BEST PRACTICE MANGROVE PLANTING FOR FIJI

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A DISCUSSION DOCUMENT[1]

Summary

Currently, Fiji has no national policy, plan or official guidelines for mangrove planting. This, notwithstanding, there has been a plethora of interest in mangrove planting, primarily from NGOs and by the public as a result of corporate social responsibility initiatives, but also by the Ministry of Forestry's *30 Million Trees In 15 Years planting initiative* which includes mangroves, and by the Ministry of Environment requiring a 6x replanting offset of the area of mangrove lost to approved conversions for tourism, industry, residential estates etc.

The conclusions reached from a literature review, the purpose of which was to articulate 'Best Practice Mangrove Planting' in Fiji so that it can meaningfully support Fiji's *'Low Emission Development Strategy 2018-2050'* (LEDS). None of the recommendations are ground-breaking or new. Fiji is way behind in appreciating the lessons learned in many countries with much larger mangrove resources and which have suffered far greater losses to their mangrove resource. Many of these countries failed to heed the warnings of experienced mangrove restorers in the 1990s and enormous quantums of resources have been wasted with the concomitant development of cynicism in many coastal communities. Unfortunately today, it would appear that the architects of the Blue Economy/Blue Carbon Projects are, for the most part, also failing to appreciate the well-established constraints in respect of mass mangrove planting.

Only with a good understanding of the issues involved and careful selection and development of evidence-based, sustainable best practices in its mangrove planting will Fiji be able to support the confidence placed in mangroves in the LEDs.

The following are draft guidelines drawn from the literature review of international best practice which are applicable for Fiji

Guidelines for Best Practice Mangrove Planting in Fiji

1) Planting should only be attempted in areas that naturally support mangroves ("reforestation"), and not in areas where mangroves are not known to have grown ("afforestation").
2) Planting mangroves should not be undertaken in isolation but only after a full appreciation of the risk of any potential planting site in terms of hazard, exposure and vulnerability.
3) Planting in areas which never had natural mangroves may destroy other, equally important ecosystems such as sea grass beds and sub-surface invertebrate life, and a productive habitat for foragers – inshore marine fishery and migrating shorebirds.
4) Effective coastal protection from swell waves and wind require hundreds of meters of mangroves, and thousands of meters are required for significant storm surge abatement, not the narrow belts such as are often produced by current planting projects.
5) Planting mangroves will not stabilise on-going erosion, but well-established mature mangrove stands may resist erosion.

[1] This review has been prepared by Dick Watling, and is founded on nearly 40 years of observation and interest in Fiji's mangrove, assistance as a member of the Mangrove Management Committee since its inception (when functioning) and consultant to the private and public sector on mangrove issues in Fiji. He is the author of the Mangrove Management Plan for Fiji 1985-86 and its follow up in 2013.

6) Local community involvement in planting initiatives through informed consent, equitable benefit and an understanding of mangrove planting potential and constraints, is an essential pre-requisite for planting projects.
7) Mangrove planting without proper planning can appear to be a short term success yet still fail in the medium and long term. Permanence in respect of planting is an essential consideration prior to planting.
8) Planting mangrove without assured monitoring for success is a wasteful use of resources.
9) Damaged mangroves will usually regenerate naturally over time if left undisturbed. Planting is never as successful as natural regeneration. Wherever possible facilitate natural regeneration (ANR – Assisted Natural Regeneration).
10) Mangroves should not be planted 'Plantation Style', such stands are not found in nature and may not develop the same values of natural stands.

Introduction

Mangrove Management in Fiji – an Historical Reminder

Fiji was one of the first countries to pursue a national policy of sustainable mangrove management and several thousand hectares of mangroves in the Ba, Labasa and Rewa deltas were harvested sustainably in delineated coupes in the early 1940-50's (Marshall undated; MMC 1986). A national yield of over 50,000 m^3 was recorded in 1952. The management plan specifically identified sustained yield as the goal of mangrove harvesting and the plan correctly determined that natural regeneration would preclude the need for replanting provided the underlying tidal conditions were not altered. No planting was required or undertaken. Evidence of these harvested areas are readily visible today where uniform stands of well-formed Dogo *Bruguiera gymnorrhiza* persist.

Recent Mangrove Planting in Fiji

There has, in recent years, been a plethora of interest in mangrove planting primarily from NGOs and by the public as a result of corporate social responsibility initiatives. This is because of ready access, ease of accomplishment of planting, the lack of appropriate policy or best practice guidance and a virtual absence of sustainable mangrove management by the regulatory authorities. It is encouraged by the Ministry of Forestry *30 Million Trees In 15 Years planting initiative* which includes mangroves, and by the Ministry of Environment requiring a 6x replanting offset[2] of the area of mangrove lost to approved conversions for tourism, industry, residential estates etc.

A significant area of mangroves has been planted piecemeal in Fiji over the past 20 years (visit, for instance, http://mangrovesforfiji.com/ https://www.youtube.com/watch?v=2N5gsqZYWHA). Some of it predates this – for instance the stand adjacent the Queen's Road at Korotogo which has had regular replacement and extension plantings over three decades thanks to OISCA and commitment from Korotogo village. A touted 'success' is at Suva Point adjacent the Maritime College which is the result of almost continuous planting and infilling over the past 15 years in an area which has clearly accreted because of the construction of a groyne. Overall there is very little evidence of any significant success of mangrove planting in Fiji in contrast to areas of natural regeneration of mangrove.

It is a well-trodden path worldwide that when tree planting programs of any sort are initiated to loud acclaim, there is minimal or an absence of a professional review of planting success at an appropriate interval thereafter. So it is for Fiji's mangrove planting to date, however, Fiji's *'Low Emission Development Strategy 2018-2050'* (LEDS; MoE 2018) provides the view of a former Director of Fisheries '*that only 6-7% of seedlings survive 12 months after planting*'.

Mangrove Management Policy or Guidelines, and Fiji's 'Low Emission Development Strategy 2018-2050'

Currently, Fiji has no national policy, plan or official guidelines for mangrove planting. A national mangrove management plan (MMC 2013) has not been endorsed and no apparent action has ensued to replace or amend it, or provide official alternatives. It would appear, however, that the LEDS has become the guiding document as Fiji's mangrove is seen to play a key role. The strategy's foreword by the Prime Minister Hon. Voreqe Bainimarama states:

> *We all should be proud of the Fiji LEDS as it is among the first long term emission reductions strategies in the world to address the Blue Carbon Sector – and in our case, that "blue" focus is particularly honed on Fiji's vital mangrove ecosystems. We've seen the wide-ranging benefits of cultivating the blue sector first-hand: reviving and restoring our mangroves not only sequesters carbon, but it allows sustenance of our people's livelihoods with a constant supply of fish and other marine organisms.*

[2] Fiji's *Low Emission Development Strategy 2018-50* (MoE 2018) states '*The scientific basis for the required offset is unclear, except that it is twice the area recommended in the only mangrove carbon emission study done to date in Fiji'.*

The confidence that mangrove ecosystems can play a significant role in contributing to meeting the emission reductions that the LEDS articulates is driven by a growing understanding worldwide that mangroves can sequester and store large amounts of carbon dioxide from the atmosphere, and the carbon buried in mangrove sediments of mangroves can remain there for millennia if left undisturbed, making them critical long-term carbon sinks. These high levels of above ground and below ground carbon stocks have elevated the importance of mangroves in climate change mitigation and adaptation, and in addition because successful restoration and conservation activities can also be used in nationally determined commitments or in voluntary carbon markets (MacKenzie *et al.* 2021).

The confidence which the LEDS articulates is based solely on the assumptions made as to how Fiji's mangrove will be able to contribute in the four scenarios presented. However, the mangrove data supporting these assumptions are for the most part little more than speculative, they are not rooted in evidence-based data, ecology, forestry and achievable sustainable practices. As such, so too the economic projections of the blue carbon mangrove must be considered speculative. To be fair to the authors of the mangrove section in the LEDS document, it is full with caveats about the inadequacy of fundamental data, and also the LEDS is considered a 'Living Document' which will be updated as and when data are available. Whichever approaches are taken, Fiji needs to carefully select and develop evidence-based, sustainable best practices in its mangrove planting. This like many other countries before it, it is patently failing to appreciate and practice, at present.

Tree planting now dominates political and popular agendas and is often presented as an easy answer to the climate crisis, as well as a way for corporate companies to mitigate their carbon emissions, but sadly, it isn't as simple as that. When people plant the wrong trees and/or plant in the wrong place, it can cause considerably more damage than benefits, failing to help people or nature (Di Sacco et. al. *2021)*

Mangrove Planting – Lessons Learned

Mangrove Afforestation[3] On Inter-Tidal 'Empty' Areas

Mangrove planting in Fiji today is all but exclusively planted on the 'empty' intertidal zone. This is because of ready access, ease of accomplishment of planting and the lack of appropriate best practice guidance and management. It is encouraged by the Ministry of Forestry's *30 Million Trees In 15 Years* planting initiative which includes mangroves, and by the Ministry of Environment requiring a 6x replanting offset[4] of the area of mangrove lost to approved conversions for tourism, industry, residential estates etc..

However, it has been accepted in the scientific community for over 20 years that mangrove afforestation on inter-tidal areas amounts to 'conversion' of a valuable habitat[5] (Lewis 1999), which is the 2nd of his five Principles of Mangrove Restoration:

> *2. Do not build a nursery, grow mangroves and just plant some area currently devoid of mangroves (like a convenient mudflat). There is a reason why mangroves are not already there or were not there in the recent past or have disappeared recently. Find out why. (Lewis 2005)*

> *……the use of the terms "restoration" or "rehabilitation" in such cases is inappropriate, since intertidal mudflats have not been covered in mangrove forests before. Such efforts should therefore rather be termed "afforestation". Although generally poorly acknowledged outside the scientific community, these intertidal mudflats represent a rich and productive ecosystem in themselves, providing an important habitat that supports high densities of intertidal benthic invertebrates and fulfilling a range of key ecological functions. (Erftemeijer & Lewis 1999)*

More recent analyses are more direct in their distinction between best and unsustainable practices, providing a strong indication of a worrying trend which Fiji is indubitably following:

> *…….successful rehabilitation[6] is still challenging to achieve at scale, and current rehabilitation projects around the world fail because key ecological thresholds and rehabilitation best practices are ignored, as when planting in low-intertidal locations that are not suitable for mangrove growth…….Work is required to overcome key socio-political hurdles, including lack of training, unclear land tenure and unrealistic planting targets set by national governments or NGOs that encourage and incentivise rehabilitation efforts in unsuitable coastal locations. (Saintilan* et al. *2021)*

> *Current mangrove planting schemes aimed at reversing global losses are prioritising short-term increases in area over long-term establishment. Without sound, evidence-based restoration policies, this approach could accelerate the demise of mangrove forests and the ecosystem services they provide. (Lee* et al*. 2019*

> *…….. ambitious, short-term mangrove restoration projects often plant mangroves on lands that are not owned by anyone. Such lands are frequently low in the intertidal frame and are therefore unsuitable for mangrove growth, thus ultimately leading to the failure…..The key performance indicators of restoration success*

[3] Afforestation – planting of forests or mangrove where they previously did not exist, as opposed to Reforestation – planting on sites where forests or mangroves formerly existed.

[4] Fiji's LEDS states '*The scientific basis for the required offset is unclear, except that it is twice the area recommended in the only mangrove carbon emission study done to date in Fiji'.*

[5] Refer Lee et al. (2018), Morton (1995) and Morton & Raj (1990), Singh (2019) for information on Fiji's foreshore ecology and fisheries

[6] There is a technical difference between forest restoration and rehabilitation which are the two forms of reforestation but which are rather variably used in discussion and in the literature.

should include indicators of socio-economic sustainability rather than simple measures of mangrove propagules being planted and mangrove area being created, (Lovelock & Brown 2019)

The Philippines has lost nearly 70% of its natural mangrove cover since the early 1900s. As a result, large investments have been made to restore mangrove forests and the many ecosystem services that they provide. Most of these restoration efforts have been through out-planting of Rhizophora *sp. seedlings, many of which have failed because the proper hydrological and ecological conditions were not properly assessed. Other afforestation projects involved planting seedlings in inappropriate places (e.g., seagrass beds, mudflats) that resulted in replacing one valuable ecosystem with another…….. mangroves should not be planted in areas that are naturally occupied by other ecologically important ecosystems. The purpose of mangrove restoration should be clear and efforts should be focused on formerly deforested or degraded areas.* (*Sharma* et al. *2017*)

The majority of mangrove restoration/replanting projects in Indonesia have experienced high or even complete mortality (MAP 2007). ……..mangrove rehabilitation efforts in Indonesia, both large and small, have mainly failed. The majority of projects (both government programs and non-government initiatives) have oversimplified the technical processes of mangrove rehabilitation (Brown et.al. *2014)*

We found that about 1000-1200 ha of mangroves …23 sites… have been under restoration with the participation of several governmental and non-governmental organizations……about 200-220 ha showed successful mangrove restoration. The level of survival of the restoration project sites ranged from 0-78% and only three sites showed a level of survival higher than 50% (Sri Lanka – Kodikara et.al. 2017)

Why Is Planting Mangrove In Fiji's Inter-Tidal Zone Likely To End In Failure?

The first and most obvious reason is evidence-based – there is very little evidence of any significant success – the current 'success' at Suva Point is the result of almost continuous planting and infilling over the past 15 years, in an area which has likely accreted because of the construction of a groyne. It is a well-trodden path worldwide that when tree planting programs of any sort are initiated to loud acclaim, there is no professional review of planting success at an appropriate interval thereafter. So it is for Fiji's mangrove planting to date, however, the LEDS itself provides the view of a former Director of Fisheries '*that only 6-7% of seedlings survive 12 months after planting'*.

The second reason is even more obvious as Lewis (2005) states in his 2nd Principle of Mangrove Restoration – *'if there are no mangroves at a particular site, especially the low inter-tidal zone – there must be a good reason for it*'. This is certainly the case in Fiji where the mangrove environment has been stable (as measured by Relative Sea Level Rise) for much of the last 6,000 years of the Holocene and more particularly the last 2,000 years (Saintilan *et al*. 2021). Mangroves generally fruit continuously as recorded in Fiji (Tyagi 2004) and have no plant competitors. As such the constraints that have prevented an invasion of the mudflats for the past 2-6,000 years at least, can be expected to impact any planting on the mudflats today which will in any case be accentuated by sea level rise.

Fiji Government is a member of IUCN and as such should be aware of IUCNs position on replanting mangroves, prepared by its Mangrove Specialist Group[7] which responds with four reasons to counter simplistic calls for mass planting (IUCN 2017 & 2020; Attachment 1):

1. *there is a danger that an emphasis on tree planting distracts from the priority, which is to conserve what we have. Old-growth natural forests are irreplaceable……..*
2. *the recent history of mangrove planting and restoration is a sorry one. Studies from around the world have shown that most attempts at mass planting of mangroves fail……..*
3. *even when newly planted mangroves do survive and grow, the resulting forest may be very different from a natural one……*
4. *growing and planting mangroves can be very expensive and time consuming. If planting is not necessary, then this diverts funds from other conservation activities and breeds cynicism.*

A third reason is that the two species of mangrove which are the fringe colonists of mangrove habitats in our neighbours to the west – Vanuatu and the Solomons and elsewhere in south east Asia – *Avicennia marina* and *Sonneratia* spp. do not occur in Fiji. Fiji's four Rhizophoraceae mangroves (*Bruguiera gymorrhiza, Rhizophora stylosa, R. samoensis* and *R xselala*) which constitute almost the entire national mangrove resource are not fringe colonists where they occur elsewhere.

What is the Regulatory Framework in respect of Mangrove Afforestation?

The mudflats of the tidal foreshore are not the empty spaces which they might appear to be, they constitute a variety of ecologically important ecosystems with values that complement those of mangroves and offshore coral reefs. And as such are a coastal resource which are intricate in the sustenance of the coastal fisheries and those Fijian communities which have relied on the fisheries since their first arrival in these islands (Lee *et al.* (2018), Morton (1995) and Morton & Raj (1990), Singh (2019)).

Section 3 (2 & 3) of the Environmental Management Act 2005 (EMA) determines their inclusion as matters of national importance which requires application of the Act in respect of their utilisation:

> **3.**-(1) ……..
> (2) The purposes of this Act are-
>
> *(a)* to apply the principles of sustainable use and development of natural resources; and
> *(b)* to identify matters of national importance for the Fiji Islands as set out in subsection (3).
>
> (3) A person required to perform any function under this Act relating to the use and utilization of natural and physical resources must recognize and have regard to the following matters of national importance:
>
> *(a)* the preservation of the coastal environment, margins of wetlands, lakes and rivers;
> *(b)* ……;
> *(c)* the protection of areas of significant indigenous vegetation and significant habitat of indigenous fauna;
> *(d)* the relationship of indigenous Fijians with their ancestral lands, waters, sites, sacred areas and other treasures; or
> *(e)*……..

The Dilio's Egg

"Kunekune na yaloka ni Dilio" – in search of the unobtainable, the egg of the D*ilio* – one of the most widely known Fijian sayings, but why the egg of the *Dilio*? Well, early Fijians knew what they were talking about, for the *Dilio's* egg is not to be found in Fiji but some 9000 km away in the Arctic.

The *Dilio* or Pacific Golden Plover is one of several common shorebirds in Fiji which migrate to the Arctic to breed but return each year to overwinter in Fiji and other Pacific Islands. The tidal flats are the most important feeding grounds for these migrants.

It is both surprising and disturbing that we have more monitoring data on our shorebirds than any other bird or bat. The Suva Foreshore has been counted regularly, between 10 and 40 counts in 20 of the years since 1997 (Watling 2006; O'Brien *in litt.*). In addition historical counts, in 1961/62, 1968/70 and 1981/82, have been published. The number of one of these migrant shorebird, the J*uli* or Wandering Tattler on the Suva Foreshore regularly exceeds 1% of the global population - qualifying the site as both an Important Bird and Biodiversity Area (IBA) and Key Biodiversity Area (KBA; O'Brien, *pers. comm.*).

This demonstrates both how little we know about our wildlife and how globally important some poorly known and supposedly empty habitats may be. It is encouraging that Fiji is a Party to the Convention on the Conservation of Migratory Species of Wild Animals (www.cms.int), and as such Fiji has a responsibility to ensure that in pursuing a Blue Economy due consideration is given to the *Dilio*, the *Juli* and all its other migrant shorebirds.

And, if we believe that mangroves will never impact important shorebird habitats, we should consider the Saweni Flats at Vuda. Both Saweni and the Suva Foreshore were identified as Sites of National Significance in the 1993 State of the Environment Report, based on their migratory shorebirds. While Suva Foreshore survives (but is threatened not just by mangrove planting plans but also reclamation), Saweni no longer qualifies as it has become overrun with mangroves.

[7] https://www.leibniz-zmt.de/images/content/pdf/AG-Mangrovenoekologie/IUCN_MSG_2020_Position_Paper_Pause_before_you_Plant.pdf (Attachment 2)

As such any planned afforestation of tidal mud flats with mangroves (including projects by government ministries), would need determination through the EIA Process[8].

In addition, the Traditional Fishing Rights Owners will need to be consulted in respect of compensation for Loss of Fishing Rights. This is not a straight forward issue, firstly the communities who live adjacent to foreshore areas and have traditional usufruct access to those areas are often only a small portion of the TFRO, as registered, and who all share in any compensation award. Secondly, mangroves are not part of the current REDD + project which is designed to provide an agreed reward system for landowners who participate. At present there appears to be no applicable compensatory means for the potentially affected TFRO or those communities most closely impacted by any mangrove afforestation.

What Is The Area Of Mangrove In Fiji And Why Its Measurement Is So Important ?

As noted above the LEDS is full with caveats about the inadequacy of fundamental data required for sustainable and best practice mangrove management. Nothing exemplifies this more than the foundation knowledge for any mangrove-based projections – an ability to measure the area of mangrove accurately and consistently. The LEDS notes that figures for the area of mangroves in Fiji vary, and it includes five published/officially presented recent estimates of: 48,317 ha (2013), 38,500 ha (2015), 42,460 ha (2018), 49,500 ha (2018), 52,000 (2018). The LEDS correctly goes on to note this 25% difference as "*significant and will require considerable additional data collection and analysis to resolve*". A similar recommendation on the critical importance of an accurate national figure was made in Fiji's Mangrove Management Plan 1985-86 (MMC 1986) and its replacement in 2013 (MMC 2013). An inability to accurately measure the area of mangrove, either nationally or regionally, fatally undermines the foundation on which predictions can be made, because all the economic projections are ultimately founded on changes in mangrove area and to a much lesser extent in Fiji, in its condition.

Further confusion on this critical issue is a recent paper which reports that Fiji's mangrove area is 65,243 ha, raising a 25% to a 40% difference in recent estimates of mangrove area. Cameron *et al*. (2021) is the first published response to assist Fiji's LEDS '*develop management responses including the potential to develop forest carbon projects*'. It bases its assessments of mangrove area and loss on two sources – the Global Forest Watch (Hansen *et al.* 2013) and GIZ, SPC, SPREP PacGeo[9], both of which are viewed with considerable scepticism by observers in Fiji, both by those with an understanding of what is happening on the ground, and those with a good understanding of satellite imagery[10] - as such it is 'not fit-for-purpose'.

Until such time as Fiji Government is able to resource its own capability of accurately measuring mangrove area and its changes over time (based on the same or suitably calibrated data set), and ensure that there are personnel available to ground truth the results, then the hoped for scenarios and apparent successes of the LEDS will never gain credibility.

What Is The Potential For Restoration Of Mangroves ?

Mangrove afforestation of low-tide mud-flats is not a Blue Carbon opportunity for Fiji. Apart from the Fijian experience showing it to be highly unsuccessful as in most places world-wide where it has been undertaken, it is internationally considered unsustainable and bad-practice – except in certain circumstances such as the Sunderbans, Bangladesh for stabilising fast-accreting deltaic mudbanks. Nothing comparable occurs in Fiji.

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[8] Environment Management (EIA Process) Regulations 2007

[9] http://www.pacgeo.org/layers/geonode:fiji_fcd_2019_w84_1

[10] Cameron *et al.* (2021) itself records that an area of clear felling of mangrove in the Rewa Delta was visited which was not recorded by its analysis of mangrove cover loss. Given the minimal area of mangrove 'ground-truthed' in the study, such a finding confirms scepticism of all the methodology of the study in respect its mangrove cover/loss estimates.

Cameron *et al.* (2021) acknowledges this by excluding (through omission) afforestation activities from consideration – "*In the context of Blue Carbon in Fiji, for instance, ARR projects could involve the restoration of mangroves degraded by activities such as agriculture (e.g. conversion to sugarcane), clear-felling, dredge spoil placement, or damaged by tropical cyclones (i.e. reforestation or revegetation).* Their omission, being no comment at all on the sustainability or feasibility of mangrove afforestation, or the widespread afforestation attempts being undertaken in Fiji at present is counter to the stated purpose of their study '*Results were then framed within the context of developing management responses, including the potential to develop forest carbon projects*'. This is a serious dis-service for the Fijian Government in its wish to ensure that the LEDS as a "living" document may be updated with reliable data and guidance:

> *The Fijian Government reserves the right to periodically update the Fiji LEDS, as may be needed, to ensure validity, transparency, and accuracy over time. Most notably, the Fijian Government understands that not all data relating to GHG emissions from the different sectors in the LEDS are currently fully known, nor are all mitigation actions fully investigated. As such, the collection of additional data and the inclusion of new or improved technology, and its costs over time, will have an impact on future national planning.*

The important information required for the LEDS is What is the actual potential (best current knowledge) for Blue Carbon mangrove projects in Fiji. Cameron *et al.* (2021), in the best review to date which includes field work in Fiji, identify the following potential mangrove restoration projects comprising the reforestation or revegetation of:

Mangrove areas converted to agriculture: historically significant coastal areas have been converted to sugar cane and some for rice, the last being Raviravi in Ba in the 1970s. Over time these have become for the most part productive and titles issued. Lal (1990) provides a detailed account of the economics of such conversions if natural resources are appropriately included. Given the significance, level of development and tenural sensitivity of all coastal areas on Fiji's main islands, there is little to no chance of these reverting to mangrove even under significant relative sea level rise.

Clear felling of mangrove: Cameron *et al* (2021) could not accurately assess the level of large and small scale clear felling of mangrove but believed it to be low and they did not comment on whether planting would be necessary in such cases, or whether or not regeneration would be sufficient over time. Small scale commercial and subsistence mangrove harvesting has long been known and continues to be an issue of some local but not national concern. This is clearly an issue of mangrove management rather than a Blue Carbon opportunity.

Dredge spoil placement: Cameron *et al* (2021) identify 33 ha of mangroves lost to dredge spoil placement but this does not include mangrove loss in the Labasa delta – (c.15 ha; MMC (2013)) and verified but not quantified lesser areas at the mouth of the Sigatoka R., the Nadi R. delta and the Navua R. removed in the past decade. Wherever, dredge spoil is placed in mangroves it alters the hydrodynamic regime and can affect mangroves in a variety of ways. More often than not it kills all the mangroves and becomes a terrestrial habitat and is unavailable for mangrove restoration. In certain circumstances where the hydrology is only slightly altered small areas of the disposal do become colonised by mangrove regeneration, but this substitute is never a replacement of the original IUCN (2020). Dredge spoil placement in the mangrove causes a significant loss of mangroves which is avoidable and completely incompatible with the LEDS and competent administration of the Environmental Management Act (refer MMC 2013). It is a remarkable and unfortunate fact that by far the most detailed and comprehensive Environmental Impact Assessment Guideline available today written for Fiji's circumstances of any sector, is that

for dredging and river improvement by Tortell *et al.* (1992). A document completely ignored by the Ministry of Waterways and Environment with nothing provided to replace it[11].

Cyclone damage: Even though mangrove area estimates of Cameron *et al.* (2021) are considered not fit-for-purpose (refer above), the study concludes that 77% of all mangrove cover losses between 2001-2018, amounting to 870 ha, were caused by four cyclones. This is by far the largest driver of mangrove cover loss identified by the study and there is no reason to believe that cyclones were more or less common or severe during that period and the relative magnitude of cyclone impacts as compared to others will not be affected. It strongly reinforces a conclusion from another wide-ranging review:

> *……...studies describe repeatable types of impact and a variety of responses of mangroves that make them ecologically resilient to high velocity winds, and which have served to advance the notion that mangroves are disturbance-adapted ecosystems (Krauss and Osmond 2019).*

It is important to understand, however, that loss of mangrove cover identified remotely does not equate with mangrove mortality and as such potential opportunities for restoration / Blue Carbon projects. Cameron *et al*. (2021) go on to discuss at length the issues associated with cyclone damage to mangroves either through physical damage to vegetation from severe winds or hydrological changes brought about by sediment stripping or loading during accompanying storm surge and extending this to the potential for Blue Carbon projects and other management interventions. This is an extensive and detailed coverage of what is clearly a very complex, site and event specific subject which is receiving a significant amount of research internationally. As such it is a very useful account for the LEDS consideration of mangrove Blue Carbon potential, it is, however, the briefest of snapshots in terms of applying the complexities to Fiji's circumstances. The paper's final word on the subject is a telling reminder to all and is very relevant as well to the unsustainable mangrove afforestation initiatives currently being encouraged in Fiji.

> *Finally, given the long-term recovery of mangroves is often dependent upon the restoration of hydrological regimes as well as both the frequency, intensity and disturbance legacies of TCs, successful interventions would need to be framed against the degree of risk of future reoccurrence undoing carbon gains – 'permanence'…….an increase in the frequency of the most intense storms (e.g. TC Winston) and the amount of rainfall produced combined with an increased poleward expansion in the range of TCs creates significant uncertainty and risk for mangrove restoration projects (Cameron et al. 2021)*

Cameron et al. (2021) aside there is very little record of cyclone damage to mangroves in Fiji from other sources. Anecdotal accounts from long-time observers in Fiji generally relate localised impacts and considerable variability in severity, much the same as observations of impact in the native forests. Jaffar (1992) noted the physical effect of cyclones is generally restricted to a narrow external fringe of mangroves with broken branches and leaf stripping. Sykes (2017) describes serious damage to a deltaic mangrove stand in the Sabeto River following TC Evan in December 2012, natural regeneration has ensued but is far from attaining full coverage in 2021 GoogleEarth images (pers.obs.). In Queensland, Asbridge *et al.* (2018) provide a detailed account of the damage caused by Category 5 TC Yasi and the nature, extent and severity of damage especially to *Rhizophora stylosa* (Fiji's almost exclusively dominant 'front of the mangrove' species in exposed coastal areas). The lack of recovery was attributed to sediment-stripping, '…..*to the inability of* R.stylosa *to resprout from remaining plant material and persistent inundation*

[11] Similarly ignored is a well-prepared Government commissioned EIA for dredging of the Labasa delta (SKM 1999) which demonstrates how the guidelines can be applied in practice, which they were when the dredging was undertaken at the time. In contrast, more recent dredging in the Labasa delta and elsewhere have caused major, avoidable mortality of mangroves (MMC 2013, Cameron *et al.* 2021).

due to a decrease in sediment elevation thereby preventing propagule establishment' Asbridge *et al.* 2018).

However, there are two important studies which were commissioned specifically to determine mangrove rehabilitation and/or management (including reforestation) requirements in Fiji:

RESCCUE (2016) provides a descriptive account of the damage to mangroves in several areas of Ra Province following TC Winston within an 'integrated coastal management' approach supporting ICM implementation activities including mangrove planting. The report includes pre and post TC Winston mangrove assessments and prepares for surveys to identify mangrove planting areas. The project area included the Viti Levu Bay study site of Cameron *et al.* (2021) where ~307 ha of dogo *Bruguiera gymnorrhiza* damaged by TC Winston was not recovering and as such made it ' *a potential option for an augmented or assisted recovery (ARR) blue carbon project ……. but further research is required in order to assess the biophysical factors limiting recovery which would help determine the feasibility of interventions.* Greenhaigh *et al.* (2018) provides a same project follow up to RESCCUE (2016) to document the benefits and costs of mangrove restoration. However, no further research was undertaken of mangrove condition, and no mangrove reforestation in the areas of destroyed mangrove vegetation was undertaken, the conventional 'build a nursery plant the mudflats' had eventuated. The reasons for this varied but in general planting was not considered possible because of the density of the dead and downed vegetation, and some villages were more interested in planting in front of the village in the understanding that mangroves would protect the village from climate change and future storm surge (RESCCUE (2016), Sykes (2017); Spalding *et al*. 2014, Naikatini pers.comm. (2021)). It seems evident that the planting evaluation surveys and community collaboration required for successful planting projects was not what is required (see for example Wodehouse & Enright 2020 – Attachment 2; MAP 2021).

IAS-USP (2018) reports on a study in the Ba delta 30 months after the passing of TC Winston with one objective being '*to suggest and map areas that would be suitable for reforestation'.* A total of 26 vegetation plots were sampled with six vegetation communities identified – two of these were terrestrial (old gardens and dredge dumps), one was the mixed 'back of the mangrove' habitat, and three were mangrove communities. All vegetation communities/habitats were evaluated for reforestation. Extrapolating this evaluation and using Google Earth, the areas with reforestation potential were then mapped. The only mangrove community which was identified for potential reforestation was the damaged seaward strips of tiri *Rhizophora stylosa* totalling 2.8 ha. Whilst it was noted that certain internal areas of mangrove in the delta had been badly damaged, their extent was limited and fragmented, and access was all but impossible because of the dead material remaining and there was in any case regeneration clearly visible (Naikatini *pers.comm.* 2021). This was subsequently verified (refer Figure 4 in Cameron *et al*. 2021).

Irrespective of methodology adopted and/or resources available for these surveys, the area of mangroves available for reforestation/restoration following the close passage of TC Winston the most severe cyclone to ever cross Fiji is remarkably limited. It is by no means certain that even the 307 ha of 'dead' dogo *Bruguiera gymnorrhiza* at Viti Levu Bay, Ra will, after a further, appropriately detailed investigation be amenable to cost effective reforestation, it may well be that the cause which is likely sediment loading and hydrodynamic changes are so severe that mangrove will no longer grow there. Or natural revegetation may just take an uncomfortably long time in today's world of instant need and ecologically irrelevant project time spans.

How Useful Are Mangroves In Protecting Villages From Waves And Storms ?

The role of mangroves in protecting coasts against natural hazards such as storms, tsunamis and coastal erosion has been widely acknowledged. Even so, the level of protection provided by mangroves remains subject to debate. In Fiji it is one of the most frequently cited reasons for planting mangroves and in the face of actual sea level rise, mangroves are seen as a convenient solution. An alternative view is that the confidence in such planting is misplaced and can create

greater risks to those living in vulnerable coastal locations by inducing a false sense of security (Spalding *et al*. 2014).

Spalding *et al*. (2014) is the current standard, a practical guidebook summarising a wide ranging review which yielded three technical reports on the subject (McIvor *et al.* (2012, 2012a, 2013) and which provides practical management recommendations for coastal zone managers and policymakers. The report stresses that an appreciation of the risk of any site in terms of hazard, exposure and vulnerability is an essential prior requirement to determining what role mangroves can play.

Refer Attachment 3 for key messages from " Mangroves for Coastal Defence: Guidelines for Coastal Managers & Policy Makers.

Pertinent conclusions are that mangrove coastal widths of:

'*Hundreds of meters needed to significantly reduce waves (wave height is reduced by 13-66% per 100m of mangroves)* for waves', and '*Thousands of meters needed to reduce flooding impact (storm surge height is reduced 5-50cm/km)* for storm surge', Table 1.

There are relatively few coastal locations in Fiji, other than the main deltaic formations where there is a 100m or more of coastal mangrove width, and the potential without undertaking afforestation to plant 100m is even more limited. As such the potential role mangroves can play in coastal protection in countries with extensive mangrove landscapes, cannot be inferred automatically for Fiji where the potential needs to be applied with great caution lest cynicism and a false sense of security be induced in vulnerable coastal communities.

		HAZARD				
		Waves	Storm surges	Tsunami	Erosion	Sea level rise
MANGROVE FOREST PROPERTIES	Width	Hundreds of meters needed to significantly reduce waves (wave height is reduced by 13-66% per 100m of mangroves)	Hundreds of meters needed to significantly reduce wind and waves on top of surge Thousands of meters needed to reduce flooding impact (storm surge height is reduced 5 - 50 cm/km)	Hundreds of meters needed to reduce tsunami flood depth by 5 to 10% Mangroves do not provide a secure defence (nor do many engineered defences)	Sufficient mangrove forest width needs to be present to maintain sediment balance. This can help to prevent erosion and may encourage active soil build-up.	
	Structure	The more obstacles the better: dense aerial root systems and branches help attenuate waves	Open channels and lagoons allow free passage, while dense aerial root systems and canopies obstruct flow		Complex aerial root systems help slow water flows, allowing sediment to settle and causing sediment to accrete rather than erode.	
	Tree Size	Young & small mangroves can already be effective	Smaller trees and shrubs may be overtopped by tsunamis and the very largest storm surges		Young trees already enable soils to build up. The more biomass input into the soil the better.	
	Link to other ecosystems	Sand dunes, barrier islands, saltmarshes, seagrasses and coral reefs can all play an additional role in reducing waves				Allow room for landward retreat of the mangrove
	Underpinning factors	Healthy mangroves are a prerequisite for all aspects of coastal protection. Healthy mangroves require sufficient sediment and fresh water supply and connections with other ecosystems. Conversely, pollution, subsidence (due to deep groundwater/oil extraction or oxidation upon conversion) and unsustainable use jeopardises mangroves.				

Table 1: The role of mangroves in coastal risk reduction (Source: Spalding *et al.* 2014)

How Useful Are Mangroves In Stabilizing Coastal Erosion ?

The role of mangroves in protecting coasts from coastal erosion is widely acknowledged and has been demonstrated in many countries where mangroves have been removed from erosion prone coastlines, as has the difficulty in restoring mangroves at such sites (e.g. Naohiro *et al.* 2012,

Lang'at *et.al*. 2009, Lewis 2000). Ellison (2010) collates some reports from different locations in Fiji where removal of mangroves has resulted in erosion of village foreshore and road batters. Nunn (2000) found in Ovalau and Moturiki that settlements that deliberately preserved their mangrove fringe report no landward movement of the shoreline in living memory, while those where mangroves were cleared found abrupt shoreline erosion. In contrast, there appear to be no records where the planting of mangroves has arrested coastal erosion in Fiji.

Coastal erosion is a natural phenomenon worldwide. It is common in Fiji, especially on coasts exposed to the trade winds and tropical cyclones. In its management zonation mapping of Fijian mangrove, MMC (1986) identified coastal and riverine mangrove areas which were zoned for shoreline protection. There are many resorts in Fiji which will attest to the relatively gradual unidirectional movement of coastal sands by the trade winds, only to find that every decade or so a cyclone moves all the sand back to the starting point, drives it inland or takes it all out to sea. A rough equilibrium plays itself out but in an inconvenient timeframe for many developers. This situation is now exacerbated by sea level rise, and there are now cases of erosion of village shorelines where it has never previously been experienced.

For the most part current problem coastlines are ones from which mangroves have never been removed, although some have been damaged by cyclones . In such situations, mangrove afforestation of coastal mudflats has no role to play in arresting actively eroding shorelines. Whilst existing and long established mangrove can certainly resist erosive forces to varying degrees, freshly planted mangrove propagules have no special ability to withstand erosive wave action and they are easily washed away[12]. One proven traditional method of enabling mangrove colonisation in certain exposed tidal locations is the construction of rock built '*moka*' walls which can provide initial support for colonising mangrove propagules, but the substrate needs to be amenable for the establishment of a strong rooting system to develop further.

Where villages are under threat from eroding sea fronts and a solution is needed, the most important requirement is to understand the risk in terms of hazard, exposure and vulnerability prior to determining what role mangroves can play (Spalding *et.al*. 2014). If there is a clear indication of any potential mangrove planting being reforestation rather than afforestation, then there is a possibility of mangroves having a role to play but only on the basis of the results of a pragmatic risk assessment which needs to include issues of climate change. Without a positive assessment, the immediate conclusion that mangroves should be planted is a naïve assumption.

[12] Mangrove propagules are not in any way the marine equivalent of rooted Vetiver Grass seedlings.

Conclusions

The review above provides some clear guidance on internationally accepted best practice for mangrove planting. Some of this is not practiced in Fiji today, indeed poor practice is the norm and is tacitly or directly encouraged through an absence of policy/guidelines and poor regulatory understanding which is resulting in afforestation attempts of tidal mudflats, the setting of unrealistic planting targets, the adoption of simplistic indicators of success – specifically mangrove propagules planted and area planted, and misplaced confidence of speculative economic projections in Fiji's LEDS.

It is anticipated that the international profile of the LEDS document will provide the necessary impetus for a significant change to be brought about in respect of the current lack of good or best practice in mangrove management, including but by no means confined to planting in Fiji today.

On the basis of this review the following Mangrove Planting Guidelines are offered for general consideration:

1. Planting should only be attempted in areas that naturally support mangroves ("reforestation"), and not in areas where mangroves are not known to have grown ("afforestation").
2. Planting mangroves should not be undertaken in isolation but only after a full appreciation of the risk of any potential planting site in terms of hazard, exposure and vulnerability.
3. Planting in areas which never had natural mangroves may destroy other, equally important ecosystems such as sea grass beds and sub-surface invertebrate life, and a productive habitat for foragers – inshore marine fishery and migrating shorebirds.
4. Effective coastal protection from swell waves and wind require hundreds of meters of mangroves, and thousands of meters are required for significant storm surge abatement, not the narrow belts such as are often produced by current planting projects.
5. Planting mangroves will not stabilise on-going erosion, but well-established mature mangrove stands may resist erosion.
6. Local community involvement in planting initiatives through informed consent, equitable benefit and an understanding of mangrove planting potential and constraints, is an essential pre-requisite for planting projects.
7. Mangrove planting without proper planning can appear to be a short term success yet still fail in the medium and long term. Permanence in respect of planting is an essential consideration prior to planting.
8. Planting mangrove without assured monitoring for success is a wasteful use of resources.
9. Damaged mangroves will usually regenerate naturally over time if left undisturbed. Planting is never as successful as natural regeneration. Wherever possible facilitate natural regeneration (ANR – Assisted Natural Regeneration).
10. Mangroves should not be planted 'Plantation Style', such stands are not found in nature and may not develop the same values of natural stands.

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ATTACHMENT 1: PAUSE BEFORE YOU PLANT (SOURCE: IUCN MANGROVE SPECIALISTS GROUP)

https://www.leibniz-zmt.de/images/content/pdf/AG-Mangrovenoekologie/IUCN_MSG_2020_Position_Paper_Pause_before_you_Plant.pdf

Pause before you Plant

Despite the terrifying recent fires in Australia, California and Brazil there are grounds for hope that the world could finally start valuing its forests. Many governments now say they love trees. There is an increasing international effort to slow rates of forest decline and restore forests where they once stood. Seventy-six world leaders have just signed the Leaders Pledge for Nature, committing to reversing biodiversity loss by 2030, including the restoration of a significant share of degraded ecosystems. As we approach the United Nations Summit on Biodiversity, this shows the international community may be willing to chart a new direction in environmental decision-making. It follows several other international restoration initiatives, such as the Bonn Challenge to restore 350 million hectares of lost and degraded habitat over the next 10 years and calls for mass planting such as the Trillion Tree Campaign.

This new political discourse on the importance of trees is welcome. It reflects a growing understanding that forests are essential for our future. Two years ago, the Intergovernmental Panel on Climate Change (IPCC) published their Special Report on Global Warming of 1.5°C. They described four scenarios that could lead the world to this best-case level of warming. All of them require both massive cuts in new carbon emissions and removal of carbon that is already in the atmosphere, which will have to continue long after 2050, when emissions approach net-zero. Many ecosystems, including tropical forests, peatlands and seagrass meadows, are efficient carbon sinks; mangrove forests are amongst the most powerful of these natural allies against climate change. The more these ecosystems can be preserved and expanded, the less reliance we will have on untested and (in some cases) yet-to-be invented technologies for carbon removal. Carbon-rich ecosystems typically bring many co-benefits – with mangroves, these include coastal protection, production of food, other natural resources and medicines, and habitat for biodiversity. Short-term thinking often drives deforestation and so removing forests frequently makes no economic sense. The case for 'nature-based solutions' (enhancing natural ecosystems that trap and store carbon and provide many co-benefits) is overwhelming.

We have made substantial progress in conserving the world's mangrove forests; in some respects, this is a conservation success story. We are still losing them, but rates of loss have declined from 1-

2% to around 0.13% per year over the past three decades. Many countries, including Sri Lanka and Indonesia, have made serious and high profile commitments to conserving what mangroves remain. Major international campaigns are raising the profile of mangrove conservation and channelling funds towards their conservation and expansion. However, mangrove experts express concerns about simplistic calls for mass planting, for four reasons:

First, there is a danger that an emphasis on tree planting distracts from the priority, which is to conserve what we have. Old-growth natural forests are irreplaceable. For example, mangroves may contain more than a thousand tonnes of carbon per hectare, which has accumulated in their soils over millennia. Removing these forests will result in the rapid mass release of carbon. Planting new forests cannot compensate for such losses on a timescale relevant to the immediate climate emergency.

Second, the recent history of mangrove planting and restoration is a sorry one. Studies from around the world have shown that most attempts at mass planting of mangroves fail. The reasons for failure are mixed. Poorly designed incentives combined with a lack of basic ecological knowledge often result in people planting in completely unsuitable sites – such as low tidal mudflats or sensitive seagrass meadows - which have never supported mangrove trees. Where attempts at restoration are made in areas of former forest, the reasons for tree destruction must first be addressed and mitigated before a new forest can survive.

Third, even when newly planted trees do survive and grow, the resulting forest may be very different from a natural one, lacking its diversity. Mass planting often focuses on only one or two species that are easy to plant and creates species-poor stands that cannot perform all the biological functions of a natural forest.

Fourth, growing and planting mangroves can be very expensive and time consuming. If planting is not necessary, then this diverts funds from other conservation activities and breeds cynicism.

Mangrove restoration can work. The coasts of many countries are scarred with abandoned shrimp ponds, man-made salt pans, stump-strewn mudflats where mangroves had been cut for charcoal or timber and marginal agricultural fields. Where the damage is severe, for example when excavation has caused gross subsidence, these sites may be beyond saving. Happily, that is rare, and many damaged areas can be restored to mangrove forests. Groups such as the Mangrove Action Project have refined ecological techniques of rehabilitation that emphasise restoring the right conditions for tree growth and allowing nature to do the rest: ‘ecological mangrove restoration’. And sometimes it

does make sense to plant trees directly. In the Philippines, for example, there is an urgent need to protect coastlines left vulnerable to the frequent tropical storms. Planting naturally available wildings has restored mangrove cover to abandoned fishponds much faster than the 15-20 years that might be needed by natural regeneration alone. Another example comes from Kenya, where areas of former forests had become so saline, as seawater evaporated without the protection of a canopy, that trees could not regenerate naturally and needed some help in getting established. So planting mangroves is not bad *per se*, but planting the wrong species in the wrong place is. There is no single solution to mangrove restoration. Rather we need to pause and think through the right interventions for each site and context to produce a diverse and resilient forest.

It is time to put our protective arms around the Earth's forests, including her mangroves. This means, above all, preserving what we have. It also means increasing total forest cover, on land and along our coasts. If we co-operate with nature– by bringing back the circumstances that allow trees to establish and grow – she will do much of the work for us. Sometimes we will need to help by directly planting trees. We should all now be tree huggers. When needed we should be tree planters too, but let us pause before getting our spades out to make sure we are digging in the right areas and for the right reasons.

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on behalf of the IUCN-SSC *Mangrove Specialist Group*

ATTACHMENT 2: MANGROVE RESTORATION: IT'S MORE THAN JUST PLANTING

Source: Mangrove Action Plan (2020) Unpublished

Mangrove Restoration: It's More Than Just Planting

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Introduction – The Importance of Conservation Before Restoration

This article is a practical summary of Mangrove Action Project's (MAP) 'Community-Based Ecological Mangrove Restoration' (CBEMR) technique for restoring mangroves, which focuses on facilitating natural regeneration of the trees and plants. This summary has been developed for groups who wish to understand the CBEMR process or take on their own restoration project. However, MAP encourages the **conservation of existing mangroves before the restoration** of degraded forests. The full complement of ecosystem goods and services only come from mature mangroves. Well established stands of mangrove are likely to be much more biodiverse than restoration efforts and can act as a seed and propagule source for many species. Restoration is a risk and many projects has failed in the past. Disturbing the soils of mature forests, particularly for aquaculture, risks rapidly losing huge amounts of carbon stored in the soil, as the organic material comes in contact with air and decomposes. Live mangrove roots enhance the quality of the soil around their fine root hairs by leaking oxygen and carbohydrate into the soil nearby. Losing live roots is likely to lead to poorer quality soils that might be much more difficult to restore. For all these reasons, when considering budgets, effort and time we encourage groups to conserve existing mangroves and ensure their health with good hydrology and limited use, before restoration.

Every site is different and there is no one-size-fits-all solution to restoration. However, there are some general scientific principles which all mangroves around the world adhere to. Mangrove restoration is NOT like dry-land forestry planting as mangroves have to contend with salt and flooded soils and the objectives are likely to be different. Elevation relative to sea level is extremely important and normally the key factor controlling species distribution. Fortunately, there is a significant amount of published research as well as MAP's practical experience to draw on, to avoid the mistakes that have compromised previous projects.

Figure 1: Where mangrove forests meet mudflats. No mangroves should be planted in the mudflat zone (left side of this photo), lower than this mangrove fringe. This fringe will be located at approximately at mean sea level. Careful observation of nature reveals where mangroves can and cannot live, confirmed by a lack of natural regeneration on the mudflats (left).

Getting Started - Community Collaboration & Background Research

1. First, we recommend that you get to know the site and its context in great detail. This is much more than a morning's visit with a GPS and camera. From a **socio-economic** point of view, discuss with local people **who owns the site** and what's going to happen to it in the future. There needs to be absolute clarity about who owns and controls the site as there is no point working on a site, only to see it built on or turned into an aquaculture pond a few years later. Further, what do the local people want from their mangroves? Men and women may use different resources and have different views of the root problems. The same goes for fishers, farmers and business people. Additionally, what local knowledge do they have and what is their advice? How do they use the restoration site (as it could be where they moor their boats, or where their animals graze, etc.)? Have the local people been over-harvesting mangrove wood? What materials do they build with and how do they earn a living? What fuel do they cook with? Is there a need to introduce 'Improved Cooked Stoves' (ICS) which reduces fuel consumption by about 30%, or to introduce alternative cooking fuels or building materials as part of the project?

Figure 2: Collaboration with the local community is key to getting to know the site's social, historical, geographical, economic details and project success in general. Start working with and training the local conservation group right from the first visit. Time spent conducting informal 'scoping' interviews around the community is time well spent. This will help to dissipate misunderstandings held by villagers. Informal discussions will also reveal mangrove stressors, village needs, provide understanding about village politics and help identify a local mangrove expert.

Do not assume that the community does not understand the mangrove forests around them, as they have lived their entire lives near them and will have seen many changes including seasonal changes which may not be evident to outsiders on brief visits. Their local knowledge of the site, its history and how it's utilized are immensely important. Conversely, don't assume that all villagers are aware of all the mangrove benefits, know how to restore them or are able / willing to manage them sustainably. Talk to as many members of the community as possible, both male and female, especially the fishers whose livelihoods depend on the mangroves. Conducting a number of community consultation meetings is essential (Fig. 2) and take great care to set appropriate expectations. Reaching a consensus is often difficult or may not even be possible. More broadly, conduct a stakeholder analysis or your site to establish which groups are interested in the restoration site and how much influence they have. This might include local government units; NGOs; national government (policy); ministries of Fisheries, Land Development, Agriculture, Aquaculture, Forestry, Environment; the military & coast guard; local businesses, etc.

From a **technical / biophysical** point of view, explore with local people why are there no mangroves or degraded mangroves on the site now? This might need some careful and honest reviewing. Are there stressors (problems) which have degraded or killed the mangroves, and will you be able to remove or reduce these stressors (e.g. fresh water being diverted away from the mangrove system; road building cutting off hydrological tidal connection or aquaculture pond walls isolating areas). Sometimes mangroves can be restored by reconnecting and improving the **hydrology** and topography to improve tidal flushing,

Figure 3: Researchers assessing the high and low tide points at a restoration site. It is important to understand the elevation of a restoration site relative to sea level as mangroves grown in the top half or top third of the intertidal zone only. Working too low down within the intertidal zone (below mean sea level) will result in poor results or project failure.

drainage and letting natural regeneration do the rest. Therefore, it is important to walk the site and the water channels to observe how well water flows in and drains out, fresh water input, tidal range and context of the site. Make sure you understand how often your site is inundated and for how long. This is because the soil around mangrove roots should be drained and therefore oxygenated >50% of the time. If it's a former aquaculture pond, there might be no or insufficient flushing at this stage or waterlogged soils caused by poor drainage of the flat bottom of the pond. You should observe the site at various times of the tidal cycle and at different times of the lunar cycle - Spring tide (full moon), and Neap tide (just after the first or third quarters of the moon) when there is least difference between high and low water. Different seasons will also affect freshwater input, wave energy and av. temperature.

Figure 4: Mangrove area suffering from soil erosion with roots exposed

Next, is there **natural regeneration** on the site? If so, which species? If not, why not? This is a crucial indicator suggesting whether the site is appropriate for restoration or not. For example, much planting of mangroves is attempted on mudflats. Mudflats are unsuitable for mangroves for many reasons and natural regeneration is very unlikely to be present, as shown on the left side of Fig. 1. We strongly advise you not to utilize these areas (or coral flats, seagrass beds or salt pans). MAP staff have personally witnessed many planting attempts on mudflats and unless the area is accreting soil rapidly, and this soil is becoming firm enough to support mangroves, these projects have failed. Also check soil pH, soil type (sand / silt / clay), soil pore water salinity (because this is the water the roots are in contact with), erosive forces (see Fig. 4), levels of wave / wind energy the site will be exposed (particularly in the monsoon season) and what species are expected to thrive on the site. Conduct all this research with local people to encourage their involvement and build their capacity.

If you are trying to produce **new mangrove** where mangroves did not grow previously (afforestation), you need to answer the question, *why is nature not colonizing this area naturally?* If a site is not being colonized by pioneer species such as *Sonneratia alba, S. apetala, Avicennia marina, A. alba* your planting effort is unlikely to succeed.

2. Many Answers are at a Reference Mangrove Site

Second, again with local people, visit a reference mangrove site nearby. By this we mean find a local mangrove, natural (not planted[1]), or at least one that is healthy, and study it carefully. Try to ensure that it is subject to the same inundation regime and conditions as the restoration site. A 'healthy' mangrove will have a canopy that has closed over your head, the tops of the trees have a full complement of leaves and the water flows through this area and drains unimpeded. Get to know the tides. See what species are thriving, where plants are growing relative to mean sea level ('species zoning'), which seeds and propagules are floating about (in the seeding season), the salinity of the water and soil pore water, soil conditions, and record how long the mangrove soil is drained of water before an incoming tide covers the site again. Mangroves live naturally within the upper half to the top third of the intertidal range. Again, if the restoration site you are interested in has constantly saturated soil or standing water at low tide, these areas will not work, as mangrove roots need to breath.

[1] Note that in many countries, much of the nation's mangrove has been previous cut for charcoal and replanted. There might be very little original, old-growth forest left. Replanted mangrove tends to feature very few species and planted in rows like terrestrial plantation forestry. Low zone and back mangrove species are either marginal or absent altogether and the mangrove trees all of the same age. There will be very limited species zonation evident and little variation within stands. Use these sorts of reference sites with care.

3. Detailed Knowledge of the Expected Species

Third, work out which species are expected to grow on the restoration site, and their preferences including zoning. This might not be what local people want. There are some species that will grow only in the upper zone of the tidal range, tolerating being inundated only once or twice a month maximum and like free-draining sandy soils. Other species are happy to be flooded every day, with their roots in clay. Pioneer species will often be first to appear on a new site as they are best adapted to colonize new, wet sites in the lower mangrove zone. At higher elevations, plants such as *Acrostichum* sp. fern or *Acanthus* sp. might arrive first on site. Other species will survive somewhere in the middle of the mangrove range such as *Rhizophora* sp. Additionally, there are plenty of species which cannot tolerate full sea water but need mixed, brackish water or indeed almost fresh water. For information on species preferences try local mangrove guidebooks or the internet. E.g. http://www.fao.org/3/ai387e/ai387e06.htm

The good news is that if your activity (see step #5) facilitates natural regeneration which we strongly recommend, rather than planting, nature will automatically put each species where they should grow, rather than you having to work out where to plant each species. Unfortunately, what many mangrove restoration projects do is jump straight into planting *Rhizophora* sp. (a mid and low-mid mangrove species) too low down, in saturated, soft mudflat or indeed anywhere. This usually fails or at best produces stunted mangroves due to stress from difficult soil conditions and a lack of oxygen. Sometimes the planted species is whatever is available in the nursery at the time or ones that are easily grown from seed. Government mangrove agencies are as guilty of putting the wrong species on the wrong site as any other group. Do not assume they know what they are doing, either.

4. Sharing your Research, Discuss and Agree Objectives, Plan Activities

Fourth, now that the complexity of mangroves and the surrounding social situation is understood, we suggest you **discuss and plan** activities with local villagers and other key stakeholders. Take great care to discuss and **agree** on **project objectives**, now it is clear what is possible on the restoration site. Keep in mind that different stakeholders might have different objectives, and these might change over time. Objectives will affect implementation activity and monitoring emphasis, therefore take the time to debate and agree objectives. Also agree before any work starts, who can receive benefits from the restored mangrove, whether wise use is permitted or if the mangroves will be left to grow up untouched.

Draw a map of the site or have some way that allows all local stakeholders and villagers to see what's going to happen. This is particularly useful and inclusive if literacy is an issue, and / or a lack of internet, electricity or mobile phone signal. Community map drawing, pictures from Google Earth (GE, see Fig. 5) which can have boundaries drawn on them before printing, drone imagery and maps from the local authority can all help.

Figure 5: A Google Earth 'screen grab', saved as a high-resolution jpeg, printed on vinyl, makes it easier for villagers to understand and discuss the next steps of restoration and conservation efforts. These maps cost only a few dollars to produce and villagers find them very useful.

Ensure the project has the co-operation, support and assistance of local people. Better, if they are willing and interested, encourage the local people to take on and lead this mangrove project - outside groups acting only as (technical and facilitation) support. It is likely that the village team will need training to raise their capacity and understanding, as well as other nearby stakeholders, such as local government units, local government mangrove agency field office staff, local businesses, local fishers, forestry department officials and so on. Therefore, make sure that in the plan, there is time and budget

for this training (which MAP will be able to help with) in advance of any implementation. Mangrove restoration should not be just a short-term photo opportunity for websites and corporate brochures, but should improve ecosystems, build capacities and empower local stakeholders.

5. Implementation

Fifth, keep a holistic view of the village and its needs. Solutions and work needed might be predominantly social, rather than biophysical. For example, the reason why a restoration site is degraded or the mangroves are missing might be the lack of income generating opportunities. Please note that **conservation of existing mangroves should always be the priority** over restoration activity. The full set of ecosystem goods and services only come from mature mangroves that are well connected to daily tidal inundation.

From the plan, and depending on the project objectives, your activity list might include the below:

- Build awareness about the benefits of mangroves (local people are generally only aware of what they can see), mangrove ecology & biology, what climate change adaptation means, restoration work, and the importance of hydrology, topography, and biodiversity. Arranging for older members of the community to share mangrove knowledge with students at the local school is an effective way to pass-on traditional knowledge. Environmental education for the community's students, a mangrove study visit, small-scale test planting or field maintenance work by youth on the restoration site will all help ensure long-term community support for the project. Explain what will happen if they lose their mangroves. This is a good way to reduce or tame over-harvesting of mangroves.
- Co-operation from the local people might include finding a way to exclude grazing livestock from the site to allow natural regeneration to establish and thrive. We have seen a government project in Myanmar where planting was conducted on areas where local people landed their boats. After a short period, only the project sign remained, with zero survival of planted mangrove seedlings.
- Initiate wider community meetings to explain the project and why it is NOT just building a nursery and planting in straight rows. Explain what is feasible on the given restoration site. (Note that from your research you might have concluded that the choice of site was inappropriate, for social or technical reasons.)
- If the research has shown that the **hydrological connectivity** was insufficient or the drainage was poor, make the necessary adjustments to the topography (see Fig. 6) and hydrology, which might well be followed by a long period to observe whether the work the community has done is sufficient, and whether natural mangrove regeneration occurs on its own. A project in El Salvador had to dig out and improve almost 10km of channels to bring their mangrove back to life. No planting was needed. If restoring a former aquaculture pond, this has more technical challenges and we suggest you get in contact with MAP for specific help.
- Clear all **debris** which is likely to float over the site and damage young plants. Make sure young plants are not broken by entanglement with seaweed or smothered by mangrove vines and creepers like *Finlaysonia* sp. or *Derris* sp. **Weeding** of natural regeneration might be all that is needed.
- If the community members are expecting to show people around the site, you might want to **'interpret' the site**, by installing signs, producing leaflets, roping off test monitoring plots, training village guides and so on, so visitors will be able to understand what has been done.

Figure 6: Villagers regrading shrimp pond embankment to increase the area where mangroves will grow. Before this work, the pond had steep walls and a flat, poorly drained bottom. This work produced more area at an elevation suitable for mangrove growth and improved the pond drainage.

- Other possible activities might include: establishing a community forest management group to monitor and control wise use; removing mangroves growing in channels; providing alternative livelihoods; encouraging the change of species if the salinity is high; providing more fuel efficient 'improved cook stoves'; establishing terrestrial woodlots to take the pressure of mangroves; providing alternative fuels for cooking; cutting back *Acrostichum* sp. (a fern) until mangroves can grow over it and shade it out; talking with neighbouring village leaders to stop timber poaching by outsiders; asking the government to ban sales of mangrove wood in local markets; and broadcasting additional seeds and propagules onto an incoming tide if there is insufficient natural regeneration on site. This is not an exhaustive list.
- We would encourage you to grow as many different species which would naturally occur as possible, without importing species from far away or another country. **Biodiversity** helps ensure that as conditions change due to sea level rise and climate change, at least some of the species will be able to survive, adding to mangrove resilience.

6. Monitoring

- Six, make sure you collect sufficient **baseline data** before any work starts.
- The project **objectives** will suggest what should be monitored beyond making sure that the initial mangrove stressors have been mitigated. Continue to **monitor**, patrol and protect the site for at least 3-5 years. The only way to make sure this happens over the long-term is to ensure that local people are trained how to monitor and provided with appropriate support.
- Key elements to monitor are: whether the hydrology is still working well or whether the water channels need constant re-digging; if the soil is well drained at low tide; if natural regeneration is coming back on its own; and whether other issues have been resolved such as salinity levels and social agreements. Some governments use a 'fishbone'-shape hydrological solution in all situations, even though research has shown that it needs continuous maintenance after it is excavated due to its inappropriate shape. MAP does not recommend its use: restoration requires flexible, adaptive solutions.
- If natural regeneration proves to be insufficient, understand why. Are there no sources of seeds locally? (This should have been discovered in your initial research.) Is something blocking their arrival? Are crabs / goats / water buffaloes / pigs / feral camels eating the seeds or natural regeneration? If this is the case you can supplement the natural regeneration by collecting seeds and propagules from nearby areas and 'broadcasting' (throwing) them on an incoming neap tide. Maybe there is something wrong with the soils, such as high acidity, pollution (e.g. an oil spill) or high salt levels. Are inappropriate species such as *Acrostichum* sp. arriving and adversely affecting your site conditions?

7. Planting only if Long-Term Monitoring Shows it is Necessary

Seven, if natural regeneration is still insufficient, but the hydrology is working well, **consider planting**. Please note that in general, planting is only considered at this stage, after having completed the other stages, described above. If you decide that planting is necessary, it is advised that **test planting** is conducted first, to see if the conditions and species choices are suitable, before planting on a larger scale. Planting (the correct species in the right zone) is no substitute for well-functioning hydrology and good drainage.

There are several different methods of planting, and much advice on the internet. Most importantly, be aware of what mangrove zone the planting will take place in, and for how long that area is inundated. *Rhizophora* sp. is NOT the one-size-fits-all planting solution for every zone. Planting methods include direct 'dibbling' or insertion of seeds/propagules into the soil, growing material in plastic 'polybags' and planting out after a few months, transferring young 'wildlings' which have been uprooted or dug up from one area to another, amongst other methods. Each method has pros and cons. If you are transferring propagules, and wildlings in particular, make sure they are planted as soon as possible after collection. Wildling roots, exposed to the air and hot sun will die off in minutes. Propagules will quickly lose water and viability if not stored well, or be attacked by wasps and insects. Proper storage is vital if they're not planted right away. Ensure that propagules are firm and ripe. They should be picked up from the ground or if collected from a tree, come away easily from the tree with only a gentle pull. Discard propagules with small holes in them as an insect has already laid an egg inside and it will break later. If the propagules are

dry, bendy or rubbery-feeling they will not be worth planting. If you're not sure ask an experienced community member about seed collection. We would also recommend that you test your direct planting before doing anything on a large scale. Plant as many species as possible over your site with zonation in mind. Do not rely on just one or two species. **Test** any planting first, before planting on a large scale. Plant near existing mangroves, noting which species they are, but do NOT plant in channels.

A planting example. A community near Sittwe and NGO 'Mangrove Service Network' in Myanmar wanted to establish a greenbelt to slow coastal erosion. MSN took the village conservation group through MAP's CBEMR process, above. The site was just above mean sea level, i.e. low mangrove zone, suitable for pioneer mangrove species. (There is plenty of advice on the internet about where to site a nursery and how to do this.) Note that low mangrove zone pioneer species listed earlier need to be grown up in polybags until their stems turn woody (probably beyond six months) to avoid crab damage, and planted out as seedlings. Being a slightly energetic site, with wet clay that was inundated every day, MSN grew the seedlings for a year before the community planted them out. They used several pioneer species. They also fenced the planting to exclude grazing animals and the community monitored and maintained the mangroves in the early stages. They now have a healthy greenbelt and the erosion has slowed considerably.

*Figure 7: An example of what **not** to do: planting in straight lines and in the water channel contradicts nature's processes, and will block tidal inundation, if they survive at all.*

DO NOT PLANT IN STRAIGHT LINES. **DO NOT PLANT IN CHANNELS.** Fig. 7 is a good example of what NOT to do. Just because the government plants in rows, and plantations are in straight lines, this is no reason for your planting to be conducted in rows, unless your objective is production forestry. Planting in lines often results in changes in micro-topography being ignored and channels filled with mangroves. You might find that the activity needed on the site is to REMOVE mangroves which are growing in water channels. If they have naturally developed in a channel, this is a good indicator that the hydrology needs assistance.

Mangroves are quite different to dryland forests and forestry. Rarely are sites flat. We recommend that you plant in clumps or clusters, by which we mean groups of propagules perhaps 5-10cm apart, on the more elevated parts of your site. Nature will self-thin, as it has been doing for millions of years. Groups of seeds planted close together enjoy advantages which will help establishment. Physically, they protect each other from impact damage, share soil they have improved as the roots leak oxygen and carbohydrate, thereby reducing acidity and promoting beneficial bacteria, and seed clusters are more likely to encourage appropriate hydrology by allowing water to flow around the developing clumps. Nature itself does this, as you will observe, as the majority of seeds and propagules stay close together under the canopy of the mother tree.

More on hydrology. Whether using natural regeneration or planting, aquaculture pond (Fig. 8) or open site, the hydrology and drainage of a site HAS to work. Natural river-delta mangroves have big, wide, snaking channels, which are narrower upstream, and wider at the river mouth where they meet the sea, allowing the free flow of water. If you are having to excavate new channels, they should mimic these natural dimensions. Soil that is regularly well drained is much 'healthier' than soil that is constantly saturated. Good hydrology brings in seeds and propagules for natural regeneration; brings in bacteria which the soil needs; keeps the soil salinity level low; washes away toxic substances and acid build-up in the soil; and exports leaf and plant litter which form the basis of the local in-shore food web. Algae, fungi and bacteria grow on this litter, and this combined organic matter provides food for fish, crabs and shrimp and other animals. These in turn provide food and livelihoods for local people.

Figure 8: Hydrology is essential to success in restoration. The drainage rate needs to be the same at the restoration site as in the natural mangrove outside the pond. If the channel has a bottleneck at some point (here, the entrance to a former shrimp pond) widen by digging (as done here to the side of the former sluice gate) until drain rates equalize.

What should a Natural Mangrove look like?

Figure 9. View of a section of back mangrove, Pangani, Tanzania. Note the undulation of the mangrove floor, with a well-formed clear channel for the water to flow in and out unimpeded. There is no standing water on the higher ground. The channel is not straight, but bends and curves. Nothing is growing in the channel. Various trees are growing on the higher elevations, in a mix of heights, densities, species and forming a variety of light intensities on the mangrove floor. (There is limited natural regeneration evident here as mangroves are generally shade intolerant with little understory when the canopy has closed.)

Next Steps- Resources and Readings

Thank you again for your interest in mangrove forests. We hope that you found this information sheet helpful and informative. Please remember that this is an introduction into the complexities of mangrove restoration, and not an exhaustive guide. From this point on we suggest that you get very familiar with the CBEMR methodology before you do anything else. There are many other resources to download on MAP's site:

https://mangroveactionproject.org/mangrove-restoration/

Please join Yahoo e-group of 290+ mangrove practitioners at
https://groups.yahoo.com/neo/groups/cbemr_group/info

CBEMR Blog: http://www.mangroveactionproject.org/cbemr/blog/

CBEMR on MAP's YouTube: https://www.youtube.com/user/MAPmangrover

If you still have specific questions about a particular site, we encourage you to reach out to MAP, as we would love to try and help! See below for further readings and resource recommendations.
https://mangroveactionproject.org/resources/

Also, please consider inviting MAP to run a training course on CBEMR.
Contact: dominic@mangroveactionproject.org for more information.

Good Luck!

Further Readings:

Mangrove Restoration: To plant or not to plant (available in 9 languages)
https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/

Mass mangrove restoration: Driven by good intentions but offering limited results
https://www.iucn.org/news/forests/201702/mass-mangrove-restoration-driven-good-intentions-offering-limited-results

Global Nature Fund. 2015. Mangrove restoration guide: Best Practices and lessons learned. GNF. Germany
https://www.globalnature.org/en/themes---projects/sustainable-development---development-cooperation/mangroves-i

Lewis & Brown. 2014. Ecological mangrove restoration- a field manual for practitioners. Version 3. 275 p.
http://mangroverestoration.com/pdfs/Final%20PDF%20-20Whole%20EMR%20Manual%20(web)%20(1).pdf

Lewis. 2005. Ecological engineering for successful management and restoration of mangrove forests. Ecol. Eng. 24: 403-418.
http://www.mangroverestoration.com/Ecol_Eng_Mangrove_Rest_Lewis_2005.pdf

The Global Mangrove Alliance has posted many resources on their site.
http://www.mangrovealliance.org/resources/

There are also mangrove papers available for download free: (Please see bottom of the page)
http://www.mangroverestoration.com/

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ATTACHMENT 3: KEY MESSAGES FROM " MANGROVES FOR COASTAL DEFENCE: GUIDELINES FOR COASTAL MANAGERS & POLICY MAKERS"

Source: Spalding M, McIvor AL, Tonneijck FH, Tol S and P van Eijk 2014. *Mangroves for coastal defence. Guidelines for coastal managers & policy makers*. Published by Wetlands International and The Nature Conservancy. 42 p

A Review based on:

McIvor, AL., Möller I., Spencer, T. and Spalding, M. 2012a. Reduction of wind and swell waves by mangroves. Natural Coastal Protection Series: Report 1. Cambridge Coastal Research Unit Working Paper 40. Published by The Nature Conservancy and Wetlands International.

McIvor AL., Spencer, T., Möller, I. and Spalding, M. 2012b. Storm surge reduction by mangroves. Natural Coastal Protection Series: Report 2. Cambridge Coastal Research Unit Working Paper 41. Published by The Nature Conservancy and Wetlands International. ISSN 2050-7941. URL: http://www.naturalcoastalprotection.org/documents/storm-surge-reduction-by-mangroves

McIvor, AL., Spencer, T., Möller I, and Spalding, M. 2013. The response of mangrove soil surface elevation to sea level rise. Natural Coastal Protection Series: Report 3. Cambridge Coastal Research Unit Working Paper 42. Published by The Nature Conservancy and Wetlands International.

KEY MESSAGES FROM THE FOUR SECTIONS OF THE REPORT[13]

Section 1. Is My Shore At Risk?

- Coastal managers need to understand risk in terms of hazard, exposure and vulnerability prior to determining what role mangroves can play
- The importance of mangroves in coastal defence and disaster risk reduction will depend both on the site characteristics and the local hazard context.

Section 2. The Role Of Mangroves In Coastal Risk Reduction

- Wind and swell waves are rapidly reduced as they pass through mangroves, lessening wave damage during storms.
- Wide mangrove belts, **ideally thousands of meters across**, can be effective in reducing the flooding impacts of storm surges occurring during major storms (also called cyclones, typhoons or hurricanes). This can significantly reduce flood extent in low lying areas. **Narrower mangrove belts, hundreds of meters wide,** will still be able to reduce wind speed, the impact of waves on top of the surge and flooding impact to some degree.
- Wide areas of mangroves can reduce tsunami heights, helping to reduce loss of life and damage to property in areas behind mangroves.
- The dense roots of mangroves help to bind and build soils. The above-ground roots slow down water flows, encourage deposition of sediments and reduce erosion.
- Over time mangroves can actively build up soils, increasing the thickness of the mangrove soil, which may be critical as sea level rise accelerates.

Section 3. Managing Mangroves For Coastal Defence

- Mangroves don't always provide a stand-alone solution; they may need to be combined with other risk reduction measures to achieve a desired level of protection. If they are integrated appropriately, mangroves can contribute to risk reduction in almost every coastal setting, ranging from rural to urban and from natural to heavily degraded landscapes.
- For mangroves to optimally contribute to risk reduction, their conservation needs to be incorporated into broader coastal zone management planning: they need to be protected and restored, allowing wise use where possible.
- Mangroves, and their coastal risk reduction function, can recover in most places where appropriate ecological and social conditions are present or restored.

Section 4. Recognizing The Multiple Values Of Mangroves

- Mangroves are among the most valuable ecosystems in the world. Decision makers, and the public, need to take full account of the many benefits that mangroves provide, and consider the true costs that may incur from mangrove loss.
- The benefits offered by mangrove forests include timber & fuel production, productive fishing grounds, carbon storage, enhanced tourism and recreation, and water purification.

[13] See also Table 1 section 0