CHALLENGES OF IMPLEMENTING NATURE-BASED SOLUTIONS IN THE MEXICAN CARIBBEAN

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INTRODUCTION

Poor developing planning has caused the deterioration of coastal areas worldwide, resulting in the loss and degradation of ecosystem services crucial for coastal communities' well-being. Human activities, driven by inadequate planning, modify the natural matter and energy flow through coastal areas, leading to flooding and chronic erosion that affect human livelihoods (Newman, 2019). In addition, the flawed implementation of coastal zone management strategies and the effects of climate change exacerbate these challenges, jeopardizing the environmental, social, and economic sustainability of coastal communities (Silva *et al.*, 2019).

Nowadays, there is enough evidence of the adverse effects of neglecting environmental factors, encompassing matter and energy flows, within gray infrastructure planning, particularly evident in projects designed to address coastal flooding and erosion, many of which, over time, have proven to be nonviable, worsened rather than alleviating these issues (Martell *et al.*, 2020). Nature-based solutions (NbS) are part of a new global vision that promotes sustainable human development (Chávez *et al.*, 2021), implying to enhance human well-being without exceeding ecological boundaries. The IUCN (2016) defines Nature-Based Solutions (NbS) as "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature."

However, implementing NbS needs a comprehensive understanding of the biological components to be incorporated into the project. Likewise, the feasibility of NbS focused on recovering regulating ecosystem services such as flood control depends on the suitable space's current and future availability. Given that the site conditions may differ from the ecosystem that used to provide the desired service, it is crucial to analyze the NbS implementation viability while accounting for anthropogenic pressures, including the expected effects of climate change. Thus, two fundamental questions to evaluate the viability of an NbS are: What are the disturbances that the NbS will have to face? Despite the current disturbances, will NbS be sustainable?

In the Mexican Caribbean (Figure 1), several beaches have chronic erosion processes primarily associated with the alteration of the natural hydrodynamics, extreme weather phenomena, and inadequate coastal management practices (Ruiz-Martínez *et al.*, 2013; Silva *et al.*, 2012). Simultaneously, the interconnected ecosystems the Caribbean beaches rely on, such as coral reefs, provide crucial ecosystem services that range from options for recreation to coastal protection. These manifold benefits highlight these systems as valuable elements to be considered in the NbS strategies to mitigate coastal erosion in the Mexican Caribbean. Nonetheless, the extent of the positive effect under actual and future conditions has to be proven.

This work aimed to determine the disturbances that affect coral reefs throughout the Mexican Caribbean and to analyze whether their presence allows the sustainability of a hybrid infrastructure (coral-concrete) that reduces wave energy.

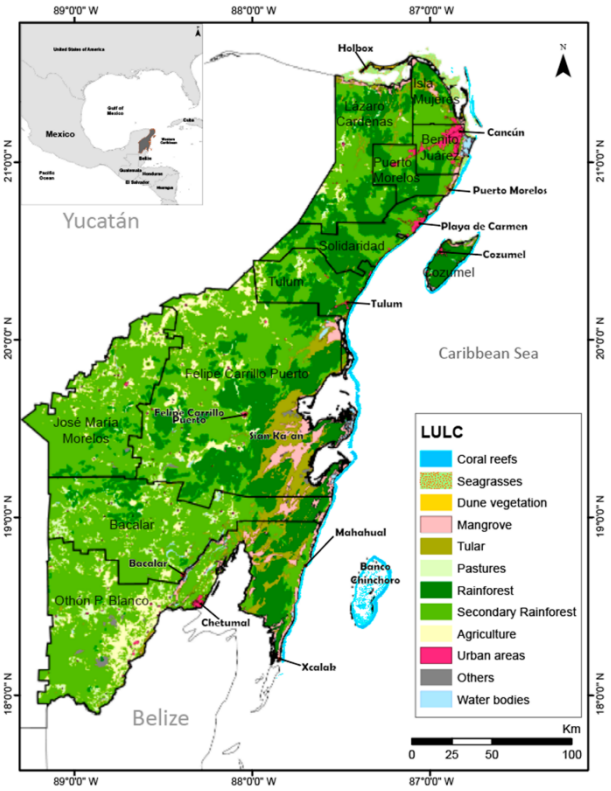

Figure 1 – Land use and land cover (LULC) in the Mexican Caribbean region (Gómez *et al.*, 2022).

RESULTS

The results identify the disturbances to which the corals coupled to the hybrid infrastructure will be exposed (Figure 2). Likewise, the origin of the disturbances is identified. In addition, the difference between the ideal environmental conditions for establishing corals and those currently

present are analyzed to determine the sustainability of a hybrid infrastructure project (coral-concrete) in the Mexican Caribbean. Finally, mitigation/adaptation strategies around hybrid infrastructure that could contribute to the success of its implementation are discussed.

CONCLUSION

From the proposed methodology, the disturbances present along the Mexican Caribbean coast and their origin are identified. Based on identified disturbances, we point out those that will not allow the establishment of hybrid infrastructure. Furthermore, places in the Mexican Caribbean where it is possible to implement hybrid infrastructure are located. Finally, we advise about the disturbances that can and must be controlled to allow for the sustainability of the hybrid infrastructure project.

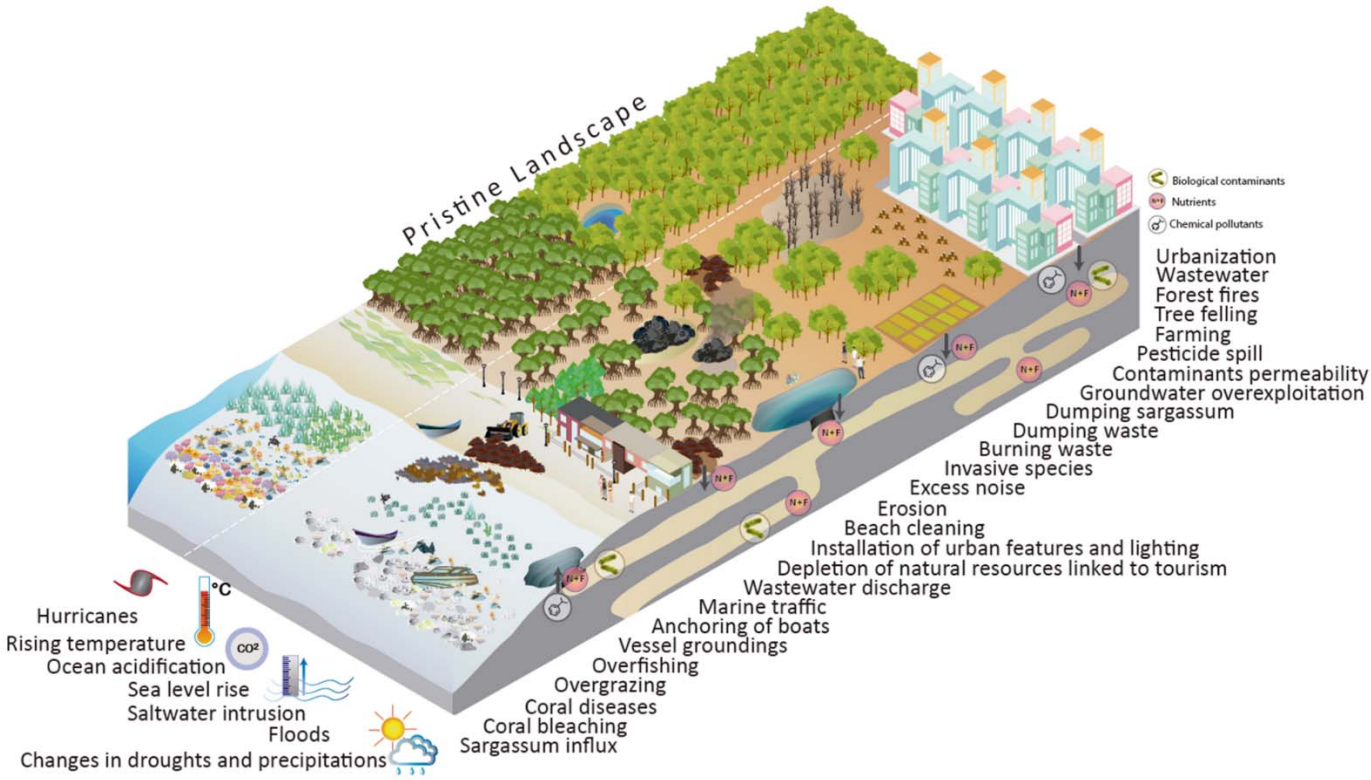

Figure 2 – Disturbances reported in representative ecosystems of the Mexican Caribbean (Gómez *et al.*, 2022).

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