MONITORING AND EVALUATING ADAPTATION INTERVENTIONS IN NIUMI NATIONAL PARK, THE GAMBIA, AND SANGOMAR MARINE PROTECTED AREA, SENEGAL

A GUIDE FOR PROTECTED AREA MANAGERS, STAFF AND COMMUNITY ASSOCIATIONS
The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the specialist biodiversity assessment centre of the United Nations Environment Programme (UNEP), the world’s foremost intergovernmental environmental organisation. The Centre has been in operation for over 30 years, combining scientific research with practical policy advice.

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Introduction

1.1 Who is this guide for and what is its purpose?

This guide has been developed for the protected area managers, staff and relevant community associations in Niumi National Park, the Gambia, and Sangomar Marine Protected Area, Senegal, and aims to strengthen their capacity in monitoring change in their marine protected areas. It brings together a range of simple methodologies to carry out regular climatic, socio-economic and environmental monitoring and proposes some resource-efficient and practical techniques that can be used to collect data.
This guide was developed in the context of the project Climate Resilient Communities and Protected Areas, funded by the MAVA Foundation and executed by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) in cooperation with ENDA – Energie Environnement Développement, the Regional Network of West African Marine Protected Areas (RANPAO) and the West African Regional Marine and Coastal Conservation Programme (PRCM). The project aims to enhance livelihoods and increase social-ecological resilience in West African coastal protected areas to the negative effects of climate change. It was implemented at three pilot sites across Nioumi National Park and Sangomar. At each pilot site, a Community Planning Workshop was held, which assessed the vulnerability of the community to climate change, mapped resources and capacities, gathered information on local values and future aspirations, and developed Community Action Plans. These Action Plans aim to build resilience to climate change through adaptation, among other options. The Community Action Plans resulting from the Community Planning Workshops guided the implementation of several community-based and ecosystem-based adaptation interventions.

This guide focuses on how to monitor these interventions. It is not a comprehensive protected area-wide monitoring protocol, but focuses on the monitoring of the adaptation interventions implemented as a result of the project, all of which align with the management priorities of the two marine protected areas. The interventions contribute to addressing challenges mentioned in the protected area management plans and complement current monitoring objectives. This guide proposes a number of indicators linked to the interventions that are suitable for the protected areas to monitor, but the list is by no means exhaustive and protected area managers and their staff can choose to add to, modify or select between the proposed indicators. Using the monitoring methods in this guide is a good starting point and will help inform wider adaptive management strategies of both marine protected areas in the longer-term. The methods described in this guide might also be useful to managers of other protected areas where similar interventions with similar objectives are being implemented.

1.2 What is monitoring and evaluation?

Monitoring and evaluation (M&E) is an essential component of any successful management activity. Monitoring is a process of collecting and analysing information in order to detect signs of change. It can be used to quantify change from a baseline, identify the causes of change and determine acceptable levels of change.

In the context of protected areas, monitoring can focus on management processes, as well as on ecosystem and biodiversity health and the well-being of local communities who depend on the protected area. Monitoring ecosystem and biodiversity health usually focuses on collecting information on specific species or ecosystem components or functions. Socio-economic monitoring focuses on the knowledge and attitudes of people towards an ecosystem as well as their use of natural resources and dependence thereon. Both require collecting information on contextual factors such as changes in climate. Together, they provide a picture of the human and environmental changes that occur over time in a particular place, how they are interlinked and how protected area managers and staff might improve management strategies in order to address changes and threats.

Evaluation is when we take a look at the information collected, either as a one-off activity or repeated regularly, to assess the monitoring data collected in order to identify how well the protected area’s objectives are being met and to determine gaps or barriers to progress. An evaluation can be done of individual projects or interventions, overall management effectiveness or of all protected area processes as a whole.
Together, M&E processes are used to inform adaptive management, which is “the cyclical process of systematically testing assumptions, generating learning by evaluating results of such testing, and further revising and improving management practices” (Pomeroy et al., 2004). Practicing good adaptive management will result in improved effectiveness and progress towards reaching protected area targets and objectives.

1.3 Why is monitoring and evaluation important?

To inform adaptive management

The main reasons for M&E are to assess the status of the key values of the protected area and to determine whether management is effective and is having its intended impact. In response to this knowledge, protected area managers can continuously adjust management practices to better achieve the protected area’s biophysical and socio-economic goals – this is the essence of adaptive management. For example, adaptive management can help determine changes and threats to ecosystems; inform zoning of resource areas to maximise sustainable resource extraction; track changes in people's knowledge, perception and use of ecosystems; or plan and implement restoration activities.

In order to comprehensively inform adaptive management, it is important for monitoring to track changes in the different processes that affect the protected area; that is, monitoring should incorporate environmental, socio-economic and climatic variables. Traditionally, protected areas have monitored ecological processes, but it is becoming common practice for protected area management plans to have objectives that achieve both environmental outcomes and respond to the needs and aspirations of communities affected by conservation activities. Therefore, thinking about the protected area as a linked social-ecological system can help monitor important interactions between the environmental and socio-economic status, influences and threats and inform managers on how to react to these.

As both nature and humans are increasingly being affected by negative impacts of climate change, protected area managers must now also incorporate an additional dimension of climate change into their management strategies. Around the world, rising temperatures are causing many changes, including: changes in timing, duration and intensity of rain and storms; the range, abundance and composition of species communities and ecosystems; ocean temperature and acidity; and sea level rise and erosion in coastal areas (Gross et al., 2014). There are many uncertainties about the exact magnitude and occurrence of such climatic changes, but protected area managers should expect an acceleration and intensification of changes, and corresponding ecological shifts and human responses, especially over the mid- and longer-term. As change will be ongoing and continuous, protected area managers will need to consider appropriate options to adapt to the changing climate. However, climate adaptation should not be viewed as simply adjusting to a new static regime with a fixed endpoint, but as an ongoing process. Monitoring climate change adaptation interventions is therefore key in order to understand whether, over time, they are having their desired effect or whether they are working against the desired outcome, causing maladaptation and therefore requiring a change in management actions.

In order to integrate environmental, socio-economic and climatic monitoring, protected area managers need to develop an integrated monitoring plan that relates the findings from one discipline to the other, and looks at how to effectively track and achieve all protected area objectives. If the results of such integrated monitoring are used to adapt management strategies, the protected area can build its social and ecological resilience under the uncertainty of climate change.
To expand the evidence base for policy and management

In addition to helping protected area managers make well-informed decisions about their protected area, the information collected through monitoring and the results of evaluations are also useful to stakeholders beyond the protected area. This information helps build a picture of what works where, when and why. It should be shared with technical staff of other relevant government departments or non-governmental organizations and managers of other protected areas, as well as with policy makers. If monitoring protocols are standardised and comparable across protected areas, information from one protected area can be combined with information from others to inform the evidence-base of interventions. This can eventually be used by other stakeholders to formulate robust, science-based conservation legislation and policies and implement reliable governance and management decisions.

Box 1. Useful definitions

**Climate change**
Adaptation: the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or to exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Adaptive capacity: the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Resilience: the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014).

Vulnerability: the predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

Maladaptation: actions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future (IPCC, 2014).

**Results-based management**
Theory of change: a clear logical pathway for how an intervention and associated activities will contribute to achieving its goals and broader objectives. A theory of change approach involves starting with the desired project goal, then identifying what mid- to long-term impacts are needed to collectively achieve that goal, what project outputs can achieve those impacts and, finally, what activities are needed to produce the outputs. In addition, it involves specifying the assumptions that have been made. The assumptions are the set of beliefs that describe the relationships between activities, outcomes and impact, and the expectations about how and why proposed activities will bring them about (UNEP, 2015).

Activities: practical, time bound actions carried out to deliver the desired project outputs (UNEP, 2011).

Outputs: the products and services which result from the completion of activities within a project leading towards achievement of the project outcomes (UNEP, 2011).

Outcomes (short term): the intended or achieved short-term and medium term effects of project outputs, usually requiring the collective effort of partners. Outcomes represent changes in Behavior, Action/Attitude, Condition, Knowledge and Skills (BACKS) that occur (even if only in part) due to the project’s activities (UNEP, 2011).

Impact (long term): positive and negative, primary and secondary, lasting and significant effects contributed to by project activities. A fundamental and durable change in the condition of people and their environment (UNEP, 2011).

To ensure accountability

It is important for protected area managers to use M&E results to demonstrate the accountability of their actions to local communities. M&E processes should in themselves include elements that ensure accountability and transparency, for example, by including relevant stakeholders in M&E processes. Demonstrating whether the protected area, or interventions therein, are having desired impacts can
also be important for many donors in order to help them ensure that objectives are being met and that funding is allocated appropriately.

To facilitate ownership
Information can be collected in ways that involve local communities and the process designed so that those who have relevant information to offer can, in return, benefit from information coming out of the interventions. Doing so will enhance community ownership of interventions, or protected area-wide management or monitoring processes, and is known to enhance sustainability and create positive outcomes for conservation.

1.4 What are the key components of monitoring and evaluation?

There are a number of key components that any M&E system should have. Each of these are briefly described in this section but more information is available in additional sources (see ‘useful resources’ for suggestions).

Setting monitoring objectives
Every protected area management plan should have a set of objectives, which can range from preserving desired ecological processes, to offering local communities sustainable livelihood options, to helping animals and humans adapt to climate change. Monitoring objectives should align with the management objectives in order to help protected area managers understand if they are being met. Monitoring objectives can also be linked to individual assumptions made when developing the theory for how the protected area will achieve its intended impacts (Theory of Change) and test if these assumptions are valid. Monitoring needs to take place while an intervention is being implemented, but also over the mid- to long-term to assess sustainability and achieve longer-term objectives.

Establishing a baseline
In order to know how things are changing, we need to know what they were like from a particular starting point (a baseline). The baseline provides a snapshot of the situation at the beginning of the monitoring process and tells us, for example, what the ecosystem looks like, which species are present and in what numbers. A socio-economic baseline study might tell us how people currently live, what their livelihood activities are, how much income they generate from these, or how they interact with the protected area. Climatic baseline information can include temperature or rainfall measurements for a particular year. Monitoring from such baselines will show protected area managers whether things have stayed the same, improved or deteriorated since they started monitoring.

Establishing targets
To better understand to what extent the protected area is making progress towards reaching its overall objectives, protected area managers should set specific, measurable conservation targets. To do so, they should think about what the ideal ecological or socio-economic scenario is that they would like to achieve by a certain point in time and monitor whether this is being achieved. For example, if the overall objective is to restore and protect an intact mangrove habitat, given the baseline of current intact mangrove habitat, how many hectares of mangroves does the protected area want to restore by 2020? And how many hectares by 2025? Monitoring indicators that assess progress towards such targets will allow managers to understand not only if they are generally achieving protected area objectives, but also whether they are doing so in a way that is considered to be meaningful in terms of reaching conservation goals.
Developing indicators

As it is not feasible to document every relevant process, parameter or change that takes place across the entire social-ecological system of a protected area, we need to identify key indicators to monitor. Indicators are units of information (e.g. particular objects, conditions or characteristics) that represent, or act, as markers for broader environmental, socio-economic or climatic status. When measured over time, indicators document change, allowing us to draw more general conclusions about trends and understand whether we are meeting our objectives.

Different types of indicators help us monitor different levels of activity, change and impact:

- **Context indicators**: provide information on external factors that can influence interventions or wider ecological or socio-economic processes, such as climate change.
- **Activity, or output, indicators**: give information about the activities or processes of a particular intervention and allow us to track the status of their implementation.
- **Outcome and impact indicators**: provide information about the immediate changes (outcomes) that interventions are creating and their long-term impact.

There is no single correct indicator for any monitoring strategy and the most appropriate indicator may change over time, which is why it is important to review indicators on an occasional basis. There are, however, some overarching principles to consider when developing and selecting indicators (adapted from IUCN, 2004):

- **Linked to an objective**: an indicator is not a generically useful insight; it must closely track the objective that it is intended to measure and track change towards an ideal target status. For example, abundance and diversity of mangrove species would be good indicators if the protected area’s objective is to maintain a healthy mangrove ecosystem.
• **Measurable**: an indicator must be able to be recorded and analysed in either quantitative (i.e. numerical) or qualitative (i.e. based on perceptions) terms and each indicator should concern just one type of data. An indicator can cover either visible objectives or activities (e.g. mooring buoys installed) or behavioural change (e.g. women’s empowerment increased).

• **Precise**: a good indicator should be precise and unambiguous so that different people can measure it and get similarly reliable results.

• **Consistent**: an indicator should be able to measure the same thing over time.

• **Simple**: a good indicator should be simple so that it can easily be measured, observed and tracked over time.

• **Feasible**: an indicator must be able to be measured within the resources of the protected area and the community, for example, within the constraints of available personnel, skills, funds, time and equipment. It is not helpful to choose indicators that require highly detailed research, expensive equipment or complicated analysis to track that are beyond the means and capacities of the group in charge of monitoring them.

• **Representative**: as it is not practical to monitor everything, a group of indicators should be representative of the overall system. They should also be present frequently enough for meaningful data to be gathered (e.g. very rare species or events are generally not good indicators as there will be many ‘zero’ observations and trends will be difficult to determine).

• **Adapted to local context**: each protected area and community is different: what works in one community may not work in others, so indicators need to be tailored to the local context.

• **Be inclusive, if applicable**: if inclusivity and a participatory process is important and applicable to the indicator, then it is important the collection of information on the indicator involves more than one person.

• **Address next steps**: monitoring is a means to an end, not an end point in itself. An indicator must be able to inform the relevant decision-makers and enable adaptive management.

### Collecting data

#### Making a plan

To be successfully implemented, monitoring needs to be well planned and coordinated. Each protected area should therefore develop a general monitoring plan that includes (adapted from IUCN, 2004):

- A timetable for the main monitoring activities and components.
- The indicators and data collection methods chosen.
- Responsibilities assigned to each component.
- Reporting requirements (e.g. formats, frequency) for the protected area agency, donor or other authorities.
- A budget including all components, taking note of the funding source as different components may come from different sources.

### Assigning staff and responsibilities

As monitoring can often be considered less urgent than other day-to-day management activities, M&E responsibilities must be clearly specified in the job responsibilities of relevant staff. The staff responsible for M&E should also be given enough time for later data entry, management, analysis and interpretation. To ensure that the monitoring staff are complying with the tasks specified in the M&E plan and have enough time to carry them out, the protected area manager should monitor their work load and make appropriate adjustments.

In order to most effectively carry out an integrated approach to monitoring, the monitoring staff should also be integrated: ecological, socio-economic and climatic monitoring should be carried out at the same time, by the same team. Ideally, some members of the monitoring team will have prior experience in
different monitoring techniques and the protected area manager should ensure that staff receive relevant training to ensure that data are collected accurately and reliably. If possible, the monitoring team should include members of the local community to increase their active support and involvement in conservation activities, incorporate their perceptions and knowledge, and build their capacity to take over monitoring activities in the longer term.

**Frequency**

The frequency of data collection (e.g. annually, monthly, daily) depends on which parameter is being monitored. For example, monitoring tree growth once a year may be sufficient, but monitoring sediment levels in an estuary may need to be done following major weather events. Regardless, the monitoring plan should be implemented regularly and data collected in a way that is representative of any regular changes or fluctuations in the local environment. This means, for example, considering whether certain environmental or socio-economic processes take place during different seasons (e.g. dry and rainy season).

Data entry and storage

Collecting monitoring data is only one step in the process of using information gathered in the field to inform adaptive management. Data storage, analysis and reporting are likely to take as much time as the data collection itself. Protected area managers therefore need to ensure they have given their monitoring staff enough time for these activities in the work plan and budget accordingly.
All monitoring data collected should be stored in computerised format (e.g. Excel spreadsheet, MS Access or specialist monitoring package such as SMART (www.smartconservationtools.org)) and entered as soon as possible, ideally within 2 weeks of collecting the data. Regardless of the data management system used, a number of procedures are recommended when managing data electronically (Annex 2). Overall, it is important to agree on a standard protocol of how to name different types of data collected, or photos taken, and that all staff are thorough and consistent in their data entry in order to avoid mistakes or confusion. Furthermore, databases must be kept up-to-date, which requires good maintenance, and it is advisable to make someone responsible for this.

1.5 Evaluation and reporting

When the time comes to evaluate the data collected (e.g. end of reporting period, donor requirements, etc.), a final report should be compiled that integrates the environmental, socio-economic and climatic aspects of the monitoring, describes the status and trends in all of the measured indicators and discusses changes (either negative or positive) from the baseline, as well as the potential management implications thereof. Some key stages involved in an analysis and interpretation process are (adapted from Sriskanthan et al., 2008):

- **Identifying trends and patterns**: evaluation requires information about any given situation over time and an analysis of this information should reveal what changes are taking place. Some trends may take a long time to become evident, which is why long-term monitoring is important.

- **Identifying factors that may be influencing these trends**: it is important to think about the links between observed trends and to avoid jumping to conclusions, or making assumptions about what might be causing that trend. More than one factor is usually involved in creating change over time and it is important to understand all contributing factors.

- **Identifying implications and opportunities for management**: evaluating monitoring data and thinking about trends and the possible consequences thereof will help us decide how to adapt management strategies to either rectify problems or increase benefits.

- **Identifying implications for future monitoring**: evaluating monitoring data is also useful to identify if monitoring is being carried out at the right frequency and with the right methods. If monitoring data seems insufficient or is not of high enough quality for meaningful evaluation, then necessary adjustments should be made to the monitoring methods for the next reporting period.

- **Reporting and making recommendations**: the final stage is to produce a report that details the results of the monitoring and evaluation and makes clear recommendations for adaptive management.

1.6 Sharing and disseminating information

Once a M&E report has been produced, it is important to share results with relevant stakeholders in an appropriate format tailored to the target audience. Relevant stakeholder groups include the government departments responsible for protected areas, environment, forestry, fisheries, development, water and energy, as well as non-governmental organisations. Monitoring results should also be shared with the local communities in order to encourage interest and ownership in management and monitoring activities. This can also help enhance transparency.

Ideally, protected area managers and staff should organize a public meeting that invites key external stakeholders and the local communities. This offers an opportunity to discuss and agree the monitoring
results and the required management responses with all relevant stakeholders, strengthening participatory management.

1.7 Adapting management

After evaluating monitoring results and, in consultation with relevant stakeholders, deciding how management strategies need to be adapted, protected area managers need to make the necessary amendments in the management and monitoring plans, revise targets and indicators, if necessary, and begin the new cycle of implementation and monitoring.

Useful resources:
The toolkit aims to act as a first point of call in the search for information on issues that managers of marine protected areas face in day-to-day operations. It contains theme sheets on management topics or inputs (human, financial, organizational and technical) required for effective management and for meeting objectives. It also covers topics related to the results or outputs of marine protected area management.

The document includes general guidance on good practice methods for monitoring and evaluation. It also provides detailed guidelines for socio-economic and ecological monitoring of mangroves using different indicators based on work carried out in the Maldives.

This guidebook was developed to assist marine protected area managers in assessing the performance of their marine protected area. Based on this assessment, it shows how necessary changes can be made to improve management measures. It presents a flexible approach that offers a variety of specific biological, socio-economic and governance indicators to measure the effectiveness of management actions in achieving protected area goals and objectives.

This guidance document is aimed at helping protected area managers think about and develop useful adaptation strategies for protected areas in the face of climate change. It provides extensive information on how climate change is impacting protected areas, how protected area management can plan, manage, build capacity and monitor in the context of climate change, as well as assess vulnerability and design adaptation options.

The Coastal EBA Decision Support Tool aims to support national environmental units in the selection, design, implementation and evaluation of options for coastal EBA to climate change. It outlines seven key steps that support the planning and implementation process of EBA.

This IPCC glossary contains many useful definitions for climate change and adaptation related concepts.

Results-based management is a strategic management approach used by UNEP. It contains useful definitions on key terms relevant to developing a theory of change.
Monitoring and evaluation methods for adaptation interventions in Niumi National Park and Sangomar Marine Protected Area

This section provides guidance on monitoring and evaluation methods that focus on the climate change adaptation interventions implemented under the project Climate Resilient Communities and Protected Areas, starting with a set of general climate change context indicators. This guide proposes a number of indicators considered suitable for Niumi National Park and Sangomar Marine Protected Area to monitor. These indicators will provide information on the climatic context and will help track outcomes and impacts of the adaptation interventions, rather than focus on processes and outputs. The list of
indicators is by no means exhaustive and protected area managers and their staff may choose to add to, modify or select between the proposed indicators. Using the monitoring methods in this guide is a good starting point and will help inform wider adaptive management strategies of both marine protected areas in the longer-term.

Table 1 provides an overview and description of the indicators used in this guide. The indicators should be planned, implemented and reviewed together in order to make monitoring as efficient as possible in terms of time and resources spent. When collecting monitoring data, it is important to think about which information can be collected on the same day, by the same people, from the same transects, plots, or community groups. For example, information from a mangrove transect along the coastline can be useful both to monitoring the effectiveness of mangrove protection and sustainable oyster harvesting interventions and can be gathered at the same time. While collecting data and reviewing the monitoring results, it is also important to think about the ways in which data collected for an indicator of one intervention can inform an indicator of another. Creating such links will help create a fuller picture of why things are changing in the protected area and how management strategies can be adapted appropriately. It may, of course, take some time for these monitoring strategies to become embedded in the overall management of the protected area, but with time, practice and regular review, the process will become more efficient.

Table 1. Description of the indicators used in this guide

<table>
<thead>
<tr>
<th>Description</th>
<th>Indicators used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Context indicators</strong></td>
<td>Monitor the climate change context</td>
</tr>
<tr>
<td></td>
<td>Fluctuating rainfall and temperature, increased frequency of storms, sea level rise, coastal erosion, saltwater intrusion</td>
</tr>
<tr>
<td><strong>Perception indicators</strong></td>
<td>Monitor how the community feels about an intervention; possibility of enhancing community awareness and participation</td>
</tr>
<tr>
<td></td>
<td>Mangrove restoration and protection, success of oyster line-harvesting technique, success of sustainable stoves and entrepreneurial training, community perception of the vegetable garden</td>
</tr>
<tr>
<td><strong>Role of community indicators</strong></td>
<td>Monitor the role of the community in enhancing or threatening the effectiveness of interventions</td>
</tr>
<tr>
<td></td>
<td>Use and potential degradation of mangroves, role in mangrove restoration and protection</td>
</tr>
<tr>
<td><strong>Success of training indicators</strong></td>
<td>Monitor effectiveness of training interventions</td>
</tr>
<tr>
<td></td>
<td>Perception of success of sustainable stoves and entrepreneurial training, knowledge of climate-smart vegetable production, skills gained from beekeeping, economic benefits of beekeeping</td>
</tr>
<tr>
<td><strong>Economic indicators</strong></td>
<td>Monitor the economic gain of interventions</td>
</tr>
<tr>
<td></td>
<td>Economic gain from the vegetable garden, economic benefits of beekeeping</td>
</tr>
<tr>
<td><strong>Environmental indicators</strong></td>
<td>Monitor the biological state of interventions</td>
</tr>
<tr>
<td></td>
<td>Number and size of trees in existing mangrove ecosystem, signs of stress in current mangrove population, population and growth rates of planted mangroves, oyster yields, food production by vegetable garden, health of hives/bee populations</td>
</tr>
</tbody>
</table>

2.1 Understanding context: climate change

To comprehensively monitor the effectiveness of the interventions implemented in your protected area, you need to understand the context in which the interventions are operating. If you do not collect information on how external factors are influencing a particular intervention, it will be difficult to gain a full understanding of why certain changes are taking place, why there is a problem with the intervention,
or what is making it particularly successful. In the case of adaptation interventions, monitoring the climate change context is essential. Measuring the impacts of climate change on adaptation interventions in your protected area over time will help you:

- Clarify whether the climate change impacts that the intervention was designed to address are actually occurring. If these climate change impacts are not a real and measureable hazard, implementing the intervention may be a waste of resources or result in maladaptation.
- Understand whether climate change is having an impact on the effectiveness of the intervention, and why the intervention is or is not able to deliver its intended results.

Understanding the exact links between the climate change patterns you observe and the changes you notice in the interventions can be challenging as you may not have enough data to provide evidence for these links or to establish a pattern. With time and experience, however, your data bank will grow and you may be able to better understand the relationships between a climatic change and an ecosystem response.

Collecting climate data over a long period of time is therefore important in order to build a solid evidence base that can reliably inform future management strategies. For example, data collected on coastal erosion can help you pinpoint the areas that have been most damaged by this climate related hazard. Using this information, you could focus your management response to reinforce the worst affected coastal areas by, for example, planting mangroves. Data collected on levels of saline intrusion, for example, could allow you to better designate agricultural zones in your protected area in order to provide local communities with land that will more reliably support their livelihood activities. Long-term monitoring data on climate change is therefore important for informing management decisions that can build social-ecological resilience in your protected area.

### 2.2 Monitoring climate change impacts

Climate change hazards are made up of many aspects that are interconnected in different ways, which makes it difficult to measure the impacts of these hazards using a single indicator. This section outlines several climate change indicators related to the hazards that have the potential to enhance or reduce the success of the adaptation interventions implemented in your protected area. Therefore, this section does not provide all indicators for all climate change impacts. Instead, monitoring these proposed indicators will help explain the context of interventions. In particular, the chosen indicators will help answer the following questions:

1. Is the climate change threat that the adaptation intervention was designed to address actually occurring?
2. Is climate change impacting the effectiveness of the intervention?

**Hazard: fluctuating rainfall and temperature**

You may have already observed a change in how much it rains, when it rains, the variability in rainfall and changing temperature patterns. Fluctuating rainfall and temperature are two of the many hazards that can be related to climate change. These patterns may become more unpredictable in the future. If you collect enough data over time, however, you may be able to start recognising new patterns. This could help you answer the following questions:

1. Has the growing season for crops changed? (this provides some of the information needed to successfully implement climate-smart agriculture)
2. Has the dry season/rainy season shifted? How will this affect the community and their livelihoods?
Possible indicators you can use to respond to these questions include:

- Total or mean precipitation (daily, weekly, monthly)
- Maximum/minimum/mean temperature (daily, weekly, monthly)

**How to measure these indicators:**
Rainfall can be measured using a rain gauge or a container that can collect water. For example, you could use a bucket or a 1 litre plastic bottle with regular markings that can be used to measure the amount of rainfall collected. Make sure that the markings are the same across the same types of containers.

Record temperature using a thermometer.

Set up several monitoring stations (rain gauge, bucket or bottle, and thermometer) throughout your protected area. These stations can be either temporary or permanent. Temporary stations should be set up for one month, at least every three months, with data recordings made daily. Make sure that these stations are set up in the same spot every time, as this will make your data more reliable. Permanent monitoring stations recording temperature and rainfall that you visit every day will provide a more holistic picture of weather changes but also require more resources and time than temporary stations. These permanent monitoring stations should be easily accessible, for example, at the edge of a village.

Measurements of temperature and rainfall are so dynamic, even within the context of a single day, that, these measurements should always be taken at the same time of day and by the same person. These measurements are only useful if you collect them very frequently. To ensure accurate recordings, empty the container once you have measured the amount of rainfall in it.

Globally, there is an extensive network of weather stations that regularly record data. It would be worthwhile to contact your nearest weather station and discuss the possibility of receiving additional data from this station and adding it to your local data.

**Hazard: increased frequency of intense storms**
The frequency of severe storms changes due to the effects of climate change. Storms may impact your protected area by, for example, increasing coastal erosion and destroying coastal infrastructure and vegetation. Keeping a record of storm occurrence can help explain changes in the effectiveness of several of the adaptation interventions implemented and may help answer the following questions:

1. Have storms had an impact on the mangroves we restored?
2. Have storms impacted the oyster yield of the new line-harvesting technique?
3. Have storms impacted agricultural yield?
4. Have storms affected honey production in the beehives we set up?
5. Has the coastal landscape drastically changed due to storms?

Possible indicators you can use to respond to these questions include:

- Frequency and intensity of storms

**How to measure these indicators:**
To monitor the frequency of storms, record the nature of severe storms every time one occurs. This includes describing the wind; rainfall; power of the waves; what the sea looked like; any potential damage that may have occurred to infrastructure or vegetation; how long the storm lasted; when it occurred; and who was affected by it. Provide as much detail on any of these aspects, and anything
else that you think might be relevant, as this information can help you understand changes in your environment.

Compare this information with previous storms to start thinking about which measures you may need to take to be better prepared for the next storm. Make sure you and your colleagues agree on a definition of what constitutes a storm. For example, rustling leaves might just indicate a particularly windy day whereas movement of large branches or whole trees may constitute a severe storm. Having these definitions will help you standardise recordings and provide more accurate comparisons of changes in storm intensity and frequency over time.

**Hazard: sea level rise**

Sea level rise is an important climate change hazard to monitor mainly because it can have devastating direct impacts on coastal communities (e.g. flooding that destroys houses), but also because of its many secondary effects, such as increased impacts of waves and saltwater intrusion. These secondary effects can also have further impacts on, for example, crop production and the availability of fresh water.

Monitoring sea level rise in itself can help you determine how high the risk is of secondary effects of sea level rise occurring. It can help you answer the following questions:

1. Why is the mangrove forest in my protected area moving inland?
2. Why does my mangrove forest show signs of stress?
3. Why is land available for coastal infrastructure changing/disappearing over time? (the answer to this question can be further supported with data from monitoring coastal erosion)
4. Why are my crops showing signs of stress? (the answer to this question can be further supported with data from monitoring saltwater intrusion)

Possible indicators you can use to respond to these questions include:

- Sea level at standard high tide over time

_How to measure this indicator:_
When monitoring this indicator, it is very important to perform all measurements in the same spot at the same point in the tidal cycle over several years or decades as this will give you the most reliable data. Changes in sea level will be slow, so it is not necessary to take measurements of sea level more than three or four times a year. Make sure to choose a spot that is easy to access at high tide and is as close to shore as possible. In this spot, insert a long pole with 0.5 centimetre markings securely into the sediment, preferably between mangroves where there is less chance of it being knocked over in a storm. Check regularly that the pole is still secure, particularly after a large storm.

Using this method does not take account of seasonal tidal changes (neap tide, spring tide), storm surges, bathymetry, etc. Therefore, it is important to standardise measurements when you take them. Consulting tidal charts will help you identify when in the tidal season the neap or spring tides occur, and you should choose to only measure sea level during a standard high tide. This will help standardise your data. Similarly, avoid taking measurements during or directly before/after a storm surge as these also have an effect on sea level. Always record the date and time at which you make the measurements, which will allow you to correlate this data with tidal data for your area.

**Hazard: coastal erosion**

Coastal erosion is not a simple hazard to monitor because it is affected by many factors including sea level rise, wave energy, wind energy, frequency of coastal storms, etc. When monitoring sea level rise, one of the questions you may have asked is why land available for coastal infrastructure/development is changing or disappearing – this may be due to coastal erosion. To monitor coastal erosion, it may be useful to ask the following questions:

1. Why is the landscape and seascape in my protected area changing? For example, why is vegetation close to the sea disappearing?
2. Why is there more silt in fresh water habitats?

Possible indicators you can use to respond to these questions include:

- Changes in physical features of the coastline over time

_How to measure this indicator:_
To measure this indicator, you need to create initial descriptions of what your land- and seascape along the coast look like and track how this description changes over time. You can do this by drawing maps of the coastline with its physical features, counting large trees that are close to the sea, and taking note of any infrastructural development along the coast. Take note of any fences along the coastline and record or draw a marker of how much soil or sand is built up along the side of the fence – take note of any changes in this build-up over time.

Similarly, if you notice that the water in a stream or lake is becoming less clear and has more silt or mud in it, add this to your description (note that this may not necessarily mean that coastal erosion is occurring, as increased silt deposition also can be a result of impacts on inland waters).
You can also look for trees along the coast that have exposed roots and record the number of exposed roots. Take new counts of these roots three or four times a year. It can be useful to draw a picture of the tree each time you perform the counts as this will allow you to directly see changes in how many and how much of each root is exposed, changes in the angle at which the tree stands, and whether the tree is expressing any signs of stress (e.g. loss of leaves, changes in bark colour, reduced growth, etc.). You should perform these descriptions of the coastline several times a year and following major storms. Keep in mind that impacts of climate change (e.g. storms) are not the only contributing factors to coastal erosion, but that human factors, such as deforestation and development of new infrastructure, may also be causing changes. You should therefore also take note of such developments when updating your descriptions of the coastline.

You might not see very big changes in these descriptions over time, but it is the little details that will help you understand if coastal erosion is having an effect on your protected area and help you adapt your management plans in the future. For example, it may be helpful to plant trees in areas where you see a large build-up of soil along fences and where streams have less clear water. These trees may help hold the soil and therefore may reduce erosion.

**Hazard: saltwater intrusion**

Climate change can increase levels of saltwater intrusion due to reduced rainfall and rising sea levels, particularly in coastal areas that rely heavily on groundwater extraction. Too much salt in groundwater...
can reduce crop productivity and the amount of drinking water available to local communities. Monitoring saltwater intrusion will help you identify areas that may or may not be appropriate for certain agricultural practices or for building new wells. Answering the following questions can be useful in helping you monitor saltwater intrusion:

1. Are my crops not surviving or are they producing less than they used to? Or are only certain crops growing in areas that used to support many other crops?
2. Does the drinking water taste like salt?

Possible indicators you can use to respond to these questions include:

- Concentration of salt in community wells

**How to measure this indicator:**
Testing water in existing wells in communities can help you find out whether the area is affected by saltwater intrusion. You can either do this using chloride strips that test the quality of water, which shops in big cities might sell. If the water in your well has a chloride content of more than 100mg/L, which you will be able to identify on the chloride strip following the instructions provided in the testing kit, the area may be affected by saltwater intrusion. Alternatively, you can place several buckets, each containing one litre of water from a well, under a roof (out of reach from disturbances and rainfall) and allow the water to evaporate. Once the water has evaporated, collect and weigh any salt that remains in the container.

You will need to perform either the chloride test or evaporation technique several times a year, for example monthly, to see if there are changes in the amount of salt entering the system. Record the amount of mg/L of chloride or the milligrams of salt remaining in the container every time you perform the technique. If these amounts increase, this is a sign that saltwater intrusion is occurring.

**Useful Resources:**
This scientific article provides detailed information on using mangrove ecosystems as indicators of coastal change. The methods are not straightforward on-the-ground techniques, but provide longer-term monitoring options using remote-sensing data.

This report describes the use of chemical indicators to monitor saltwater intrusion in British Columbia. It provides detailed technical explanations, methodologies and thresholds that can provide further understanding for why chloride concentrations can be used as an indicator of saltwater intrusion.

This fact sheet provides data on thresholds of chloride concentrations found in aquifers across Europe.

This fact sheet provides pictures and basic descriptions for indicators of soil erosion.
2.3 Monitoring adaptation interventions: mangrove restoration and protection

Description of the intervention
In both Niumi National Park and Sangomar Marine Protected Area, community members and protected area staff have worked together to plant various species of mangrove seedlings in order to restore areas of degraded mangrove habitat.

Challenges the intervention aims to address
In the protected areas, sea level rise has been reported as an ongoing and increasingly severe problem caused by climate change. It has been observed as contributing to coastal erosion, which has multiple secondary effects, in particular in combination with human activities that degrade the natural environment including loss of vegetation cover, disappearance of some tree and animal species, and damages to some eco-tourism infrastructure along the coastline. In Sangomar, sea level rise has also contributed to the loss of fishing infrastructure (i.e. no space available for transforming fish products between ocean and village; no room for boat mooring) and a complete loss of agricultural and pastoral lands along the coastline, both of which have negative impacts on the principle livelihood activities of the communities. In the village of Niodior in Sangomar, coastal erosion has also led to increased siltation in channels. In response to such challenges, community members have had to expand areas for vegetable production and harvesting of marine resources and have, as a result, encroached on protected area resources.

Desired outcomes of the intervention
The ultimate aim of the intervention is to reduce the extent to which climate change driven sea level rise and increased severity of storms cause coastal erosion and, thereby, to decrease the exposure and sensitivity of the physical assets and infrastructures on which communities depend for their livelihoods. By restoring degraded mangrove habitats, this intervention aims to add to the ability of the mangrove ecosystem to stabilise the coastline, reduce coastal erosion, and reduce the impact of extreme weather events, such as storm surges and flooding. The intervention is designed to have multiple social and ecological benefits, such as restoring ecosystem functions that support community livelihoods and maintain biodiversity.

Table 2. Theory of change for the mangrove restoration and protection intervention

<table>
<thead>
<tr>
<th>Impact</th>
<th>Reduced exposure and sensitivity of assets to climate change (e.g. fishing areas preserved, pasture areas protected)</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mangroves can keep up with the pace of rising sea level</td>
<td></td>
</tr>
<tr>
<td>Outcome</td>
<td>Reduced erosion (in comparison to areas with degraded mangroves)</td>
<td>Assumptions</td>
</tr>
<tr>
<td></td>
<td>Mangroves are sufficient to reduce erosion</td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>Mangroves can decrease wave intensity and trap sediment</td>
<td>Wave intensity is not too severe for mangroves to withstand</td>
</tr>
<tr>
<td></td>
<td>Recovery of mangroves</td>
<td>Other threats do not prevent recovery</td>
</tr>
<tr>
<td>Activity</td>
<td>Mangrove seedlings planted</td>
<td>Planted mangrove seedlings survive</td>
</tr>
<tr>
<td></td>
<td>Mangrove propagules reared/mangrove nursery established</td>
<td>Capacity to rear propagules available; propagules survive</td>
</tr>
</tbody>
</table>
1. **Socio-economic indicators**

1.A. **Indicator: community perceptions of the mangrove intervention**

It is important to know whether the mangrove intervention, including the restoration and protection of mangroves, is seen favourably by the community and that other interventions are not preferred. By asking the wider community for their opinion on the success of the intervention, and by using this as an indicator, you also create a participatory process for the whole community. Participatory processes help create a sense of ownership which can contribute to the long-term sustainability of the intervention. This will, in turn, improve the communities’ resilience, adaptive capacity and help address the challenges identified above.

*How to measure this indicator:*

To monitor community perceptions, knowledge, understanding and awareness of mangroves you can ask community members the following questions:

1. Do you think mangroves in your protected area are in good condition?
2. How do you feel about allocating resources to protect mangroves?
3. Whose responsibility is it to protect the mangroves in your protected area? Do you agree with this arrangement?

You can carry out interviews with members of the community to get answers to these questions and build an understanding of their perceptions (see Box 2 for further guidance). These interviews can be carried out in coordination with awareness-raising initiatives (Indicator 1.C), but it is important to keep in mind that community perceptions may be affected by changes in awareness. Therefore, it is important to carry out monitoring of community perceptions more regularly, in particular after awareness-raising initiatives, training sessions or new interventions being implemented in your protected area.

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*Figure 5. Community members replanting mangroves*
Box 2. How to measure socio-economic indicators

There are many different methods you can use to collect monitoring data to measure socio-economic indicators. The most common methods include one-on-one interviews, focus group discussions and questionnaires:

- One-on-one interviews are carried out individually with either key informants or people selected randomly from the community. Interviews usually use a set of semi-structured or open-ended questions that generate detailed qualitative data.

- Focus group discussions are another type of semi-structured interview, but involve a group of selected people. The focus group participants can be selected in many different ways, depending on what information you are interested in getting from them. For example, they can share a common background or knowledge base, be involved in certain types of livelihood activities, or represent gender interests.

- Questionnaires are structured sets of questions with pre-determined answer options or short, open-ended answers. They are a good way to collect standardised information from any group size. Especially if respondents are literate, they can easily be distributed widely and collected later. If respondents are illiterate, you will need to read out the questions and possible answers, and record their responses.

For any of the socio-economic indicators included in this guide, you can decide which of these data collection methods is most suitable and appropriate in your given context. When choosing a method, consider, for example, how big the group is from which you are collecting information; how much time you have to gather information; how much time the respondents are likely to have to provide answers; their level of literacy/numeracy; and how much detail you want to collect on certain questions. In any of the methods, you can structure your question-answer format to be as simple as “yes/no”, or use multiple choice answers, ranking scales, or open-ended answers. The shorter the answer, the quicker it will be to collect, standardise and analyse the data, but the less detail it will provide on why certain changes are taking place or why interventions are performing well/badly. Open-ended answer formats used in interviews or focus groups will take longer to gather, synthesise and analyse, but they will provide details that will give you a more nuanced understanding of the relationships and links between different factors that influence interventions. Choosing a mix of methods and answer formats can therefore be a good compromise. In any case, even when using short answer formats, you should always give respondents the opportunity to elaborate on their response if they wish to do so and take note of these. And when designing more elaborate interviews or questionnaires, do not make them so long that respondents may get bored or rush through answers at the end. Sometimes people answer differently if asked in person or asked through a questionnaire, so you should think about which method would be more appropriate with the group of people you have chosen.

The resources required for each method are minimal, but planning, recording and analysing the data collected can be time-consuming, especially for interviews or focus group discussions. You need to think carefully about which people, and how many, need to participate – a balance should be met between having a more representative sample of the community and the resources required to collect the data. A good starting point is the original group of participants of the interventions, but the sample group can later be expanded to include any others who have learned from the original group of participants, as well as taking a random sample of the community. You should also think about whether you want to ask the same people over time, which will allow you to understand how opinions have changed, or to randomly select people, which would be more representative.

1.B. Indicator: use and potential degradation of mangroves

In order to understand the effectiveness of your mangrove restoration and protection interventions, it is important to monitor the change in threat level on your mangrove ecosystem. In addition to monitoring the climate change related threats (see Section 2.2), keeping an eye on the extractive use of mangroves for timber, firewood and oyster harvesting will give you an opportunity to intervene and reduce such pressures on the mangrove ecosystems. Changes in the type and frequency of mangrove use will give you information about the use and potential degradation of mangroves.
**How to measure this indicator:**

To help you monitor the use and potential degradation of mangroves, you can design questions for interviews or focus group discussions with community members (see Box 2 for further guidance), around the following questions:

1. What are the potential uses for mangroves in your protected area (e.g. timber, firewood, oyster harvesting)? Have these changed over time?
2. Do you have an indication of how many people/which groups of people harvest mangroves for the uses identified above? (note that it may be difficult to obtain an accurate figure to answer this question, but by observing trends over time, you will be in a better position to understand the main sources of pressure and identify where major interventions are needed)

**1.C. Indicator: role of the community in mangrove restoration and protection**

Community knowledge, understanding and awareness of the importance of mangroves and the threats they face will improve the participatory implementation of mangrove restoration and protection interventions. These participatory processes help improve ownership and thus the sustainability of interventions, which is why monitoring community perceptions (Indicator 1.A) is just as important as monitoring the role of the community in the intervention.

To increase the role of the local community in mangrove restoration and protection practices, you will need to coordinate efforts to carry out workshops, meetings or gatherings that help raise awareness and therefore build capacity. Monitoring perceptions of the intervention (Indicator 1.A) can be carried out in coordination with these awareness-raising initiatives, but it is important to remember that community perceptions will probably change as a result of increased awareness. Therefore, it is important to monitor perceptions more regularly, in particular after such awareness-raising initiatives, training sessions or new interventions being implemented in your protected area.

**How to measure this indicator:**

To monitor the effectiveness of an awareness-raising initiative, you should get answers to the following questions before and after the initiative:

1. How many people in the community can provide local or scientific names of mangrove species that grow in your protected area?
2. How many people participated in the awareness-raising meeting/workshop/gathering on mangroves?
3. How many of the people participating in this meeting can describe some of the major threats to mangrove ecosystems? For example, are participants aware that the degradation of mangroves through timber/firewood/oyster harvesting puts pressure on mangrove ecosystems, making them more vulnerable to the effects of climate change?
4. How many of the people participating in this meeting can describe some of the ecosystem services provided by mangroves? For example, can participants describe the importance of mangroves in reducing their vulnerability to climate change impacts, including protection from storm surges, sea level rise and coastal erosion? Can participants describe the importance of mangroves for sustaining fisheries, because they are an important habitat for fish and other marine biodiversity?

You can gather responses to the above questions through various methods, including through one-on-one interviews, questionnaires or observational notes. Collecting this information will help you understand whether your awareness-raising initiative was effective. Follow-up activities will help maintain community knowledge, understanding and awareness, and results from monitoring previous initiatives can be used to improve and develop new community-focused interventions.
2. **Environmental indicators**

In addition to monitoring the indicators described in this section, it is important to keep in mind that changes in climate will also affect the health of your mangrove ecosystem. Therefore, in order to determine the ecological and biological effectiveness of your mangrove restoration and protection intervention, take careful note of any major changes in weather patterns during the year while you monitor mangroves. Things to note include major storms, particularly dry/rainy years, particularly hot/cooler years, etc. As the environmental and climatic indicators are closely linked, try to coordinate the monitoring efforts of both when tracking changes in mangroves.

![](image)

**Figure 6.** Verifying the status of planted mangrove seedlings

2.A. **Indicator: population and growth rates of planted mangroves**

Monitoring the success of planting mangroves can help determine whether the intervention has the potential to reduce the impacts of climate change hazards in the future. Population and individual tree growth rates are possible indicators that can be used to monitor the effectiveness of your mangrove restoration intervention.

*How to measure this indicator:*

To measure growth rates, you may want to ask the following questions:

1. Are the mangroves that we planted growing?
2. Are the mangroves that we planted producing seedlings, and are any new trees sprouting from these?

To answer these questions, demarcate a number of 5x5 metre plots in the areas in which you are planting mangroves. To choose these plots, use a stratified sampling approach within your mangrove
restoration area (see Box 3 for further explanation), selecting areas that represent different mangrove habitats and randomly selecting numerous plots within each area. Try to have at least three plots for every habitat in which you have planted mangroves, depending on the size of the area you are trying to restore. In these plots, count the number of seedlings that you have planted and write down the height of each seedling. Return at least every six months for the first three years after planting and repeat this method, preferably returning to the same plots (note that this will require robust and well-demarcated plots). By doing so, you will be able to monitor whether the trees that you planted have grown and whether new trees have sprouted.

It may be useful to use a table similar to Table 3 to record your answers.

Table 3. Example data collection sheet for recording population and growth rates of planted mangroves

<table>
<thead>
<tr>
<th>Site</th>
<th>Niodior</th>
<th>Name of recorder</th>
<th>James Smith</th>
<th>Date</th>
<th>27 June 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of data collector</td>
<td>Sharon Williams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of mangrove habitat:</td>
<td>10 m from beach in intertidal zone, surrounded by existing mangrove forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot #</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total # of trees</td>
<td>14</td>
<td>19</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of trees (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>12</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>32</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>14</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>15</td>
<td>19.3</td>
<td>16.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate the mean height of trees by taking the sum of all heights and dividing by the total number of trees. Monitoring these mean heights over time will show you whether the trees are growing. Repeating these measurements six months later and recording the change in mean height over time will allow you to calculate the mangroves’ growth rates. Furthermore, if the total number of trees in each plot increases over time, the population of mangroves is also growing. This may not take effect within the first three years as mangroves need to reach a certain size and age before they are able to reproduce.

2.B. Indicator: number and size of trees in the existing mangrove ecosystem

In addition to monitoring the effectiveness of your restoration intervention, counting how many trees you have in your existing mangrove ecosystem, along with how quickly they grow, is an effective indicator of how well your protected area is maintaining mangrove ecosystems. This time-consuming approach takes some training, but is also a useful way of raising awareness and building knowledge on the importance of mangrove ecosystems in your local community if you involve them in the data collection.

How to measure this indicator:

Monitoring the number and size of trees will help you answer the following questions:

1. How many trees, on average, exist in 10x10 metre plots in my protected area? Is this number increasing over a time span of two to three years?
2. How large are these trees and how much do they grow over a time span of two to three years?

In order to collect data in response to these questions, run transect lines from the seaward edge to the inland edge of the mangrove forest. Try to ensure that the transects represent typical mangroves in the
area. Along the transects, mark out numerous 10x10 metre plots, which is the standard plot size used for monitoring mangrove forests (Figure 7).

In these plots, identify all trees that have a trunk larger than 4 cm in circumference and measure the circumference at chest height. If a mangrove tree has more than one trunk at chest height, record each trunk as a separate tree. Also record the number of trees/saplings that have a trunk circumference of less than 4 cm in your plot. This will help you determine whether your protected area is helping the existing mangrove population grow, and will also help you reflect on approaches that may be important to monitor, evaluate and manage your restored mangrove forest in the future. Consider random sampling techniques when choosing where to locate transects and systematic sampling (Box 3) for the placement plots along each transect. Together, these provide a stratified sampling approach.

Figure 7. Transect and plot placement for monitoring mangrove protection. The environmental conditions within the mangrove habitat will vary a lot so it is important to measure mangroves spanning the whole habitat

It may be useful to use Table 4 to record your answers. In this, you can list the name of your site, who is recording and collecting data for future reference, the date, the number and length of your transect, which plot it is, the number of trees, and the circumference of the trunk of each tree recorded.
Table 4. Data collection sheet for counting and measuring mangroves

<table>
<thead>
<tr>
<th>Site</th>
<th>Name of recorder</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name of data collector</td>
<td></td>
</tr>
<tr>
<td>Transect #</td>
<td>Length of transect (metres)</td>
<td>Plot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total # of trees</th>
<th>Total # of trees with trunk circumference &lt;4cm</th>
<th>Total # of trees with trunk circumference &gt;4cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree #</td>
<td>Circumference of trunk (cm)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.C. Indicator: signs of stress in current mangrove population

Ecosystems exhibit signs of stress when pressure is exerted on them. Stress can be a result of climate or human pressures and are relatively easy to monitor. If the signs of stress are placed in a climate change context and/or compared with results from the indicator measuring potential use and degradation of mangroves (Mangrove Environmental Indicator 2.A), management practices can be adapted to better combat these threats.

*How to measure this indicator:*

Signs of stress in a mangrove community include:
- Large or small areas where trees are removed
- Cut off branches
- Cracked bark
- Uppermost branches in the sun are dying at their tips
- Trees have fewer leaves
- Leaf pairs on shoots are shorter than on healthy trees
- Leaves are distorted: smaller, twisted, curled, dead parts, spotted
- Trees have no flowers
- Fruits fall off before maturity
- Seedlings are deformed, have abnormal growth or may die
- Aerial roots (pneumatophores) develop on the tree’s trunk instead of coming up from the mud
- Aerial roots are branched, twisted or curled
- Young trees grow at an angle

Identify mangrove areas that are particularly vulnerable to stress. Potentially, these will mainly be areas that are easily accessible, for example, near community settlements and close to the border of the protected area. The above characteristics of stressed mangroves can be examined in 10x10 metre plots two to three times a year and following major storms. Ensure that you do not demarcate or label this plot because placing too much attention on the area will deter potential human-induced disturbance, which can give a false representation of the disturbances that mangroves may still be exposed to in non-demarcated areas. If disturbances are still occurring in your protected area, carrying out this monitoring may help you identify measures to overcome these threats. Long-term monitoring should preferably be carried out in the same areas and on the same trees because this creates a more accurate picture of changes over time – so ensure that you have taken note of where the plots are so that you can find them again. To save time and resources, it may be worth monitoring stress in the inward most plots chosen along your transects for Environmental Indicator 2.B.
Box 3. Choosing the right sampling technique for quantitative sampling

Just as there is no one right indicator with which to monitor an intervention, there is no one right quantitative sampling technique with which collect data. That does not mean, however, that all sampling strategies are equally suited for all purposes. Various sampling techniques are mentioned in the ‘how to measure this indicator’ sections throughout this guide and it is important to have a firm grasp of these before you start collecting data.

There are three main sampling strategies that you should be aware of (Figure 8) and each has its own advantages ('pros') and disadvantages ('cons'), as stated below:

1) **Systematic sampling**: this is done at fixed intervals, usually along a line (e.g. plots along randomly selected transects in Mangrove Environmental Indicator 2.B). It is often used where there is a continuous gradient in a habitat, for example, moving inland from the coastline or moving up in changing altitudes.
   - **Pros**: it is the most straightforward type of sampling and can easily provide representative coverage of samples.
   - **Cons**: it is more biased than other techniques as not all areas/people have an equal chance of being selected and the natural world rarely conforms to such neat spatial and temporal patterns.

2) **Random sampling**: random sampling means you monitor at random times or locations (e.g. from which markets to measure profit in the Oyster Harvesting Socio-Economic Indicator 1.B, or where to place transects for Mangrove Environmental Indicator 2.B). Random sampling is used when the ‘habitat’ being measured is uniform. Random sampling would therefore not be appropriate for the economic success of vegetable produce that is strictly seasonal.
   - **Pros**: all samples (e.g. markets or mangrove sampling plots) have an equal chance of being chosen, which makes it the least biased sampling technique.
   - **Cons**: random sampling can, however, lead to poor representation (e.g. clustering shown in Figure 8).

3) **Stratified sampling**: this method takes into account distinct areas within a larger area, for example, using subgroups of the overall community when undertaking a knowledge test (Vegetable Production Socio-Economic Indicator 1.B) or selecting where to place your transects in a relatively uniform habitat (Mangrove Environmental Indicator 2.B). You can implement systematic and random sampling within the context of stratified sampling, but be careful to get a proportionate sample for each subset. Despite stratified sampling being more complex and time consuming to undertake, it is often the preferred sampling strategy as you can ensure that you sample from all of the subsets of a population (e.g. age groups in a community or different mangrove habitats) but still systematically or randomly choose the individuals to interview or the habitat areas to measure.
   - **Pros**: it is very flexible and applicable and also more representative as populations are often made up of subsets.
   - **Cons**: it can be hard to stratify the overall population into subsets.

![Figure 8. Sampling strategies](image)

16 samples are taken in each strategy. Systematic sampling results in a rigid pattern, whereas random sampling by chance can result in an over-representation of the bottom left. In stratified sampling, by creating subsets and enforcing one sample per subset (eight in grey squares and eight in white), you have a more representative sample that can be done either systematically or randomly.
Useful resources:
The document provides detailed guidelines for socio-economic and ecological monitoring of mangroves using different indicators based on work carried out in the Maldives. It also includes helpful guidance on good practice methods for monitoring and evaluation.

This sourcebook provides straightforward descriptions of methods to monitor coral reefs, mangroves and seagrasses. It also includes case studies that may help highlight important considerations to make when selecting a monitoring method.
2.4 Monitoring adaptation interventions: sustainable oyster harvesting

Description of the intervention
In Sangomar Marine Protected Area, groups of women have been trained to use a sustainable oyster harvesting technique in which lines are attached to mangrove roots on one end and to poles on the other. Oysters then latch onto the lines, instead of the mangrove roots. This technique was also used in Niumi National Park in the past and has recently been revived under the Biocos project funded by the MAVA Foundation. In Sangomar, the women have also received sustainable stoves, which use less fuel wood and are less damaging to their health. These stoves can be used to smoke oysters and other fish produce to a higher quality. Additionally, they have received entrepreneurial training on how to market and sell their products.

Challenges the intervention aims to address
Oyster harvesting is one of the main livelihood activities for women and it is often a fall-back option for the whole community in times of scarcity. Currently, in order to harvest oysters, people cut the roots of mangroves, which is extremely damaging. By degrading the mangroves in this way, an important source of protection from many negative impacts of climate change is lost. Communities therefore become increasingly vulnerable to sea level rise, coastal erosion, saltwater intrusion and extreme weather events. Furthermore, valuable habitats for important biodiversity are lost, which further degrades the ecosystem services on which communities rely. Additionally, the traditional cook stoves used by women to smoke oysters and fish require large quantities of fuel wood to run and also produce a lot of smoke, which is damaging to their health.

Desired outcomes of the intervention
The ultimate aim of the intervention is to contribute to the protection of communities against negative climate change impacts resulting from sea level rise by reducing the degradation of mangroves through the provision of sustainable oyster harvesting techniques. The provision of sustainable cook stoves also aims to contribute to decreasing habitat degradation in the protected area as the stoves require less fuel wood. In addition to the positive impacts of this on biodiversity, the cook stoves will allow participating community members to smoke oysters and fish in a safer way and produce higher quality goods. Accompanied by the entrepreneurial training, this should enable them to increase their income levels and strengthen their adaptive capacity.

Table 5. Theory of change for the sustainable oyster harvesting intervention

<table>
<thead>
<tr>
<th>Impact</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased adaptive capacity (through increased asset base of community)</td>
<td>Revenues from oyster products enable the adaptive capacity of the community to increase; oyster revenues are less vulnerable to climate change than other livelihoods</td>
</tr>
<tr>
<td>Decreased exposure or sensitivity to sea level rise, coastal erosion, salt intrusion and extreme weather events</td>
<td>Mangroves reduce sensitivity to these threats; mangroves can keep up with rates of sea level rise; mangroves are sufficient to reduce erosion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased revenue from oyster products</td>
<td>Line-harvesting technique is more successful than traditional harvesting methods</td>
</tr>
<tr>
<td>Mangroves maintain their coastal protection function</td>
<td>Women do not continue to harvest oysters directly latched onto mangroves</td>
</tr>
<tr>
<td>High yield from oyster harvesting</td>
<td>Oyster harvesting methods are successful</td>
</tr>
</tbody>
</table>
Reduced damage to mangroves | Women do not continue to harvest oysters directly latched onto mangroves
---|---
Output | Change in oyster harvesting method | Women are willing to change harvesting methods
 | New stoves used | Women are willing to use new stoves
Activity | Training on oyster harvesting | Women understand importance of new technique to conserving mangroves
 | Stoves provided | Women are aware of negative impacts on health and biodiversity from using traditional stoves

As the sustainable line-harvesting intervention aims to reduce some of the threats posed to mangrove ecosystems, its effectiveness can also in part be measured using many of the indicators described in the monitoring mangrove restoration protection sections. Particularly, you may want to monitor the indicators of mangrove stress in areas that are usually harvested for oysters. You should also consider monitoring whether there are changes in the uses of mangroves in your protected area. If, for example, oyster harvesting is less frequently identified as a potential use of mangroves, this may be an indication that the implementation of the line-harvesting technique is effectively reducing pressures on mangroves.

1. **Socio-economic indicators**

1.A. **Indicator: perceptions of success of the line-harvesting technique**

It is important to know whether the oyster line-harvesting technique is seen favourably by the community and that other interventions are not preferred. By asking community members for their opinion on the success of the intervention and using this as an indicator, you also create a participatory process, which contributes to creating ownership and improving long-term sustainability.

*How to measure this indicator:*

Asking community members the following questions will help you monitor their perceptions:

1. Do you feel the line-harvesting technique, overall, has been a success?
2. Do you feel that you can support your family using this technique as well as with the old technique?
3. Do you feel that the technique will reduce threats to mangroves?
4. On a scale of 1 to 5 (1=low, 5=high), how successful do you think the implementation of the new technique has been in supporting your livelihood?

These questions can be posed as “yes/no” or open-ended questions to the women who participated in the original intervention, as well as any other women who have started using the technique since, or who had already used it in other villages in your protected area (see Box 2 for further guidance). It is important to ask these questions as soon as possible after the intervention has been implemented and to repeat them regularly in order to track changes in how the use of the new technique is going.

1.B. **Indicator: perceptions of success of sustainable stoves and entrepreneurial training**

An important aspect of implementing the sustainable line-harvesting of oysters as an intervention was to improve the efficiency and reduce the risks of processing oyster products. Sustainable cook stoves are designed to reduce degradation of forests due to fuel wood harvesting, improve the efficiency of smoking fish products and reduce the negative health impacts. Entrepreneurial training was provided to bolster each of these steps. Indicators such as changes in the perception of family health, use of fuel wood, business and financial success can help monitor the perceived success of the sustainable stoves and entrepreneurial training.

*How to measure this indicator:*
To monitor the intervention as a whole, you can ask the women participating in the intervention the following questions:

1. Do you find that your/your family’s health has improved since using the new cook stoves?
2. Do you find that you are using more or less firewood with the new stoves in comparison to the old stoves?
3. How has your business changed since you received entrepreneurial training? (asking this question may provide information on new potential areas for livelihood diversification)
4. How much money did you make per day/week/month from selling fish produce using the old technique?
5. How much money do you make per day/week/month from selling oyster/fish produce using the new techniques (line-harvesting, cook stoves and training)?
6. On a scale from 1 to 5 (1=low, 5=high), has the intervention improved your business?

You can also gather information on the following questions by designing knowledge-based questions to ask the original participants and those who have learned the new technique since:

7. Are people who received training able to relay the knowledge they have gained? Have any new people learned about the line-harvesting technique and use of cook stoves? The success of this intervention depends on the knowledge gained being passed on.

See Box 2 for further guidance on which method to choose to gather answers to these questions. As it will take some time for the benefits of the intervention to set in, it may be worthwhile to carry out this survey one year after the implementation and to repeat it every other year.
2. **Environmental indicators**

2.A. **Indicator: oyster yields**

As oyster harvesting is an important livelihood activity across communities in your protected area, the sustainability of the line-harvesting technique is dependent on its ability to continue to provide similar or higher yields compared to the traditional harvesting methods. In order to establish this, you need to have a relatively accurate idea of what yields were like before implementing the new technique (baseline). From such a baseline, you can gather information on how the numbers and size of harvested oysters have changed with the new line-harvesting technique. You can complement this information with the data collected from monitoring the mangrove restoration and protection intervention to help understand the effectiveness of the line-harvesting technique in reducing the degradation of mangroves.

**How to measure this indicator:**

In order to monitor the size and number of oysters, it may be useful to answer the following questions:

1. Have the oysters increased or decreased in size since the implementation of the new technique?
2. Are more or fewer oysters being harvested per day than previously (e.g. using the mangrove-harvesting technique/during the previous year)?

Answering these questions can help you identify if changes in the size of oysters are having an impact on the number of oysters being harvested.

To answer the first question, you need to take accurate measurements (in millimetres) of the height of at least 50 live oyster shells (see Figure 10 to know which axis is the height of the oyster shell) and document these. You can ask the women harvesting oysters to help you record this information over time as they will also have a direct interest in knowing the extent to which their yields have changed. In order for them to help you collect this data, you will need to organize a short training session on how to accurately measure oysters and record the information (you may need to designate data recorders if not all women are numerate/literate).

Measuring and recording data on oysters should be carried out every year at the end of the oyster growing season. This will provide an accurate indication of whether the new technique affects the size of the oysters. Additionally, a documented increase in the size of oysters coinciding with fewer oysters being harvested may be able to provide the groundwork for establishing harvesting quotas if this becomes necessary in the future.

![Figure 10. Illustration of where to measure oysters to establish their size](image)
To complement the data collected on actual changes in yield, it can be useful to gather information on perceived change in yield. It could be, for example, that the actual yield is higher than using the old harvesting method, but that women perceive the yields of the new techniques as being lower for some reason. You could then use the information on actual yields to justify and promote the new technique.

To gather information on perceptions of yield, you can ask women who participated in the original intervention, as well as any other women who have started using the technique since, or who had already used it in other villages in your protected area (see Box 2 for further guidance) the following questions:

1. How many oysters were you able to harvest per day using the old technique?
2. How many oysters are you able to harvest per day using the sustainable line-harvesting technique?

Useful resources:
This scientific article does not provide guidance on simple monitoring methods, but may be able to provide inspiration for more long-term and large-scale monitoring initiatives. These do, however, require substantial resources and capacity.

2.5 Monitoring adaptation interventions: climate-smart vegetable production

Description of the intervention
In Sangomar Marine Protected Area, a climate-smart vegetable production intervention has been established in the village of Niodior. To do this, a piece of land was set aside that is removed from the coastline and is located above a steadily supplied aquifer that is not intruded by salt. This plot was fenced and wells were restored and/or built for farmers to have easy access to water for irrigation. The participants of this intervention have been supplied with seeds for a number of drought tolerant crops (varieties of pepper, sweet potatoes and onions) and have received training on how to plant and maintain these crops.

Challenges the intervention aims to address
Vegetable production is one of the main livelihood activities and sources of food for both women and men in Niodior, as well as in the other communities of Sangomar and Niumi National Park. It is therefore essential to maintain this activity; however, it suffers from negative climate change impacts, including low and erratic rainfall accompanied by rising temperatures. The rainy season has been reported as becoming increasingly shorter, its onset more unpredictable and the intensity of rains sometimes difficult to manage. This makes it challenging for farmers to plan their planting season and severely threatens their harvest. Furthermore, due to low rainfall and increasing temperatures, the level of salt in the vegetable fields becomes very high, which is damaging to crops. Fields located near the coastline have experienced higher levels of salinity from intruding sea water and, in some instances, have vanished entirely due to coastal erosion. Due to a lack of fencing, livestock have also been reported to trample and destroy crops.

Desired outcomes of the intervention
The ultimate aim of the intervention is to reduce the exposure and sensitivity of vegetable production to climate change and thereby maintain crop yields. In doing so, it aims to increase the community's resources and income levels and so build their adaptive capacity to other climate change impacts. Receiving training on agricultural practices aims to help farmers better plan and manage their crops and form the basis to explore further methods in the future that may increase their productivity.

Table 6. Theory of change for the climate-smart vegetable production intervention

<table>
<thead>
<tr>
<th>Impact</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased adaptive capacity of local community to drought and salinity of land (through increased asset base of community)</td>
<td>Revenues increase from the new vegetable gardens</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced exposure and sensitivity of local community to drought and salinity of land (higher crop yields)</td>
<td>New crops flourish in the climatic and environmental conditions in the long-term</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants survive to produce yield</td>
<td>Climate change impacts are not too severe and do not destroy crops; farmers maintain crops correctly</td>
</tr>
<tr>
<td>Fences and wells are maintained</td>
<td>Farmers have the necessary resources and time to maintain the fences and wells</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought tolerant crop varieties are planted</td>
<td>The crops are planted in the correct way to enable successful plant development</td>
</tr>
<tr>
<td>Fences are erected and wells are restored/built</td>
<td>Construction is solid and build to withstand stresses</td>
</tr>
</tbody>
</table>
1. **Socio-economic indicators**

1.A. **Indicator: perceptions of the new vegetable gardens**

It is important to know whether the vegetable farming intervention is seen favourably by the community and that other interventions are not preferred. By asking the intervention participants their opinion on the success of the intervention and using this as an indicator, you are also creating a participatory process for all those involved. Participatory processes create ownership and improve the long-term sustainability of interventions.

**How to measure this indicator:**

Questions you could ask participating community members to monitor this indicator include:

1. On a scale of 1 to 5 (1=low, 5=high), how successful do you think the vegetable garden has been?
2. In times of drought, what happened to your vegetable garden?
3. Have there been any problems associated with the vegetable garden?
4. Has your level of food security changed?
5. Has your level of income changed since you have been involved in this new form of vegetable gardening?

You can add to this list of questions and tailor them to areas of interest to your protected area. See Box 2 for additional guidance on different methods for collecting socio-economic data.

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1.B. **Indicator: knowledge of climate-smart vegetable production**

Measuring the number of people who have the knowledge on how to plan, plant and manage drought tolerant crops, will give you a targeted method of measuring the success of the intervention. This

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**Figure 12.**
Farmer irrigating the new vegetable garden
information will complement the data collected on community perceptions of the intervention, which may change over time. By measuring how many individuals were initially trained, and how many additional individuals have been trained since, you can measure the spread of knowledge and adaptive capacity throughout the community.

*How to measure this indicator:*
To monitor the community knowledge on the vegetable garden, you may want to gather information on the following questions:

1. How many people in the community/what proportion of the community are trained in managing the vegetable garden?
2. Are these people able to pass this information on to other community members so that the practice can carry on in the future? (the long-term success of this intervention is dependent on the knowledge being passed on to other community members)
3. How much arable area is receiving drought tolerant management practices?
4. How many farms are growing drought tolerant crops?

What people think of the intervention and what they know about it can change very fast so you should measure these social factors often. Because you are measuring knowledge rather than perception, it is important that the person asking the questions knows how to manage the vegetable garden and can test others on their ability to do the same. The method for doing this could be through interviews or by a questionnaire test, if participants are literate. However, there is a risk that if people do the questionnaire, they may ask others for help. To prevent this, you could undertake 'hands on' tests with individuals at the vegetable garden itself. You could ask individuals questions such as "when would you plant a crop of onions?" or "show me how you would harvest sweet potatoes" and you could rank them on their ability to answer the questions. Everyone will have different levels of knowledge, so you will have to decide threshold levels of knowledge for a person to have. To determine this knowledge threshold, you can speak with the person who originally trained the group of participants and discuss which pieces of information the participants can be tested on.

1.C. Indicator: economic gain from the vegetable garden
One of the intervention's objectives is to increase food production and thereby promote one of the farmers' primary sources of income. Even if the vegetable farm is producing high levels of produce, if you do not have any surplus food to sell at local markets, then the intervention will not have met its desired impact of fully building adaptive capacity. Economic gain from the vegetable garden is an indicator you could use to monitor the effectiveness of the intervention.

*How to measure this indicator:*
Questions you could ask to assess the garden's success in promoting alternative sources of income include:

1. How much profit do you make from selling vegetable garden products per market?
2. How much profit do you make from each crop per market?
3. How much profit does each household make from selling all vegetable products per time period (e.g. month)? How much profit does each individual make from selling all vegetable products per time period (e.g. month)?

An economic indicator not only shows the scale of the crop yield, but also the scale of the food surplus (assuming the vegetable gardens were prioritised for local consumption), therefore indicating the degree of food security. The more produce is sold, the more secure the community is in their food production. This indicator could possibly require a lot of resources (especially time) because in addition
to knowing how much produce has been grown per crop, you have to put this knowledge in an economic context, for example, how much have you spent on the farming (in time and money) and what profits have you received? In addition to the profit made at markets from selling the garden’s produce, it is important to take into account the costs put into the creating the produce in the first place, for example, the amount of time you spend farming and the costs from buying necessary equipment (e.g. tools and fertiliser). You may want to record extra information, such as the price each crop sells for at each market and how many other people are selling the same crops, which will give some additional context to the data. An example of how you can measure the net profits from selling vegetable produce is shown in Table 7.

Table 7. Financial table: a simple table can quickly show how much effort is going into vegetable production and how much financial profit is coming from it

<table>
<thead>
<tr>
<th>Month</th>
<th>Farming costs</th>
<th>Time spent farming (days)</th>
<th>Sum of sold produce</th>
<th>Farming profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>= (c – a) / b</td>
</tr>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>....</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Environmental indicators

2.A. Indicator: amount of food produced by vegetable garden

If you use socio-economic indicators that track the community’s perception of the garden, how many people know how to tend to the garden or profits made from the garden, you will get a useful insight into the success of the garden, but you will not necessarily know if the garden is effectively increasing food security. To measure food security, you should measure how much food the garden is producing.

How to measure this indicator:

Some possible questions you could ask, which focus on the garden’s outputs and will help you monitor this indicator, are:

1. How many onions/sweet potatoes/peppers are grown by the garden per time period (e.g. month)?
2. What weight of onions/sweet potatoes/peppers is grown by the garden each per time period (e.g. month)?
3. How much additional food does each household get from the vegetable garden per time period (e.g. month)?
4. How much additional food does each person get from the vegetable garden per time period (e.g. month)?
5. How much produce is made from the vegetable garden in comparison to other arable areas?

The answers to these questions will show the raw benefit received directly from the vegetable garden. However, there are several aspects you need to consider in relation to this indicator. The seasonal nature of vegetable growing is such that choosing the right time interval to measure production is important. Monitoring every week would be too often, but monitoring once a year not often enough.

The benefit of just counting the number of vegetables you grow is that it is fast, but it doesn’t tell you how much food you have grown – for that, you should weigh the produce. When weighing the produce, make sure you take note of the weight of the bag you weigh the produce in and look out for any additional weight, such as soil, that may stick to the produce.
Asking how much extra food is grown per household or per person is important because the vegetable garden could produce successful harvests, but if the community’s other crops fail due to climate change, has the garden been successful enough in benefitting the wider community? In this example, the garden will have helped in reducing the impacts of climate change, but the wider community could still be hungry. The garden will be considered successful if it aids in the production of crops by the community, but especially successful if it produces higher yields than the other arable areas. You could measure the amount of food grown from the vegetable garden compared to all other sources of food – this way, you can make sure that there is enough food overall, but that the vegetable garden is being effective at the same time.

**Useful resources:**
This report goes into more detail about how traditional farming systems can adaptively improve the resilience of farming communities. The report analyses the strengths and weaknesses of traditional farming systems in an era of climatic change and further discusses potential coping mechanisms such as water capture in dryland environments.

World Bank, 2013. Turn down the heat: climate extremes, regional impacts, and the case for resilience
http://www-wds.worldbank.org/external/default/WDSContentServer/Ib/2015/07/17/090224b0828c0f20/1_0/Rendered/PDF/Turn0ndown0the00lience000full0report.pdf
The report gives a detailed look at how the negative impacts of climate change already in motion could create devastating conditions for those least able to adapt.
2.6 Monitoring adaptation interventions: beekeeping

Description of the intervention

In Niumi National Park, a group of both men and women have been trained on beekeeping and the production, distribution and marketing of honey and other beeswax products.

Challenges the intervention aims to address

The primary livelihood activities practiced in the communities, including vegetable production, fishing, rice farming and oyster harvesting, are all threatened by combined climatic and human pressures. Sea level rise, coastal erosion, increased saltwater intrusion, low rainfall, rising temperatures, overfishing and overharvesting of wood, all contribute to making communities very vulnerable both in terms of their food and income security. A further lack of basic services and social infrastructure means that communities have little or nothing to fall back on when their livelihood activities fail, or in times of extreme events.

Desired outcomes of the intervention

The ultimate aim of the intervention is to enhance socio-economic conditions in the community by promoting a local and sustainable revenue stream while at the same time enabling greater ecological resilience to the negative impacts of climate change. Beekeeping is a comparatively cheap and easy activity to start, it requires little land and creates an incentive for local people to keep natural habitats intact. By providing beekeeping as a supplementary livelihood activity, which is thought to be less vulnerable to the climatic challenges the communities face, participating community members should be able to increase their adaptive capacity. The training on production and marketing of honey and beeswax products will allow them to produce quality goods that are attractive on local and international markets, thereby offering an important source of income. With increased income, community members will be able to improve their general well-being, re-invest into their other livelihood activities or be able to deal with setbacks in those. Furthermore, this intervention produces multiple co-benefits: not only is it sustainable within the protected area, but bees are the main pollinators of many trees and food crops, such as mangoes and cashews, and also pollinate non-food crops, which helps the regeneration of natural vegetation. Bees thrive when surrounded by abundant trees and mangroves, therefore this intervention also encourages communities to conserve their environment.

Table 8. Theory of change for the beekeeping intervention

<table>
<thead>
<tr>
<th>Impact</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased adaptive capacity (through increased asset base/revenue streams of community)</td>
<td>Revenues from beekeeping enable the adaptive capacity of the community to increase; beekeeping revenues are less vulnerable to climate change than other livelihoods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased financial revenues from beekeeping products</td>
<td>A market exists for the honey and beeswax products</td>
</tr>
<tr>
<td>Greater pollination of specific agricultural crops</td>
<td>An increase in the abundance of bees will correlate to greater crop yields</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production and marketing of honey and beeswax products</td>
<td>Training enables community to produce and effectively market products</td>
</tr>
<tr>
<td>Bee hives produce honey and other beeswax products</td>
<td>There are sufficient food sources for bee colonies to grow and these are free from pests/diseases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bee hives are set up and colonised</td>
<td>Training enables community to successfully set up hives and maintain them in good health</td>
</tr>
<tr>
<td>Training of community members</td>
<td>Trainees understand and adopt methods learned during the training session</td>
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</tbody>
</table>
1. **Socio-economic indicators**

1.A. Indicator: skills gained from beekeeping

This intervention aims to diversify the community’s income by creating a revenue stream that is less affected by the negative impacts of climate change. Learning the skills to successfully manage bees and harvest bee derived products underpins the success of the whole intervention and is therefore a key indicator of the effectiveness of the intervention.

*How to measure this indicator:*

Gathering information on the following questions will help you monitor the skills gained from beekeeping:

1. How many people trained in beekeeping are using their knowledge on a regular basis?
2. Are people who received training able to pass on the knowledge they have gained?
3. Have any new people learned about beekeeping? (the long-term success of this intervention depends on the knowledge gained from beekeeping being passed on)
4. Do people think that beekeeping is a sustainable and long-term income option? Will people continue to keep bees as a livelihood option?

You could use questionnaires or interviews to assess how viable participants think the intervention is in the long-term in diversifying your community’s revenue stream. Another option could be to bring all participants who undertook the beekeeping training together and create a working group in which you discuss, as a group, how well the intervention is going. This method gives you a lot of information very quickly, but can mean that some people speak a lot more than others, so it is important you hear from everyone. If you use the working group approach, you can either use questions like in the interviews and ask participants for absolute answers (e.g. “yes/no”) or ask them open-ended questions. Ensure that someone in the working group is taking notes on people’s responses (see Box 2 for further guidance).
1.B. Indicator: economic benefits of beekeeping

This intervention also aims to improve general well-being through beekeeping by enabling individuals to re-invest into their other livelihood activities or be able to better deal with other financial setbacks. Ensuring the intervention is not only socially and ecologically, but also financially sustainable is therefore essential. You should therefore measure what economic benefits the intervention is having over time. Note that such benefits may not be very noticeable after the first harvest, or even longer, as it takes time for the hives to generate a steady flow of honey, for participants to establish their business and to become integrated in the market.

*How to measure this indicator:*

To monitor this indicator, you should gather information on the following questions over time:

1. How much profit is made from beekeeping related products per time period (e.g. month)?
2. How much money from beekeeping related products is re-invested into other livelihood activities, and which ones?
3. Do participants feel more financially secure from the added revenue from bee related products? If so, how many?
4. Has marketing training improved participants’ ability to sell bee derived products?

This intervention aims to increase the incomes of participants and, therefore, it is important to see what proportional impact it has had. To measure this, you need to know all income sources for an individual/household/community, how much those sources add up to and what proportion of that consists of bee derived products. As highlighted in the vegetable production intervention (Socio-Economic Indicator 1.C), it is important to include all the costs into this estimation. This is can be very sensitive information, so you could do this anonymously through a questionnaire if participants are literate. Another option is to not ask people to tell you exactly how much they earn but to provide boundary boxes (e.g. from $0 to $50, $51-$100, over $100, etc.). You should also consider the temporal component of this: despite tropical bees working all year round, hives are traditionally set up at the end of the rainy season in the Gambia, around October to November, and then left for eight to nine months before harvest (PLANBEE). Therefore you should measure economic benefits throughout the year, or at least before and after the harvest, which will provide very different results.

2. Environmental indicators

2.A. Indicator: health of hives/bee populations

Understanding how people feel, and how well they understand the training does not tell you how well the bees are doing. If you directly measure how many bees there are per hive, you can immediately understand the ecological health of the intervention and, over time, whether the bee population is growing. This kind of indicator is important in informing adaptive management. For example, if particular hives are doing very poorly or well, then you can undertake further analysis to identify the causes of this and incorporate as appropriate into management plans.

*How to measure this indicator:*

Potential questions that you could ask to monitor the health of hives/bee populations are:

1. How many bees are there per hive?
2. How many populated hives are there?
3. How many grams of bee derived products are made per time period (e.g. month)?

Counting bees will be a difficult task, and you may only be able to get a rough estimation of the total number. To do this, you could use the number of bees counted in a certain time period, for example, one minute, or in one part of the hive. Alternatively, if you have a camera, you could take a photo of
each part of the hive and count the number of bees in the photograph. A good resolution camera would be needed for this task. This only provides a very rough estimation of colony health, however, because many bees may not be in the hive at different times of the year and day.

2.B. Indicator: increased pollination through bees
In addition to the direct socio-economic benefits this intervention aims to achieve, it also hopes to create other environmental co-benefits, including increasing pollination in agricultural fields. A way in which this can be done is by measuring how much bee-pollinated crops produce in comparison with other crops. This can help you see if bee-pollinated crops do better over time.

How to measure this indicator:
Potential questions that you could ask to monitor the health of hives/bee populations are:

1. Do bee-pollinated crops near the beehives produce more than those further away?
2. Do bee-pollinated crops far from beehives produce less than those closer to the beehives?

To measure this, you could use what is called a ‘control’. In this case, your ‘control’ is a bit of land which is as unaffected as possible from the bee hives (Figure 15). You then compare the output from the crops on this land to the output from the bee-pollinated crops right next to the beehives. If the crops next to the beehives have a significantly higher output, then there is some evidence that your beehives are helping to increase crop production. It is important that the control site is in no way influenced by bees, as this will affect the results of your monitoring. To monitor this indicator, the FAO suggests that there are no more than 10 hives per kilometre², and that beehives be around 100-200 metres away from the key crops. A control site should therefore be at least 1 kilometre away from the beehives.
When monitoring the impact of an intervention it is important to have baselines against which to compare data – in this case controls.

Useful resources:
Apiconsult. Why Beekeeping?
http://apiconsult.com/why-beekeeping/
This website is dedicated to promoting beekeeping on the African continent as a means to generate sustainable livelihoods and beat poverty. The website hopes to share information based on practical experience with African bees.

Beekeeping in Africa.
This short document reports on beekeeping practices within Western and North-East African countries. Despite being dated it provides good regional context for beekeeping in these parts of Africa.

http://www.fao.org/docrep/t0104e/t0104e00.htm
This document provides practical guidance on how to establish and maintain bee hives in Africa. It draws on a wealth of information based on the experiences of beekeepers from around the world, especially the United States, but focuses on the problems, opportunities and resources that pertain to Africa.

This field manual is designed for use by field-based trainers in Africa. It is based on colour pictures with few words and covers basic techniques needed to start a beekeeping business. It also offers some new ideas to help beekeepers to become independent by making their own equipment from local materials.

This manual provides more advanced management techniques and problem solving for beekeepers. It aims to promote discussion so that people develop successful methods and solve problems locally.
3.1 Annex 1: Suggested monitoring equipment and notes on their use

It is important that your measuring equipment is both practical and accurate. If, for example, a measuring bucket has the wrong volume markings, then that error will be present in every measurement. This is called systematic bias. Alternatively, a factor that introduces errors, which vary in severity each time randomly, is random bias. Both of these forms of bias can create significant problems when undertaking analysis and forming conclusions from your monitoring data, so be sure to take measures to overcome these.

General equipment required for all monitoring and some notes on their use are:

- Pens/pencils
- Pencils are often the preferred choice for taking notes in the field as ink can run if it comes in contact with water.

- **Note paper**
  - You should always bring extra note paper to record additional information regarding your sites. This will enable you to quickly write down anything that may have happened that does not fit in the description of your data collection sheets, for example, broken fences, termite damage in the beehives, increases in the market price of sweet potatoes or signs of stress in your mangrove population.
  - These additional notes are more important for some interventions than others. For example, the dynamic nature of bee colonies would benefit from additional notes more than testing for saltwater intrusion.

- **Survey sheets**
  - Any questionnaires or data forms should be created in a standardised format before the interview/data collection starts.
  - Certain information should always be recorded on these, inducing: name of data recorders, date, time and location (ideally in coordinates).

- **Clip boards**
  - Survey sheets and note paper need to be legible for later data entry so, if possible, use a clip board with a waterproof cover to avoid damaging the paper.

- **Global Positioning System (GPS)**
  - You can easily forget where you took measurements in the past, and markers such as tape can be blown away. Taking measurements with GPS is a very accurate and effective method of showing where you have collected data and how to find the same location for future measurements.

- **Digital Camera**

- **Specific equipment required for ecological monitoring:**
  - Cast Nets
  - 1 litre buckets
  - Measuring tape (minimum length of 25m)
  - Highly visible tape to mark areas of interest
  - Nylon rope
  - Binoculars
  - Plastic containers of various sizes for specimen collection

- **Identification guides for birds, crabs, fish, mangrove species, mangrove associate plant species, mammals, other invertebrates (e.g. molluscs, butterflies, etc.).**
3.2 Annex 2: Data management

One person in the field team should be made responsible for collating the field data sheets. On each day of the monitoring exercise, the completed sheets should be reviewed at the end of the day in order to highlight any inconsistencies/errors in data collection so that these issues can be resolved with the assistance of the data recorder concerned (e.g. any missing data can be collected during the next day’s field work). Data sheets should be carefully stored and kept for reference even after data has been copied.

All data should be inputted electronically on the day that it is collected. If this is impractical due to lack of computer facilities, the data should be inputted within 2 weeks of returning from the field. All monitoring data collected should be stored in computerised format (e.g. Excel spreadsheet, MS Access or specialist monitoring package such as SMART (www.smartconservationtools.org)). If available, electronic, packaged databases (e.g. Oracle, Microsoft SQL Server, or Microsoft Access for PC users, or FileMaker Pro for MAC users), rather than MS Excel, should be used for quantitative data because they can better deal with large quantities of data, can more easily record changes over time, take less space, can be duplicated, and enable efficient, accurate data entry and retrieval, safe storage and better accessibility (IUCN, 2004). However, using databases requires specialist technical capacity that may not be available within the staff resource.

Regardless of the data management system used, a number of procedures are recommended when managing data electronically (adapted from IUCN, 2004, and Sriskanthan et al., 2008):

- **Data collection**: agree on the terms, format and abbreviations before data are collected, and use them consistently. Always indicate measurement units, and be clear about how dates are to be recorded. Maintain a logbook as a back-up. Fill in all fields on data sheets to show that no data are missing and note any problems or irregularities. Transcribe data onto clean datasheets after returning from the field if necessary, and make photocopies so that the originals can be stored.
  - Image files should also be named in a way that allows easy reference, including a description of what the photo is depicting, the date the photo was taken and a location reference, if possible. For example:
    - File name: brug_gym_15apr15_SQ3; information: *Bruguiera gymnorrhiza*, 15 April 2015, strip quadrat 3
    - File name: plntd_seedlings_17apr15_nurs; information: *planted seedlings*, 17 April 2015, nursery
- **Designing the database**: This should be done jointly by the staff responsible for the monitoring, research or management programmes and those responsible for information technology. A management-oriented database must have data entry, verification and analysis pages designed for easy use by non-specialist staff. Focus on what is relevant or essential for the analysis so that the required outputs are obtained. Numerical data fields are preferable for analysis; comments can be added in text fields.
- **Data entry**: A key aspect of data entry is quality control. The following procedures are recommended:
  - Enter data as soon as possible after collection; it is best if the data collector does this or at least is available for consultation.
  - Enter raw data. These can be aggregated later to produce summaries (e.g. daily averages, site totals), but it is generally impossible to extract raw data from a summary.
  - Be consistent, as abbreviations, misspellings and data entered in a different format will not be recognised and risk being lost.
  - Customised data-entry forms assist by:
- Allowing (or requiring) users to select entries from a list (e.g. species, pre-determined ranking systems) which makes data entry quicker and ensures that the same terms are used every time.
- Standardising formats (e.g. the user has to enter dates as dd-mm-yy) and preventing entry of text into numerical fields.
- Automatically filling in data fields from entries made in other fields, which speeds up data entry and provides additional checks.

- **Data verification**: summary analyses of data should be carried out regularly to check that the data being collected are what is required and that data entry is accurate and complete.
- **Data archiving**: data must be archived for future users, and backed up in case of damage or loss. Back-ups are short-term copies of current work. An archive remains in storage as a record of a database at a particular time, and should be conducted regularly, perhaps every few months. Back-ups are done much more frequently (e.g. weekly) and a new back-up is written over the old one.