

Dissertation:

Socio-economic vulnerability to climate change: a regional
assessment in the context of water stress and tourism
development in north-eastern Morocco

Summary

vorgelegt von Vera Tekken,
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Water resources in north-eastern Morocco are increasingly under pressure from a growing human demand and a regional drying trend caused by changing climate patterns. Recently, water resources have reached or already fallen below critical limits. The human exploitation of water resources represents the main reason for an alarming decrease of freshwater resources: caused by population growth, high agricultural irrigation water needs, and the recent implementation of a water-intense tourism sector. The lack of appropriate policies to respond to these challenges determines regional vulnerability and puts socio-economic development at risk.

The overarching research objective of this thesis is **the identification of human and climate-induced drivers for increasing water stress in north-eastern Morocco** with a focus on regional tourism development. With particular regard to climate change and to the water-intense regional development plans, it is necessary to analyse how this will influence the near-term water situation and water demand, respectively.

The key economic sectors with the highest share of working population are highly water-dependent, thus sufficient water availability represents the basis for socio-economic development. Climate change in the region can aggravate the scarcity situation: precipitation is now the main hydrological variable, as the quality and quantity of groundwater resources has seriously deteriorated and as water efficiency measures and technologies currently are not appropriate to cover increasing demands.

Further, this thesis aims to support the development process of improved water management strategies for the facilitation of socio-economic development. By the means of an integrative research approach the vulnerability to increasing water scarcity is empirically investigated. The chosen research design is a vulnerability assessment approach. Vulnerability assessments have emerged over the past decade as appropriate frame of analysis to assess the impact and scope of different drivers causing socio-ecological vulnerability in the context of climate change. The underlying hypothesis is that regional climate change aggravates existing water scarcity in north-eastern Morocco, which is currently pressured by an inadequate demand-supply ratio (water deficit situation). From this general aim overarching research questions and issues have emerged and were refined by sub-questions during the process of research.

The causes and the extent of vulnerability and the development and governance context of water scarcity are subject to four articles which support the present thesis. Article I outlines the specific regional problems of the coastal zone of the case study area under climate change and socio-economic development pressure. Article II contrasts the human influence (indicators: population growth, water demand) on decreasing freshwater availability with the potential impacts of a changing regional climate (indicators: precipitation, temperatures, evapotranspiration). Article III analyses the additional water demand in north-eastern Morocco caused by the recent establishment of a large-scale luxury tourism sector in the coastal zone. Article IV discusses the sustainability of regional development plans in the light of severe water problems and outlines concrete adaptation measures for the regional water management.

The results show that water availability already fell below minimum water levels needed to ensure the water regional water supply. The regional water situation is in a situation of disequilibrium of water abstraction and water availability. Further population growth and water-intense economic development pathways will increase the risk of recurring water shortfalls. The

analysis of long-term climate series reveals a manifest drying trend and shifting climate patterns. The “*absolute water scarcity level*” that is “*beyond the water barrier of manageable capability*” has become a normal situation (based on the Falkenmark Index; Falkenmark 1989; Gleick et al. 2002).

Governmental development plans focus on luxury tourism to diversify the regional economy. Tourism is a promising sector in Morocco, and is needed to diversify the agriculture-dependent economy. However, tourism requires continuous water supply and contributes to the increase of seasonal water demand.

All four articles in this thesis emphasize the urgent need for societal and institutional responses to safeguard water supply in the Moulouya basin. Given the aggravating water situation and the underlying two-fold causes, three main strategies are considered reasonable and achievable:

- (1) Increase of regional water efficiency: the modernization of water infrastructures (no-open channel water transport, no gravity irrigation), the inclusion of ‘green’ water in calculations of water supply, innovative and traditional water collection measures, using the opportunities of virtual water trade;
- (2) Modernization of the regional water management: monitoring of the water situation and climatic variability, participatory approaches to engage the local population and to create awareness; and the
- (3) Implementation of and compliance with legally-binding regulations for the public administration, supported by national water policies.

Clearly, these measures require substantial investments. However, this thesis emphasizes, that regional natural water resources are finite and already in a state of severe degradation. A better understanding of the respective influence of climate-induced or human-induced pressures provides the basis for the implementation of adequate adaptation strategies. Human-induced impact can be influenced by policies, and with this the degree of socio-economic vulnerability. Water-based economies which do not explicitly react to aggravating pressures, are at risk of economic failure, as (a) climate change is an irreversible process, and (b) as socio-economic development builds upon water availability.