

## Chapter 2

# Associations Between Climate, Ecosystems, and Ecosystem Services in the Pre–Sahara: Case Study of Tafilalet, Morocco

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### ABSTRACT

*This chapter focuses on the richness and wide variety of Sub-Saharan ecosystems particularly in the region of Tafilalet, Morocco. The Tafilalet ecosystems provide an extensive list of goods (see below) to the region, as well as “ecosystem services” for the inhabitants. However, in the last 30 years, these ecosystems are threatened by conjugated impacts of climate change and human overuse of the nature resources. The primary objective of this chapter is to evaluate both the damage inflicted on Tafilalet ecosystems and the associated ecosystem services due to climate change. Adaptation to climate change is of paramount importance to keep the survival of the diversity of Tafilalet ecosystems including agro-ecosystems, forests, and inland waters. Adaptation is a process to reduce the vulnerability of people to prevent displacement and conflict for scarce ecosystem services. The findings of this chapter show that a large number of ecosystem services of the region are limited by climatic conditions that affect the resilience of the whole oasis of Tafilalet.*

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## INTRODUCTION

The term ecosystem services (ESs) refers to the benefits that the local population can obtain from ecosystems (MEA, 2005). According to a UN report, ecosystem services include provisioning, regulating, cultural, and supporting services that directly affect human well-being. The trend of climate change (CC) is an important environmental force with significant implication for the state of water resources. The Earth's surface temperature during the last two decades has increased by about 0.5° C and an ongoing rise with similar amplitude is expected up to 2025 (IPCC, 2007). Variability in climatic conditions is already impacting ecosystems and associated ecosystem services. The impact and the link to ecosystem services are obvious and profound. CC is increasing and is affecting some extreme events such as floods and droughts. Several studies explored the impact of climate change on agriculture in general (Xie et al., 2018), on wheat production (Chelleri et al., 2014; Hernandez-Ochoa et al., 2018) on forest (Pirovani et al., 2018), oasis desert (Karmaoui et al., 2014), on ecosystem services (Lee et al., 2015), on water and food (Minucci & Karmaoui, 2017; Karmaoui et al., 2018). Besides, several problems are accelerating these changes such as population growth, land-use, overgrazing... Every year CC and the associated events are affecting ecosystem services such as water and soil in both quality and quantity. These problems are affecting many parts of the region called “hot spots”, where the frequency of occurrence is greater, the sensitivity is higher, the devastation is more severe, and local communities are more vulnerable. Water resources are a crucial area of vulnerability in Tafilalet, affecting water supply, agriculture, pasture, forest, and others.

Since 1970s, several Moroccan zones have experienced a general rainfall decline (Driouech, 2009; Khomsi, 2015). For the Tafilalet Oases, groundwater and surface water are interconnected resources. This connectivity can have significant implications for both water availability and quality, and presents major challenges for water managers and policy makers (Messouli et al 2009). In this area, a typical gradient can be observed from humid/sub-humid subtropical mountains and sandy desert. In the Oro-Mediterranean (mountainous Mediterranean) zone, between 2600 and 3400 m which coincides, with the most important zone for karstic groundwater creation, a large-scale degradation of vegetation has occurred. Regarding the climatic conditions, Tafilalet is characterized by a low rainfall, high temperatures, and evaporation. Those severe climate conditions influence the availability of water for the vegetation growth.

Regarding to adaptation strategies, the issues related to climate change in the preservation of oases, their preservation and their development “according to a model of resilience to climate change”, Morocco have adopted pricing policies and extension services to increase the cropping intensity of existing cultivated land (Sowers, 2010). The oasis rehabilitation project is also part of wider national strategies, such as the 2020 Rural Development Strategy, the National Plan of Action to Combat Desertification and Drought, and the Green Morocco Plan.

This chapter aims to evaluate the ecosystems and the associated ecosystem services under climate change context in Tafilalet zone, which is part of the South East Moroccan oasis biosphere reserve (ReBOSuM) UNESCO 2000. A description of ecosystems, assessment of ecosystem services and the impact of climate change on agro-ecosystems and water resources, as ecosystem services, were addressed through a discussion of available principles, approaches and assessment methods.

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