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Study of the impact of climate change on water resources in the Prerif mountains (Morocco)

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INTRODUCTION

The study titled «Study of the Impacts of Climate Change on Water Resources in the Prérif Mountains (MOROCCO)» focuses on analyzing the effects of climate change on water resources in the Prérif Mountains, a particularly vulnerable region in Morocco. The Prérif region is essential for biodiversity and socio-economic life, but it faces significant challenges due to increased climate variability and anthropogenic pressure. The primary objectives of this research are to analyze recent climatic trends and future projections in the Prérif Mountains, evaluate the impacts of climate change on water resources, especially precipitation and river flows, identify drought periods and their intensity over the past decades, and propose adaptation and resilience measures for local communities and ecosystems facing water challenges.

METHODOLOGY

To achieve these objectives, a multidisciplinary methodological approach was adopted. The first step involved the collection and analysis of climatic data. Historical meteorological data, including temperature and precipitation, were collected from local stations and international databases. This data collection helps understand past climatic trends and project future climatic scenarios. These historical records were supplemented by more recent satellite data, providing a comprehensive overview of climate variability over an extended period. Detailed statistical analyses were conducted to identify trends, anomalies, and patterns in temperature and precipitation, revealing significant insights into how the region's climate has evolved over time.

Next, hydrological analysis was conducted. River flows were measured and modeled to understand seasonal and annual variations. This modeling allows for predicting how climate change may affect available water resources. Hydrological models, such as the Soil and Water Assessment Tool (SWAT), were employed to simulate river flow responses to different climatic scenarios. These models integrated data on land use, soil properties, and topography, providing a robust framework to assess how changes in precipitation and temperature impact river flows and water availability in the region. The modeling results highlighted key periods of water scarcity and helped identify critical thresholds beyond which water resources would be severely impacted.

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The study of drought indices, such as the Standardized Precipitation Index (SPI), was used to identify drought periods. These indices are essential for quantifying the severity and duration of droughts, thus providing crucial information for water resource management. The SPI, calculated over multiple timescales (e.g., 1-month, 3-month, 6-month), offered a nuanced view of short-term and long-term drought conditions. Additionally, the Palmer Drought Severity Index (PDSI) was used to complement SPI analysis, focusing on soil moisture conditions and providing insights into agricultural droughts. These indices collectively provided a comprehensive assessment of drought dynamics in the Prérif Mountains.

Additionally, previous works by Rafik, Asri, and Gertet were integrated to enrich the analysis. These earlier studies provide historical context and comparisons that enhance the robustness of current conclusions. Rafik's work on hydrological variability, Asri's research on climate impacts on agriculture, and Gertet's findings on socio-economic adaptations to climate change offered valuable baseline data and methodological frameworks. By integrating these studies, the research benefited from a multi-perspective approach, ensuring that the analysis was comprehensive and grounded in existing scientific knowledge.

Surveys were conducted with local communities to understand their perception and adaptation strategies in response to climate change. These surveys provide important insights into the socio-economic impacts of climate change and existing adaptation practices. Structured interviews, focus groups, and questionnaires were utilized to gather data from a diverse cross-section of the population, including farmers, local officials, and community leaders. The findings revealed a range of adaptive practices, from traditional water conservation techniques to innovative approaches such as rainwater harvesting and crop diversification. However, the surveys also highlighted significant gaps in knowledge and resources, underscoring the need for targeted interventions to enhance community resilience.

A historical approach was also used to study the evolution of climate risks and their impacts on the region. This historical perspective helps understand how climatic conditions have changed over time and how these changes have affected water resources. Archival research, including the examination of historical weather records, agricultural reports, and oral histories, provided a rich context for understanding long-term climate trends and their socio-economic consequences. This historical analysis revealed patterns of recurring droughts and floods, helping to contextualize the current challenges faced by the region within a broader temporal framework.

RESULTS

The results obtained reveal alarming climatic trends. A significant increase in annual average temperatures and a reduction in precipitation have been observed in the Prérif Mountains over recent decades. These trends indicate regional climate warming, which directly affects water resources. The temperature data showed a clear upward trend, with average annual temperatures rising by approximately 1.5°C over the past fifty years. Precipitation patterns exhibited increased variability, with more frequent and intense dry periods interspersed with heavy rainfall events. This increased variability poses significant challenges for water management, as it leads to both drought conditions and increased risk of flooding.

An intensification of droughts has been detected, with particularly severe periods between 1985 and 1995, and prolonged dry monthly sequences between 1998-2001 and 2007-2008. These prolonged droughts have devastating impacts on agriculture, potable water availability, and local ecosystems. The SPI and PDSI indices confirmed these findings, showing extreme drought conditions during these periods. The prolonged droughts led to significant agricultural losses, reduced water supply for domestic use, and stressed local ecosystems, including critical habitats for endemic species.

River flows show a downward trend, exacerbating issues of water availability for agriculture and local population needs. This decrease in river flows is a major concern for the sustainable management of water resources in the region. The hydrological models projected that under current climate trends, river flows could decrease by up to 30% by 2050, severely impacting irrigation, drinking water supply, and hydropower generation. This projected decrease underscores the urgent need for adaptive water management strategies to ensure sustainable water supply in the face of changing climatic conditions.

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Perceptions and local adaptations reveal that local communities have developed various adaptation strategies, but they remain limited in the face of the magnitude of climate changes. Existing adaptation strategies include crop diversification, water conservation, and the use of traditional agricultural techniques. However, these measures are insufficient to offset the increasing negative impacts of climate change. The survey findings indicated that while communities are aware of climate change and its impacts, they often lack the resources and technical knowledge to implement more effective adaptation measures. This highlights the need for external support, including capacity-building programs and financial assistance, to enhance local adaptive capacities.

CONCLUSION

The conclusions of this study underscore the urgency of implementing robust adaptation measures to address the impacts of climate change on water resources in the Prérif Mountains. Key recommendations include strengthening local capacities, integrated water resource management, developing climate policies based on scientific data, and establishing continuous climate monitoring and research programs. Strengthening local capacities is essential for improving community adaptation strategies. This can include training and awareness programs to teach resilient agricultural practices and water conservation techniques. Integrated water resource management is an approach that considers the entire water cycle and the interactions between different water users. This approach allows for developing sustainable management strategies that balance the needs of all users.

Developing local and regional climate policies based on scientific data is crucial for planning and effectively responding to climate challenges. These policies must include prevention and mitigation measures for climate risks, as well as adaptation strategies. Effective policies should be informed by robust scientific data and should prioritize the most vulnerable sectors and communities. Additionally, policies should promote sustainable land and water use practices, support the development of drought-resistant crops, and encourage the adoption of water-saving technologies.

Finally, establishing continuous climate monitoring and research programs is necessary to adapt strategies based on new data and climate projections. These programs allow real-time monitoring of climate changes and adjusting policies and practices accordingly. Continuous monitoring ensures that emerging trends and anomalies are promptly identified, enabling proactive and adaptive management. Research programs should focus on improving climate models, understanding local climate dynamics, and developing innovative adaptation technologies.

Furthermore, interdisciplinary collaboration is critical to addressing the complex challenges posed by climate change. Researchers, policymakers, and local communities must work together to develop comprehensive strategies that integrate scientific knowledge with traditional practices. Engaging with local stakeholders ensures that adaptation measures are context-specific and culturally appropriate, increasing their effectiveness and sustainability.

In summary, this study highlights the considerable challenges posed by climate change for water resources in the Prérif Mountains. It also emphasizes the importance of developing robust adaptation strategies to protect water resources and support local communities in facing these increasing challenges. The results of this research provide valuable information for policymakers, water managers, and local communities and can serve as a basis for future actions aimed at mitigating the impacts of climate change in the region. By implementing the recommended measures, the Prérif region can enhance its resilience to climate change, ensuring sustainable water resources for future generations and preserving its unique environmental and socio-economic landscape. The integration of scientific research, local knowledge, and policy initiatives is crucial for building a resilient future in the Prérif Mountains, capable of withstanding the multifaceted impacts of climate change.

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