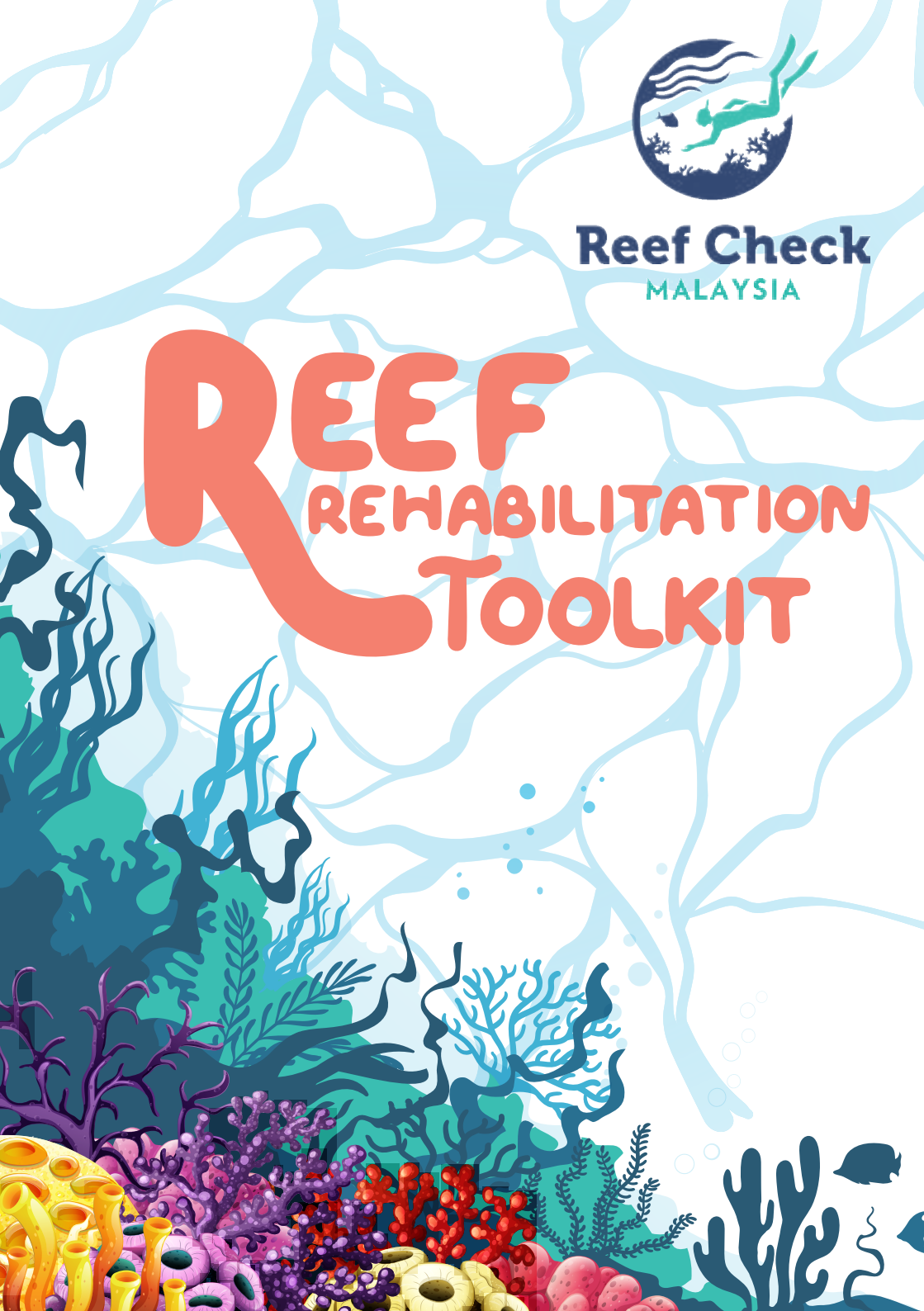
Reef Check
MALAYSIA

REEF REHABILITATION TOOLKIT



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Reef Check
MALAYSIA

Since it was registered in 2007, Reef Check Malaysia (RCM) has become established as a leader in marine resource conservation in Malaysia. RCM recognises the importance of local community participation in conservation, and has designed this toolkit specifically to meet the needs of local groups that wish to engage in reef rehabilitation efforts. We hope that this will empower local communities to take a greater role in the management of the very marine resources upon which their livelihoods depend.

Acknowledgements

Reef Check Malaysia would like to thank Lee Jen Nie, Sebastian Szereday, Affendi Yang Amri and James Tan for their contributions to the development of this toolkit. We would also like to thank the Redang Marine Conservation Group (RMCG) for field-testing the toolkit.

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NCTF

Contents

1 Why rehabilitation?

Initiating a reef rehabilitation project

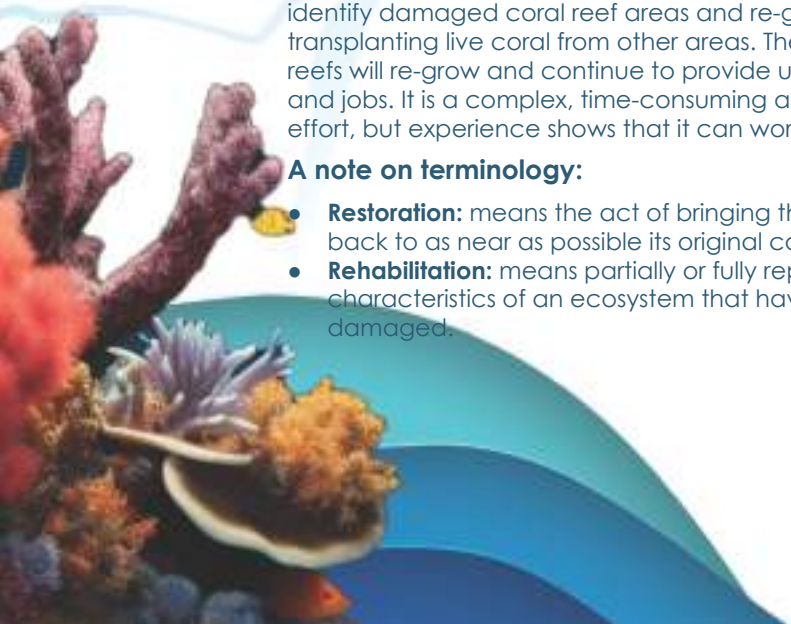
Coral reefs provide things that communities need, particularly island communities. We call these "ecosystem services". Reefs are a source of food; they are also an important tourist attraction, which in turn creates many jobs in the tourism industry.

But coral reefs are being damaged by human activities, which reduces their ability to provide things we need. Pollution, physical damage and waste are among the main impacts damaging reefs.

One response to this is to rehabilitate coral reefs so that they return to their original condition, and continue to provide the things we need. In layman's terms, we identify damaged coral reef areas and re-grow corals by transplanting live coral from other areas. The idea is that reefs will re-grow and continue to provide us with food and jobs. It is a complex, time-consuming and long term effort, but experience shows that it can work.

A note on terminology:

- **Restoration:** means the act of bringing the ecosystem back to as near as possible its original condition
- **Rehabilitation:** means partially or fully replacing characteristics of an ecosystem that have been damaged.



We have chosen to use the word **"rehabilitation"** rather than restoration to highlight the point that it is almost impossible for us to fully restore a coral reef back to its previous condition, as coral reefs are unique and complex ecosystems.

Examples of rehabilitation include:

- Direct replanting: live coral fragments are attached to dead coral and re-grow
- Coral gardening: coral fragments are gathered and stored in one place to grow, and then planted out onto a damaged reef
- Artificial structure: when the structure of the original coral reef is very badly damaged (e.g. by a storm) it may be necessary to introduce structures for coral to grow on.

This toolkit follows a decision tree flow chart through the rehabilitation process (see figure 1) and provides simple guidelines to help communities to launch their own rehabilitation efforts. The sections in this toolkit provide advice on how to assess and select suitable sites, what practical techniques are available and how to maintain the system to ensure long term success.

There is also a section to help communities to develop a programme to involve tourists in rehabilitation efforts, providing a source of income to help keep the programme going.

The guidelines are designed for local communities and citizen scientists and provide practical, hands-on information, not lots of science. However, we encourage local communities to work with scientists and NGOs to help to develop and implement their local rehabilitation programme.

A note on legal issues

In many parts of Malaysia, specifically inside protected areas that are gazetted as, for example, Marine Parks, the management authority controls activities such as coral reef rehabilitation.

You may be required to apply for a license to conduct such activities. You should check with relevant government agencies on licensing conditions and procedures.

In Peninsular Malaysia, contact:
Department of Fisheries (https://www.dof.gov.my/en/)
In Sabah, contact:
Sabah Biodiversity Centre (https://sabc.sabah.gov.my/)
In Sarawak, contact:
Sarawak Forestry Corporation (https://sarawakforestry.com/)

Figure 1: Coral Rehabilitation Decision Tree

2 Introduction to Coral Reefs

Coral reefs, known as the "Rainforests of the Sea", cover less than 1% of the ocean floor, and are mainly found in the warm, clear waters of the tropics.

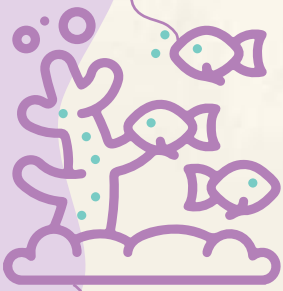
Malaysia has large areas of coral reef, providing a range of ecosystem services that communities rely on. Located within the Coral Triangle, the area of the world's oceans with the highest marine biodiversity, Malaysia's reefs are hotspots of diversity.

2.1 What is coral?

Corals are often mistaken as rocks or even plants, but they are actually animals. A coral colony is made up of thousands of tiny animals, called polyps, that can feed, grow and reproduce. Corals get their colour from tiny algae that live in their tissues, providing food to the coral. In return, corals provide protection for the algae. When corals become stressed, they expel the algae and lose their colour. This is known as coral bleaching. Bleached corals are not dead and can recover if the stress goes away.

2.2 Coral growth forms

Corals can be divided into two groups: hard corals and soft corals. Hard corals have a strong calcium carbonate skeleton that forms the solid structure of the reef that you are familiar with. Hard corals are essential in reef-building. There are many growth forms of hard corals including branching, laminar (thin plate-like), massive, encrusting, columnar and free-living. Soft corals do not have a solid, calcium carbonate skeleton.



2.3 How do corals reproduce?

Some corals reproduce sexually, which means they release eggs that move around in currents until they find a suitable surface to attach to, at which point they begin growing into a new coral colony. Other corals reproduce asexually, either by fragmentation or budding, which creates a new colony.

2.4 Importance of coral reefs

Corals are extremely important as they provide many "ecosystem services" – things that people need. Coral reefs are a source of food for millions of people, as many important commercial fish species are usually found in reef areas, or spend a phase of their life in reef areas. Coral reefs are home to 33% of all known fish species, and also a nursery ground for 25% of all marine species.

Coral reefs are also known to protect 20% of the world's coastline from wave erosion. They also provide various employment opportunities for island communities including boat, snorkel and dive operators, resort and restaurant operators.

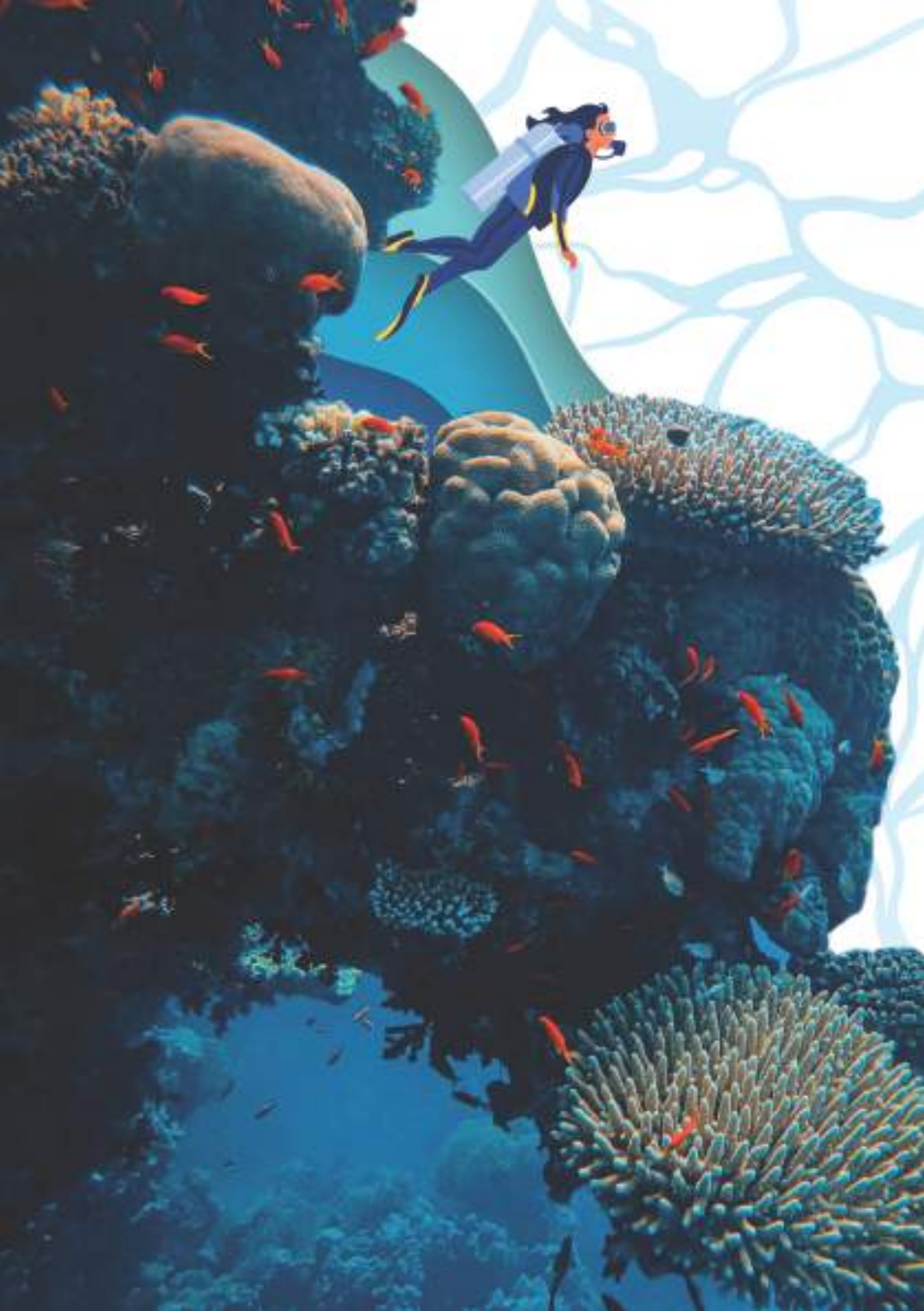
2.5 Threats to coral reefs

Despite being very valuable, coral reefs face many threats, which we divide into local and global:

- Local threats include pollution from sewage and other sources; coastal development and physical impacts from tourism operations; coral-eating starfish and snails; overfishing or destructive fishing methods. These can all be controlled, but can still lead to reef damage.
- Global impacts include climate change caused by global warming and ocean acidification. These cannot be controlled at a local level, but can lead to significant reef damage.

Recommended reading:

1. Reef Rehabilitation Manual: https://bit.ly/492rY5U.
2. https://reef-world.org/blog/introduction-to-coral-reefs
3. https://ocean.si.edu/ocean-life/invertebrates/corals-and-coral-reefs
4. https://reefresilience.org/ms/coral-reef-ecology/



3 Site Assessment & Selection

This section tells you how to assess whether a site is suitable for rehabilitation. Use the Site Assessment Decision Tree shown in figure 2 below.

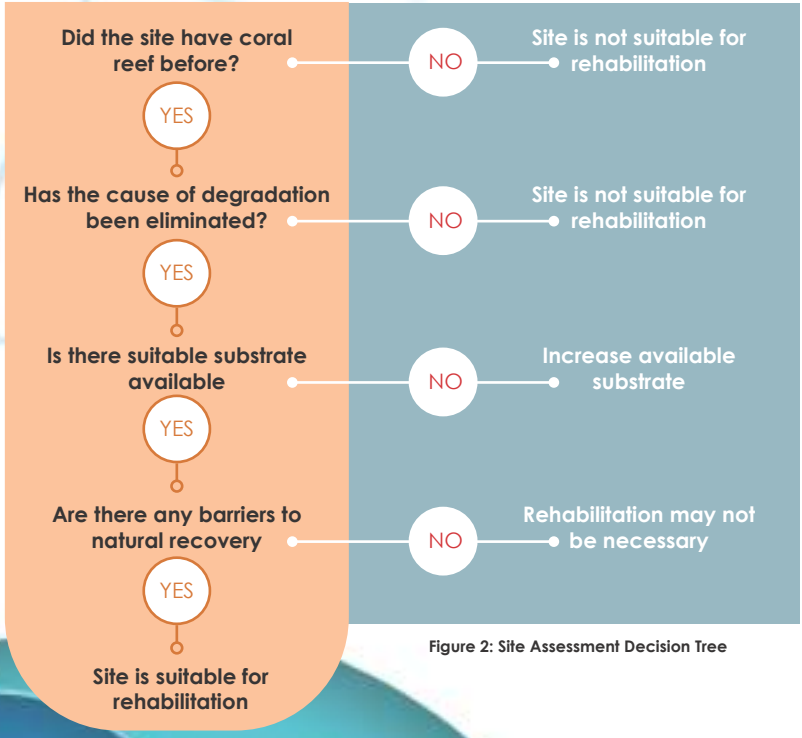


Figure 2: Site Assessment Decision Tree

You can use various sources of information to help you to go through this decision tree, including:

* Visit proposed rehabilitation site
* Visit other rehabilitation sites to understand process, techniques and success factors
* Maps and charts of the area including dive site maps
* Local ecological knowledge (local communities, dive operators, snorkel guides)
* Previous records e.g. annual Reef Check survey report
* Journals and research papers.

3.1 Prepare "long-list" of sites

Use local knowledge of coral reefs to prepare a "long-list" of potential rehabilitation sites. Local stakeholders (tourism operators, dive operators, snorkel guides, local community) can provide information on the history of the area.

Visit each site and gather information that will help to answer the questions in the Site Assessment Decision Tree.

3.2 Did the site have coral reefs before?

A visual site survey will probably answer this question. Observe the area for evidence of previous coral reef such as coral rubble or coral base.

Dive operators, snorkel guides and local community members may also provide information on whether a coral reef previously existed in a given area. Conduct research to identify background or scientific information on the intended rehabilitation site.

If there is no evidence of the site having coral reef in the past, it is not a candidate for rehabilitation. If there is evidence of the site previously having coral reef, such as availability of live coral or "corals of opportunity" (suitable for transplanting), then consider the next step in the Decision Tree.

3.3 Has the cause of degradation been eliminated?

If there was previously coral reef at the site, and rehabilitation is being considered, it is important to identify the original cause of the damage to the original site, and to ensure that the cause has been eliminated. If not, any efforts to improve the site will suffer the same fate as the original reef.

Coral reefs can be degraded by a number of factors including:

- Predators (e.g. Crown of Thorns starfish, *Drupella* snails)
- Human activities:
  - Pollution
  - Sedimentation
  - Unsustainable tourism activities (diving, snorkelling, anchoring)
  - Fish bombing
- Natural disaster e.g. storms
- Disease.

Conduct a site survey to find evidence of the above factors. A verbal survey of stakeholders will provide additional information as will a review of scientific literature and relevant news media.

Analyse information collected to determine whether the cause of reef degradation has been eliminated. If there is evidence that the cause is still present, then the site is not a candidate for rehabilitation. If there is a high degree of confidence that the cause has been eliminated or controlled, then consider the next step in the Decision Tree.

3.4 Is there any suitable substrate available?

The visual site survey will help you to establish whether there is suitable substrate. If there are solid surfaces available at the site (e.g. dead coral, rock), with little or no algal growth or siltation, this will provide suitable substrate onto which to attach coral transplants. If the site has little solid substrate or has extensive areas of coral rubble, then it will be necessary to improve the substrate if rehabilitation is to be successful (see methods in section 5).

3.5 Will the site recover naturally?

Coral reefs affected by a major disturbance – such as storm damage or coral bleaching – can take up to 10 years to recover naturally, so just because a site is damaged doesn't mean it will never recover. Recovery is faster if:

- There are large areas of substrate suitable for new corals to settle on and grow
- There are healthy nearby reefs to provide a source of coral larvae
- The site has large populations of algae-eating fish (such as parrotfish).

Conduct a visual survey of the site to review the above factors. If it appears that a site could recover naturally then it may not be a suitable site for rehabilitation. Alternatively, consider whether short term rehabilitation should be conducted to kick-start natural recovery by providing new habitat for marine life and suitable substrate for recruitment of new corals.

If your survey shows that the reef is degraded beyond the potential for natural recovery in the medium term (up to 5 years) then the site should be considered suitable.

3.6 Select short-list of sites for rehabilitation

Analyse the information collected above to prepare a "short-list" of sites suitable for rehabilitation. From these you need to select 2 or 3 sites at which you are going to implement your project. The sites you select must be suitable for one of the methods shown in section 5, and that factor must be included into your selection criteria. Selection of a suitable site is based on several factors:

- Distance to site must take into account the budget available for regular maintenance, servicing and monitoring. If your only

options are sites that are distant and therefore prohibitively expensive to maintain, you may need to implement a pilot project to test the site's suitability and ensure low levels of siltation and algae growth, so that maintenance and servicing needs can be reduced.

- Low level of hazards of human origin (e.g., mooring lines, sewage, wooden jetties, etc.)
- Intact and stable substrate or rubble, ideally with sufficient structural complexity to enhance new coral recruitment
- Avoid active sedimentation activity or any active agent of degradation
- Presence of herbivorous fishes (e.g. nearby reefs)
- Depth 5-10m
- Good water circulation (avoid sites in narrow bays)
- Clear water
- Avoid areas with strong currents
- Avoid tourist hotspots (e.g. snorkelling, scuba diving sites).

Opinions from local stakeholders should be included into the decision.

Once you have selected the sites, conduct a dive at each site to:

- Prepare a map of the site including location, topography, depth, distance from known landmarks, existing reefs and other features
- Mark the area using a buoy or other suitable surface marker. This should be located such that boats using the mooring and deploying divers do not damage the installation
- Conduct a survey of nearby reef areas using the Reef Check methodology to provide data on the rehabilitation site and nearby reef areas.

For each site, where possible, find a reference site nearby as a guide to determine species to restore and suitable density.

This completes the site assessment and selection process. It is now time to move on to planning and implementing the actual rehabilitation (see section 4).

4 Implementation

This section helps you to plan the programme. Use the Implementation Plan shown in figure 3 below.

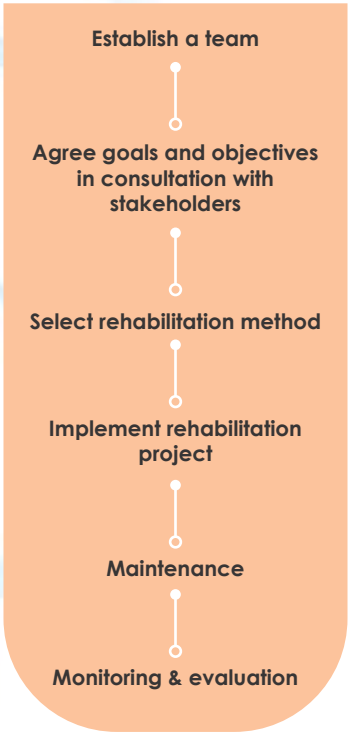


Figure 3: Rehabilitation Implementation Plan

For each of the sites selected for rehabilitation, use this to plan your project.

4.1 Establish a team

A successful project requires teamwork, with different team members bringing different skills and sharing responsibility for the range of tasks you will undertake. Not all team members need to be resident on site.

Build a team with the following skills:

- Scientists who can provide technical know-how
- NGOs which have experience working on community-based projects
- Local residents with knowledge of how the island's ecosystems have changed over time
- Community leaders who will help you to engage other stakeholders
- Local community members, who are certified scuba divers with good buoyancy skill, who will undertake the bulk of the site activities.

4.2 Agree goal & objectives

Having goals and objectives agreed in advance will help to plan the rehabilitation and keep it on track. The goal of the project describes the broad primary outcome, what you hope to achieve in the long term. The objectives are the measurable steps you take to achieve your goal. In consultation with local stakeholders, develop a project goal and 2 or 3 objectives for each site.

The following are examples of goals you could consider:

- To create new habitat at selected sites
- To improve the aesthetic value of marine ecosystem in the site
- To encourage local community to reconnect with local reef environment and be active in reef conservation.

You should also set two or three objectives for the project. The following are examples of objectives you can consider:

- Restore 100 m^2 of coral reef
- Re-establish connectivity between two reef areas
- Train 10 local villagers to conduct coral reef rehabilitation
- Provide education and awareness materials for local stakeholders
- Establish the coral rehabilitation site as an educational attraction

There are many other objectives that are possible, depending on what you want to achieve at each site. Consider these carefully, as your objectives will determine the type of activities you will conduct – both for the rehabilitation itself and in supporting the effort.

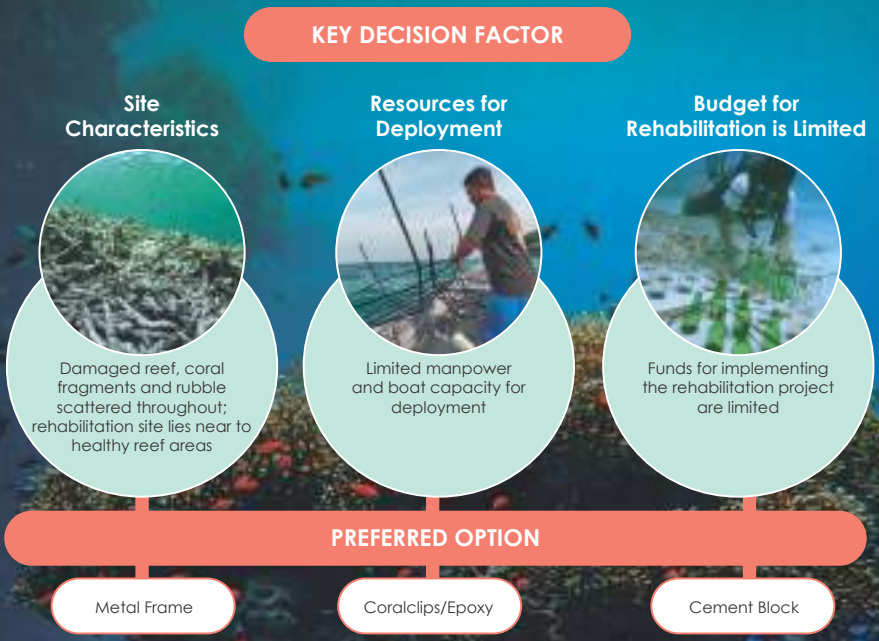
4.3 Select rehabilitation method

This is the most important decision you will make for your project. Section 5 describes four different approaches to rehabilitation and how to implement them. But at this stage, you need to decide which is the most appropriate for your particular project. The decision will be based on a number of factors such as cost, substrate, deployment, as described in the table in appendix 1.

One of the key selection criteria is the substrate at the site:

- An area with lots of rubble would need a structure with a solid base that would provide weight and stability (e.g. metal frame, cement blocks, reef star)
- An area with high siltation would need a structure that minimises silt settlement and can be anchored into a silty bottom without sinking (e.g. metal frames)
- An area with many boulders, rocks and dead coral would be ideal for direct transplant (e.g. coralclips, cement/epoxy)
- An area with existing marine life should not use an approach that can create shade and harm other marine life (e.g. direct transplant, coralclips)

Other important criteria in selecting a method include distance to site, availability of coral fragments and ease of deployment and maintenance. All these factors should be considered when selecting the most appropriate method to use. An example of a decision process is shown in figure 4 below.



4.4 Implement rehabilitation project

You are now ready to mobilise your team and deploy and populate the selected method.

If using an artificial substrate (frames, cement blocks):

- Fabricate the structure
- Deploy to site several days before populating to allow the structure to equilibrate with local conditions
- Collect coral fragments and populate the frames
- Note data required for monitoring.

If using a direct transplant approach:

- Procure/prepare attaching substance
- Gather materials required for deployment (e.g. brushes, hammer).

When conducting site work to implement the project, the following key considerations guide your work:

- Follow all safe diving procedures, including monitoring time and depth; consider having an extra team member as supervisor responsible for dive safety
- Ensure all divers are fully equipped with tools they will need
- Use gloves while handling coral fragments; do not use harmful sunscreen and skin care products or hand lotions
- Do not break coral fragments from healthy colonies
- Collect "corals of opportunity" for your rehabilitation project. These are natural fragments (approximately the size of your palm) that are not fixed in place but are moving around on the bottom in currents and have a poor chance of survival
- Do not collect fragments with predatory marks or predators
- Use pliers to cut off dead parts of the fragment
- Source of coral fragments should be not more than 30 minutes away by boat; where possible it should be within 50m of the rehabilitation site. Do not expose fragments to air.
- Ensure coral fragments selected are healthy
- Ensure there is a mixture of species to imitate a natural reef, regardless of shape and growth form
- Collect corals from several different sources to increase genetic diversity.

When implementing your project, attach tags to 5-10% of coral fragments for future monitoring purposes.

4.5 Maintenance

Maintenance of the site is a critical part of the project. It is necessary to control silt, algae and coral predators that can reduce coral growth and survival. This maximises the chances of success of your rehabilitation project.

During regular maintenance you should:

- Carefully remove silt and algae from structures and around direct transplants using small brushes (toothbrushes are ideal)
- Remove coral predators and other organisms growing on any structures
- Remove encrusting organisms to reduce competition with corals
- Replace dead coral fragments on structures.

Maintenance requirements will vary by site due to different local conditions and impacts (e.g. near dive/snorkelling site; adjacent to resort or village). Therefore, there is no hard and fast rule for maintenance requirements and you will need to adjust maintenance schedules based on experience. As a rule, start off with one of the two approaches below:

- For sites with anticipated high levels of impacts (such as sedimentation or algae growth) the following maintenance schedule is recommended:
  - Twice per week for three months after deployment
  - Weekly for the following three months
  - Monthly for the following six months.

- For sites with lower anticipated impacts:
  - Twice a month for six months
  - Monthly for the following six months

Based on initial experience:

- If your regular maintenance indicates that the site has lower than expected natural levels of siltation and/or algae growth, you may be able to reduce the frequency of maintenance. If higher, then increase frequency.
- If your sites are distant and pilot projects indicate low natural levels of siltation and/or algae growth (see section 3.6 above) you may be able to reduce the frequency of maintenance.

However, it is strongly recommended that initial maintenance is carried out as closely as possible with the above schedules.

4.6 Monitoring

Monitoring is a critical part of the project, providing quantitative data on the performance of the rehabilitation effort.

Conduct monitoring of the rehabilitation site according to the following schedule:

- Monthly for 12 months after deployment
- Twice per year for the next two years.

During monitoring dives, observe the following, recording all information on the form shown in appendix 2:

- Survival: percentage of coral fragments alive
- Growth: measure the height of tagged corals to record growth rate
- Ensure tags are intact
- Look for coral recruits a few months after deployment and record species, size, etc.
- Record marine life inhabiting the site over the time.

4.7 External Evaluation (optional)

Evaluating the rehabilitation project provides qualitative information about the impact of the project. Ideally it should be carried out by an independent body to provide external perspective.

Factors to consider during the evaluation of the project should include:

- Results of monitoring data – survival rates, etc. How do the data compare with other sites?
- Was there any natural recruitment to the site (e.g. onto concrete blocks?
- Did fish populations start to recover, and which species took up residence in the site?
- To what extent has a functioning reef become established?
- Is there any identifiable economic impact from the rehabilitation effort?
- Is there any identifiable ecological impact from the project?

Share the results of the evaluation with all stakeholders and use the results to continually improve future projects.

5 Rehabilitation Methods

5.1 Overview

The table below provides an overview of the four recommended approaches to reef rehabilitation. Use this table to decide which method best suits your needs, and then follow the guidelines in the individual sections to implement your rehabilitation project.

Design	Metal frame	Cement block with glass bottles
Material	Steel reinforcing rods ("rebar")	Mixture of cement, water and sand. Glass bottles
Shape and size	a) Trapezoid b) Square c) Hexagon d) t-shaped * depending on bottom profile	Any shape can be produced depending on the mould. Generally square or rectangular but there is considerable flexibility
Cost	Medium - High Around RM100 per structure (depending on shape and size)	Low RM20-30 per structure
Bottom suitability	Medium to high sedimentation; sandy; damaged reef; low rubble accumulation	Sandy; damaged reef with low sand movement
Ease of deployment	Medium	Easy
Maintenance	Low	Low
Attraction for recruit	High	Medium
Ability to withstand strong current	High	Medium
Approximate total nubbin per structure	Trapezoid-shaped – 15-20 fragments Square-shaped – 20-25 fragments Hexagon shape - 7-15 fragments t - shaped - 2-3 fragments	6 – 8 fragments
Others	-Frame anchored with metal hooks, to reduce movement caused by wave action - Frame coated with sand, cement, resin or eco-friendly paint - Coral fragments secured to the structure using cable ties	- To fill in the gaps between corals on flat bottom
Advantages	- Suitable for areas with extensive rubble - Can be used to cover large areas	- Low cost - Flexible – can deploy individual unit in a small damaged area
Disadvantages	- High cost	- Small area covered

	Coralclips	Direct transplant with cement or epoxy/ marine glue
	Orthopaedical pins	Cement; epoxy or marine glue
	Nail size	None
	Low unit price but large numbers of transplants will increase total cost	Cement is low cost; epoxy/marine glue is high cost
	Dead corals, rocks	Cleaned (brushed) rocks or dead corals
	Medium	Easy
	Low	Low
	None	None
	Low to High	Medium to High
	Individual fragments	Individual fragments
	- Stainless steel springclip attached by a nail integrated through the spring coil	- The site must have stable existing substrate such as dead coral or rock - The substrate needs to be cleaned (by brush) before attaching the coral fragments - Corals will grow over the attachment medium
	- Very flexible – allows attachment of coral fragment anywhere on suitable substrate	- Very flexible – allows attachment of coral fragment anywhere on suitable substrate - Low cost of cement attachment method
	- Difficult to maintain and monitor the dispersed fragments	- Difficult to maintain and monitor the dispersed fragments

5.1 Metal Frames

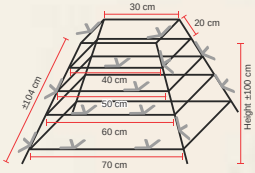
Metal frames can be fabricated in different designs and shapes based on topography and bottom profile of selected area.

Steps

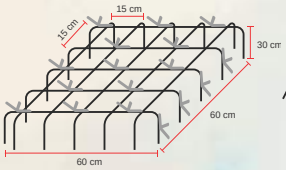
1 Design to required shape

The frame can be any shape and should be tailor made to suit the location:

Design 1

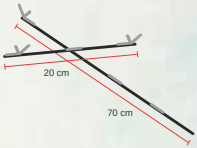


Design 2



Design 3

Design 4



For large flat areas with rubble, consider design 1 to stabilize the rubble
For large flat areas, use design 2 to create a 3-dimensional structure.
In sites with currents, consider design 3.
To fill gaps in a patchy reef, consider design 4.

Metal frames give much flexibility to design and size according to your needs. Metal frames are ideal to cover large areas that have suffered physical damage by storms, fish bombing or coastal development.

2 Purchase materials, fabricate frames

A local workshop will be required to cut and weld the frames.

The downside of using metal in a marine environment is galvanic corrosion between two different types of metal.

This will take place at the joints where the metal is welded together. Ensure welds are thick and strong to avoid frames from coming apart.

3 Coat frames with selected coating

Metal frames need to be protected otherwise they will rust and break down very quickly.

Type of coating usually used:
1. Cement
2. Oil-based paint
3. Rust converter
4. Sand+resin

Sand-Resin Coating

1. Coat the frame with rust converter
2. Let it dry.

Sand-resin coating method*

A. Mix boat resin and talc with ratio 1:0.7 (Mixture A).
B. Add organic peroxide (MEKP)** in Mixture A with ratio 0.001:1 (Mixture B).
C. Quickly coat the frame with Mixture B using a brush.
D. Dip the frame in coarse sand. Make sure the sand fully sticks to the coated frame.
E. Leave it to dry overnight.
F. Repeat Step A to E as a second coating.
G. After the second coating dries, apply a thin layer of resin as a third coating.
H. Let it dry.

** Do contact RCM members to facilitate in the process*
*** Corrosive substance. Handle it carefully*



4 Deploy frames at selected site

Ensure frames are handled with care to avoid damage. Use ropes and several divers to manoeuvre and place frames.



5 Arrange frames according to site needs; anchor using spikes; attach any signage

Frames should be placed according to the site needs. Frames should be anchored to the substrate using spikes at least 50cm long to prevent movement.

Signs or labels should be attached to the frame describing the site and purpose of the project.

6 Collect nubbins to be used at rehabilitation site

Collect "corals of opportunity" for your rehabilitation project.
Refer to section 4.4

7 Attach nubbins using cable ties, remove loose ends; ensure good distribution

Coral nubbins should be attached to the frames using cable ties. Cable ties must be in contact with live parts of the coral nubbin and attached securely. After one week tighten all cable ties as some will come loose; and cut loose ends of the cable ties.

Ensure corals are distributed evenly at a distance of approximately 5-10cm.

8 Count total nubbins planted; tag selected nubbins for monitoring

Count total of nubbins attached to each frame. Tag 5-10% of nubbins for monitoring survival and growth (Growth is optional).

9 Maintenance (frequency depends on site)

Frequent:
- Twice per week for three months after deployment.
- Weekly for the following three months.
- Monthly for the following six months.

Infrequent:
- Twice a month for six months.
- Monthly for the following six months

Remove any unwanted biofouling marine life near the coral fragments. This includes algae, sponge, ascidians, and hydroids.

Be gentle and careful not to knock the nubbins. Look out for small recruits (corals, giant clams) before brushing.

10 Monitor regularly

Schedule:
- Monthly for 12 months after deployment
- Every 6 months for the next 2 years.

Keep detailed records of your observation. (refer to section 4.6)

Take pictures and video for record and reporting purposes.

5.2 Cement blocks

Steps

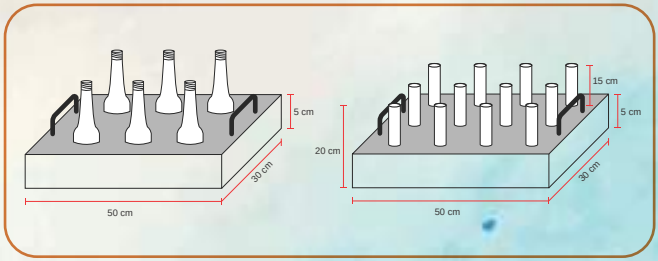
1 Prepare cement blocks

A ratio of 1 cement : 3 sand is mixed in the mould

2 Insert iron rebar or glass bottles to attach the nubbins

Clean the bottles. Ensure all plastic and metallic labels, etc. are removed from the bottles.

- Insert 6 bottles per block.
- Cement should cover at least one third of the bottle.
- Evenly space out the bottles.



3 Deploy blocks at selected site

Blocks can be carried in by divers or can be deployed using a boat or a kayak

4 Arrange blocks according to site needs; attach any signage

Ensure blocks are handled with care to avoid damage. Use ropes and several divers to manoeuvre and place frames.

Blocks should be placed according to the site needs.

Signs or labels should be attached to the blocks describing the site and purpose of the project.

5 Collect nubbins to be used at rehabilitation site

Collect "corals of opportunity" for your rehabilitation project.

Refer to section 4.4

6 Attach nubbins

Coral nubbins should be attached to the mouth of the bottles using cable ties.

Cable ties must be in contact with live parts of the coral nubbin and attached securely.

After one week tighten all cable ties as some will come loose; and cut loose ends of the cable ties.

Corals nubbins can be attached to the bottles using marine epoxy as well.

7 Count total nubbins planted; tag selected nubbins for monitoring

Count total number of blocks. Tag 5-10% of nubbins for monitoring survival and growth (Growth is optional).

8 Maintenance (frequency depends on site)

Frequent:

- Twice per week for three months after deployment
- Weekly for the following three months
- Monthly for the following six months.

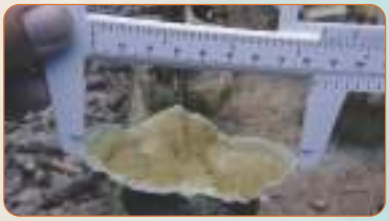
Infrequent:

- Twice a month for six months
- Monthly for the following six months

Remove any unwanted biofouling marine life near the coral fragments. This includes algae, sponge, ascidians, and hydroids.

Be gentle and careful not to knock the nubbins. Look out for small recruits (corals, giant clams) before brushing.

9 Monitor regularly



Schedule:

- Monthly for 12 months after deployment
- Every 6 months for the next 2 years.

Keep detailed records of your observation. (refer to section 4.6)

Take pictures and video for record and reporting purposes.

5.3 Coralclips

Steps

1 Collect nubbins to be used at rehabilitation site

Collect "corals of opportunity" for your rehabilitation project.

Refer to section 4.4

2 Locate suitable areas of substrate

Look for large (>50cm) rocks or dead corals, that do not have any corals growing on it or close by (<50cm radius).

3 Clean the surface using brush

Use a brush to clean the surface. Remove any sand or biofouling marine life from the surface of the rock.

4 Attach coralclip to cleaned area of substrate

Hammer the nail into the cleaned surface of the rock.

5 Clip the nubbin onto the cleaned section; ensure good attachment

Lift the metal clip and place the coral nubbin under the clip. The tension should hold the coral nubbin in place. If it is loose, hammer the nail deeper in or use a larger nubbin.

Ensure corals are distributed evenly at a distance of 50cm.

6 Count total nubbins planted; tag selected nubbins for monitoring

Leave a small space (few cm) between the coralclip and the tag. It is advisable to use blue tags. The tag can be attached to the rock with a regular nail.

Count total number of nubbins attached. Tag 5-10% of nubbins for monitoring survival and growth.

7 Maintenance (frequency depends on site)

Frequent:

- Twice per week for three months after deployment
- Weekly for the following three months
- Monthly for the following six months.

Infrequent:

- Twice a month for six months
- Monthly for the following months

Remove any unwanted biofouling marine life near the coral fragments. This includes algae, sponge, ascidians, and hydroids.

Be gentle and careful not to knock the nubbins. Look out for small recruits (corals, giant clams) before brushing.

8 Monitor regularly

Schedule:

- Monthly for 12 months after deployment
- Every 6 months for the next 2 years.

Keep detailed records of your observation. (refer to section 4.6)

Take pictures and video for record and reporting purposes.

5.4 Direct transplant with epoxy/marine glue/cement

1. Collect nubbins to be used at rehabilitation site
2. Locate suitable areas of substrate for attachment of nubbins
3. Clean the surface using brush
4. For branching coral fragment, attach to dead branching corals or rock using cable tie
5. For plate/vase coral, attach the fragment using epoxy
6. Count total nubbins planted; tag selected nubbins for monitoring
7. Maintenance
8. Monitor regularly

Steps

1 Collect nubbins to be used at rehabilitation site

Collect "corals of opportunity" for your rehabilitation project.

Refer to section 4.4

2 Locate suitable areas of substrate for attachment of nubbins

Look for large (>50cm) rocks or dead corals, that do not have any corals growing on it or close by (<50cm radius).

3 Clean the surface using brush

Use a brush to clean the surface. Remove any sand or biofouling marine life from the surface of the rock.

4 For branching coral fragment, attach to dead branching corals or rock using cable tie

Cable ties must be in contact with live parts of the coral nubbin and attached securely.

After one week tighten all cable ties as some will come loose; and cut loose ends of the cable ties.

5 For non-branching coral, attach the fragment using epoxy

Mix the epoxy and place generous amounts to ensure the nubbin is securely attached to the substrate.

6 Count total nubbins planted; tag selected nubbins for monitoring

Count total of nubbins attached. Tag 5-10% of nubbins for monitoring survival and growth.

7 Maintenance (frequency depends on site)

Frequent:
- Twice per week for three months after deployment.
- Weekly for the following three months.
- Monthly for the following six months.

Infrequent:
- Twice a month for six months.
- Monthly for the following months.

Remove any unwanted biofouling marine life near the coral fragments. This includes algae, sponge, ascidians, and hydroids.

Be gentle and careful not to knock the nubbins. Look out for small recruits (corals, giant clams) before brushing.

8 Monitor regularly

Schedule:
- Monthly for 12 months after deployment
- Every 6 months for the next 2 years.

Keep detailed records of your observation. (refer to section 4.6)

Take pictures and video for record and reporting purposes.

6 Getting started and sustaining your rehabilitation efforts

So you want to do a rehabilitation project? What do you do first? How do you keep it going? Here are some suggestions.

6.1 Seed funding

You will need some funds to get started – to pay for materials, petrol for your boat, rental of scuba tanks and equipment, and so on. Consider the following:

- Start small: if you can do at least a small installation, you will find it easier to get supporters to enlarge it.
- Local sources: is there a vibrant tourism industry in your location? Ask tourism operators to contribute – but be sure to have a good plan to present to them (this toolkit should form part of that plan).
- Ask government: Marine Park authorities or other government agencies might be able to help with small amounts of seed funding.

The most important thing you will need is support from other stakeholders. This is described below.

6.2 Getting support from your community

You should obtain support from your local community before setting up your coral rehabilitation effort. This will ensure that you have strong buy-in from your community, which will help you in every stage of the programme. It might even help with raising some initial seed funding.

Consider the following steps to get your community on board:

- Consult them in the design process for your coral rehabilitation project. Provide relevant capacity building and livelihood development opportunities for them.
- Make sure you have constant engagement and communication on your project as it progresses.
- Ensure they understand the value to them of the ecosystem services that you are supporting.

6.3 Advice from experts

Identify local experts (scientists, NGOs, marine resource management authorities) who can assist in your rehabilitation programme. These experts can provide advice on which sites are most suitable, the best techniques, problem solving and funding for programmes. While not full-time members of the team, these experts are an important resource for long-term efforts.

Here are some suggestions on choosing the right experts to consult:

- Check their track record on coral rehabilitation efforts – have they done successful projects before?
- Are they active, with on-going coral rehabilitation projects?
- Do they have experience helping local communities in coral rehabilitation?
- Are they well known, with a wide network among government and non-government stakeholders?

These organisations may also be able to bring funding for your efforts.

6.4 Engaging external stakeholders

Finally, it is recommended that you engage relevant external stakeholders prior to implementing your coral rehabilitation project. Why?

- In some areas you might need to inform key people who have authority in your project area. For example, the District Council or the Head of Marine Park may have jurisdiction in protected areas.
- To establish a network and develop potential partnerships. You may find groups who already have plans to initiate coral rehabilitation projects; others might have resources that they can share. Partners could be an existing NGO, scientists, companies, tourism operators, etc.
- External stakeholders might be able to help with funding your project.

At the same time, regular engagement with external stakeholders during implementation will help to build awareness of the rehabilitation programme, why it is important, and how it is progressing. The goal is to get stakeholders to support the programme. Key external stakeholders are likely to include:

- Non-government organisations.
- Regional / international organisations.
- Regulatory agencies.
- Tourism management.

Different stakeholders will have a different role in supporting the programme, such as financing, providing technical advice, introducing regulations to support rehabilitation, and helping to promote experience programmes to tourists. The project should develop a plan to ensure external stakeholders are kept informed of progress.

Find ways that are appropriate, and you are comfortable with, to communicate with groups that you think are important in your location.

6.5 Long term funding

Trends in sustainable tourism are creating demand for products that allow tourists to participate in conservation programmes. There are several levels at which tourists could participate in coral reef rehabilitation efforts – anything from building and deploying structures, through populating structures, to helping with maintenance.

Work with local tourism operators to establish how to promote such experiences to tourists, to raise funds for long-term efforts and provide livelihoods for local communities. There are also growing demands from the corporate sector to fund marine conservation projects. Consider approaching them for grants.

There are a number of potential financing mechanisms that could support your coral rehabilitation programme in the long term. It is important that there is at least one person in your team who will look into sustainable financing options. If this is too complicated or beyond your team's capacity, reach out to your experts or your partners to help to develop funding options.

Three simple options you can implement locally are:

- Conservation diving package: some tourist divers will be interested to pay to participate in planting, maintenance and monitoring of your rehabilitation project. Partner with a responsible dive operator locally to agree how to market the experience dive, and how to charge for it. This activity might be of interest to corporate sponsors so consider how you can reach out to local and large multi-national companies.
- "Adopt a Coral" programme: tourists who do not dive might be interested to pay to "adopt" a coral that you plant as part of your rehabilitation efforts. Provide a variety of options including adopting a single coral fragment, funding a metal frame – or even an area. Prepare information posters to share with resort operators and display in popular tourist attractions. Partner with local resorts and dive operators to promote this package. This activity might also be of interest to corporate sponsors.
- Voluntourism package: some tourists who are on long trips might be interested in a package that allows them to spend several days or weeks working on the rehabilitation project. You will need to develop a package including accommodation, food and diving costs. Identify partners in the voluntourism travel market to help to promote the package.

Appendix 1: **Monitoring data collection form**

Date:	**Time in:**	**Temp (°C):** *29*	**Vis (m):** *5m*
Tide: *low tide*	**Depth:** *3m*	**Condition:** *sunny/ cloudy/choppy/ wavy etc*	
Other physical parameter:	No. of dead coral:	No.of live coral:	
Rehabilitation technique			

Rep. name	**Type**	**Coral height (cm)**	**Notes**
Eg. 1	*Branching Acropora (Br Acp)*		*Minor bleaching, Trapezia crab, minor break*
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Appendix 2: **Cost analysis**

You will need to consider the following costs for your rehabilitation project. This should form part of your fund-raising strategy.

Item	No. Units	Unit cost	Total cost
6.1 Structure			
Metal Frames Y10 (and above) rebar Resin coating Welding Cable ties			
Cement blocks Cement Square mould Cable ties			
Coralclips Coralclips			
Reef star Y10 (and above) rebar Fibreglass boat resin Catalyst Fibreglass powder Rust converter/anti rust Thinner Sand sieves Gloves Face mask Brushes Cable ties (S & L)			
Direct transplant with epoxy/ marine glue Epoxy Marine glue Cable ties			
6.2 Coral collection			
Gloves Hammer Coral cutter/ pliers Basket			

6.3 Maintenance and monitoring kit			
Hammer Tags (see note below table) Cable ties Brushes Gloves Data recording slates			
6.4 Dive equipment rental			
Dive equipment Air tank			
6.5 Diving/Transportation			
Boat rental: Structure deployment Attaching coral fragments Maintenance/ Monitoring			
6.6 Manpower cost			
Person hours: Structure deployment Attaching coral fragments Maintenance/ Monitoring			

Note: You can buy animal ear tags online.

Cost-benefit analysis

Calculate the cost of materials, time, transportation and dive cost for installation and maintenance. Compare this cost to the available budget and decide if it is worthwhile or feasible.

Consider options for high cost items such as structures; cement blocks and coralclips will be cheaper than frames for an example. Include cost for long-term project monitoring

NOTES

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