Modeling extreme climatic events: case study of Senegal droughts using the SPI method

CONFERENCE SCIENTIFIQUE INTERNATIONALE SUR LE CHANGEMENT CLIMATIQUE • NIAMEY (NIGER)

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OUTLINE

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I. CONTEXT AND PROBLEM STATEMENT

In most studies, authors use climatic parameters such as temperature and precipitation, or the deviation of these parameters from the mean, to measure the impact of climate change on agriculture, livestock farming or the economic sector in general.

However, the use of these parameters alone does not clearly demonstrate the direct relationship between climatic events, particularly drought, and the variables of interest cited.

I. CONTEXT AND PROBLEM STATEMENT

As a prerequisite, further processing of the data would consist in identifying drought periods and their duration, which would give a better understanding of the phenomenon and a more detailed interpretation of the relative results of the impact of climate change on economic, social or ecosystem variables.

IPCC, AR6, Chapter 11, Chapter 12

Climatic Impact-driver and Extreme Indices

II. RESEARCH OBJECTIVE

The objective of this study is to detect and characterize meteorological extreme climatic events, particularly droughts in floods in Senegal during the last three decades in Senegal.

II. RESEARCH OBJECTIVE

- Short-term SPI (SPI-1 and SPI-3): Short-term soil moisture and crop stress during the growing season;

- Medium-term SPI (SPI-6 and SPI-9): Interseasonal precipitation patterns on a medium time scale and help identify abnormal flow and reservoir level situations;

- Long-term SPI (SPI-12) reflects drought situations related to river flows, reservoir levels and groundwater levels.

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IV. METHODOLOGY AND DATA

Data : Time series of rainfall data recorded over recent decades (1990-2020) in Senegal.

Methodology: Standardized precipitation index (SPI) developed by McKee et al. (1993)

The following formula is applied:

$$SPI = \frac{P - P_m}{\sigma_p}$$

where

P is total precipitation of a period (in mm),

Pm is the historical average precipitation of the period (mm),

σ_p the historical standard of precipitation of the period (mm).

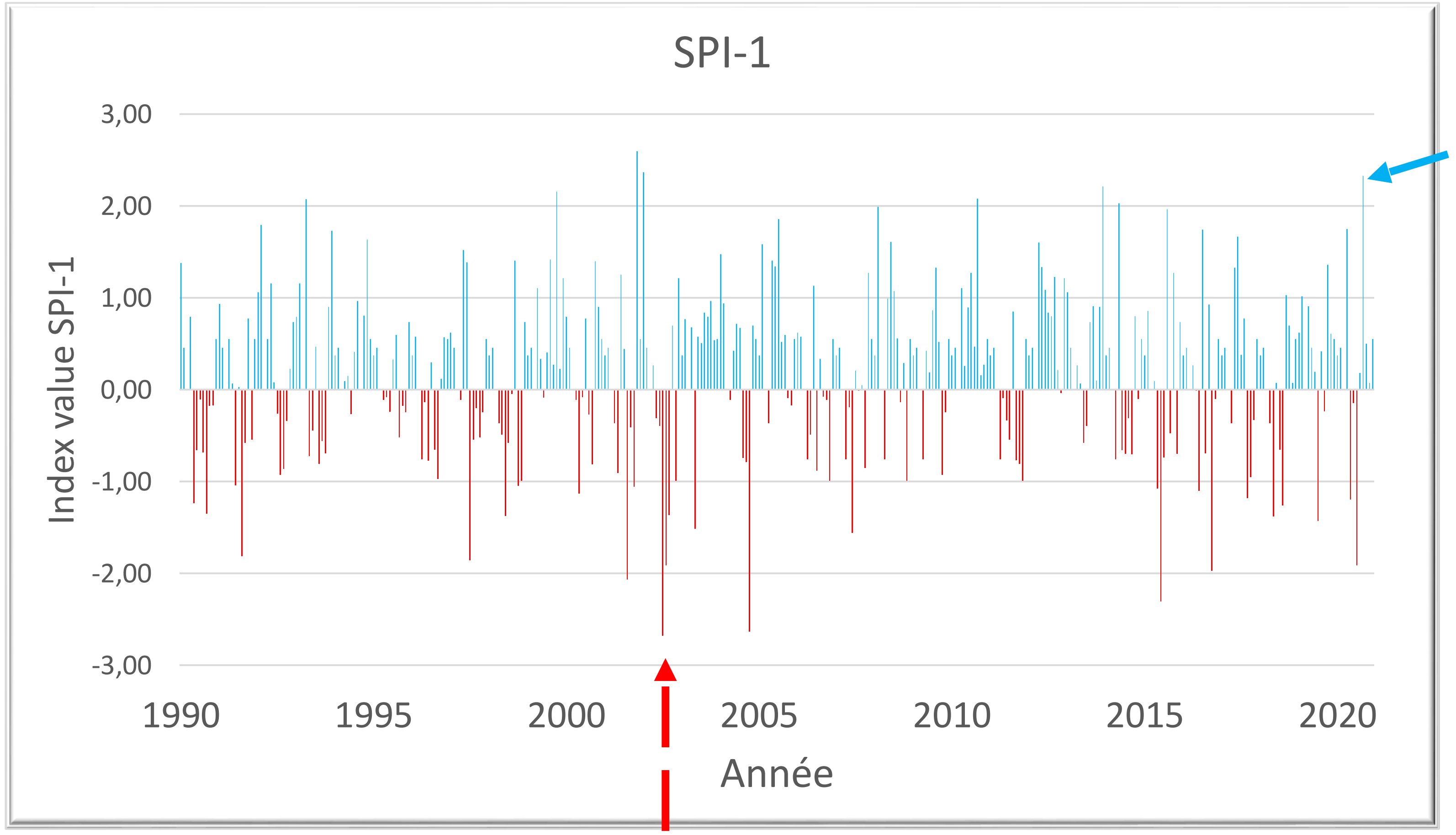
IV. OUTPUT

Table 1: Classification of droughts in Senegal according to the Standard Precipitation Index spi-1, spi-3, spi-6, spi-9, spi-12.

SPI drought classification						
Drought class	**SPI Value**	**Event frequency (%)**				
		SPI-1	**SPI-3**	**SPI-6**	**SPI-9**	**SPI-12**
Extremely humid	SPI ≥ 2.0	2%	1%	1%	0%	0%
Very humid	1.5 ≤ SPI < 2.0	12%	14%	14%	15%	15%
Moderately humid	1.0 ≤ SPI < 1.5	8%	12%	13%	14%	15%
Close to normal	-1.0 ≤ SPI < 1.0	71%	64%	63%	62%	60%
Moderate drought	-1.5 ≤ SPI < -1.0	4%	5%	5%	5%	4%
Severe drought	-2.0 ≤ SPI < -1.5	2%	2%	2%	3%	2%
Extreme drought	SPI < -2.0	1%	2%	2%	2%	3%

IV. OUTPUT

SPI-1



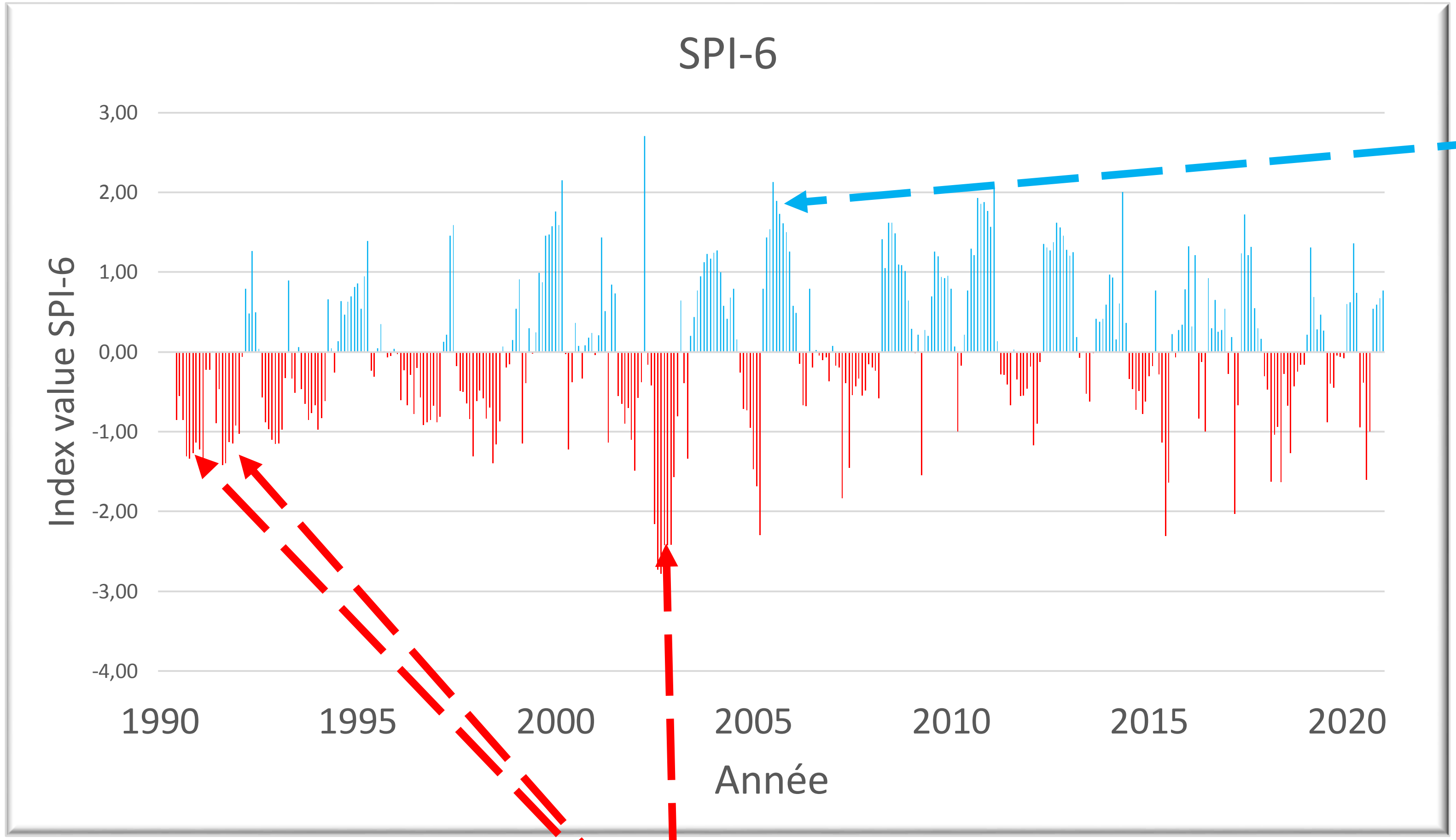
Extremely humid in 2020
Flood

Year	June	July	August	September
1991	-1,0	0,0	-1,8	-0,6
2002	-0,4	-2,7	-1,9	-1,4
2010	0,9	1,3	0,5	2,1
2020	-0,1	-1,9	0,2	2,3

Extreme drought in July 2002
Stress crop

IV. OUTPUT

SPI-6

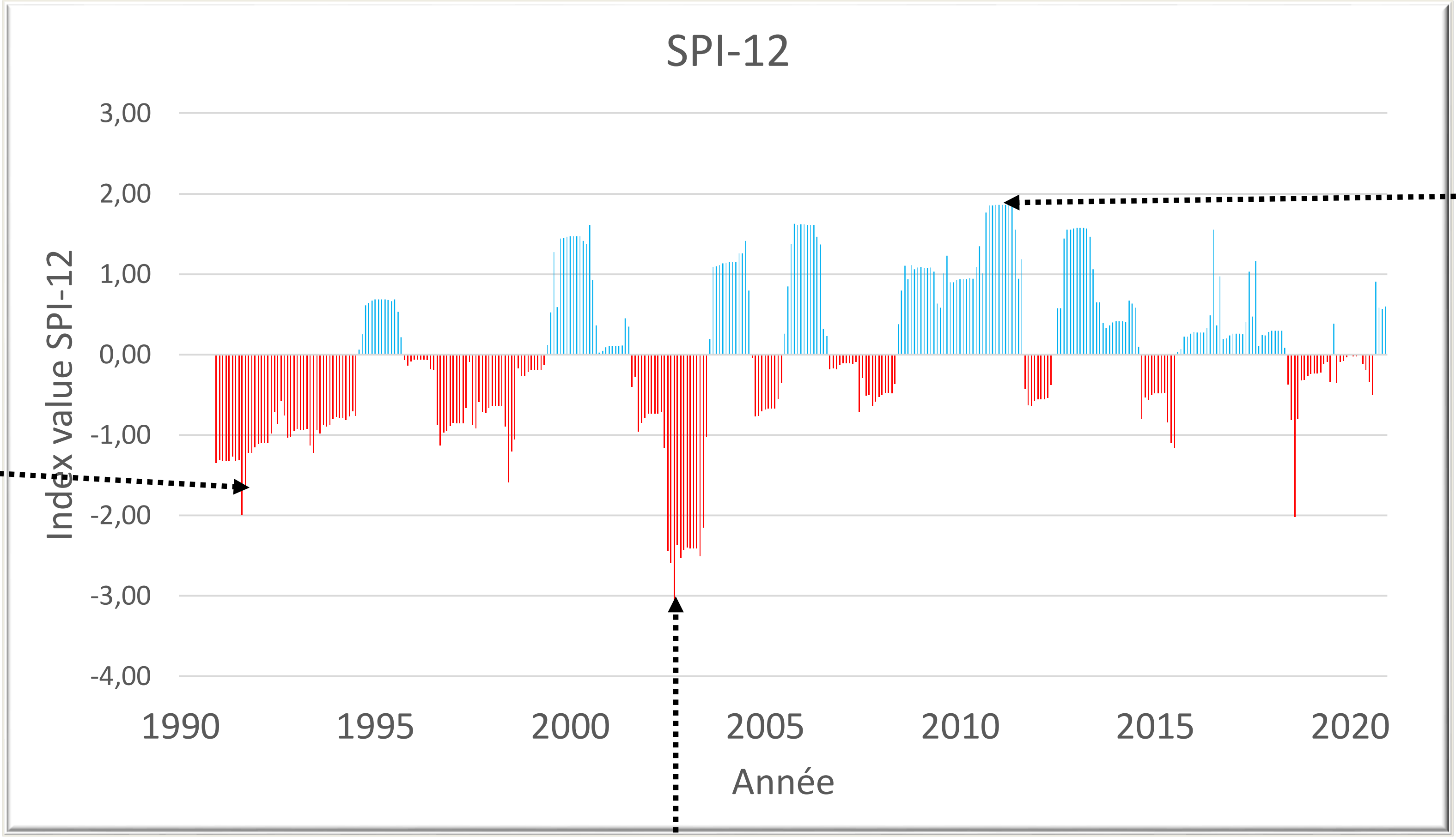


Very humid season in 2005
Increase in river flow

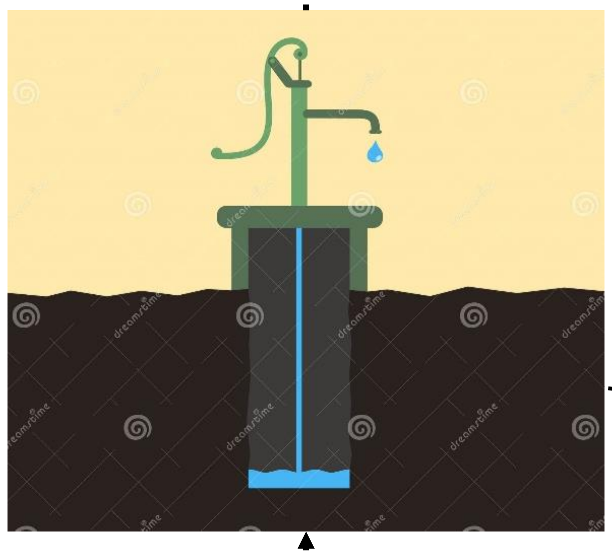
Two successive years of moderate drought in 1990 and 1991,
One year of Extreme drought in 2002
Decrease in river flow

Year	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1990	-0,6	-0,8	-1,3	-1,3	-1,3	-1,1
1991	-0,5	-1,4	-1,4	-1,1	-1,1	-0,9
2002	-2,2	-2,7	-2,8	-2,4	-2,4	-2,4
2005	2,1	1,9	1,7	1,6	1,5	1,3

SPI-12



Two successive years of moderate drought in 1990 and 1991



Severe drought in 2002

High humidity in 2010

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	-1,3	-1,3	-1,3	-1,3	-1,3	-1,3	-1,3	-2,0	-1,6	-1,2	-1,2	-1,2
2002	-0,7	-0,7	-0,7	-0,7	-0,7	-1,2	-2,4	-2,6	-3,1	-2,4	-2,5	-2,4
2010	0,9	0,9	0,9	0,9	0,9	1,1	1,3	1,0	1,8	1,9	1,9	1,9

V. CONCLUSION AND SUGGESTIONS

In summary, modeling climate events is an important task to identify the intensity of the climatic impact-driver in each period and in each region.

Determining climate extremes based on historical and projected data is a fundamental work and a prerequisite to study the impact of climate change on different sectors.

For this purpose, to understand how climate change affects water availability, food security, infrastructure, etc., it would be important to see how these vary depending on climatic events.

Furthermore, the SPI can also be used to see the impact of climates extremes on macroeconomic aggregates, and monetary policies.

THANK YOU FOR YOUR ATTENTION