Working group sessions on developing "Diagnostic Tools"

Four working group sessions were held in parallel to develop "diagnostic tools" to assist in identification of situations under which forests and trees would be suitable to protect coastal areas against (i) tsunamis, (ii) cyclones, (iii) coastal erosion and (iv) wind and salt spray. Groups were asked to assume the roles of experts called upon to develop a tool to assist coastal planners in deciding where trees could be planted to protect a coastline from one of the other four natural hazards. The steps suggested to construct the tool were as follows:

1. Identify the various criteria/conditions that can influence whether or not it makes sense to use trees in coastal protection;
2. Roughly sequence these on the basis of importance and the level of information likely to be available;
3. Put the criteria/conditions into dichotomous format;
4. Test the criteria/conditions for a specific set of circumstances (e.g. an urban area, a rural coastline, a bay, a headland or a specific location/s known to group members) and adjust the tool accordingly.

Suggestions were made for possible initial criteria/conditions as follows:

- is the coastline affected by the natural hazard?
- is existing coastal protection present?
- are there populations or assets present that should be protected?

Criteria/conditions appearing further into the diagnostic tool were suggested as follows:

- is space available to establish trees?
- is funding available to establish trees?
- are other forms of coastal protection more appropriate?

The point was made that in a proportion of cases, the appropriateness of trees or forests for coastal protection may depend on several factors that must be weighed against one another. Further quantification, analyses or assessments could also be required and, in such cases, it was suggested that relevant comments be recorded. In cases where specific information on the capacity of trees/forests to protect against a specific hazard was unknown it was suggested that required information be noted.

Tsunami working group results

The tsunami working group began with the same objectives as the other groups but in spite of the concerted efforts all members, the meeting ended in deadlock with little movement towards the objectives owing to fundamental disagreement over the validity of the question. Several opposing points of view fielded by different sections and individuals were involved. These can be summarised as follows:

- Physicists and engineers ready to entertain the question given there is no reason to deny the notion that obstacles such as trees could modify the motion of tsunami waves and potentially provide protection for people and assets.
- Pragmatists unwilling to concede that planting mangroves and other coastal forests could be proposed as a serious solution to alleviate damage from tsunamis – trees take years to grow, occupy valuable space and the return period for tsunamis may be 200 years in much of the Indian Ocean.
- Sceptics, who did not think that the scientific evidence for tree and forests protecting against tsunamis was strong enough to support planting for this reason.

- Field based practitioners with funding to plant trees in coastal areas who, because their mandate removed several of the aforementioned obstacles, reasoned that if trees could provide even a limited degree of protection then so much the better.
- Those believing that trees are good in all areas and at all times, and therefore that it is inherently "good" to plant whenever and wherever possible.

Other points noted, included the following:

Limitations on using trees and forests as coastal protection:

- Coastal greenbelts cannot provide complete protection.
- Tsunamis rarely strike areas where *mangrove* forests occur;
- Land would have to be available and people would have to be prepared to live behind the forest for greenbelts to be proposed as a protective measure;
- Trees and forests are not relevant where the shore is steeply sloping.
- Trees and forests are less relevant where local bathymetry provides protection or where other means of protection are present.
- Exposed high risk areas are often the most attractive for development and in such cases trees and forests are not appropriate to provide protection.
- Governance structures and institutions are frequently unable to enforce regulations governing construction in green belts.

Interactions between trees/forests and tsunamis:

- Although trees can significantly slow a tsunami, flooding can still occur;
- Although a porous barrier can reduce the height of a tsunami, the speed of flow may increase.
- Trees and forest are likely to reduce the penetration of water inland as the period of tsunami waves is in the same order as the time it takes a wave to travel across a few hundred metres of land.
- Gaps and channels through vegetation can increase the intensity of a tsunami as a result of funnelling of waves and intensification of backwash. The frequent presence of habitation along such channels may amplify catastrophic effects (river gates may provide protection).
- Larger tsunamis are overwhelming and trees and forests would not provide protection in these cases. For smaller tsunamis a wide belt of vegetation may provide protection; width estimates vary between 20 and 100m.
- Tsunamis can break trees that form projectiles although the possibility of broken trees acting as projectiles should not be a relevant given that evacuation from danger areas should be the priority.
- Broken trees and branches can become lodged in vegetation and provide greater resistance against passage of water.
- Trees with strong roots and trunks are likely to provide the most effective resistance to tsunamis and undergrowth also slows the advance of water.
- Reef maintenance, dune protection and protection and establishment of other protective structures should be considered in addition to possible establishment/protection of trees and forests.

The wealth of information and view points make summary problematic. Overall, the consensus during the workshop was that trees and forests *can* provide protection against tsunamis. The main questions therefore revolve around the quantity and quality of forest necessary to provide protection against a tsunami under a set of local conditions and whether the result can be implemented under prevailing socio-economic conditions. To make the diagnostic tool operational, and not withstanding questions of feasibility, it would be necessary to bring together detailed information quantifying the physical parameters that define the effectiveness of trees and forests in protecting

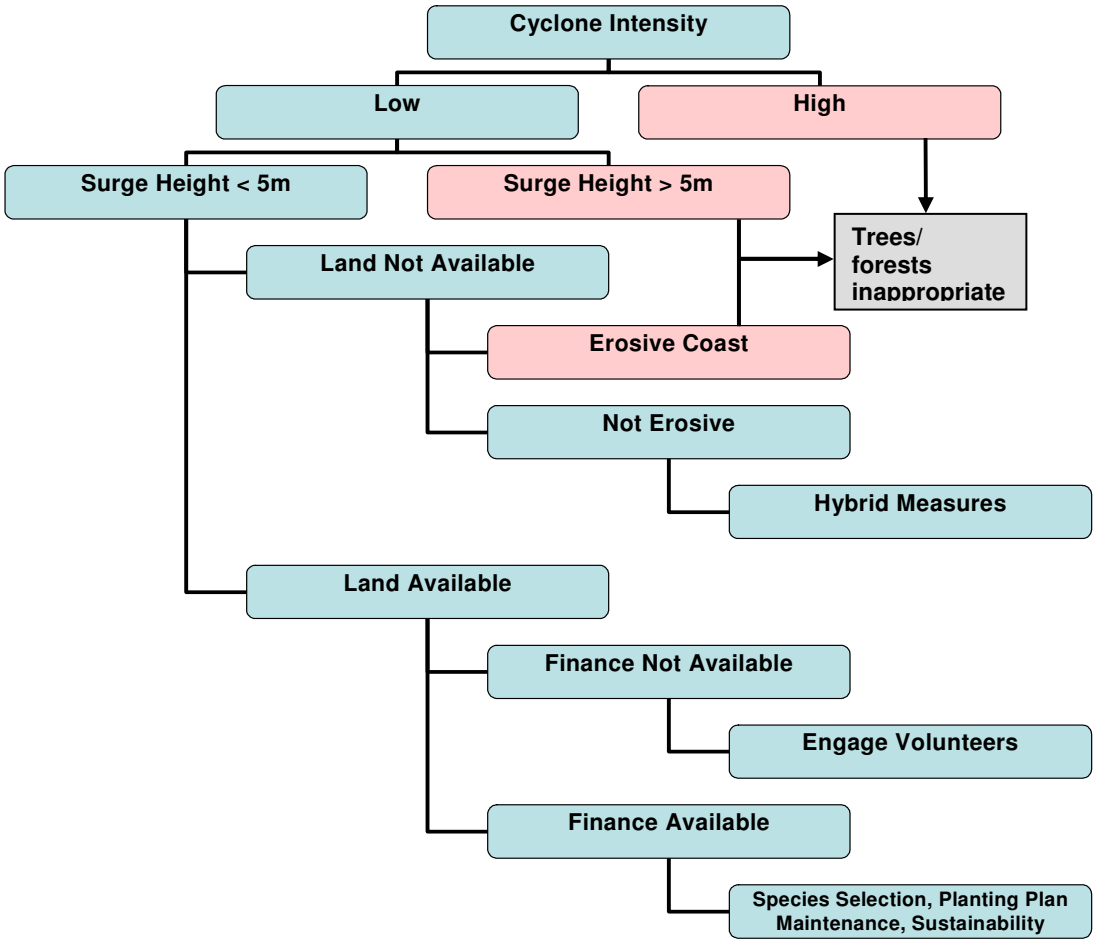
against tsunamis. With this basic information could then be applied at the local level prior to implementation of analyses to assess environmental, social and economic costs and benefits of trees and forests in comparison with other forms of coastal protection.

Cyclone working group results

The diagnostic tool developed by the cyclone group is shown below. The key decisions relate to the size of the expected storm surge. If the surge is expected to be above 5 metres, other measures should be taken as trees and forests will have little impact on influxes of water of this magnitude. A further important point is that, where coasts are eroding, trees will not secure the coastline in the long-term and engineered measures are required. This point also relates more generally to the other coastal hazards. Other key points relating the potential protection provided by trees and forests against cyclones were recorded as follow:

- Trees should only be considered appropriate protection against the effects of cyclones for low intensity storms;
- During cyclones, water kills an order of magnitude more people that wind;
- If the coastal bathymetry is predominantly shallow, the storm surge is greater;
- Barrier islands, although protecting against tsunamis, do not affect cyclone related surges;
- Although a depth of around 10 km of mangroves is required to protect against cyclones, they *can* provide protection, as in the case of the Sunderbarns.
- Penetration of flood water cannot be stopped by trees and flood levels may remain for a day;
- Storm waves related to cyclone winds can be attenuated by trees;
- Cyclones and tsunamis do not usually affect the same areas.

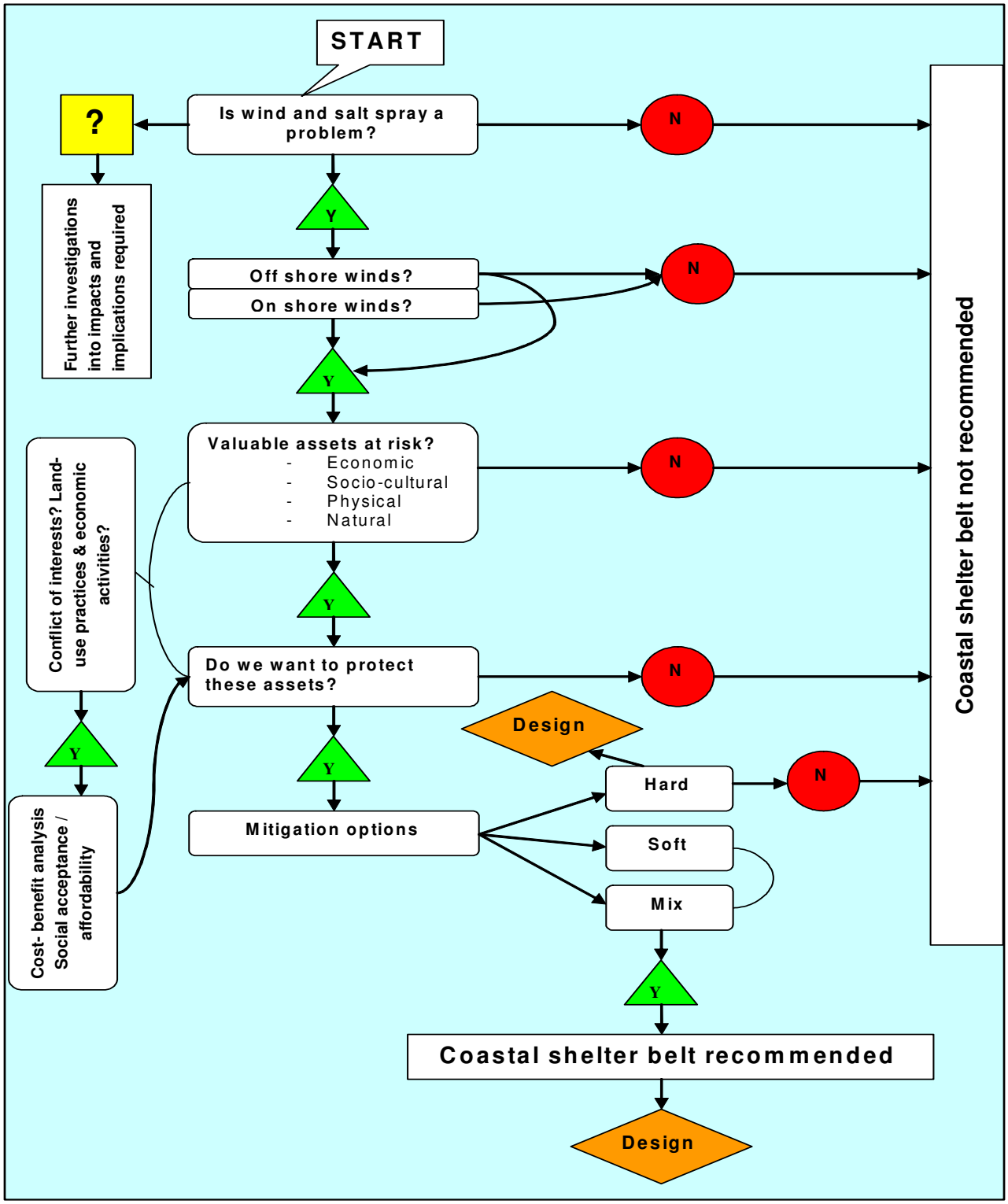
A major misapprehension concerning the effects of cyclones is that wind is the main danger to life. As recorded above, water kills many more people than wind and this has important repercussions on the protective functions of trees and forests. Because flood levels are likely to remain for a day or more, porous structures such as forests will not prevent influx of water. They will, however, attenuate wind driven waves. Given these observations, it is the clear that a broad breadth of tree cover would be necessary to provide protection from cyclones. It is commonly held, for example, that the Sunderbarns in Bangladesh provide cyclone protection and recent data from Orissa, India indicate that a 0.5 km band of mangroves protects lives with a statistical confidence level of 95% whereas a 1.5 km strip protects lives with a confidence level of 99% (Saudamini Das, unpublished data). Further data is likely to emerge to further inform the area but with the large areas of land required for tree planting appropriate for protection of people and assets, it would be more likely that the above arguments would be used in calls for conservation rather than establishment of forests.



Wind and salt spray working group results

The diagnostic tool developed for wind and salt spray followed a similar approach to that adopted by the cyclone group. Information required for the tool relating specifically to wind and salt spray included the nature of local wind, whereby coastal shelterbelts would only be appropriate where on-shore winds occurred. It was also noted that trees used should be deep rooted to enable water uptake and to provide adequate support in sandy soils and that they should also be sturdy and salt resistant.

Further information could be included in the tool to specify the degree to which salt spray and wind effects could be alleviated using shelterbelts and also the area over which benefits would be experienced. It should be noted in this context that salt may be suspended throughout the boundary layer and transported inland. Larger crystals of salt are likely to fall out of the air mass under less turbulent conditions but smaller particles may be carried far inland. Therefore the effects of costal shelterbelts maybe fairly localised and it is tree planting would probably be best targeted at protecting specific valuable structures or assets. For additional information see Tackle (this volume).


START
Is wind and salt spray a problem?
?
Further investigations into impacts and implications required
N
Y
Off shore winds?
On shore winds?
N
Y
Valuable assets at risk?
- Economic
- Socio-cultural
- Physical
- Natural
N
Y
Conflict of interests? Land-use practices & economic activities?
Do we want to protect these assets?
N
Y
Y
Design
Hard
N
Mitigation options
Soft
Mix
Cost- benefit analysis Social acceptance / affordability
Y
Coastal shelter belt recommended
Design
Coastal shelter belt not recommended

Coastal erosion working group results

The coastal erosion group developed a tool based on a coastal protection strategy including possible short- and long-term measures in combination with prioritisation of areas according to the severity of erosion. The group agreed that economic, environmental, social and cultural values are likely to be the subject of protection from coastal erosion and that national governments should determine priorities, depending on their specific situations.

In the short-term, it was put forward that engineering solutions should be targeted at critical areas, according to a prioritisation of all areas. In the long-term, guidelines, shoreline management plans within ICZM initiatives and coastal laws should be developed to support short term measures and overall aims. Areas are categorised to facilitate prioritization, as follows

- **Critical** – erosion is serious and is immediately threatening (i) property and human activity of high economic value (ii) sensitive irreplaceable ecological systems;
- **Significant** – erosion serious, entities same as above will be threatened in 5 years or more if nothing is done (the situation will become critical);
- **Acceptable** – erosion affecting areas with no economic, ecological or heritage value.

According to this prioritisation, critical and significant erosion areas first are protected first to prevent loss of land, natural resources and heritage, to avoid displacement of population and to maintain/improve tourism value.

Once consensus is reached on areas in which protection is needed, processes are initiated to consult local residents and stakeholders, collect and analyse data and develop understanding of erosion and key coastal processes in the area. Following this process, available options, including hard engineering, soft engineering, reforestation and combined measures are considered for a period according to the urgency of the situation, with critical situations requiring more immediate action. Points considered include:

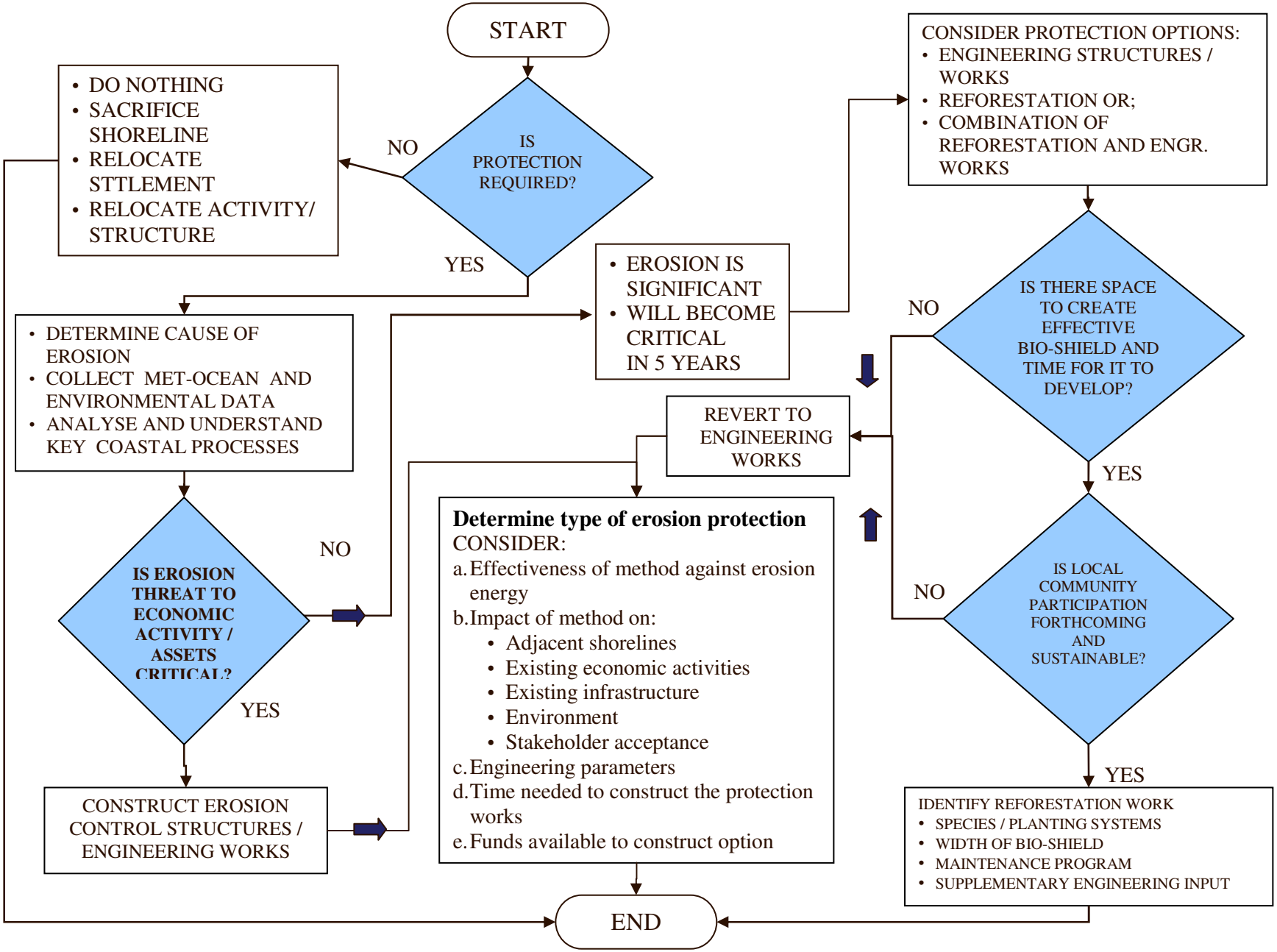
- The effectiveness of each option in overcoming/reducing the threat,
- Socio-economic and environmental impacts of each option (hard engineering structures generally cause more serious environmental impact than soft solutions);
- Engineering parameters (hydraulics/hydrodynamics, geotechnical matters, construction materials/technique);
- Time needed for construction;
- Funds available.

In summary it was noted that reforestation is not for all areas and the following are requisite:

- Sufficient time frame,
- Local participation,
- Available space.

Following this assessment, an identification of minimal data requirements for reforestation is carried out and reviews are undertaken by experts at critical decision making stages throughout the process. A note was made that the tool focuses on continental coastlines and mangroves and that small islands require different approaches and considerations as environmental conditions and guiding principles are different.

Little information was included in the diagnostic tool on the circumstances under which trees could be suitable for arresting or reversing coastal erosion. In relation, it should be noted that trees may not slow the pace of erosion at all on naturally eroding coastlines, and therefore local circumstances should be reviewed before decisions are made.


START
IS PROTECTION REQUIRED?
NO
YES
• DO NOTHING
• SACRIFICE SHORELINE
• RELOCATE STTLEMENT
• RELOCATE ACTIVITY/ STRUCTURE
• DETERMINE CAUSE OF EROSION
• COLLECT MET-OCEAN AND ENVIRONMENTAL DATA
• ANALYSE AND UNDERSTAND KEY COASTAL PROCESSES
IS EROSION THREAT TO ECONOMIC ACTIVITY / ASSETS CRITICAL?
NO
YES
CONSTRUCT EROSION CONTROL STRUCTURES / ENGINEERING WORKS
• EROSION IS SIGNIFICANT
• WILL BECOME CRITICAL IN 5 YEARS
CONSIDER PROTECTION OPTIONS:
• ENGINEERING STRUCTURES / WORKS
• REFORESTATION OR;
• COMBINATION OF REFORESTATION AND ENGR. WORKS
IS THERE SPACE TO CREATE EFFECTIVE BIO-SHIELD AND TIME FOR IT TO DEVELOP?
NO
YES
REVERT TO ENGINEERING WORKS
IS LOCAL COMMUNITY PARTICIPATION FORTHCOMING AND SUSTAINABLE?
NO
YES
Determine type of erosion protection
CONSIDER:
a. Effectiveness of method against erosion energy
b. Impact of method on:
• Adjacent shorelines
• Existing economic activities
• Existing infrastructure
• Environment
• Stakeholder acceptance
c. Engineering parameters
d. Time needed to construct the protection works
e. Funds available to construct option
IDENTIFY REFORESTATION WORK
• SPECIES / PLANTING SYSTEMS
• WIDTH OF BIO-SHIELD
• MAINTENANCE PROGRAM
• SUPPLEMENTARY ENGINEERING INPUT
END

Conclusions and further refinements

A number of elements contained in each diagnostic tools were generic and could be used for a variety of coastal hazards with minor adjustments made to accommodate technical information. The following questions were central:

1. What is the coastal hazard?
2. Are valuable assets at risk?
3. Are trees effective in protecting against the type and intensity of hazard expected?
4. Is the coast undergoing erosion?
5. Is land available in terms of area and possible lost opportunity costs?
6. Are finances available to establish trees?
7. Are different types of protection more environmentally or socially preferable?
8. Do trees or forests offer comparative advantages over other types of structure in terms of protective capacity, cost, environmental benefits or social benefits?

To further develop and operationalize these diagnostic tools a greater level of technical detail is required to quantitatively define the relationships underlying points 2 and 8 above. This information has proved not to be available in forms readily accessible to foresters and policy makers but discussions during the workshop indicated that there is further information available to quantify the degree to which a trees can protect against a coastal hazard under given sets of coastal conditions. A number of the technical experts present at the workshop supported follow-up work to unearth, consolidate and make public such information and by doing so resolve some of the controversy over the protective capacity of trees and forests – especially in relation to tsunamis.