Contribution of ecological restoration to mangrove resilience: case study of the Philippines, West Africa and Costa Rica.

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According to the FAO (2007), it is estimated that mangroves have declined at rate of 180 000 ha per year between 1980 and 2000, representing a global cumulative loss of 35% of the ecosystem surface. Mangroves are threatened by their conversion to aquaculture farms and by urbanization, although they provide a multitude of services and participate in the mitigation of climate change effects. As a result, the resilience threshold of many mangroves is likely to be reached rapidly(Laffoley and Baxter 2018), exacerbating their degradation and calling for urgent restoration, when conservation efforts aren't enough. Since then, a plethora of mangrove restoration measures have been carried out around the world, although most have failed to restore resilient ecosystems. Scientists agree there is a need to pursue efforts in the understanding of mangrove Ecology while promoting efficient governance systems in order to achieve better restoration results.

In this context, my thesis will aim to analyze in several localities the restoration effort and to identify the factors of success and success of the projects, then to measure their effects.

The aim of this thesis is to carry out an integrated analysis of mangrove ecological restoration, considering ecological, biophysical and socio-economic criteria all three directly affecting mangrove resilience potential.

With regards to the current unsatisfactory results of mangrove restoration projects, there is an urgent need to assess and improve such methods in order to shift the tendency to decline. Which responses can be proposed to improve the performance of restoration project and how does socio-economic settings influence their success or failure?

Our working assumption is that restoration efforts vary with local socio-economic setting. Local settings influence the relation to Nature and willingness to preserve and restore (López-Angarita et al. 2016). Governance analysis can shed light on the causes of mangrove degradation, on the motivation to reduce or not the degradation source and elude the locale rationale of decision-making. This scientific contribution finds its originality in the comparison of projects located on several continents, therefore considering mangrove geomorphological and ecological diversity, as well as its cultural and institutional diversity. The case studies are:

- Costa Rica, where it is a question of restoring sites formerly used for agriculture (FFEM funding within the Mangrove Initiative);
- Benin, Togo and Senegal, where the coast undergoes significant erosion affecting human communities, gathered on the coast (FFEM funding);
- The archipelago of the Philippine in the central Visayas sea where coastal communities are particularly vulnerable to meteorological and geological events (hurricanes, tsunamis).

Finally, the thesis aims to produce a decision support tool for measuring the ecological efficiency of restoration projects. Ecological restoration refers to a process facilitating the return of a disturbed or degraded ecosystem to an ecologically desirable trajectory (SER 2004). The objective is to "recreate" a reference ecosystem chosen for its ability to self-organize and sustainably maintain its functionality after disruption, without further assistance. Recent studies have focused on mangrove spatial dynamics, but few have assessed restoration projects success through multi-criteria performance metrics. The criteria are of

three categories: landscape criteria analysing ecosystem functionality at the scale of the landscape (e.g fragmentation / connectivity, land use land cover); the abiotic criteria (e.g. geomorphology, hydrodynamics, meteorological and physicochemical factors); and the ecological criteria assessing the adequacy of ecological conditions for the maintenance of species (eg stand structure, species richness, self-organization, migrations, corridors).

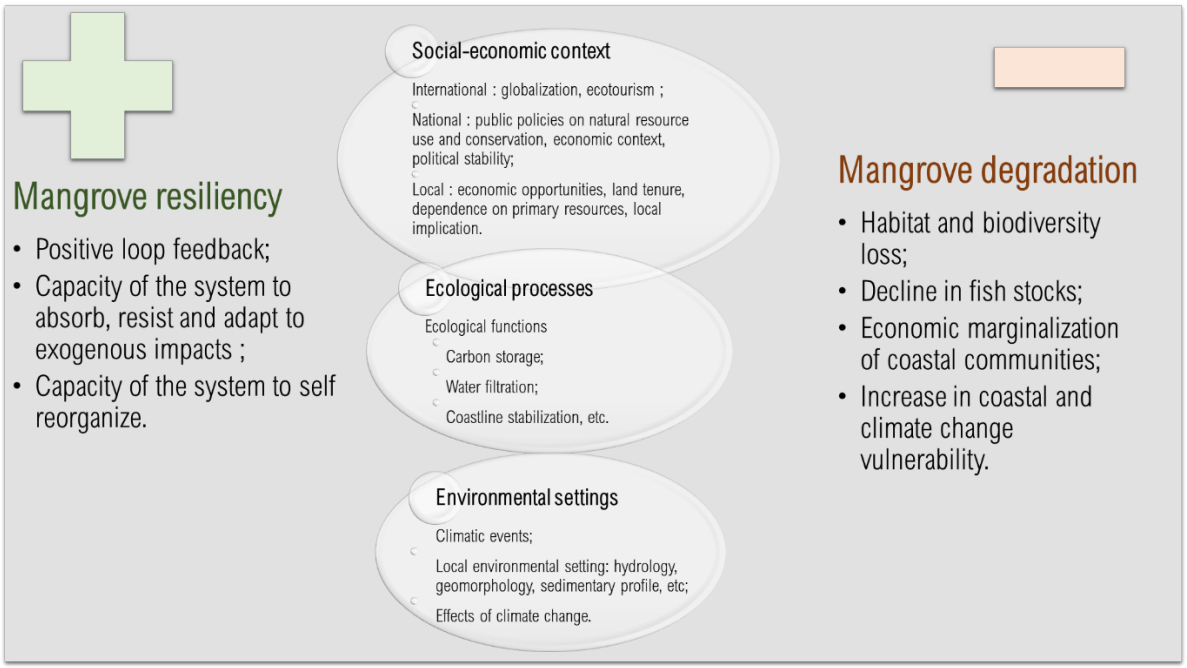

Figure 1 : Drivers of mangrove health state (center) between two opposite environmental state, one being system resiliency (left) and the other mangrove degradation (right). Adapted from Armitage (2002) and Zaldívar-Jiménez et al. (2010).

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