

Climate change and water resources management in the coastal sub-basin of El Jadida Safi, Morocco

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Abstract. According to the 5th assessment report of the Intergovernmental Panel on Climate Change (IPCC), the temperature is projected to rise over the 21st century under all assessed emissions scenarios while precipitation will likely decrease, thus reducing renewable surface water and groundwater resources in most dry subtropical regions such as Morocco. Moreover, most projections of global circulation models predict a dryer future for North African countries. This work aims to assess the impact of climate variability on water resources in the coastal sub-basin of El Jadida-Safi, located in the Oum Er-Rbia basin. In order to determine future climate projections in the coastal sub-basin by the year 2099, we are using SDSM, a statistical downscaling tool based on both observed and anthropogenic emission scenario data for the pessimistic scenario RCP 8.5 and the optimistic scenario RCP 4.5. Results will help decision-makers and stakeholders better manage their water resources, prepare for extreme hydrological hazards, and enhance development planning in the river basin.

1 Introduction

Since 1950, changes in climate events have been observed worldwide, including an increase in temperature and a decrease in precipitations [1]. Climate change is projected to increase water demand, especially for irrigation in dry subtropical regions, and reduce surface and groundwater resources [2-7].

North African countries are expected to be the most affected by climate hazards, climate studies predict that temperature is to rise between 2 and 3°C while precipitation is to decrease between 10% and 20% until 2050 [8-9] (Paeth et al. 2009, Christoph et al. 2010, Schilling et al. 2012). Morocco already bears the effects of climate change, with a sequence of droughts or extreme precipitation events leading to floods. According to Modelling System for Agricultural Impacts of Climate Change (MOSAICC) which is a dynamic tool developed by the Food and Agriculture Organization (FAO) between 2013 and 2015, the average temperature could increase from 1.1 to 1.6 °C by 2030, from 2.3 to 2.9 °C in 2050, and from 3.2 to 4.1 °C in 2080. At the same time, the precipitation could decrease by 14% in 2030, from 13 to 30% in 2050, and from 21 to 36% in 2080.

Water resources management studies require fine resolution climate data [10] (Timbal et al. 2009). However, General Circulation Models (GCM) have coarse resolutions, which make their application at the level of regional or local scales minimal. Consequently, downscaling methods were developed to span the spatial gap between the coarse GCMs outputs and the hydroclimatic basin variables [11-13].

In this study, future precipitation and temperature of the sub-basin were projected using a statistical downscaling approach under two RCP scenarios; results follow the trends of climate change projection worldwide. Some adaptation measures implemented at the level of the study area to face these imminent threats were discussed.

2 Study area

The coastal sub-basin of El Jadida - Safi is located southwest of the Oum-Er-Rbia basin. Its total area is of the order of 13070 km². The basin includes the major cities of Safi, El Jadida, and Sidi Bennour, the industrial zone, and the port of Jorf Lasfar (Figure 1).

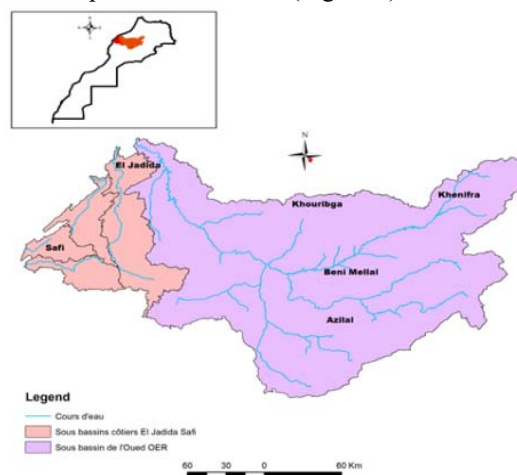


Fig 1. Location of El Jadida-Safi sub-basin

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A temperate coastal climate characterizes the sub-basin; annual precipitation varies between 200 and 300 mm, while temperature varies between 7.5 and 26°C. Surface water inputs to the study area are of the order of 50 Mm³/year. In addition, all non-consumed water from the upstream of Oum Er- Rbia basin estimated at 1590 Mm³/year are recovered by Al Massira dam and its compensators (Imfout, Daourat, and Sidi Said Maachou) and are transferred mainly to the coastal sub-basin of El Jadida – Safi. As to groundwater resources, they are generally contained in the aquifers of Sahel -Doukkala over an area of 6350 Km² and allow the supply of more than 43 Mm³/year.

Mobilized water is mainly used to meet the needs for drinking and industrial water of the different urban and rural agglomerations in the sub-basin; it is also used to irrigate the Doukkala perimeter.

3 Statistical Downscaling

The statistical downscaling technique assumes that the relationships between the GCM outputs and the hydroclimatic catchment variables for the past observed climate are equally valid for the future, under changing climate [14]. In this study, multiple linear regression was used to project future temperature and precipitation at the level of the coastal sub-basin of El Jadida-Safi under two climate scenarios, RCP4.5, and RCP8.5.

The general equation for statistical downscaling based on the transfer function is:

$$R = F(X) \quad (1)$$

Where R represents the local climate variable, known as the predictand (precipitation, temperature), X is the set of GCM generated large-scale climate variables (predictors), and F is the stochastic or deterministic function that establishes the relationship between the predictands (R) and predictors (X) [15]. Using twenty-six predictors from the second generation Canadian Earth System Model (CanESM2) developed by the Canadian Centre for Climate Modelling and Analysis (CCCma) of Environment and Climate Change in Canada for RCP 4.5 and 8.5 scenarios for the period 1961-2100, we statistically downscaled both temperature and precipitation data taken from the meteorological station of Al Massira (Table 1). The predictors with the best correlation were chosen to project future climate from 2020 until the year 2100 (Table 1).

Table 1. Meteorological station characteristics

Station		Data period	Predictors	
Al Massira		1984-2017	Precipitation	Temperature
Longitude	Latitude		P8_fgl	p500gl
-7.63	32.47		p8_ugl	p850gl
			prcpgl	tempgl

Results of statistical downscaling for Al Massira station follow projections for the Oum Er-Rbia basin and Morocco in general with an increase in temperature and a decrease in precipitations. It will decrease by 3.21% for

the RCP4.5 scenario and 3.44% for the RCP8.5 scenario for precipitation. In contrast, the temperature will increase by 2°C for the RCP8.5 scenario and by 2.2°C for the RCP4.5 scenario (Figures 2 and 3).

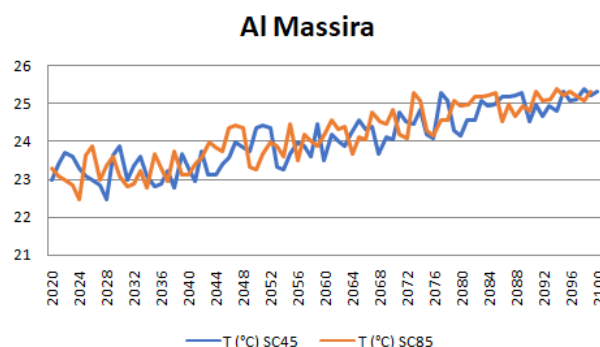


Fig 2. Evolution of temperature for both scenarios from 2020 to 2100

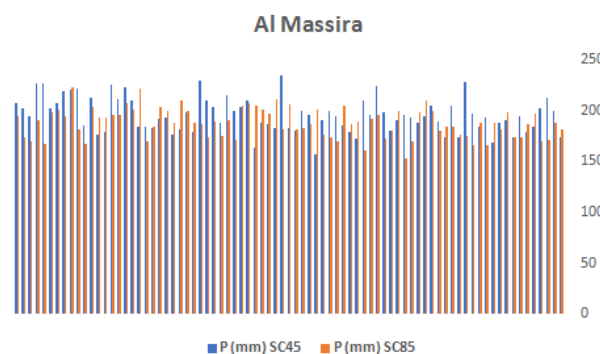


Fig 3. Evolution of precipitation for both scenarios from 2020 to 2100

Observed data over 37 years was used for calibration (1980-1998) and validation (1999-2017). The results of these two steps for precipitation and temperature are shown in Table 2. The values of R² indicate a good correlation for temperature. However, for precipitation, and as already stated before, it is challenging to develop a perfect multiple regression equation because of the conditional behavior of precipitation.

Table 2. SDSM calibration and validation results for Al Massira station

Station	Predictand	R ²	
		Calibration	Validation
Al Massira	Precipitation	0.309	0.532
	Temperature	0.946	0.960

4 Adaptation measures

Considering the alarming climate projections in the sub-basin, and ensuring rational and sustainable management of water resources in the area to delay water availability for all users under acceptable conditions, policymakers and decision takers must integrate adaptation measures in programs and plans bound to water resources

management. In recent years, at the level of Morocco and the study area in specific, several measures were implemented, such as the project of desalination of seawater launched by the Cherifien Office of Phosphates and which will reduce the excessive use of groundwater and allow the supply of 100 million m³/year through the plants of El Jadida and Safi. Besides, the Office of Agricultural Development of Doukkala adopted a strategy to rationalize and enhance the value of water use that involves several actions that limit water loss, improve performance of hydraulic structures and encourage users to save water by introducing new water-saving techniques leading to 40% of water savings [16-17].

5 Conclusion and recommendations

Results of statistical downscaling using SDSM for the sub-basin of El Jadida Safi confirm results and predictions of previous studies in the North African region. In fact, in the coming years, temperatures will tend to increase, while for precipitation, these will decrease with the alternation of dry and wet years.

These trends will indeed have a direct impact on water resources in the region. Thus, adaptation measures are necessary to maintain consistent offers to respond to different demands.

In order to quantify the impact of climate change on available water resources, the next step should focus on hydrological modelization of the sub-basin using available data and the results of this statistical downscaling.

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