2. Adaptive Approaches to Coastal Zone Management
Adaptive Approaches to Coastal Zone Management

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2.1. Introduction

While Chapter 1 has provided a general overview of the different adaptation options to coastal hazards (protect, accommodate and retreat), it is important to realize that an optimal coastal management, consist of more than implementing one of the above mentioned adaptation options. Rather, adaptation is a policy and implementation process involving comprehensive decision making and decision support (by e.g. modeling, data analysis) (Linham and Nicholls, 2010). Integrated Coastal Zone Management (ICZM) is one framework that helps achieving this complex objective by integrating the Bio-Physical, the Socio-Economical and the Institutional environment (the three main pillars of ICZM, Figure 2.1). Data and Tools are the basis of these pillars, helping identifying the problem (e.g. coastal erosion, coastal flooding, etc.). Knowledge development and technology alongside the entire project support the development of an ICZM plan.

Figure 2.1 The Three Pillars of an ICZM Framework: Institutional, Socio-Economical and Bio-Physical.
Simple assessments of Coastal Problems, Adaptation and Disaster Risk Management Solutions

Box 2.1: Aims of ICZM (French, 2005; USAID, 2009; Linham and Nicholls, 2010).

- Aims to manage coastal zones in a sustainable and informed fashion which accounts for the wide range of important factors in coastal decision-making
- Attempt to promote compatibility and balance of coastal uses
- Promote cooperation between departments, ministries or agencies which have control over specific aspects of the coast. Also, promote cooperation with other formal institutions such as universities and user groups
- Apply preventative and precautionary approaches in respect to coastal development. I.e. attempt to limit coastal development in unsustainable areas
- Account for both the economic and environmental costs and benefits of coastal management strategies in order to ensure the most beneficial use of the coastal zone
- Facilitate communication with all interested parties on coastal planning and decision-making processes to ensure that all viewpoints are considered
- Ensure the scope and complexity of the climate change issues selected as priorities for adaptation measures are appropriate to the capacity of the institutions involved

In this knowledge note, the main objectives of an ICZM plan are underlined. A framework of analysis for the implementation of a Coastal Zone Management Plan is also presented, with a specific example referring to a Small Island state.

Additionally, the Dynamic Adaptive Policy Pathways (DAPP) approach is described. DAPP offers a method to incorporate both longer-term adaptation strategies and uncertainties into the ICZM planning process, neither of which may be usually considered under a more traditional ICZM approach. The use of coastal indicators to monitor and evaluate the effectiveness of a certain measure is described in a separate section.

Despite the fact that the example used in this note refers to Small Island states, these guidelines are generic and could be easily translated to any country with a coastline.

2.2. Implementation of an ICZM plan

A lot of literature is available which describes the main steps for the implementation of a coastal zone management plan. Some of these stages are common in most of the literature and can be summarized in the following 5 steps (Figure 2.2; USAID, 2009):

1) Issue identification and assessment
2) Program preparation/planning
3) Formal adoption and funding
4) Implementation
5) Evaluation

The different steps are here explained using the example of a small island state, and for which a coastal zone management plan still does not exist. However, the procedure is generic and applicable to the coastline of any country.
The procedure starts with the identification of an issue (or trigger) which needs to be addressed. This could be for example the rise in sea level with consequent landward coastal retreat and increase in flooding levels (or reduction in return period for a certain flooding event).

**Figure 2.2**  ICZM policy cycle for coastal practitioners (adapted from USAID, 2009).

In step 1 (“Issue identification and assessment”), the issue is identified by means of data analysis (e.g. long term water elevation data) and public consultation. The assessment of the problem also involves the identification of the possible consequences related to the specific issue (e.g. coastal erosion, loss of private properties and infrastructures, coastal squeeze with loss of valuable habitat, increase in flooding levels, salinity intrusion, etc.). Numerical modeling can be used to support during the assessment phase of the problem. For the quantification of some of the coastal issues (e.g. coastal erosion), we refer to the accompanying free tools and tutorials.

Step 2 (“Program preparation and planning”) aims at prioritizing the different issues, defining possible adaptation options and selecting possible adaptation measures. The selection is based on technical effectiveness, costs, benefits and considerations related to the practical implementation of the specific option (e.g. how easy is it to design and implement the option in terms of the level of skill required, information needed, spatial and temporal scale of the implementation, maintenance required, etc.). Data analysis, numerical modeling, cost-benefit analysis and public consultation can help during this step and will be further explained in the knowledge notes “coastal processes and problems” and “coastal solutions”. In our example, we assume that possible adaptation measures could consist in a combination of beach replenishments (i.e. to address the issues of coastal erosion, loss of properties, salinity intrusion and
flooding), the construction of seawalls and the establishment of set-back lines (to avoid settlements too close to the coastline).

During step 3 ("Formal adoption and funding"), the specific concern should be mainstreamed in policy, plans and programs, securing mandate and funding. In our specific case, this means integrating the concern of sea level rise and adaptation responses into relevant development policies, plans, programs, and projects at the national, sub-national, and local scales. National adaptation strategies are more effective when guidance on adoption is mainstreamed into development and sectoral plans and strategies and is “owned” by those authorities responsible for preparing and implementing them (USAID, 2009). There are many entry points for mainstreaming coastal adaptation. 1) national or regional level public policy, 2) sectoral investments and projects, and 3) sub-national, place-based initiatives (e.g. municipalities, communities, NGOs). Each entry point offers challenges, creates new roles for citizens, the private sector and government, and can create new opportunities. Government must play a pivotal role in creating enabling policy, financial and legal frameworks, capturing and sharing experience, and raising public awareness.

In Step 4 ("Implementation") actions are taken to avoid implementation barriers and to build local capacity. Implementing new adaptation measures can bring new challenges and potential conflicts. Practitioners and coastal professionals need to be aware of these and address them proactively. Among others, those challenges might include: inadequate administrative, institutional, and staff capabilities; lack of sustainable financing or cost recovery; weak legal frameworks and enforcement; information gaps on the costs of acting vs. not acting (doing nothing); maintaining scientific data and monitoring to sustain the measures; unengaged political leadership and stakeholders; and poor technical effectiveness of the measures. Many of these challenges can be anticipated and addressed prior to implementation—i.e., during the assessment, design, and mainstreaming steps of coastal adaptation. Coastal practitioners and professionals must be alert to implementation challenges and address them proactively as they become evident. Recommended actions include periodic program reviews at the national or local levels to ensure agencies and communities are aware of successes and failures. Another action is to educate and encourage the public and property owners to be active in the stakeholder process. Also, take action to keep coastal adaptation on the public agenda, and conduct monitoring and scientific studies to reduce uncertainty about the effectiveness of the measures being implemented (USAID, 2009) and gather better insight in the potential pressures and impacts on the coast.

A crucial role is here covered by monitoring activities and by the definition of a number of suitable indicators to be evaluated in time and compared with the reference situation, prior to the implementation of any adaptation option (see section 2.3 and knowledge note “Data collection and monitoring”). The indicators will provide the information relative to the effectiveness of the intervention which will be used during step 4 and 5.

In our example, possible challenges could be related to the maintenance of the coastline by period nourishments, conflicts with other activities on the island (e.g. turtles hitching on the beach), or to the definition and enforcement of set-back lines, which might involve the shifting of private properties and infrastructures away from the coastline.

During step 5 ("Evaluation), the plan for possible adaptation options is evaluated to fine-tune the proposed plans and solutions. Policymakers will try to demonstrate the performances and results achieved by means of the chosen options. Moreover, they will assuage stakeholders who have borne some of the costs of the measures. All relevant data and information will be reviewed and analyzed. Coastal indicators, as defined under 4), will be used to quantify the performances and changes consequent to the
implementation of the specific adaptation option. If measures do not perform according to expectations, they must be adjusted. The process of reflecting on and adjusting the course of action based on evaluation results, new information, and changing conditions fits well with an adaptive planning approach such as DAPP (Section 2.3).

In our example, during this step it could be for example decided to have a shift from beach to shoreface nourishments not to interfere directly with the activities on the beach and turtle hitching.

The cycle 1) to 5) is not a close cycle but rather an iteration process, to allow for growth in project scope (Figure 2.2). In our example, it could be included to add additional issues/triggers in the planning process (e.g. river flooding or landslides which might be very relevant when defining the set-back lines) or extend the plan to new regions/communities.

The process is expected to be continuous, and there is no end point after which the process is considered complete. Links between component phases should allow retroaction mechanisms and the timely correction of activities (UNEP, 1995).

### 2.3. Dynamic Adaptive Policy Pathways

In developing an adaptive ICZM plan, policymakers must also recognize and confront the sources of uncertainty related to that plan. For example, the precise levels and impacts of future climate change, population growth and economic development are all unknown, as are future societal attitudes and preferences. Furthermore, decisions and actions taken today will often hold implications for those needing to be made in the longer-term. Policymakers will want to ensure they are able to derive maximum benefits from any adaptation investments that are made in spite of the changing conditions. It is therefore useful to consider adaptation as a path, with its endpoint not only determined by what is known or anticipated at present, but also by what will be experienced and learned as the future unfolds. The Dynamic Adaptive Policy Pathways (DAPP) approach (Haasnoot, Kwakkel et al., 2013) has recently been developed to better incorporate such uncertainties into adaptive planning methodologies and to enable the creation of longer-term adaptation strategies. DAPP encompass a strategic vision of the future, complete with commitments to short-term actions and a framework to guide future actions.

A central concept to the DAPP approach is adaptation tipping points (Kwadijk, Haasnoot et al., 2010). An adaptation tipping point specifies the conditions under which a given plan or action will fail (e.g. not meet acceptable system performance by surpassing a critical threshold) due to the magnitude of external change, and can occur in either the short-, medium- or long-term. The timing of an adaptation tipping point is termed the ‘sell-by date’ for that particular plan or action and is scenario dependent. After reaching an adaptation tipping point, additional actions are needed and, as a result, an adaptation pathway emerges.
Figure 2.3  Simple explanation of adaptation tipping points. The horizontal axis depicting the change in climate conditions (e.g. SLR) and the vertical axis showing system performance (e.g. coastline retreat, houses lost, damage etc.) Note that for different metrics these curves will look differently.

The DAPP approach is illustrated by the central blue cycle presented in Figure 2.4, and can be completed as part of the five-step ICZM implementation framework presented above in Section 2.2 (indicated in the figure in green). As Figure 2.4 illustrates, the majority of DAPP activities occurs under Step 2: ‘Program preparation and planning’.

Figure 2.4  Dynamic Adaptive Policy Pathways approach (blue boxes adapted from Haasnoot, Kwakkel et al., 2013) within the framework of ICZM (green boxes)
The DAPP approach begins by identifying those objectives and constraints for the coastal system that will be relevant for decision-making, including the desired long-term time horizon (e.g. until 2050). This results in a specification of the desired outcomes for the system in terms of indicators and targets (or performance metrics) to be used in later steps (e.g. reducing coastal erosion and flooding). Relevant uncertainties are also identified during this step (e.g. sea level rise), and are used to generate an ensemble of plausible futures or scenarios for the specified time horizon (e.g. alternative futures that assume low, moderate and high sea level rise). The ensemble of futures is then analyzed against the objectives via numerical modeling to see if any problems or vulnerabilities arise (e.g. communities at risk of inundation) or if opportunities emerge (e.g. ability to undertake new economic activities). This determines if and when any policy actions will be needed.

The second step is to identify those actions that may be taken to help achieve the desired objectives by addressing vulnerabilities and exploiting opportunities identified in the previous step. The aim is to assemble a rich set of possible actions, which can be completed through stakeholder engagement and public participation. The performance of these actions is then assessed against the previously determined indicators, targets and ensemble of futures to determine the adaptation tipping point for each action (Figure 2.5). Actions are also assessed to determine whether the identified vulnerabilities and opportunities have in fact been reduced, removed, or utilized. Any ineffective actions are screened out and only promising actions are used in the development of the dynamic adaptive plan.

In our Small Island state example, erosion actions that may be identified could include beach replenishment, construction of seawalls and implementing set-back lines. Adaptation tipping points for each of these actions can then be calculated for each of the low, moderate and high sea level rise scenarios. Seawalls, for example, may be a sufficient action until 2100 in a low sea level rise scenario, until 2055 in a moderate sea level rise scenario, but only until about 2040 in a high sea level rise scenario.
Once a set of actions seems adequate, potential adaptation pathways (a sequence or combination of actions) are constructed under step 3. This can be achieved in a number of ways, and it may again be useful to utilize numerical models in this step. For example, analysts can examine all possible routes with all available actions, which can then be evaluated according to their performance (Figure 2.6). However, some actions may exclude others, and some sequences of actions may be illogical. In addition, other criteria such as the costs of actions, the positive and negative benefits of actions (e.g. on ecology or local economy) need to be evaluated to further select/develop a set of promising pathways. This evaluation can be done qualitatively by using expert consultation sessions. The result of this analysis is an adaptation pathways map summarizing all the logical potential pathways in which the defined objectives for the plan are met. For the construction of the adaptation pathways map, we refer to the accompanying free tutorial “Dynamic adaptive policy pathways”.

An adaptation pathways map for our Small Island state example is presented in Figure 2.7. One can see that for the high sea level rise scenario (refer to the bottom scenario axis), current policies will only suffice until about 2020, or for a sea level rise of 0.25m above mean sea level. At that point, policy makers can choose to implement any of the three actions, however some will reach their tipping points before others. When this occurs, other actions or combinations of actions will need to be taken. For our example pathway (dotted orange line), the construction of a seawall (red line) could successfully limit coastal erosion and flooding until about 2035, when it could be replaced by beach replenishment (blue line). Replenishment then reaches its tipping point in about 2055, when it could be combined with the construction of another seawall behind a beach replenishment (dashed blue and red line) to extend these policies until about 2075. At that time, a combination of all three actions (dashed blue and green line) would be needed to meet our objectives until 2100. Note that this is just one of the possible adaptation pathways in Figure 2.4.
The fourth step is to use the pathways map to develop the dynamic adaptive plan. A selection of preferred pathways is made from the complete pathways map (for example, the dotted orange line in Figure 2.7). Preferred pathways are those that conform to an identified perspective (e.g. environmental conservation, economic development, water safety, etc.) and will generally exhibit not only physical, but also social, robustness. The aim of the dynamic adaptive plan should be to stay on the preferred pathways as long as possible. For this purpose, contingency actions may also need to be specified. These are actions that will anticipate and prepare for one (or more) of the preferred pathways, but which will also provide corrections to stay on track in case the future turns out differently than expected. A trigger for each contingency action is specified to determine if and when it should be activated. All of the above information is then summarized in the plan. This specifies the short-term actions to be taken immediately, those that can be delayed or postponed, as well as the monitoring system to be implemented to ensure that the plan stays on track.

In our example, an important trigger to be monitored could be related to mean sea level measurements. When these were observed to have increased by 0.25m, this would signify to decision-makers that the decisions surrounding the first actions need to be made. Similarly, depending upon which of the sea level rise scenarios actually occurs (established through trigger monitoring) will determine whether or not other decisions need to be taken in the future.

In the final two steps, the actions to be taken immediately are implemented and the monitoring system established. Then, time starts running, signpost information related to the triggers is collected, and actions are started, altered, stopped, or expanded in response to this information. After implementation of the initial actions, activation of any other actions is suspended until a trigger event occurs.

As with the more traditional ICZM approach presented in Section 2.2, the above process is both iterative and cyclical in nature, with the dynamic adaptation plan left open for later review and revision as new information comes to light.
2.4. **Indicators**

Effective monitoring and evaluation is an indispensable tool in the planning and implementation process. Indicators serve both as a corrective function during both the ICZM and DAPP process cycles, enabling adjustments, as a guide to structuring implementation effectively, and as a communication tool.

Indicators are quantitative/qualitative statements or measured/observed parameters that can be used to describe existing situations and measure changes or trends over time. Their three main functions are: simplification, quantification and communication. Indicators generally simplify in order to quantify complex phenomena so that communication of information to policy-makers and other interested parties, including the general public, is enabled or enhanced. They are powerful tools in the feed-back loop to an action plan, as an early warning signal about an emerging issue, or in providing a concise message for engagement, education and awareness (UNESCO, 2006).

According to UNESCO (2006), the indicators should therefore be:

1) Readily measurable, on the time-scales needed to support management, using existing instruments, monitoring programs and available analytical tools. They should have a well-established confidence limit, and their signal should be distinguishable from background noise;

2) Cost effective: Indicators should be cost-effective since monitoring resources are usually limited;

3) Concrete: Indicators that are directly observable and measurable (rather than those reflecting abstract properties) are desirable because they are more readily interpretable and accepted by diverse stakeholder groups;

4) Interpretable: Indicators should reflect properties of concern to stakeholders; their meaning should be understood by as wide a range of stakeholders as possible;

5) Grounded on scientific theory: Indicators should be based on well-accepted scientific theory, rather than on inadequately defined or poorly validated theoretical links;

6) Sensitive: Indicators should be sensitive to changes in the properties being monitored (e.g., able to detect trends in the properties or impacts);

7) Responsive: Indicators should be able to measure the effects of management actions so as to provide rapid and reliable feedback on the consequences of management actions;

8) Specific: Indicators should respond to the properties they are intended to measure rather than to other factors, i.e., it should be possible to distinguish the effects of other factors from the observed responses.

A list of possible indicators to assess all different coastal problems can be nearly infinite as it will depend on the issue to be monitored, the time scale of the analysis, the type of data and instrument available to derive the indicator, etc. In Table 2.1, for example, a list of coastal indicators which can be used to monitor the coastal morphological development is provided. Some of those have contributed to the development and have become part of the Dutch coastal policy (Giardino et al., 2014).

For small island states with limited resources to purchase very expensive monitoring instrumentation or modeling tools, easy-to-measure coastal indicators are preferable. Among those, the shoreline position, the dune foot position or the beach width. The drawback of these indicators is that they are subject to large inter-annual variation (time scale of storms/year). For a more sustainable analysis of the coastal
development it is recommended to derive, with a lower time-frequency (e.g. once a year), more complex but more stable indicators, such as the momentary coastline position, function of the volumes of sand in the near shore zone, (for example between +3 m and -5 below MSL). We refer to the knowledge note “Data collection and monitoring”, for information on how to collect the data in order to derive and monitor the development of these indicators.

Table 2.1 List of used coastal state indicators for different coastal functions and linked to different time scales and policy objectives (Giardino et al., 2014)

<table>
<thead>
<tr>
<th>System function</th>
<th>Coastal indicator</th>
<th>Time scale (~ years)</th>
<th>Policy objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term safety</td>
<td>Shoreline position</td>
<td>1</td>
<td>Maintenance of safety</td>
</tr>
<tr>
<td></td>
<td>Cross-shore erosion length</td>
<td></td>
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<td></td>
<td>Probability of breaching</td>
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<tr>
<td>Medium-term safety</td>
<td>Momentary coastline position</td>
<td>10</td>
<td>Sustainable maintenance of safety</td>
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<tr>
<td></td>
<td>Momentary dunele position</td>
<td></td>
<td></td>
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<tr>
<td>Long-term safety</td>
<td>Sand volumes at different water depths</td>
<td>100</td>
<td>Sustainable maintenance of safety</td>
</tr>
<tr>
<td>Nature and recreation</td>
<td>Beach width</td>
<td>1</td>
<td>Tourism development</td>
</tr>
<tr>
<td></td>
<td>Dune foot position</td>
<td></td>
<td>Sustainable maintenance of dune</td>
</tr>
</tbody>
</table>
2.5. References


UNESCO, 2006. A handbook for measuring the progress and outcomes of integrated coastal and ocean management. Manuals and Guides, 46; ICAM Dossier 2, IOC