Why Should We Be "Greening the Coast"? A Case Study of Mangrove Restoration in South-West Bay of Bengal

young mangrove, Chilaw lagoon

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ABSTRACT

It has been recognised that biodiversity is of great importance for human well-being by provision of ecosystem services that humans depend on. Still, despite this notion, biodiversity is in decline and poor communities are the most vulnerable to the loss of ecosystem services due to their high dependency on nature and its resources. Therefore, in certain extremely degraded habitats efforts are made to revive ecosystems and restore ecosystem services for the benefit of local communities. This thesis focuses on mangrove restoration in south-west Bay of Bengal. It examines projects in the Indian states of Tamil Nadu and Andra Pradesh, which are experiencing significant coastal development, as well as the west coast of Sri Lanka which has been recently proclaimed a top tourist destination. Coastal development is identified as the biggest threat to mangrove ecosystem making these locations important to research.

The findings of this thesis demonstrate that mangrove restoration, if made in an adequate way, has potential for biodiversity enhancement, regeneration of ecosystem services and provision of benefits for poor local communities. Unfortunately, some mangrove restoration projects are doomed to fail due to various reasons.

Through analysis of different projects and identification of achievements and the challenges, this thesis aims to create a set of recommendations for NGO'-s that conduct restoration, funding agencies and policy makers in order to achieve successful restoration of mangroves. It is noted that restoration success is being differently perceived from different organisations, why there is a need for understanding what actually successful program should encompass. Therefore, this thesis evaluates success through lens of sustainability science. At the end, the attempt is made to contribute to the debate on general ideas behind the ethics of ecosystem restoration; should we restore ecosystems, and why?

Key words: biodiversity, ecosystem services, mangrove restoration, sustainability, India, Sri Lanka

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List of acronyms and abbreviations

CBD - Convention on Biological Diversity
COPDANET - Coastal Poor Development Network
CReNIEO - The Centre For Research On New International Economic Order
FAO - Food and Agriculture Organization
FD - Forest Department
GNF - Global Nature Fund
GTZ - Gesellschaft fur Technische Zusammenarbeit
ITTO - International Tropical Timber Organisation
IUCN - International Union for Conservation of Nature
JMM - Joint Mangrove Management
MAP - Mangrove Action Project
MEA - Millennium Ecosystem Assessment
MEF - Ministry of Environment and Forests
MFF - Mangroves For the Future
MSSRF - MS Swaminathan Research Foundation
NARA - National Aquatic Resources Agency
NGO - Non-governmental Organisation
OMCAR - Organisation for Marine Conservation, Awareness and Research
REDD - Reducing Emissions from Deforestation and Degradation
RRI - Rainforest Rescue International
RSBS - Research on the Scientific Basis for Sustainability
SFFL - Small Fishers Federation Lanka
SHS - Self-help Groups
UN - United Nations
UNDP - United Nations Development Program
UNEP - United Nations Environment Programme
UNOPS - United Nation Office for Project Services
WWF - World Wildlife Fund

foc. –focus group
int. -Interviewee
nd.- Not dated
p.-page

1 euro = aprox. 60 Rs

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1. INTRODUCTION

1.1 Problem definition

Biodiversity[1] is the foundation of life on Earth. It underpins the functioning of ecosystems from which we derive essential products and services such as oxygen, food, fresh water and medicines. Therefore, healthy biodiversity is essential to human well-being, sustainable development, and poverty reduction (IUCN, 2009a). However, humans have become disconnected from nature forgetting that we constitute one human-nature system, and that in spite all technology achievements we still rely on nature and biodiversity for our survival.

Today's notion of the need to protect biodiversity is nothing new. Earth Summit in Rio 1992, in chapter 15 of Agenda 21, titled "Conservation of Biological Diversity" calls for immediate action in protecting biodiversity (UNEP, nd). In April 2002, the Parties of the Convention committed themselves to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth (CBD, 2010). In order to reflect upon achievements in biodiversity protection, and to focus on the urgency of our challenge in the future, the year 2010 was declared by UN The International Year of Biodiversity (CBD, 2010). The emphasis is put on the dependency of our lives on nature and human power to destroy but as well to protect it. The targets set in 2002 apparently are not met, but there have been positive moves.

The most important direct drivers of biodiversity loss and ecosystem service changes are habitat change, climate change, invasive alien species, overexploitation, and pollution (MEA, 2005a). The pressures on ecosystems will increase globally in coming decades unless human attitudes and actions change (MEA, 2005b). However, this is not easy to achieve. Part of the problem lays in not understanding why biodiversity loss should be of concern. We can argue that biodiversity should be protected because of its intrinsic value, but a more effective approach to reach understanding of wider masses, and especially policy makers, is to emphasise the value of biodiversity as provider of ecosystem goods[2] and services[3] important for human survival. Biodiversity at genetic, species, population and ecosystem levels contributes to maintaining these functions and services (Badola & Hussain, 2005).

The core idea of the Millennium Ecosystem Assessment[4] is that the human condition is

[1] Biodiversity encompasses scales from genotypic diversity within population, through population diversity within the species, and species diversity within regions, to patch diversity within the landscapes, landscape diversity within regions and biome diversity within the continents (Field et al., 1998a).

[2] Ecosystem 'goods' include food, medicinal plants, construction materials, tourism and recreation, and wild genes for domestic plants and animals (IUCN, 2010b).

[3] Ecosystem services are the transformation of natural assets (soil, plants and animals, air and water) into things that we value. They can be viewed as provisioning such as food and water; regulating, for example, flood and disease control; cultural such as spiritual, recreational, and cultural benefits; or supporting like nutrient cyclng that maintain the conditions for life on Earth (IUCN, 2010b).

[4] Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The MA has involved the work of more than 1,360 experts worldwide. Their findings, provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they and the options to restore, conserve or enhance the sustainable use of ecosystems (MEA, 2005c).

tightly linked to the environmental condition (Tallis et al., 2008). This tight relation between people and biodiversity is especially visible in developing countries where a significant number of people are directly dependent on services and goods from nature. Nearly two thirds of the services provided by nature to humankind are found to be in decline worldwide, and the cost is being felt often by people far away from those enjoying the benefits of natural services (Badola & Hussein, 2005). The poorest people are not necessarily the ones that destroy environment, but they can be the ones most affected by destruction. Development is often happening in their neighbourhood, but not benefiting them. Therefore, the loss of services derived from ecosystems is recognised as a significant barrier to the achievement of the Millennium Development Goals to reduce poverty, hunger and disease (MEA, 2005a).

Mangrove ecosystems are recognised by various authors as providers of vast amount of goods and services (Badola & Hussein, 2005). These ecosystems protect some of the world's most vulnerable people from extreme weather and provide them with a source of food and income. They are as well becoming a vital component in adaptation to climate change (IUCN, 2010a). Nevertheless, mangrove forests rank among the most threatened of coastal habitats, particularly for the developing countries (Badola & Hussain, 2005). More than 50 % of the worlds mangroves have been destroyed, 35% in the past two decades to aquaculture and coastal development, altered hydrology, sea level rise, and nutrient over-enrichment (Feller et al., 2010). The results of the first-ever global assessment on the conservation status of mangroves for the IUCN Red List of Threatened Species reveal that more than one of six mangrove species worldwide are in danger of extinction due to coastal development and other factors (IUCN, 2010a).

After the Asian tsunami in 2004, the effect of mangroves as natural barriers, so called bio-shields that protect local communities from storms and cyclones, brought attention to mangroves conservation and restoration as priority in local coastal management plans for developing countries that resulted in numerous projects that were concerned wit the establishment of mangrove belts.

Restoration[5] is rapidly expanding discipline that combines many fields of science, including ecology, geology, sociology, economics, and engineering (Taylor & Francis Group, 2006). It is agreed among many scientists that ecological restoration of mangrove habitats is feasible, it can be done cost effectively and it can create benefits for communities and nature, if it is done in a proper way (Tallis et al., 2008). However, many projects of mangrove restoration fail due to the various reasons. To make a good project, to include all parameters and to ensure the successful restoration of the site has become a great challenge (Taylor & Francis Group, 2006).

This thesis is grounded on the claim that the loss of biodiversity through loss of the ecosystem services that it provides has a negative effect on human well-being. In order to preserve ecosystem services we need to conserve biodiversity, in this case mangrove forests. Unfortunately, mangrove ecosystems all over the world are degraded to such an extent that conservation alone is not enough. This thesis explores restoration of ecosystems as a possible tool to reverse the negative effect of biodiversity loss. It

[5] Definition by Morisson (1990): restoration is re-introduction and re-establishment of community like groupings of native species to sites which can reasonably be expected to sustain them, with the resulting vegetation demonstrating aesthetic and dynamic characteristics of the natural communities on which the are based (Kairo et al. 2001).

explores the options available to restore biodiversity and bring degraded ecosystems back to function in a way that benefits local communities with economically reasonable means. This is followed by an examination of how this is done in the case of mangrove restoration in south- west Bengal.

1.2 Thesis structure

Restoration will be examined through the concept of ecosystem services and their connection with human well-being. Emphasis will be put on the most relevant services in the mentioned research area: nurseries for juvenile fish and bio-shields for coastal storm surges, cyclones and tsunamis. The introduction of purpose and scientific relevance of the research is followed by brief overview of methodology used in order to answer the research questions. Further, the thesis introduces the settings of the study, objects of study and main concepts and ideas behind restoration. The following section will illuminate the results from literature review and field findings, followed by analysis of the projects through the lens of sustainability science. Results will therefore be interpretive from economic, environmental and social perspective. The following discussion focuses on the achievements and limitations to mangrove conservation, with recommendations of how to approach the mangrove restoration in order to reach sustainable outcomes. At the end, findings from this case study will be used in a general debate on ecosystem restoration and its ethics.

1.3 Scientific relevance and the thesis outcome

IUCN (2010) argues that when applicable, ecosystem restoration should be an important component of conservation and sustainable development programmes so that the livelihoods of people depending on these degraded ecosystems can be sustained. Guided by that claim and based on examples of mangrove restoration from Bay of Bengal, the scope of this study is to demonstrate the implications of ecosystem restoration on three pillars of sustainability: society, environment and economy. In other words, the aim of this thesis is to analyse to what extent mangrove restoration project can be a positive driving force of local community development enhancing the biodiversity at the same time.

Based on the analysis of achievements and challenges seen in different projects, and comparison with the restoration framework developed by Biswas et al. (2009), set of recommendations for organisations involved in restoration and funding agencies will be proposed to guide them towards sustainable restoration outcomes. Another practical aim is to provide a scientific base for lobbying for those who are affected by biodiversity loss, environmental degradation and ecosystem services loss, poor fishermen communities, for creation of programmes that can help them to improve their livelihood situations. Findings of the research will be communicated to Mangrove Action Project, (MAP) Asia, who expressed their interest in certain information.

In the context of India and Sri Lanka these cases will touch upon local and regional policies towards nature conservation and local development, as well as foreign funding preferences. Selection of India and Sri Lanka for this research is grounded on notion that even though they are different countries they are closely connected and similar in many ways. Even though they show a significant economic progress, much of which was happening at the expense of the environment, India and Sri Lanka have many social issues and inequalities to deal with. Gender and ethical issues as well as poverty and

hunger are still wide spread however, more in India than Sri Lanka (UNDP, 2009). To make situation worse, this area was hit by tsunami on December 26, 2004, leaving devastating consequences on people, their livelihoods and mangroves. The damage in all cases was vast in terms of casualties, property damages and environment devastation and it has been a big misfortune for locals and slowed down the development of these areas. Post-tsunami recovery initiated many mangroves restoration programs as a mechanism to increase resilience of local populations to catastrophic events. On all above stated grounds, these areas and issues are of interest to foreign donors that are investors in mangrove restoration, which makes this an interesting area to research.

1.4 Analytical framework

The research is guided by the following question:

To what extent can mangrove restoration be an effective way to re-establish ecosystem services, enhance biodiversity and facilitate sustainable development strategies for local communities in the context of south-west Bay of Bengal?

This will be followed up by sub-questions:
What are the main barriers in reaching social, environmental and economic sustainability of mangrove restoration and how can we overcome these? How do different stakeholders identify the goals of mangrove restoration and how do they perceive success? Does this correspond to sustainability science principles? Is there a potential for restoration to enhance further conservation?
Furthermore, I intend to give a small note to the discussion about the ethics of restoration projects by asking if conservation of biodiversity should be done in the name of human needs and benefits. The question raised is: Should we restore ecosystems at all, and if so, on what grounds?

2. THEORETICAL FRAMEWORK

In order to make sense of what is going on in the social setting being studied the study will use the analytical and interpretative framework, theory (Anfara & Mertz, 2006). Therefore, the results of the study will be analysed through the lens of sustainability science. The term sustainability belongs originally to the field of ecology, referring to an ecosystem's potential for subsisting over time, with almost no alteration. When the idea of development was added, the concept would no longer be looked at from the point of view of the environment, but from that of society and the capital economy (Jabareen, 2008).

In general, mangrove restoration projects are described as sustainable practice to bring about positive moves in environment and society. Sustainability became a common and popular label for various projects in the field. However, sustainability in this case, as in many other fields, is differently understood by different actors and can be interpreted in various ways. The background of this problem lies in the most frequently used definition of sustainable development[6] found in Brundtland Commission Report from World Commission on Environment and Development.

[6] Sustainable development is development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations (Bell & Morse, 2003 from WCED 1987).

The same concept of sustainable development represents a paradox de-emphasising the environment, while underlining human needs to be realized through development. Bell & Morse (2003) see the difference of sustainable development from other macro theories of development that it rests not so much on its focus on people, but more on the underlying philosophy that what is done now to improve the quality of life of people, should not degrade the environment and resources that future generations are put in disadvantage. In this sense, sustainability means that the stock of natural capital should not decrease endangering the opportunities of future generations to generate wealth and well-being. Well being is a term without a single definition, and some authors use it as synonym for welfare, which is seen as the benefit that individual derives from consumption of goods and services (Dasgupta, 2007). In this paper welfare and well-being are considered as two different terms, and the author accepts Dasgupta's (2007) view that wellbeing encompasses welfare, but goes beyond it to include benefits derived from things other than consumption.

In this research I address three important components of sustainable development as identified by The U.S. National Research Council and found in Ness, (2008): what is to be sustained, what is to be developed, and the intergenerational component. The three areas to be sustained are nature, life support systems and community. Furthermore, the thesis advocates for transdisciplinary approach (Max-Neef, 2005) arguing that mangrove restoration is a complex issue that cannot be tackled from spheres of individual sciences. This thesis supports and is guided by Agyeman, Bullard and Evans (2002) who believe that a truly sustainable society is one in which wider questions of social needs, equity, welfare, and economic opportunity are integrally related to environmental limits imposed by supporting ecosystems. Furthermore, the author accepts the approach from Folke et al. (2002) that the goal of sustainable development is to create and maintain prosperous social, economic and ecological systems, and that these systems are linked: humanity depends on services of ecosystems for its wealth and security.

Guided by previously stated principles, an attempt is made to observe and document the constituents of three pillars of sustainability on the case of mangrove restoration. In order to answer the posed research questions, the analysis will require the use of sustainability indicators. Parris & Kates (2003), emphasise that there are no indicator sets that are universally accepted, backed by compelling theory, rigorous data collection and analysis, and influential in policy. This is due to the ambiguity of sustainable development, the plurality of purpose in characterising and measuring sustainable development, and the confusion of terminology, data, and methods of measurement. The indicators used for this case study are the author's personal choice based on the rationale judgement of what would be appropriate depending on the case study conditions.

3. METHODOLOGICAL APPROACH

3.1 Research strategy and research methodology

The research strategy applied in this case is defined as qualitative research. The design applied in the research is a case study design[7]. The author's choice for case study design

[7] A case study is en empirical inquiry that: investigates the contemporary phenomenon in depth and with its real life context especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2003).

can be explained by reflecting on Yin's (2003) explanation that need for case studies arises out of the desire to understand complex contemporary social phenomena within the real life context, where the investigator has a little control over events, restoration of ecosystems in these case.

According to Silverman (2006), this study could be classified as an instrumental case study, a study where case is examined mainly to provide insight into an issue or to revise a generalization. Following Bryman (2008), this case study can be viewed as evaluation research. He defines evaluation research as the evaluation of occurrences as social and organisational programmes or interventions. It is used to question if the intervention achieved its anticipated goals and to understand in depth the context in which intervention occurs and the diverse viewpoints of stakeholders.

This particular case study investigates the phenomenon of mangrove restoration in south-west Bay of Bengal. Even though the research is undertaken in two different countries and was examining different projects the author is classifying it as single case study, a mangrove restoration case study. The justification for the use of data from India and Sri Lanka is based on notion of similarity of the condition for restoration, practicality and necessity.

The research primarily started with theory that poor people destroy mangrove because they have no alternative and if we offer them an adequate alternative, they will not degrade environment and even the alternative livelihood will benefit them. From that theory I was about to collect data, for what would be a deductive approach (Bryman, 2008). After realising that I would not be able to extract the data needed (the theory would not be proven or rejected), I have changed the research question and took an inductive approach (ibid) mostly inspired by my field observations.

3.1.1 Data collection

Before the field work a detailed literature review was undertaken. However, literature review continued during the whole research process, up to the end of thesis writing. Some of the documentation is not available on the internet and was provided by organisations. Literature review was an important for insight in current projects and achievements. Furthermore, it made possible for me to understand different relations between various variables and to set the research questions.

Semi-structured interviews (Bryman, 2008) were made with persons engaged in mangrove restoration or conservation projects. The choice of interviewees was based either on snowball sampling[8] or on researcher personal choice based on judgement about the possible knowledge of interviewees and their relevance to the research. Interviewees were scientists, villagers, government officers, NGO-s representatives etc. (see Appendix 1). The intent of the interviews was to discover more about mangrove degradation, restoration, involvement of local communities, relations between stakeholders, approaches to problems and general attitudes of interviewees on the issues of restoration. The interviews were based on a certain set of questions; however, I also introduced further questions based on answers provided.

[8] The researcher made contact with certain groups, and used it to establish contacts with others. (Bryman 2008).

Some of the interviews were done in form of the focus groups[9]. Two focus groups were formed with the aim to find more about attitudes of woman involved in mangrove restoration projects and local fisherman towards mangrove restoration and mangrove in general. The primary intention was to distribute questionnaires to villagers but because of high percentage of illiteracy, this was not possible. The questions were therefore discussed in the group.

In Sri Lanka, the communities are not illiterate, what enabled the use of self-completion questionnaires (Bryman, 2008). The questions were translated in Sinhala and distributed to families that were involved in restoration. Local organisation translated the answers to English and returned questionnaires to me. However some of the questions remained unanswered and some of the questions and answers were mixed, making questionnaires not usable to greater extent. Due to incorrectly translated questionnaires, the data gathered by questionnaires will not be used as evidence but rather as guidance in combination with other sources in triangulation[10].

Personal observations played an important role in research. I visited fully restored mangroves, recent restoration sites, nurseries, educational and research centres (see Appendix 2). Being inside certain organisations resulted as well in deeper insight in their work.

3.1.2 Data analysis

As an analytical technique, an explanation building system[11] was chosen. Due to multiple sources of evidence, triangulation was used in analysis. The events and facts were supported by more than two conditions; personal observations, interviews, and documents. Secondary analysis of data (Bryman, 2008) collected by other researchers was an important segment of this research. Secondary data used include documents, brochures, and publications by other researchers. The advantage of secondary data use is in terms of cost and time, high-quality data, opportunity for longitudinal analysis. During my analysis, the focus was put on connection between existing findings and my findings.

3.2 Limitations

The main limitation to this research was inadequate access to required information as a result of the lack of understanding between me as a researcher and my contacts. Organisations envisioned the research differently from what was imagined by me. One of the biggest limitations included language barriers. All the interviewees spoke English, and communication with them was not a problem. On the other hand, villagers in India spoke Tamil, while in Sri Lanka they spoke Sinhala, which required an interpreter that was appointed by the organisation. On a few occasions the interpreter had limited knowledge of English language that resulted in difficulty to extract information.

[9] Focus group is an interview with several people on a specific topic or issue. The idea of focus group is that people who were known to have had a certain experience could be interviewed in a relatively unstructured way about that experience. The focus group offers opportunity of allowing people to probe each other's reasons for holding a certain view. (Bryman, 2008).

[10] Observations are often checked by interviews, ethnography, to determine if they might misunderstood what they have observed (Yin, 2003).

[11] Explanation building occurs in the narrative form and it explains phenomenon of why and how something has happened (Yin, 2003).

One of the biggest limitations was as well inertia of some organisations and people not willing to cooperate. In many cases the contacts did not answer e-mails, which resulted in announced personal visits to the organisations. Sometimes the organisations are located in remote settings, not easy accessible and in few cases addresses could not be found. Time and financial constrains were other factors that limited my research.

3.3 Overview of the research process

Exploration needs to begin with some rationale and direction, even though initial assumption might later have been proven wrong (Yin, 2003). The initial idea and primary goal of the research was to use only a single in depth case study of the project, Pulicat Lagoon, and look at the effect of the project on the well-being of local community by making a livelihood assessment. However, upon arrival at the setting it was obvious that this will not be possible because the project was finished with a failure and there was a general lack of data for in depth case study. At that moment I became interested in the reasons why this project failed but I also wanted to see some successful projects and discover what made them succeed. These new insights resulted in a change of research questions and the core idea of research. This occurred at the beginning phase of the research, that still enabled me to ask the right questions. However, because of the change of problematique, the literature that has been read before didn't correspond to the new background, that demanded a new literature review. This led to further research in India and later to Sri Lanka, based on personal recommendations. However, having this various locations and various project made the research much more complicated and difficult.

4. BACKGROUND

4.1 Settings

The research was conducted in south Indian states Tamil Nadu and Andra Pradesh, and island of Sri Lanka, both located in South Asia. Two landmasses separated by the narrow strip of sea were connected by land in geological past. Both countries are characterised by tropical monsoon climate. This has resulted in rich and unique flora and fauna. Western Ghats in Tamil Nadu and the island of Sri Lanka are classified as one of the 18 biodiversity hotspots (Conservation International, 2010). Sri Lanka alone may be a home to as many as 140 endemic species of amphibians. However, biodiversity is under threat mainly because tremendous population pressure and the demand for timber and agricultural land (ibid.).

Sri Lanka is a small country with long history of internal conflicts. After two decades of fighting between Sinhalese majority and Tamil separatists, the government and Liberation Tigers of Tamil Eelam (LTTE) formalized a cease-fire in February 2002. However, violence continued until May 2009 when the remnants of the LTTE were defeated and its leader had been killed (CIA, 2010). This conflict resulted in poor tourism development, and many areas of the country were not reachable. After the war, the recovery of the Sri Lankan economy and tourism (the quite significant contributor to economy) took an uprising curve. In the recent The New York Times, (January 2010) Sri Lanka was listed as no._1 tourist destination in 2010. There is no doubt that this will put a lot of pressure on natural resources, in this case mangroves that are located near the main tourist resorts.

On the other hand India is a new emerging economy, with the second largest population in the world, over 1.1 billion estimated in July 2009 (CIA, 2010). Development demands resources which puts a lot of pressure on already fragile ecosystems. However, even though India is facing economic growth, inequalities within the country are vast. According to UNDP Human Development [12] Report 2009, India is ranking as 134th from 182 countries, while Sri Lanka is ranking as 102nd. They are classified as medium human development countries (UNDP, 2009).

4.2 Mangrove ecology

"A mangrove is a tree, scrub, palm or ground fern, generally exceeding one half metre in height that normally grows above main sea level in the intertidal zone of marine coastal environments and estuarine margins" (Giesen et al., 2006). A mangrove is also the tidal habitat comprising such trees and scrubs (Duke, 2006). In order to distinguish mangrove habitat from mangrove individuals, habitat is often referred as 'tidal forest' or 'mangrove forest' (ibid). Tidal forests include mangroves and mangrove associates. Associates occur only occasionally in intertidal sediments and are found elsewhere most of the time (ibid). True mangroves comprise some 54-70 species[13] (Ellison, 2000). The factors that influence the natural distribution of mangroves are salinity, tides and temperature (Duke, 2006). In this research the term mangrove refers to mangrove habitat unless it is mentioned differently.

The mangrove species themselves are adapted to their unpromising habitat, and can cope with periodic immersion and exposure by the tide, fluctuating salinity (Feller et. al. 2010) and low oxygen concentrations in the water (Giesen et. al., 2006). Many mangroves have evolved a specialised reproductive strategy in which seed lacks dormancy and are viviparous, germinating precociously while still attached on the parent plant (Feller et. al. 2010). Mangroves typically display zonation. The cause of zonation has been attributed to salinity, elevation and exposure to the wave action. The general consensus, however is that these patterns are determined by a combination of these factors, but the tidal inundation is the dominant factor (Griesen et. al., 2006).

4.3 Mangrove ecosystem services

Mangroves yield many valuable products and perform many important functions that support often densely populated regions. Economically, they are thus highly important, be it at local, regional or even national level. The economies of coastal villages are often very dependent on mangroves, either directly, because of the products that they derive from these habitats, or because coastal fisheries are directly correlated with the area of mangrove (Giesen et al. 2006). The values derived from mangrove are presented in Figure 1.

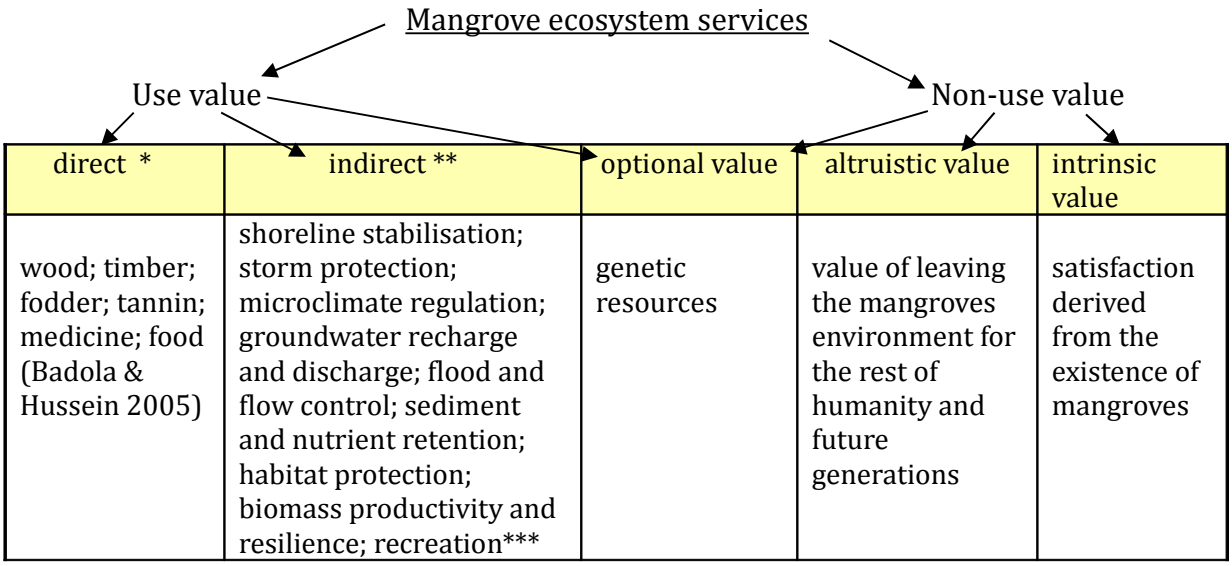
By far, the most important economic gain derived from mangrove products in many areas is that of the coastal fisheries. Known as highly productive ecosystems, mangroves provide optimal breeding and nursery grounds for many commercial and economically important fish and shell fish, and species feeding habitats for many water birds (Badola & Hussain, 2005). There are many studies that have shown a decline in off

[12] HD process of enlarging people's choices and enhancing human capabilities and freedoms, enabling them to: live a long and healthy life, have access to knowledge and a decent standard of living, and participate in the life of their community and decisions affecting their lives (UNDP, 2009).

[13] Other authors provide different data; Hogart (2007) 55 species, Field (1998b) 70 species.

shore harvest of catch where mangroves are removed (Kaly & Jones, 1998). The results from research in Pichavaram mangroves by Kathiresan & Rajendan (2002) show that shellfish catch and income were 13-fold higher and finfish catch and income 2-fold higher in mangrove rich waters than in mangrove poor waters.

Figure 1. *Mangroves economic services value classification*
Based on RSBS, (2006).



direct *	indirect **	optional value	altruistic value	intrinsic value
wood; timber; fodder; tannin; medicine; food (Badola & Hussein 2005)	shoreline stabilisation; storm protection; microclimate regulation; groundwater recharge and discharge; flood and flow control; sediment and nutrient retention; habitat protection; biomass productivity and resilience; recreation***	genetic resources	value of leaving the mangroves environment for the rest of humanity and future generations	satisfaction derived from the existence of mangroves

* market value resulting from direct usability of environmental products
** value derived from ecosystem services
*** based on Chong (2005), adopted from Lindenmayer & Hobbs (2007).

Mangroves are able to sequester some 1.5 metric tons[14] of carbon per hectare per year (Ong, 1993). Mangrove forests are responsible for substantial fluxes of dissolved organic carbon (DOC) to the ocean, accounting for 15% of the carbon stored in marine sediments (ibid).

Mangroves are important in protecting shorelines from waves, winds and storms. The roots of mangrove plants bind and stabilise the substrate and dissipate wave and current energy. Mangroves significantly reduced the number of deaths during the 1999 cyclone that struck the eastern coast of Orissa in India, as confirmed with statistical evidence (Das & Vincent, 2009). The potential of mangroves to mitigate the effects of tsunami was explored rural area south of Chennai. The study that examined the damages from tsunami in 18 fishermen villages in a range of 0.2-2.5 km from the coast shows that the causalities and damages are less in the villages protected by the dense strip of mangroves (Kathiresan & Rajendan, 2007).

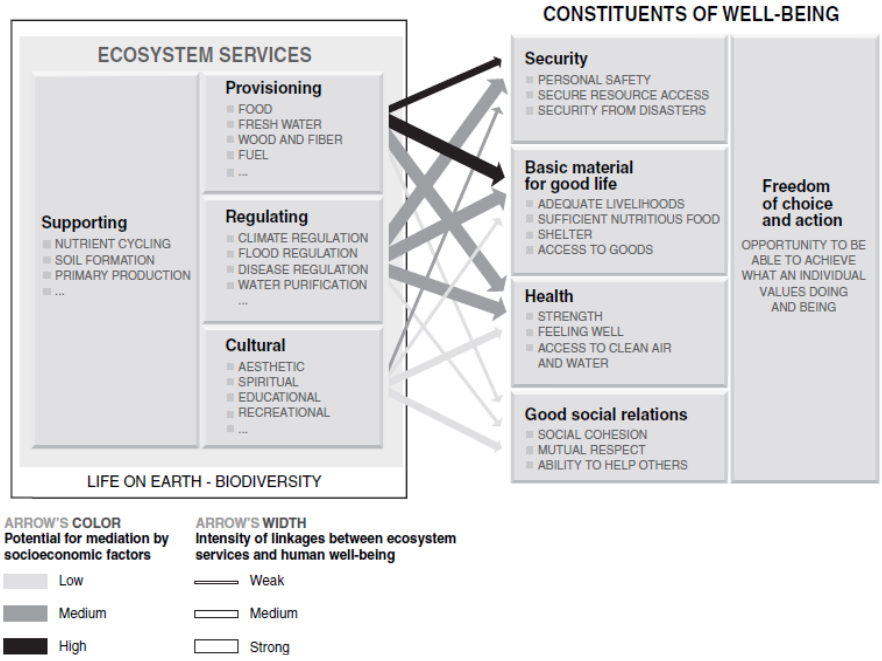
4.4 Ecosystem services and human well-being

Looking at the evidence for three major ecosystem services provided by mangrove (fish nurseries, coastal protection and carbon storage) we could understand more easily the importance of mangrove conservation and restoration. Mangroves systems are critical not only for sustaining biodiversity but also because of their direct and indirect

[14] This value is not precise, and different authors give different values

benefits to human activities. Degraded mangrove ecosystems result in loss of ecological functionality, putting millions of coastal inhabitants in jeopardy (Feller at al. 2010). Inland fisheries are of particular importance in developing countries, and they are sometimes the primary source of animal protein to which rural communities have access (MEA, 2005a). The relation between ecosystem services and human well being and the strength of certain linkages is visible in Figure 2.

Figure 2. *Linkages between ecosystem services and human well-being*



Source: MEA, (2005a)

MEA (2005a) assumes the existence of dynamic interaction between people and other parts of ecosystems. Humans change ecosystems and by that, they influence their wellbeing. At the same time, other factors independent of environment can change human wellbeing, and many natural forces can influence ecosystems. On time and spatial scale, some changes may have little effect over days but could be visible over years, and changes at the local scale may have little impact on some services at that scale, but major impacts larger scale.

4.5. Ecosystem restoration[15]

In the 1990s restoration ecology was hailed as a new paradigm for biological conservation (Field, 1998b). It came from growing realization that we will not be able to conserve the Earth's biological diversity only through the protection of critical areas and that conservation alone is not enough. The ultimate goal of restoration is to create a self-supporting ecosystem that is resilient to perturbation without further assistance (Ruiz-Jaen & Aide, 2005).

[15] Ecosystem restoration is a process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004).

In terms of ecology, restoration will seldom mean the return of ecosystem to its initial state, but will more often mean bringing it back to a state of effectiveness. The need to restore a particular ecosystem implies that such ecosystem has been altered or degraded in a way that conflicts with the defined management or conservation objectives (SER, 2004). Various authors suggest that restoration success could be based on vegetation characteristics, species diversity, or ecological processes (Ruiz-Jean &Aide, 2005).

SER Primer, (2004) produced a list of nine ecosystem attributes as a guideline for measuring restoration success:

1. similar diversity and community structure in comparison with reference sites
2. presence of indigenous species
3. presence of functional groups necessary for long term sustainability
4. capacity of physical environment to sustain reproducing populations
5. normal functioning
6. integration with landscape
7. elimination of potential threats
8. resilience to natural disturbance
9. self sustainability

Considering that many people now depend on what have become degraded ecosystems to sustain their livelihoods ecosystem restoration needs to address four elements. It should improve biodiversity conservation, improve human well-being, empower local people, and improve ecosystem functions (Lewis, 2001). These elements are critical to successful ecosystem management. It is important to emphasise that ecosystem restoration does not include future exploitation (Lewis, 2001).

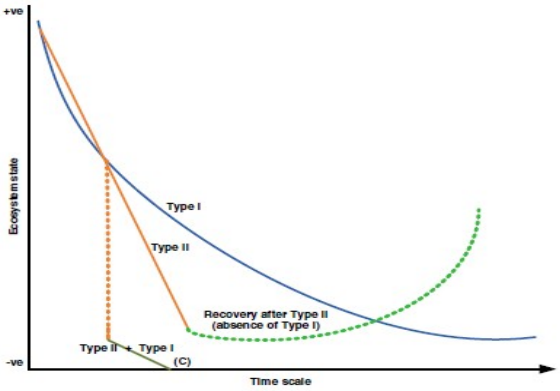
SER & IUCN, (2004) argue that restoration can be a primary component of conservation and sustainable development programmes throughout the world.

4.6. Mangrove ecosystem restoration-why it is needed to apply it?

Mangrove ecosystems are very dynamic and influenced by various factors (soil salinity, frequency of tidal inundation, sedimentation, soil chemistry, freshwater inputs and groundwater availability) resulting in the complex patterns of mangrove community structure and function (Field, 1998b). Given this complexity, mangrove restoration is a more complex process than just planting a few trees (Kaly & Jones, 1998). Natural regeneration of mangrove should be the first choice of any rehabilitation programme, unless there is evidence that it will not be successful (Field, 1998b).

According to Biswas et al. (2009) tropical mangroves are shrinking rapidly due to the five reasons: conversion to shrimp/aquaculture, conversion to sea salt farms, conversion to agriculture, natural calamities, infrastructure development and hydrological diversion. They consider economic pressure from increasing populations in tropical coastal areas as a dominant driving force behind Type I mangrove degradation. Beside human destruction (Type I), mangroves are exposed to usual disturbance events such as periodic cyclonic storms, tidal surges and floods (Type II). Figure 3 demonstrates the response of mangroves to degradation in terms of recovery. However, after events of great amplitude as strong cyclones and tsunamis, recovery is uncertain.

Figure 3. *Hypothetical relationship between disturbance type and recovery pattern in mangrove ecosystems (3 scenarios)*



Source: Biswas et al., 2009

The uncertainty of natural recovery is amplified with the frequency of these events that became more frequent in the past years and it is expected that their occurrence will be even more frequent with the climate change (Harun-or-Rashid et al., 2009).

Fransworth (2000) confirm that mangrove species can be easily replaced by mangrove associate species and invasive species because real mangrove do not possess persistent soil seed bank which can lead towards cryptic ecological degradation and biological invasion after catastrophic disturbances. Therefore, they suggest that instead of relying only on natural regeneration, forest managers should actively consider plantation of mangrove species in the larger canopy gaps created after catastrophic disturbances (Harun-or-Rashid et al., 2009). Furthermore, Field (1998b) defines three main reasons for mangrove ecosystem rehabilitation: conservation and landscaping, multiple use systems for high and sustainable yield and protection of coastal areas.

Bosire et al. (2008) argue that with the current rate of loss of mangrove, achieving no-net-loss of mangroves worldwide would require the successful restoration of approximately 150,000 ha/year, unless all major losses of mangroves ceased. Increasing the total area of mangroves worldwide would require an even larger scale effort.

Prior to 1982 the only explicit rationale or goal for mangrove restoration was silvaculture (Ellison, 2000). In 1982 Lewis articulated for the first time that "restoration of mangrove should emphasise ecological values, animal habitats, and detrital food sources for inshore and pelagic food webs". There was a change in attitudes over the goals of mangrove restoration, but still prior 2000 the primary objective of mangrove restoration remained to be silvaculture (Ellison, 2000). After tsunami 2004, mangrove gain recognition as bio-shields, restoration experienced a boom. The list of organisation that support mangroves planting is long, starting from NGO's and national programs to international institutions as World Bank, Asian Development Bank, WWF, IUCN, FAO, UNESCO, UNEP, Wetlands International, ITTO, GNF, European Union etc.

4.7 Economics of mangrove restoration

The estimated cost of mangrove restoration is in range of 225-1600$ per hectare, depending on the technique (Lewis, 2001).

Mangrove restoration can be divided into three types:

a) planting alone
b) hydrolytic restoration
c) excavation or fill

First one is cheapest (100-200 $/ha), but often fails because it doesn't recognize the physiological tolerances of mangroves to tidal inundation. It is not rare that the result is replacement of one productive marine habitat like sea grass or mudflats with mangroves (ibid). Second type is applied often for restoration of abandoned mangrove shrimp farms. Scientific data indicates that using this method; ecological functions are quickly restored, with fish populations typically reaching reference site diversity and densities within 5 years (ibid).

In his review, Lewis pointed out the danger of "gardening approach" to mangrove restoration, which emphasises planting without investigation of the reasons why mangroves are not present there in the first place. This approach often fails and at the end is more expensive since investment is wasted.

4.8 Problems facing mangroves restoration

However while great potential exists to reverse the loss of mangrove forests worldwide, most attempts to restore mangroves often fail completely, or fail to achieve the stated goals. Restoration has, unfortunately, emphasized planting mangroves as the primary tool in restoration, rather than first assessing the causes for the loss of mangroves in an area, then assessing the natural recovery opportunities, and how to facilitate such efforts (Bosire et al, 2008). In addition, few restoration efforts are embedded in a larger framework that also consider the fate of the planted mangroves, in terms of stand structure and regeneration, return of biodiversity and recovery of other ecosystem processes (Dahdouh-Guebas & Koedam, 2002). Sometimes, the human dimension is ignored as an important consideration in mangrove restoration projects resulting in failure (Ellison, 2000).

4.9 Achieving a successful mangrove restoration

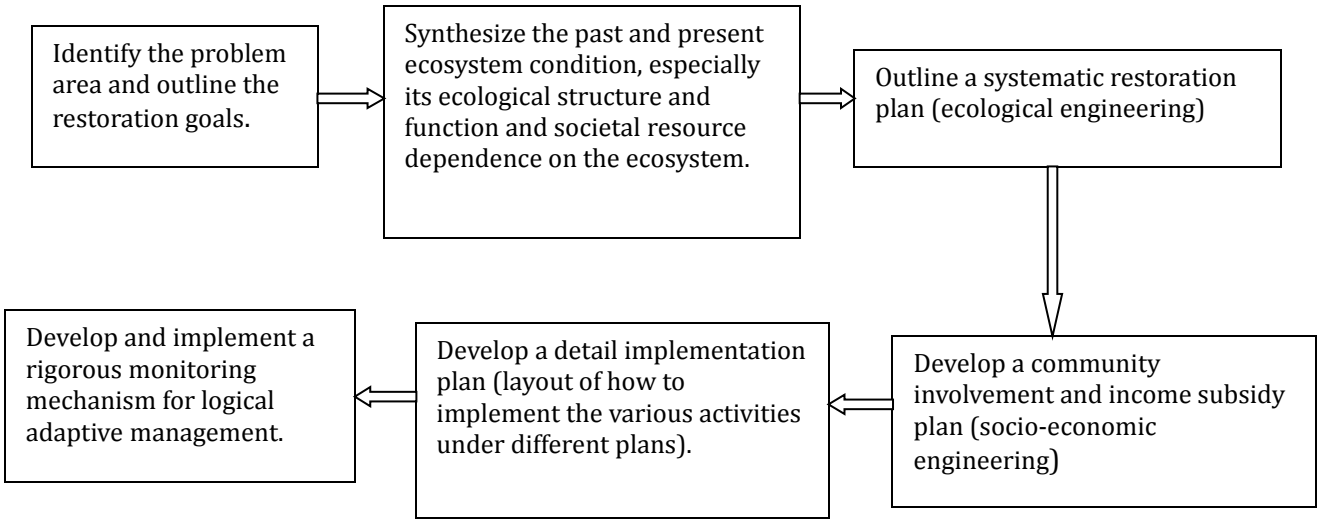
In this thesis I accept Naveh's (1998) argument that exclusively discipline orientated and most reductionist scientific paradigms must be replaced by transdisciplinary concepts and methods. "Restoration represents an intersection of objective based science and policy based practice, involving scientists, ecosystem managers, public agencies, NGO´s and public" (Taylor & Francis, 2006).

Reviews of mangrove community ecology and ecosystem dynamics show that there is enough scientific data to backup restoration. Lewis (2001), points out that successful mangrove restoration is possible, it has been done and it can be done cost effectively. It is unlikely that we can return an ecosystem to pristine pre-development condition, but we can reach a state similar to the beginning one (ibid). Newly created mangrove ecosystems may or may not resemble the structure and function of undisturbed mangrove ecosystems but information about their sustainability is important (Field, 1998b).

The effect of human influence in South Asia is so great that we cannot ignore the human component in restoration. Therefore the inclusion of local communities social and economic issues are important (Biswas et al., 2009). Society and economics are very

much inter-related and always act together instead of as isolated factors. Biswas et al. (2009) believe that only people's notion of ecosystem services is not enough, and that some sort of immediate improvement of livelihood programme and establishment of a self sustaining mechanism can ensure societal participation. However, they acknowledge that there is always a danger that community expectation of receiving financial benefits might be raised too high. "It is not uncommon that the whole effort collapses as soon as the external support is withdrawn" (Biswas et al. 2009). Furthermore, they translate the mangrove restoration paradigm into a practical guideline of six major steps (Figure 4).

Figure 4. *Practical guidelines for mangrove restoration*



Based on Biswas et al. (2009)

In their framework Biswas et al. (2009) argue that the most important factor behind restoration is ecological knowledge; anthropogenic influence can be addressed by ensuring sustained community participation; sustained community participation can be encouraged by economic considerations for the livelihoods and substance of local communities. However, sometimes, weak and incomplete implementation of ecological and sociological monitoring makes it impossible to assess what is working and what is not (Tallis et al. 2008).

5. FINDINGS AND ANALYSIS

5.1 Who is doing restoration of mangroves?

In south-west Bengal, mangrove restoration is being carried out by various local NGO´s, and research institutions as well as the government through Forest Department. It is supported by international institutions such as IUCN, MFF, UNEP etc. Due to time constrains and no return information from organisations, from the variety of projects presented in Table 1, only four were examined deeper. However, information, lessons and observations gathered from other projects could be used when necessary, because the researcher tried to achieve a clear image about the general situation in mangrove restoration. Projects were chosen on the grounds of information accessibility.

Table 1. *Overview of some of the major restoration projects in region*

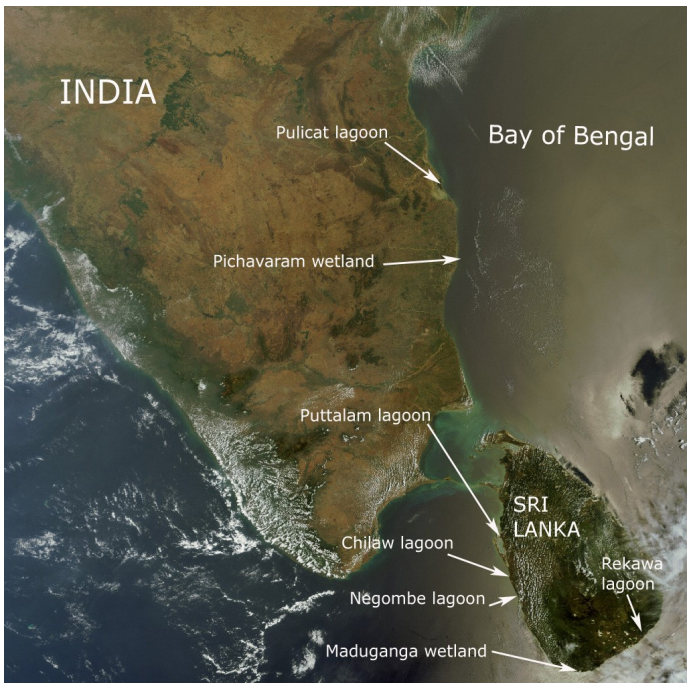
Restoration site	Organisation performing restoration	Partnership and funding
Pulicat (IN)	CReNIEO	GNF, EU Commission in the frame of Asia Pro-Eco II Post Tsunami Program
Pichavaram(IN) Andra Pradesh(IN)	MSSRF	State Forest Department, Canadian international Development Agency; India-Canada Environmental Facility
Palk Bay(IN)	OMCAR	Deepwave, Lighthouse Foundation, Germany
Pulicat (IN)	COPDANET	Svalorna
Chilaw lagoon, Puttalam lagoon (SL)	SFFL	MAP, IUCN, Dutch Government, Seacology
Panama lagoon (SL)	Sewalanka	IUCN
Maduganga (SL)	Saviya Development Foundation	IUCN
Bolgota Lake (SL)	EMACE	GNF, EU Commission in the frame of Asia Pro-Eco II Post Tsunami Program
Kogala lagoon (SL)	Green movement	No data found
Panama lagoon (SL)	RRI	Swiss Labour Assistance
Bolgota, Maduganga, Madampeganga (SL)	Nagenahiru Research foundation	GNF, EU Commission in the frame of Asia Pro-Eco II Post Tsunami Program

IN- India; SL- Sri Lanka

5.2. Project locations

Figure 5 illustrates the positions of some of the major mangrove wetlands and restoration sites visited. However, only four of them were examined deeper.

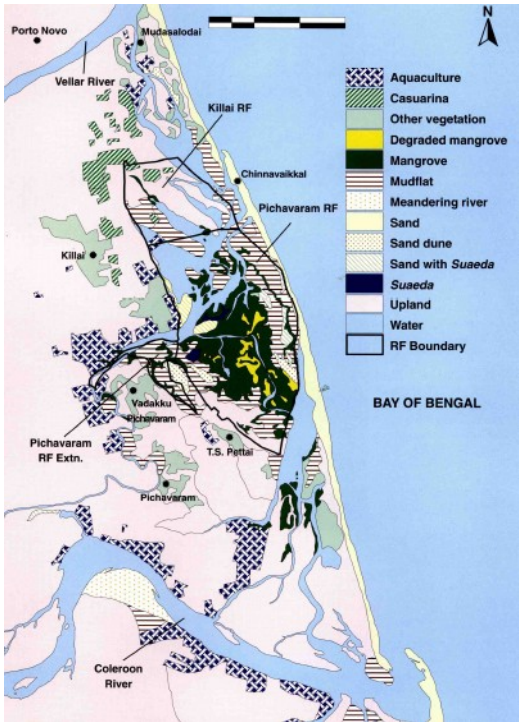
Figure 5*. Locations of the mangrove restoration projects*



Adapted from www.eosnap.com

Pichavaram mangrove wetland is located on the southeastern coast of south India, in the northern extreme of the Cauvery delta, near the mouth of River Coleroon (Figure 6). The surface of Pichavaram wetland is approx. 1400 ha from which 700 ha are mangrove forest located mostly on the small islands (MSSRF, 2005).

Figure 6. *Estuarine Complex showing the Vellar Estuary, the Pichavaram Mangrove and the Coleroon Estuary; vegetation cover, land use, geology*



Source: MSSR , (2003)

Pichavaram is also rich in fish resources, of which prawns alone constitute 85% of the catch. The people belonging to 17 hamlets of five revenue villages utilise the fishery and forestry resources of the Pichavaram (MSSRF, 2003). A total number of 1,900 fishers are annually dependent on the fishery resources for their livelihood; some 1,000 fishers fish seasonally in the mangrove waters (ibid). Mangrove restoration in Pitchavaram was a joint project between MSSRF and FD of Tamil Nadu. The project started in 1994 and finished in 2004. It resulted in restoration of 675 ha of mangroves and many other accomplishments (ibid).

Pulicat is the second largest lagoon on the east coast of India, located 60 km north of Chennai, between south Indian states Tamil Nadu and Andra Pradesh. It is a natural coastal wetland of about 30,000 to 46,000 ha. The present-day vegetation mainly comprises commercially planted woody forest of *Casuarina, Prosopis* and *Acacia* sps. This hinders the natural vegetation succession and the ecosystem not favourable for mangroves (Farooqui & Vaz, 2000). Stray occurrences of *Avicennia* and *Excoecaria* sps. in the northern part of the lagoon and the Pulicat Bird Sanctuary are conserved by the FD Andhra Pradesh that has jurisdiction over Pulicat lake (ibid). Pulicat lake supports the livelihood of about 44,000 fisher folks and an equal number of poor people. It is a vast nursery of about 12 species of prawns, 19 species of crabs and 168 species of finfish and harbours several endemic, endangered and keystone species (Sanjeeva Raj,

2006). NGO COPDANET did restoration of mangrove from 2004 until 2008 on a small island Kuruvithitiu in Pulicat lagoon. There are some plants left and growing, but most of the seedlings didn't survive.

Chilaw lagoon is 5 km long and 2 km wide and it opens into ocean from two sides resulting in a daily influx of seawater into the lagoon (Verheyden et al., 2002) Restoration in Chilaw took place at 3 locations. It was conducted by Small Fishers Federation Lanka (SFFL) with local fishermen, women, youngsters, school children, and with the approval of forest officers and local authorities. First planting, sponsored by government with ½ million of rupees, occurred in 1994, when 35000 seedlings were planted. Second planting in 1998 (35000 seedlings) was sponsored by the Dutch government, and the third was funded by UNDP (75 000 seedlings) (Int. 5).

Puttalam lagoon-Duch bay- Portugal Bay is the largest complex of mangrove in Sri Lanka and it covers 3385 ha (IUCN, nd) where SFFL is planting mangrove. The lagoon is shallow (1-2m) except in the middle where the depth reaches about 5m. In 2002 the human population was 168106 persons, and the community along lagoon mostly comprised of fisher folk (Kumara, 2009). The fish production from the lagoon is rich all around the year. Most of the production is exported while certain percentage is consumed domestically or converted into dry fish. The lagoon thereby provides food and employment (fishers, local fish collectors, fish sellers, boat and engine workers) for many dwellers (ibid). Mangrove restoration sites in Puttalam lagoon are smaller and are situated in front of family homes. Two locations are run by fishermen, one by a retired police officer and one by a boat engine mechanic. On two locations SFFL planted mangrove in June 2009. The planting (overall 15000 seedlings) was financed by SFFL. Main land use around both lagoons include capture fishery, aquaculture, shrimp farms, salt pans, coconut farms, human settlements, boat landings and road construction and part of the land is leased to Voice of America Station (CEA, 1994).

5.3 Reasons of mangrove degradation in the past and today

In the past decade the major reason of vast destruction of mangroves on the West coast between Colombo and Puttalam was aquaculture development (Dahdouh-Guebas et al. 2002). Profitable for few in the short term, it caused a range of environmental problems with long term consequences for local residences and ecosystem These include not only destruction of marshland and mangroves, but as well pollution of surface water, salt intrusion, limited access to fisherman (IUCN, nd).

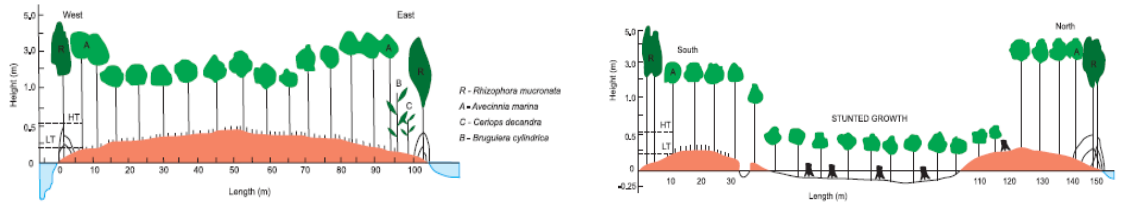
Pambale shrimp farms cover 50ha. After being active for 5-6 years, due to the harmful accumulation of toxicants (antibiotics, pesticides) many shrimp farms faced epidemic disease and had to close (Int.5). SFFL would like to restore abandoned shrimp farms but due to the land ownership issues they cannot. It is government owned land but on the lease (Int. 5). Today, urbanisation and coastal development are seen as the biggest threat to mangroves of Sri Lanka (Int. 5, 6, 8). The prices of the land went up recently, and being close to coast, mangroves are seen as potential places for development of tourist resorts (Int.8).

In India, cultivation of brackish water shrimp increased from 3868 tones in 1980 to 30 805 tones in 2005 making India world´s fourth largest shrimp producer (Knowler et al., 2009). Still, shrimp farms were not the main reason of mangrove degradation in

India (Kathiresaaan, 2008). However, the toxicants leaking from shrimp farms present a huge problem for the environment (Int. 1).

Pichavaram forests already lost 75% of its green cover within the last century (Kathiresean, 2008). Ecological studies carried out in the Pichavaram by MSSRF between 1993 and 1995 show that unscientific management practices followed in the past are the main causes of degradation. Mangroves were clear-felled in coupes by rotation every 20 to 25 years what led to the development of hyper-saline conditions in the coupe-felled area, and prevented natural regeneration of mangroves. The exposure of this soil to the sun due to clear felling caused evaporation of soil water. This in turn led to increased decomposition and subsidence of sediment in the clear felled area on account of which the topography of the coupe felled area became trough shaped (Figure 7). As a result, tidal water entering into these "troughs" during high tide became stagnant; evaporation of stagnant tidal water led to increase in salinity, which is lethal to any mangrove plant (MSSRF, 2003). The second major problem identified is cattle grazing. During the monsoon season the propagules are damaged (especially *Avicennia* species), by cattle and natural regeneration is not possible (Kathiresan, 2008).

Figure 7. *Microtopography of a) healthy and b) degraded mangrove areas*



a) b)

Source: MSSRF, 2003

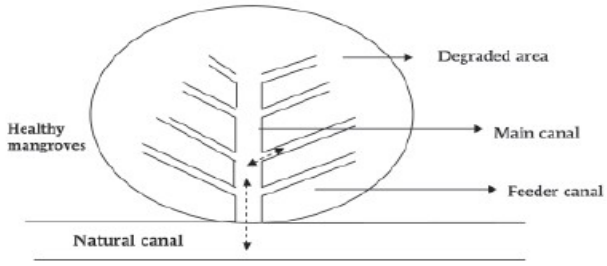
The amount of fresh water reaching Pichavaram forests through river Coleroon has become reduced from 73 TMC[16] in 1920s to 31 in 1980is, to 3-5 TMC in 1990s due to the construction of large dams (MSSRF, 2003). Due to the silitation the river mouth has narrowed, which interfered with the entrance of the juvenile fish from the Bay of Bengal to mangrove of Pitchavaram (Kathiresan, 2008). This resulted in the decline in fishery resources, food security and income.

5.4 Methods and considerations applied in restoration of mangroves

As mentioned (p. 19) there are three basic approaches to mangrove restoration and many variations of those three. MSSRF and State FD use techniques that primarily address the issues relating to changes in the biophysical condition resulting from the past management practices (MSSRF, 2003). Development and demonstration of restoration by this technique began late 1995 in the Pichavaram mangrove wetlands. This technique is called fish bone canal or trench method (Figure 3) and it involves constructing trenches in the hyper saline soil to allow soil to flush and successful rise of mangroves (Kathiresan, 2008). The application of this technique resulted in the drastically fall of salinity in the degraded area (see figure 7) and increase of soil moisture. The survival rate of first planted seedling was more than 80% (MSSRF, 2003).

[16] thousand million cubic feet

Figure 8. *Fish bone type of canal system, normally applied in restoration of degraded mangrove areas in Tamil Nadu and Andra Pradesh.*



Source: MSSRF, 2003

MSSRF (2005) has developed a detailed guide how to conduct mangrove restoration. They address technical aspects of mangrove restoration and describe in details what has to be done and how.

SFFL has shown considerations for ecological aspects of restoration but they do not dig the canals due to the high costs. In 2000 they have as well developed a "Planting manual for the mangroves in Sri Lanka" (Liyanage, 2000), which describes technicalities behind mangrove restoration. SFFL restored 50 ha of mangrove (Int.5). SFFL staff demonstrates high knowledge on restoration and mangroves in general and is guided by advice of the scientific community. On the other hand COPDANET is planting mostly on the mudflats, and it doesn't address ecological conditions. However, this method is the cheapest one (Lewis, pg 19).

RRI Sri Lanka uses a relatively new approach in restoration called analogue forestry[17]. They replanted 15 hectares together with UNOPS. However, it will take time to see the results (Int. 8).

5.5 Goals of different projects

Setting goals are important steps in restoration. COPDANET is mostly people oriented. They do want to restore biodiversity, but their primary aim is "creation of alternative livelihoods for women and empower them with economic incentives" (Int.1). On the other hand MSSRF is focusing on biodiversity restoration and enhancement of livelihoods. The aim of their programme titled Joint Mangrove Management is to enhance the capacity of the local community, Forest Department and other interested parties to restore, conserve and sustain mangrove wetlands through participatory analysis and action (MSSRF, 2003).

The Tamil Nadu FD sets as one of the goals to bring to existence the species that have been extinct but were present before based on pollen analysis. *Rhizophora* grew in Mutuphet 200 years ago but it vanished due to overexploitation. Now the FD is

[17] Analogue forestry establishes a tree-dominated ecosystem that is analogous in structure and function to the original climax and sub-climax community. With time, the natural progression of any undisturbed forest community is to increase in diversity and stability until a highly complex ecosystem or Climax State is reached. When an ecosystem is designed to mimic the indigenous Climax State, the efficiency and dynamics of the natural processes can be replicated. Such forests are referred to as analogue forests. In addition to their ecological characteristics, analogue forests are designed to provide economic benefits (Gill et al., 2001).

reintroducing it again (Int. 11).

SFFL promotes fisher folk community-based coastal resource management and eco-friendly fisheries livelihood development process (Int. 5).

5.6 Community participation in mangrove restoration

There is no doubt that the inclusion of the local community is one of the crucial factors in restoration (Stone at al., 2008). However, the extent and nature of community involvement are different from one project to another.

In many cases the knowledge on certain factors doesn't exist, therefore, local communities are important databases of information and information can be extracted by participatory methods (MSSRF, 2003). In the research for conditions prior to restoration, local knowledge played an important role. Also, local communities depend on the resource. The flow of information and knowledge has to go in both ways.

In order to achieve community participation it is crucial to make people aware of the importance of mangroves, link them to their livelihood and create direct benefits from mangrove conservation and restoration. This is done, first of all, through education and secondly through creation of incentives.

5.6.1 Education and awareness facilitation

Mangrove restoration programs had a huge impact on local communities in terms of education and awareness rising. In Pulicat lagoon, 12 villages were included in the education program. After the initial education of women at Kallur Training Centre about the importance of mangrove, these women became facilitators of knowledge and awareness on mangroves among the villagers in the lagoon, sharing knowledge and experiences. Special attention was given to inclusion of children in the educational programs (Int. 2, Foc.1).

The focus group discussion with fishermen in Varagali village in Andra Pradesh revealed that perception of mangrove contributing to the fish nursery is very strong among the fisher folk, though before education by NGO´s they didn't know anything about mangroves and how they are connected to their livelihood. Now, when they know their importance, they act to conserve it.

Interviewee 3 emphasises that orientation and education of locals was a great challenge at the beginning stage of their project. They are all tribal people without any education, so they were provided with basic education about mangroves and how to manage their resources. Furthermore, they see sharing experiences as an important component of the projects, as the knowledge from one project can be applied on another in similar settings.

The impact of SFFL on the education on mangrove is impressive. SFFL has established Mangrove Resource and Training Center in Pambala and Mangrove Biological Garden in Kiralakele. At these centres they gathered a vast amount of material and they educate local population about mangroves, with the emphasise on dependence of their livelihoods on mangrove resources and the need for conservation. Again, their target group are school children that they see as well as facilitators for further change. They

support many national and international researchers, and there have been more than a few papers written on the ecology of this area.

In addition, NARA in Rekawa and Negombo lagoon has an important educational role. Their concern for mangrove is connected to the link between mangrove and fisheries that are important for local fishermen (Int. 7). RRI as well puts a strong emphasis on the education of local people as an important factor in restoration and conservation. *"People will not restore or conserve mangrove if they do not understand why mangroves are important or if they do not have any benefits from that act"* (Int. 8). They collected all the data on mangroves and translated them into Sinhala and Tamil, and organised workshops with locals in order to raise awareness.

5.6.2 Incentives for mangrove conservation and restoration

In most of the cases, knowing the importance of mangrove alone is not enough for communities to protect mangroves. It is important to link mangrove restoration to peoples livelihood but as well, they need other benefits to help them improve their situation. Mangrove restoration should help people to deal with depleting fish resources and poverty. In Pichavaram fishermen were digging holes in mangroves for fishing. In order to encourage people to abandon this harmful technique, MSSRF provided groups with alternative livelihoods, built a school and provided other community structures. In order to create an additional income they started Integrated Mangrove Farming System, carefully planned, non-harmful program of fish production in mangroves. The team lead by Dr. Kathiresan together with local communities practiced cultivation of crabs, sea weed and fish in cages in natural conditions. Other alternative sources of income are training for boat reparation in Maduganaga (Int. 6), development of ecotourism, establishment of home gardens by RRI, and animal husbandry by IUCN.

For many people mangrove planting became an important source of income. The benefits were especially emphasised in nurseries in Pulicat, where COPDANET employed women from 4 villages: Kallur, Kyrapakka, Peremangaloru, Chinamangaloru. Women would work from 7am to 12 am and would be paid 50 rupees. Money from the nurseries means a lot for women involved in project. In fact, when they were asked to elaborate on the most important benefit from the project, they choose income. Still, women feel that they need permanent employment. Even though they are not planting mangroves at the moment, they still work in nurseries. Seedlings are sold to other organisations. In Pichavaram some 560 members of the village-level institutions and SHGs have been trained in leadership and membership qualities, functional aspects of SHGs, mangrove restoration, and in a number of micro-enterprises as well as agriculture and fishery related activities.

In Chilaw lagoon, people were not paid for planting mangrove, but they do get other benefits for exchange as computer access, education (training courses) for children etc. In Puttalam families did not get any financial compensation for mangrove in front of their houses. They looked at it as a long term investment, and that mangrove can protect them from tsunami However, these patches are small and they didn't have to invest a significant amount of labour in planting. As well, these people have other sources of livelihood, and are not economically endangered.

5.7 Reflections of the projects in community

5.7.1 Empowerment and social connections

In Kallur training centre, Dalit[18] and fisherman women work together; even though there is still strong divide between the castes. This indicates the creation of social connections between different castes. The focus group discussion revealed that women have gained more power since they started to work in mangrove restoration project. They feel that they are more respected and they have more self-esteem, and they can help their families. Maliga, 35 : "*Husband respects woman more when she brings money in the house".*

In Pichavaram, during the project people from different communities started to socialise. As well as in Pulicat, the Pichavaram project was especially beneficial for women that were before excluded from any decision-making and were powerless. In fact the project was gender based, so MSSRF demanded presence of women. Women are now active decision makers.

5.7.2 Change of perceptions

Different sources show that in all the cases people had no knowledge of the ecosystem services that mangrove provided before restoration projects started. After educational programs they became aware of importance of mangrove for their livelihoods and became more interested in the projects. Villagers were as well satisfied that they have learned something. NARA emphasised how people's attitudes towards mangrove changed especially after the tsunami. Now they look on mangroves as lifesavers. This was noted as well in focus groups, and by personal observation in several occasions. People are in general enthusiastic about mangroves and they perceive mangroves that they have planted as their common resource, and they are strongly committed to protect them. The women from Kallur village went to shell-miners village with transparents in order to protest against mangrove destruction.

5.8 The life after the project; monitoring

Care, maintenance and monitoring are extremely important in restoration. During initial stages, plantation site should be visited daily during the low tide and saplings should be checked for entanglement by pests (MSSRF, 2005). In Puttnam lagoon Mr. Thisera once a week checked all mangroves for the pests, predation by goats and other disturbance. However, each family as well monitored mangroves planted in their backyard.

In Pitchavaram, monitoring is done both by local communities on regular basis and by experts every five years (Int. 4). For local community, monitoring is welcomed as an additional source of income. Monitoring in Pulicat was weak and it was done less than once a month, primarily due to the high cost of renting a boat.

5.9 Evaluating success

Different stakeholders, depending on their goals, perceive success differently. Even though COPDANET failed to restore mangrove ecosystems they argue that "*at least community gets some benefits*" (Int. 1). They do acknowledge that they are not scientists and that undermines their efforts. But most of the blame for failure COPDANET

[18] In south India cast system, Dalit, untouchable, is a person outside four Varnas, and is considered below of all and polluting

proscribes to inertia of local authorities to deal with illegal cutting. Illegal cutting is done by a cast of shell miners that extract shells from mud for local limestone production company (Int.1). With the permission from FD, COPDANET has planted around 50000 mangrove seedlings 5 year ago on the island Kuruvithitiu in Pulicat. Now there is almost nothing left. They tried to convince them to stop destroying mangroves, but they do not even want to listen. The fishermen from a nearby village were too afraid to confront them and FD did not do anything regarding that issue (Int. 2). Furthermore, the Space Project Station on one of the islands in Pulicat caused the neglection of the lagoons environmental issues through the construction of roads, division of lagoon, and the presence of military. Conflicts among stakeholders were seen as a huge barrier to success of the restoration projects.

SFFL managed to restore big patches of mangrove forest. It is seen as success looking at the increase of mangrove cover. The mangrove forest appears lush and if we compare it to initial state, there is definitely increase in biodiversity and ecosystem services, still, there is no real scientific results to back up that observation.

MSSRF described its projects titled Joint Mangrove Management (JMM) as a great success, based on the fact that they have restored mangroves, created a lot of benefits for local communities and that the project design was replicated in other sites and adopted by other organisations. Six years after the program was finished, mangrove ecosystems are well developed and locals communities have continued the practices initiated during the project. They organised meetings every month and reported the results to MSSRF (Int.3). The success, as they argue, lies in respecting ecology, inclusion of all stakeholders and linking conservation with community. The results of JMM in Pichavaram were (according to MSSRF): creation of village-level institutions to plan and implement JMM and socio-economic development programmes; restoration of 675 ha of mangroves, and protection of 2,720 ha of healthy mangroves by the above village-level institutions; total number of 85 self-help groups (50 of women and 35 of men) have been formed with 815 members belonging to the poor and the poorest sections of the mangrove-dependent community; initiation of 16 types of micro-enterprises, both group-based and individual-based.

The Ministry of Environment and Forests (MEF), Government of India now includes this JMM model as one of the strategies for conservation and sustainable management of mangrove wetlands, as envisaged in its National Mangrove Action Plan. Approach of JMM as process-oriented, people-centred and science-based approach followed in preparation and implementation is the main cause for the success of current JMM programmes (MEF, 2008).

One of the biggest restoration projects in Sri Lanka is facilitated by IUCN and financed through MFF Small grant fund. The program ended on 21 December 2009 and it is regarded by IUCN as a success. When asked to clarify the reasons for considering this program as success, Interviewee 10 states that they have enhanced the livelihoods of local people and from 41 organisations doing restoration only three were failure. *"After receiving initial amount of money, we never heard from them again".* From this statement and relatively big number of NGO´s involved, it could be concluded that they do know very little about organisations that they are partnering with. The previous restoration by IUCN in Rekawa was a failure (Int. 7), but facts about restoration are not to be found.

Table 2 provides a comparative summary of mangrove restoration interventions in the mentioned areas. The values indicated in the table are based on my personal impressions and evaluation. The notion of subjectivity is not disclosed.

Table 2. *Comparative summary of mangrove interventions*

Parameter/restoration project	Pichavaram	Pulicat	Chilaw	Puttalam
Ecological and hydrological considerations	**+++**	**-**	**+++**	**++**
Social considerations	**+++**	**+++**	**++**	**+**
Community participation	**+++**	**+++**	**+++**	**++**
Financial benefits for community	**+++**	**+++**	**-**	**-**
Monitoring	**+++**	**-**	**+++**	**+++**
Removal of ground cause of destruction	**+++**	**-**	**+++**	**+**
Involvement of key players	**+++**	**+**	**++**	**++**
Overall success*	**+++**	**-**	**+++**	**+/?**

+ indicates the level of consideration, (+++ maximum, ++ medium, + minimum)
– absence of consideration
+/? – the effects are positive but it is too early to judge about overall success
*success is defined in this case according to Fieled (1998) as effectives of planting, rate of recruitment of flora and fauna and efficiency of rehabilitation (amount of labour, resources and material used).

5.10 Legal status of mangrove restoration and protection

Both in India and Sri Lanka, mangrove forests are under jurisdiction of Forest Department. Almost all the major mangrove wetlands of India have been declared as Reserve Forests even before independence, and some of these mangroves have been declared as Wildlife Sanctuaries recently. As such, they are managed by the respective State Forest Departments (MSSRF, 2003).

India´s main national Environmental Policy of 2006 is that the conservation of the environmental resources is necessary to secure livelihoods and well-being (Kathiresan, 2008b.) The committee has established The National Coastal Zone Management Action Plan with the objective to protect the coastal zone with people´s participation, the livelihood security of the coastal fisher and other communities, and the coastal ecosystem which sustains the productivity of the coastal areas, while promoting sustainable development that contributes to the nations economy and prosperity (MFF, 2008). Concerned about the negative effects, government of India has put a ban on intensive or semi-intensive type of prawn farming practices, especially among ecologically sensitive mangrove areas (Kathiresan, 2008a).

MSSRF describes the role of FD as important in the whole process, especially in bringing collaboration with locals. In order to plant mangrove the permission from FD must be obtained. COPDANET is not pleased with that and criticises FD. Their arguments are that FD should allow people to plant mangrove in Pulicat, and that they should be more effective in conservation of already planted mangroves that are being

destroyed. Yet they are not doing anything. However, Chief Wildlife Warden (Int. 11) emphasises that Pulicat lagoon is not suitable for planting mangrove because of hydrological conditions, and therefore they do not support planting there. Due to the dispute with FD, COPDANET even had to remove the first mangrove plantation from Arumbakum at Pulicat, on grounds that they do not have legal base for it. They see FD as corrupt and they are disappointed with its work (Int. 1).

In Sri Lanka the main strategy is to conserve the existing mangrove and to protect them from overexploitation. Although the legal jurisdiction of the mangrove falls under the Forest Department, Department of Wild life Conservation, the coastal Conservation Department, and local government authority, protection is inadequate (IUCN, nd). Interviewee 8 argues that existence of all these bodies create a problem of jurisdiction because no one wants to take responsibility and act.

Mangrove conservation is also practiced by rural communities, International organizations, and NGO´s. Furthermore, many mangroves are located on private land. Destruction of mangroves is a criminal act even on private land, but it happens anyway (Int. 9). One of the identified problems is the lack of coordination between institutions.

5.11 The effect of the mangrove restoration on three pillars of sustainability

The results show different issues, approaches, difficulties and strategies in mangrove restoration. Based on the different examples presented, I was able to get an image of the overall situation in mangrove restoration and its impacts on environment, society and economy. The results are summarised and presented in table 3. Not all presented effects are to be found in all cases. The presence of positive effects and lack of negative effects is what makes certain projects successful and sustainable, and others not. However, the overview presents all identified factors.

If done in the proper, ecological way, mangrove restoration will have a positive effect on environment as argued by Lewis (2001). This is noted to some extent in Pichavaram and Chilaw lagoon. The mangrove cover did increase, and the functional communities were established. It is presumed that biodiversity and ecosystem services were established as well. Personal observations also indicated biodiversity and rich life. We can also draw conclusions from studies in other settings (Bosire et al. 2008) showing the recovery of biodiversity in restored mangrove..

The provision of indirect mangrove ecosystem services as fish nurseries is presumed, but not tested. The recently planted forests will not be able to provide services for at least 5 years (Int. 4), and in that term it is hard to estimate the environmental positive gain of mangrove, because in many cases gains are not something instantly visible. Impact of mangrove plantation has been studied in Anamalai University laboratory for ecosystem service, but still they haven't published any results (Int. 4).

In rehabilitating mangrove ecosystems first and basic consideration should be the topography of the site, followed by hydrology (Field 1998b). The selection of the site for planting is a basic step, that too many times is not considered. Erftemeijer and Lewis (1999) suggest that planting mangrove on mudflats would represent a form of "habitat conversion" since mangroves were not present previously on mudflats. Mudflats constitute an important habitat in themselves, supporting high biodiversity and

biomass, sustaining fisheries, providing important feeding grounds for migratory shore birds and supporting livelihoods of many coastal villagers who collect shellfish and crabs (Ertermeijer & Lewis, 1999). Therefore, Wildlife Chief Warden (Int. 11) doesn't support planting in Pulicat area because unfavourable hydrological conditions make Pulicat lake unsuitable for planting. He emphasised that when FD is doing restoration, they are careful to design projects in a way that biodiversity is enhanced.

Table 3. *The effect of mangrove restoration on the three pillars of sustainability*

effects of mangrove restoration		
a) positive effects:		
environment	**society**	**economy**
- mangrove cover increased - biodiversity increased * - certain ecosystem services restored * * - overall conservation of mangrove improved - the perception on mangrove changed and their perceived value increased with the restoration project - awareness of ecological connections and environmental problems within local community	- capacity building and training - increased participation in decision making -empowerment of community -empowerment of women - higher degree of openness and social inclusion - higher degree of awareness - education, knowledge and skills enhancement - infrastructure development - equality (gender, cast) - social connections - self-esteem -networking, partnership - collective action and perception of the resource as common resource - increased food security - reduced vulnerability to natural hazards and increased resilience	- alternative income generation for communities (revenues from mangrove planting of involvement in microcredit system) -employment, production, recognition - diversification of livelihoods and less dependency on fishing as only source of income - better standard of living - increase in natural resource - ecosystem services****
b) negative effects and costs :		
- possibility of change in water fluctuation - replacement of one habitat with another (restoring on mudflats) - monoculture	- possible conflicts between different stakeholders -mangrove restoration without community involvement***	-dependence on the external funds -cost of restoration -cost of monitoring - in some cases employment is temporary

* comparing to initial state, but it cannot be argued that it is equal to reference forest
** this is not visible in newly planted forests though
*** today, most projects are community based, but the possibility of exclusion exists
**** not direct economic benefits
b) appear only if projects are not designed in the proper way and if ecological considerations are not taken in account

Almost all mangrove restoration projects in researched settings are community based, and their aim is to enhance livelihoods of local people. The benefits should be visible in the long term by establishment of ecosystem services, and in the short term by involvement of community in projects. It is understood from the results that involvement of communities in projects brought many benefits to them, and it had a positive effect on their development.

In case of Pichavaram and Pulicat landless rural poor are provided with employment opportunities. They work either temporary in nurseries or on mangrove plantings sites, or have created alternative sources of income all year around. Employment opportunities are of special importance for women.

It is noted that education and awareness rising programs by NGO´s facilitated community involvement in managing mangroves. Establishment of self-help groups is seen as great achievement.

In Sri Lanka case workers were not paid for planting but they were provided with some other services (p. 28). Family mangrove plantations are small so they didn't need to invest a lot of time and effort in planting and maintenance. Even they do not benefit directly from mangroves, they see them as their common resource, and they value it highly.

As mentioned before, costs of restoration vary depending on technique, from project to project. Kathiresan (Int. 4) states that in general the cost is around 40000 Rs per hectare for a density of 10 000 mangrove seedlings per hectare. Almost all projects are funded by foreign donations. In some cases this creates a dependency and if not planned well, program is running only when there is funds to support it. This is not seen as sustainable in the long run and therefore, development of mechanisms that reduce or eliminate dependency on external funds is needed. Mangrove restoration is costly but justifiable if we include ecosystem services gains.

More information and deeper insight in each mention case as well as insight in other not analysed cases, could possibly result in more precise results. However, that was not possible at the time due to the time and financial constrains.

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6. DISCUSSION

6.1 Why should we restore mangroves at the first place, and can it be done in sustainable way?

One of the questions raised is should we restore mangrove at all, and why should we do it? Many philosophers argue that ecosystems have an intrinsic value that can never be restored by humans (Taylor & Francis, 2006). That is maybe true, but the goal of ecological restoration is to bring ecosystems in state most similar to natural, and it acknowledges that absolutely natural state is hard to reach (Lewis, 2001). In Taylor & Francis, (2006) R. Elliot compares restoration projects as fake art, arguing that reproduction can never reach the same value as original. Kats sees restoration as a big lie, and that it is just another way for humans to dominate nature. Restoration is as well

criticised from the standpoint that our confidence in our ability to restore nature may indeed serve as an excuse for further degradation (ibid).

These are all justifiable arguments, and conservation of remaining mangroves should be absolute priority. However, if we have capabilities to restore some ecosystems, and benefit the people in the process, should we not do it? As mentioned by MEA (2005) the loss of ecosystem services through loss of biodiversity represents a barrier to development. As extracted from interviews, many fishermen are thinking to leave the villages and try to find the job in the city because there is just not enough fish to ensure their livelihoods. It is not something that they want; it is more something that they see as their only choice.

The poor people have little or no use of admiring the nature, while on the other side, their livelihoods and well-being are dependent on nature through provision of ecosystem services as food. If we accept the claim that sustainable development is about sustaining wellbeing of today's and future generations, then mangrove restoration is a sustainable practice, because it doesn't comprises the needs of present generations, in fact it enhances their well-being and it creates benefits for future generations in terms of ecosystem services.

6.2 Possibility of generalization

It was shown in results that mangrove restoration affects positively the environment, brings many benefits to community development, and contributes to economical development. In that sense we can say that some projects are sustainable but we cannot make generalization. The sustainability and the success of project depend on meeting certain parameters. Each project is specific, but there are some general steps that need to be taken in restoration (pg. 21). If we do not consider them, the project is most likely to end as a failure. Much worse, not addressing all steps could even create more damage to ecosystem or communities (see table 3). As well as positive force, restoration can be negative. Planting mangroves without following certain rules and steps is not restoration; it is waste of money and energy, thereby, it is not sustainable.

Mangrove restoration is complicated and it is not often understood. It has it supporters but opponents as well (NARA for example). Interviewee 9 states that "*Mangrove restoration has become fashion after tsunami ".* Furthermore, interviewee 6 argues that *"Many NGO's just want money for planting".* There is no written evidence to support that statement, but it does seems that funds can go into unsustainable projects.

6.3 Mangroves restoration and community

The extent of mangrove destruction by local communities was not great as it was expected prior the research. It was presumed that the locals are the major degraders of mangrove and that in order to conserve mangrove we need to offer them alternative livelihoods. However, during the interviews it became clear that local communities are not degrading mangrove significantly. Nevertheless, their livelihoods are affected by degradation and the creation of alternative livelihoods is a desirable outcome of restoration in order to help them reduce their vulnerability. For most community members, additional incomes from planting and nurseries, as well as newly created services, are an important factor to engage in the project. Immediate improved livelihood programme and establishment of a self sustaining mechanism do ensure

societal participation, but they are not always a prerequisite for success as shown in example of family plantations in Puttalam lagoon, where benefits were perceived as provision of coastal protection. It is possible to attribute this to existence of stabile income in families from different activities and fishing being not main activity. Satisfying the needs of local people is therefore the prerequisite for sustainable management of mangrove resources. However, different communities have different needs.

As mentioned (p.26), with awareness rising and involvement in project, local communities do not only restore mangrove but they as well conserve them afterwards. They are abandoning harmful techniques of fishing, replacing them with less harmful ones. When asked to rank ecological services performed by mangrove according to their notion of importance, fishermen gave high preference to fish nurseries, while other respondents gave highest preference to cyclone/tsunami protection. This could be attributed to newly developed understanding of the connection between mangrove and their livelihoods. Furthermore, with the involvement in restoration, people start to perceive project as their own accomplishment. Interviewee 7 states that in failed IUCN restoration in Rekawa, one of the problems was that people didn't feel the importance of the project or the connection with their livelihood: "*they didn't think that it is their project...they were just paid to plant*". It is noted that if community is strongly connected to the project on multiple levels, restoration can play an important role not only in re-establishment of ecosystem services, but as well in enhancement of mangrove conservation by local communities.

6.4 Lessons to be learned

The literature analysis confirmed Biswas et al. (2009) claim that success is reported, but failures almost never. I was lucky (or not) to get insight in a failed project and saw what went wrong. From the interviews it was noted that this was not the only case. Even the failure case that I was analysing is nowhere described as unsuccessful. Here we touch upon problematique of how to believe different resources, and that situations are not always as they are presented to us. It would be useful to have a database of all projects, the ones that succeeded and the ones that failed, because we can learn as much from failures as from successes. There is no such data-base of the projects.

On the other side, success is differently perceived by different actors. Success might be judged in terms of cost and speed recovery of facilitated mangrove systems versus those left to regenerate on their own (Taylor & Francis 2006). According to Dr. Sugirtharaj (Int. 1), there are three elements for success: political support, economical base, and people's organisation. Much emphasis is put on community, less on biodiversity. Even though re-establishment of ecosystem services is often stated as reason for restoration, generating direct benefits for people seems to be a primary objective of many projects.

Because of different backgrounds, restoration goals are set differently and valued according to valuator preferences. As suggests by Biswas et al. (2009), successful ecological restoration should improve biodiversity conservation, improve human wellbeing, empower local people, and improve ecosystem functions. It is important to reach all four targets and not just some of them which is often the case. Therefore, I would recommend a single set of principles to be reached in order to measure success.
According to SER, for testing any restoration program, we need long term monitoring, that often success is judged just by area planted. The ecosystem services and

biodiversity are factors that cannot be visible in a short run. Monitoring, however, represents one of the major problems. It often happens that when the project is finished, no one is doing monitoring (Int. 9). Therefore, monitoring needs to be included in plans from beginning, it needs to be visible how it will be done and with what funds.

Based on previous information, Table 4 is constructed with the main aim to suggest recommendation for different stakeholders that have power to effect the plan of projects.

Table 4. *Achievements, challenges and recommendations in mangrove restoration*

Achievements	Environmental, social and economical benefits stated in analysis (see table 3)	
Challenges	Achieving sustainable funding Stakeholder dialogue Creation of database of all the failures and successes Long term monitoring Following principle of ecological restoration Land ownership issues Coordination between institutions	
Recommendation	Funding agencies	- examine carefully the objectives of NGO's and try to avoid "elaborate dance" -support projects that have clear plan and include consideration of environmental conditions along social ones - support project that aim at long term sustainability and that have developed monitoring plan
	Government /institutions	- sustainable management and conservation of existing natural mangrove forests - investment in research of establishment of ecosystem services, and ecology in restored mangroves - investment in scientific monitoring - cooperation with NGO-s in restoration and monitoring - support educational and awareness programs on mangroves
	NGO-s	-plan your project carefully from the start - remove initial problems of degradation - restoration is done for people, therefore learn their preferences - take advantage of the local knowledge -educate communities and facilitate awareness -identify possible future problems and solutions - set clear goals - create sustainable funding for communities - think about monitoring in advance - do not underestimate the role of environmental factors prior restoration - report on success or failure of your project, for others to learn from it

All projects include the social sphere but they give less attention to establishment of ecosystem services, the principle reason why restoration should be done at the first place. The involvement of scientific community is a must. The involvement of local communities is crucial for success, but it doesn't guarantee success if ecological conditions are not respected.

Looking at mentioned three components of sustainable development (p. 10) that need to be sustained (nature, life support, community), that need to be developed (people, economy and society) (Paris, 2003), and intergenerational components, we can see that these projects have potential and can achieve restoration of nature, can provide life support, can contribute to nature conservation, can sustain community and contribute to community development. Some of the aspects of the projects are not visible today but will benefit future generations.

6.5 Further research

Mangroves are recognised as potential safeguard against the extreme weather events associated with climate change. This resulted in planting mangrove to protect shorelines from the wind-generated waves of storms and hurricanes as a mitigation and adaptation method (Climate Action, 2009). This method, called "ecosystem-based adaptation" aims to increase resilience and reduce vulnerability of ecosystems and people due to the climate change. Mangrove restoration is seen as a potential for ecosystem-based adaptation measure by many organizations and international Institutions such as GTZ, CBD, UNESCO, Diakonia; Nature Conservancy etc. The potential of mangrove restoration to increase resilience of local communities to climate change is definitely something that deserves more considerations.

Furthermore, mangroves are recognised as significant carbon sinks. If mangrove restoration became classified as REDD mechanism, how will that reflect on restoration and will the mangrove be planted at bigger scale to sequester carbon? This is very important issue because there is a danger that mangroves will be planted without ecological considerations or inclusion of local communities, as might happen after tsunami restoration.

In Sri Lanka mangroves are seen as opportunities for development of ecotourism. How this will effect mangrove and local community development is another potential topic to explore.

7 CONCLUSIONS

It is seen in the examples of mangrove restoration projects in South West Bay of Bengal that mangrove restoration has a potential to enhance biodiversity, re-establish ecosystem services and at the same time be a positive driving force for local community development. This is possible if restoration is done in appropriate way, with full community involvement, substantial funding, and scientific approach.

Success in not always reached and there are many barriers for sustainability in these projects. In order to overcome these barriers it is necessary to approach restoration taking in account ecological, social and economic aspects all together, and include all

stakeholders. Achieving positive results in one sphere but ignoring others is not sustainable and it should not be perceived as success. It is noted that different actors perceive success differently, and it in some cases environmental component is being ignored, even though project is qualified as successful. Good funding has shown as a crucial for starting the projects, and it is necessary to transform initial support in sustainable income for the next generation.

In the context of South West Bay of Bengal, restoration of ecosystems is not luxury, but a necessity due to the high dependency of local communities on mangrove ecosystem services and resources. These benefits may not be visible momentarily, but will be seen in the future. Therefore, mangrove restoration projects should be perceived and planned as long-term projects, for current and future generations.

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9. APPENDIX

9.1 *Interviewees*

1. Dr. Felix N. Sugirtharaj, Honour Secretary of COPDANET (Coastal Poor Development Action Network), Chennai, India
   arpmds@vsnl.net; www.copdanet.com

2. J. Alexander, COPDANET, Chennai, Interpreter for Kallur village

3. Dr. Shivakumar, MS Swaminathan Research Foundation, Project manager, Chidembaram, India;
   sivakumar1410@yahoo.co.in

4. Dr. K. Karthiresan, Prof. Annamalai University, Centre of Advanced Marine Biology, Parangipettai, India
   kathirsum@rediffmail.com

5. Mr. Daglas Thisera, Small Fishers Federation Sri Lanka, Mangrove project manager

6. Mr, Ananada Kodikara,O.I.C. Planning assistant, Coastal Environmental Centre, Maduganga, Sri Lanka

7. Mr. Upul Liyanage and Kamal Tennakoon, NARA (National Aqatic research Agency), Rekawa lagoon, Sri Lanka

8. Mr. Charith Senanayake, Managing Director; Rainforest Rescue International, Galle, Sri Lanka
   charith@rainforestrescueinternational.org;
   www.rainforestrescueinternational.org

9. Mr. D.D.G. L. Dahanayaka, B.Sc, Zoology special, National Aquatic Resources Research & Development Agency, NARA, Division Negombe, Sri Lanka;
   ddgldahanayaka@gmail.com; www.nara.ac.lk

10. Mrs. Kumudeni Ekaratna, Senior Programme Officer; Coastal Resources Management Group; IUCN Sri Lanka
    kum@iucnsl.org; www.iucnsl.org

11. Mr. Sundararaju, Chief Wildlife Warden, Government of Tamil Nadu, Chennai, India

9.2 *Locations visited*

INDIA

1. Pulicat lagoon;
   Kallur Village; - mangrove resource training centre
   - focus group discussion with women
   Chinamangolu village
   Kuruvithitiu island - mangrove restoration site by COPDANET
   Arumbakum village - former mangrove restoaration site and training center
   Varagali village –focus group with local fishermen
2. Pichavaram mangrove fores –site developed and conserved by FD and MSSRF
   - tourist center
3. Parangipettai - mangrove restoration site by prof. Kathiresan and his team

SRI LANKA

4. Chilaw lagoon
   Pambala mangrove training and resource centre
   Mangroves restoration sites in Chilaw lagoon
   Visit to 5 families that were involved in restoration
5. Putallam lagoon
   Visit to 4 families that host mangrove restoration sites and informal conversation with them about mangrove restoration
6. Rekawa lagoon, NARA aquatic research centre
7. Nagombo lagoon, NARA research centre and mangrove park
8. Kiralakele mangrove biological garden
9. Maduganga mangroves - Ramsar site