Climate change impact and adaptation in the complex lagoon of Bizerte

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Introduction

The complex lagoon of Bizerte is located on the north coast of Tunisia and appears today as one of the most attractive areas of the country for its multiple assets, both natural and socio-economic. It presents itself as a rich and fertile region in terms of climate and agriculture and dynamic in the areas of industry and services. Its immediate proximity to the capital also gives it an additional attraction.

The lagoon is characterized by its complex hydrodynamic regime, and its waters are influenced by both the Mediterranean Sea and the Mediterranean climate. However, due to the impact of climate change, the lagoon is facing serious environmental problems that are affecting the local ecosystem, socio-economy, and human health. This paper will explore the impact of climate change on the lagoon of Bizerte and identify the adaptation measures that can be taken to mitigate these effects.

Impact of Climate Change on the complex Lagoon of Bizerte

The lagoon of Bizerte is a highly dynamic system that is affected by several natural and anthropogenic factors. However, the impact of climate change has been the major cause of environmental degradation in recent years. Rising sea levels, increased temperatures, and changing rainfall patterns are some of the climate change factors that are affecting the lagoon.

Sea level rise is causing the intrusion of seawater into the lagoon, leading to the loss of freshwater resources and alteration of the lagoon's salinity.

The increased temperatures are causing thermal stress on the local fauna and flora, while changing rainfall patterns are affecting the lagoon's water balance and leading to increased nutrient pollution and eutrophication. The increased temperatures are causing thermal stress on the local fauna and flora, leading to reduced biodiversity and changes in the distribution of species. The changing rainfall patterns are leading to increased nutrient pollution and eutrophication, affecting the lagoon's water quality.

Species may be forced to migrate to new areas to find suitable habitats. In the lagoon of Bizerte, this could lead to changes in the composition of the ecosystem, affecting both the ecological and socio-economic systems.

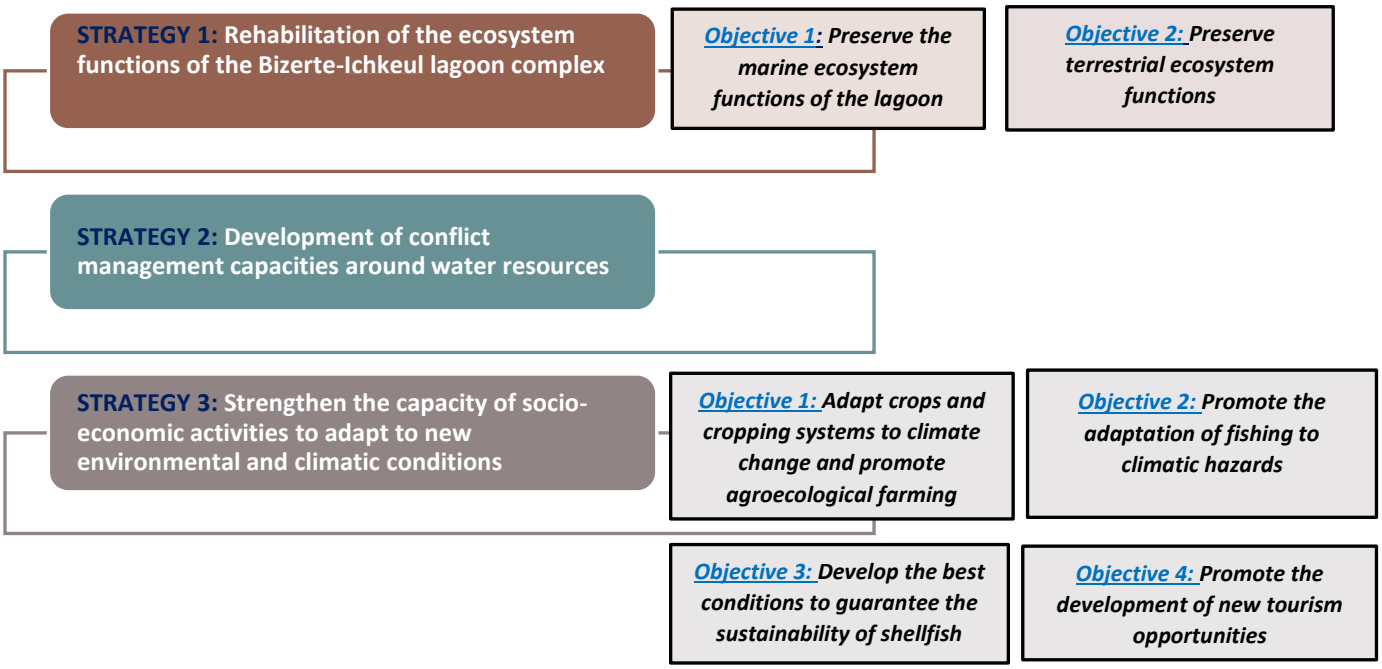
Ocean acidification is also one of the impacts that affecting the growth and survival of shell-forming organisms such as mollusks and corals which could affect the local fishing industry, as well as the ecological balance of the ecosystem.

Moreover, climate change can have direct impacts on human health, such as increased heat stress, respiratory illnesses due to poor air quality and the extension of Aedes mosquito breeding grounds.

These factors are affecting the local ecosystem, reducing biodiversity, and leading to the loss of important ecological services that are critical to the local economy. In fact, the loss of freshwater resources and increased salinity is affecting the local agriculture, which is highly dependent on the lagoon's water resources. The loss of biodiversity is affecting the local fishing industry, which is one of the main sources of income for the local community.

Adaptation Measures

Several adaptation measures can be taken to mitigate the impact of climate change on the lagoon of Bizerte. These measures were developed through three different strategies and its strategy is devoted to objectives to maintain the balance between the different components in the in the complex lagoon.



STRATEGY 1: Rehabilitation of the ecosystem functions of the Bizerte-Ichkeul lagoon complex

Objective 1: Preserve the marine ecosystem functions of the lagoon

- *Periodic dredging of the navigation channel of Menzel Bourguiba*

Periodic dredging of the navigation channel is one of the measures that can be taken to preserve the marine ecosystem functions of the lagoon complex of Bizerte. It can help maintain the flow of water in and out of the lagoon complex, which is essential for the health of the marine ecosystem.

By regularly removing sediment from the navigation channel, dredging can help maintain the flow of water and ensure that the marine ecosystem functions of the lagoon complex of Bizerte are preserved.

- *Rectification of the shores of the lake to avoid dead zones*

Dead zones are areas of water that have low or no oxygen, which can occur when excessive nutrients, such as nitrogen and phosphorus, enter the water and promote the growth of algae. When these algae die and decompose, they consume oxygen and create a low-oxygen environment that can be deadly for marine life. By reshaping the shoreline, water can flow more freely and prevent the accumulation of nutrients in one area, which can help prevent the formation of dead zones.

- *Maintaining effective exchanges between the Bizerte lagoon and Lake Ichkeul*

The exchange of water, nutrients, and sediment between the Bizerte lagoon and Lake Ichkeul is essential for maintaining the health of the marine ecosystem. By monitoring and managing the exchanges between the two bodies of water, it is possible to minimize the impact of climate change and preserve the marine ecosystem functions of the lagoon complex.

- *Management and control of invasive species*

Invasive species are non-native plants or animals that can have negative impacts on the native species and disrupt the natural balance of the ecosystem such as the blue crab and the Pacific oyster that have been identified as potential threats to the native species. By implementing measures to control and

manage these invasive species, such as using traps or removal programs, it is possible to minimize their impact and preserve the marine ecosystem functions.

Objective 2: Preserve terrestrial ecosystem functions

- *Limit submersion*

Rising sea levels due to climate change can cause submersion of coastal areas, including terrestrial ecosystems. To protect these ecosystems, measures should be taken to limit submersion. This can be achieved through the construction of sea walls, dikes, and other protective measures.

- *Monitor and prevent the appearance of any introduced or invasive species*

Introduced or invasive species can have negative impacts on the local terrestrial ecosystem by outcompeting native species and disrupting the natural balance of the ecosystem. It is important to monitor the appearance of any introduced or invasive species and take measures to prevent their spread.

- *Destruction of invasive plants*

Invasive plant species can take over and degrade terrestrial ecosystems, impacting native species and altering ecosystem functions. It is important to identify and remove invasive plant species, and if necessary, carry out destruction of these species to prevent their continued spread.

- *Revegetate degraded spaces by local species*

Revegetating degraded spaces with local species can help restore the ecological balance and ecosystem functions of the area. Native plant species are better adapted to the local climate and soil conditions and are more resilient to the impacts of climate change

STRATEGY 2: Development of conflict management capacities around water resources

- *Promote new water mobilization technologies*

Innovative technologies such as rainwater harvesting, desalination, and water reuse can increase the availability of water resources and reduce the dependence on traditional sources. The promotion and adoption of these technologies can help prevent conflicts over scarce water resources.

- *Protect available resources*

Protecting available water resources from pollution and overuse is crucial for their sustainability. This can be achieved through effective water management practices, such as water pricing, water allocation schemes, and water use regulations.

- *Developing unconventional water potential*

Developing unconventional water sources, such as treated wastewater, can increase the availability of water resources and reduce the pressure on traditional sources. However, it is important to ensure that these sources are safe for human and ecological use.

- *Develop and promote specific water governance*

Developing and promoting specific water governance practices can help ensure sustainable and equitable use of water resources. This can include stakeholder participation, water management planning, and conflict resolution mechanism.

STRATEGY 3: Strengthen the capacity of socio-economic activities to adapt to new environmental and climatic conditions

Objective 1: Adapt crops and cropping systems to climate change and promote agroecological farming

- *Increase the cultivation of legumes*

Legumes, such as lentils, chickpeas, and beans, are known for their ability to fix atmospheric nitrogen and improve soil fertility. Increasing the cultivation of legumes can improve soil health and reduce the dependence on synthetic fertilizers

- *Decrease soft wheat cultivation*

Soft wheat is one of the most cultivated crops in the complex lagoon of Bizerte. However, it is highly sensitive to heat stress and drought. Decreasing the cultivation of soft wheat and replacing it with more resilient crops can help farmers adapt to the changing climate.

- *Promote salinity-tolerant crops*

The lagoon complex of Bizerte is characterized by high salinity levels in some areas, which can limit crop productivity. Promoting the cultivation of salinity-tolerant crops, such as barley, oats, and sorghum, can help farmers adapt to these conditions.

- *Use of local varieties and breeds*

Local varieties and breeds are often better adapted to the local environment and can be more resilient to changing climate conditions. Promoting the use of local varieties and breeds can help preserve local biodiversity and promote adaptation to climate change.

- *Conservation agriculture*

Conservation agriculture is a set of practices that aim to improve soil health and reduce soil erosion by minimizing soil disturbance, maintaining soil cover, and crop rotation. Adopting conservation agriculture practices can help farmers adapt to changing climate conditions and improve the long-term sustainability of agricultural production.

- *Biological agriculture*

Biological agriculture is an agroecological approach that emphasizes the use of natural processes and resources to promote plant and animal health. This approach can help farmers reduce their dependence on synthetic inputs and promote the use of locally available resources.

Objective 2: Promote the adaptation of fishing to climatic hazards

- *Artisanal and coastal fishing coupled with recreational fishing*

Diversifying fishing activities can help reduce the dependence on a single fishery and increase the resilience of fishing communities to changing climate conditions. Promoting artisanal and coastal fishing coupled with recreational fishing can help increase income opportunities for fishing communities and reduce pressure on vulnerable fish stocks.

- *Preservation and development of living resources*

The preservation and development of living resources, such as fish and other aquatic organisms, is critical for the long-term sustainability of fishing activities. This can be achieved through measures such

as implementing sustainable fishing practices, establishing protected areas, and promoting the regeneration of fish habitats.

- *Upgrading fishing infrastructure*

Fishing infrastructure, such as ports, landing sites, and storage facilities, can play a key role in promoting the adaptation of fishing to climatic hazards. Upgrading fishing infrastructure can improve the safety and efficiency of fishing activities and help ensure the sustainability of fish stocks.

Objective 3: Develop the best conditions to guarantee the sustainability of shellfish

Shellfish farming requires specific environmental conditions, such as adequate water quality and temperature, to ensure the growth and survival of shellfish populations. To ensure the sustainability of shellfish farming, measures such as monitoring water quality, controlling pollution sources, and regulating aquaculture practices can be implemented.

Objective 4: Promote the development of new tourism opportunities

The complex lagoon of Bizerte is a unique ecosystem with high natural and cultural values that can attract tourists. By promoting the development of new tourism opportunities, such as eco-tourism and cultural tourism, local communities can diversify their income sources and reduce their dependence on shellfish farming. Additionally, the development of tourism can also raise awareness about the importance of preserving the lagoon's ecosystem, which can lead to increased support for conservation efforts.

Conclusion

The complex lagoon of Bizerte is a unique ecosystem that is facing numerous challenges due to climate change including rising sea levels, increased water temperature, ocean acidification, and changes in precipitation patterns.

To address these challenges, it is essential to implement a range of measures to adapt to the impacts of climate change. These measures include preserving the marine and terrestrial ecosystem functions of the lagoon complex, protecting terrestrial ecosystems from climate change, developing conflict management capacities around water resources, adapting crops, and farming systems, promoting agroecological farming practices, adapting fishing to climatic hazards, and ensuring the sustainability of shellfish farming.

Overall, it is crucial to continue monitoring and assessing the impacts of climate change in the lagoon complex and to promote awareness-raising and education efforts among local communities, decision-makers, and the public to build support for climate change adaptation and mitigation measures which will be more developed in the next steps of the study.

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