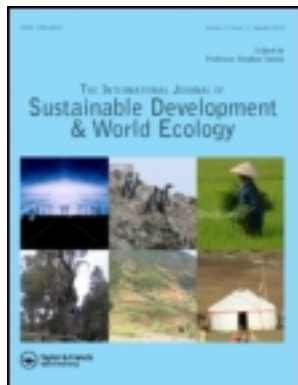


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Rising sea and threatened mangroves: a case study on stakeholders, engagement in climate change communication and non-formal education

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Scientific consensus shows that the changes related to climate change are already occurring and will intensify in the future. This will likely result in significant alterations to coastal ecosystems such as mangroves, increase coastal hazards and affect lifestyles of coastal communities. There is increasing speculation that mangrove, a socio-economically important ecosystem, will become more fragile and sensitive to uncertain climate variability such as sea level rise. As a result, mangrove-dependent societies may find themselves trapped in a downward spiral of ecological degradation in terms of their livelihoods and life security. Strengthening the resilience capacity of coastal communities to help them cope with this additional threat from climate change and to ensure sustainability calls for immediate action. In this context, this paper critically examines the regional implications of expected sea level rise and threats to mangrove-dependent communities through a case study approach. The main objective is to highlight the requirement for climate change communication and education to impart information that will fulfil three expectations: (1) confer understanding; (2) assess local inference on climate change through a participatory approach; and (3) construct a framework for climate change awareness among mangrove-dependent communities through community-based non-formal climate change education. This scale of approach is attracting increasing attention from policymakers to achieve climate change adaptation and derive policies from a social perspective.

Keywords: climate change; sea level rise; mangroves; adaptation; communication; participatory approach; non-formal education

Introduction

Global climate change is likely the greatest challenge that society will face in the century. Although geological records show climatic changes throughout history, the present rate of global warming threatens the survival of entire ecosystems (McLeod and Salm 2006). Coastal ecosystems are more vulnerable to these changes and among the most highly affected ecosystems are the mangroves, coral reefs and salt marshes. Climate change components that affect mangroves include changes in sea level, high water events, precipitation, temperature, atmospheric CO₂ concentration, ocean circulation patterns, health of functionally linked neighbouring ecosystems as well as human responses to the changes (Gilman et al. 2008). Of all the outcomes from changes in atmospheric composition and alterations to land surfaces, relative sea level rise may be the greatest threat to mangrove ecosystems (Field 1995; Lovelock and Ellison 2007). Mangrove systems do not keep pace with changing sea level when the rate of change in elevation of the mangrove sediment surface is exceeded by the rate of change in relative sea level. The physiographic setting, including the slope of land upslope from the mangroves relative to that of land the mangroves currently occupy, and the presence of obstacles to landward migration affect mangrove resistance (Gilman et al. 2008). Thus, the survival of mangroves is threatened

by sea level rise and loss of mangroves will also reduce coastal water quality, biodiversity, fish and crustacean nursery habitats, adversely affect adjacent coastal habitats and eliminate a major resource for human communities that rely on mangroves for numerous products and services (Ewel et al. 1998; Mumby et al. 2004).

According to the Intergovernmental Panel on Climate Change (IPCC), global sea level rise during the twentieth century was between 10 and 20 cm and is predicted to further accelerate to 9–88 cm by 2100, with a mid-estimate of 48 cm (Kennedy et al. 2002). This faster rate of sea level rise of 1–2 mm per year (Boesch 2002) is a result of human-induced global warming. However, the global mean sea level rise will not be uniform around the world since the local change in sea level at any coastal location depends on the sum of global, regional and local factors, which is termed relative sea level change (Nicholls and Leatherman 1996). Using records from coastal tide gauges in the north Indian Ocean over more than 40 years, Unnikrishnan and Shankar (2007) estimated that sea level rise was between 1.06 and 1.75 mm/year. These rates are consistent with the 1–2 mm/year global sea level rise estimates of the IPCC. Moreover, a mean sea level rise of 15–38 cm has been projected along India's coast by the mid-twenty-first century, reaching 46–59 cm by 2100 (National Action Plan on Climate Change 2008). In the

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case of Tamil Nadu, India, a 1 m rise in average sea level would permanently inundate 1091 km² along the Tamil Nadu coast, but the total area at risk would be nearly six times higher. About 551 ha of mangrove wetland at Pichavaram, Cuddalore District, Tamil Nadu, is less than 1 m above sea level (Byravan et al. 2011) and is at high risk from rising sea levels. A rise in mean sea level may be the most important factor influencing the future distribution of mangroves but the effect will vary dramatically depending on the local rate of sea level rise and the availability of sediment to support re-establishment of the mangroves (Field 1995). Geological records show that previous sea level fluctuations have created both crises and opportunities for mangrove communities, and they have survived or expanded in several refuges. Thus, the response of coastal ecosystems to sea level rise is strongly influenced by continuing developments that often lead to over-exploitation of resources, pollution, sediment starvation and fragmentation of ecosystems through urbanisation and development of infrastructure (World Coast Conference 1993).

According to sustainability theory, development should be designed to ensure that the environment is positively preserved, alongside the economy and society (Tarafdar and Bjonness 2010). However, more developments without a sustainability focus will increasingly lead to a decrease in the resilience of coastal systems in coping with natural climate variability, adversely affect the natural capacity of these systems to adapt to changes in climate and lead to increased hazard potential for coastal population infrastructure and investments. In many cases, the assessment of impacts of climate change on coastal areas involves the estimation of the additional risks posed by climate change to systems that are already under significant stress (Bijlsma 1997). It is important to note that climate change-induced human migration could exacerbate conflict and be a stress multiplier by accentuating competition for land and water, ethnic tension and distrust or by adding to existing socio-economic fault lines. Given the scarcity of the resources and a rising population, competition for access to resources may become a reality (Mahajan et al. 2009). To address these issues, urgent and immediate action is required to communicate and educate the local community and create awareness of the anticipated threat. Article 6 of the United Nations Framework Convention on Climate Change (2011) addresses the importance of climate change communication and engaging stakeholders in the issue. It further highlights the responsibility of participating countries to develop and implement educational and public awareness programmes on climate change and its effects to ensure public access to information and to promote public participation in addressing the issue. Community-based environmental communication and education are important components of lifelong learning and are crucial to raising awareness, building partnerships and influencing action to engage people in working towards sustainability (Tilbury and Wortman 2008). A well-designed environmental message could convince people that they can reduce the scale of the phenomenon and could link adaptation and mitigation actions to people's positive

aspirations through providing local examples of climate change impacts and illustrated information. Many scientists recognise the importance of communicating scientific findings to citizens to help them become aware of the urgent need to act and to enable them to carry out anticipatory actions. However, this is one of the most difficult and sensitive objectives of environmental communication and education. The population that must be educated include people of different ages with varying levels of scientific literacy and interacting in multiple social, economic and political spheres. The educational objectives are equally as ambitious to help a community to understand complex climate and meteorological concepts, change their daily lifestyles and adapt to a phenomenon having several as yet unpredictable impacts. Thus, improving public awareness and developing overall communication strategies make climate change science accessible to the average citizen and could reduce their vulnerability (United Nations Framework Convention on Climate Change 2007). This, in turn, will enhance capacities of various stakeholders in the community and improve sustainability at the local level. In this context, the main objectives of this case study are to improve understanding; assess local inference of a changing climate through a participatory approach; and construct a framework to create climate change awareness among a mangrove-dependent community through community-based, non-formal climate change education in the Pichavaram mangrove region of Tamil Nadu, India.

Study area

The study area of Pichavaram Mangrove Forest (11°25'24"N, 79°47'69"E) is on the southeast coast of Tamil Nadu, India (Figure 1). It is located 225 km south of Chennai and 5 km northeast of Chidambaram, Cuddalore District, Tamil Nadu (Planning Commission, Government of India 2008). The Pichavaram mangrove forest consists of three reserve forests (RFs), namely, Killai RF, Pichavaram RF and Pichavaram extension area. Thus, the total area of the Pichavaram Mangrove Forest is 1358 ha. The inhabitants of the Pichavaram Mangrove Forest belong to 17 hamlets of 5 revenue villages, namely, Manambadi, Killai Town Panchayat, Pichavaram, Thandavarayan Solan Pettai (T.S. Pettai) and Thillaividangan. Among the 17 hamlets, 9 are fishing communities and 8 are farming communities. In total, there are 4760 households, with a population of 17,780 (Selvam et al. 2002). For this case study, only Killai Town Panchayat was considered as a pilot study.

Methods

The aims of this study were to identify different stakeholders, assess their levels of exposure (i.e. mangrove-dependent community) and vulnerability to sea level rise and formulate a methodological framework to create climate change awareness among the mangrove-dependent community (Figure 2).

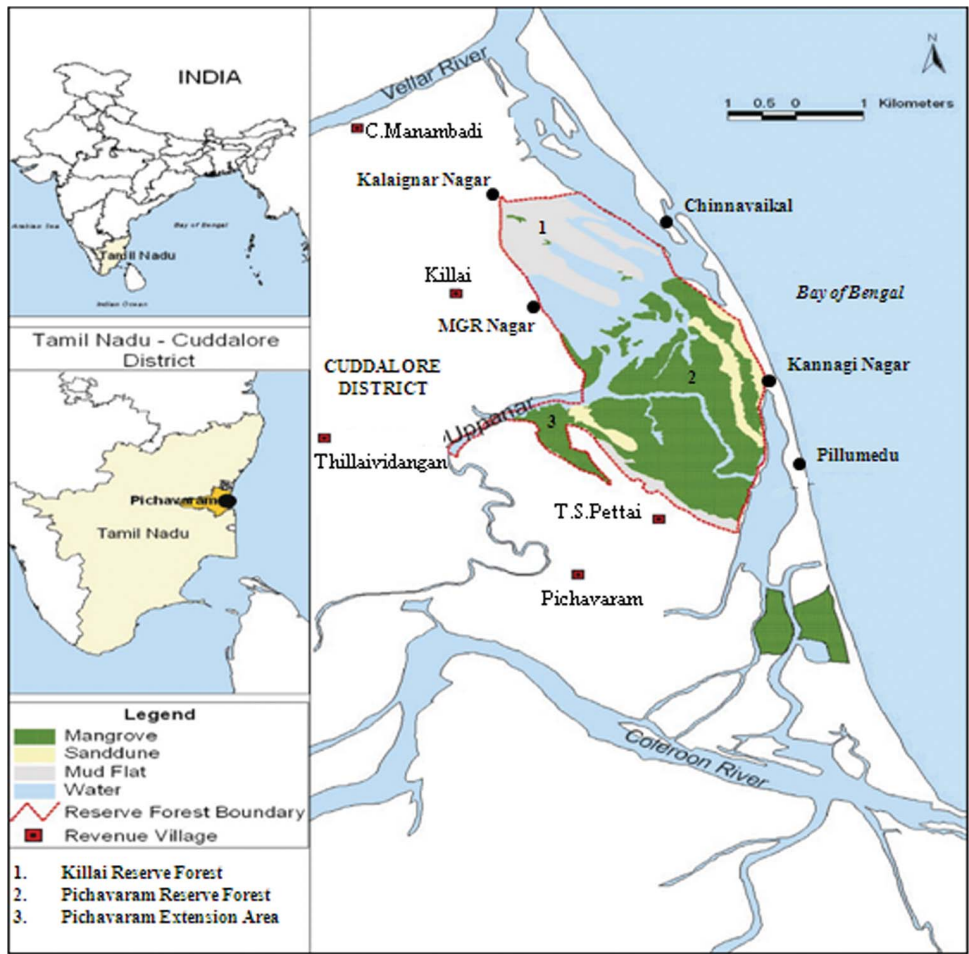


Figure 1. Map of the study area, Pichavaram mangrove forest and Killai Town Panchayat.

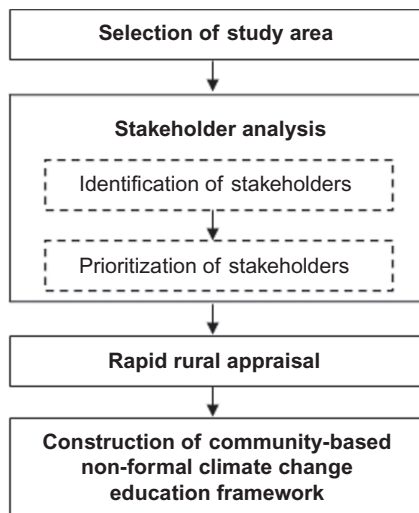


Figure 2. Methodology flowchart.

Stakeholder analysis

Stakeholder analysis is frequently used to identify and investigate any group or individuals who will be or are affected by a change and whether they are equipped to deal with it. It is a process of systematically gathering and analysing qualitative information to determine interests

that should be taken into account when developing and implementing a policy or programme. Studies are often undertaken at local or regional level, as these scales can reveal the specific adaptation options among particular actors. In the context of climate change, the key considerations in stakeholder studies are to produce information on the circumstances, problems and climate change perceptions of stakeholders with the aim of informing policy processes (Carina and Keskitalo 2004). In this case study, stakeholder analysis was performed following the methodology of McCracken and Narayan (1998). Stakeholder analysis is best done in the field, together with a project development team, and with extensive use of participatory consultation techniques to understand the perspectives and concerns of the different groups involved. It was conducted to (1) identify stakeholders; (2) prioritise different stakeholders; (3) assess stakeholders who may be affected by a sea level rise; and (4) outline the importance of stakeholder participation to build resilience to climate change.

Rapid rural appraisal

Rapid rural appraisal (RRA) is a bridge between formal surveys and unstructured research methods such as

in-depth interviews, focus groups and observation studies. It provides a rapid method to gather information for planning and formulating community projects (Lamug 1985) and for eliciting local community participation at the outset of any development programme. RRA in this case study followed the methodology of International Institute for Sustainable Development (1995) to obtain new information and formulate new hypotheses on the mangrove-dependent community with respect to climate change. It was performed using (1) a review of secondary sources, including mapping; (2) direct observation, foot transects, familiarisation and participation in activities; (3) interviews with key informants and group discussion; (4) diagrammatic representations; and (5) rapid report writing in the field.

Community-based non-formal climate change education framework

It is often difficult for climate scientists to communicate with a non-specialist audience, and this is a challenge that arises in policy areas having significant technical content (Pidgeon and Fischhoff 2011). Research in social and decision science has identified several key lessons that are especially relevant to communicating climate science. First, identify climate risks and convey the message to targeted people; second, understand climate risks and make people understand the extent of risks, which can be voluntary, controllable, uncertain, irreversible or catastrophic (Slovic et al. 2000); third, equip people with skills to cope with the anticipated risk; and fourth, find suitable solutions to face or overcome the risk. In this context, the aim of the framework is to create a climate change awareness initiative at the community level to enhance the capacity of the community to adapt to and address impacts of climate change at local grassroots level. It is important to engage in community mobilisation and awareness raising through designing activities that are tailored to local practices and establish strong relationships with the communities. Community-based climate change awareness in this study followed the method of Monroe et al. (2008). The four objectives were to convey information, build understanding, improve skills and enable sustainable actions. These categories were used in a community-based education and communication initiative; in particular, focusing on sea level rise and a mangrove-dependent community. The success of the strategies listed depends on the quality of interaction with the community.

Results

Understanding vulnerability is an important first step in minimising the impacts of climate change on social systems. Vulnerability also refers to the likelihood of a social or ecological system to suffer harm from exposure to external stresses. It is related to exposure to events and stresses, sensitivity to such exposure (which may result in adverse consequences) and resilience through adoption of adaptive

measures to anticipate and reduce future harm (Kasperson et al. 1995).

Stakeholder identification and prioritisation

Killai Town Panchayat is one of five revenue villages around Pichavaram Mangrove Forest (MGR Nagar, Kalaignar Nagar, Chinnavaikkal, Kannagi Nagar and Pillumedu). The stakeholders in these revenue villages directly depend on mangroves as they provide nursery ground for a number of commercially important fish, prawn and crab species (Selvam et al. 2003). Unlike neighbouring regions, these hamlets are close to the sea, and access to Pichavaram Mangrove Forest is the main reason for selection of this study area. In all five hamlets, fishing, farming and local trading are the main occupations and sources of income of the total population of 1166 in the study area (Selvam et al. 2002). Stakeholder analysis was used to prioritise different stakeholder groups (Figure 3) based on their exposure and sensitivity to sea level rise. In this study area, fishermen and farmers are the *key stakeholders*, with high exposure to sea level rise and a high need to build resilience to such a rise. *Primary stakeholders* are local vendors and shopkeepers, who have high or equal exposure to sea level rise but minimum or low importance in participation to build resilience to sea level rise. *Secondary stakeholders* are local non-governmental organizations (NGOs) and local government bodies who have the low exposure to sea level rise but are of high importance to build resilience to sea level rise. *Tertiary stakeholders* are people such as tourists and visitors who have low exposure and low importance in building resilience to sea level rise.

Observations from RRA

The combination of short, formal surveying and exploratory RRA methods was performed among

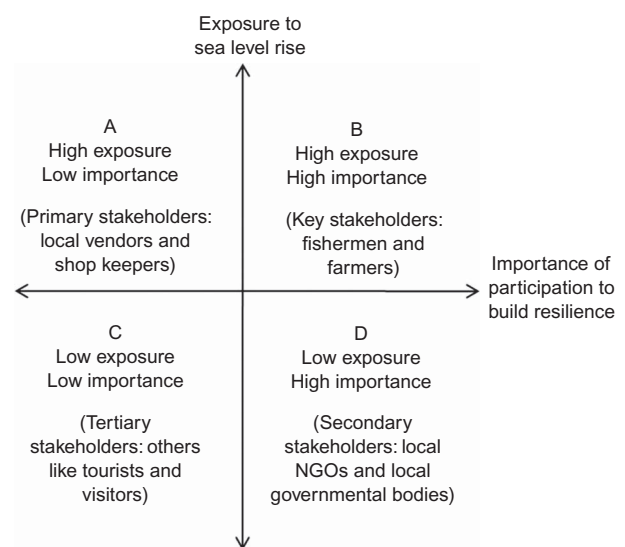


Figure 3. Stakeholder exposure and importance matrix.

150 people, including a combination of all types of stakeholders. Both male and female stakeholders aged 40 years and above were involved in this process. The following attributes were noted: (1) socio-economic data were complemented and informed by a broad range of qualitative data, providing more understanding of environmental and economic dependency on mangroves; (2) crucial information regarding livelihood strategies was compiled, and locally valid criteria for identifying threats of climate change (in particular to sea level rise) and their influence on livelihoods were fairly reliable; and (3) group discussion and personal interviews collected information on indigenous knowledge with respect to mangroves and sea level changes. Different stakeholders may have different levels of exposure to sea level rise; however, they unanimously feel the threat of uncertain sea level changes and the expected influence on resources like mangroves, livelihoods and lifestyles. The local fishing community has experienced the loss of native fish species in the last two decades, which has altered or shifted species abundance, distribution and composition, and residents feel that this may be due to changes in sea level. Changes in the sea can lead to salinisation of groundwater, which is detrimental to freshwater fisheries, aquaculture and agriculture and limits domestic water use in the region. One participant stated that mangroves in their locality act as a bio-shield, especially during the Indian Ocean tsunami. However, survival of these mangroves after extreme coastal events is unpredictable. Another participant thought that rising sea level and a decline of mangrove resources might make them and the next generation climate exiles and force them to migrate from their native land. People who are forced to leave their known resource area in search of work create a new migration pattern termed 'climate refugees' (Saha 2009). Migration may take place in waves to places where people have existing family or social networks, cultural affinities and economic opportunities. This might further increase competition for resources and other opportunities, like unemployment and conflicts. Thus, this study has helped to understand the stakeholder's perception of sea level rise at Killai Town Panchayat.

Community-based non-formal climate change education framework

RRA demonstrated the urgency, immediate awareness and preparedness of climate change education to face the threat at community level. Community-based climate awareness through non-formal climate change education and learning strategies was designed (Table 1) to build climate knowledge and capacity at the local level and to empower people to play an active role in planning suitable adaptation strategies. Thus, awareness through community participation is viewed as an essential component of conservation and sustainable use strategies, because local people are important and direct managers and users of the resources (mangroves) to be conserved, particularly from the context of climate change (sea level

rise). In this case study, stakeholder climate awareness (key, primary, secondary and tertiary stakeholders) of the mangrove-dependent community at Killai Town Panchayat was done using four interventions methods: (1) *Convey information*: a one-way transmission of information to provide basic understanding of climate science, provide missing facts or data on the global and local climate and build awareness of their present and future state of exposure and sensitivity to changing climate, in particular, sea level rise. This method used dissemination of information through community radio, information campaigns, news articles, exhibits, posters, brochures, drama and street plays. (2) *Build understanding*: a two-way transmission of information that aims to facilitate opportunities for stakeholders to develop their own methods to understand the concept of climate change and clarify their doubts. The impact of sea level rise on mangroves and the level of vulnerability to the dependent community were emphasised through location-specific investigations and presentations with discussions (e.g. on location-specific investigations of mangrove density, population of the mangrove-dependent community at Pichavaram – Killai Town Panchayat and highlighting anticipated projections of sea level rise), vulnerability mapping (e.g. mapping various degrees of vulnerability to mangrove location and degree of vulnerability to different stakeholders), and focus group interviews and guided field trip (e.g. direct interviews and guided field work with different groups, including the fishermen's association, the Irulaas – a unique indigenous community of the region – along with local NGOs who work on mangrove conservation and community development). Thus, strategies in this category help in exchange of ideas and in dialogue to build a sense of place and clarify and enhance understanding and concern of climate change impact information. (3) *Improve skills*: stakeholders learn to apply or implement a skill or to organise and critique information. Programmes such as the citizen science programme, which aims to promote stakeholder engagement with climate research and climate science, motivate volunteers and network volunteers from the local fishing community to perform and manage research-related tasks such as indigenous observation and recording of daily weather changes in the study area and periodic measurements of tides; training the trainers programme to develop a network of informed trainers who can set up their own initiatives to design and deliver resilience training programmes on mangroves and the dependent community; cooperative learning workshops to provide opportunities for stakeholders to share knowledge and experience in technical aspects of mangroves, in particular, to identify climate-vulnerable mangrove species (e.g. *Avicennia*, *Rhizophora* and *Sonneratia* species in the study area) and introduced capacity building for the mangrove-dependent community to face the threat posed by the sea level rise. (4) *Enable sustainable actions*: transform stakeholders through a process of critically addressing the problems. This allows stakeholders to work together to define goals and methods of intervention, as well as develop organisational leadership among the local

Table 1. Framework for community-based non-formal climate change education and learning strategies.

| Category | Purpose | Climate context | Subject | Some non-formal climate education and learning strategies |
|----------------------------|---|--------------------------|--|--|
| Convey information | To disseminate information, to raise awareness, to inform | Exposure and sensitivity | Science of climate change (sea level rise) and its threats | Community radio, information campaigns, news articles, exhibits, posters, brochures, drama and street plays |
| Build understanding | To exchange ideas and provide dialogue, to build a sense of place, to clarify and enhance understanding of information and issues and to generate concern | Impact and vulnerability | Impact of climate change (sea level rise) on mangrove ecosystem and its dependent community | Presentation with discussions, vulnerability mapping, issue investigation, focus group interviews, guided field trip |
| Improve skills | To build and practise skills | Capacity building | Enhancing mangrove resilience to changing climate (sea level rise) through community participation for effective mangrove management and restoration | Citizen science programme, training the trainers programme, cooperative learning workshops, project-based education |
| Enable sustainable actions | To build transformative capacity for leadership, creative problem solving and monitoring | Adaptation action plan | Identification of suitable climate change adaptation measures at community level | Training for organisational effectiveness, adaptive collaborative management, action research, facilitating partnerships and networks, design and select model adaptation action plans |

community to combat climate change. Previous strategies could conceivably be limited to climate change information; this tends to include suitable adaptation options (e.g. grappling with different dimensions of the same problem to redefine it can help bring new solutions). In this case study, stakeholders of the mangrove-dependent community are motivated to design adaptation projects; learn how the decision-making process works for planning suitable adaptation options for their locality; and how they can effectively influence decisions. Stakeholders are then encouraged to cooperate and work with local NGOs, the Forest Department, Ministry of Environment and Forests, Government of India and other international agencies in mangrove conservation, management and restoration from the perspective of climate change.

Discussion and conclusions

Climate change creates both risks and opportunities; it is not necessarily an impending catastrophe, but an ongoing, long-term threat. Its impacts will be strongly determined by the quality of our decision making for the exploitation of coastal areas. In the longer term, adaptation to climate change will be necessary to minimise the impacts of rising sea levels on societies and ecosystems and to protect quality of life (World Business Council for Sustainable Development 2008). The social and cultural impacts of the sea level rise are just beginning to be explored, particularly in terms of how resource use will be affected and how these changes will affect social relations and belief systems regarding the customary environments. Therefore, adaptation is, in many cases, the improvement of coastal management through capacity building. By understanding, planning for and adapting to a changing climate, individuals and societies can take advantage of opportunities and reduce risks. To fulfil these requirements, climate change communication and education play a crucial role in information dissemination, especially in translating technical information to increase public understanding and incorporating indigenous knowledge into climate change adaptation for policy planners. According to climate experts, climate change is a real issue in which knowledge is shared among their peer group (Sharples 2010). Climate change education should also be viewed as a two-way process where climate experts and decision-makers seek input and learn from the public about their preferences, needs, insights and ideas for climate change solutions and policy options (Nisbet 2010). For climate change communication to be effective, there needs to be a fundamental shift in the human–nature relationship (Cramer and Foss 2009). Information, communication and education are essential, along with technical and scientific efforts, to achieve a well-balanced adaptation plan. Such recognition is inseparable from creating an equitable and respectful space for knowledge co-creation that brings together local indigenous and conventional scientific paradigms for developing climate change adaptation strategies and action (Green and Raygorodetsky 2010).

This will also entail promotion of awareness about the science of climate change, impacts and solutions. Growing awareness and concern for the climate have increased opportunities for community participation and action in climate change adaptation. Agenda 21 and the World Summit on Sustainable Development Implementation Plan recognised the need to involve communities in conservation actions and in decision making to address environmental and sustainability challenges (United Nations 2002). Both action learning and participation at the community level constitute prerequisites for climate change communication and education. Through action learning, citizens obtain a deeper understanding of the specific issues important in their communities, which could lead to social change (Krasny and Lee 2002). The focus for this is the community, identified as a group of people who live in the same geographic area and share common interests and aims (Deri 2005), where members (all stakeholders, namely, fishermen, farmers, shopkeepers, local vendors and others) can address their local needs. In this case study, the Pichavaram Mangrove Forest and Killai Town Panchayat are linked with hundreds of people's livelihoods. Changing climate not only influences the mangrove forest, but also affects the mangrove-associated ecological services. Stakeholders who depend on the mangrove ecosystem were identified, and priority was given based on their exposure and sensitivity to sea level rise. RRA was useful in understanding indigenous community knowledge on climate change and its impact on the mangrove ecosystem. However, the ultimate aim of this study is to throw light on the importance of climate change communication and non-formal education through a climate change awareness framework construction. The process of identifying and working together with community leaders to understand the effects of climate change on mangroves and the mangrove-dependent community at a local level forms the essence of this case study. It is hoped that the measures put forward will form a basis for conservation and sustainable use of mangroves in the face of physical stress caused by climate change (Wiles 2005). It also highlights the need for preparedness and taking suitable and effective adaptation measures together with the local community in response to the expected influence of climate change, in particular sea level rise, and to find ways to ensure coastal sustainability and human security.

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