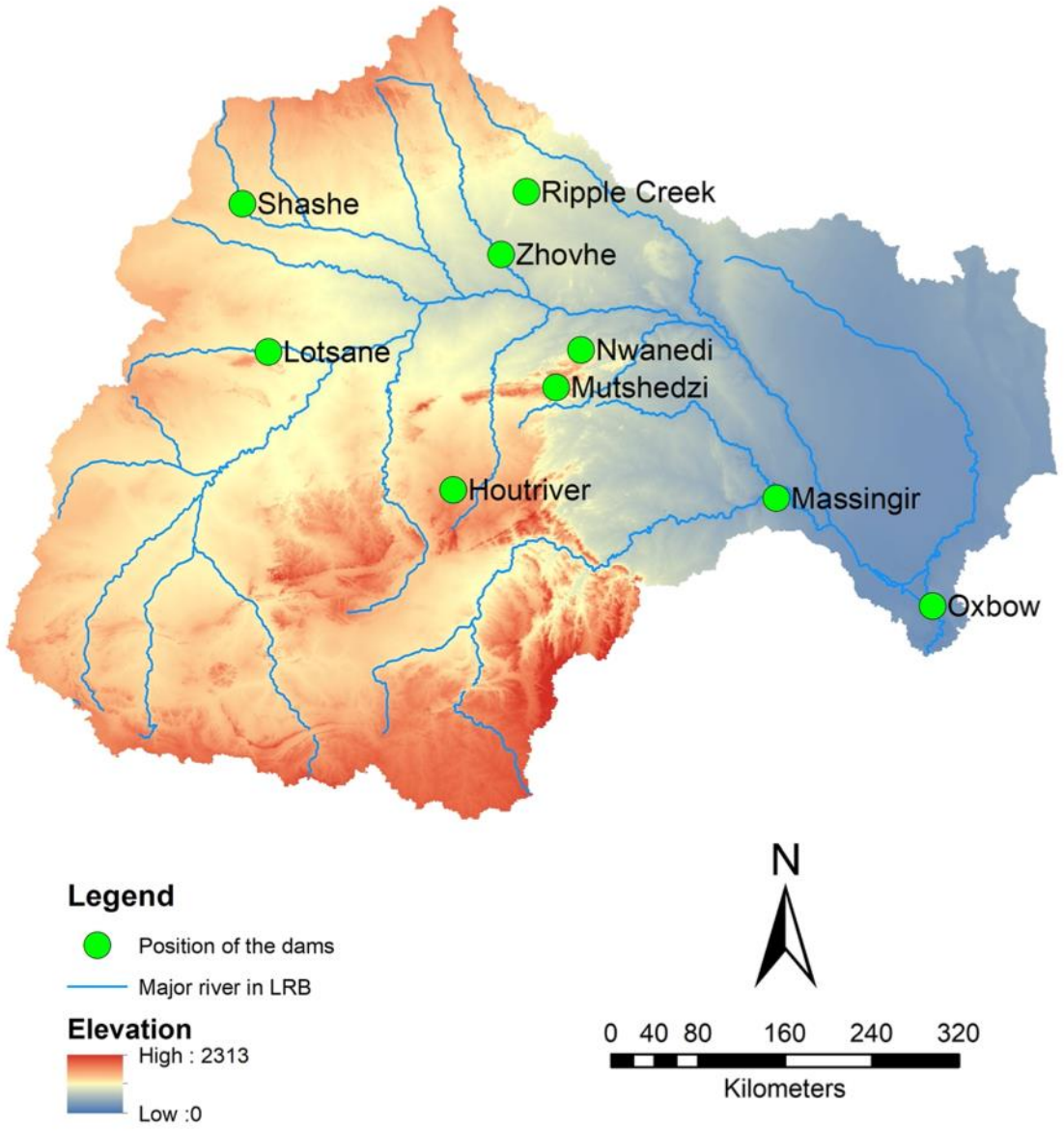
Mustafa et al. 2021

Flooding Frequency and Intensity are Increasing

Peaks Over Threshold (POT) series of river (quick) flow



Coupling RS data and sediments archives for better understanding of floods



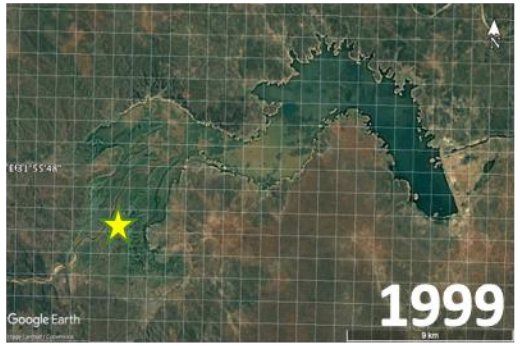
We sampled 8 dams and 1 oxbow lake in order to identify the major flood events in the past 50 to 60 years and

- estimate the magnitude
- Assess effects on sediments transport
- pollutants

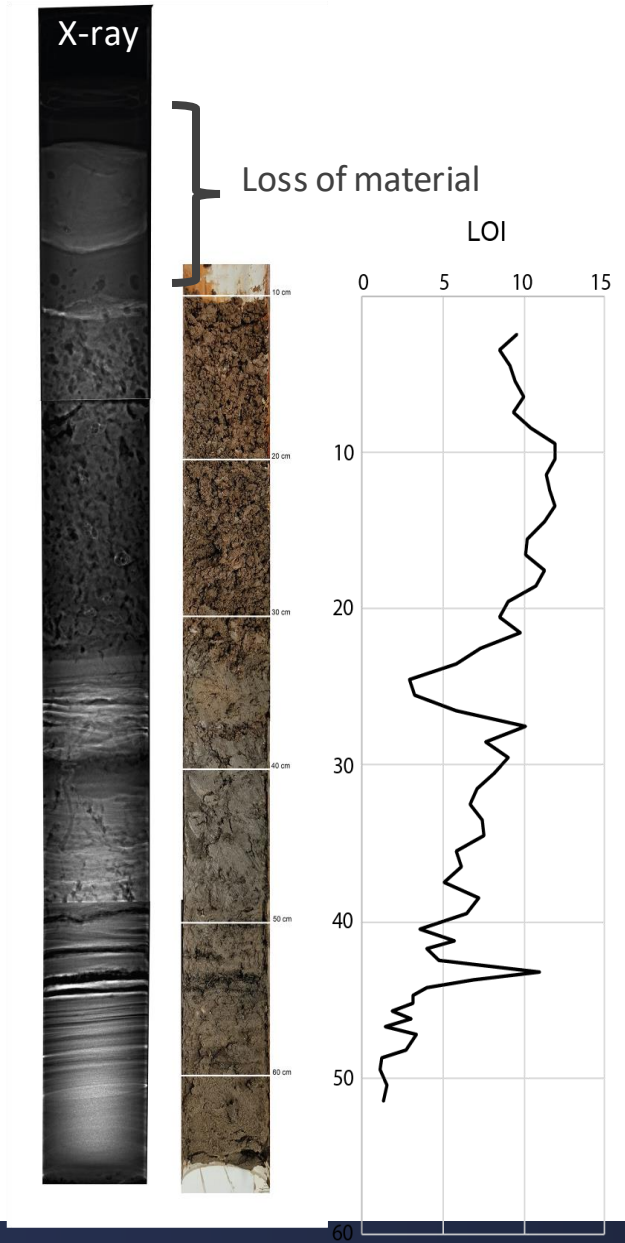
Houtriever dam, completed in 1988

Coupling RS data and sediments archives for better understanding of floods

Satellite images

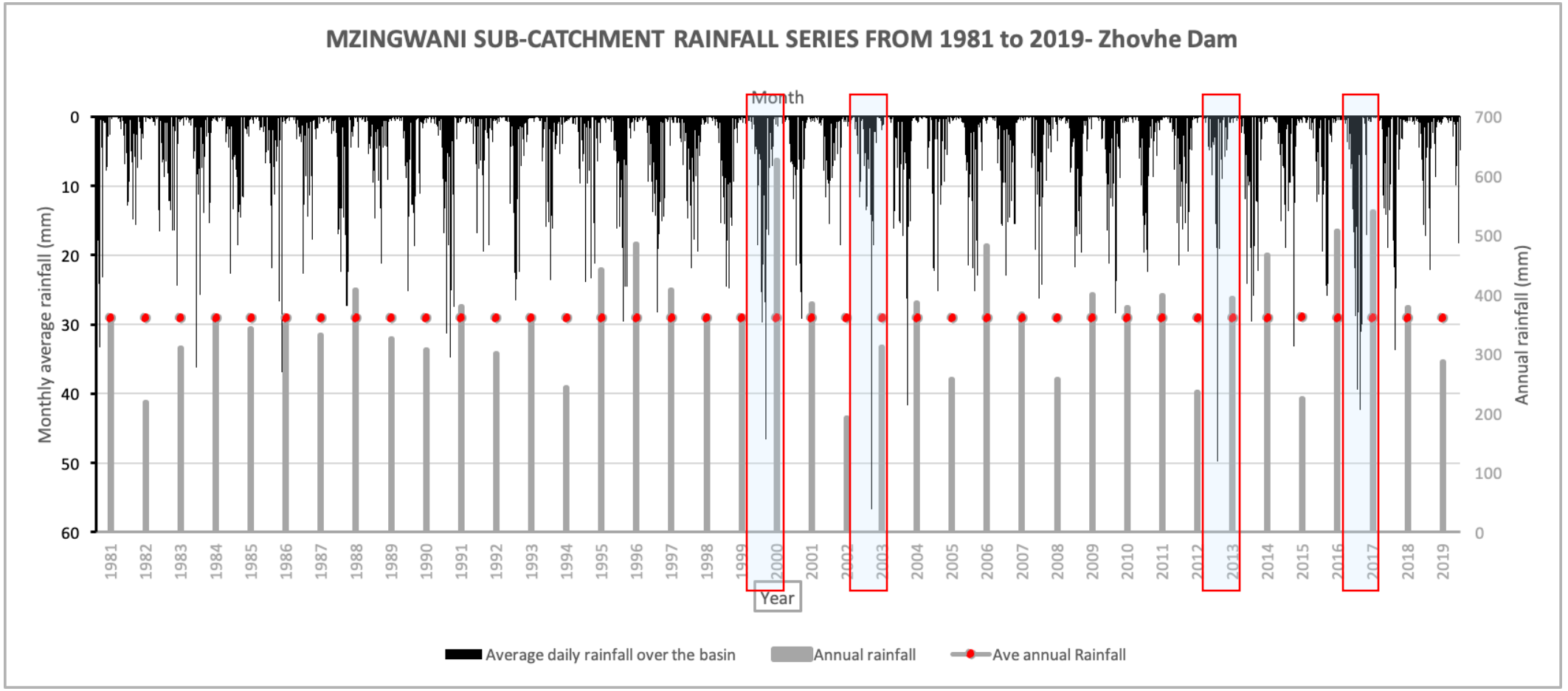


Massingir dam
(MOZAMBIQUE)

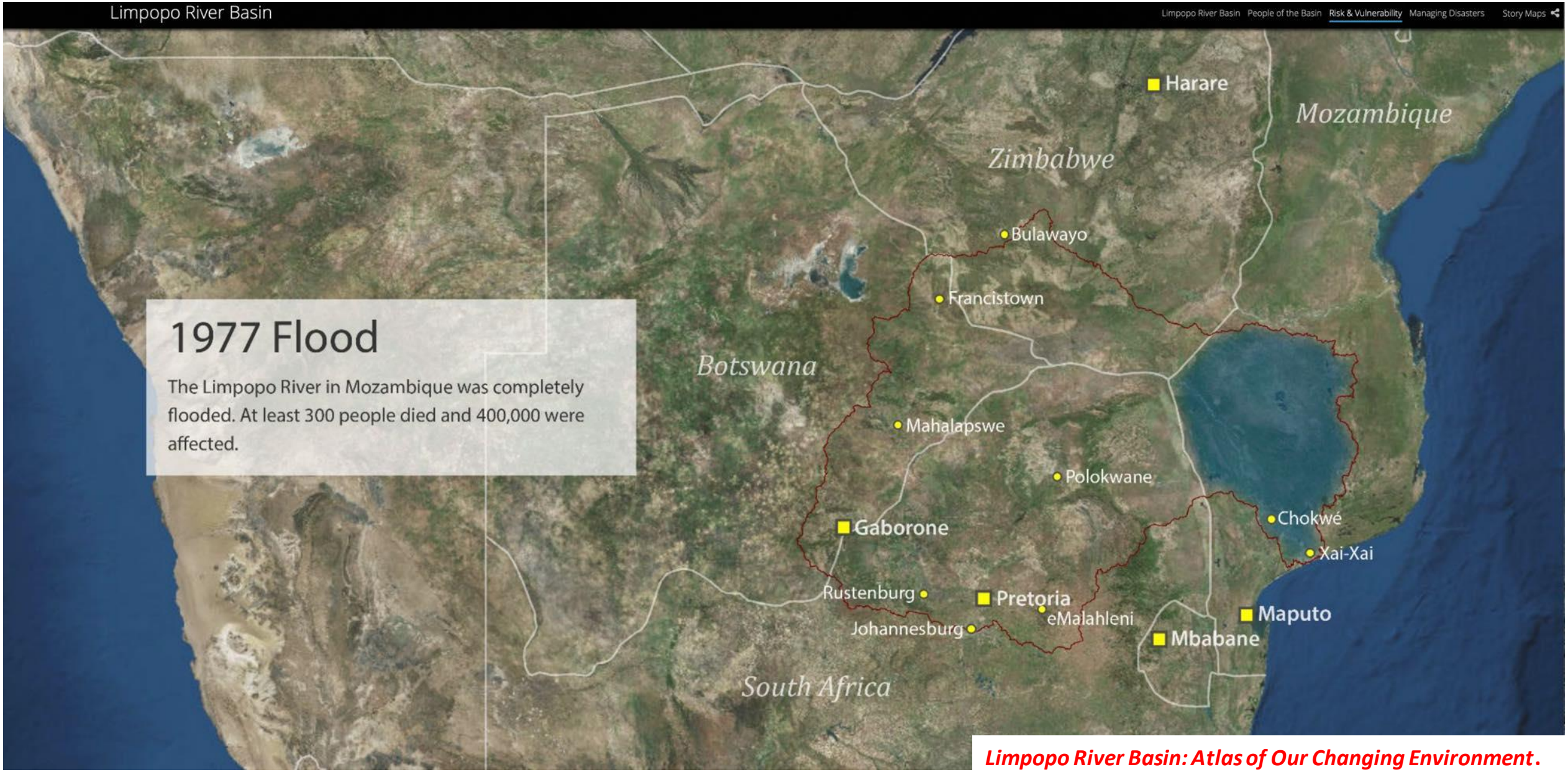


Coupling RS data and sediments archives for better understanding of floods

CHIRP (hybrid data set)



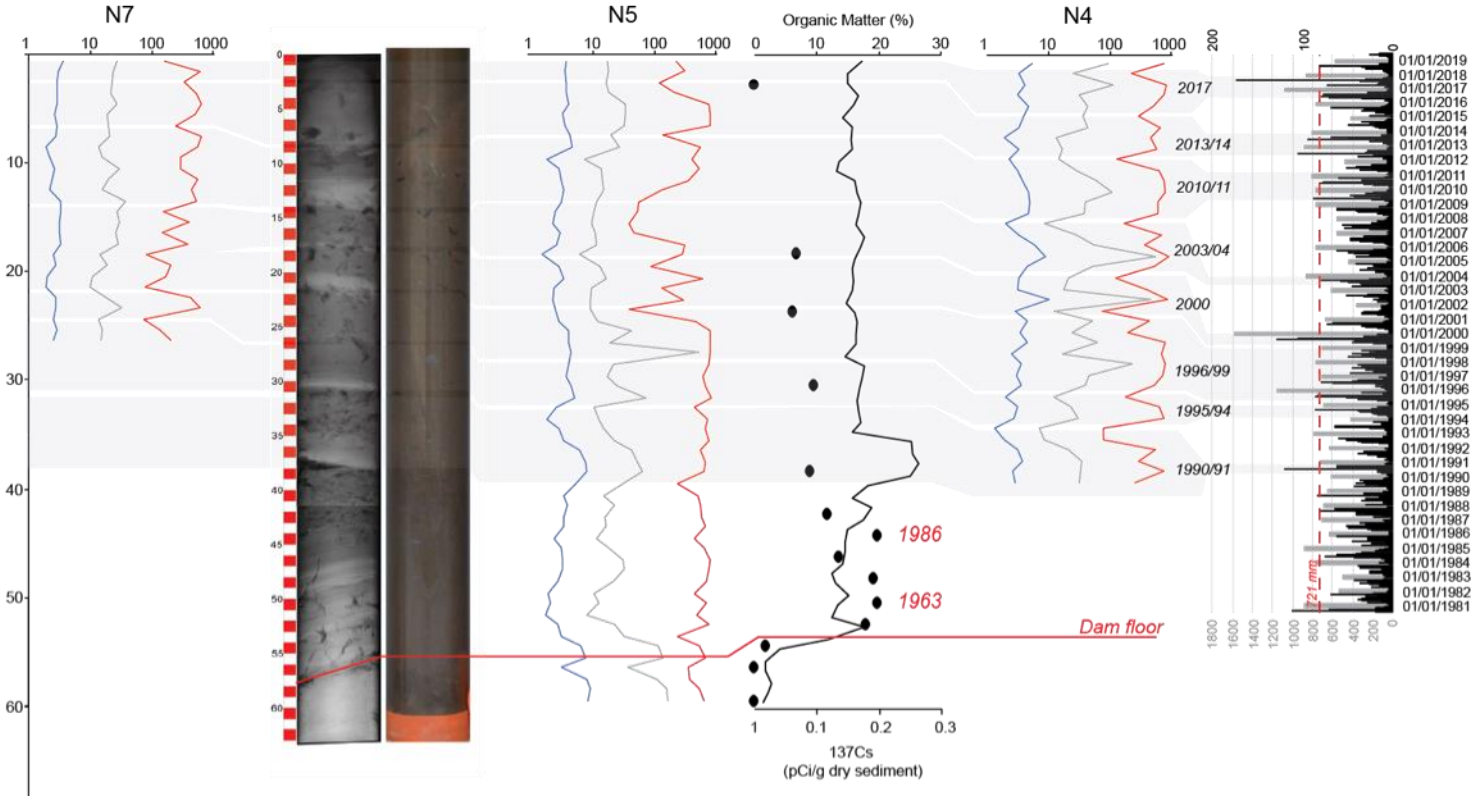
Final model based on RS data, sediments and hydrometric data



Limpopo River Basin: Atlas of Our Changing Environment.

Year	Reported Drought	Reported floods	CHIRP*			GRDC																	
			Nwanedi	Mutshedzi	Houtrivier	1196600 (POT = 150)	1196101 (POT = 300???)	1196102 (POT = >20?)	1196100 (POT = 190)	1196150 (POT = 70?)	1196210 (POT = 20?)	1196380 (POT = 20?)	1196570 (POT = 80???)	1196425 (POT = 50??)	1196410 (POT = 20)	1196130 (POT = 6?)	1196500 (POT = 80)	1196330 (POT = 50)	1196310 (POT = 30)				
						Oliphant river						Lephalale River		Crocodile River			Sand River	Luvuvhu River					
1949							Flood																
1950																							
1951																							
1952																							
1953																							
1953/54							Flood (?)																
1955							Severe																
1956							Severe																
1956/57							Flood (?)																
1958							Flood						Flood										
1959													Severe										
1960													Flood										
1961																	Flood						
1962									Flood														
1963																							
1964							Heavy		Flood														
1965																							
1966																							
1967	Basin-Wide Drought						Flood					Heavy	Flood	Flood		Severe							
1968	Basin-Wide Drought																						
1969	Basin-Wide Drought						Flood		Flood		Flood		Heavy										
1970	Basin-Wide Drought						Severe (69/70)		Heavy														
1971	Basin-Wide Drought								Flood														
1972	Basin-Wide Drought						Severe		Heavy		Severe	Heavy						Flood					

We built a matrix comparing all available data sets (USGS GIS data, CHIRP, Peak Over Threshold data from GRDC) from 1949 until 2019 and confirmed extreme events that where then correlated with sediments record in the dams.



Model is also using for the future scenario analysis to identify appropriate management solutions

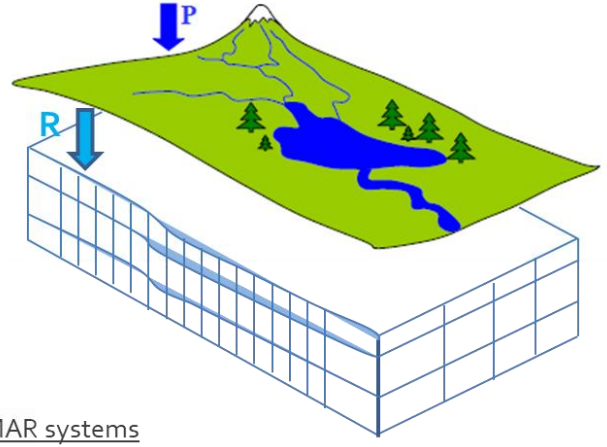
- to improve resilience to hydrological extremes in the LRB

Rainwater harvesting system

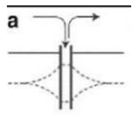
Change Land Use

Change type of crops

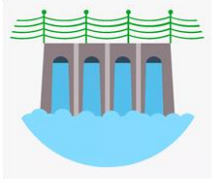
Increase GW abstraction



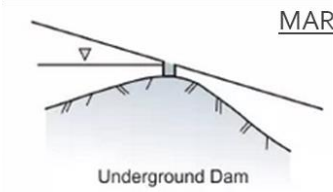
MAR systems

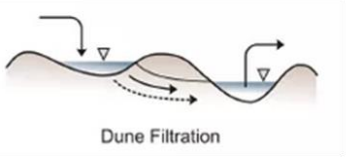


Injection well



Dams & reservoirs





Conclusive remarks

- Frequency and intensity of hydrological extremes (flood & drought) events are increasing
- In data scarce regions, RS enabled us to pinpoint extreme weather events and lay the foundations for a hydrological model
- Coupling RS data and sediments archives provide better understanding of flood events across the LRB
- Model can be used for the future scenario analysis to identify appropriate management solutions to improve resilience to hydrological extremes in the LRB
- RS, sediments archives, and hydrological model-based approaches can be used for monitoring and management of hydrological extremes (flood & drought)

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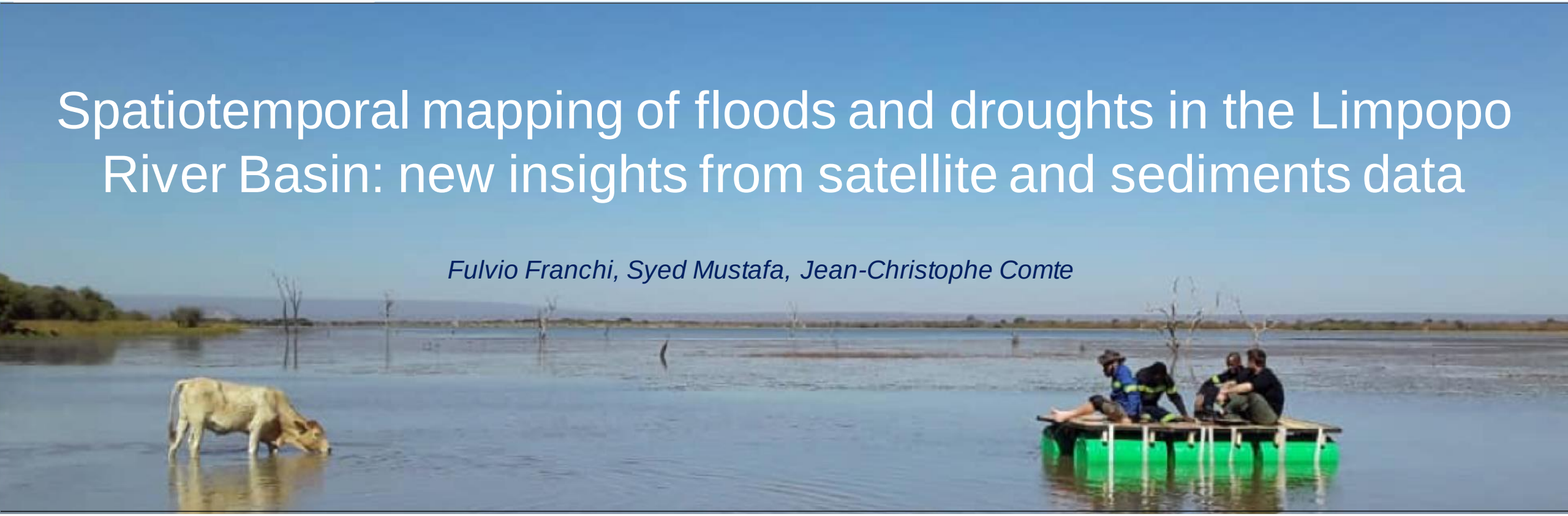

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