UNDP
India

STATUS OF COASTAL HABITATS

Learnings from the Post Tsunami Environment Initiative of UNDP

FERAL

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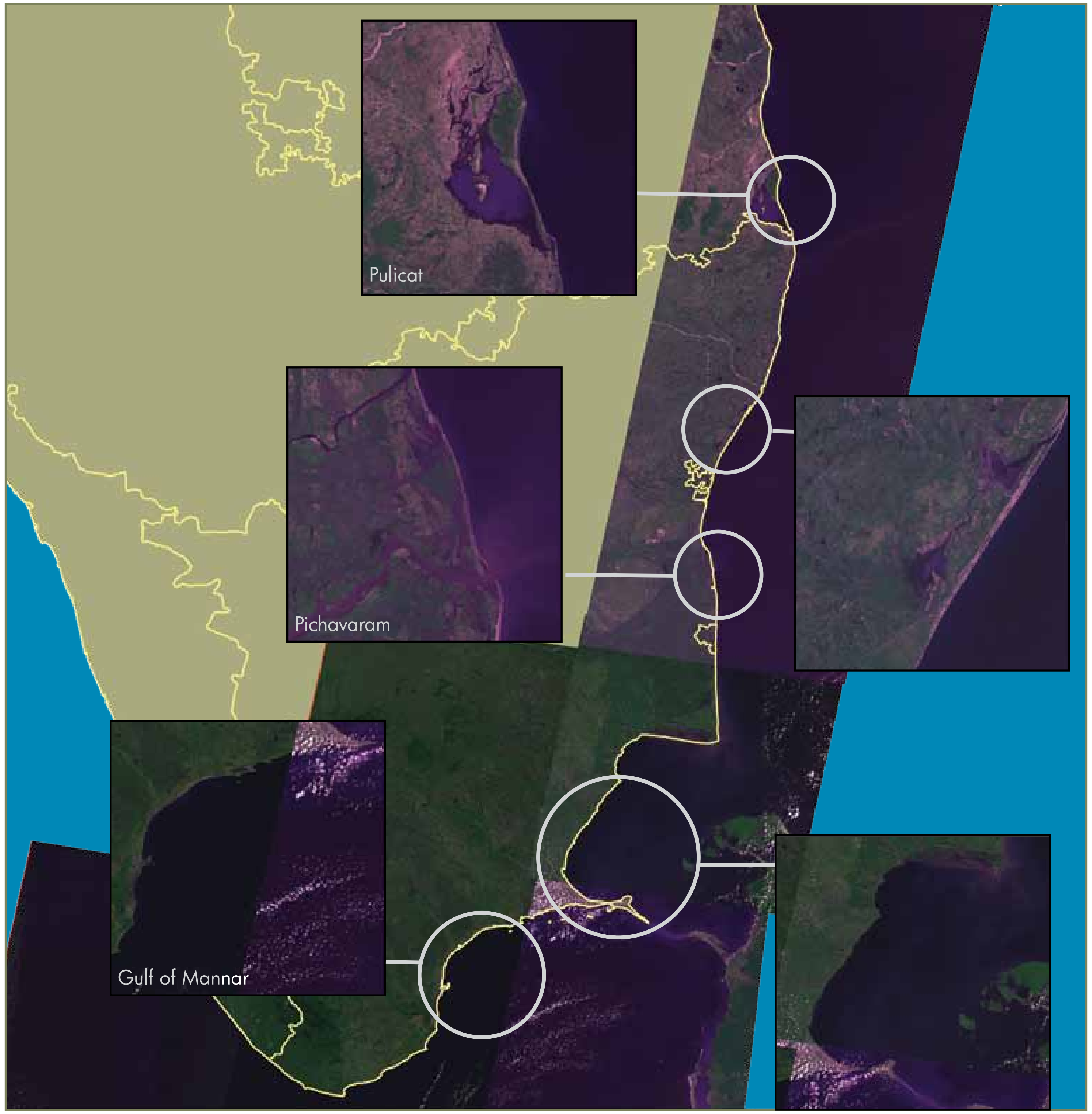
Contents

Map of Area



Context

The tsunami that struck the Indian coast on December 26, 2004 devastated populations along the coast and impacted the natural coastal systems in a manner never experienced before. The large-scale destruction of habitations, coastal infrastructure and human casualties evoked an immediate humanitarian response. Subsequently, there were growing concerns regarding the extent of the impact of this extreme event on these fragile coastal habitats. The UNTRS/UNDP formed the Post Tsunami Environment Initiative (PTEI) to address these concerns.

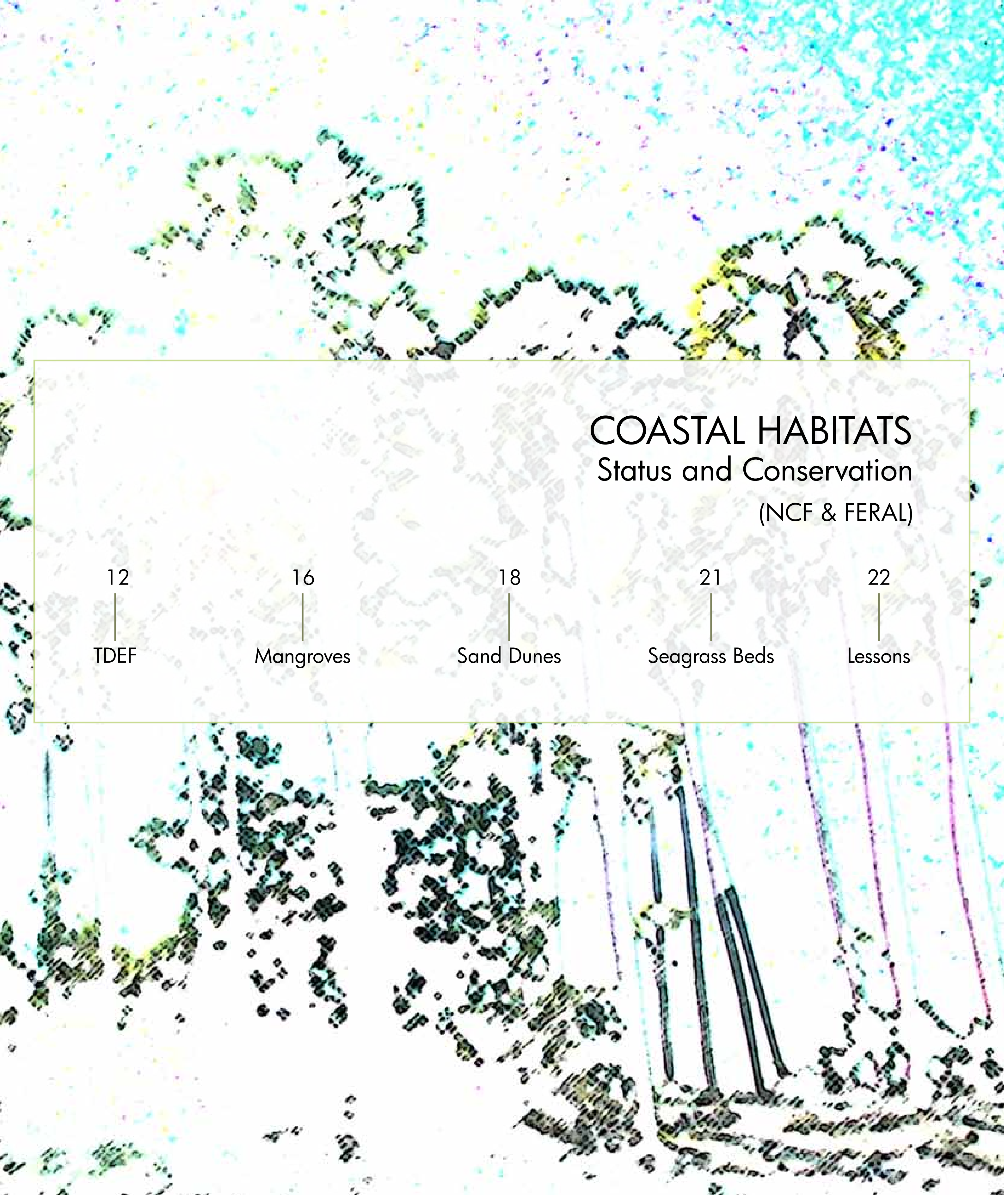
As the relief phase progressed towards rehabilitation, it was evident that environmental impacts and their effect on coastal communities, both in the short and long-term, needed to be assessed. The consequences of the rehabilitation efforts themselves on the natural resilience of ecological and social systems were questioned. This was even more imperative given that coastal landscapes have remained poorly understood. Despite the diversity of terrestrial and aquatic habitats along the coast, there have been very few studies on them, and there was an acute deficiency of baselines and reliable information about their status, resources, extent and the dependence of local communities on these. Additionally, these habitats have been under tremendous anthropogenic pressure in the last few decades.

The PTEI aimed to identify the many issues that were influencing the coastline and establish a preliminary level understanding of the ecological and sociological impacts, while identifying the information gaps on marine and coastal systems. As the programme developed, these issues were also analysed in the context of rapid coastal development, increasing resource needs and changing legislative mechanisms.

The tsunami, while undoubtedly tragic, provided an unprecedented opportunity to evaluate the status and changes of coastal systems and assess the vulnerabilities caused by these changes. Focussed studies were carried out on the social impacts of the tsunami, the fisheries sector and each type of coastal habitat – mangroves, sand dunes, estuaries, coastal forests, coral reefs and seagrass ecosystems, to address the issue of overall resilience of coastal landscapes and populations.

Three agencies partnered in this effort: Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore; Foundation for Ecological Research Advocacy and Learning (FERAL), Pondicherry and Nature Conservation Foundation (NCF), Mysore.

This document attempts to put together a snapshot of the important findings and learnings of the detailed assessments, as well as the monitoring and restoration activities that were implemented through the PTEI.



COASTAL HABITATS
Status and Conservation
(NCF & FERAL)

Status and Conservation

Coastal regions are complex habitats that reflect the interaction between land and marine systems. They function both as a filter system and as a protective buffer. They are important for biological and economic productivity, work as storm barriers, help erosion control and provide breeding grounds for marine species. They also play a vital role in reducing vulnerabilities of coastal communities and provide essential resources. These regions are among the most threatened in the world due to increased pressures from a wide range of anthropogenic activities. The inherently dynamic nature of these systems and their dependence on materials and flow from adjacent systems makes them vulnerable to changes from within and without. Monitoring these changes, addressing the factors causing them and developing effective methods of restoring affected areas are therefore imperative along the coast.

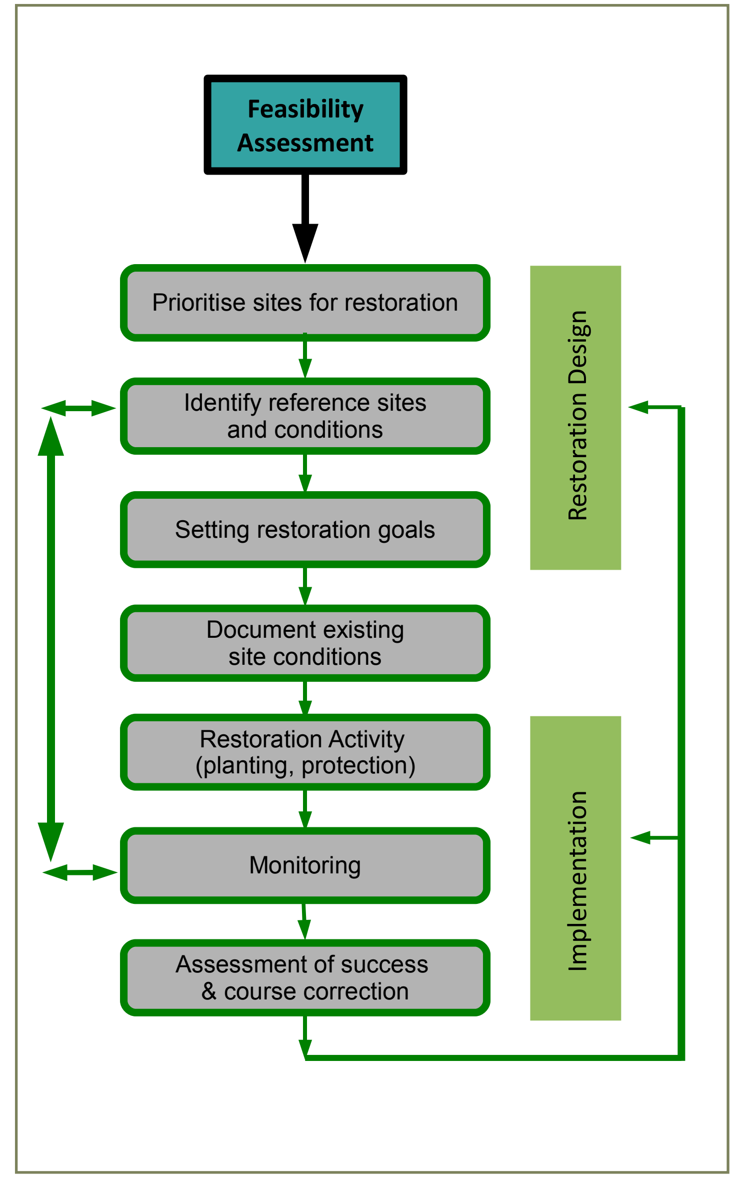
The focus of activities in coastal habitats was an attempt to determine these factors, their impact on ecosystems and coastal communities and assist in the recovery of degraded habitats.

Restoration Protocols

Restoration ecology is a relatively new multidisciplinary science, although the practice has been followed for many decades. Several overlapping factors drive restoration projects and the protocols for such efforts have been synthesised from different sources. These attempt to incorporate the various conceptual models such as landscape, community assemblage, ecological succession, etc. with an aim to maximise the likelihood of achieving restoration goals.

Challenges to restoration include the magnitude and scale, economic and social costs of such activities and the likelihood of these restored sites being sustained in the future. Conceptual challenges at the stage of design include:

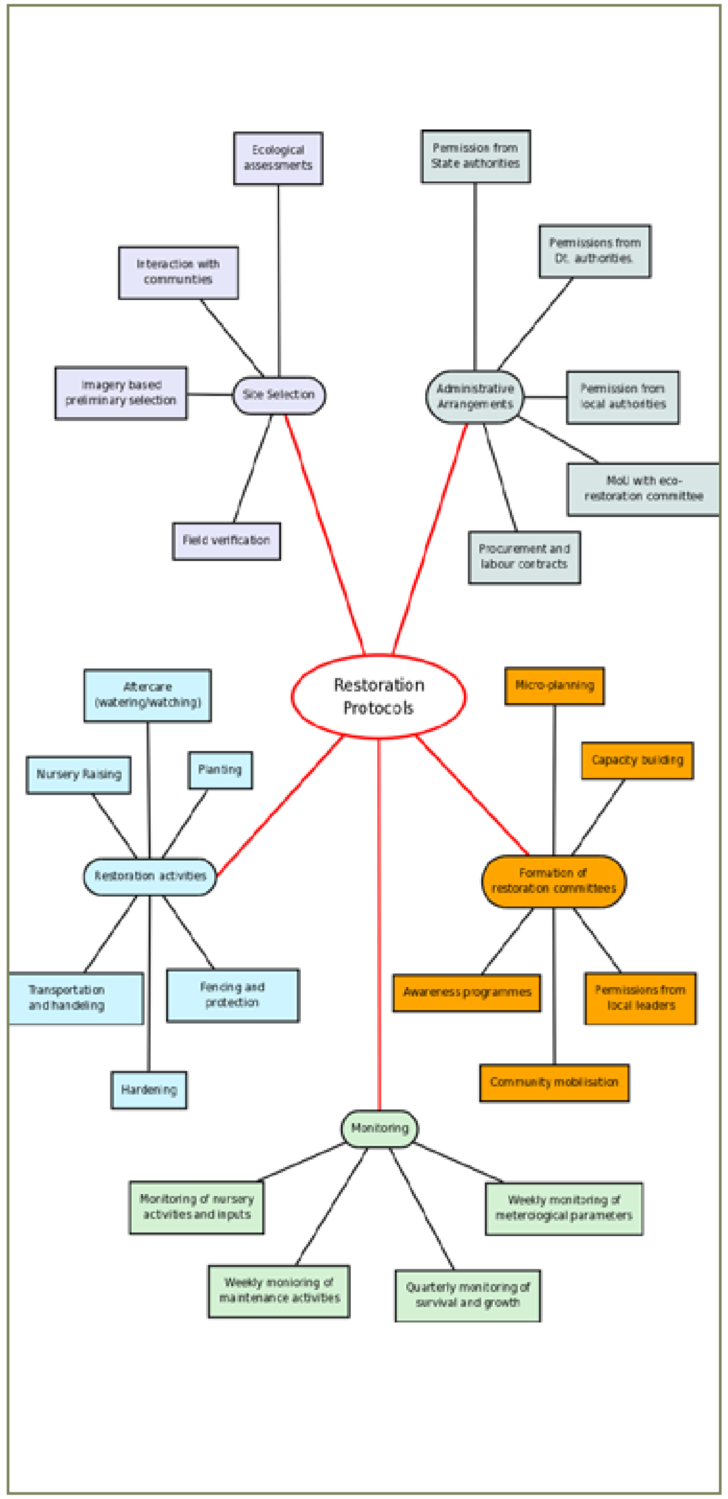
- Arbitrariness in determining which time period in the past should be the target of restoration efforts.
- An implication of finality with the word "restored", while nature itself does not remain static.
- True restoration is not possible, given changes in climate, absence of keystone species or presence of new species.
- Goal setting is often determined by preconceptions or misconceptions which lay more emphasis on "what might have been".



Protocols for restoration adapted from Nature Conservation Foundation and Vattakanal Trust, (2006) and Clewell et.al., (2005) The project adopted the following strategies with a focus on interventions that would increase awareness of the value of the habitats, while taking into consideration how they could be protected and restored. All these efforts were aimed at non-forest areas, controlled and managed by local communities. Broad scale site selection was done using GIS and remote sensing, followed by ecological and social surveys to identify specific locations. The strategy for restoration included:

- Experimenting with low cost techniques and keeping maintenance costs low
- Community mobilisation, negotiations and formation of eco-restoration committees, which ultimately took over the maintenance of the sites - this was a community based initiative
- Flexible administrative arrangements in keeping with the numerous configurations of site ownership and control that were encountered
- Monitoring of survival, growth and environmental parameters after planting to provide inputs into management strategies and species performance

This approach meant that the project consciously looked at constant evaluation of efforts and allowed for mid-course correction in implementation of activities. While this increased the challenges of implementation, the benefits were in ensuring that activities had the maximum potential impact.



Diagrammatic representation of protocols followed during restoration activities

TDEF

Importance

The Coromandel Coast is covered along its length by a unique forest type – Tropical Dry Evergreen Forest or TDEF. This form of vegetation existed historically as a 30 to 50 km wide belt from Vishakapatnam to Ramanathapuram in the south. The composition of vegetation in these patches is driven by the climatic pattern of the area, which is distinguished by its inconsistency. One of the main influences is rainfall, wherein intensity, amounts and distribution are quite varied both within and between years. These forests are short-stature, largely three-layer, tree-dominated evergreen forests with a sparse and patchy ground flora.

Only about 4 – 5% of the original TDEF areas are estimated to exist today. At present, they survive as patches along the coast, the majority of which are in the form of "scared groves" or "temple forests". The large number of species – flora and fauna – recorded across different sites in the available published literature gives an idea of the species richness in these areas. Although many of these forest patches are in close proximity to each other, there is considerable variation in the species composition observed across sites. In terms of fauna, a checklist of animals includes 36 species of mammals, 29 species of reptiles and about 80 species of birds. These fragments play an important ecological role in acting as repositories of biological specimens and are believed to contribute towards maintaining regional biodiversity by augmenting regional populations.

Forests in India are managed through any one of several schemas that differ in their levels of protection and accessibility to local communities for resource use. These include the category of Community Forests allowing the maximum use, with the majority of TDEF falling under it. Traditional beliefs and cultural taboos of communities in relation to these forests have also played a major role in their survival. The east coast is a highly populated and rapidly developing region. These forests are disappearing at a rapid pace, with the most significant factor being conversion of land use to agriculture, pasture or urbanisation. The erosion of traditional management systems and the changing cultural outlook of current generations have also taken their toll.

The Work Done

The PTEI programme focus was to demonstrate strategies to revive these habitats within the socio-economic and environmental realities along the coastal

Site	Area (hectares)	No. of Species
Point Calimere	2400 ha	200 dicots, 317 flowering plants (Balasubramanian and Bole, 1993; Blasco and Legris, 1972)
Kunzhanthaik-uppam	1.2 ha	54 (woody species ≥ 10cm GBH, sites combined) (Parthasarthy and Karthikey-an, 1997)
Thirumanikuzhi	1.6 ha	54 (woody species ≥ 10cm GBH, sites combined) (Parthasarthy and Karthikey-an, 1997)
Puthupet	14 ha	51 (woody species ≥ 10cm GBH, sites combined) (Parthasarthy and Sethi, 1997)
Arasadikuppam	1.5 ha	31 (woody species ≥ 10cm GBH, sites combined) (Venkateswaran and Par-thasarathy, 2003)
Oorani	1.8 ha	30 (woody species ≥ 10cm GBH, sites combined) (Venkateswaran and Par-thasarathy, 2003)

Number of TDEF species recorded from different sites

TDEF patch at Kothattai

regions. A selection process was developed to take these factors into account and help in decision making towards effective restoration activities. Criteria evolved covered spatial attributes, social data and ecological parameters. Several studies have covered climate, edaphic factors and inventories of species, but these have been restricted to a few sites. Administrative aspects in terms of ownership and control have also not been documented.

Information on presence and location of TDEF sites along the Coromandel Coast was determined from existing literature, with surveys restricted to within 25 km from the coast. Information on ownership, control, extent, baseline ecological information and level of anthropogenic disturbances was collected. A ranking matrix using these criteria provided the basis for a final selection of sites surveyed. Seventy-six TDEF patches were surveyed, from which a final list of three was identified for carrying out the restoration activities.

Data Parameter	Weightage Provided
Area of the patch (Ha)	25
Perimeter (m)	1
Perimeter/Area ratio	2
Distance from sea (km)	1
Community participation	20
Data parameter	1
Average canopy height (m)	1
Mean number of seedlings	1
Mean number of saplings	2
Mean number of cut stems	2
Site basal area	1
Species richness (number of species)	4

Weighting factor given to criteria

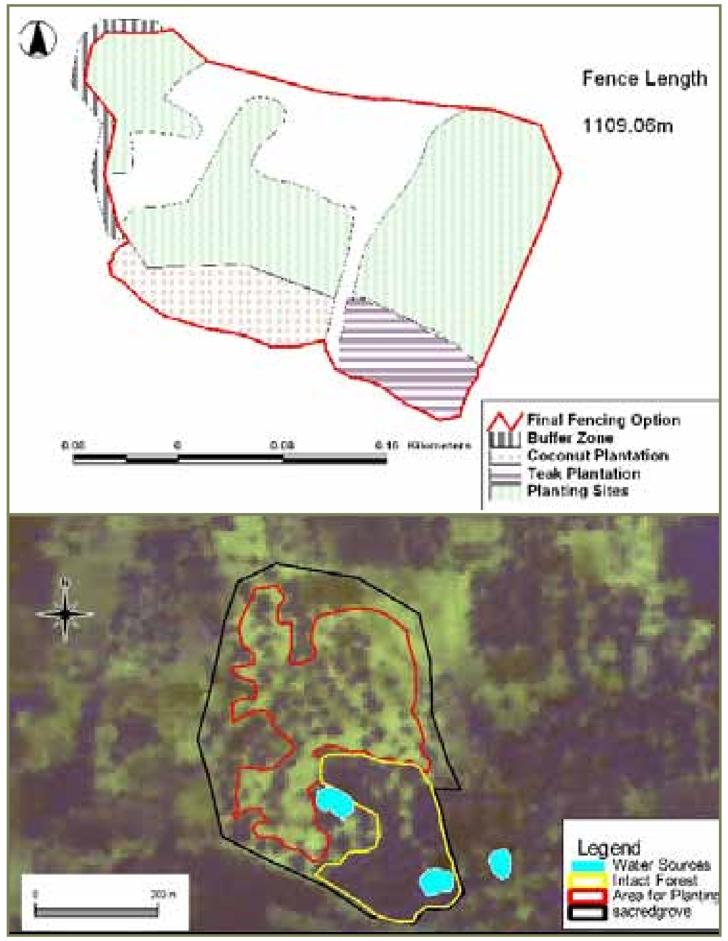
Scores for different criteria for site selection

Selection Criteria and Rules Where Applicable	Scoring Factor	Score
LOGISTICAL		
Presence of TDEF patch	Yes	1
	No	0
Presence of a TDEF or a sand dune patch at site was a requirement		
ADMINISTRATIVE		
Land ownership	Temple	1
	Revenue land	0.5
	Patta	1
	Forest Dept	0.2
Ranking order favoured temple/putta lands because it is easier to get permission and therefore forest areas areas were ranked lowest.		
Control	Temple	0.8
	Panchayat	1
	Private	0.5
	Forest Dept	0.1
	Temple endowment authority	0.2
	Fisheries Panchayat	0.2
Ranking order favoured Panchayats as they are democratically elected bodies. Privately or temple controlled areas are prone to unilateral decisions on removal of forest cover.		
Permission by controlling authority to take up restoration	Yes	1
	No	0.1
	Tentative, pending confirmation / ratification by others	0.25
Area available for restoration	Yes	1
	No	0
This refers to the presence or absence of area to restore not the extent of the area itself.		
SOCIAL		
Community participation	Yes	1
	No	0
Women Self Help Groups (SHG)	Present	1
	Absent	0.9
Pressures on patches are from low intensity but continuous use/extraction by the local community. Their involvement and willingness to protect the patch was crucial. Having existing community based organisations facilitated mobilisation and routing work to persons below the poverty line and representing weaker sections.		
PHYSICAL ATTRIBUTES OF THE PATCH		
Size of patch: Larger patches were assigned a higher score as probability of restoration success for larger patches will be greater		1/ha
Distance from coast (km): Given that the project objectives were limited to coastal and tsunami affected areas, this criteria has been included; sites further away from the coastline got a smaller score than those closer to the coast.	Inverse of distance	1/distance from sea

Planting at sites was accomplished after restoration plans were discussed and ratified by the local community members. The plans included identification of the specific area to be restored, species composition, fencing needs and provision for watering and watching. These micro-planning sessions paved the way for better local participation and ownership of the project and were instrumental to the success of the restoration activities.

Micro-planning sessions such as this one, formed the core of the community mobilisation and participatory planning done prior to physical activities. The resulting plans were the basis for a formal MoU between restoration communities and FERAL and guided the activities taken up at each site.

Planting and fencing was completed in two of the selected sites. A third site was discontinued because of internal conflicts regarding the use of the area identified for restoration. Shallow auger wells were dug at the planted sites to ensure watering, and watchmen were hired who assisted in the monitoring of sites. Fencing played a fundamental role in the long-term protection of the sites from grazing and trampling.



Restoration plans for the selected sites; Vadagaram (top) and Kothattai (bottom)

Results

The TDEF patches are managed by prominent members of the community, along with local temple authorities in some cases. Consultations with the different stakeholders proved to be essential in arriving at a consensus. This was particularly noticeable during decision making with regard to after-care agreements, persons to be hired for implementation and especially in the case of awarding fencing contracts. Planting had to occur during the monsoon to ensure that newly planted saplings experienced the least possible amount of water and heat stress. This meant that the women hired for planting had to work in difficult conditions. Organising required labour at the right time was a constant challenge.

MANGROVES

Importance

Mangroves are recognised as one of the most productive systems in coastal habitats, supporting a vast array of flora and fauna. These systems are the source of a wide range of ecological goods and services, and they provide primary livelihood options to many dependent coastal communities. They are also among the most threatened, owing to pressure from dense coastal populations and alterations in river flows which affect inflow of fresh water, nutrients and sediments. Indian mangroves account for about 5% of the mangroves in the world with Sunderbans in West Bengal accounting for half of this. Along the Coromandel Coast, the protected forests of Pichavaram and Muthupet form the bulk of the area under mangroves, yet they account for a meagre 2.5% of total mangrove forest coverage along the east coast of India. Outside these protected areas, they survive as small strips of remnant vegetation along the numerous backwaters and estuaries. They are dominated by a single species, Avicennia marina.

While mangroves in the Andaman Islands experienced large-scale damage, those on the coast of Tamil Nadu were not seriously affected. A few trees (10 to 400 at different sites) were reported to have been uprooted, newly planted saplings were washed away in some places and the observed increase in soil salinity returned to normal after subsequent monsoon floods. Restoration efforts were taken up with renewed vigour by the Forest Department and local NGOs after the 2004 tsunami. Forty-four sites were covered in a preliminary survey with basic environmental parameters such as species composition and canopy height recorded. Administrative frameworks at each site were examined, and this was a significant factor in the final selection of sites.

The Work Done

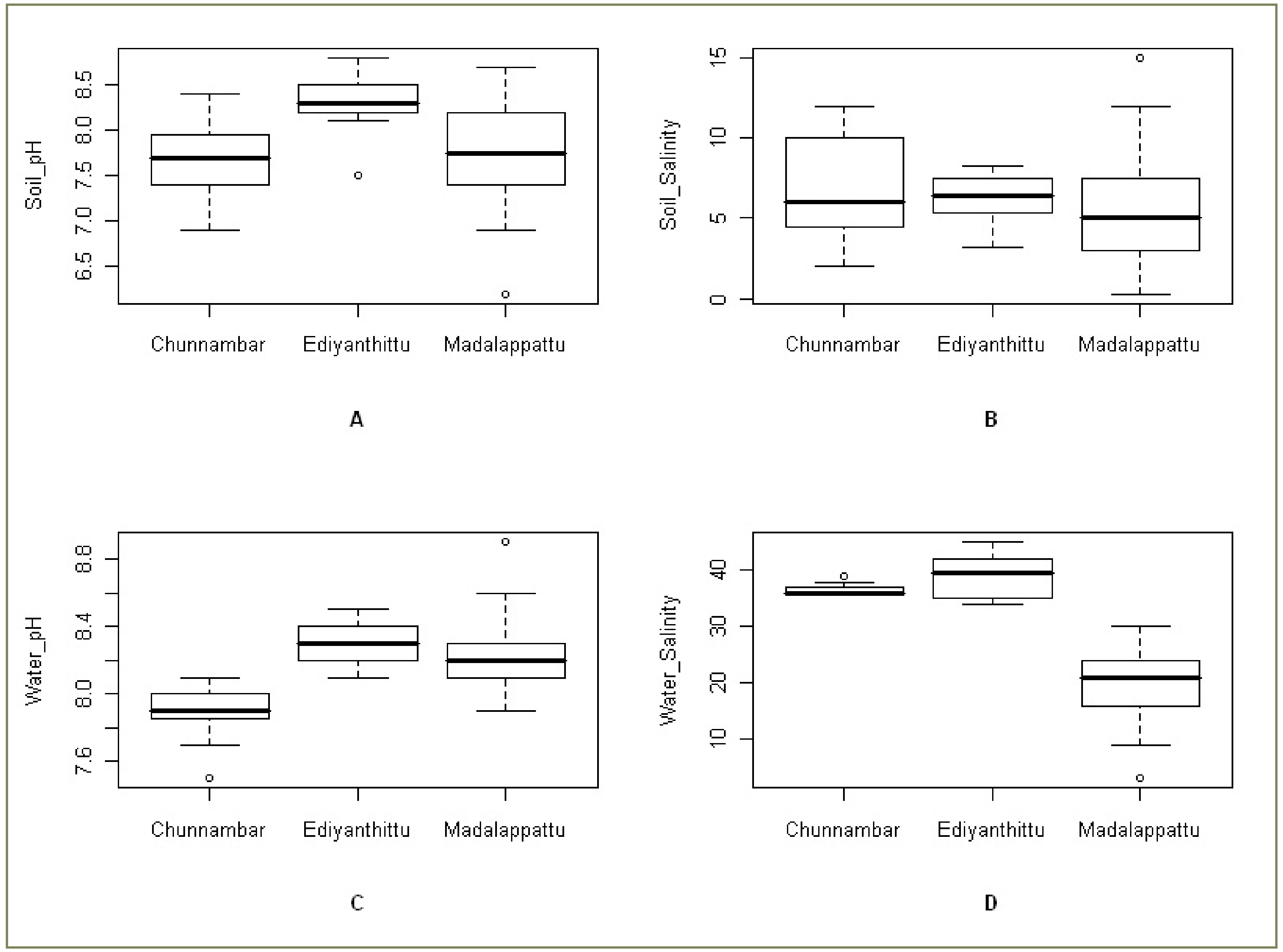
The project identified several sites suitable for restoration; however, many of these tracts were either under intense pressure for conversion into shrimp farms or considered to be important grazing grounds. Of the six sites short-listed, the full range of activities was carried out in only two, as permission did not materialise for the others during the final stage of negotiations.

Mangrove physiology, growth and placement can be affected by variables such as water salinity, soil pH, available nutrients, and tides. Changes and fluctuations in each of these have a resultant impact on distribution and species composition of mangrove systems. Soil and water quality analysis, both physical and chemical, was done at each of the sites. Soil pH did not differ significantly between sites, while water pH did. Salinity levels recorded were between 24 – 36 ppt for water, and these were probably at their highest, given that sampling took place during the hottest and driest months of the year. On final evaluation, each site offered tolerable salinity levels, neutral pH, and a sandy loam soil mixture that was suitable for planting common mangrove species.

Restoration activities focussed on removal of exotic weeds, mainly Prosopis sp., restoring tidal movements through digging channels, planting locally available propagules as well as those obtained from other parts of the coast and providing adequate protection. Nursery raising of propagules involved traditional bagging and maintenance in flooded beds lined with polythene sheets. The latter method ensured immediate transfer of transported seedlings into a suitable environment, allowed for dealing with large numbers and reduced wastage costs. Mortality due to transportation of saplings was reduced through defoliation and transporting in the early morning or evening to reduce heat stress.

Results

Considerable literature is available on the restoration of mangrove systems. Methodologies were therefore not a constraint. Important lessons were learnt on the logistics required with particular reference to conditions prevalent along the Coromandel Coast. The costs of restoration were substantially reduced by utilising plastic lined beds and combining prosopis removal with channel digging. Large tracts of backwater areas were identified as suitable for restoration activities. The challenge here was to deal with the tremendous pressure on these landscapes for conversion to other uses, especially shrimp farms.



Box plots showing results of water and soil salinity and pH across the sites studied

SAND DUNES

Importance

The east coast of India is known for its sandy beaches and dunes. These coastal habitats play an important buffering role against coastal erosion, storms and cyclones, protecting near shore areas from excessive damage. Indian coasts in general are prone to frequent cyclonic storms, which have the potential for large-scale destruction. Meteorological information from the last century shows that there were over 400 cyclonic or severe storms on the east coast making it one of the most vulnerable coastlines in the world.

While coastal ecosystems such as mangroves and coral reefs have received substantial attention, sand dune habitats have been overlooked and are poorly understood. An analysis of research done in India showed that these systems have rarely been documented and there are practically no studies conducted on the Tamil Nadu coast prior to the 1990s. Most studies have focussed on macro and meiofaunal assemblages, or on nesting sites for marine turtle species, specifically the olive ridley. Preliminary mapping of dune formations carried out along the Coromandel Coast showed a wide variation in morphology and land use.

Sl.	Region	Characteristic and Use Pre-Tsunami: From Sanjeevi (1996)
1	Pulicat to North Madras	Well developed dunes, nearly 3m high, gently undulating and covered by vegetation (Casuarina spp.)
2	Madras City, Marina beach, Covlong, Mahabalipuram	Non-undulating wide sandy beaches, nearly 1km wide at Marina
3	South Madras, Tiruvanmaiyur	Major source of fresh water
4	South of Mahabalipuram	Dunes used for coconut and casuarina plantations
5	Pondicherry and Porto Novo regions	Dunes not wide but well developed and 10m high
6	Cauvery delta and Point Calimere region including Nagapattinam	One of the remarkable dune fields in the Coromandel Coast, attributed to the sand supplied by the Cauvery. Some dunes as far as 35km from Pt. Calimere are paleo-dunes indicating Holocene period coastlines. Used for agriculture, dunes cause blockage of drainage leading to flooding

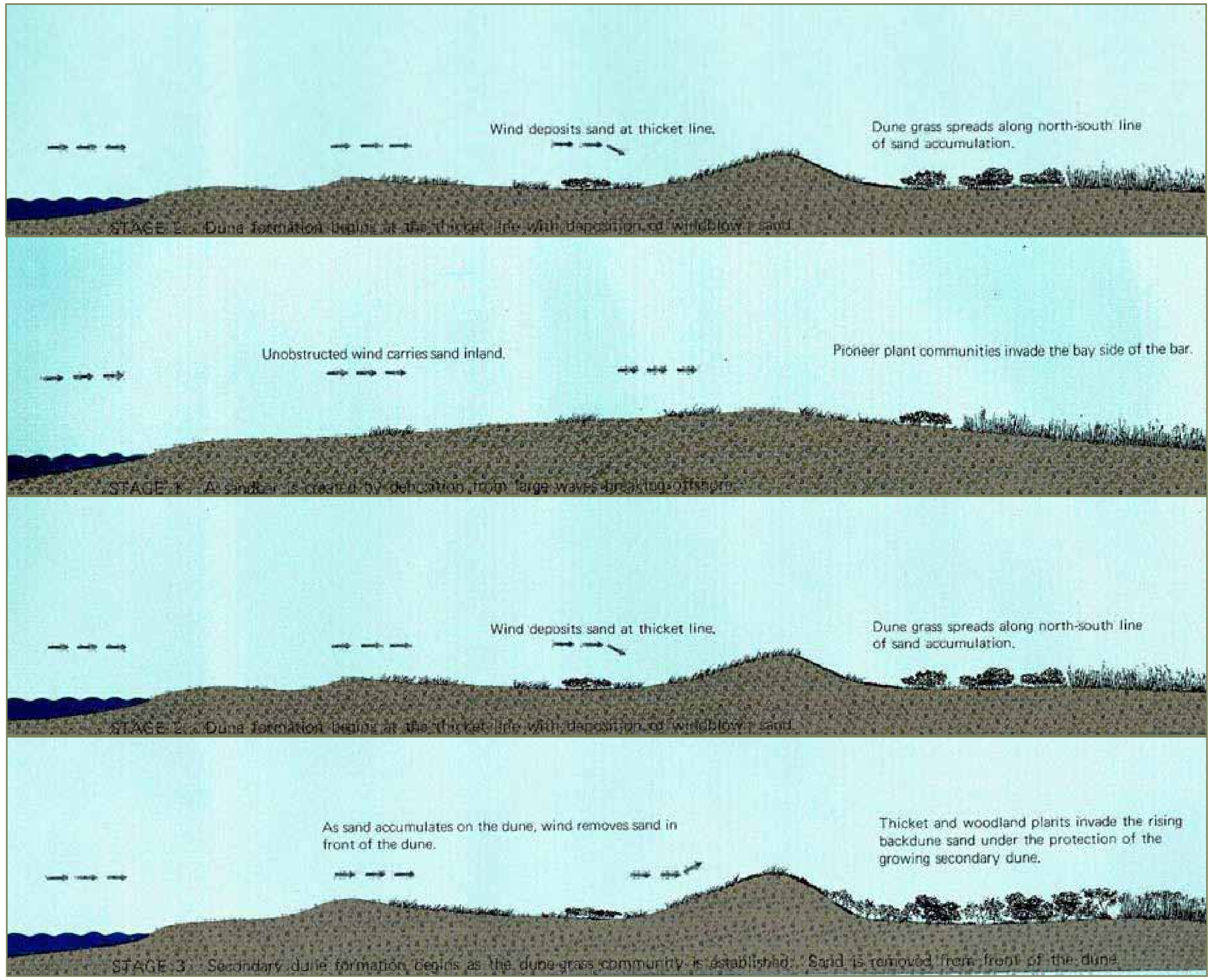
Characteristics of dunes in regions of the Coromandel coast

Both sandy dunes and beaches are subject to a variety of threats, the main threats being sand mining for construction and mineral extraction. Habitat alteration for construction of habitations, resorts, roads, etc. can be equally damaging. Seawalls and groynes constructed during coastal protection efforts have also dramatically affected sand movement along the coast, leading to large-scale erosion and accompanying accretion at other locations. Threats from pollution and various anthropogenic impacts are plentiful. These poorly understood and neglected ecosystems have now begun to receive some attention for the role they may have played in protecting people and habitations during the tsunami.

The Work Done

Beach and dune areas are under considerable pressure from developmental activities, and in many locations, the typical zonation found on dunes – pioneer areas with herbaceous vegetation, scrub zone of low shrubs and grasses, followed by coastal forest of low shrubs and stunted trees – has been lost. Their topography is highly dynamic, formations are based on sand movement and deposition, as well as wind action, and may undergo rapid changes when not anchored by vegetation.

Forty-six sites were surveyed for potential restoration activities. Information on spatial extent, social use, vegetative cover, zonation and basic dune structure was collected. Availability of land and community participation were important factors, as was the



Process of dune formation

prevalent use of areas by local communities. Given the high level of anthropogenic pressure and private ownership of land, availability of space was severely restricted. Thus, detailed surveys of vegetation and dune profiles were carried out in only four sites. Of these, two sites were finally selected for restoration activities and implementation done in accordance with the overall strategy adopted.

Presence of specialised dune plants such as *Spinifex littoreus* and *Ipomea pescaprae* are critical to the formation, stabilisation and post-storm recovery processes of dunes. Other local sand binding specifics such as *Kyllinga triceps* are also important. Planting and dune stabilisation focussed on these and other species such as *Pandanus, Thespesia, Pongamia,* and *Borassus*, all of which are common along the dunes in the region.

Spinifex littoreus (top) and Ipomea pescaprae (bottom)

Casuarina planted as bio-shield along the coast often replacing native vegetation

The Bio-shield Debate

The role of coastal vegetation and its composition in mitigating effects of storms, cyclones and the tsunami in particular continues to be widely debated. Based on initial rapid studies that claimed a phenomenal role played in providing protection, large amounts of money have been spent in creating bio-shields as natural coastal defences. Another body of research suggested that rather than vegetation, coastal features such as topography, near shore bathymetry and distance to continental shelf needed to be examined in more detail to explain the resultant impact of the tsunami.

Reviews of literature carried out during the project highlighted that mere observational, anecdotal or simplistic models with single parameters were used and these could not be the basis to build a definitive case for the erection of large stands of vegetation along the coast. The analysis carried out used a series of spatial models to explain inundation distances with various physical features and vegetation cover in these areas.

Variable	∑ AIC wt	Co-efficient	Std. Error
Coastal Slope	1	-41.75	±8.943
Shelf Slope	0.99	270.35	±152.143
NDVI	0.94	-3717.79	±1729.303
Near Shore	0.64	6.23	±6.864
Shelf Distance	0		
Elevation	0		
Intercept		1454.27	1322.14

The relative importance of the variables determined using the AIC weights

The best model that explained the inundation seen was – inundation distance reduces with increasing topographic slopes, increasing continental shelf slopes, near shore bathymetry and is inversely proportional to vegetation cover.

While coastal vegetation has relevance in terms of providing resources for local communities, its effectiveness as a protective barrier needs to be addressed with detailed studies. Otherwise, there is the danger of a false sense of security being instilled in vulnerable coastal populations. In addition, plantation projects which do not take into account beach and dune dynamics could alter the very processes essential to their survival.

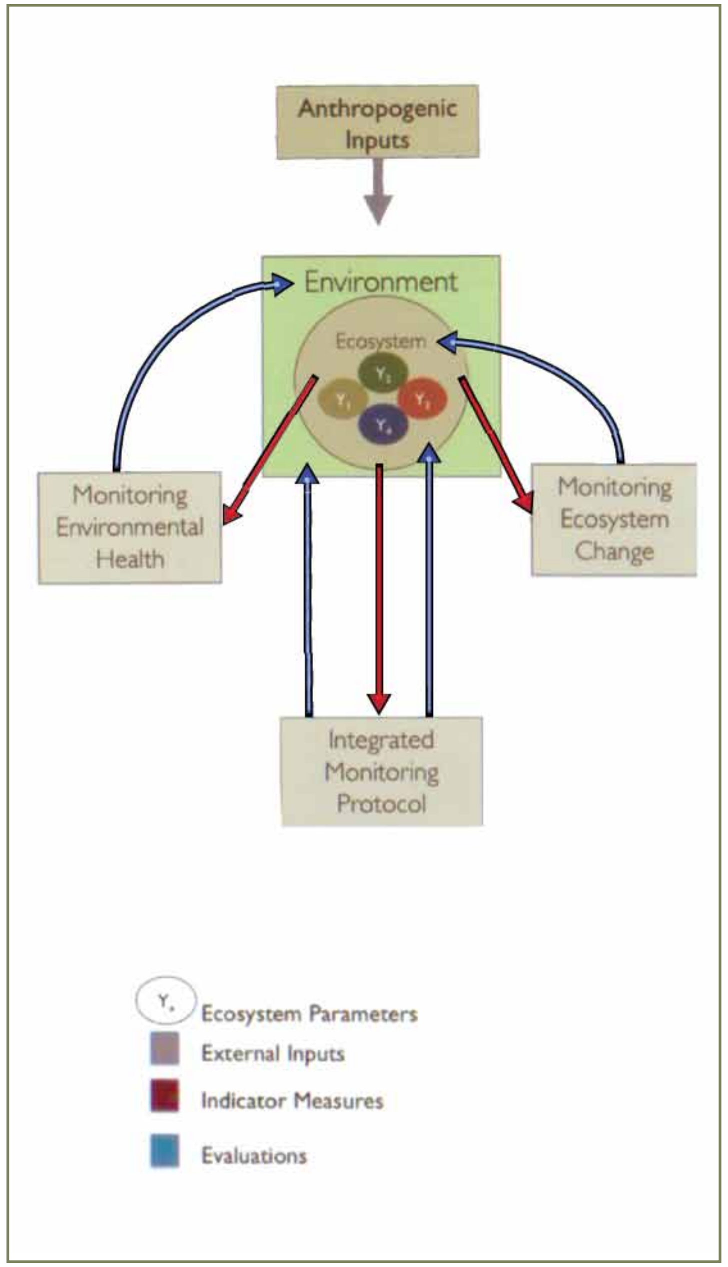
SEAGRASS BEDS

Importance

Seagrass meadows contribute significantly to primary productivity in near shore areas and perform several ecological and economic functions sustaining the marine environment. They are also efficient engineers that help sediment accretion and colonise these shifting sediments by virtue of their rapid vertical growth. Thus, sediment regimes are vital to these ecosystems – too much sediment and they risk being buried, too little and they may be uprooted from the meadows. Turbidity, and therefore light availability, has a bearing on the depth of water in which meadows are established. Any event, natural or anthropogenic, that changes sediment dynamics and turbidity in these waters can have a significant impact on the functioning of seagrass communities.

Seagrass species grow at scattered locations all along the east coast. The majority are restricted to river mouths and estuaries. Fully formed meadows dominated by long-lived species are most abundant in the Gulf of Mannar and the Palk Bay and comprise the largest meadow complex off the coast of mainland India. With only 54 species worldwide, 14 are found in these regions, making them one of the most diverse in the world. These meadows are restricted to shallow waters, partly due to the shallow bathymetry of the region and probably due to the characteristic high turbidity of these waters.

Monitoring protocols have generally focussed on change in status of ecosystem (diversity, density, ecosystem function, etc.) or environment characteristics such as water quality, sediment, etc. over time. An integrated approach was tested for seagrasses of the Gulf of Mannar and Palk Bay region.



Monitoring Ecosystem Change, Environmental Health, and a proposed Integrated Approach, which combines the two. Vital ecosystem parameters (Yx) are altered by anthropogenic inputs into the general environment (grey arrow). These are recorded inYx, which can be measured as indicators (maroon arrows). Whether these parameters are used to evaluate ecosystem status or environmental health will depend on the purpose of the monitoring (blue arrows). It is possible to combine the two approaches to evaluate both simultaneously (the Integrated Monitoring Protocol).

The Work Done

This area of the coast is highly populated with fisheries which play an important role in the economy, and is characterised by shallow bathymetry and high turbidity. Sedimentation and eutrophication are probably the most significant threats to seagrasses. The status of seagrass meadows was analysed using a range of parameters encompassing meadow, population and shoot characteristics, along with physiological factors to test possible combinations of relations. A sampling gradient of relatively undisturbed to severely disturbed sites was used.

A useful indicator of sediment dynamics can be the vertical growth of seagrass rhizomes, and using reconstructive methods, the age of the shoot can be used to track past disturbances. The plastrocone interval (distance in millimetres between nodal scars) was measured for a dominant species of seagrass in the region (Cymodocca serrulata), along with total number of scars on the vertical rhizome, number of leaves on each shoot and the length and width of each leaf. Nutrient and metal analysis was done on the leaves collected to estimate conditions in water and sediment.

Results

Levels of nitrogen, phosphorous, zinc and manganese in leaves (a representation of conditions in the water column) and phosphorous, zinc and iron (conditions in sediment) had significant differences across locations. Number of leaves per shoot, length of first ten node intervals and length and width of third leaf showed significant variation across zones as well as locations, indicating sensitivity to micro level environmental differences.

An Ecological Quality Ratio (EQR) derived from these analyses provided relative scores for the conditions at each site. The basic rationale of the index is that it helps locate each site along a gradient of environmental quality based on a-priori ordination of reference sites. This 0 (worst) to 1 (pristine) scale can be utilised for tracking changes over time and assist in setting realistic targets for site improvement. A simple field manual has been developed as a tool for field managers to organise and oversee a monitoring programme. The manual provides an overview of seagrass ecosystems, approaches to their monitoring and steps through every stage of the monitoring process.

LESSONS

Documentation

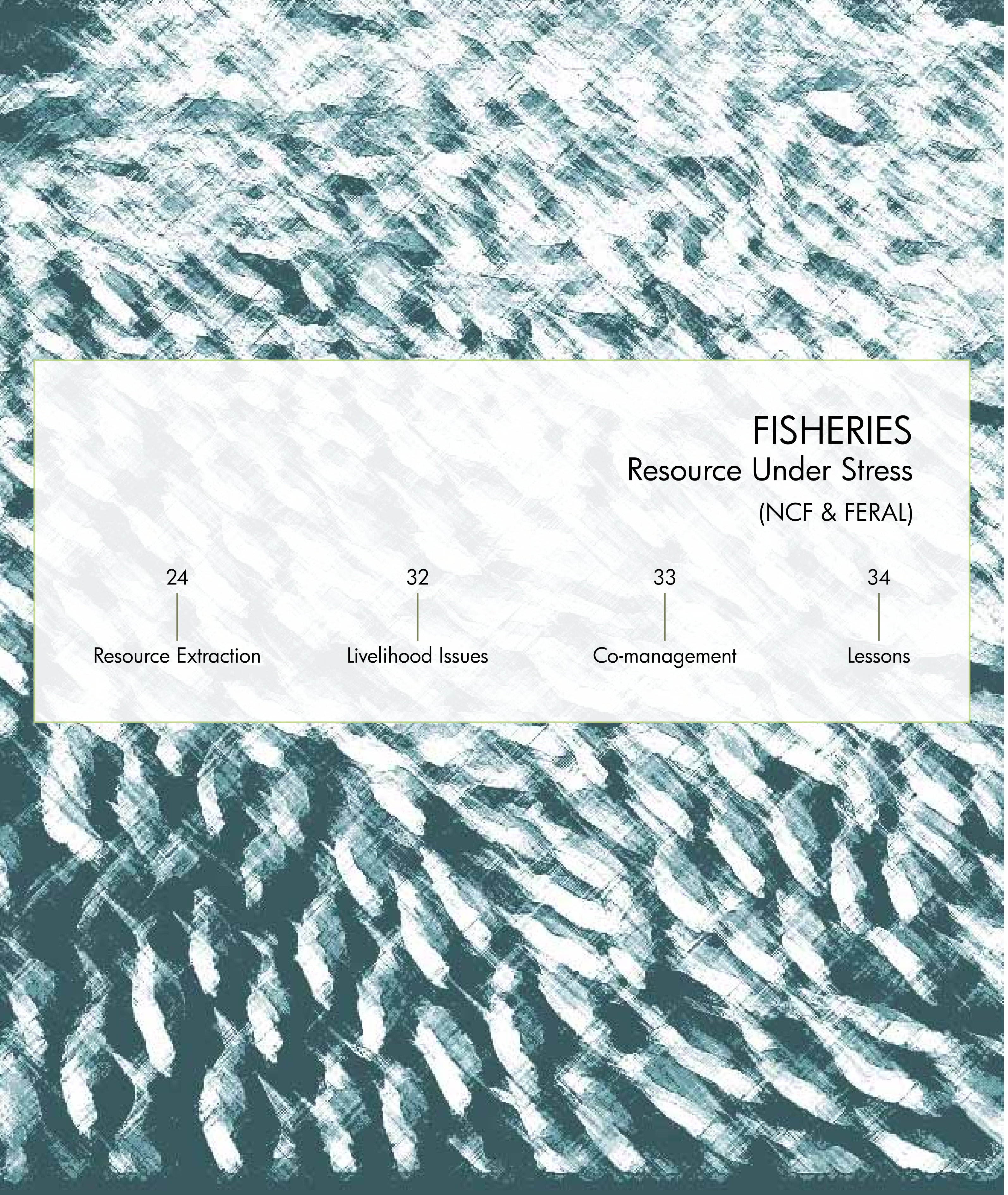
- Gaining a thorough knowledge and understanding of what exists and the parameters within which this is possible is an essential and inescapable component of planning any restoration, monitoring or management activity.
- Such investigative efforts open the door for participation of a wider range of stakeholders and help to make their involvement more meaningful.

Community Participation

- Understanding community dynamics and providing members the space to participate effectively increases ownership of activities.
- Creating awareness about the activities to be undertaken and their implications in the short and long-term is important to ensure effective participation.

Monitoring

- The necessity of monitoring impacts of current activities along the coast was demonstrated throughout the many studies conducted.
- Successful establishment of planted species across the different habitats gave inputs into potential species composition for different environmental conditions on site.
- Tracking growth of a single species of seagrass can help in developing strong monitoring processes, which would help identify threatened spots.



FISHERIES
Resource Under Stress
(NCF & FERAL)

Tamil Nadu has an extensive coastline of 1,076 km and ranks fourth in fish production in the country. The 13 coastal districts have 591 fishing villages with nearly 817,832 people involved in the fishing sector. They target all available marine resources found along the Tamil Nadu coast as well as extending to regions outside the State. There was a general increase in total fish catch along the Tamil Nadu coast during the 1990s. Since then catches have shown a decreasing trend. Long-term trend analysis of fish catch for a period of about 20 years (1985-2006) showed that pelagic fish are the most dominant group followed by demersal fish, crustaceans and molluscs. All available resources of the sea are being harvested and in spite of improved techniques and increasing efforts, fish yield is on a decline. The very nature of this sector – highly variable and seasonal, also results in thorough harvesting whenever the opportunity arises. The fisheries related studies focussed on the current practices and status of this sector.

RESOURCE EXTRACTION

Capacities

There are 11,992 mechanised boats, 21,717 vallams and 42,825 kattumarams presently operating in Tamil Nadu as per the state Fisheries Department records. The artisanal sector employs a wide variety of nets and a range of mesh sizes. Nets used were mostly gill nets, drift nets and trammel nets, classified by the fishermen according to mesh size and the species they are supposedly targeting. Fishermen reported more than 35 types of nets being used. This diversity of nets and species caught is evidence of the multi-species nature of this fishery.

Kattumarams (“kattu” - to tie, “maram” - tree or log) have been largely replaced by FRP (fibre reinforced plastic) boats powered by outboard motors. This trend has been mainly driven by tsunami relief, which saw a large number of FRPs being distributed to the fishing community. These boats are popular due to their versatility; they are used for deep-sea line fishing, fishing with nets or as carrier boats for ring seine operations. The other advantage of FRPs is their ability to go further out to sea, rather than being restricted to the near shore areas and more shallow regions, which is the case with kattumarams. With the large variety of nets in use, the entire spectrum of available species is being harvested. This has resulted in much of the catch being discarded, because it has little or no economic value. Additionally, near shore and pair trawling in the same shallow waters is taking place regularly along certain parts of the coast. Thus, overall fishing efforts in areas of about 20m depth have increased dramatically and this has increased pressure on the resources available.

Catch Composition

Over 83 families, the majority of which were fish, with a few crustaceans and molluscs, were brought in by the artisanal fishers from the waters of the Coromandel Coast. Sorting and sales happen in rapid succession once the catch has landed onshore, making on site specimen collection or identification difficult. Thus, photographs of catch were taken on site, followed by later identification of individuals. While Indian guides were mostly restricted to commercially important species, the FAO FishBase database had wider coverage of species. This approach allowed for survey of a much larger number of landing sites, thereby giving a better picture of resource extraction. Records also showed that the availability of some of these species has decreased and there has been a reduction in the size of individual fish across the entire range of species, barring the shoaling species.

Most of the catch was sold locally, while “high value” species were marketed commercially. Given the large number of species recorded in the catches and high proportion of juveniles and sub-adults, it can be assumed that these waters are quite productive and serve as feeding grounds. The size classification of the catches showed comparatively fewer adults to fingerlings or sub-adults. The highest number of individuals in each catch belonged to the sub-adult class, and thus

Tamil and English names of nets used

Tamil Name (Net)	English Name (Net)	Mesh Size (mm)	Weight (kg)	Height (ft)	Length (ft)	Season	Species Targeted
10.Number	Gill net	26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 45, 48, 50	50, 75, 100, 150	2	200	All months	Sardine
Aadha	Gill net	28	50, 100	3	200	Summer	Mullet
Adantha	Ring seine	32	50, 75	30	600	Summer	Sardine
Athula	Gill net	38, 40, 43, 45, 46, 50, 60, 65, 75, 80, 85, 90, 110	40, 50, 60, 75, 100	3	200	Oct, Nov	Solefish
Disko	Gill net	22, 30, 32, 34, 35, 36, 38, 40, 42, 44, 45, 46, 50	40, 50, 60, 75, 100	4	600	Summer	Sardine
Eraal	Trammel net	30, 38, 18, 60	75, 100	2	200	Summer	Prawn
Izhou	Trawl net	25	100, 400, 500	15	500	All months	Prawn
Kanankaruthai	Gill net	38, 40, 42, 46, 52, 54, 55, 56	100, 75, 150	3	600	Summer	Mackerel
Kanavaa	Gill net	60	150	3	600	All months	Squid
Kavalai	Gill net	16, 26, 27, 28, 32, 56	75, 100, 200, 250, 300, 150	4	600	Jan, Feb	Sardine
Kenda	Gill net	48, 65, 80, 90	75, 150	2	200	All months	Mullet
Kezhanga	Gill net	36	75	2	200	All months	Whiting
Kolaa	Gill net	16, 17, 18, 24, 27, 28, 30, 32, 34, 36, 38, 52	75, 100, 150, 200, 300	2	1000	Summer	Flying fish
Line	Line				3000	All months	Seer
Maappu	Gill net	40, 60	75, 150	2	200	All months	Sardine
Madavai	Gill net	50, 54, 70	75, 100	2	200	All months	Mullet
Malappu	Gill net	56	1000	2	200	All months	Mullet
Mani	Trammel net	18, 40, 42, 44, 70	75, 100, 150	2	200	Nov, Dec	Prawn
Mathappuvalai	Gill net	40, 45, 48, 50, 54, 60, 120	50, 75, 100	4	600	All months	Mullet
Mathee	Gill net	28, 36, 38, 40	75, 100	4	600	Summer	Sardine
Nakku	Gill net	47, 90, 180	75, 100	3	200	Oct, Nov	Solefish
Nall	Gill net	38	100	2	100	Summer	Mullet
Nandu	Gill net	28, 30, 40, 45, 50, 55, 56, 60, 70, 75, 80, 85, 90, 95, 100, 110, 120, 62, 54, 135	30, 50, 75, 80, 100, 150	3	200	Oct, Nov, Dec	Crab
Nethilee	Gill net	14, 16, 18, 38	75, 100	4	100	Summer	Anchovy
Othaadukku	Gill net	54	50	5	100	Summer	Mullet
Pannu	Gill net	26, 28, 30, 32, 38, 40, 42, 44, 45, 50, 52, 53, 54, 55, 56, 85, 100	50, 60, 75, 100, 150, 200	3	600	Summer	Sardine
Pantha	Ring seine	40, 44, 48, 50, 56	50, 100	30	600	Summer	Sardine

Tamil and English names of nets used (continued)

Tamil Name	English Name	Mesh Size (mm)	Weight (kg)	Height (ft)	Length (ft)	Season	Species Targeted
Pas	Gill net	54, 56, 60	100, 150, 200	2	600	Summer	Mullet
Periya	Shore seine	16, 28, 38, 60, 80, 85	500, 1000, 1500	4	500	Summer	Anchovy
Pothu	Gill net	45	75	3	300	Summer	Mullet
Rettaivalai	Trawl net			6	600	All months	Prawn
Salanka	Gill net	20, 38, 45, 50, 54, 65	50, 75, 100, 150	2	200	Nov, Dec	Mullet
Sanghu	Gill net	80	100	3	200	Oct, Nov, Dec	Shell
Sannavalai	Gill net	40	75	3	300	All months	Mullet
Singe	Gill net	60, 85	100, 200, 300	3	250	Oct, Nov	Slipper lobster
Surukku	Ring seine	18, 24, 28, 32, 76	1000, 1500	30	1000	Summer	Sardine
Thavukola	Gill net	44	150	2	500	All months	Flying fish
Valaa	Gill net	52	100	2	1000	All months	Sardine
Valaa	Gill net	50	150	2	1000	Summer	Sardine
Vanjiram	Gill net	24	150	5	100	Summer	Seer

represented the average size class of the species. More research is clearly required to ascertain if length or size classes can also indicate stages of maturity in the life history of fish. In addition, the significance of these waters as breeding and maturing grounds needs to be studied further.

Local sales typically occur as auctions, where the market is formed at the landing site and local traders manage the sales. Larger traders, including those from Chennai or Kerala, operate in the case of bulk catches with ring or shore seines, and this is also the case with sharks, tuna and seer caught through line fishing. While larger fish are sold fresh, the smaller ones are dried and preserved for later sale. Bycatch and discards are dried and sold for poultry feed and fishmeal when possible.

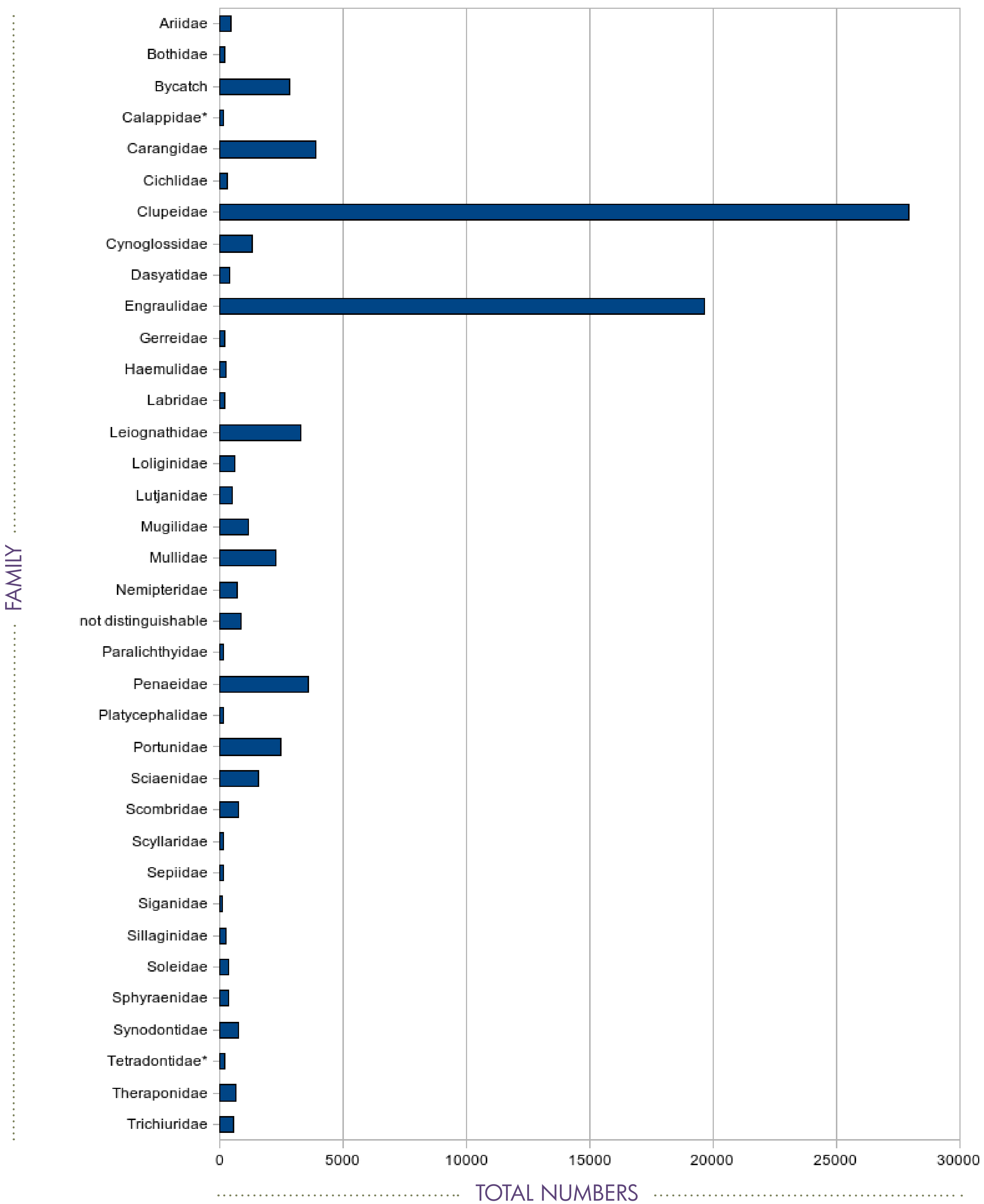
Thus, the entire spectrum of available species is being harvested, either through targeted efforts or as incidental catches, with many being discarded because they have little or no economic value.

Bycatch

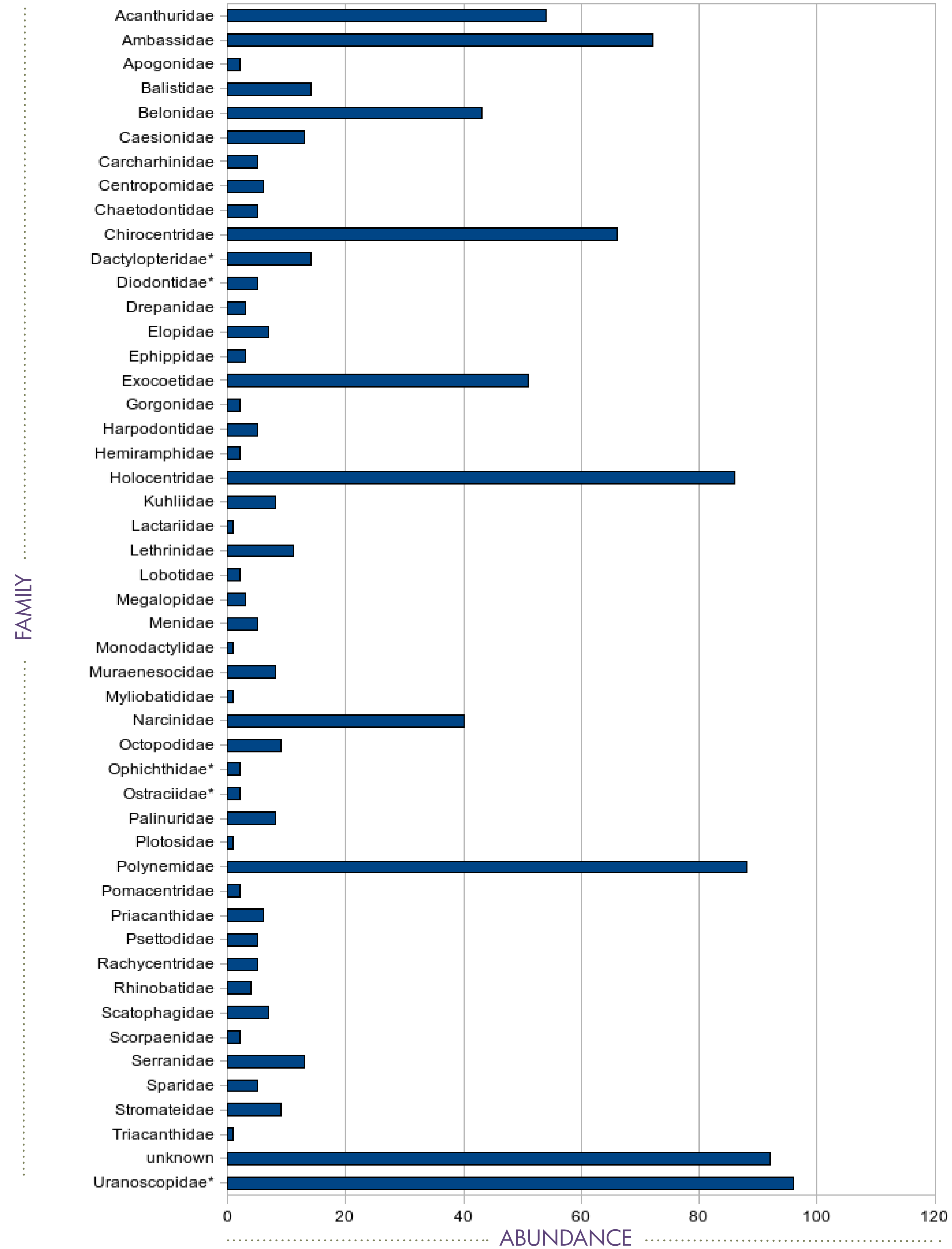
Trawl fishing is considered highly destructive, resulting not only in rapid decreases in fished populations but also causing considerable collateral damage through bycatch. A highly efficient but non-selective gear, trawls capture large quantities of non-target species or bycatch. This often exceeds the amount of targeted species caught. Previously discarded, there is now a clear trend towards increased retention of bycatch species.

The main species targeted along the Coromandel Coast are shrimp and cephalopods (cuttlefish and squid). Several other species of commercial value such as groupers, snappers, bream, barracuda, etc. are caught

Abundance of the common species caught



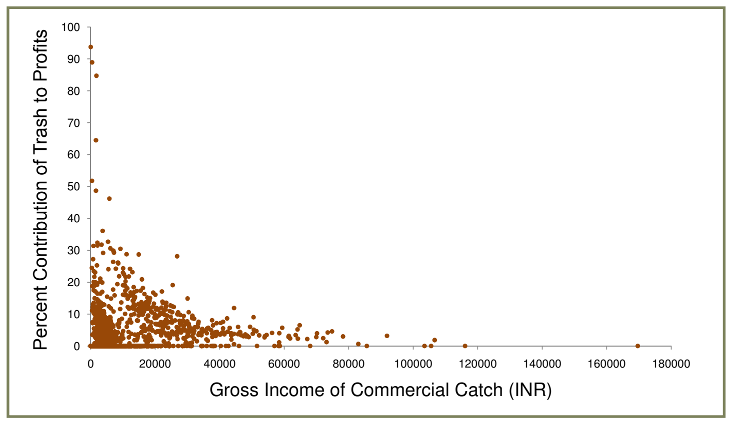
Abundance of the rarer species caught



incidentally. While the majority of the bycatch reaches the export market, some species, including croakers, ribbonfish, sardines, etc. are sold to the domestic market. Given that trawlers can no longer rely on their target species for profit, this "incidental" commercial bycatch has increased in importance.

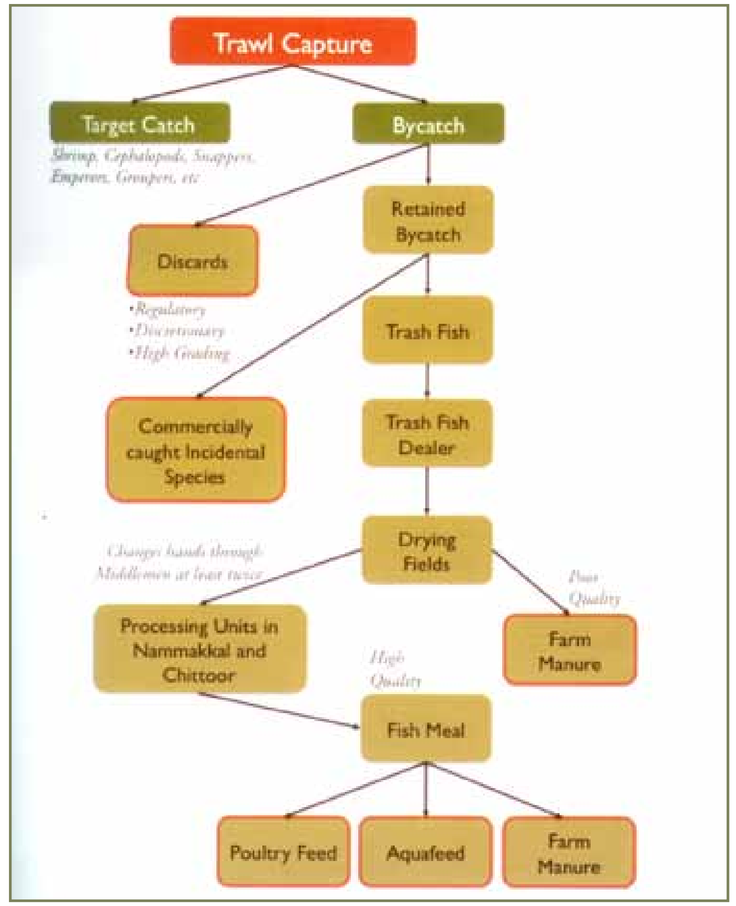
Costs of trawling are high and they increase with duration at sea with major contributors being fuel, labour and purchase of ice. Of these, fuel constitutes about 59%. Operating costs are also influenced by the many systems of profit sharing and wages that exist between owners and labourers. While operating costs per hour remain quite constant, profits realised are highly unpredictable, being based on fish catch.

Bycatch of trawls comprise a huge diversity of marine taxa – molluscs, echinoderms, adult and juvenile fish, as well as the commercially important species. Most of this is considered "trash" and fishers make active decisions on whether to bring it back to shore or discard it at sea. These decisions are driven by various factors including whether they are single or multi-day excursions, storage space available and adequate sunshine for further processing. Single day trawls bring most bycatch to shore, while multi-day trawls use premium storage space for catch of higher value. Discarding at sea is common during the monsoons as there are few options to sun-dry and process the trash.



Contribution of trash to the total gross profits earned from trawling. As gross profits increased, there is a distinct decline in importance of trash as a contributor to overall profits.

Bringing back trash is not without its costs (low input, high volume, it tends to rot quickly), but given the inherent unreliability of commercial catch, the relative stability of trash economics makes it an important supplement for fishermen. The increasing importance of trash has been due to the phenomenal growth of the aquaculture and poultry industries in the last few decades. Thus, from being of marginal value with only agricultural fields as potential destinations, processed trash follows multiple routes and supports a growing fleet of workers comprising dealers, sorters, fishmeal processors and transporters.



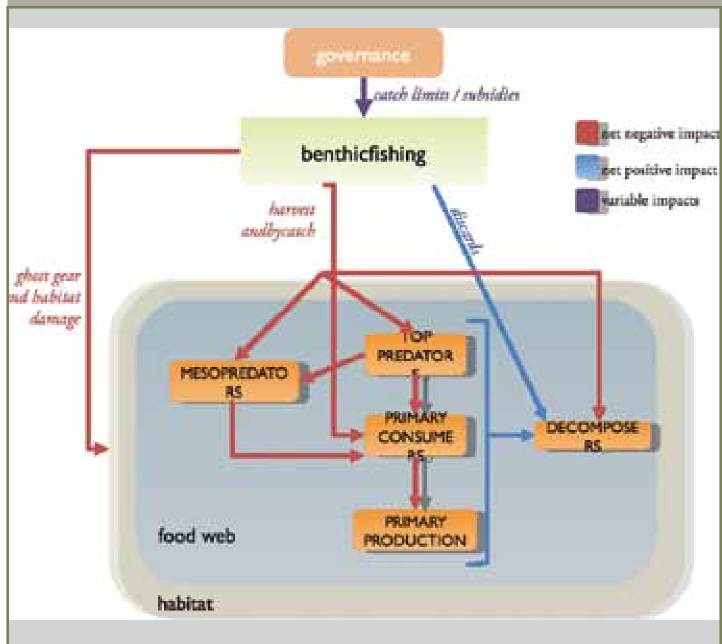
Tracking the fate of trash from the trawler to the fishmeal factory

The issue of bycatch – discarded at sea or brought back – has serious ecological as well as socio-economic impacts. The removal of these species in sustained trawling areas has seen the replacement of higher trophic groups (large, long-lived) with lower trophic groups (smaller, short-lived) in the marine food web. Discarded bycatch is known to have very low survival rates. Drastic population changes have also been recorded in several scavenging sea birds who feed on floating trash. Additionally, unconsumed bycatch sinks to the bottom and decomposes causing hypoxic conditions and algal blooms in near shore waters.

Bycatch could thus be subsidising an unprofitable and already overexploited trawl fishery. Technical and regulatory mechanisms for bycatch reduction are present, but uptake by fishers is low. The practice of discarding at sea must also be discouraged, given its potential deleterious impacts. Possible links between increased value of commercial fish and adoption of bycatch reduction mechanisms could be explored to provide incentives to the fishing community. Dealing with the bycatch issue along the Coromandel Coast is imperative given the current status of fisheries in the region.

Elasmobranchs

TThe ecological impacts of bottom trawling are well documented; an overall reduction in population numbers of the target species and changes in food web architecture. In addition, resultant changes across population, community and ecosystem parameters can push these systems beyond recovery. Adequate baselines to measure these changes are few, given that there are hardly any "normal" near shore marine habitats. In such cases, a gradient approach, which assesses relative impacts can provide a better understanding of ecosystem responses to sustained trawling.



Impact of benthic trawl fishing on marine trophic networks. Modified from Crowder et.al.(2008)

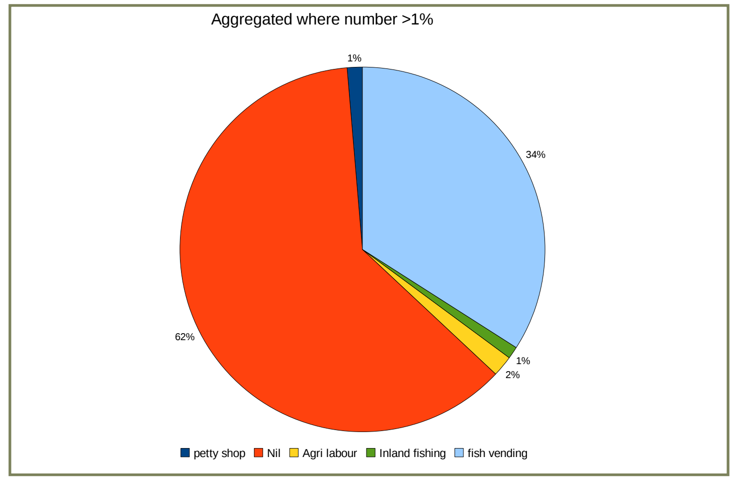
Elasmobranchs as a group, and in particular batoid elasmobranchs, have very low resilience to benthic trawling as they are slow growing, late to mature and have a low fecundity rate. They are reasonably abundant along the coast and are effective barometers of predation levels as they occupy higher trophic levels in the food chain. Their capture is less influenced by changes in gear. Relatively common as trawl bycatch, this group can be used as a potential indicator of trawling intensity. They are not discarded at sea as many other species are, because they have some commercial value and are thus brought to shore.

Findings from observations across five trawl bases between Pondicherry and Nagapattinam showed populations estimated as catch per unit effort varied considerably between bases, and abundance and biomass data showed similar trends for the ubiquitous species. Gradient of fishing intensity was a ten-fold increase from the lower to higher trawler numbers. Clear species-specific patterns were observed across the gradient of fishing intensity with *Narcine maculata, Narcine timlei* and *Rhinobatsus obtusus* showing consistent decline in catch rates. Average disc width appeared to be an equally sensitive measure.

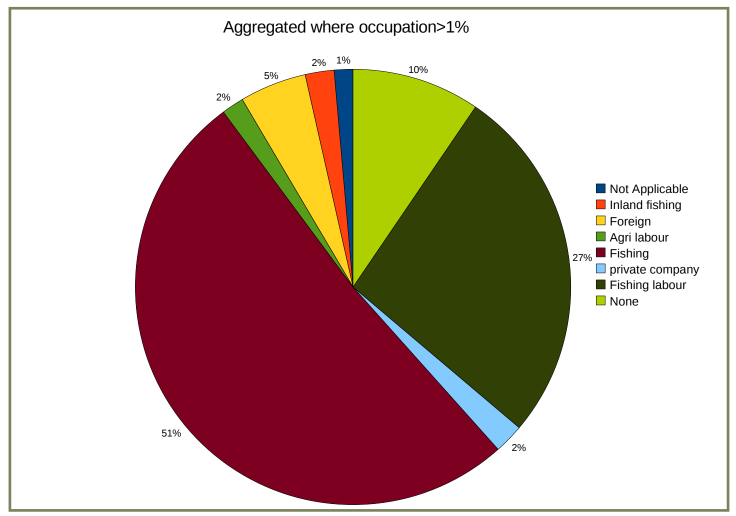
A monitoring protocol tracking abundance, biomass and morphometric characteristics based in six common species may provide sufficient information to identify thresholds. Additional research linking numbers with trophic structure, habitat integrity and ecosystem conditions can help in determining limits to resource offtake.

LIVELIHOOD ISSUES

The fishing community's complete dependence on fisheries for a livelihood is of concern given the intense pressure on the resource. Household surveys conducted across 62 settlements showed that fishing continues to engage men in 80% of the households as their primary occupation, and it is the primary occupation for women in 35% of households. While 38 secondary occupations were recorded, the majority were taken up by less than 1% of the households surveyed and thus only a small proportion of households actually diversified their income sources.



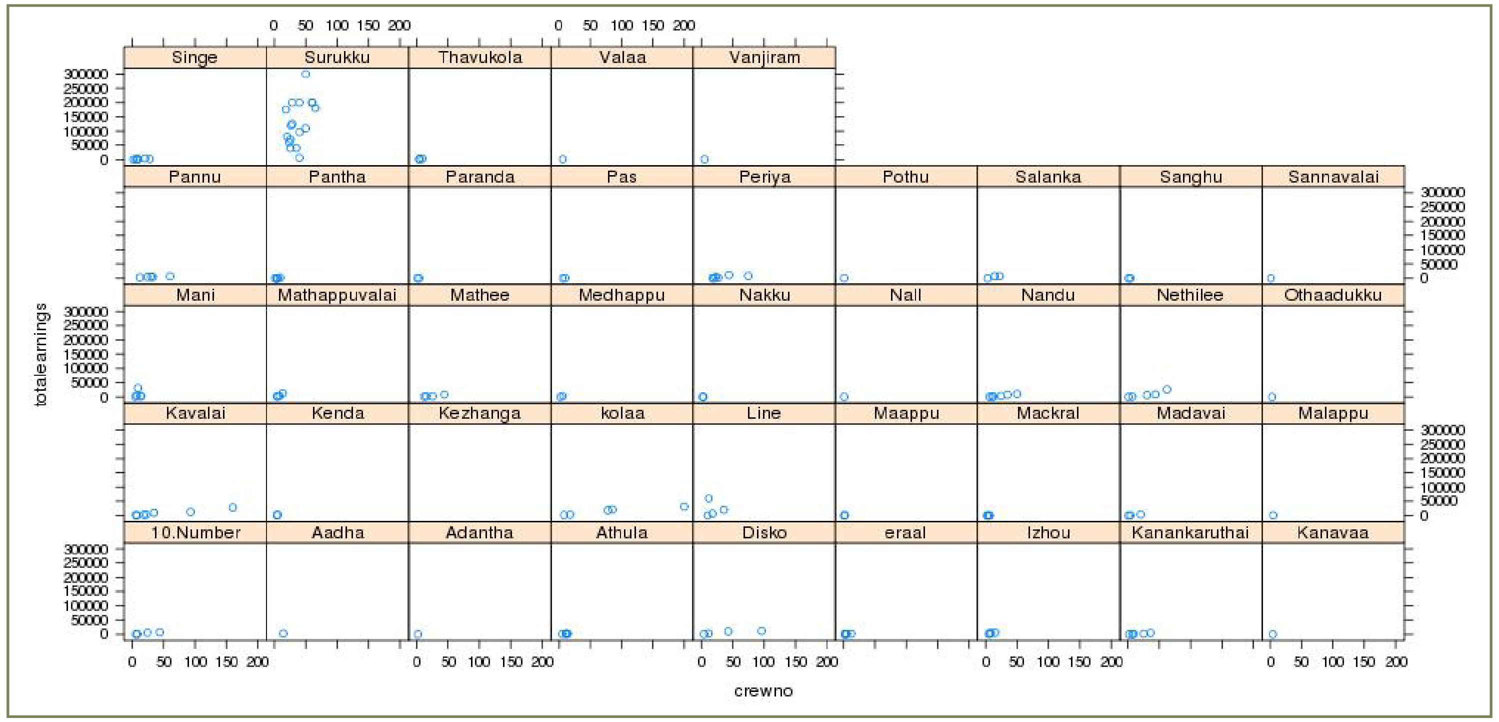
Primary and secondary occupations of women



Primary and secondary occupations of men

Earnings from fisheries are observed to be highly seasonal, variable and dependent on both the gear used and the species caught. Average incomes observed in the case of ring seine and anchovy nets were highest, followed by those using lines and then by shore seining. Ring seine operations bring in large quantities of catch, while line fishing targets highly commercial species such as tuna and seer fish. Other nets rarely bring in large catches and thus generate smaller incomes. Returning with no significant catch for the day was also frequently observed.

Earnings per boat is divided between boat owner, crew and operational costs. In the case of FRPs, owner and crew share is approximately 60:40, with the owner taking up the costs of operation. Ring seine operations see a 75:25 share between owner and crew. The higher share for owners is due to the much larger investment required for these nets. Overall, earnings of boat and gear owners are higher than crew earnings.



Per capita earning per gear

Issues of alternative livelihoods, both long-term and for the period of the fishing ban, were a major concern. In addition, diversification within the sector was seen as an option if supporting infrastructure such as ice plants, storage space, drying units, etc. could be set up.

CO-MANAGEMENT

Traditional panchayats (councils) of the fishing communities play a central role in the management of resources at the local level. While they have no connection with government constituted bodies, they are essential in resolving conflicts in resource management. The relevance of panchayats has changed dramatically in the last few decades – mechanisation, changes in fishing practices, influence of market forces, entry of non-fishing community players and tsunami relief distribution have all had an impact. Yet, they still hold sway in many areas and are an important constituent in decision making processes within the community.

A consultative process, micro-planning, was initiated with the numerically larger stakeholders within fishing settlements to analyse their perceptions of livelihood issues within the fisheries sector and to identify specific action points or probable areas of intervention. Boat owners, crew members and fish vendors were the three largest groups in the sector. This process involved structured surveys, participatory GIS exercises and stakeholder analysis using the livelihoods enhancement and diversification framework developed in an earlier UNTRS programme. Additionally, discussions regarding management issues and the role of the community in this were held at these settlements, followed by district level meetings. Representatives of the Fisheries Department were invited to these discussions.

A high level of awareness among fisher communities on current issues and the perceived crisis was demonstrated. Overall, there is a consensus that the fisheries sector and thereby the fishing community is undergoing a crisis. There is also recognition that the community and the government need to work closely together to arrive at suitable mechanisms to manage fisheries resources more efficiently. Enforcement of current regulations was identified as a key lacuna; while the government is the primary responsible agency, the communities were willing to step in, provided they had the full support of the local agencies. Many of the problems faced by these artisanal groups were associated with trawling activities in near shore areas and other practices in vogue with these larger boats.

There is a general understanding of the need for regulation of mesh sizes, fishing ban periods, etc. to ensure that juveniles are not caught and bycatch reduced. However, this is seen as the purview of the government. A moot point was that nets that are considered destructive should be banned at the point of manufacturing itself, and then the question of misuse would not arise.

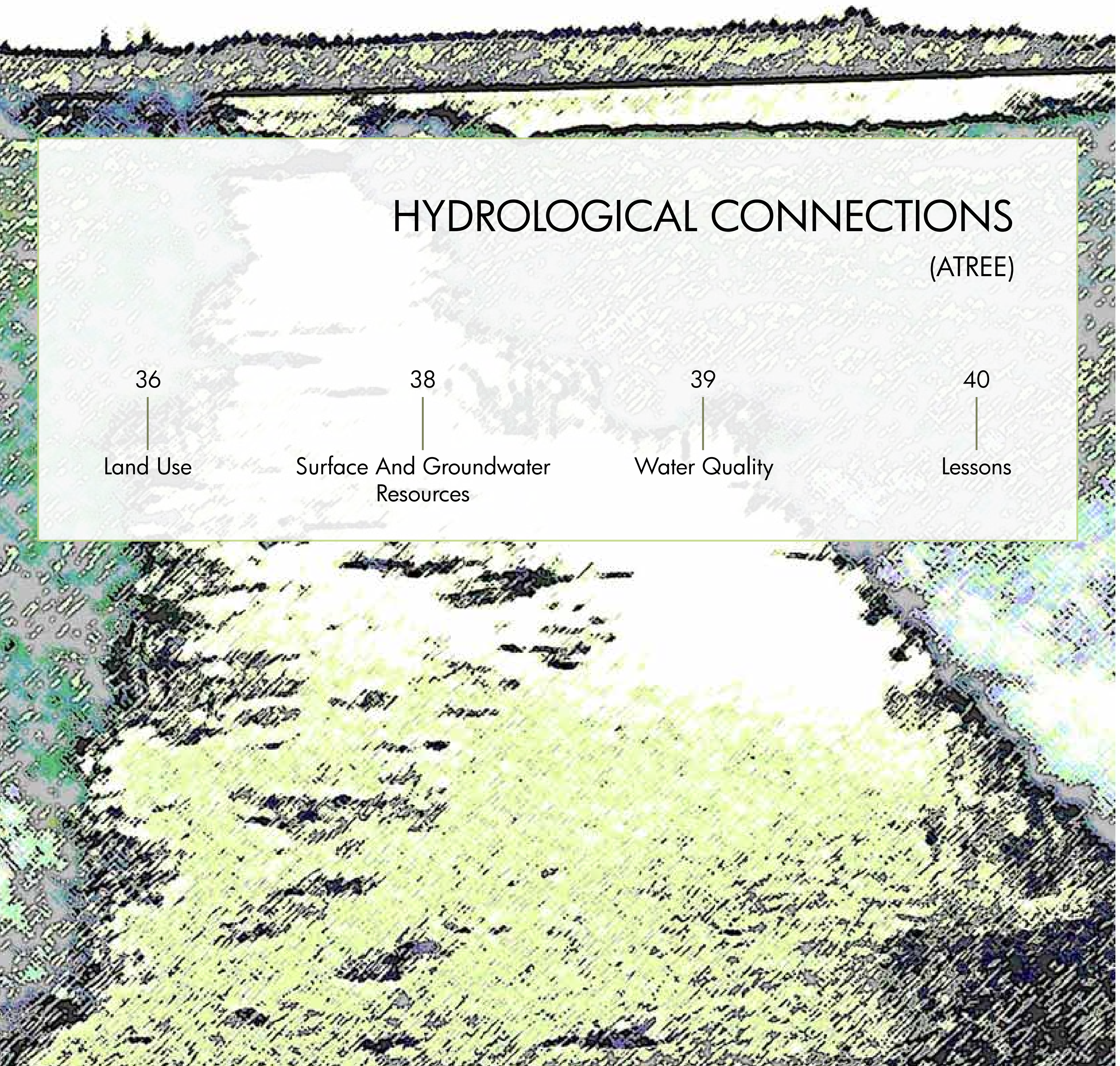
There was also a sense of disconnect between scientific information flow and actual practices on the ground. Fisheries information is mainly collected from larger landing sites, with a focus on commercial species. The overall impact of current fishing practices on the ecology of these waters is not fully addressed. Furthermore, the results of these surveys rarely reach the communities and they are not incorporated into any local level planning.

LESSONS

- Combination of gear, fishing zones and destructive fishing practices are three areas that need to be tackled simultaneously if pressure on the resource base is to be reduced.
- Community involvement in design and implementation of the MFRA is necessary for these regulations to gain acceptance and to ensure their proper implementation.
- Fishing communities in general need to be provided alternate livelihood opportunities, which will reduce pressures on fishing and help during periods of fishing bans.
- The approach of photographic identification of catch ensured coverage of a larger number of landing sites, which is essential to gain an accurate picture of the resource extraction in this sector.
- Identification of indicator species such as elasmobranchs can provide a handy tool to track fishing trends and determine thresholds for fisheries offtake.
- Scientific information on status, changes and future prediction of the fisheries resource base must reach the communities to help them take informed decisions.
- The shift seen in marketed species, including bycatch, has major implications on the economics and overall sustainability of the fisheries industry.

HYDROLOGICAL CONNECTIONS

(ATREE)



Importance

The impact of the December 2004 tsunami, while most evident on human populations along the coast, also did considerable damage to the coastal and marine environment. These systems provide several resources that directly or indirectly sustain livelihoods of coastal populations. Understanding the vulnerability and resilience of these systems is therefore an imperative, not only for such rare high impact events but also for the gradual and long-term changes that occur in these regions.

Changes occurring directly along the coast are not the only factors that affect these systems. They are also sensitive to upstream changes in land use and hydrology, which change the nature of fresh water flows, nutrient and sediment loads, which in turn affect biodiversity and productivity in these regions. There has been no systematic and comprehensive study of these changes, and baseline information for most of these indicators is lacking, which makes monitoring or assessing impacts a difficult task. Assessing the current status and analysing changes in the last few decades will enable a baseline to be established which would assist in future monitoring efforts.

This component of the UNDP-PTEI project aimed to study the impacts of upstream modifications of hydrology, sediment and nutrient fluxes due to reservoir construction and their likely effects on downstream coastal and marine systems. The coastal sites were located in the state of Tamil Nadu, most affected by the tsunami, and included the river systems of Cauvery, Tambraparani, Vaigai and Gingee.

The Work Done

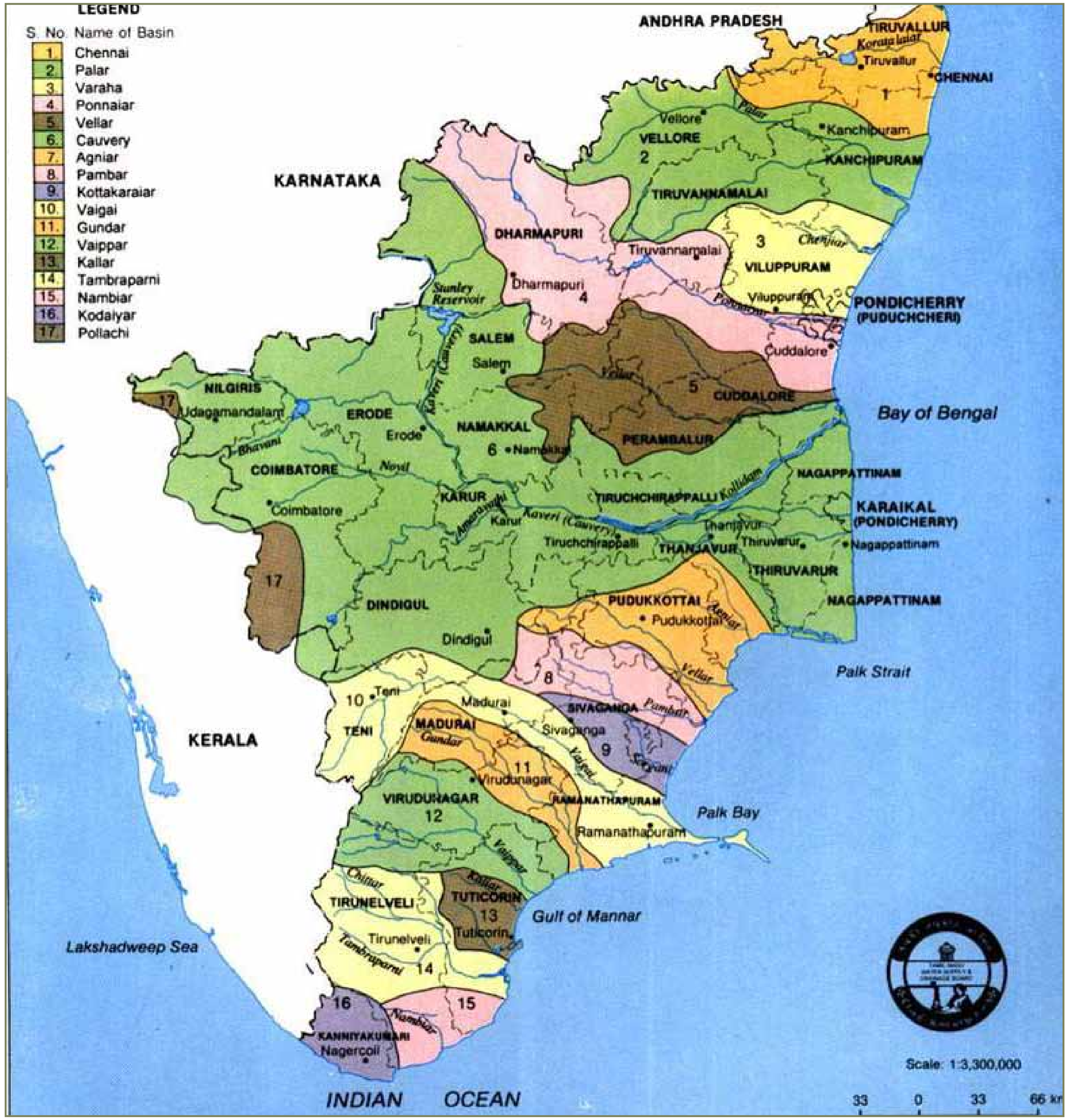
Assessments were done on trends in water resources and land use/land cover changes in the catchment areas along the river course, and water quality in the wetlands and estuaries influenced by these rivers. Data from the extensive Hydrograph Network Stations, established by the Central Ground Water Board and their nearest meteorological stations provided information on groundwater levels and rainfall in the selected sites. Land use maps from two time periods, 1996-97 and 2003-04, were used to analyse changes in important classes of land use such as crops, fallow, mangroves, industries, aquaculture and urbanisation, to name a few. Changes in areas of land under particular use observed over a time period of 20-30 years at the district level was also assessed. Water quality was assessed for physical and chemical parameters in specific estuaries and wetlands that had undergone changes in the land use around them.

Land use / Land cover

The quality and quantity of water is affected by several changes such as

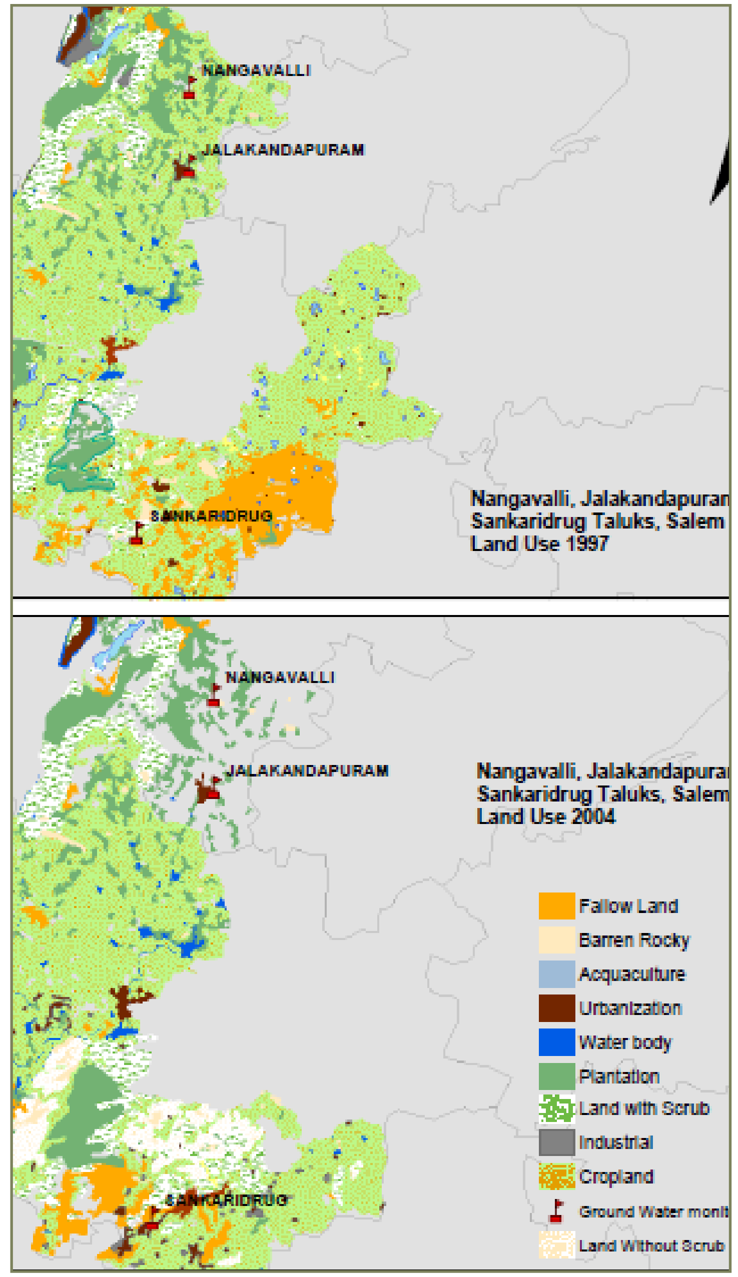
- deforestation and poor land use practices in the catchment areas
- over-exploitation of surface water resources
- water pollution
- agricultural runoff and sub-surface drainage
- encroachment on agricultural land and watersheds for urbanisation and industrial development

Each of the four river systems showed significant changes across different land use categories both in their inland catchment areas and at their coastal outlets. In the Gingee watershed, fallow land, plantation areas and non-agricultural areas had increased significantly in the catchment, and the outlet had several new aquaculture units. Significant decreases in barren areas and open grazing lands, reduction in gross area sown and large numbers of chemical industries with discharged effluents affecting groundwater resources were changes seen in the Cauvery catchment. At the outlet in Nagapattinam, large scale aquaculture, reduction in forest, available fallow and gross area under agricultural production were seen, along with the large coastal marine fisheries showing fluctuation in both quantity and value. The Vaigai catchment and coastal outlet at Ramanathapuram showed similar trends, along with increased inland fisheries in the catchment area. The Tambraparani catchment, in addition to other

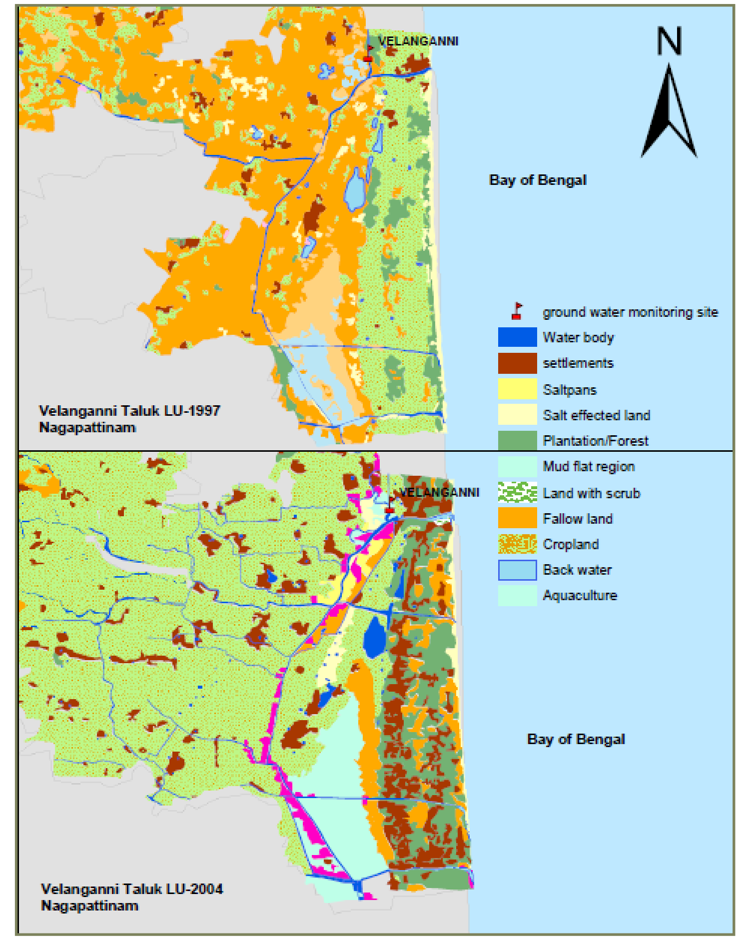


Rivers of Tamil Nadu

changes, had the interesting feature of being classified as a dry region, with most of its river water utilised and little flowing to the sea. The outlet at Tuticorin was subject to effluent discharge from chemical industries and aquaculture, extensive saltpans and increased urbanisation.



Land use change of Salem in Villupuram district 1997 and 2004



Land use change of Velanganni in Nagapattinam district 1997 and 2004

Surface And Groundwater Resources

Tamil Nadu has several perennial and non-perennial rivers flowing from upstream, inland catchments and draining across the coastal areas into the Bay of Bengal. Canals, tanks and wells are the source of irrigation for farmers in these areas. Most of the surface water is already tapped, primarily for agriculture, with utilisation at about 90%. The shallow alluvial phreatic and deep sandy alluvial aquifers are extensively pumped. The Pondicherry coastal aquifers are over-pumped and show signs of salt-water intrusion. Over the last five years, the number of “safe” blocks had declined from 35.6% to 25.2% with a similar increase in the number of semi-critical blocks. Over-exploitation had already occurred in more than a third of the blocks (35.8%), while 2% or eight blocks have turned saline. The comparison of trends in groundwater in the pre and post-monsoon periods indicated that recharge is unable to meet current levels of extraction, which are therefore unsustainable.

The flooding of the coastal areas with seawater caused salinisation of the groundwater by infiltration, and it is expected that this will also occur through subsequent leaching of salts from the unsaturated zones. The landward shift of the coastline in some areas is expected to have a similar impact on seawater intrusion. Disturbance of the fresh water lens is also anticipated, given the likely changes in the fresh water/salt-water equilibrium due to the underground pressure caused by the tsunami wave.

Water quality

The coastline of Tamil Nadu accounts for about 15% of the total coastal length of India and occurs as a narrow belt, except in the Vedaranniyam-Muthupet region where there are extensive mudflats. It has a large number of estuaries, brackish water lagoons, mangroves, coral reefs and seagrass beds. Other landforms include mudflats, dunes, beaches and rocky outcrops. These habitats are dynamic, diverse and productive regions. They form critical habitats for thousands of species and act as important buffers by filtering sediments, recharging aquifers, preventing erosion and reducing the effects of waves and storm surges. The large-scale changes observed in land use/land cover and their resultant impacts are major stresses on coastal habitats. Surface water quality was assessed at selected mangrove wetlands and estuaries influenced by aquaculture and saltpans.

The Pichavaram and Muthupet mangroves receive copious fresh water inflows during the northeast monsoon months. Throughout the rest of the year it decreases and is in fact negligible in the months of July to September, mainly due to the many dams and reservoirs constructed along the rivers that feed them. Nutrient loads have been impacted by the many anthropogenic activities occurring nearby. The geo-chemical behaviour of nutrients was influenced by the tsunami and increased concentrations of nitrate and phosphate were seen. The disturbance of the sediment column by the waves caused a huge increase in dissolved oxygen, and as a result of this, the redox potential has changed. This has led to a change in the nutrients absorbed/associated with these sediments.

Estuaries are dynamic systems that have strong gradients in chemical composition of water, variable suspended matter concentration and complex hydro-dynamic processes. They are important in regulating the amount of river borne nutrients that enter the coastal and marine environments. All sampled sites showed very high levels of calcium, magnesium, chlorine, sulphate and salinity. Nitrate and phosphate levels were within range, indicating less nutrient pollution at all sites. Waters on the landward side at Chnunnambar, showed signs of eutrophication, which could be due to water stagnation, cattle rearing and human settlements. Suspended and dissolved solids values were normal for all sites, although Muthupet showed signs of siltation.

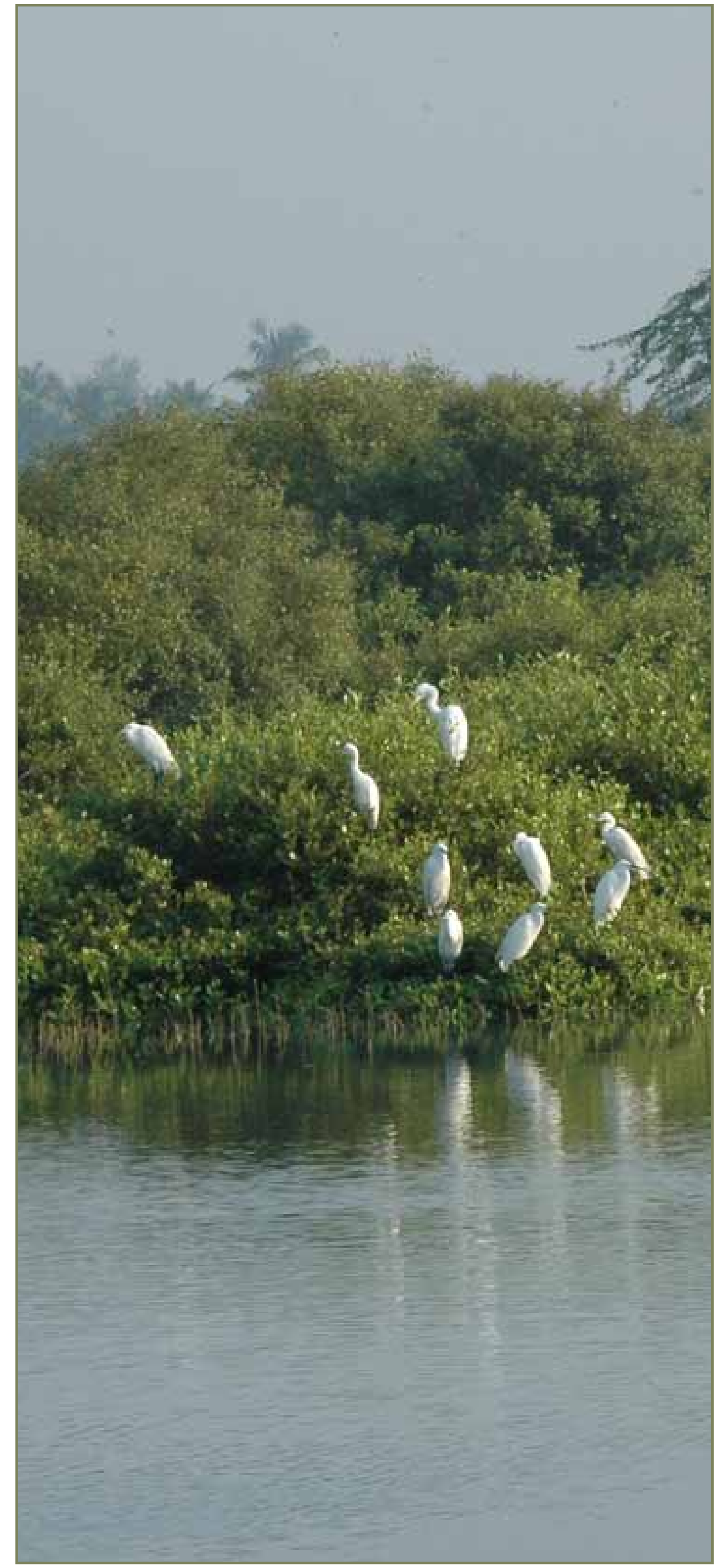
Sandbar

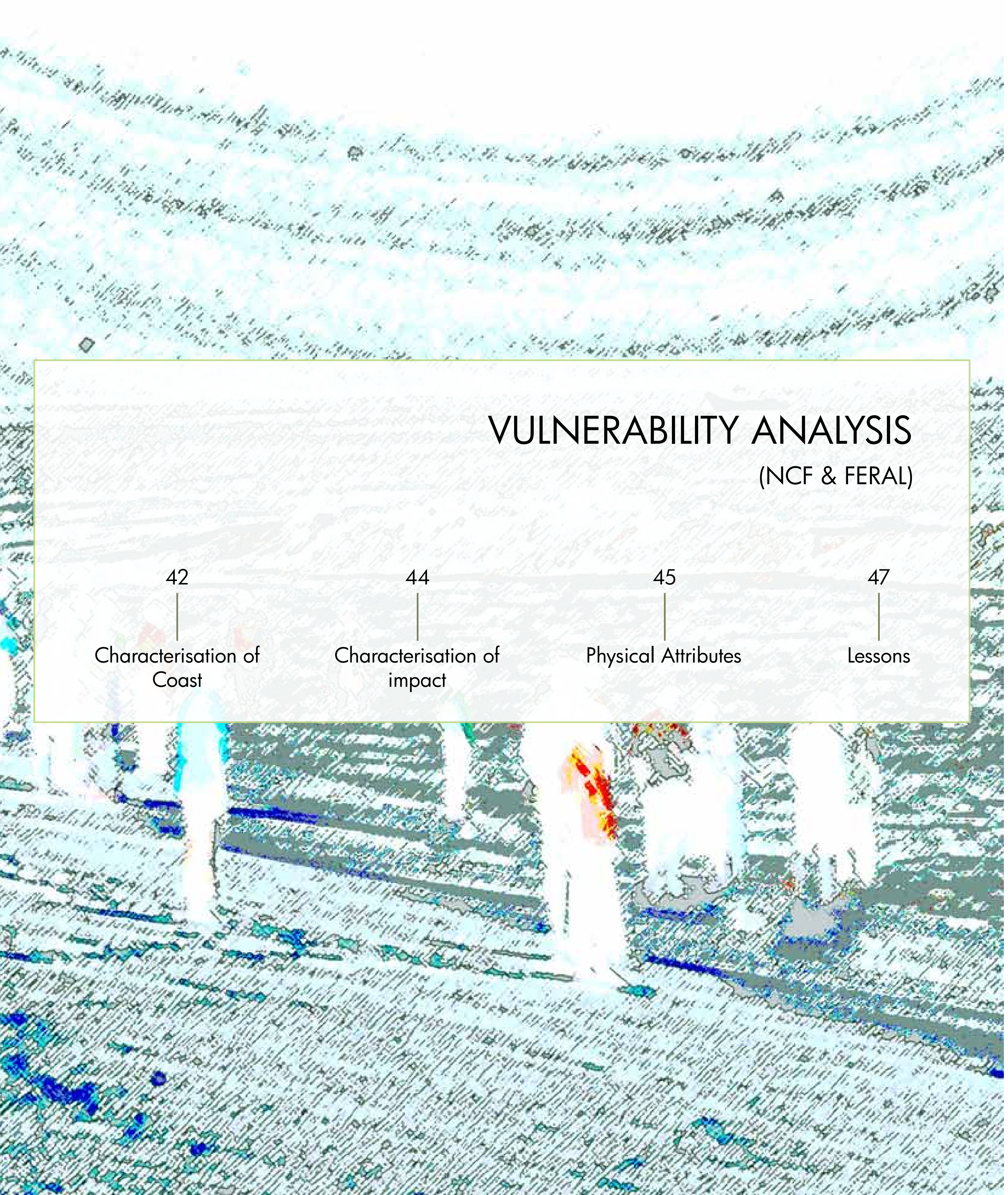
Results

Major transformations were observed in the land use and land cover in the upstream regions of coastal ecosystems. The key changes were increase in fallow areas, decrease in regular cultivation and a rise in urban development. Large-scale industrialisation, often chemical based, has occurred in most of the catchment areas of the primary rivers. A clear association was also seen between groundwater recharge and exploitation rates which affected the area under cultivation. In addition, there has been considerable reduction in fresh water inflows (surface and sub-surface) into coastal systems due to upstream abstraction and diversion. These factors are further compounded by discharge of untreated sewage, saline effluents from aquaculture and industrial effluents into coastal waters. The overall result is that coastal wetlands and estuaries are increasingly becoming marine in their water chemistry.

Lessons

There is an urgent need to raise awareness about the threats facing coastal systems and the many services they provide due to upstream land use and water use. Maintaining minimum environmental flows in rivers discharging into coastal wetlands and estuaries is essential and its importance should be highlighted. Additionally, groundwater use needs to be regulated and enforced in coastal areas, as well as sand mining from river beds. The overall dynamics and survival of these systems, their resilience and diversity are dependent on these factors.





VULNERABILITY ANALYSIS

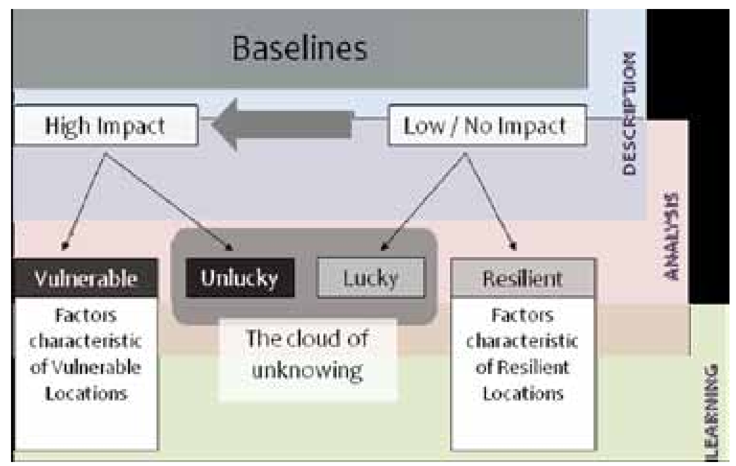
(NCF & FERAL)

Importance

The Indian coastline is about 7,500 km, and the east coast is 2,545 km in length. The coastline experiences frequent natural disasters such as storm surges and cyclones. Meteorological information shows that more than 1,000 cyclonic disturbances occurred in the Bay of Bengal in the last century, among which some 500 were either depressions or deep depressions, and over 400 were either cyclonic storms or severe storms, making the east coast of India one of the most vulnerable coastlines of the world.

The tsunami was a huge regional scale event, which affected almost the entire south eastern coast of India. However, there was tremendous variation in the levels of actual impact observed. After the initial rapid humanitarian response, there has been growing appreciation that a medium term response is essential, focussing on a sound understanding of the patterns and processes that determined how the coast and its inhabitants responded to this devastating event.

A conceptual framework was designed to deal with the wide range of data required to determine the resilience of the coast to environmental catastrophes. Descriptions of ecological, demographic and socio-economic baselines and subsequent comparison with the changes brought about by the tsunami can help in understanding the vulnerability of these regions. Further analysis was carried out on the role played by physical features along the coast in the varied impacts observed. This manner of scientific inquiry has important implications on policy design and actions which are formulated and implemented towards securing the lives and livelihoods of coastal communities and the fragile ecosystem.



A broad conceptual framework for understanding vulnerability of the coast to impacts of the December 2004 tsunami

Determining coastal vulnerabilities has received a great deal of attention in the last two decades due to increasing concerns about rising sea levels and the resultant increased dangers of coastal erosion and floods. Since most coastal areas are densely populated and greater damage is caused by storms and cyclones, there is also a sense of urgency in identifying areas and populations at risk. Despite this momentum, there are no standard methodologies or guidelines to be followed, with most studies focussing on physical or socio-economic parameters.

The Work Done

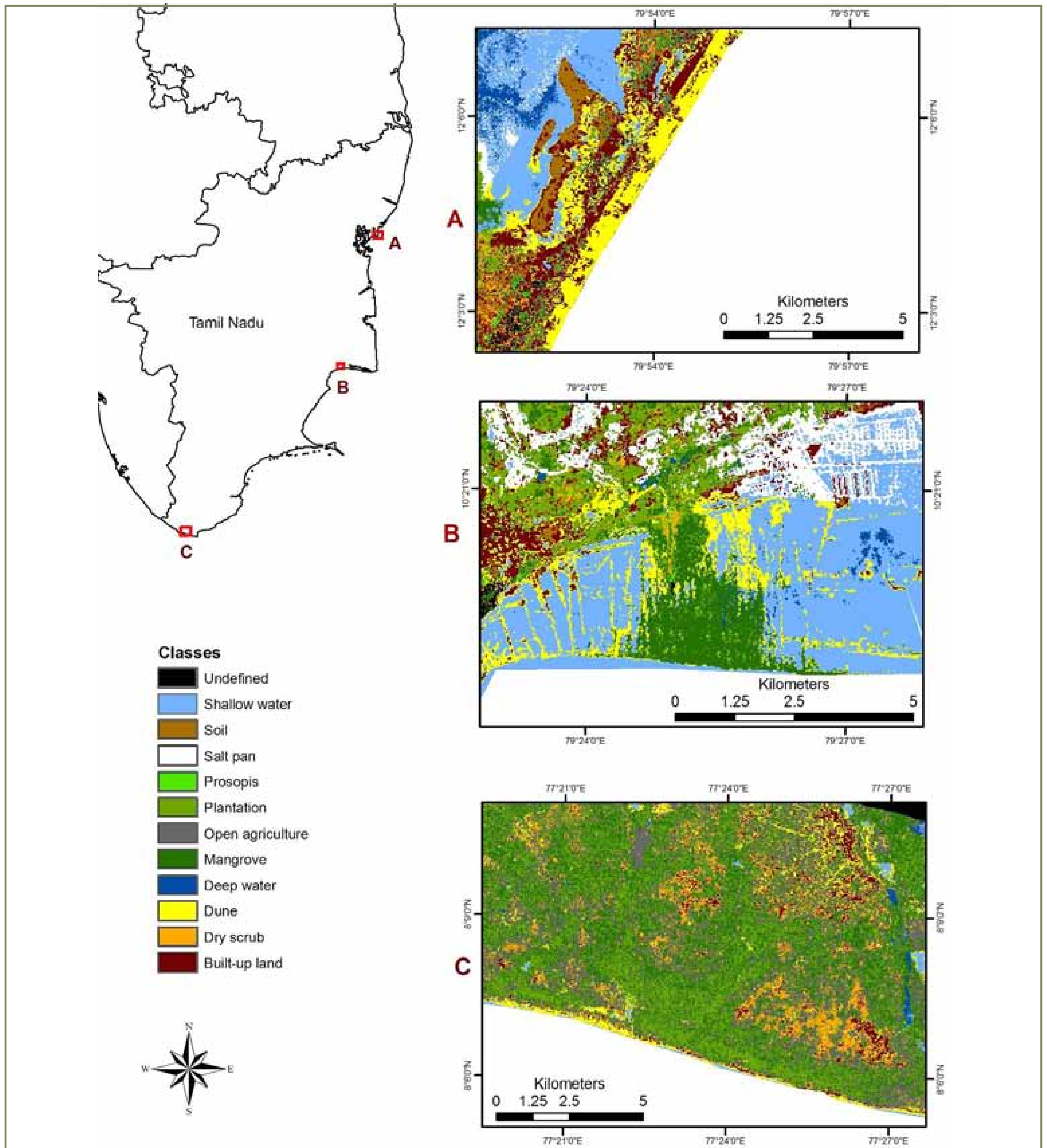
The UNDP-PTEI project attempted to describe and understand the patterns of spatial variation in tsunami impact and further to analyse the factors that govern such variation. An effort to arrive at a broad scale picture, with as much data spatially referenced as possible, of the southern coastal states of Andhra Pradesh, Tamil Nadu, Pondicherry and Kerala was initiated. Characterisation of regions was done based on both the coastal features and the nature of impact.

Characterisation of Coast

Three broad categories of data were gathered and analysed – the administrative landscape, human landscape and ecological landscape. A subsequent study included physical features such as land form and bathymetry.

Administrative Landscape

Taluk boundaries for coastal areas were extracted based on the 2001 census data. These were then linked to a database designed to hold all pre and post-tsunami data pertaining to demography, livelihoods, infrastructure and ecosystems.



Sample detail from the preliminary classification of ecosystems from pre-tsunami satellite imagery from LandSat ETM+. Insets: (A) region north of Pondicherry clearly showing dune, built up areas and bare soil; (B) mangrove forests to the west of Vedaranyam and (C) plantations and dry scrub habitats west of Kanyakumari.

Human Landscape

Pre-tsunami demographic information was summarised from the 2001 census, utilising population densities and proportion of population affected by the tsunami. Livelihood information focussed on fisheries, specifically craft and gear, since data on fisheries themselves was not available. Agricultural information such as the extent of actual cropping areas and the diversity of crops or yields was also unavailable. Some information on groundwater status was available, i.e. presence of sulphides, chlorides and fluorides from sample villages in Tamil Nadu. Infrastructure information was obtained for residential housing from census data, while it was difficult to gather and/or unavailable for roads and other structures along the coast such as seawalls, bridges and jetties.

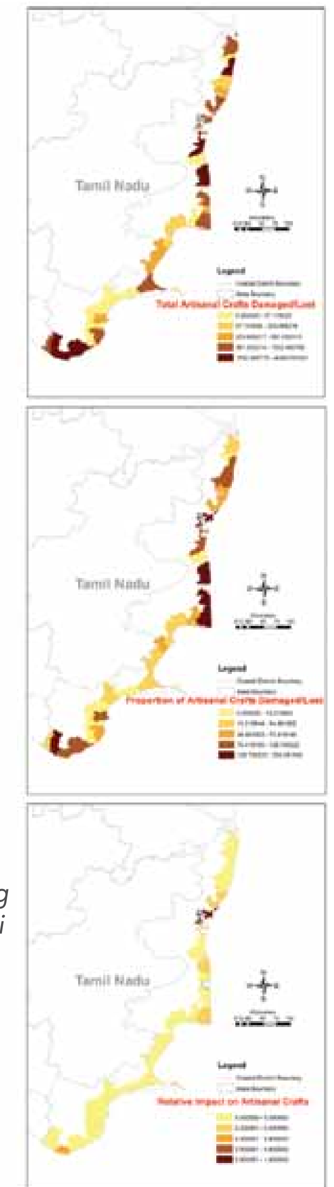
Ecological Landscape

These landscapes are poorly understood and undervalued despite their diversity of terrestrial and aquatic habitats, and they are subject to intense human pressures. Classification of land cover and identification of coastal ecosystems was done using a combination of remotely sensed imageries in conjunction with opportunistic sampling in the field. Imageries from various sources were edge matched and mosaiced, with ecosystem features being classified as either anthropogenic (agriculture, plantations, built up areas, saltpans) or natural (mangroves, scrub forests, dunes, water, bare soil).

Characterisation of impact

The impact of the tsunami was both immediate – inundation of coastal habitats and habitations, as well as extended, including loss of life, injuries, damage to infrastructure, loss of livelihood and displacement. It is important to measure the impact of disasters using different methods to understand vulnerability and see whether these methods yield similar patterns of impact or provide complementary information.

Measurement of impact was thus assessed for both immediate and eventual effects. Run-up distance of the wave and level of inundation was assessed from images acquired immediately after the tsunami based on standing water and washed up debris. Data on injury and loss of human life, loss to infrastructure (houses and roads) and loss to ecosystem derived livelihoods (fishing gear and craft) were collated. These provided vital heuristic surrogates of impact. A lacuna was non-availability of data on impact to agriculture. These three broad categories were analysed with different measures across total numbers, proportion, and densities of specific parameters present pre-tsunami.



Maps showing effect of the tsunami on artisanal fishing crafts in Tamil Nadu using three different measures of impact; (a) total number of artisanal fishing crafts damaged (left); (b) proportion of total number of artisanal fishing craft damaged (centre); and (c) normalised proportion of artisanal fishing craft damaged in the tsunami (right). This discrepancy between total loss, proportionate loss and relative loss underlines the need for explicit definitions of impact in assessments that form the basis for rehabilitation and reconstruction efforts.

Physical Attributes

There are large-scale modifications both in progress and proposed along the coast after the tsunami, based on general assessments of vulnerability. Most of these have been derived from observed impacts, which in itself can be problematic as discussed later in this chapter. A composite index of vulnerability from major risk variables – coastal erosion, geomorphology, sea level rise, etc. was derived. Furthermore, the performance of the model developed was tested to see how well it explained observed impacts of the tsunami.

Decadal mosaics of LandSat imageries were used to assess rates of soil erosion and accretion along the coast. Geomorphology was derived using a combination of land-forms, soil and vegetation cover index, and the coast was classified into five categories. Time series tide gauge data was collated from the Permanent Service for Mean Sea Level, which monitors a global network of gauges. In addition, data from the National Institute for Oceanography and other published sources were used. Tidal ranges were obtained from tide tables and wave heights compiled from published sources along with the NOAA Wave Watch III model that provides potential wave heights. Regional coastal slopes were calculated from topographic and bathymetric elevations extending 50 km landward and seaward of the shoreline. The Coastal Vulnerability Index or CVI, was calculated as the square root of the geometric mean of the ranked variables.

$$CVI = \sqrt{(a \times b \times c \times d \times e \times f) \div 6}$$

Where:
a = Erosion/accretion
b = Geomorphology
c = Sea level rise
d = Mean tidal range
e = Mean wave height
f = Coastal slope

Equation

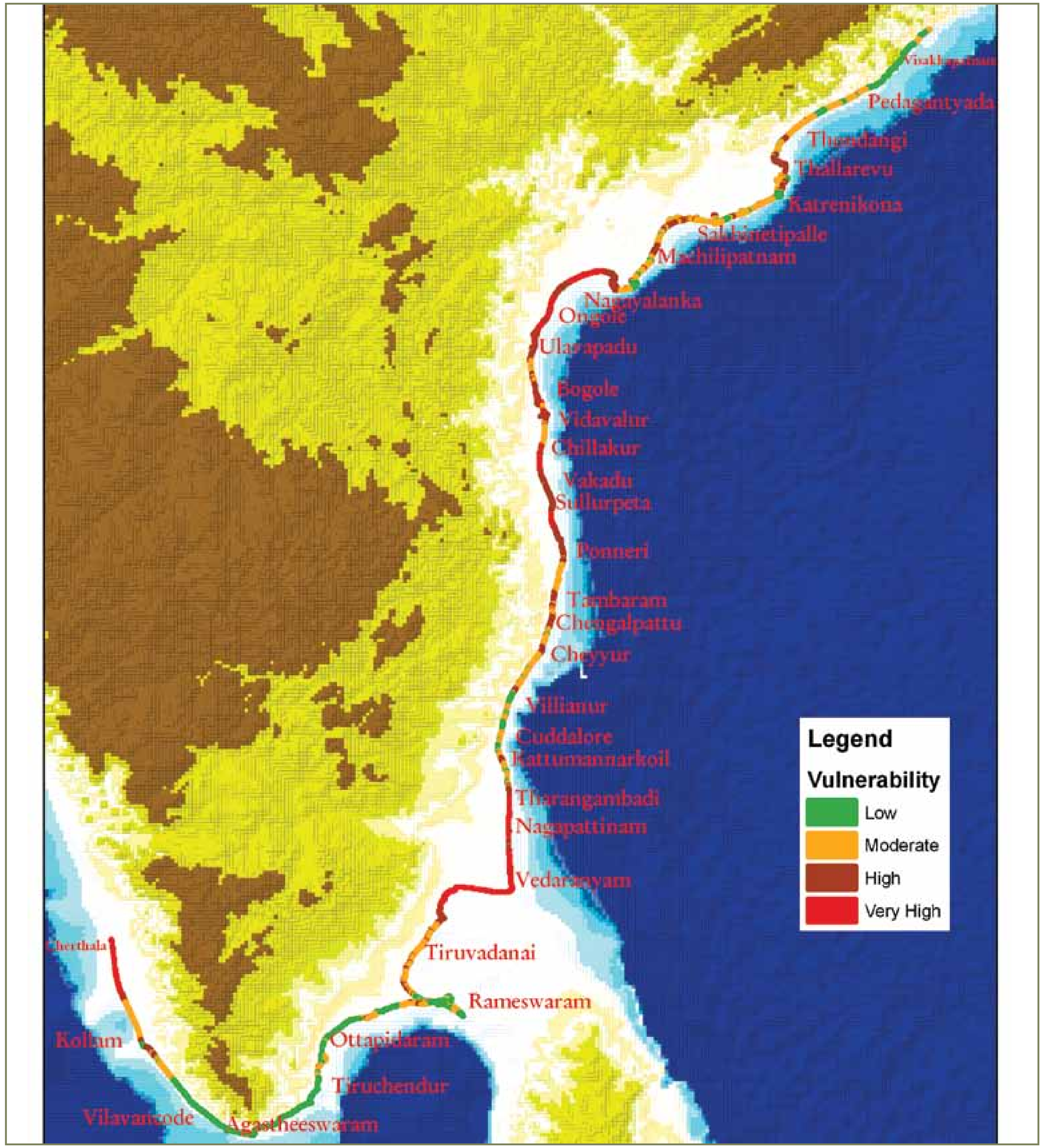
Results

An evolving open-access spatial database of pre-tsunami baselines was established and a wide range of maps depicting spatial variation in parameters such as demographics, infrastructure, distribution of fishing craft, etc. were produced. The land mass of Sri Lanka provided a significant buffer to large parts of the east coast and the Palk Bay was not heavily impacted, while the Gulf of Mannar and the west coast were affected by a wave reflected off the southern tip of Sri Lanka. Point Calimere was the closest straight line distance

Level of Vulnerability	Very Low	Low	Moderate	High	Very High
Parameter	1	2	3	4	5
Erosion/Accretion (percent change)	100 to 50	50 to 20	20 to -20	-20 to -50	-50 to -100
	Accretion		Stable	Erosion	
Geomorphology	Rocky, steep cliffs	Medium cliffs, indented coasts	Alluvial plains	Estuaries and backwater	Sandy beaches, mudflats, mangroves, deltas, coral reefs and salt marshes
Sea level rise (mm/year)	<1.8	1.8 - 2.5	2.5 – 2.95	2.95 – 3.16	>3.16
Mean tidal range (m)	>6	4-6	2-4	1-2	<1
Mean wave height (m)	<0.55	0.55 - 0.85	0.85 - 1.05	1.05 - 1.25	>1.25
Coastal slope (%)	>1.611	0.681-1.611	0.323-0.681	0.160-0.323	<0.160

Criteria for ranking of coastlines from 1 (very low vulnerability) to 5 (very high vulnerability) for each of the risk variables considered in this study

Coastal vulnerability map of the southern coast of India which incorporates coastal erosion/accretion rates, geomorphology, wave energy, tidal range, topography and bathymetry.



from the point of origin of the tsunami but run-up distance were higher in regions north of Point Calimere and increased uniformly north of Nagapattinam before decreasing again. This indicates that intensity was strongly influenced by local factors such as near shore bathymetry and coastal topography, as has been experienced elsewhere. At its maximum, inundation reached as far as 2.5 km inland.

While there was a broad correlation between settlement densities and casualties, there were important departures from this pattern. For example, regions around Chennai are the most densely populated, but the highest casualties were found in the Nagapattinam area. A similar pattern is seen in the case of artisanal fishing craft. The manner in which impact is measured and methods of analysis have a profound bearing on how we understand the fallout of such disasters. The highly variable pictures that emerged with different approaches emphasise the need for better baselines, which provide adequate direction to reconstruction and rehabilitation efforts.

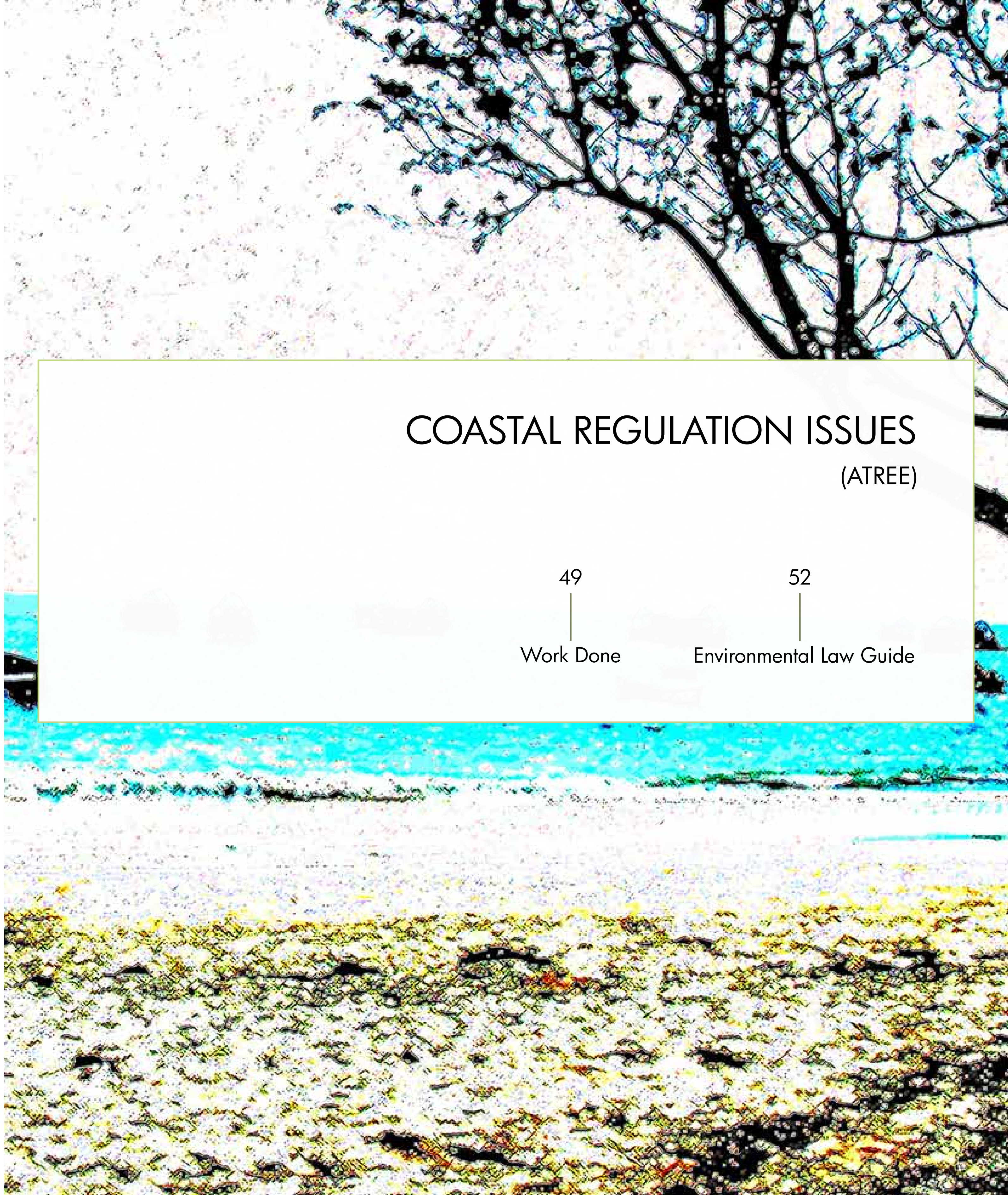
Analysis along physical features showed that 88% of the coast did not show erosion or accretion, while 10% recorded erosion. Vast stretches of the coast were observed to be highly susceptible to erosion, because the prominent features are sandy beaches, mudflats, salt marshes, mangroves and river deltas. Regional slope values showed nearly half the coastline as vulnerable to inundation. The coastline was classified as low, moderate, high and very highly vulnerable based on the CVI and 38% (915 km) of the coastline was categorised as high vulnerability, with almost half being very highly vulnerable. Patterns of human casualty and damage to property followed a similar pattern along the coast. The rapid survey on impacts on ecosystems undertaken by Daniels et al. (2006) along the coast in segments of 50 km each was taken as a basis for analysing CVI of habitat types. The region between Nagapattinam and Muthupet consisting of all types of ecosystems, and the region around Karaikal, consisting of all ecosystems except seagrass and rocky inter-tidal habitats, were classified as most vulnerable. Overall agreement of the CVI with the observed impacts was 41%.

Lessons

Available high-resolution, multi-spectral imageries enable identification of different habitats along the coast. Improved accuracy, however, can only be achieved through thorough ground verification efforts distributed across the region. Given the large extent of the coast, it is advisable for efforts to be focussed on selected regions. In addition, one needs to a priori define what is considered as change and how these changes are meaningful.

The destruction caused by the tsunami has also had a major impact on the approach of policy makers and managers towards coastal development and has led to acknowledgement of the hidden costs of coastal degradation. One needs to go a step further in understanding “impact” and recognise the complexities inherent in description and definition, given that results can vary substantially based on the currency used to evaluate or quantify impact.

Much of the discourse on coastal resilience focuses on future tsunamis, though an event of such magnitude may not occur for at least another 200 years. While long-term horizons are commendable, it is more imperative that annual and decadal threats, both natural and anthropogenic, that challenge coastal integrity are addressed in a comprehensive manner.



COASTAL REGULATION ISSUES

(ATREE)

Importance

The tsunami of December 2004 focussed attention on the nature and extent of changes that have been occurring along the coast. The Indian coastline is under tremendous pressure from the divergent needs of a wide range of stakeholders. The livelihood needs of coastal communities dependent on coastal and marine resources, increased infrastructure development catering to coastal tourism, ports and harbours, along with associated industrial activities and a burgeoning population all compete with each other making it a highly contested space. In an effort to address this increasingly complex development vs. conservation, official resolution in the form of a slew of legislations has been put into place. There are several laws that govern development activities along the coast, some of which have an explicit mandate to protect the coastal environment and resources therein. One important piece of legislation is the Coastal Regulation Zone (CRZ) Notification that was promulgated in 1991 using the provisions of the Environment (Protection) Act, 1986 and the Environment (Protection) Rules, 1986. The crux of this legislation is that its actions are "for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution."

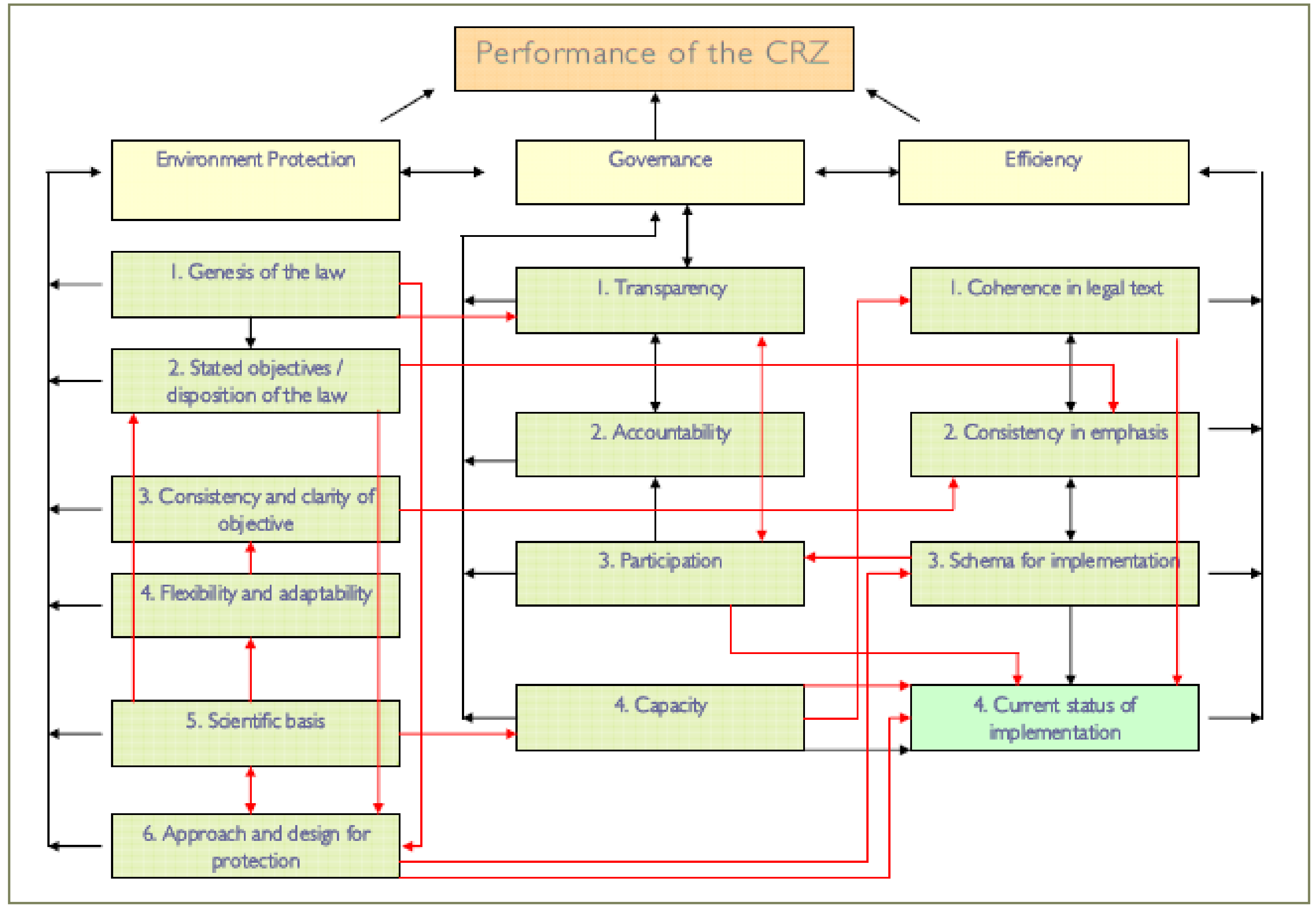
The implementation of the law has been severely compromised by a number of factors. The disaster wreaked by the tsunami focussed attention on this, with connections being made between the scale of impact and non-compliance with the Act. The UNDP-PTEI programme explored the reasons for this and assessed the performance across the three indices of environmental protection, governance and efficiency.

The Work Done

Environmental protection rendered by the CRZ was examined by understanding the genesis of the law, its stated objectives, consistency, adaptability, scientific basis and design envisaged to provide this protection. Implementation was assessed across the parameters of transparency, participation of different stakeholders and capacity of the bodies constituted for the translation of the law into action. Finally, the extent to which the various structures created and coherence/clarity in the provisos of the law, either inhibited or facilitated its overall efficiency was analysed.

The early 1980s saw the articulation of the need for protection of coastal areas by several environmental activists. These concerns arose from the rapid development of coastal cities, pollution of coastal waters and demand for land from various industries. The involvement of the fishing community, who were the most affected by these changes, was minimal. The timing of the notification coincided with the onset of economic reforms in the country, which had a major influence on the implementation of its original objective. Up to July 2003, 19 amendments and 3 corrigenda had been made which were yet to be incorporated into the original notification. These changes were primarily made to facilitate industrial and other large-scale commercial development projects. The ambiguities in definition of key terms such as "local inhabitants" or "traditional rights and customary uses" are yet to be resolved. Coastal Zone Management Plans (CZMP) prepared by each state have still not been approved by the Ministry of Environment and Forests.

Fishing communities have traditionally seen their rights to land along the coastal stretches as an extension of their occupation. Thus, the need for formalising ownership was not considered essential, and in many cases, these lands were under the trusteeship of temples or local institutions. The initiation of large projects such as ports, harbours and industries brought into focus the importance of formalising land rights. The CRZ did not take into account any socio-cultural aspects and use of the coast by this section of society, and was thus primarily seen as an imposition and a curtailing of their freedom. Awareness created by associations of fisher groups, such as the National Fishworkers' Forum and other coastal action NGOs, played a major role in publicising the CRZ and helped in utilising its framework



Analytical framework used to assess performance of the CRZ notification

to benefit the local community.

The different zones created within the CRZ restrict specific activities based on the nature of each type of habitat and resources present along the coast. However, these restrictions have been subject to interpretation and constant revision, reducing the potential impact of these provisions. Furthermore, the demarcation of areas as ecologically sensitive and the provision of adequate protection was to be detailed in the CZMPs, which are yet to be completed/initiated in many regions. Keeping in mind that the notification was envisaged primarily as a zoning framework to deal with the many demands of development, there are several gaps in the scientific basis of drafting the CRZ that could have potentially been addressed. Thus, many of the provisions have been arrived at quite arbitrarily, such as the 500m distance from High Tide Line, and key issues such as the process for environmental clearances leave much to be desired.

Coordinated functioning between the governments at the Centre and the various States is an essential prerequisite for successful implementation of the CRZ. A broad three-tier hierarchical structure has been put in place. Adequate attention has been given to critical

Increase in area under salt pans and aquaculture. The inset shows the sites that show an increase. The images for one of the locations (red spot) shows the change.

areas of planning, management, monitoring and enforcement. However, the constitution, composition and functioning of these authorities has generally been overlooked. This has created anomalies regarding who comprises these bodies, their level of autonomy and their overall ability to take informed decisions in the absence of approved and accurate CZMPs. State level bodies find financial allocations insufficient to implement the necessary investigations/effectively scrutinise submitted projects. The procedures and requirements for these submissions vary greatly from state to state. Additionally, there are no systems in place for monitoring and ensuring compliance either before or after projects are cleared.

In general, transparency and accountability of the authorities in charge of CRZ implementation, as well as the decisions taken by these bodies, have been lacking. While the original notification was circulated among the general public for comments, most of the amendments have been made invoking clause 5(d) of the Environment

(Protection) Rules, wherein the government can dispense with this process if deemed necessary. In many cases, clearances have been given before studies have been completed. The term "traditional users" has been replaced with "local inhabitants", which places all categories of coastal dwellers at the same level, and many amendments have been justified on the grounds of being "requested by local people". Participation sought at the level of preparation of CZMPs has been ad hoc; information regarding functioning and decision making by the relevant authorities is not accessible to the public and even when public consultations are held, there is no assurance as to whether issues raised are even taken into consideration before finalising any decision.

Environmental Law Guide

There are several laws in India that have been enacted to provide protection to the environment and its resources. The need for a complete understanding of these laws and awareness of their intricacies is imperative in making conservation and protection efforts effective. This helps to identify the deficits in these laws, conflicting directions and clauses within them, required expertise for decision making and processes available for grievance redressal. Currently, there are many groups that are concerned about the future of the coasts – local communities, NGOs, fisher unions, government officials, concerned individuals, etc. However, the availability of such legal information is severely limited and it is difficult to obtain, interpret and assess its application to the issues at hand.

A set of seven laws with relevance to the coast was selected for a thorough analysis of its content, authorities concerned, activities taken up and regulatory mechanisms. This has been compiled into a guide for easy use and as a reference tool to aid better understanding of environmental laws in India. The selected laws are

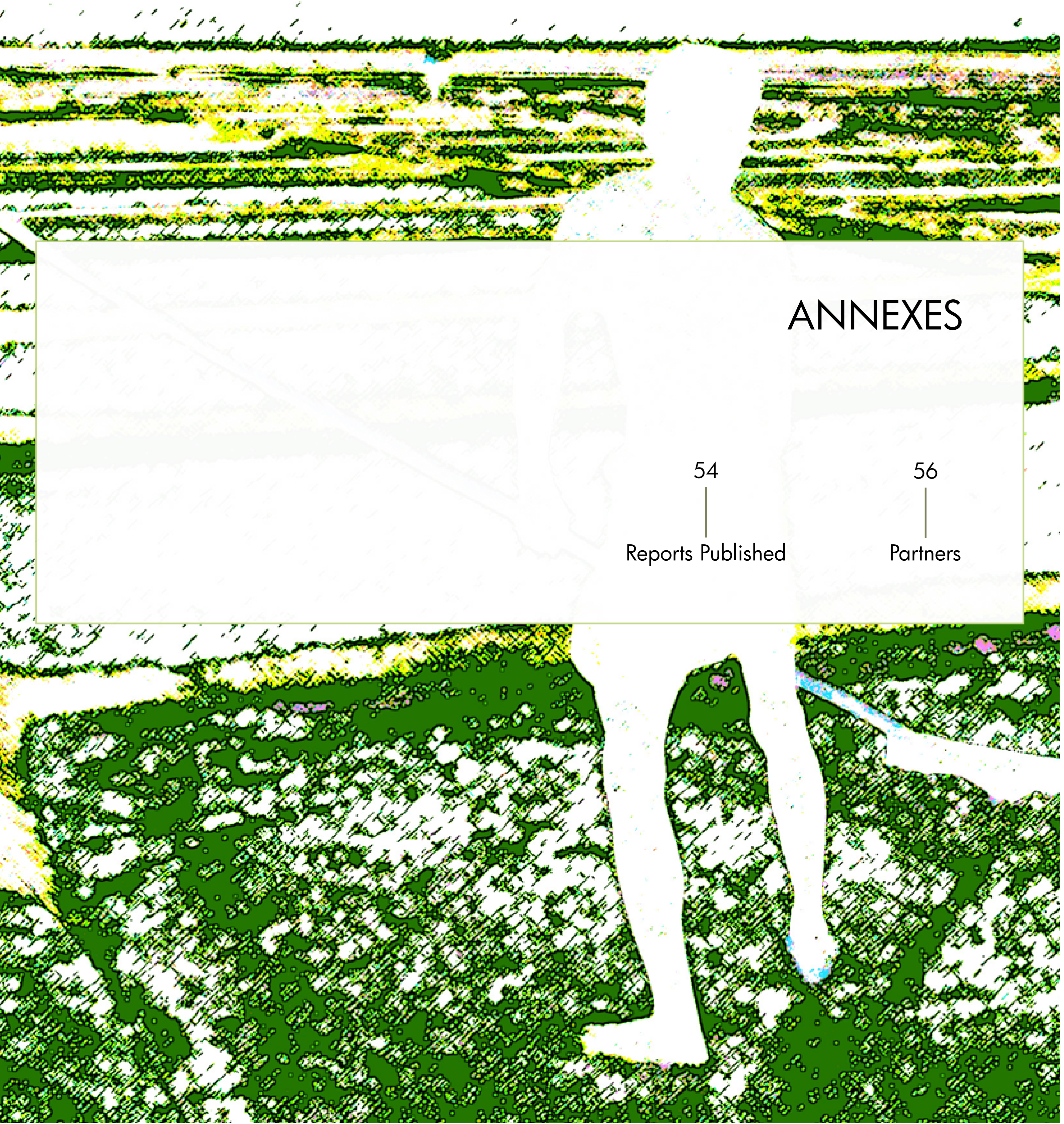
Coastal Aquaculture Authority, 2005
Coastal Regulation Zone Notification, 1991
Environment Impact Assessment, 2006
Environment (Protection) Act, 1986
Forest (Conservation) Act, 1980
Wild Life Protection Act, 1972
Water (Prevention and Control of Pollution) Act, 1974

Results

The overall implementation of the notification has thus been poor or absent in all states and is stated as such in the report of the Comptroller Auditor General of India (2006) and the Swaminathan Committee constituted in mid 2004. There has also been rampant violation of norms set within the CRZ. To address these issues a new framework for coastal management has been recommended by the Swaminathan Committee – the Coastal Zone Management notification. This framework relies heavily on Integrated Plans for several potential development activities, and these are to be formulated by the concerned ministries in the government. Another difference is that this puts aside the perspective that the coastal zone was only meant for activities that required the foreshore and the waterfront. Many of the zonations and activities permitted have been changed. No emphasis has been given to regulatory mechanisms, an important aspect of ensuring that coastal communities and threats to habitats are taken into account. In addition, the many ambiguities in definition related to who, what, how and where activities are carried out remain unresolved.

Lessons

Designing such legislation is a complex and challenging task that calls for several sources of expertise and acceptance among a wide range of stakeholders. Given the current levels of pressure on these coastal spaces from divergent lobbies, this task is even more demanding. The aftermath of the tsunami has provided an opportunity for a serious rethink of the approaches followed in the past, and it is essential that this be utilised to strengthen the mechanisms that can deliver the primary objectives of coastal zone management.



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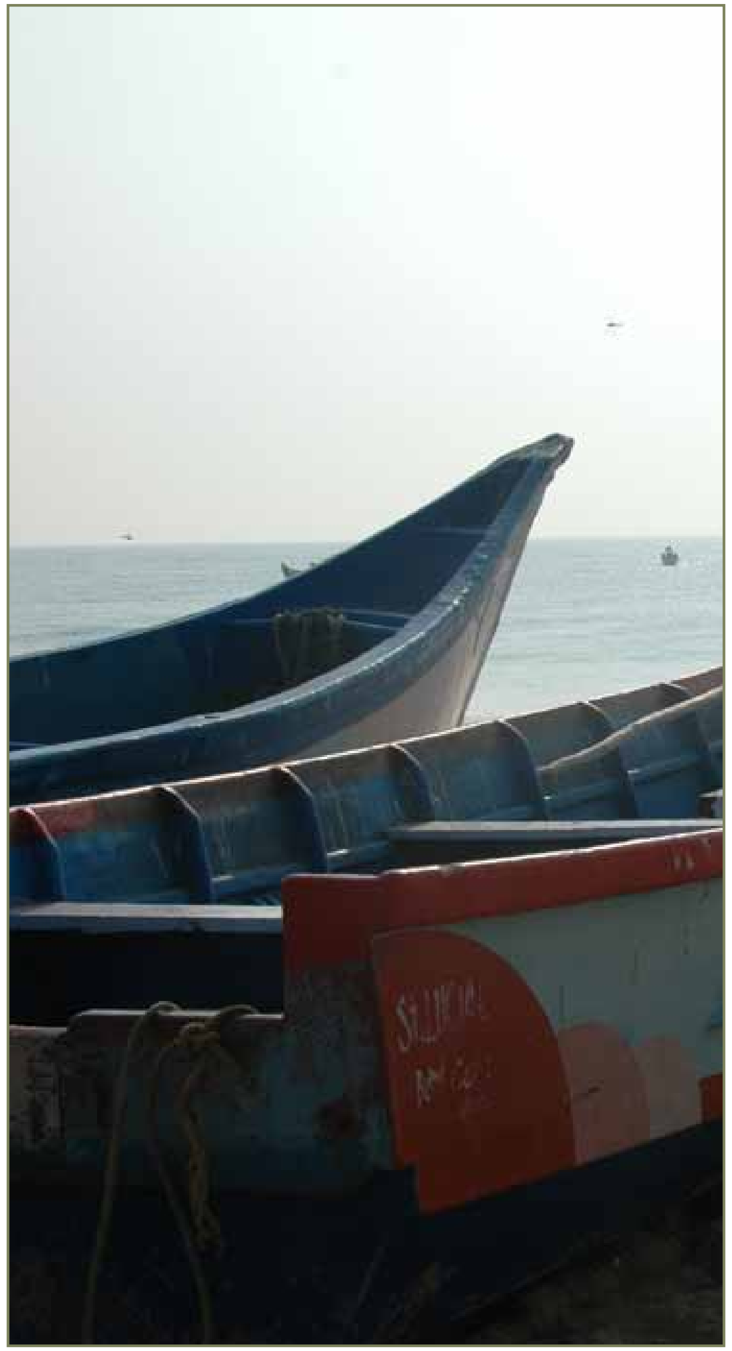

Partners

ATREE

Ashoka Trust for Research in Ecology and the Environment (ATREE)

ATREE's mission is to promote socially just environmental conservation and sustainable development by generating rigorous interdisciplinary knowledge that actively engages with academia, policy makers, practitioners, activists, students and wider public audiences.

nature conservation foundation

Nature Conservation Foundation (NCF)

NCF is a non-profit organisation created in 1996 to provide a scientific leadership to address wildlife conservation issues in India. Main areas of research include endangered species and ecosystems, wildlife and human ecology, animal behaviour and restoration ecology.

FERAL

Foundation for Ecological Research Advocacy and Learning (FERAL)

FERAL is a non-profit trust formed in 1997 with a team working on various aspects of applied research on ecological and environmental issues. Key areas of work include wildlife conservation, ecological restoration, natural resource management and capacity building in these areas.

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Pg. 42, 43, 44, 50 – Post-Tsunami Ecological and Social Impact Assessments in Mainland India.

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