



I/ INTRODUCTION : CLIMATE CHANGE AND ITS IMPACTS ON COASTAL AREAS

Between land and sea, coastlines are in constant evolution. Coastal areas are submitted to natural elements (wind, waves, currents, continental geographical dynamics) which have natural hazards: coastlines moving forward or backwards (highest water limits), storms, marine submersions or moving dunes (Tapadinhas and Dreyfus 2015). Furthermore, sediment supplies that could contribute to replenishing certain beach areas, which come from continental erosion transported by rivers, has nowadays greatly diminished, particularly due to the barriers caused by dams.

Finally, the increase of human activity on the coasts since the 1950s, causes an increase of population, of usage, of activities and of property exposed to these coastal hazards. Also, the vulnerability of coastal areas has increased over the last decades due to the combination of multiple factors: the degradation of natural areas on the land-sea interface, the disruption of hydro-sediment dynamics by human activities and coastal development, and also due to the impacts of climate change.

Climate change is now a fact, the last report from the IPCC (Intergovernmental Panel on Climate Change 2013) shows that “the atmosphere and the oceans have warmed up, snow and ice covers have diminished, sea levels have risen (0.19 m between 1901 and 2010) and greenhouse gas concentrations have increased. At the end of the 21st century, the temperature increase on the surface of the globe will probably be superior by 1.5 °C in comparison with the period from 1850 to 1900, the average sea levels around the world will continue to increase as well as the oceans’ acidification levels. The Mediterranean is one of the areas where the situation is worrying, it was identified as a climate change “hot spot” (Rochette, Magnan, and Billé 2010)

These climate changes will have several consequences on ecosystems and the use of coastlines:

- More and more extreme and frequent climate hazards: floods, droughts, storms...
- The lower coastlines will be affected by the sea with submersion and erosion of the coasts and subterranean waters will be more and more submitted to the influence of salty water;
- Effects on natural resources: increase or decrease of notable species and habitats, migration of species towards other areas, problem of exotic invasive species;
- Economic consequences: cost of protection / relocation of activities (agriculture, habitats, roads...);
- Cultural and landscape impacts: people's attachment to landscapes and their uses, consideration of local identity, change in social behaviour;

III/ RESIST, ENDURE, ADAPT... WHAT TO DO?

Taking into account natural phenomena and coastal risks is a big issue for the conservation and management of natural coastal areas. In the 19th century, heavy developments were constructed in order to maintain the coastlines (dikes, rocks, breakwaters, groynes...). Aside from their high cost and their long term inefficiency, these infrastructures have had a negative impact on the environment, landscapes and hydro-sediment dynamics (Tapadinhas and Dreyfus 2015).

Techniques with much less impact were then conceived to work with nature by integrating the coasts' natural dynamics and the mobility of the coastline (Ministry of Ecology and Sustainable Development and Energy 2011): sediment re-balancing, dune area management, vegetation restoration, prevention for the conservation of areas, limiting and guiding tourist flow and visits...

Nowadays, societies are aware of this inevitable phenomenon, and "resisting" with heavy development or "enduring" are slowly being replaced by "adapting" by anticipating and designing with climate change.

ADAPTATION - DEFINITION

Adaptation is defined by the IPCC as "an adjustment of natural systems or human systems facing a new or changing environment. Adapting to climate change shows the adjustment of natural or human systems in response to climate stimuli, present or future, or to their effects in order to diminish negative effects or exploit beneficial opportunities".

Strategies	Advantages	Inconveniences
PROTECTION Maintaining the coast lines (dikes, rocks) or taking measures on the causes of erosion (breakwaters, groynes, reloading sand)	Efficiency in terms of resolving local problems Strong social acceptance	High investment and maintenance costs Displacement of the erosion phenomenon to other areas Disruption of sedimentary functioning Non-sustainable solution
"ACCOMMODATION" (adjusting natural and human systems to a new or changing environment) Adapting to the phenomenon by issuing construction rules (zoning, raising foundations...), compensation measures for destroyed property or systems	Gaining space and preserving the natural state of the coasts Local policies Low costs Compensation and additional costs of protection work avoided	Local measures not standardised Measures not dealing with long term imperatives
STRATEGIC RETREATING Moving things at stake inland	Better efficiency on the short and long term No maintenance No impact on sedimentary functioning	Need of space inland and areas to move the infrastructures and activities Difficult to implement in important socio-economic areas or for heavy infrastructure and dense urbanisation Low social acceptability
NON-ACTION / Making the decision not to react	Respect of natural functioning	Implementation limited to natural areas with very little at stake

Table 1. Advantages and inconveniences of various adaptation options when faced with rising sea levels (Carreno et al., 2008)

MEDITERRANEAN ICZM PROTOCOL AND ADAPTING TO CLIMATE CHANGE: COMMON FOUNDATIONS (Billé & Rochette, 2008)

ICZM is in essence a tool in favour of adapting to climate change, particularly with the general shared objective of sustainable development, through sustainable ecosystems and human activities. As adaptation aims to diminish the negative effects of climate change and therefore to ensure sustainability, the ICZM protocol's goal is to "support the sustainable development of coastal areas" (article 5-a) and to "prevent and/or reduce the effects of natural hazards and in particular of climate change, which can be attributed to natural or human activities" (article 5-e). It should also be noted that "the preservation of the integrity of coastal ecosystems" and therefore of biodiversity, which is one of the main objectives of the ICZM, has a major part to play in terms of adaptation. Coastal ecosystems in good working condition in fact provide many useful services to help fight the effects of climate change (humid areas and availability of water resources, dunes and erosion, etc...).

III/ TOWARDS NEW METHODS TO MAKE DECISIONS AND TAKE ACTION

Due to climate change threats, it is necessary to plan ahead and to prepare those concerned for the long term relocation of activities and property exposed to coastal hazards. It is therefore necessary to anticipate future developments in coastal areas, to adapt them to the area by integrating natural phenomena and to preserve/restore coastal ecosystems in order to reconstitute attenuation areas. The implementation of adaptation strategies requires deep reconsideration of the way investment and development decisions are made.

It is in this optic that the French Ministry in charge of Ecology developed in 2012 a National Integrated Management of Coastlines strategy, which is used as an outline committing the state and local communities to shared local strategies and knowledgeable measures in order to take coastal erosion into consideration for public policies. This strategy is implemented through a first action plan 2012 – 2015 which is based around four axes: A) developing the observation of coastlines and identifying areas with risk of erosion to prioritise public action; B) creating shared strategies between public entities involved (local communities, state and socio-professionals;

C) evolving towards space recomposing policies, where relocating activities and property is unavoidable; D) defining the terms of financial contribution.

Hallegatte (2008) provides four directions to explore to head towards stronger decisions:

- Institutionalising a long term plan, completed by a regular reviewing process according to new information available. Adaptation is a continuous learning process supplemented by feed-back.
- Promoting "no regret strategies", i.e. strategies that reduce the vulnerability of a system at negative, null or negligible cost (for example by taking "pessimistic" margins in the design phase of an infrastructure, rather than having to intervene on it after putting it in service).
- Favouring reversible strategies rather than irreversible ones: for example, refusing to urbanise part of the coast at an immediate high but known cost, which can be rapidly annihilated by making the opposite decision when there is sufficient information. However, deciding to urbanise despite uncertainties, can provide immediate benefits, but can lead to a future situation where the only choices are between heavy protection and relocation, two options with often prohibitive costs and far from guaranteed in terms of feasibility.
- Not only focalising on adaptation technique solutions: in certain cases, institutional or financial tools are more appropriate (for example insurance in the agricultural sector or the implementation of early alert systems rather than heavy coastal protection). The main benefit of these "soft" adaptation options is that they are a lot less inert and irreversible.

Based on this, it would make sense to start a 100 year strip rather than a 100m strip. The integration or the maintaining of natural non-constructed areas on the sea front, which would serve as a buffer zone, would allow to absorb the regular regression of the coast lines as well as the submersion and flooding phenomena incurred according to evolution projections on the mid/long term (100 years) due to climate change.

These decisions are of course inseparable from the implementation of scientific research which would help to support or strengthen the decisions, which would include (Tapadinhas and Dreyfus 2015):

- Improving knowledge of hazards and their originating phenomena (changing of sea levels, monitoring coastline movements, the impacts of development on hydro-sedimentary dynamics ;
- creating tools to analyse and prevent risks (regionalised modelling, analysing site vulnerability factors...);
- implementing management solutions and decision supporting tools (restoring damaged natural areas, ecological engineering techniques...);
- evaluating measures and methods to better take into account problems of coastal development, planning approaches and urban documents.

CLIMATE THOUGHTS

Climate change causes various constraints on coastal areas, but is also an opportunity for European and Mediterranean states to reconsider their development and coastal area management strategies on the short, mid and long term.

- What role will coastal agencies play in the global awareness process and decision support?
- What strategies and measures should they implement to anticipate and integrate these unavoidable changes?
- How to adapt to the impacts of climate change on coastlines?
- How to develop intervention strategies for these agencies on sites bound to evolve or even disappear?

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