TOWARDS A METHODOLOGICAL FRAMEWORK TO ASSESS COASTAL CLIMATE CHANGE ADAPTIVE CAPACITY IN AUSTRALIA AND EUROPE

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Introduction

The research project presented in this paper aims at developing a methodology to assess coastal systems climate change adaptive capacity, that is to say the capacity of coastal communities to adapt to the effects of climate change on the coast, including sea level rise, shifts in maritime climate patterns, increased coastal erosion rates and increased probability of tropical cyclones and consequent storm surges. Using a case study approach, the methodology will be used to assess adaptive capacity at two coastal sites of Australia, one in the Gold Coast and the other on the Sunshine Coast, integrating coastal vulnerability assessments based on the physical forcing scenarios with the identification of socio-economical, environmental and institutional issues.
A systems approach, based on the post-normal science paradigm and systems thinking practice, will be the base to develop and apply specific techniques to identify critical issues and variables to practically measure adaptive capacity of coastal communities. The analysis of this system will be the base to (i) identify the most important issues to be used as key leverage points for the system and (ii) identify the corresponding indicators, to be used to measure and monitor the level of adaptive capacity, in quantitative terms where possible.
Based on these ideas and experiences, the research will be oriented to the development of a climate change adaptive capacity methodology, designed to support integrated vulnerability assessments and future coastal planning.

Background

Man-induced global warming is considered as an undisputable truth by most of the international scientific community, being by now a priority issue in global political agendas. While the implementation of emissions abatement policies could reduce atmospheric GHG concentrations, delays and uncertainties in the climate response make adaptation to changing conditions a fundamental precautionary measure to be implemented at the global level (IPCC, 2007; Sterman, 2008).

Global warming and sea level rise are top international concerns, but climate change and adaptation strategies will obviously vary depending on the regions of the world. In this sense, regional downscaling aims at improving knowledge and understanding of the effects of global warming in specific regions, providing a base to produce fundamental information for decision making at different levels of the administration. As an example, in 2004 the Spanish Agency for Climate Change commissioned the University of Cantabria to conduct a study on the effects of climate change on the whole Spanish coast (Universidad de Cantabria, 2004). That study aimed to quantify the effects of climate changes on future maritime climate and sea level rise, which could affect extreme water levels. However, the proposed methodology did not include yet an integrated assessment of the adaptive capacity of coastal systems. Meanwhile,

the assessment of adaptation measures and of adaptive capacity is getting more attention by the scientific community and decision-makers: the White Paper of the European Commission on climate change adaptation, published on April 2009 (European Commission, 2009), represents a fundamental step supporting the need of assessing coastal systems adaptive capacity. In the same way, the Australian Government has placed climate change on top of its political agenda in the last few years. Climate change in Australia's coastal zone, in terms of sea level rise, increased coastal erosion and heavier storm surges, has the potential for major impact on society, economy and environment. More than 80% of the Australians live within the coastal zone and about 711,000 residences are within 3 km of the coast and less than 6 m above sea level. Adding the fact that the number of coastal residents and tourists is growing to unprecedented levels in the last two decades (Smith & Thomsen, 2008), it can be argued that the Australian society is especially vulnerable to coastal climate change. Likewise, coastal infrastructures are critical assets supporting a wide array of industries (e.g. transport, fisheries, and tourism) and the "coastal lifestyle", a major driver for population growth. These infrastructures, including defence structures, ports, harbours waterways and artificial beaches are under threat and can be heavily affected by gradual changes and extreme events. At the same time wetlands, estuaries, coral reefs, natural beaches, dune systems and other sensitive coastal ecosystems are also vulnerable to the impacts of climate change, and their resilience is challenged by accelerated processes and human pressure (Commonwealth of Australia, 2006).

Queensland coastal communities are particularly vulnerable to the effect of climate change. Most have developed in close proximity to the beach front, estuaries and tidal entrances, or within a coastal floodplain. People in these communities assume that the physical nature of their environment will remain unchanged. However, current planning and management strategies have not embraced the full extent of known climate variability, nor predicted greenhouse induced climate change. If the projections for sea level rise and variability in the frequency and intensity of storms are correct, then future coastal realignment, inundation and waterway morphological change will be outside the extent of historical experience (Griffith University, 2007). Currently, few obligations on coastal councils exist to combat or even consider climate change impacts on the coast. Planning for adaptation should commence even in a context of uncertainty about future scenarios as failure to address risks today may make it more costly to adapt in the future (Mummery, 2008). In a context of little coordination at the local level, where potentially each coastal council will develop its own response in terms of climate change adaptation, there is a need for government guidelines to assist coastal councils in adapting to climate change (Norman, 2008).

Coastal vulnerability and adaptive capacity to climate change

The coastal zone is a highly dynamic and fragile environment, concentrating human settlements, and strategic economic sectors. A the same time, it concentrates both causes and consequences of climate change, in terms of carbon emissions (80% of the world population live within 100 km from the coastline (UN, 2008)), sea level rise (worst case scenarios indicate a rise by about 48 cm in 2100 (IPCC, 2007)) and increased storminess, plus other consequences affecting also non-coastal areas (increased average temperatures, heat waves, long droughts or heavy precipitation).

Few of the large number of coastal vulnerability studies currently available in the scientific literature analyse with some degree of sophistication how societies would and should respond to climate change. In some cases they have evaluated the technical feasibility of adaptation measures but have little or no assessment of the economic and other considerations affecting the implementation of these measures (Tol et al., 2008).

For the purpose of discussing coastal hazards and disasters, coastal vulnerability should be interpreted as a combination of exposure (E), sensitivity (S) and adaptive capacity (AC). This can be simplified with the following:

$$V = \frac{(S \times E)}{AC}$$

In this formula, increasing adaptive capacity is critical to reduce vulnerability. But how can adaptive capacity be interpreted?

The adaptive capacity of a system is defined as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). The adaptive capacity of a coastal community can therefore vary, depending on different variables: technological options, economic resources, legal and institutional framework, social awareness, among others. As a result, adaptive capacity is unevenly distributed across coastal communities of a given region. An accurate assessment of the adaptive capacity of coastal systems could beneficiate future coastal plans and resources allocation at the regional level while at the same time, increase awareness at the local level.

Currently, few references exist about the development and implementation of methodologies to quantitatively assess climate change adaptive capacity, especially in the coastal zone. Most of the approaches are oriented to the assessment of vulnerability taking into consideration mostly physical variables to be used to build more or less complex composite indices (Abuodha & Woodroffe, 2006). Other approaches and tools for adaptive capacity assessment are currently available in the literature (Brooks et al., 2005; Marlin et al., 2007). However, they are not thought to specifically measure adaptive capacity in the coastal zone.

On the other hand, an interesting experience in the application of the systems approach to identify contextual variables and assess adaptive capacity has been recently carried for the Sydney Coastal Councils Group (Smith et al., 2008). A similar approach will be also applied to the South East Queensland Climate Adaptation Research Initiative (SEQ-CARI) (Smith et al., 2009). In the same way, a recent research carried out in Europe (Sanò, 2009) aimed to designing a methodology to identify and deliver Integrated Coastal Zone Management (ICZM) indicators based on the combination of participatory techniques and statistical analysis of multi-sectoral coastal data. The idea is to identify problem-oriented coastal variables based on a systems thinking and group model building approach, using the contribution of experts and stakeholders, and to further analyse the system's model using multivariate analysis techniques, in order to provide a reduced set of indicators which can deliver cost-effective information to coastal managers.

Approach

The research project will be based on a systems approach to identify the determinants of capacity of coastal systems to adapt to future coastal climate change scenarios.

A systems approach, based on systems thinking theory and practice, will be applied to different pilot sites of the coast of Queensland, which are currently studied in the framework of the projects SEQ-CARI and Future Coastlines. While the SEQ-CARI project is looking at the linkages between physical and social assets at the regional level, Future Coastlines is a Griffith University project assessing physical impacts and

community responses against climate change in the coastal zone. These pilot sites include coastal communities of the Gold Coast and the Sunshine Coast.

The outputs of these projects, in terms of chronic sea level rise, extreme water levels and erosion rates will be used to identify areas at risk under different scenarios. The analysis of the system, based on a participative approach aiming at integrating scientific knowledge with local perception and priorities, will be the base to focus climate change adaptation issues and to identify the determinants of adaptive capacity.

These Issues should be framed in the following broad categories:

- Infrastructures and properties included in areas at risk.
- Legal and administrative framework at the three levels of administration.
- Availability and costs of technological adaptation options.
- Social awareness and disposition to adapt.

The comparative analysis of the different systems will be used to identify sets of critical variables which, in turn, will be employed to compare the level of adaptive capacity of different coastal communities along the coast of Queensland, as a component of an integrated vulnerability assessment to extreme events.

The final outcome will be a methodological framework for the assessment of coastal climate change adaptive capacity, a base to support future coastal planning adaptation strategies.

Perspectives for international collaborations between Europe and Australia

Climate change is a global issue and both Australian and European institutions have claimed for the need for appropriate tools for the assessment of adaptive capacity. The creation of the Department of Climate Change in Australia in 2007 and the recent publication “European White Paper on Adapting to Climate Change” (European Commission, 2009) clearly demonstrate the need of new research and approaches to support adaptation policies.

This project is thought to fit in a collaborative framework which will benefit both Australian and European research and public institutions with the aim of improving safety and adaptive capacity of their coastal communities. Australia is currently promoting and leading climate change science research on mitigation and adaptation options. The “National Climate Change Adaptation Research Facility (NCCARF)”, hosted by Griffith University, is coordinating research in this field, while different projects are being funded. This research project is part of the “South East Queensland Climate Adaptation Research Initiative (SEQ-CARI)” activities carried out by Griffith University and the University of the Sunshine Coast. At the same time, it will contribute to the to the Griffith University project “Future Coastlines”.

The project will also benefit from collaborations with European researchers who are currently developing innovative approaches to study climate change forcing and adaptive strategies for the coastal zone, such as the “Multidisciplinary Research Consortium on Gradual and Abrupt Climate Changes and their Impact on the Environment (GRACCIE)”, funded by the Spanish Ministry for Science and Innovation, and the newly funded European project “Innovative Technologies For Safer European Coasts In A Changing Climate (THESEUS)”. The Universidad de Cantabria is a partner of both projects.

Conclusions

The identification of adaptation measures for coastal communities and the assessment of adaptive capacity of coastal systems, both in qualitative and quantitative terms, represents an important field of exploration in the climate change sciences.

Most of the recent studies have focused on the physical components of regional coastal vulnerability (Tol et al., 2008), with little attention paid to the adaptive capacity of coastal communities.

Population growth in the coast of SEQ is higher than anywhere in Australia, being the Sunshine coast the faster developing area (Thomsen et al. 2009): the assessment of the adaptive capacity of coastal communities in areas such as the Gold Coast, and the Sunshine Coast can be critical to plan future settlement and coastal interventions; this should be based on the identification of baseline conditions of adaptive capacity to be compared to other coastal communities in the same region, in order to provide criteria for future coastal planning (e.g. funding and resources allocation).

The identification of issues, variables and indicators of adaptive capacity will be based on a participatory systems approach (Group Model Building) while the analysis of the system could rely on different techniques (e.g. Principal Components Analysis, Systems Dynamics). The objective of this approach is not only to carry out complex modelling and calculations, but also to open communication and mutual understanding channels with local communities during participatory workshops.

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