FINAL REPORT for APN PROJECT
Project Reference Number: ARCP2012-19NSY-Kamal

Assessing Climate Change Impacts on Salt Marsh and Seagrass Ecosystems in the South and South East Asian Coasts

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

Various scientific evidences worldwide have demonstrated the impacts of climate change. It is speculated to be harsher on the marginal communities who inhabit some of the biologically rich but ecologically fragile coastal areas and who are dependent on their resources for their livelihoods. Mangrove, salt marsh and seagrass ecosystems are among the most productive ecosystems in the world, including South Asia and Southeast Asian countries. However, these resources and their ecosystems are the least studied coastal habitats in these regions. They are the source of livelihoods of a third of the region's population since these ecosystems provide shelter, food and habitat for economically important fisheries, and control coastal erosion that helps to increase marine productivity via reducing coastal suspended pollutants. More recent research findings suggest that they are an effective line of defense against the impacts of climate change. But, due to their shallow (<10 m) existence in the inter-tidal and sub-tidal zone, these two ecosystems are being affected by rising sea level and increasing of temperature. The present project investigates how these climate change variables and their impacts, may affect the sustainability of the goods and services of coastal communities derived from salt marsh and seagrass ecosystems. The results of the project would be useful as a base for a more issue-based, action oriented, conservation and management research programmes, guidelines and policies.

Keywords
Seagrass, Salt marsh, South Asia, South East Asia, Climate Change, Coastal and Livelihoods

Objectives

The main objectives of the project were:

1. To gather the potential evidence on changes in salt marsh and seagrass ecosystems and their adjacent habitats including the livelihoods of the coastal communities who depend on these renewable coastal resources in the proposed areas.

2. To collect previous information related to climate change and ecosystem services of these resources in terms of life, living and livelihoods.

3. To propose a synthesis report of current salt marsh and seagrass ecosystems in countenance of climate change and sea level rise.

4. To propose mitigation and adaptation strategies in the face of climate change and sea-level rise.

Amount received and number years supported

The Grant awarded to this project was:
US$ 45,000 for Year 1:

Activity undertaken

In order to achieve the objectives, the following activities were carried out under this project:

1. Connecting with the scientists from participating countries of Malaysia, Bangladesh, India, Philippines, Thailand, Viet Nam and Japan, who were conducted research on the proejct themes.

2. Developing a common methodology to identify and measure the impacts of climate change on the seagrass and salt marsh ecosystems in the selected coastal areas.

3. Gathering the potential evidence on changes in salt marsh and seagrass ecosystems and their adjacent habitats including the livelihoods of the coastal communities depend on these renewable coastal resources in the proposed areas.

4. Collecting previous information related to climate change and ecosystem services of these resources in terms of life, living and livelihoods.

5. Organizing a 2 days regional workshop in UPMKB, Malaysia to have the country discussion paper that would also look into developing strategies to address the information gaps exist on the selected coastal areas.

Results

The project findings highlight the seagrass and salt marsh habitats of the selected coastal countries along with their vulnerability to climate change and sea level rise. The study has also examined livelihoods of the coastal communities depend on these renewable coastal resources in the proposed areas.

Bangladesh

It has been proved that Bangladesh is highly vulnerable and disaster prone country of the world due to its geographical location with lowers elevation. Being a vulnerable country coastal people especially fishermen communities are more vulnerable compared to others as they live in the mostly vulnerable area i.e. coastal areas of the country. So, in order to conserve and restore the seagrass and saltmarsh ecosystems, an integrated long term study for monitoring the impact of climate change and sea level rise on these ecosystems are essential; fishers' oriented awareness programme in regards to climate change, sustainable use of these resources are needed to stop further degradation and destruction, and development of conservation management plan (CMP) and its implementation with the active participation of relevant stakeholders especially the nearby community people may be the best option for its sustainable conservation, restoration and management of these ecosystems.

India

Climate change induced physical and ecological changes to salt marsh ecosystems force both the natural and human communities to adapt. Fragile coastal ecosystems and the societies that depend on them present particularly complex challenges because they are on the frontline facing the most immediate effects of climate change. This study confirms that, though the fisher communities were aware about the impact of climate change but their level of knowledge about their phenomena is low. The vast potential of ICT (information, communication and technology) should be tapped by decision makers to disseminate climate change information and their impact on salt marsh ecosystem to coastal communities for effective adaptation strategies. Efforts should be geared toward identifying multi-priority management schemes (ecosystem-based management) in averting the ongoing and future climate change induced crisis.

Japan
Precious ecosystem services given by seagrass beds could change drastically with ongoing global climate changes. However, the knowledge on the effects of climate changes on coastal ecosystems is still insufficient. Concurrent monitoring of the seagrass beds, experimental analyses manipulating responsible factors, and integrated long-term, broad-scale modeling are necessary to deepen the understandings about processes how climate change affects coastal ecosystems including temperate seagrass beds in Japan. Then, by adding more comprehensive evaluation on multiple ecosystem services, it could provide more science-based management plans for conservation and sustainable use of coastal ecosystems in a changing world.

Malaysia
In Malaysia, it is clear that the climate change events have increased the risks of livelihoods of fishermen as well as seagrass ecosystems and functions. Seagrass beds in Johor straits (Near Singapore) are expected to be vulnerable by both the catastrophic and manmade activities. Awareness activities within the fishermen on climate change impacts on the seagrass ecosystems may improve the knowledge on the issues, while strengthening the resilience toward climate change processes. Since seagrass beds are intricately linked to resilience of ecosystems, adaptation strategies linked to their conservation would safeguard livelihoods of communities depending on the same.

Philippines
Seagrass beds are a very important resource in the Philippines and in the rest of the Southeast Asian countries. But they are at risk of being lost in the next decade due to enormous pressures from industrialization and urbanization. However, the impacts of climate change on this ecosystem's goods and services need urgent attention. Hence, with the past and present experiences in coastal management in the Philippines and in the region, and *as a matter of policy*, they (Philippines) argued in favor of giving higher priority to seagrass conservation.

Thailand
Fishermen have utilized seagrass beds and the vicinity as their fishing ground for various fishing gears and catch several types of fishes and other aquatic animals for living. However, fishermen felt and experienced an extreme weather condition in their fishing ground and believed that the weather directly affected their fishing activities including reducing fishing day, increasing cost for fishing and destroying fishing gears. This also leads to a migration of villagers in some area for alternative livelihood. The strong evident that extreme weather condition such tropical storm directly affects seagrass habitat was yet to be noted in this area.

Vietnam
Storms have become much more powerful and difficult to accurately predict and with greater impacts now a days. Thunderstorms and tornadoes are becoming more common and unusual and more devastating than in the past. Adverse weather condition has reduced the fishing catches and fishing season time in seagrass habitats on which they depend upon. However, the fishermen have explained that this incident was not only related to the impacts of climate change, but to the impact of random fishing activities with destructive fishing gear, and to an increase in people involved in fishing as well as polluted environment.

Relevance to the APN Goals, Science Agenda and to Policy Processes
The present project focuses on the salt marsh and seagrass diversity and their ecosystems in Indo-Pacific countries i.e., India, Bangladesh, Malaysia, Thailand, Vietnam, the Philippines and Japan, which is known as biodiversity 'hotspots' in Asian region. These hotspots collectively harbor ~ 7 types of salt marsh and ~ 20 species of seagrass which contributes to the coastal communities and marine environment in numerous ways. The proposal focuses on the almost all-focal area of the APN science agenda i.e., 1.

climate change and climate variability, 2. ecosystems, 3. biodiversity, 4. changes in the atmospheric and marine domains, 5. resources utilization and sustainable development etc. The present project is also strengthen the regional collaboration of the member countries as well as helps to share the idea of global climate change and its impacts. The regional initiative with its consortium of partners could establish communication with the respective APN focal points and the focal points for the National Communications to the United Forum fro Climate Change (UNFCC).

Self evaluation

The project implementation was rather smooth and we have reached to the targets to a satisfactory degree. The information on the project objectives was summarized during the workshop held in Universiti Putra Malaysia Bintulu Sarawak Campus Malaysia on April 2014. Number of leading scientists, young researchers and experts were involved in this workshop. One of the most important outcomes of this project workshop was the proposal to publish a book entitled "**Seagrass and Salt Marsh Ecosystems at Asian Coasts in Changing Climate**" under Universiti Putra Malaysia Press by 2015. Some planning about the editors and authors were designed and few papers are already prepared. However, the main problem encountered, having a project leader (PL) is a tough job to accumulate and compile all works from the partner party, which is beyond the PL control. Notwithstanding, we have accomplished many tasks to a satisfactory level in a good teamwork.

Potential for further work

With the implementation of this project, we developed a network of scientists who are highly interested for further collaboration like Vietnam (seagrass), Bangladesh (seagrass and salt marsh) and India (salt marsh). Planning to publish a book in underway with the partner countries. Hope to publish it by June 2015.

Publications (please write the complete citation)

1. Masum, MB, 2013. Peoples' Perception about the Climate Change Impacts on the Salt Marsh and Seagrass Ecosystems in the South Eastern Coast of Bangladesh, MSc Thesis, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh.
2. Abu Hena et al., 2014. APN Project Workshop Abstract, Universiti Putra Malaysia Bintulu Sarawak Campus, 2-3 April 2014, 12 pp.
3. Some BSc and MS projects in the partner countries like Bangladesh, Vietnam and Thailand.
4. Masum MB, Abu Hena MK, Aysha A, Zamal H, Hoque MM and Nesarul MM, 2014. Saltmarsh and seagrass vegetation and their associated fisheries diversity in the southeastern coast of Bangladesh. Journal Tropical Life Sciences (Submitted).

Acknowledgments

We are grateful to the Asia Pacific Network (APN) and whole APN team for funding and without their financial support the implementation of this project would not be possible. Thanks to Universiti Putra Malaysia Bintulu Sarawak Campus for their logistic support and hospitality. Thanks to the Institute of Marine Sciences and Fisheries and Bangladesh Nature, Bangladesh, Hue University, Vietnam, Prince Songkla University, Thailand, University of Philippines, Philippines, Hokkkaido University, Japan and Centre for Environment and Economic Development, New Delhi, India. Special thank goes to Md. Khurshid Alam Bhuiyan for his the help, which we obtained to make APN workshop success.

TECHNICAL REPORT

Minimum 15-20 pages (excluding appendix)

Preface

This project includes the findings and information gathered during the implementation of the APN project ARCP 2012-19NSY-Kamal entitled "Assessing Climate Change Impacts on Salt Marsh and Seagrass Ecosystems in the South and South East Asian Coasts". This project has undertaken a details analysis of the climate change impact assessments on the seagrass and salt marsh ecosystems in the Asian coasts mainly in Bangladesh, Indian, Malaysia, Philippines, Thailand, Vietnam and Japan. The project workshop results based on the primary and secondary country reports and data are presented in this report.

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1.0 Introduction

The impacts of climate change have been demonstrated by scientific evidences world over. It is speculated to be harsher on the marginal communities who inhabit some of the biologically rich but ecologically fragile coastal areas and dependent on its resources for livelihoods. Beside mangrove, salt marsh and seagrass ecosystems are among the most productive ecosystems in the world including South Asia and South East Asian countries. However, these resources and their ecosystems are the least studied coastal habitats in these regions. They are the source of livelihood of a third of the region's population since these ecosystems provide shelter, food and habitat for economically important fisheries, and control the coastal erosion that helps to increase marine productivity via reducing the coastal suspended pollutants. More recent research findings suggest that they are an effective line of defense against the impacts due to climate change. But due to their shallow (<10 m) existence in the inter-tidal and sub-tidal zone, these two ecosystems are being affected by rising sea level, increase in temperature and in CO_2 levels. This project would investigate how these climate change variables and their impacts could affect the sustainability of the goods and services coastal communities derive from salt marsh and seagrass ecosystems. The results would be useful as a base for a more issue-based, action oriented, conservation and management research programs, guidelines and policies. Since salt marsh and seagrass diversity is intricately linked to resilience of ecosystems, adaptation strategies linked to their conservation would safeguard livelihood of communities depending on the same. The main objectives of this project were; (1) to connect with the scientists from participating countries of Malaysia, Bangladesh, India, Philippines, Thailand, Viet Nam and Japan; (2) to gather the potential evidence on changes in salt marsh and seagrass ecosystems and their adjacent habitats including the livelihoods of the coastal communities depend on these renewable coastal resources in the proposed areas; (3) to hold a regional workshop that would look into developing strategies to address the information gaps exist on the seagrass and salt marsh ecosystems in the selected coastal areas.

2.0 Methodology

Case Studies

Bangladesh

Extensive field visits and interviewing of fisherman household heads of two sites of southeastern coast of Bangladesh were conducted using a semi-structured questionnaire (Fig. 1).

A total of 200 individuals were interviewed (100 samples in each site). The samples from two sites (Salimpur, Chittagong and Cox's Bazar) were similar with regards to age (Chi-Square (χ^2)= 6.95, df=3, P >0.05), and number of family members (χ^2=1.85; df =3 and P > 0.05) but differs in demographic features like occupation (χ^2= 53.06, df= 5 and P < 0.0001) and education (χ^2 =7.96 df= 2, P < 0.05). This difference reflects the diversity and livelihood standard of the samples.

The interviews were conducted into local language. The interviews focused mainly on the perception of fishers on the major climatic vulnerabilities, impact of these vulnerabilities in their life and livelihoods, the major uses of salt marsh and seagrass ecosystems on their daily life and likely impact of climate change on these ecosystems. Interviews with key informants such as schoolteacher, village leaders, government officer to validate the data (IIRR, 1998; Hossain *et al*., 2004 and Trap, 2006).

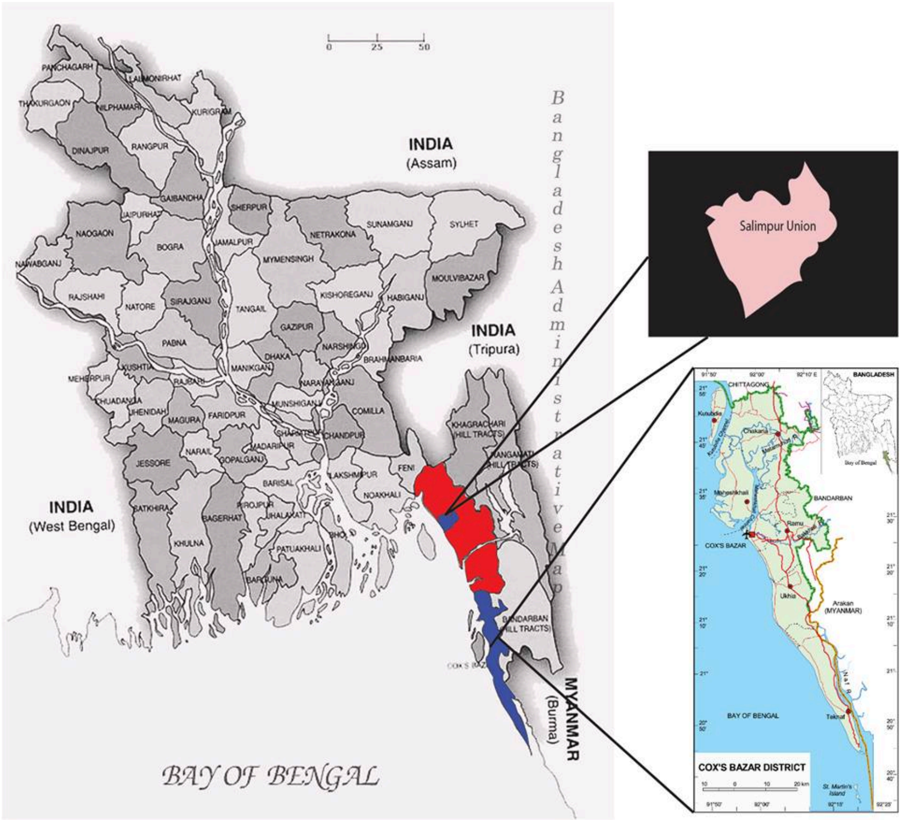


Fig. 1: Sampling sties for assessing public perception (Salimpur, Chittagong and Cox's Bazar district) in Bangladesh.

India

The salt marsh ecosystem of Bhitrakanika conservation area lies in the lower reaches of the Dhamra-Pathsala-Maipura river is a microenvironment region of the Rajnagar Block in Kendrapada district of Odisha located between 86° 45'E to 87° 50' E longitude and 20° 40' to 20°48'N latitude and shown in Fig. 2.The detailed description about the study site is given elsewhere (Patnaik*et al.,* 1995).

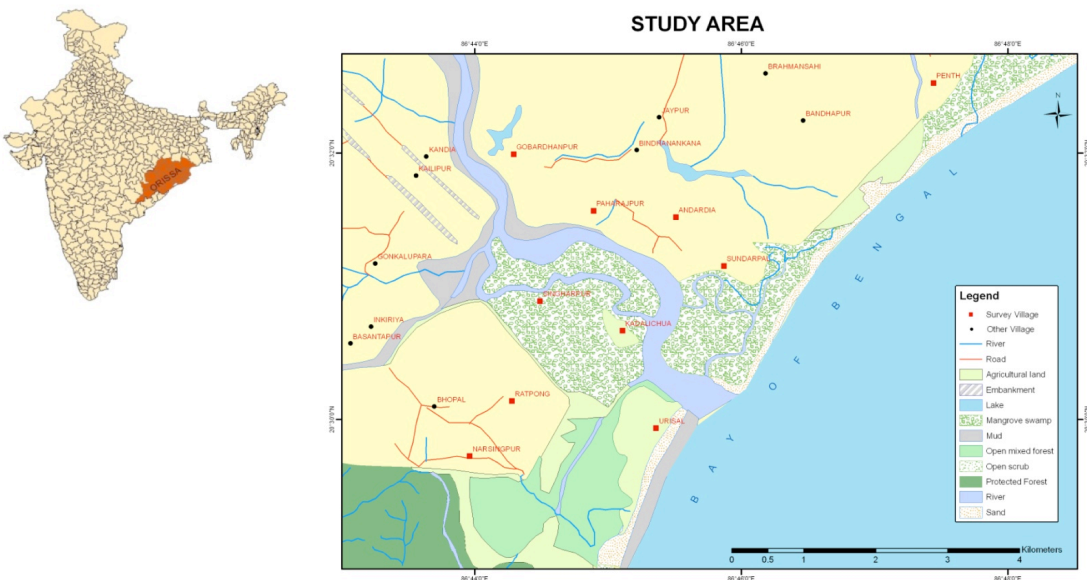


Fig. 2: Sampling area of Bhitrakanika conservation area in India.

The climate of the area is tropical characterized bythree distinct seasons; summer (March to June), winter (November to February) and monsoons (July to October). The average temperature range from 35^0 C in summer to 16^0 C in winter and with average annual rainfall of 1780 mm. Again this conservation area having more than 300 plant species, 31 species of mammals, 29 species of reptiles, 174 species of birds and the nesting ground of the Olive Ridley sea turtles (*Lepidochely solivacea*) (Banerjee, 1984; Patnaik*et al*., 1995&Pandav, 1997). These are areas are identified as protected area by Government of India and Ramsar site considering it's ecological services and social values (Hussain andBadola, 2008)

Study design

A mixed methods design using both quantitative and qualitative methods was adopted to address the main objectives of the study.The cross sectional data on public attitude, values and socio-economic resources on climate change impact on salt marshes ecosystem were administered through household survey, group discussion and key informants interviews were conducted in three phases. The sampling frame or survey was initially identified 10 villages located close to salt marsh ecosystem of Rajanagar Tehsils of Kendrapada districts. The first phase involved a rapid appraisal of study area in order to develop an overall perception of villages that located close to salt marshes ecosystems. The data on resource use, demographic profiles and socio-economic information were collected from secondary sources such as District Statistical Office, Collector's office, Panchayat offices, Block offices and District Forest Offices. In phase 2, detailed questionnaire analysis and in-depth interviews with households to investigate climate change impact on their livelihoods and coastal ecosystems. Mostly set of structured questionnaire along with few open-ended questions was put to know public perception and attitude toward climate variability, salt marches, and impact and conservation issues. The structured questionnaire were divided into three parts (1) Personal information and socio-economic profiles (gender, age, education, caste, family income, occupation and other economic activities); (2) Status of salt marshes and coastal ecosystems; (3) Awareness and attitude of climate change, salt marshes and conservation issues. Respondent answered each question according to their local empirical knowledge on related issues and got response in terms of yes, no and undecided. In last phase, detailed analyses were carried out to find out the key dimensions of the processes of adaptation and barriers of individuals and community in crafting adaptation strategies during vulnerable periods. In each randomly selected village, community meetings were held to give villagers the opportunity to raise questions about the problem and to discuss perceptions on impact of climate change on livelihood issues and the status of coastal ecosystems. Further, a series of focus group discussion i.e. combination of participatory techniques such as time line analysis, stakeholder analysis, participatory vulnerability assessment, and community mapping of vulnerable areas, conservation and developmental issues conducted with people from all sections of the communities.

Data management and analysis

All the quantitative data from the household surveys were entered in Epi-Info version 7.0 database. Data were checked for inaccuracies and inconsistencies on daily basis before entry and verification. Verification, cleaning and analysis were done before exporting data into SPSS for analysis. Data were analyzed using both descriptive and influential statistics. Preliminary bivariate tests (cross-tabulations) were carried out as part of two-stage analysis, using SPSS, to identify the factors that were associated with various responses at various significance levels ($p = 0.001$ and $p = 0.01$). The inferential statistics used to determine the relationships between the dependent and independent variables was Pearson Correlation Coefficient. Binary logistic regression model has been used to find out the nature of decision variable whether fishermen are aware about climatic changes and their attitude to adaptations in conserving salt marsh region of the study area.

Interviews were taped, translated into English, transcribed and typed into Microsoft word software. Debriefing sessions were held by the consultants and the project members and other stakeholders after each interview to provide an overview of issues that arose. Informal analyses were conducted and summaries of the collected data made after each session for clarification or follow up. Qualitative data were transcribed and analyzed based on major themes developed at the study inception. Preliminary analysis entailed open coding and progressive categorization of issues based on inductive (where analytical categories derived gradually from the data) and deductive approaches (where ideas from the interview schedule shaped the coding scheme) (Pope et al., 2000). Categories derived from the data were further analyzed through the development of analysis charts. At this stage, triangulation of data was enhanced through comparisons of analysis charts within and across sites to look for similarities and differences to support identification of key issues around the focus of the study. Final analyses were organized around a description of the main issues identified. Validity and rigor was enhanced during the interpretative analysis through a series of feedback sessions with members of the research team and project members. A range of analyses was prepared to examine experience within and across sites around key issues.

Quality control

To obtain accurate information, data was collected by trained research assistants; carefully recruited to meet the demands of such survey. The tools (questionnaire, FGD guides and In-depth interview guides) were developed after a thorough review of literature and documents available as well as discussion with experts in this area to enhance validity and reliability of the tools. The tools targeting household members were translated to Odia language. Where necessary, translations into the local language were done on site, to facilitate effective communication. The tools were pre-tested in Odisha that generally had similar characteristics as the communities in the study sites. The purpose for pre-testing was to check for vocabulary, language level and how well the questions were understood.

Limitations

Part of the information collected in this study was based on mental recall, which often is prone to error. The second limitation was cross-sectional nature of the study and therefore whether the perceptions reported in this study are persistent in the community where they were recorded could not be established.

Japan

The project implementation included collection and analysis of varies relevant data on seagrass habitats through literatures, personal experiences on seagrass research and field survey in Japan (Fig. 3). As a result, reviews of existing knowledge, research gaps and climate change impacts of seagrass habitats in this region are included in this report.

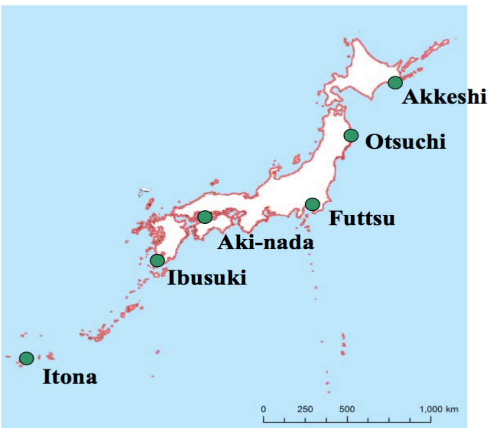


Fig. 3: Map of Japan showing 6 sites for seagrass monitoring by Monitoring Sites 1000 program.

Malaysia

The stakeholders are those individual, who would be impacted due to climate change variables and used to catch fish near or in the seagrass beds for their livelihoods. The binary and likert-scale data on stakeholders (here small-scale fishermen) and their livelihoods status, seasonality, seagrass resources, climate change impacts on seagrass ecosystems and adaptation measures were collected using a questionnaire during October 2013 to February, 2014. Field data were collected through personal interview of fishermen those used to catch fish in seagrass beds. The interviews were centered on (1) the present existence and utilization of seagrass resources by fishermen, (2) fishermen outlook and climate change impacts in seagrass ecosystems, and (3) vulnerability and adaptation measures to be taken in the seagrass beds. Other environmental changes and hazards were also discussed to know the real situation of seagrass resources and their changes in this area. All the collected information were accumulated and analyzed, and then presented in textual, tabular and graphical forms to understand the fishermen outlook on seagrass ecosystems, functions and climate change impacts in Johore Straits, Malaysia (Fig. 4).

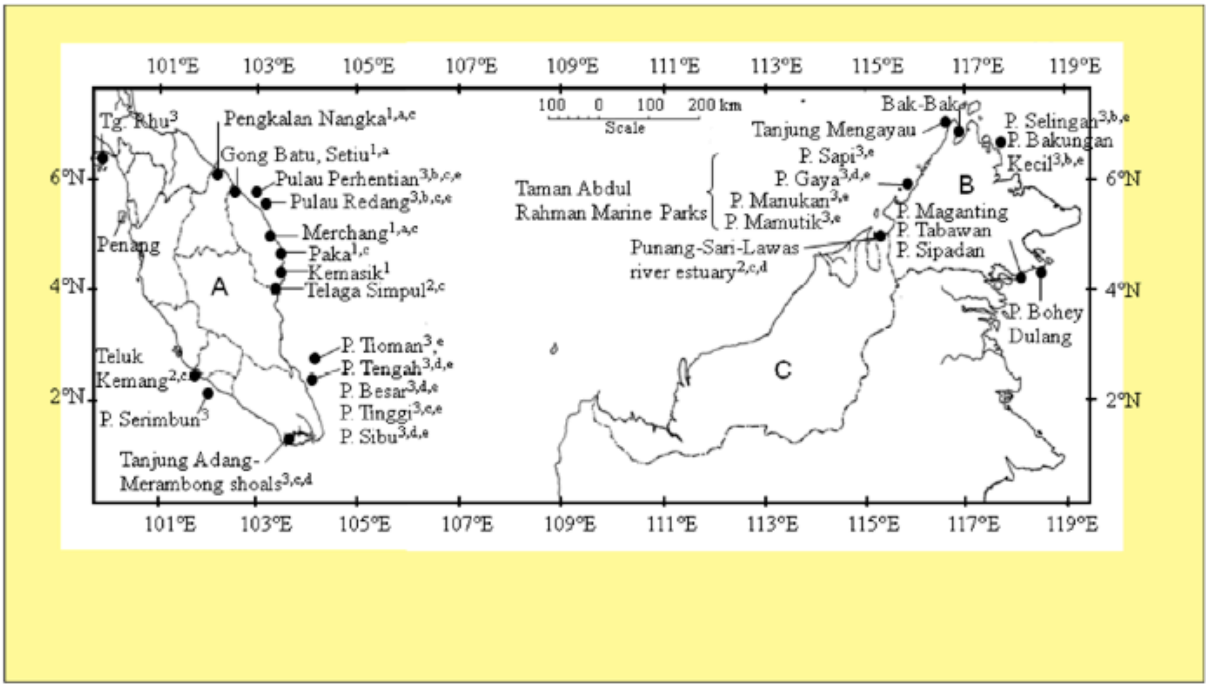


Fig. 4: The major and important seagrass beds in Peninsular Malaysia (A) and east Malaysia- Sabah (B) and Sarawak (C). Lagoon[1], inter-tidal[2], sub-tidal[3]. Aquaculture[a], turtle sanctuary[b], traditional capture fisheries[c], dugong feeding ground[d] and marine park[e] (Source: Japar Sidik and Muta Harah, 2011).

Philippines

The project implementation included collection and analysis of varies relevant data on seagrass habitats through literatures, personal site visits, 30 years personal experiences on seagrass research and field survey in various locations of Philippines. As a result, reviews of existing knowledge and research gaps of seagrass habitats in this region are summarized in this report.

Thailand

Fifty fishing households from three different localities in southern Thailand including Koh Libong island in Trang province, Koh Tha Rai island in Nakorn Sritammarat province and Pattani Bay in

Pattani province to be representatives for Andaman coast, Middle part of the Gulf of Thailand and lower part of the Gulf of Thailand, respectively. These areas are known of their seagrass beds and surrounding fishing communities. Koh Libong islands yield at least 11 species of seagrass and are considered as the richest seagrass biodiversity in Thailand with healthy condition of about 3,000 hectares. A school of dugong is present in this area. Koh Tha Rai harbors 7-8 hectares of seagrass beds with five species including *Enhalus acoroides, Cymodocea rotundata, Thalassia hemprichii, Halophila ovalis, and H. uninervis* (Prathep et al., 2010). Pattani bay, a semi-enclosed estuarine bay, hosts a four species of seagrass including *H. uninervis, R. maritima, H. ovalis* and *H. baccarii* covering an area of 83 hectares in a degraded condition. Seagrass beds in the bay have faced several threats such as reclamation, pollution and destructive fishing methods. Fishermen fishing in the vicinity of these three seagrass areas were randomly selected and asked to complete questionnaire. Simple statistical analysis was applied to analyze and interpret data.

Vietnam

The project implementation included collection and analysis of varies relevant data on seagrass habitats through literatures and field survey in various locations of Vietnam. The reviews of existing knowledge and findings from field survey of seagrass habitats in Vietnam are summarized in this report.

3.0 Results & Discussion

3.1 Fishers' Perception of Climate Change on Salt Marsh and Seagrass Ecosystems in the Southeastern Coast of Bangladesh

3.1.1 Major climatic vulnerabilities observed by the respondents

The increasing trends of climatic vulnerabilities especially cyclones cause loss and damage of assets of the coastal people. In regards to this, the respondents were inquired to mention the major climatic vulnerabilities that they experienced in their life. Seventy percent (70%) respondents in both study areas opined that tropical cyclone is the most prominent vulnerability (Fig. 5) due to climate change. On the other hand, 10% fishers of Salimpur coast cited that thunder storm is the another prominent vulnerability next to tropical cyclone, whereas, only 3% respondents of Cox's Bazar expressed their opinion regarding thunder storm as climatic vulnerability. In addition to that, in Salimpur, Chittagong, 4% respondents in regards to tidal surge and 7% respondents in regards to heavy rainfall cited as observed climatic anomaly especially in the rainy season.

3.3.2 Impacts of climatic vulnerabilities on the fisher's livelihood

The highest proportion of the respondents (over 50% in both the areas) opined that their main earing source especially daily income severely hindered and decreased due to climate change induced hazard like cyclone followed by scarcity of food during the calamities (over 10% in both study areas) (Fig. 6). Six (6%) respondents of Cox's Bazar and 3% respondents of Salimpur cited that a number of fishers migrate to nearby town and other areas of the country as a result of direct and indirect hazards of climate change prevails in the study area. 9% Respondents of Salimpur cited that impairment of boat and net was their 3rd major impact, whereas this impact was very less in Cox's Bazar (3% opined) compared to Salimpur.

3.3.3 Causes of salt marsh destruction

In Cox's Bazar (60% opined) over harvesting was the main reason for the destruction of salt marsh ecosystem, whereas, rapid horizontal expansion of ship breaking industry was the major reason cited by the 53% respondents of Salimpur. Using the marsh beds as footpath was another reason for the destruction of Salt marsh cited by the respondents of Cox's Bazar (about 14%) and Salimpur (8%). Moreover, there were few proportions of respondents who cited that in appropriate harvesting method (the way of cutting the marsh grass which is not suitable for regeneration) was also a reason for the salt marsh destruction (Fig. 7)

3.3.4 Direct use of Salt marsh

In both study areas over 60% respondents cited that they were using salt marsh for fodder, followed by thatching material (12% the respondents opined) (Fig. 8). In both study areas there were some fishermen who do not use salt marsh grass in their everyday life and their percentage were 12% for Salimpur and 9%for Cox's Bazar, respectively. Moreover, only 10% of the respondents use salt marsh grass as source of fuel in both study areas.

3.3.5 Direct benefit derived from salt marsh and seagrass beds

Crab collection from the salt marsh and seagrass beds were much popular to the respondents of Cox's Bazar than that of Salimpur, that percentage were 75% and 45%, respectively. Bait fishing in the marsh bed was popular to some of the respondents of Salimpur coast, although fishers' of Cox's Bazar usually do not practice it. In Salimpur, Chittagong around 15% of the fishers' were engaged in shrimp fry collecting in the marsh area, whereas, in Cox's Bazar it was only 5%. In both study areas there were some respondents were not benefitted directly from salt marsh and seagrass habitat and that proportions were 23% and 15% for Salimpur and Cox's Bazar, respectively (Fig. 9).

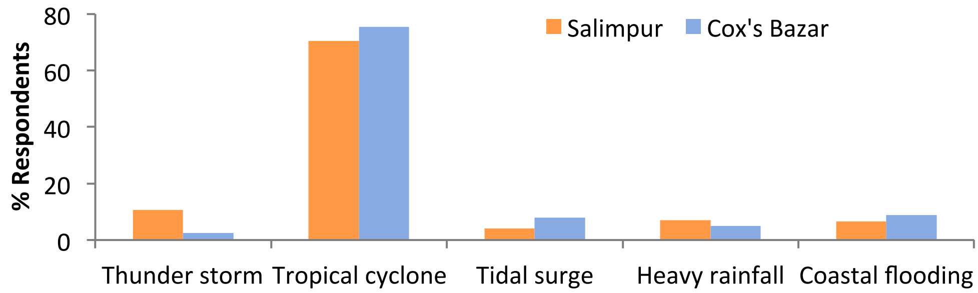


Fig. 5: Major climatic vulnerabilities observed by the respondents.

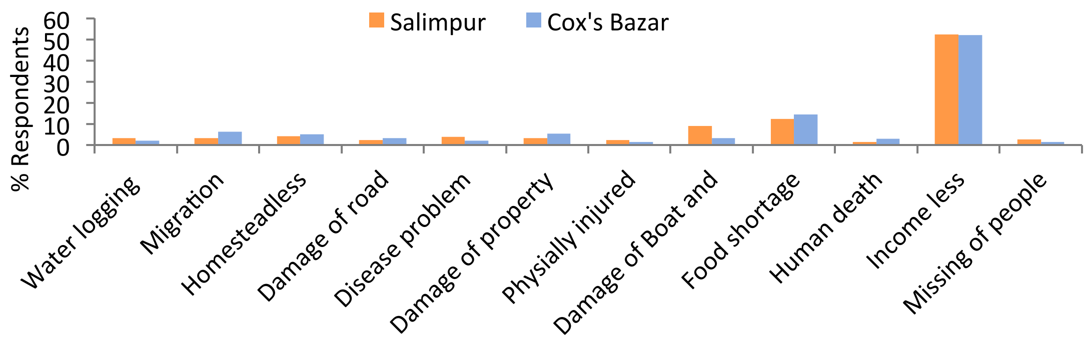


Fig. 6: Impact of climatic vulnerabilities observed by the respondents.

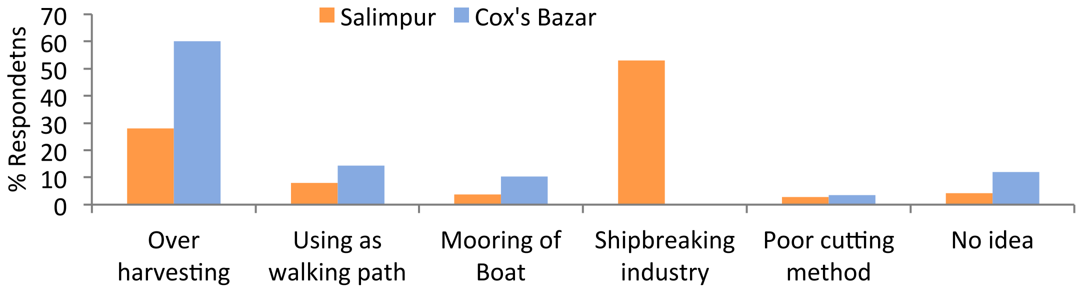


Fig. 7: Fishers' perception about the degradation of salt marsh resources.

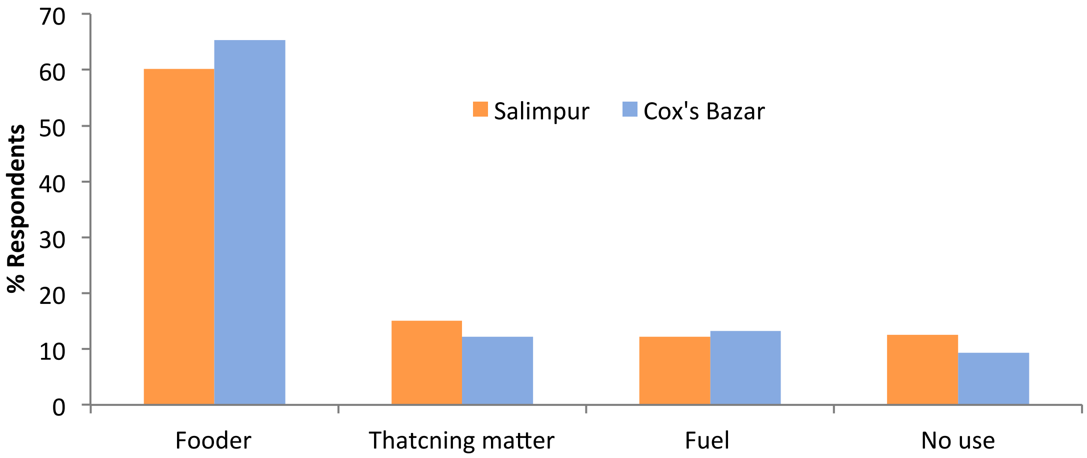


Fig. 8: Fishers' perception about direct use of Salt Marshes.

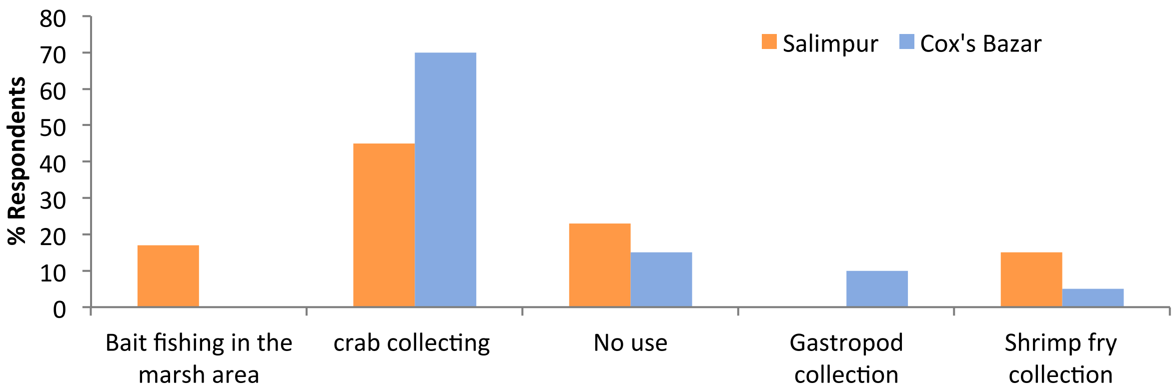


Fig. 9: Fishers' perception regarding the matter of uses of saltmarsh and seagrass resources.

3.3.6 Indirect benefit derived from salt marsh and seagrass beds

To be acquainted with the indirect benefits of salt marsh and seagrass ecosystems almost all the respondents were confused especially of seagrass ecosystem. But while it was described regarding indirect benefits all the respondents in both study area agreed and opined that salt marsh plays significant role in regards to erosion control as well as decrease the velocity of flood in the coastal areas eventually protecting the lives and livelihoods related resources especially crops and vegetables. Regarding indirect benefits of seagrass they could not mention properly may be due to lack of knowledge.

3.3.7 The loss of salt marsh and seagrass resources due to climate change

In Cox's Bazar about 45% of respondents cited that salt marsh were highly influenced by the climate change induced disasters like, cyclone, storm or high wave across the bay or river, whereas, about 15% respondents of Salimpur, Chittagong cited that climate change has high impact on this resources. On the other hand, in both the areas, 30% respondents opined that climate change plays insignificant role in regards to salt marsh and seagrass destruction. Besides, it has also been found that some of the respondents (11% in Cox's Bazar and 5% in Salimpur) have no idea about the climate change induced impacts on salt marsh and seagrass ecosystems (Fig. 10).

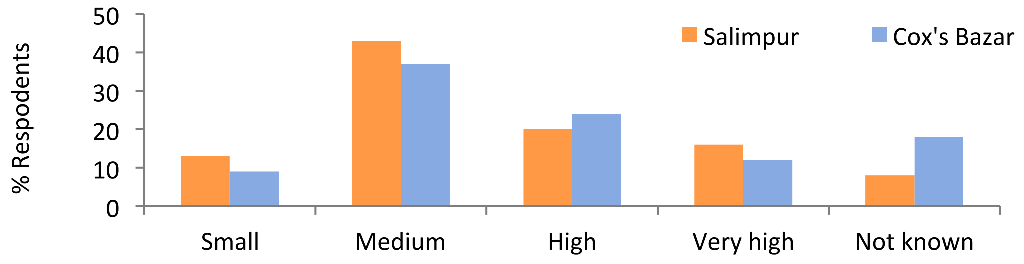


Fig. 10: Fishers' perception regarding the impact of climate change on saltmarsh and seagrass resources.

3.3.8 The previous status of salt marsh resources in 10-12 years ago

To know the previous status of salt marsh ecosystem in the study areas the respondents were interviewed and 78% respondents of Cox's Bazar and 70 % respondents of Salimpur, ranked it as high, i.e. there were healthy and noticeable salt marsh ecosystems in both study areas (Fig. 11). But very few respondents, averagely around 5% in both study areas ranked it as small to medium in regards to salt marsh ecosystem richness in the study areas and around 6% respondents in both areas have no idea about salt marsh ecosystem. The reasons might be due to lack of knowledge about this ecosystem.

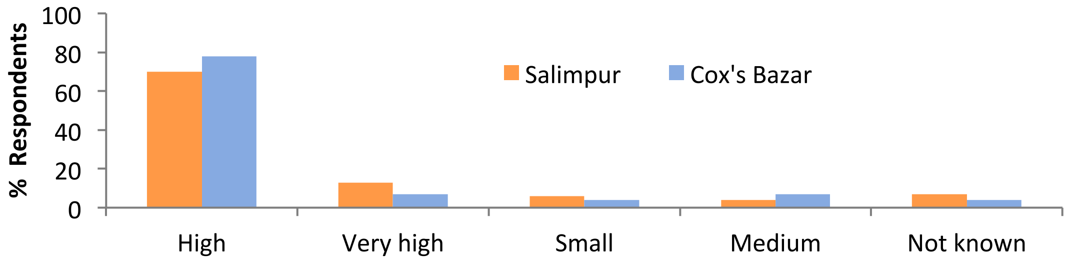


Fig. 11: Fisher's responses to status of saltmarsh and seagrass resources 10-12 years ago.

Discussion

The major climatic vulnerabilities faced by the coastal fishers' of the southeastern coast of Bangladesh were tropical cyclone followed by tidal surge, coastal flooding, thunderstorm and heavy rainfall, respectively. Fortunately, there was no massive cyclone after 1991.It is mentionable that, during 1991 drastic cyclone, not only 138,866 people were died, but also millions of people were injured along with huge loss of properties and infrastructure and socio-economic disruptions (EM-DAT 2010). A similar observation was also mentioned by a number of authors studied in the mid and southeastern coast of Bangladesh including Chowdhury et al., 2012; Sarker and Hossain, 2012; Miah 2010. Our findings show that thunderstorm was the second major climatic hazard cited by the respondents of Salimpur, Cox's Bazar; however, recent research stated that every one degree celsius of warming, there will be approximately a 10 percent increase in lightening activity (thunder storm) (Science daily, July 2012).

Fishers are highly vulnerable to climate extremes because fishing implements prove to be fragile. Tropical cyclones and tidal surges may damage house, boat, fish- landing jetty, road and other physical assets that make the fishers workless. Inexperience and unavailability of other occupations can easily insecure the livelihoods of poor fishers. Sometimes they become bound for fishing even in rough weather. Ninety-nine (99%) and 97% fishers at Salimpur and Cox'sBazar report no alternative income generating options, respectively.

The greatest threats that are facing mankind today are the climate change and its adverse effect undermines the economic development, human security, and people's fundamental rights (Clime Aisa, 2009; UNDP, 2007). The respondents cited that due to climatic hazard the main impacts on livelihood that they are facing directly and indirectly and as a result, poverty is increasing gradually due to reduction of income source, damage of boat and net as well as food shortage. During the cyclone period fisherman who use ESBN (estuarine set beg net), cannot monitor their net placed on the bay, therefore it is sometimes washed away by the strong current of the bay. Similar observations are also reported by Karaiem (2002) elsewhere.

The present study illustrates that in both study areas, 50% respondents cited that they use salt marsh grass as fodder for their cattle. It is considered that from the ancient period salt marshes are the place where livestock forages or source of hay (Adam, 2002). Seagrass meadows provide services, which include social, cultural, and spiritual resources. Many indigenous people have close cultural and religious ceremonies. The fishermen of Cox's Bazar glean gastropod from the salt marsh and seagrass habitat. In Floeres, Indonesia local people glean gastropod from the seagrass meadows (Unsworth et al., 2010). In Salimpur, Chittagong fishermen did not mention about gastropod collection from the salt marsh beds probably due to the absence of these organisms in this habitat. The respondents of Salimpur, Chittagong cited that they were practicing bait fishing in the marsh beds; whereas it was not cited by the respondents of Cox's Bazar probably due to other alternative income generating source like, fish trading, fish laborer, tourism etc. The respondents engaged themselves in crab collection during the low tide in the marsh area.

In this study coastal fishers' cited that salt marsh losses were aggravated by the intervention and establishment of coastal infrastructure like, ship breaking industry, over harvesting of salt marsh as well as mooring on the salt marsh beds. It is noted that the world's largest ship breaking yard lies in the Salimpur, Chittagong. The horizontal expansion of this industry is not only destroying the nearby salt marsh bed but also creating severe pollution on the adjacent salt marsh ecosystems, thus playing as key role behind salt marsh degradation. Adam (2002) has already described the major reasons for the destruction of salt marsh bed. The other reasons associated with salt marsh destructions are grazing by livestock, land claim (i.e., coastal infrastructure like port, jetty), sea salt production, aquaculture, tidal powered mills, tidal barriers, water storage, pollution and introducing invasive species. In USA salt marsh losses were caused by rapid urbanization, coastal construction project and possibly due to sea-level rise. It is noted in both study areas that about 34% of salt marsh resources has declined due to anthropogenic impact.

Majority of the respondents cited that climate change has medium effect on salt marsh and seagrass ecosystems. It is mentionable that increased rate of climate change induced hazard like, cyclone, flooding, and heavy rainfall may cause massive loss of seagrass beds by uprooting and clogging of the plants (Short et al 2006; Chollett et al. 2007). The distribution, abundance and communities of salt marsh may likely affected by the climate change, because there are variation of the distribution of salt marsh species in the world which reflects the influence of climate (Adam, 1990). However Change in temperature and rainfall may change the distribution of salt marshes (Bertness, 1999; Bertness & Pennings, 2000). The germination and recruitment of salt marsh species may govern by the changes of amount and seasonality of rainfall (Zoe and Zeedler, 2001). Changes of some environmental forcing factors like, relative sea level, sediment supply, erosion and freshwater inputs may also cause the destruction of salt marsh.

3.2 Climate Change Induced Impact on Salt Marsh Ecosystem: Understanding Public Perception, Values and Policy in Coastal Odisha, India

3.2.1 Socio-economic characteristics of respondents

The result from Table 1 reveals that more than half of the respondents are between ages of 31 to 50 years and having mean age of 42.5 years. This shows that they are in their middle ages with active productive years and still adopt effective measure to deal with impact of climate change. Further, younger generations are not attracted to fishing occupation. Data on Table 1, shows that majority (89.32%) respondent were males and 10.68% are females. This indicate that more males are engaged in fish catching than females due to fishing operation are laborious and tedious job to handle. Further result from Table 1, reveal that a majority (43.69%) of the respondent having secondary education followed by primary education (33.98%) and no formal education (22.33%) respectively. Again, the data shows that majority (53.40%) of respondents have more than 20 years of experience in fish catching from river and seas (Table 1). This indicates that majority of the respondent have sizable amount of experience in fish catching and further must have good knowledge about climate change impact on their livelihood in the study area. This is likely to have positive effect on their knowledge on mitigation and adaptation strategy to deal with looming crisis. It is also further reveled from Table 1, that staggering amount (80.58 %) of respondent has only one boat for fishing operation, which shows small scale fishing units for purpose augmenting their livelihood. However, majority (82.52%) of the respondent have family size of 6- 10 individuals in their households. The average household size is 7 members. Finally, the result from table reveled that a little less than half (49.51%) of respondents received less than 50,000 rupees per annum as their income from fish catching. Hence, there are indication of small scale fish catching are done with low level of income and high dependency ratio

The main gears used in sample sites are hand lines or harpoons, circular drag net and a circular frame is made of steel rod and net was fitted around it. A large proration of villagers who are involved in large scale harvesting of fish products own powerboats and big nets, locally called Bhasa, Bengapatia (types gill nets). The best fishing period is between August to December, when the tidal range is more pronounced (spring tides) for inshore fishing and May to November for offshore fishing. The major fish species caught in sampling site area are Kua, Kauntia, Sulpatia, Kaunkada, Khainga, Jalanga and Kutibengo. Further, it was found that fishing markets are well developed and self-consumption are quite high providing protein to villages around. The fisher communities having view that out of fifteen species of fish and shell fish seedling caught only three species are *Chinguri* (*Penaeus indicus*), Kaunkada (*Scylla serata*) and Bagada (*Penaeus monodon*) are having high demand in local market (Table 2). A staggering amount of the populace (87%) having view that total amount fish catch has lowered in last two decades. However, more than two-third of the respondent believes that days of fishing have been reduced. More than half of the respondents are undecided about the cause of these kind changes happening in the study region. Again 35% of respondent strongly believe that reduction in total fish catch are due to increase in frequency of depression, storm and cyclones in the study area. About 10% of populace has view that pollution from Paradeep Phosphate Limited and increase in boat and trailer has lowered the potential fish catch in sampling sites.

Table 1: Socio-economic characteristics of respondents (n = 103).

Variable	Frequency	Percentage
Size of Household		
1 - 5	8	7.77
6 - 10	85	82.52
Above 10	10	9.71
Age		
21-30 Years	12	11.65
31 - 40 Years	31	30.10
41 - 50 Years	26	25.24
51 - 60 Years	18	17.48
Above 60 Years	16	15.53
Sex		
Male	92	89.32
Female	11	10.68
Level of Education		
No formal Education	23	22.33
Primary Education	35	33.98
Secondary Education	45	43.69
Higher Education	0	0.00
Number of Boats		
1-2	83	80.58
3-4	15	14.56
Above 4	5	4.85
Fish Catching Experience		
1- 10 Years	11	10.68
11 - 20 Years	37	35.92
Above 20	55	53.40
Annual Income		
Less than 39000	29	28.16
39001 - 50000 Rupees	22	21.36
50001 - 100000 Rupees	18	17.48
100001 - 200000 Rupees	25	24.27
200001 - 300000 Rupees	5	4.85
Above 300000	4	3.88

Table 2: Biomass various species of fish found in salt marsh region

Local Name	Scientific Name	Catch (kg/hr)	Market Value (Rs/kg)
Kau	*Anabas cobojius*	1.8	85
Kauntia	*Mystus gulio*	1.5	40
Sulpatia	*Arius thalassinus*	1.1	45
Kaunkada	*Scylla serata*	0.9	50
Khainga	*Liza tade*	0.6	72
Jalanga	*Pangasius pangasius*	0.5	58
Kutibengo	*Tetradon hispidus*	0.2	80
Hilsa	*Hilsa ilisa*	0.1	300

3.2.2 Fishermen's Awareness about Climate Change Impact

The local population, coastal ecosystem and their livelihoods are inextricably entwined with their climate and a very small change can impinge them directly or indirectly. The results of the survey indicate that majority (87%) of respondents are aware about the impact of climate change on fishing activities and livelihood. However, nearly 42% of the respondent indicates that have little knowledge about the phenomena while 16% state that they don't have any idea about climate change at all (Fig 12). On other hand, about 31% of respondents have view that they have reasonable idea about climate change while 11% of respondent claimed to have in-depth understanding about impact of climate change. Hence the mean the extent of awareness (knowledge) on climate change is 4, which is moderate level in scale of awareness toward climate change in study region.

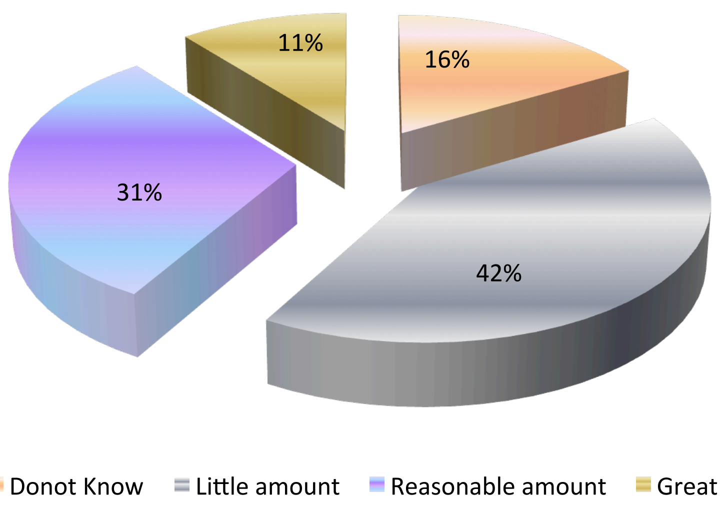


Fig. 12: Extent of knowledge on Climate Change Impact by Fishermen Communities

The main sources of climate change information to fisher communities are through Radio/Television (43%), followed by personal experience (25%), friends and neighbor (15%), newspaper (8%), internet (3%) and extension workers (1%), respectively (Fig. 13). Further, 95% of the respondents listen to weather news in Radio/TV before going to catch fish in offshore and onshore regions in study area. Again, the entire respondent listing to weather news followed signaled tone before leaving and this kind information have reliability factor. Fisher community's personal knowledge on climate change is high probably due to changes in local physical configuration and ecosystems in the study region, which will seriously affect their livelihoods. However, the roles of extension workers are insignificant (1%) in providing climate change information to fishermen in the study area. This shows low level of presence of extension administration and policy making on climate change, which are customary sources of dependable information to fisher communities in study region.

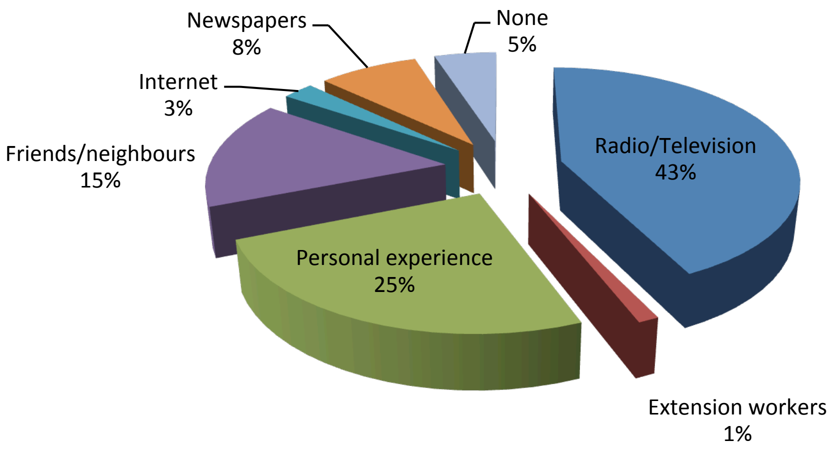


Fig. 13: Sources of information on climate change to fishermen.

3.2.3 Perceived threat due to Climate Induced Changes

The survey result from Fig. 14 shows that 94.4% of the respondent believes that weather is getting warmer and nearly 84.6% believes that onset of summer and late monsoon are advanced during last 30 years. Majority of the respondent have viewed that every season in last 10 years has shown some abnormality. According to the survey, more than 87% of respondent view that warm days have increased; 83% observed changes in season and 85% responded that season is unpredictable to predict. The key informant of the survey revealed that intensity and nature of monsoon rainfall has become erratic and unpredictable but heavy and short duration downpours are become more prevalent in this region. Moreover, there is general perception among local communities that winter period are shrinking followed by longer summer. Further, more than two-third of informant feel that water sources are drying up and three-fourth believe that level of underground is decreasing.

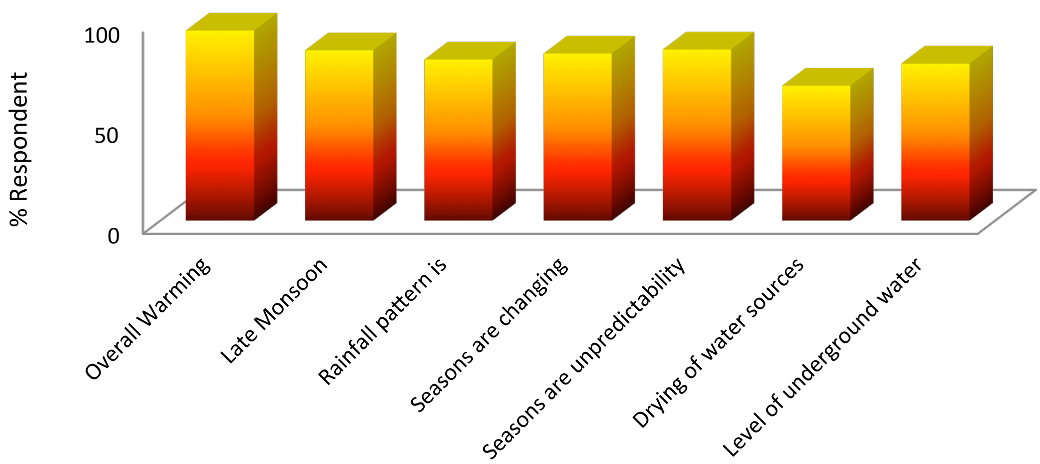


Fig. 14: Perceived threat on local weather and coastal systems

In this study, more than 74% and 78% of informants have felt that both the frequency and intensity of cyclonic storms have increased in recent years contrary to reports of research institute about significant decrease in frequency of cyclonic storms. Though 48% of the respondent felt increased incidence of flood but majorities of them have view that intensity has reduced in study area because of construction of dams and embankments in upstream area. Though, they have strong view that 89% of damage caused by cyclonic storms is due to flooding either from sea, river and heavy monsoon down pour. Further, erratic monsoon rainfall has increased the frequency and intensity of drought in the area, which was almost absent till late 1970. Again, more than 95% respondent felt that heat waves become regular phenomena in summer season since 1998. Further, more than 92% respondents have view that intensity of sea level changes has increased in study area. Again, more than two third of respondent have common view about salt water intrusion in agricultural land. Hence, local communities have learned to live with these kinds of climate induced natural disasters and have common view that intensity rather than frequency which increased in last few decades (Fig. 15).

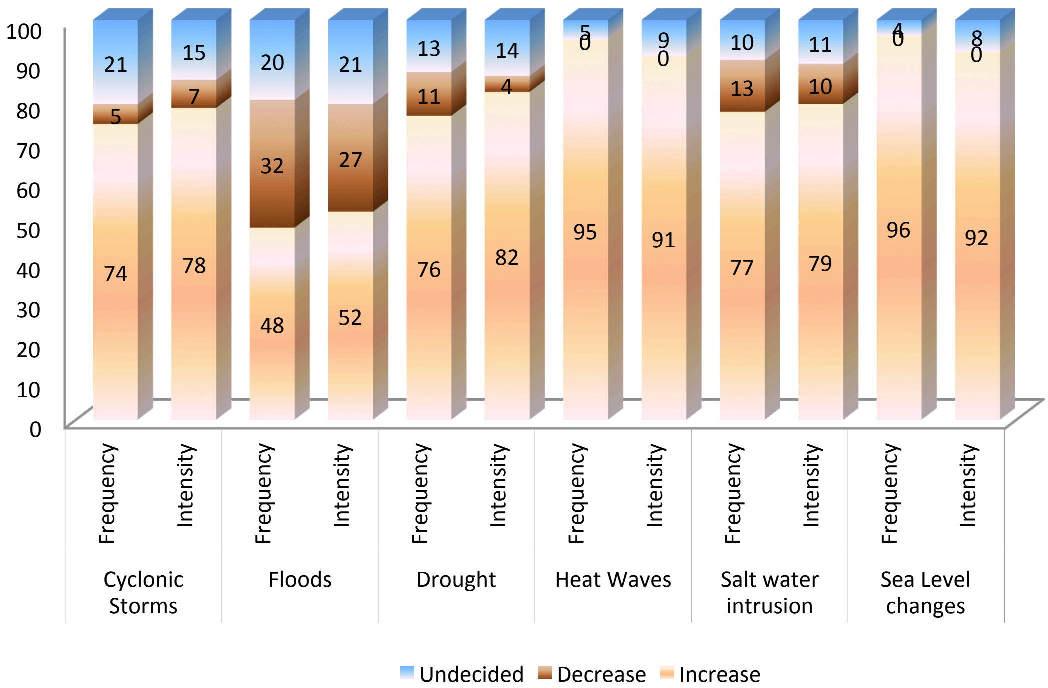


Fig. 15: Perceptions on climate induced natural disaster by fishermen communities.

The survey result shows that respondents are of the general opinion that climate change has caused drastic change in local weather conditions (3.85); damage of property and livilihood due to cyclonic storms (3.29); high temperature and heat waves in summer (3.05); poor harvest of fish from salt marsh region (2.89); invasive plant species (2.56); increased fish disease infestation (2.48); changes in flowering fruting time (2.42) and increase in food security and hunger (2.40). However, fisher communties did not belive that climate change has increased the incidence flood (2.09); increase in harvest of fish (2.13) and increase or decrease in cost of fish production (2.25) (Table 3).

The survey result indicates majority of local populace i.e. about 95% have knowledge and awareness about salt marshes and their geographical location in the study region. Most respondent are aware about the ecological function of salt marsh region the study area (Fig. 16). The respondent are having view that salt marsh ecosystem act first line of defense for cyclone and storm surge (92%), area for fishing catching (90%), store high amount of carbon dioxide (73%) and land erosion prevention (65%) area. However, they are not having knowledge about supporting services provided by salt marsh ecosystem like nutrient filtration (86%), historical (65%) and atheistic values (60%).

Table 3:Perception on impact of climate change.

Variables	Mean	Std. Deviation
Drastic change in weather condition	3.85	0.908
Damage of property and livelihood due to cyclonic storms	3.29	0.937
High temperature and heat waves in summer	3.05	1.725
Poor harvest of fish from salt marsh region	2.89	0.762
Invasive plant species	2.56	0.753
Increased fish disease infestation	2.48	0.852
Changes in flowering fruiting time	2.42	0.921
Increase in food security and hunger	2.40	0.896
Increase or decrease in cost of fish production	2.25	0.683
Increase in harvest of fish	2.13	0.613
Increased the incidence flood	2.09	0.721

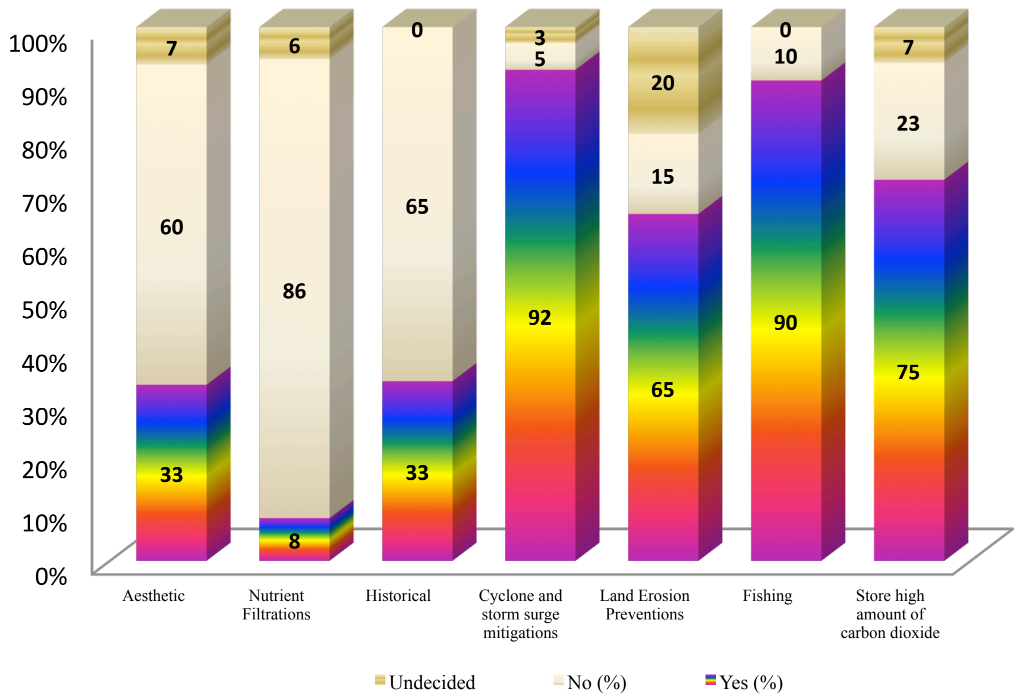


Fig. 16: Perception on services provided by salt marsh ecosystems.

A staggeringly high percentage (89%) of respondent feels that salt marshes areas have decreased significantly in last 10 -20 years (Fig. 17). When a question regarding the cause of decrease were directed to respondents following view emerged: 15%, 5%, 10%, 15%, 30% and 25% of the respondent felt that environmental changes, grazing, local interruptions, land uses, sea level changes and cyclonic storms are cause of degradation of salt marshes in the study region respectively. However, there were greater uncertainties responses given by local community about impacts the shifting climate on salt marshes. Majority of the respondent are having undecided response on loss of salt region due to climate change. Despite this confusion, they have strong view about sea level rise are profoundly the cause of altering salt marshes. These feedbacks are due to their knowledge about drowning of nearby villages in the study region. The other important parameter for cause of degradation of salt marshes was cyclonic storms and surges.

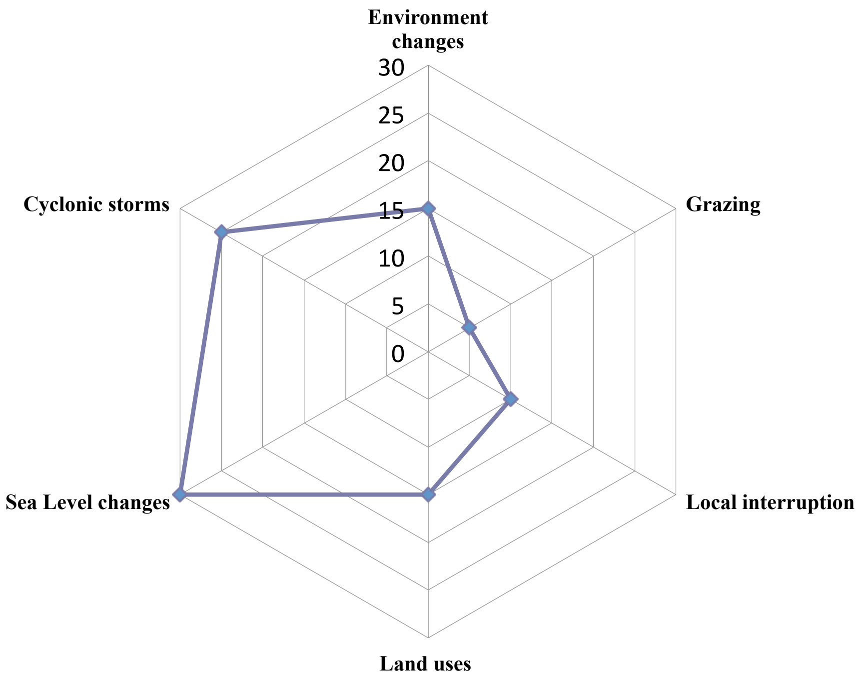


Fig. 17: Perception on cause of degradation salt marsh region in study area.

The importance of existence of salt marshes area are emphasized by the fact that very few respondent (2%) are in favor of exfoliating forest resources and 80% of the people have strong view of more mangrove plantations in degraded region. Whilst 15% of informant believe that present management situation are working good in conserving these region (Table 4). Further a significant difference was found in management and conservation method opted by respondents ($\chi 2 = 789.144$; *df = 5 and p= 0.000*).

Table 4: Perception management alternative of salt marsh area sin study area.

Management alternatives	Response (%)
Forests should be cut and land used for agricultural and other purposes	1
Present situation of protecting the forests is good	11
More mangrove plantations be carried out	78
Crocodiles should be removed and forests should remain	3
Left as wasteland	7

3.2.4 Strategies of fisher communities to alleviate impact of climate change

From the analysis of the survey data, different coping strategies were adopted by fishermen for climate change adaptations, which are autonomous (implemented without external intervention) and responsive (implemented in reaction to climatic events and impacts) in nature. The adopted strategies and coping mechanisms depended on households' perception on extreme events and the problem associated with it. The survey methods have divided the coping strategies into two categories, past and present. Past coping strategies adopted by respondent during 1999 super cyclone or before and present are most recent strategies adopted by respondent after 1999 super cyclones. Table 5 summarizes the number of respondents who adopted each strategy in the past and present. Strategies that have been widely used in the past or present include drawing down inventories: stocks & assets, drawing upon CPRs: Forest and River and livestock keeping: composition & de-stocking. Numbers of coping strategies have increased in use, most notably are seeking alternate employment: locality or migration, procurement of weather/water monitoring kits, adjustment in crop and fishing practices: change crop variety and time of fishing, seeking/listening to information about climate change and stocking fish species that are more favored by climate change. Other household strategies that have declined in use are reducing expenditures: modifying consumption and others: Co-operation, Postponing family festivals.

Table 5: Strategies to cope with the impacts of climate change by fishermen communities.

Strategy	% Respondent	
	Past	Present
Reducing expenditures: Modifying consumption	73	45
Livestock keeping: Composition & De-stocking	85	88
Drawing down inventories: Stocks & assets	88	82
Drawing upon CPRs: Forest and River	83	89
Seeking alternate employment: Locality or Migration	35	78
Adjustment in crop and fishing practices: Change crop variety and time of fishing	25	76
Procurement of weather/water monitoring kits	5	25
Seeking/listening to information about climate change	10	79
Others: Co-operation, Postponing family festivals	65	35
Stocking fish species that are more favored by climate change	19	59

On the other hand, about 38% of the respondent did not take adaptation measures in response to long term shifts in temperature and 42% did not take adaptation measures in response to long-term shifts precipitation (Fig. 18). Climatic information for rural areas coastal Odisha is greatly limited by the sparse distribution of weather stations. The number of stations is greater now than 10 years ago, but the number is still insufficient to meet the needs for information about recent climate trends or to prepare forecasts at scales useful for adaptation. More than 90 percent of the respondents who took no adaptation measures indicated lack of information, lack of institutional supports and money as major reasons for not doing so. In fact, lacks of information are cited major obstacles by respondent in adapting to climate change followed by money credit and institutional support. The details of survey result are summarized in figure below

3.2.5 Relationship between perception of climate change impact and other variables

The survey result of the Correlation analysis in Table 6 indicate that there is a significant relationship between perception of climate change impacts of fisher communities and the following variables like number of boats (0.356; $p<0.05$); fish catching experience (0.109;$p<0.05$); annual income (0.229;

p<0.05); knowledge (0.126; p<0.05) and also strategies to cope with effect of climate (0.538; p<0.05). Those fishermen with higher number boats are more likely to perceive climate change impact because it directly affects their livelihoods. On the extent of empirical knowledge, the higher the fish catching experience the more a respondent is likely to perceive climate change impact on fish catching. Further, coping strategies like autonomous and reactionary are used by fishermen to combat the climate change for sustainable livelihood in study region. Hence knowledge, awareness, practice and belief plays significant role in averting the looming crisis in coming day.

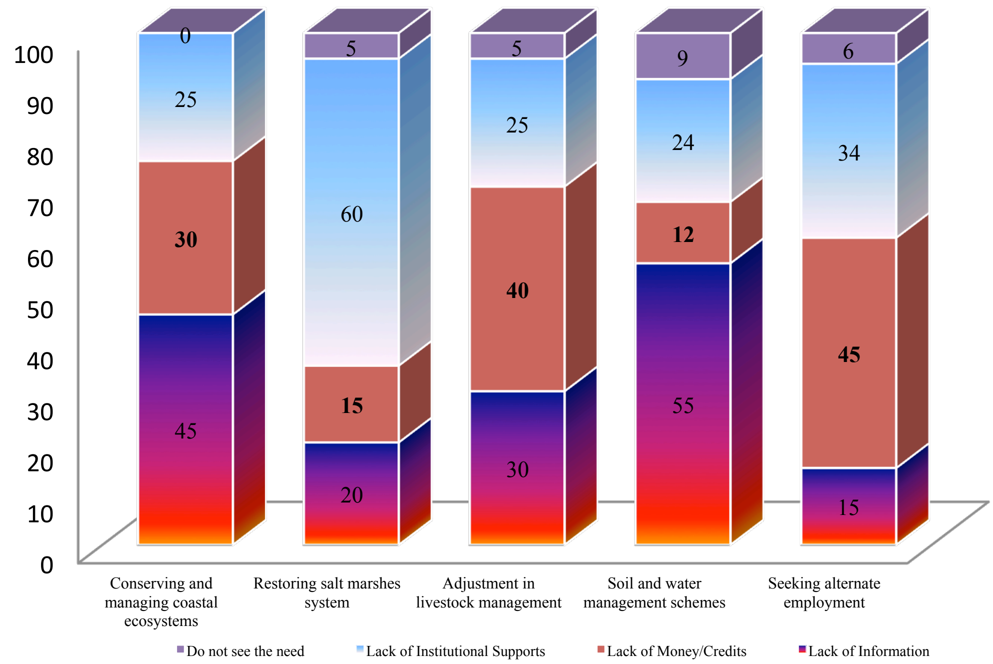


Fig. 18: Barriers and challenges in adaptations.

Table 6: Summary of the relationship between perception of climate change impact and other independent variables.

Variable	Correlation Coefficient	p-value	Remark
Size of Household	-0.478	0.621	Not Significant
Age	- 0.315	0.712	Not significant
Level of Education	0.129	0.065	Not Significant
Number of Boats	0.356*	0.012	Significant
Fish Catching Experience	0.109	0.031	Significant
Annual Income	0.229*	0.01	Significant
Knowledge	0.126*	0.015	Significant
Strategies adopted to cope	0.538**	0.001	Significant

*Significant at 5% (p<0.05); ** Significant at 1% (p<0.01)

Table 7: Results of the logistic regression model of fshermen community perception and adaptations.

Increase of One Unit Explanatory variables	Probability of Adaptations
Education	28.2
Household size	1.1
Gender of household head	1.7
Age of household head	0.4
Farm income	0.0013
Income from Fishing	0.00455
Livestock ownership	-12.1
Information on climate change	39.2
Fishermen to fishermen extension	35.5
Credit availability	48.1
Number of relatives in 'village'	0.21
Farm size in hectares	-7.3
Distance to market	-1.6
Temperature	68.5
Precipitation	-0.6

The result logistic regression suggests that by increasing one unit of credit access to fisher communities in study area will increase the probability of coping ability by 48.1 per cent. Access to climate information and years of education have positive relation with fishermen's knowledge on climate change impact on salt marsh region. Further, the study indicates that accesses to information and years of education increases the likelihood of adaptation by 28.2 per cent and 48.1 per cent respectively. Livestock ownership represents additional wealth for fishermen in coastal Odisha. Higher income communities of the study area may be less risk averse because of enough accesses to information about the changes. For this reason, ownership of livestock shows negative and insignificant effect on likelihood of adaptations. Again, by increasing one of fishermen to fishermen extension may increase the adaptive capacities of fishermen by 35.2 percent. This has implication for extension administration and policy making since knowledge of climate change impacts is related to the availability of information on the phenomenon. Further, the result indicates that by increase of one degree temperature will increase the probability of adaptation strategies by 68.5 percent in study area while negative with precipitation.

3.3 Evaluation of Biodiversity, Ecosystem Functions and Services of Temperate Seagrass Beds in Japan

3.3.1 Variation in species diversity and abundance of seagrass community along temperate Japanese waters

Temperate seagrass beds occur at the four main islands of Japan; Kyushu, Shikoku, Honshu and Hokkaido, and they consist of several seagrass species belonging to the family Zosteraceae; namely, *Zostera marina*, *Z. japonica*, *Z. caulescens*, *Z. caespitosa*, *Z. asiatica*, *Phyllospadix iwatensis* and *P. japonicas* (Nakaoka and Aioi 2001). *Zostera* spp. occurs in soft sediments whereas *Phyllospadix* spp. on rocky shores. This paper focuses on the former.

One of the prominent characteristics of Japanese temperate seagrass beds is that several congeneric *Zostera* spp. co-occur in the same beds. Different seagrass species dominate at different depth, forming specific depth zonation. Generally, *Z. japonica* occurs at intertidal part, *Z. marina* at shallow subtidal, and *Z. caulescens*, *Z. caespitosa* and *Z. asiatica* in the deeper parts of the beds (Nakaoka and Aioi 2001). The latter three species have unique morphological adaptations to live in deep, low light environments. *Zostera caulescens* forms a high canopy, whereas *Z. asiatica* produces large and long vegetative leaves, both to attain light in upper water column (Nakaoka et al. 2003, Watanabe et al. 2005). *Zostera caespitosa* has low belowground/aboveground biomass ratio (Omori and Aioi 1998), which benefits to grow at low light environment by lowering light compensation point.

Quantitative comparisons of spatial and temporal changes in seagrass species composition and abundance (% coverage) has been conducted since 2008 at 6 sites in the Pacific coast and Seto Inland Sea coast of Japan, by the Monitoring Sites 1000 project of the Ministry of the Environment, which aims to monitor the 1000 important ecosystems over the next 100 years (Biodiversity Center of Japan 2013). The monitoring has been carried out annually at each of the 6 seagrass sites among which 5 sites are temperate seagrass beds dominated by *Zostera* spp. At each site, 5-15 census stations are established along the depth gradient, and at each station, seagrass species composition and percent coverage of each species were measured for each of the 20 quadrats of $0.25m^2$ area haphazardly placed at each station (Biodiversity Center of Japan 2013).

The results obtained from the first three years (2008 to 2010) showed latitudinal gradient in seagrass species diversity, abundance and its temporal variability (Fig. 19). The species richness was higher at higher latitude, whereas average coverage did not show obvious latitudinal gradient. Temporal variability (instability), represented by the coefficient of variation (CV) was highest in the south Kyushu near the southern limit of *Z. marina*, and the lowest in the eastern Hokkaido. The interrelationship among latitude, depth, species diversity and functions (average cover and CV) were further analyzed by structural equation modelling. Although the obtained model explained only 10-16% of the total variation, it was shown that latitude is positively related to seagrass species richness and average cover, and negatively with CV, indicating that seagrass are more diverse, more abundant and more stable at the higher latitude. Depth tended to be negatively correlated with cover, indicating the limitation of abundance due to lower light availability in deeper environment. Finally, seagrass species diversity is neither significantly correlated with cover nor CV.

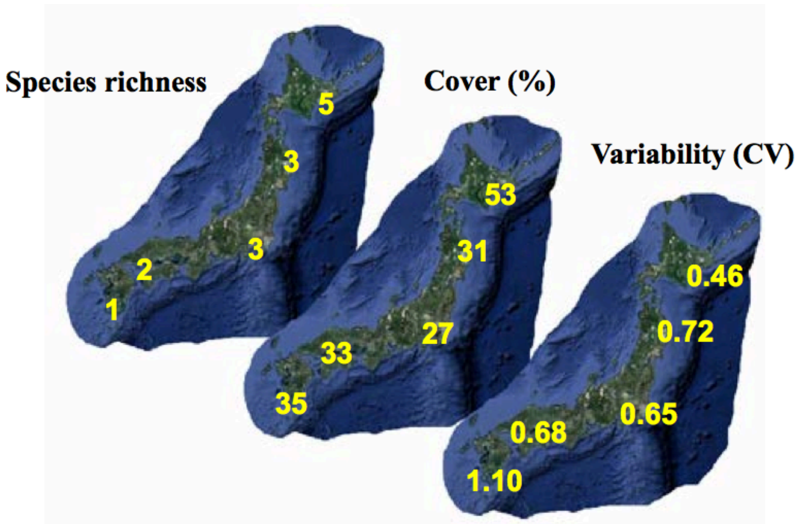


Fig. 19: Broad-scale variation in species richness, average cover and temporal variability of temperate eelgrass beds in Japan. Data for 2008-2010 were analyzed and presented based on Nakaoka et al. (2013a).

Broad-scale variation in biodiversity and abundance of seagrass-associated epiphytic invertebrates was also analyzed by collecting epifauna by a hand-covered net of 0.5 mm mesh size at subtidal *Z. marina* meadow at each of the 5 temperate seagrass beds of Monitoring Sites 1000 project (Hori, unpublished data). Mean species richness of epifauna per sample was highest at Aki-nada seagrass bed, followed by Futtsu seagrass bed in Tokyo, Akkeshi-ko estuary in eastern Hokkaido, Funakoshi Bay in Sanriku coast, Akkeshi Bay and Ibushuki in south Kyushu in order (Fig. 20). Latitude gradient was not discerned. However, species richness was significantly higher in 3 sites where *Z. japonica* co-occurs with *Z. marina* than another 3 sites where *Z. japonica* was absent (Fig. 20). The sites with *Z. japonica* have wider intertidal range in addition to subtidal *Z. marina* meadow, whereas those without *Z. japonica* consist only of subtidal part. In intertidal parts of the former seagrass beds, numerous suspension-feeding animals were found such as bivalves and tubeworms, whereas fauna in subtidal zone was dominated by grazers such as snails and amphipods. It is likely that more complex habitat structure of the bed with *Z. japonica* (consisting both of intertidal and subtidal habitats) can enhance species diversity of associated fauna by providing habitats to more diverse functional groups of invertebrate species.

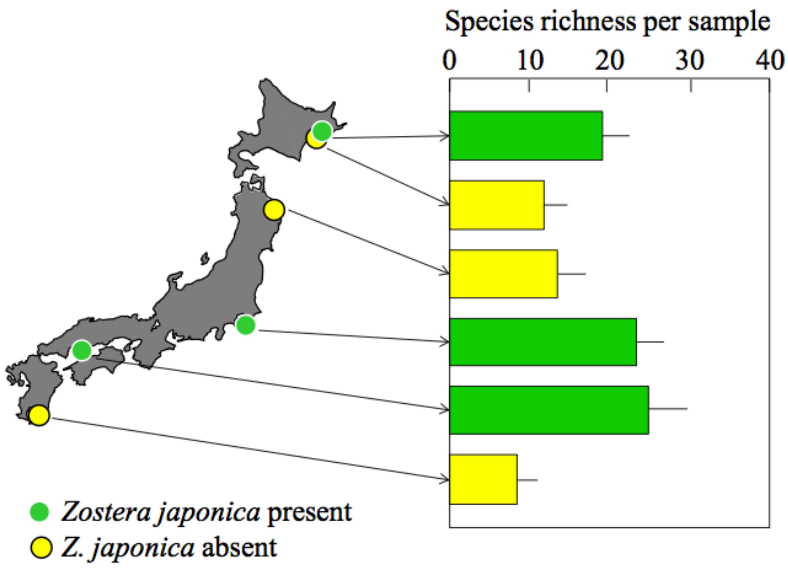


Fig. 20: Regional variation in species richness of epifauna on eelgrass bed. Based on Hori, M. (unpublished data).

Fish community in temperate seagrass beds of Japan was investigated at a total of 11 sites using a same seine net covering 100 m^2 (Fukuda et al. in preparation). Species composition differed greatly between northern and southern seagrass beds that were divided at the latitude of 38^oN. The former sites are affected by the cold Oyashio current and the latter by the warm Kuroshio current. Fish species diversity was generally higher in the seagrass beds at lower latitude, whereas fish biomass showed a reverse trend. Most notably, biomass of piscivorous fish was greater at the northern seagrass beds, suggesting more intense predation pressure to inveretebrate mesograzers in northern sites (Fig. 21). Unlike invertebrate community, the presence or absence of *Z. japonica* did not affect the species diversity and abundance of seagrass-associated fish.

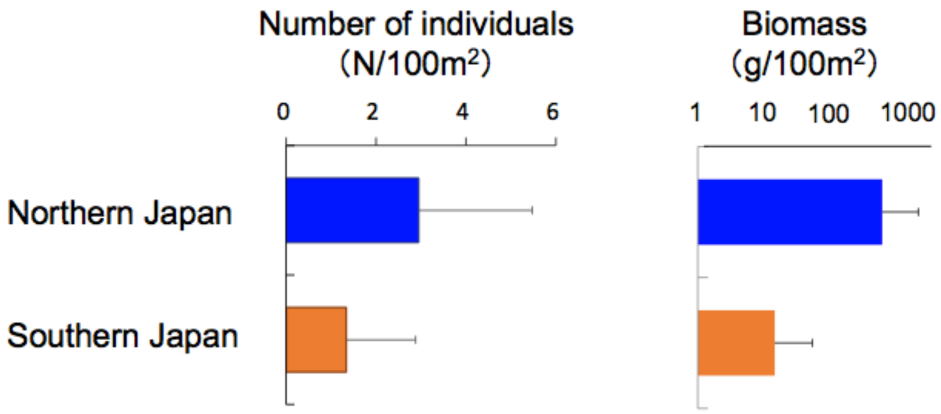


Fig. 21: Comparisons of fish abundance between northern and southern parts of Japan. Data from Fukuda et al. (in preparation).

3.3.2 Quantitative evaluation of multiple ecosystem services from seagrass beds

A variety of ecosystem services are provided by nature, which are tightly linked to human well-being (Millennium Ecosystem Assessment 2003). They are classified to the following 4 categories; provisional, regulating, cultural and fundamental services. The first three types of services are directly related to human society, whereas the fundamental services give the bases for them.

Seagrass beds provide multiple ecosystem services including all three types of direct services. Based on expert opinions of the seagrass researchers in Asia, Nakaoka et al. (2014) analyzed the most important ecosystem services of Asian seagrass beds at 13 sites in 10 countries. Provision of seafood was selected in all sites as major provisioning services. Water purification, erosion regulation, climate regulation and natural hazard regulation were selected as major regulating services at multiple sites. Educational values and recreation/ecotourism were selected for cultural services in most sites (Table 8). Notably, there were some interrelationships among the direction of changes in these ecosystem services. In some sites, both provisioning and regulating services were reported to decrease in quality and quantity, especially in sites where seagrass beds declined due to human-induced stresses such as land construction and eutrophication. In other sites, however, there was a negative relationship in temporal trends between the provisional and regulating services. In such cases, it is likely that these services are in trade-offs, i.e, excess use of provisioning services at the expense of regulation services. The potential trade-offs between provisioning and regulating services are very commonly found in other types of ecosystems such as forests and freshwater lakes (Carpenter et al. 2009).

	JPN	JPW	KR	CNN	CNS	PH	IDE	IDW	SG	MY	TH	BG	IN
Provisioning services													
Food	↑	↓	↓	↑	↓	↓	↓	↓	↓	↓	↓	↑	↑
Genetic resources	-	-	-	-	↓	-	-	-	-	↓	-	-	↑
Biochemicals	-	↓	-	-	-	-	-	-	-	↓	-	-	-
Regulating services													
Climate regulation	↓	-	-	-	-	↓	-	↓	-	-	-	-	↓
Erosion regulation	↓	-	↓	-	-	↓	↑	↓	↓	↓	→	↓	-
Water purification	↓	↑	↓	↑	↓	-	↓	↓	↓	↓	↓	↓	↓
Natural hazard regulation	-	-	-	↑	↓	↓	↓	-	-	-	-	↓	↑
Cultural services													
Cultural diversity	-	↓	-	-	-	-	-	-	-	-	-	-	-
Spiritual values	-	-	-	-	-	-	-	-	-	-	→	-	-
Educational values	↑	↑	↑	↑	↑	↑	↑	↑	↑	↓	↑	↑	-
Inspiration	-	-	-	-	-	-	-	-	-	-	↑	-	-
Aesthetic values	-	-	↑	↑	-	-	-	-	↑	-	-	-	-
Recreation and ecotourism	↑	↑	↑	↑	↑	↑	↓	↓	↑	-	-	↓	↑

Table 8: Summary of the selection of important ecosystem services and the direction of their changes in 13 seagrass beds in Asia. JPN: Japan North; JPW: Japan West; KR: Southern Korea; CNN: China North; CNS: China South; PH: Philippines; IDE: Indonesia East; IDW: Indonesia West; SG: Singapore; MY: Malaysia; TH: Thailand; BG: Bangladesh; IN: India. Data from Nakaoka et al. (2014).

In a seagrass bed in Aki-Nada, Seto Inland Sea, we quantified the amount of multiple ecosystem services (provisioning and regulating services) in relation to variation in spatial complexity of eelgrass vegetation (M. Hori, unpublished data). Fish biomass and net primary production of eelgrass were measured at various parts of the eelgrass bed where spatial configuration (patchiness) and shoot density varied. Provisioning services, which is represented by fish biomass, were highest at patchy vegetation with medium level of shoot density, whereas regulating services, represented by net primary production of eelgrass, were highest at the continuous vegetation with high shoot density (Fig. 22). The results showed that the maximum amount of ecosystem services is attained at different conditions (patchiness and shoot density) for provisioning and regulating services, suggesting the presence of trade-off even within a single seagrass bed. Generally, patchy sparse vegetation (where provisioning services are maximum) occurs at the periphery of seagrass beds, or during the early to medium stages of succession after disturbance. On the other hands, dense continuous vegetation (where regulating services are maximum) occurs in the center of seagrass beds, or in the final stage of succession. To maximize both types of ecosystem services, managers need to consider spatial and temporal dynamics of eelgrass beds. Previously, managers tend to consider that dense vegetation is most productive and of most importance, which may be true for major regulating services such as nutrient recycling and carbon segregation. However, it may not be true for provisioning services where fish cannot get access to the densest part of the bed. Alternatively, if managers plan to protect not only of the dense part of seagrass beds, but also of patchy habitats near the periphery, it can maximize the total amount of multiple ecosystem services.

By extending the quantitative analyses of ecosystem services in Aki-nada to other seagrass beds in different regions of Japan, and by extrapolate the obtained results using GIS, we are in the process of estimating the value of multiple ecosystem services at the nationwide scale. For the carbon segregation potential, which is one of the major regulating services from seagrass beds, we found that dense seagrass beds with more than 30 ha in area have high carbon fixation ability, and that the ability is further enhanced if they can trap the organic carbons from surrounding algal beds (Fisheries Agency of Japan 2014). Using GIS, we can successfully specify the positions of eelgrass beds with high carbon fixation ability along the Japanese coast (Fig. 23).

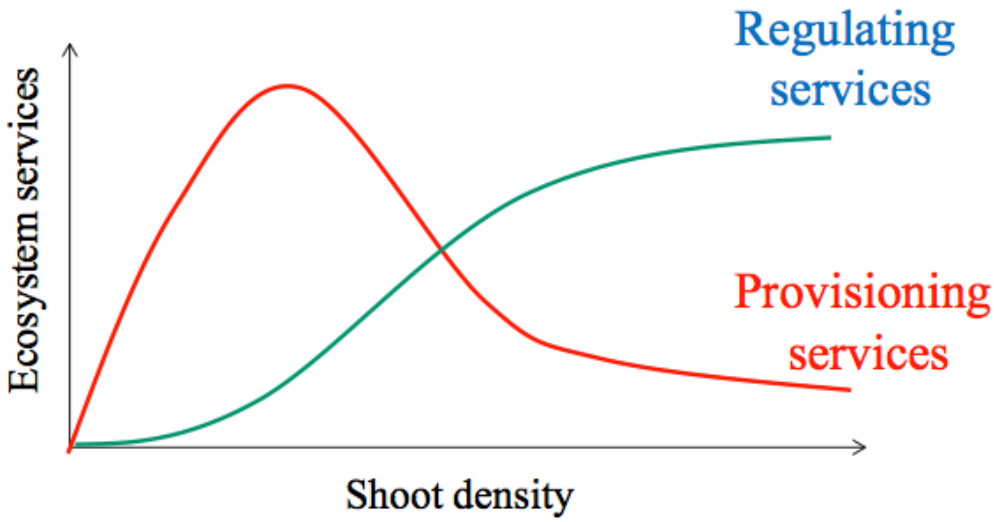


Fig. 22: Schematic presentation of the relationship between shoot density of seagrass vegetation and the amount of different types of ecosystem services from the seagrass bed in Aki-nada.

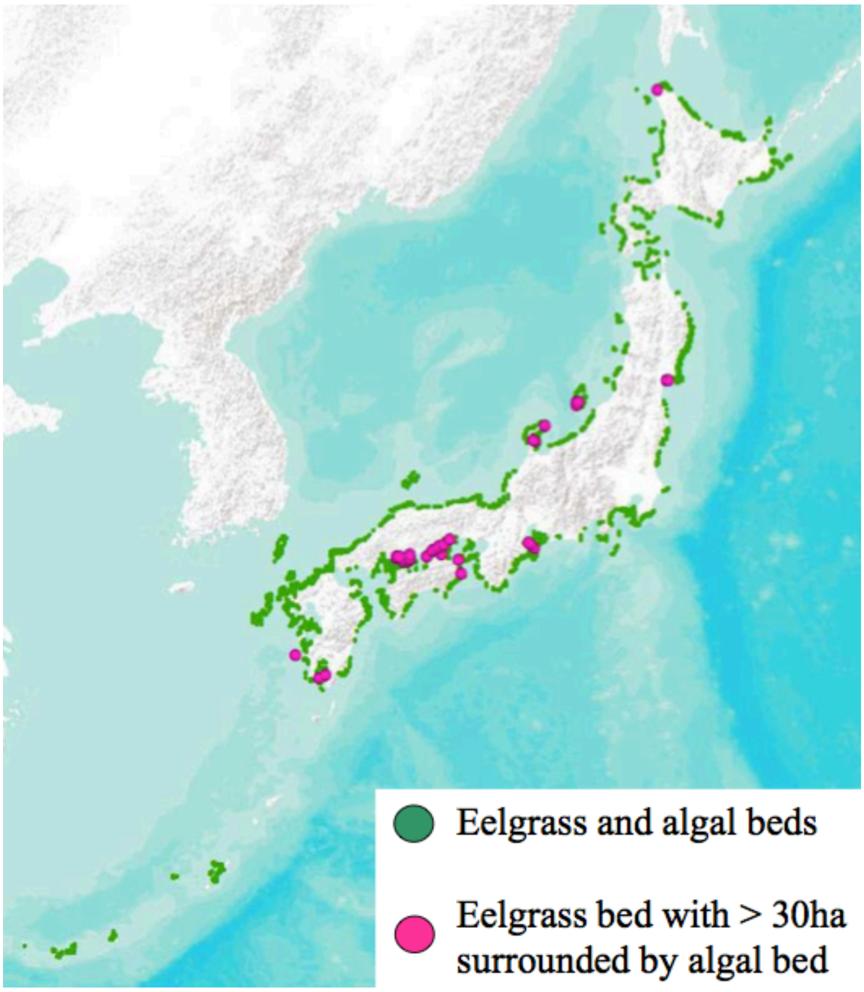


Fig. 23: GIS analyses on the distribution of eelgrass and algal beds in Japan (green dots), and eelgrass beds with high carbon fixation capacity (area with > 30 ha surrounded by algal bed). Redrawn from Fisheries Agency of Japan (2014).

3.3.3 Effects of global climate changes on seagrass beds

Ongoing climate changes of the globe are inducing heavy stresses to coastal ecosystems. The direct effects to marine ecosystems caused by climate change are multiple; temperature rise, sea level rise, ocean acidification, increased wave disturbance due to intensified storm activities, and excess river runoff due to more frequent heavy rainfall (Harley et al. 2006). These multiple stresses affect seagrass ecosystems in a variety of ways (Short and Neckless 1999, Orth et al. 2006). First of all, rising temperature may induce shift in distribution of each seagrass species. In the case of temperate Zosteraceae species in Japan, they are predicted to shift northward, as the southern limit of distribution is considered to be determine by physical tolerance to high temperature in summer (Kuwahara et al. 2006). For the effects of disturbance, decline of seagrass vegetation by sediment erosion has been more frequency observed in subtropical seagrass meadows in Okinawa (Yoshida et al. 2007). Sea level rise and decreased salinity due to river discharge after heavy rain may affect species composition and biomass of seagrass beds through changes in environmental gradient in estuarine area. In Akkeshi-ko estuary, for example, dominant seagrass species in shallow parts changed drastically from *Z. japonica* to *Ruppia maritina* in 2010 (Nakaoka et al. 2013a). During spring to early summer of this year, the area received abnormal heavy rainfall, exceeding more that 3-fold more than average years. As *R. maritime* is more tolerant to oligohaline condition than *Z. japonica*, the decrease in salinity in the estuary is considered to be a major cause for the species transition. Such kinds of rapid change in species composition may occur more frequently with ongoing climate change. Finally, the effects of ocean acidification (carbonation) on eelgrass bed remain unclear although some mesocosm experiments using *Z. marina* showed better performance of seagrass by the enrichment of CO_2 concentration in water (Palacios and Zimmerman 2008).

In addition to individual effects of climate-related environmental changes as mentioned above, synergetic effects of multiple factors can operate in a nonlinear way, making it difficult to predict the responses of marine ecosystems (Harley & Rogers-Bennett 2004, Nakaoka 2008). For example, coral reefs in Japan may shift toward north when we consider only the effect of temperature rise, whereas it may shift southward when we consider only the effect of ocean acidification. The integration of the two factors in a model predicted that coral reefs may disappear from Japan by 2070 under IPCC A2 "Business-as-usual" scenario (Yara et al. 2012).

Similar types of synergetic effects of multiple factors can affect seagrass ecosystems. For example, rising temperature affects seagrass not only by heat stress, but also by increasing feeding intensity by major herbivores such as fish and sea urchin. In fact, mass decline of eelgrass and algal beds in southeastern Japan has been observed with the increase in foraging activity by Siganoid fish (Yoshida et al. 2012). Synergetic effects can also occur between climate-related factors and local human-induced factors such as eutrophication and coastal development. Sea level rise may results in the decline in area of intertidal zone of Japan, because 30% of the coastlines of Japan are artificially modified such as for land reclamation and for constructing breakwater (Environmental Agency 1998). The synergetic effects of sealevel rise and land construction are thus critical to marine organisms inhabiting intertidal areas including *Z. japonica*. Other types of synergetic effects can also occur, such as interactions of ocean acidification and eutrophication, and of temperature rise and the invasion of non-native species (Nakaoka 2008). However, quantitative evidence of such synergetic effects is not currently available for the temperate seagrass beds in Japan.

3.4 **Seagrass Ecosystems at Johore Waters, Malaysia: Climate Change Impacts and Fishermen Outlook**

3.4.1 Seagrass beds and fishermen

Seagrass beds are scattered throughout the Malaysian marine and coastal waters. It is common in all tropical seagarss beds worldwide. Ten (10) species of seagrasses are recorded from the Johor Straits and growing in subtidal calcareous sandy mud with 2.0-2.7 m in depths (Japar Sidik et al. 2001). It is the highest species number of seagrasses recorded so far from 112 ha seagrass beds compared to other locations in Malaysia. Recently, 18 species of seagrass were recorded from 529 sites of the tropical Philippines (Fortes, 2014).

Most of the fishermen in this area were well experienced small-scale fishermen using mainly 15-40 HP mechanized boats. Shrimp trammel net and fishermen living in the vicinity of seagrass habitats occasionally used crabs net. The average age of the fishermen was 53 with the average monthly income of 1228 RM (~400 US$). Fishing was the primary occupation through the year (Table 9) and repairing fishing net often when not fishing.

Table 9: Seasonal activities of fishermen community at Tanjung Adang Darat, Tanjung Adang Laut and Merambong seagrass beds, Johor, Malaysia.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Fishing in seagrass bed	■	■	■	■	■	■	■	■	■	■	■	■
Repairing net				■	■							
Others											■	■

3.4.2 Seagrass resources and fishermen outlook

The ecological benefits of seagrasses and their economical uses have made the seagrass beds as very important ecosystems in marine waters. Compared to the mangrove and salt marsh elsewhere, the seagrass ecosystems in Malaysia represent small portion of marine and coastal ecosystems, but yet it accounts for the high diversity of fishery resources (Arshad et al. 2006; Sasekumar et al. 1989). There are numerous direct and indirect ecosystem services and goods derive from the seagrass beds (Fig. 24). Similar to the mangrove and coral reef, seagrass beds serve as habitat for many species, including fish, mollusks and crustaceans. Majority of the fishermen believed that there was a good seagrass beds previously (Figure 25), but reduced up to 70-80% at present (for example *Enhalus* sp.) due to the environmental changes and land reclamation (Figure 26). Besides, the climate changes variables probably accelerating these decreasing processes. However, they also commented that the beds of seagrass will be lost within next 10 years from now if not conserve (Figure 27).

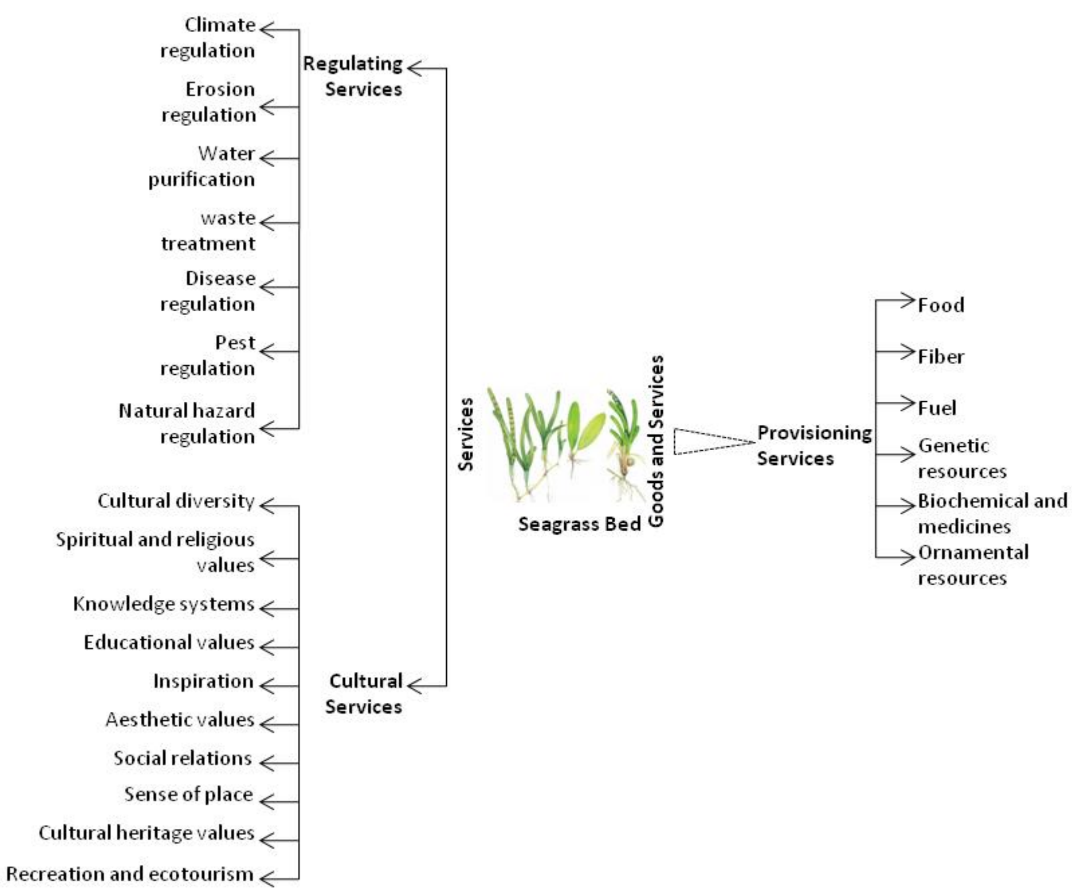


Fig. 24: Ecosystem services and goods of seagrass beds (Modified from Nakaoka et al. 2014 and Millennium Ecosystem Assessment, 2003).

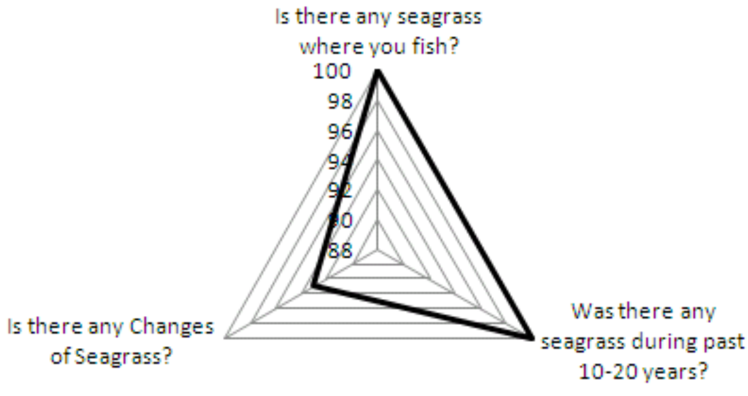


Fig. 25: Seagrass resource inventory in Tanjung Adang Darat, Tanjung Adang Laut and Merambong seagrass beds, Johor, Malaysia.

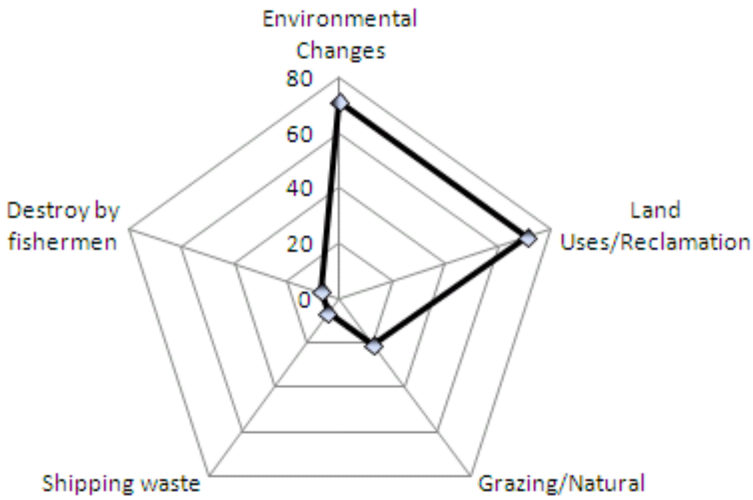


Fig. 26: Causes of seagrass loss in Tanjung Adang Darat, Tanjung Adang Laut and Merambong seagrass beds, Johor, Malaysia (multiple response).

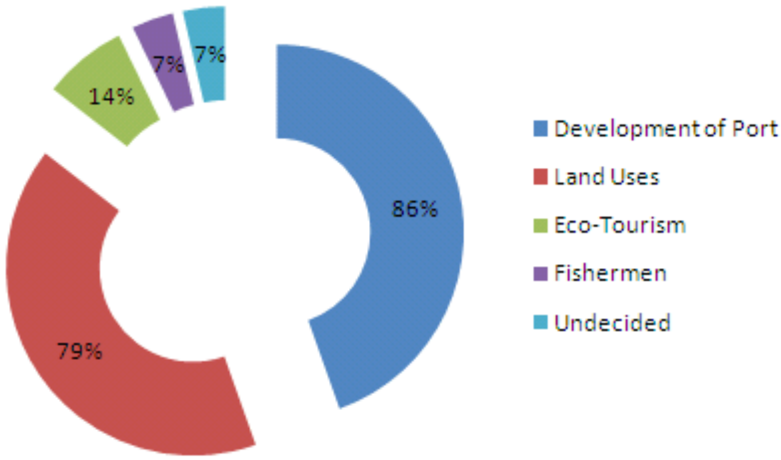


Figure 27: Consequence of seagrass beds after 10 years in Tanjung Adang Darat, Tanjung Adang Laut and Merambong seagrass beds, Johor, Malaysia (multiple responses).

3.4.3 Seagrass ecosystems, climate change and fishermen perceptions

Seagrass beds in the tropical coast are suspected to be expose by monsoonal changes like increasing in frequency of tropical cyclone and storm, changes of solar radiation, temperature and rainfall pattern. Seagrasses are sensitive to increases in sea surface temperature, sediment deposit, sea level rise and reductions of salinity that inhibit the growth of seagrasses (Waycott et al. 2011). It was also observed during the present study as majority of the fishermen noticed the abnormalities in monsoonal changes such as heavy rainfall, freshwater input, salinity reduction, strong current and tropical storms (Figs. 28 and 29). Based on fishermen observations, for example, the summer was shifted from November-January to April-June at present. These changes probably affect the seagrass beds as well as reducing seagrass dependent fishery diversity and abundance.

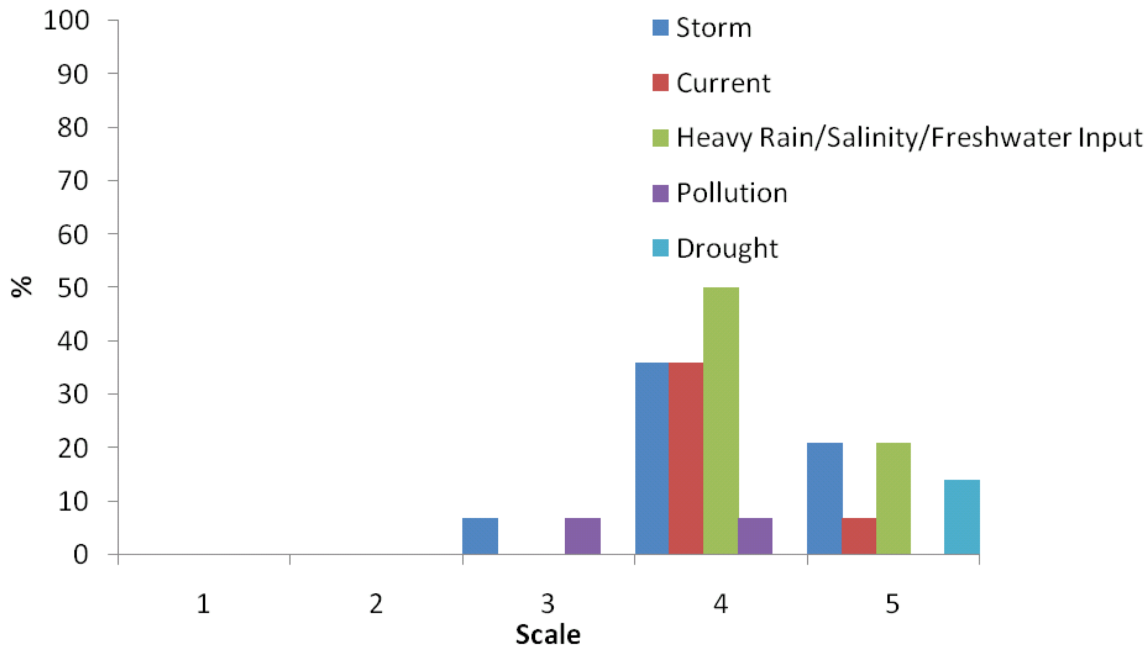


Figure 28: Fishermen perception (multiple responses) on climate change variables in the seagrass beds of Johore Straits, Malaysia (1= strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree).

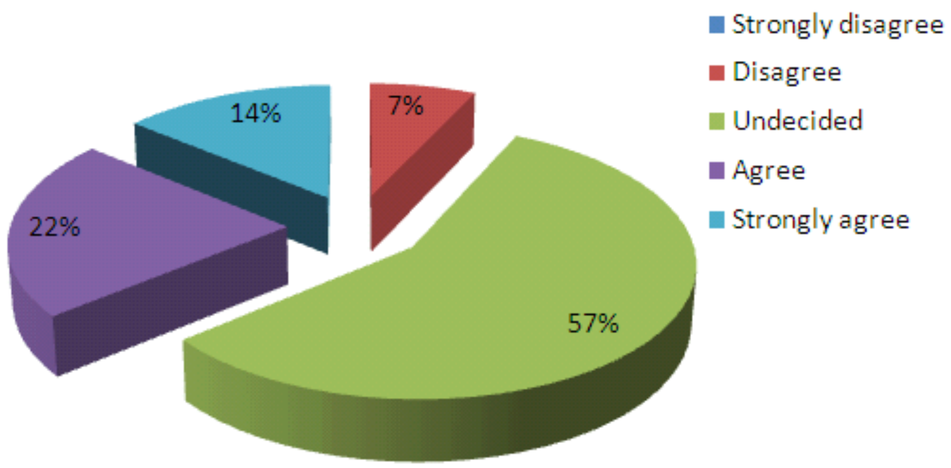


Figure 29: Perceptions on meteorological Hazards like tropical cyclone and storm in the seagrass beds of Johore Straits, Malaysia.

About 57% of the respondents believed that the season for catching fish were changed due to climate change. This change could have probable impacts in the reduction of fish number (Figs. 30 and 31), which lowering up to 28% of catches (Figure 32). The fishing activities were also decreased from 21 days/month to 14 days/month, lowering up to 67%.

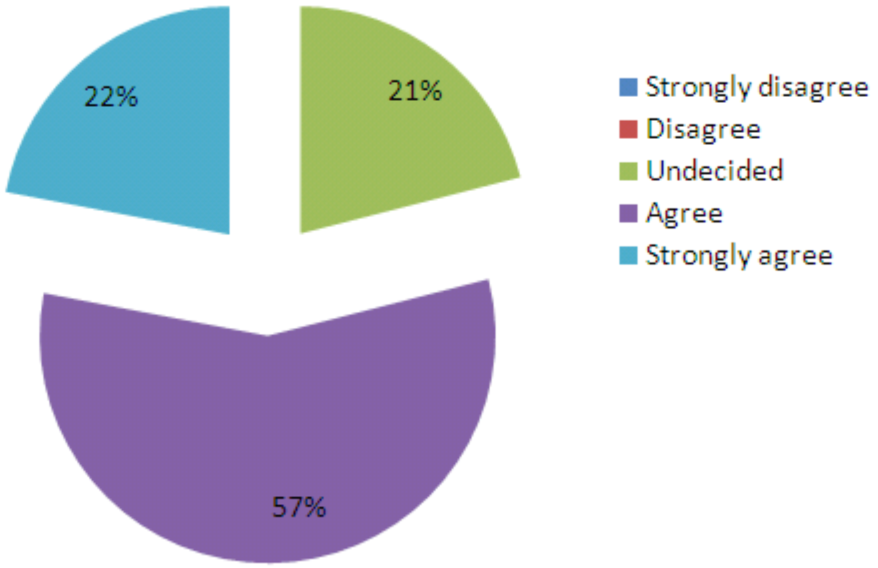


Fig. 30: Perceptions on changing of fish catching season in the seagrass beds of Johore Straits, Malaysia.

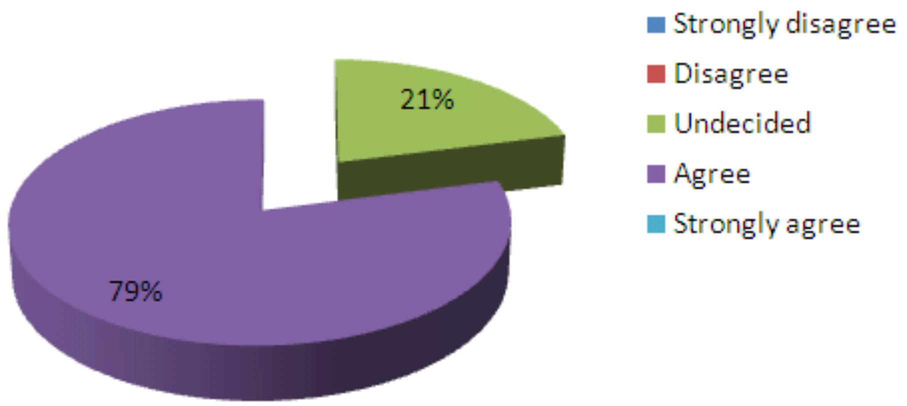


Fig. 31: Perceptions on changing of fish catch volume due to climate change variables in the seagrass beds of Johore Straits, Malaysia.

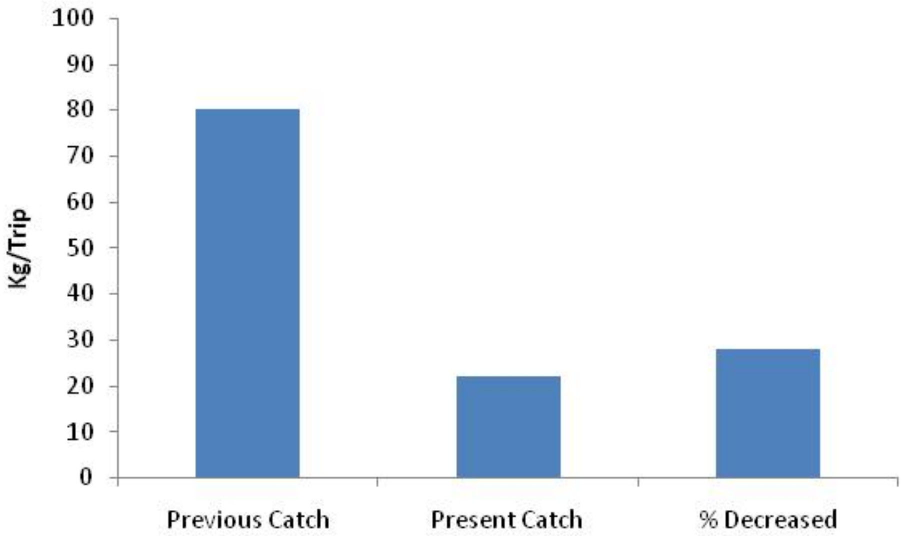


Fig. 32: Perceptions on the changes of fish catchment due to climate change events in the seagrass beds of Johore Straits, Malaysia.

Local fishermen indicated that the environmental degradation due to pollution, port development and land reclamation in this area were the another cause for the reduction of seagrass beds as well as its functions. Heavy rain and current in this area may increase the river runoff; hence increase the transfer of sediments, sand, mud, toxic materials from the catchment areas to the seagrass meadows. Several studies found that deposition of sediment is sensitive and sometime stressful for seagrasses, while it buried the plants and prevents their ability to grow. Sometime, heavy water current may move the sediments from seagrass beds, which may cause cleaning of plants (Waycott et al. 2011).

3.4.5 Vulnerability assessment

Vulnerability is the functions of geography, reliance on natural resources, social, financial and political aspects, which influence how climate change, affects different groups (Action Aid, 2005). The life and livelihoods of coastal fishermen communities worldwide are more vulnerable than the other communities stay anywhere, because of the depletion of resources on which they depend on. It is the case for the present study area seagrass beds at Johor, Malaysia. Besides the stressors of climate change and a-biotic factors such as sedimentation due to heavy rain and temperature, seagrass habitats and its ecosystem functions are in vulnerable to sea level rise because of their unique location (Short and Nickels, 1999). Similarly, habitat degradation and negative impacts on fishing activities were noticed due to the climate changes in the present study area (Figs. 33 and 34). The changes of subtidal zones due to the changes of eco-biological processes and increases of sea level could submerge the seagrass beds and resulting in the alteration of existing beds profile in this coastal area. This process may cause prolong water logging resulting the stressing and sometimes killings the seagrasses, and their dependent organism within the same ecosystems. These ecosystem processes later on may affects on the source of livelihoods of the entire coastal communities while making them in vulnerable condition. Studies by Bjork et al (2008) also listed that the different component of climate i.e., atmospheric CO_2, pH of the ocean, temperature, light and ultra violate radiations, storms, floods, sedimentation and sea level rise may affects the habitats and functions of seagrasses and their depended communities.

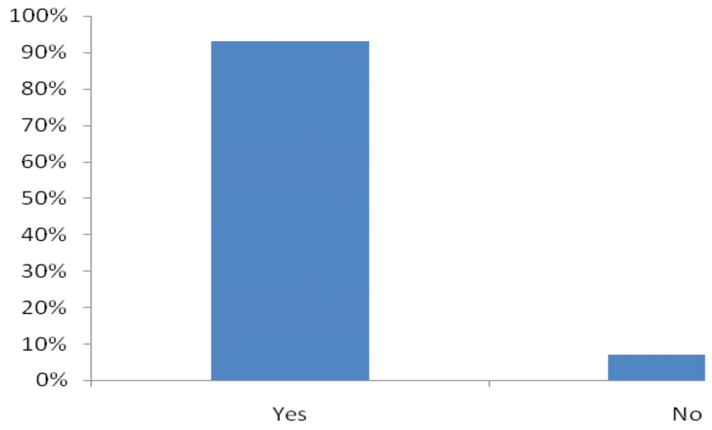


Figure 33: Fishermen perceptions on resources lost due to climate change at Johore Straits, Malaysia.

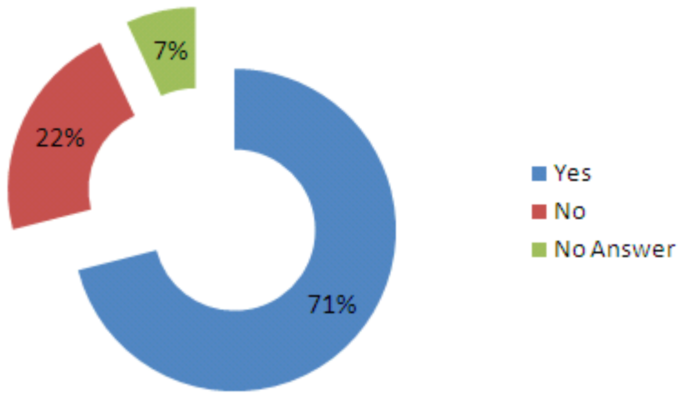


Figure 34: Fishermen perceptions on climate change events and negative impacts on fishing activity.

Observations also found that the impacts of climate change in this area may alter the functions, livelihoods and productivity of seagrass ecosystems that leaning them to changes their profession and migration to other places for job (Fig. 35). The changes of coastal ecosystems due to natural and manmade keep these coastal fishermen communities in risk.

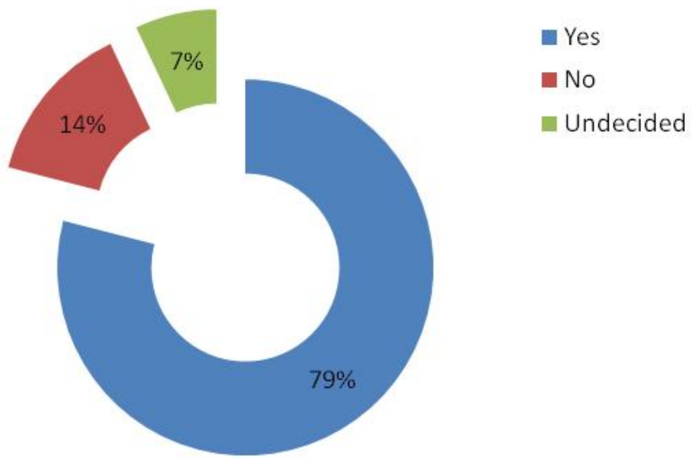


Figure 35: Migration trends of fishermen due to the climate-induced affects on the life and livelihoods at Johore Straits, Malaysia.

3.4.6 Adaptation measures

The world's environments including marine habitats are undergoing notable changes and the speed of changes shows to be accelerating time to time. Climate change is the greatest threat and challenge for sustainable coastal adaptation in South and South East Asia regions. It is clear that the climate change events increase the risks of livelihoods of fishermen as well as seagrass ecosystems and functions. Seagrass beds in Johor straits are expected to be vulnerable by both the catastrophic and manmade activities. Compared to the climate changes extremes and its affects, the land reclamation processes were believed to have more sensitive to this seagrass beds in this area. On top up of this, climate change events accelerating this degradation process. Therefore, the future management strategies and intensive research on climate change variables in this area can ensure this reduction process of the seagrass beds. Emphasis must be given to protect the existing seagrass ecosystems as expressed by fishermen communities in this area regardless of any causes of degradation. The results implicated that a good seagrass beds pledge the fishing community receives diversified benefits both the direct (tangible) and indirect (intangible) forms as well as in drawing seagrass dependent fishery species to improve productivity and livelihoods. Awareness activities within the fishermen on climate change impacts on the seagrass ecosystems may improve the knowledge on the issues, while strengthening the resilience toward climate change processes. Since seagrass beds are intricately linked to resilience of ecosystems, adaptation strategies linked to their conservation would safeguard livelihoods of communities depending on the same.

3.5 Seagrass Ecosystem Services and their Economic Valuation in Philippines and SE Asia: A Preliminary Assessment

3.5. 1 Seagrasses in Philippines

From 7 countries bordering the South China Sea, some ecosystem services provided by seagrass beds have been categorized into 5 types (Table 10). The value of total annual production of goods and services of seagrass habitats demonstrates unequivocally, although yet incomplete, the importance of seagrasses in the region, with a total annual value of production exceeding US$86 million. In comparison with coral and mangroves, this is exceedingly low, the primary reason is the almost complete lack of data and, where these exist, they are 'outrageously' unreliable. In the Philippines, the value of the total annual production of the goods and services of seagrass from the few study sites (with a total area of 23,245 ha) was worth only US$809,766 (UNEP (2007a). This is because only data from capture fisheries were considered reliable, so that seagrass goods had a total value of only US$34.84. On the other hand, seagrass services had no value, since none of the data submitted were considered and reliable. Interestingly, Fortes *et al*. (2007), in connection with the total valuation of damages due to the grounding of the coal Barge APOL in Bolinao in 2007, submitted to the insurance company a valuation of the lost benefits from a 35 ha seagrass beds (and a small portion of an unproductive reef) with 6 years recovery allowing for some spread of the rubble costing US$60,000. These data emphasizes the need for a more thorough accounting of the services from the habitats.

3.5. 2 Evaluation status

Economic valuation of the goods and, much less of services, from seagrass habitats in the Philippines has been done but only for a few sites and the reliability of much of the data on services is highly questionable. The ease or rapidity of seagrass services accounting depends highly upon the nature of the service and the state of the effort in the country. In Table 10, items under L1 for the most part have been, or are being, undertaken albeit in a few locations in the country and region, and these are more or less straightforward, in terms of 'tag' or market prices. These are where ecosystem accounting can be made more rapidly. However, at the rate local seagrass ecosystems are being degraded and lost, and how this loss impacts the coast, accounting of L2 services should also be undertaken together with some of the L3 services *as a matter of policy*. But prioritization should be based on site-specific criteria like, among others, urgency, probability of success, and overall positive benefits to the coastal community concerned. Ecosystem services all cater to aspects of human well-being. While the need for accounting of L3 services may not yet be the focus of this project, these aspects are virtually 'untouched' largely because of paucity of information and relative difficulty in their determination. For the most part, a more subjective approach may be used to complement the more qualitative approaches in the valuation process of the latter two sets of services. It should be noted that ecosystem services overlap significantly when they address aspects of human well-being. This overlapping function is one major factor for the inherent difficulty in the accounting of seagrass ecosystem services. In addition, the connectivity function of seagrass with other nearby ecosystems, one of the most important functions of the ecosystem in the tropics, is yet almost completely unstudied. It is the coastal ecosystems connectivity function that largely sustains the stability and integrity of coasts in the tropical world.

3.5. 3 Where do serious data gaps exist?

In the Philippines in particular and in SE Asia in general, the most serious data gaps exist in the following priority services (Table 10). The supporting services (nutrient cycling, sediment formation, primary productivity) need serious and immediate attention in order to come up with the data useful in the effective accounting of seagrass services. With a more reliable and robust data on these services, a fairly good idea of the values of a number of the provisioning services can be made, even predicted, and made useful as basis for policy decisions. Accounting of the services needs to be undertaken simultaneously and at the same sites, natural scientists gathering actual and real-time data and information, while economists, social scientists, and other market analysts, gathering parallel data and on the provisioning services of the ecosystem. This analysis assumes that if action were not taken, habitats would continue to be lost at current rates, and so are their economic values which will also be lost over time.

Table 10. The five categories of uses of seagrass beds in the Philippines and SE Asian countries (Fortes 2012, modified and updated from UNEP 2007a).

	Philippines	**SE Asia**
Direct (Extractive)		
Leaves	L1	L2
Fruits/propagules	L2	L2
Medicine	L1	L2
Fish, crab, prawn capture	L1	L1
Shellfish collection	L1	L1
Worms	L1	L1
Wildlife hunting	L2	L2
Jellyfish	L1	L2
Seaweed	L2	L2
Direct (non-extractive)		
Tourism/recreation	L3	L3
Transport	L2	L3
Education	L3	L3
Research	L3	L2
Fish, crab, prawn culture	L2	L1
Other culture (pearl, oyster)	L3	L2
Environmental Services		
Shoreline protection	L2	L3
Erosion prevention	L2	L3
Flood protection	L3	L3

Wind break	L2	L2
Carbon sequestration	L3	L3
Prevents seawater intrusion	L3	L3
Primary production	L2	L2
Sediment, contaminant, Nutrient removal/storage	L3	L3
Oxygen release	L2	L2
Nursery feeding areas	L2	L2
Biodiversity Services		
Existence values of species, Genes, communities	L3	L3
Migratory species	L2	L2
Endangered species	L1	L1
Ecosystem existence values	L2	L2
Social/Cultural significance		
Religious/spiritual	L3	L2
Historical importance	L3	L2
Presence of distinctive human Activities	L3	L2
Aesthetic	L3	L2

L, Level of difficulty in accessing information: L1, relatively well documented, less difficult since already being done using methodologies which are available; L2, in general, less documented, initiated, but only in very few areas in the region; accounting methods less clear-cut; L3, least documented, accounting and study methods not yet well established and reliable.

3.6 Impacts of Climate Change on Seagrass Ecosystem and Nearby Fishing Community in Thailand

3.6.1 Status of seagrass in Thailand

In the earlier period, only five species of seagrass were reported in Thai waters (Den Hartog, 1970). An intensive seagrass survey was originally conducted in 1988, particularly in the Andaman coast (Poovachiranon, 1988). Later on, many studies reported relatively completed basic information on distribution and composition of seagrass communities on both Andaman and the Gulf of Thailand coastlines (Aryuthaka and Poovachiranon, 1994; Manananansab and Ingsawang, 1997; Supanwanid et al., 1997; Satumanatpan et al., 2000). However, an intensive study in the Gulf of Thailand has been done in 2003.

To date, twelve species of seagrass representing 7 genera of 2 families have been reported in both coastlines of the Andaman Sea and the Gulf of Thailand. They are *Halophila ovalis, Halophila minor*, *Halophila decipiens, Halophila beccarii, Cymodocea rotundata, Cymodicea serrulata, Halodule uninervis, Halodule pinifolia, Enhalus acoroides, Thalassia hemprichii, Syringodium isoetifolium* and *Ruppia maritima* (Changsang and Poovachiranon, 1994; Lewmanomont *et al*., 1996; Satumanatpan et al., 2000). All species are found in both seas, except *R. maritima* is not reported in the Andaman coast. The total coverage area is 14,937ha; 9,448ha in the Andaman and 5,489 ha in the Gulf of Thailand (Poovachiranon et al., 2006). Seagrass beds in the Andaman Sea coast are more abundant than those of the Gulf. In the Gulf of Thailand, seasonal change in species and distribution of seagrass was reported particularly in Rayong and Nakhon Si Thammarat Provinces. The largest area of seagrass including the highest diversity of 11 seagrass species is located at Talibong Island or Koh Libong island, Trang Province (Poovachiranon et al., 2006). Seagrass beds around Talibong Island and Muk Island are the most important feeding ground, nursery ground and reproduction area of dugongs (Adulyanukoso and Poovachiranon, 2006).

Moreover, the status of seagrass in the Andaman coast is reported as 40% in good, 30% in fair, and 10% poor conditions (Poovachiranon et al., 2006). The degradations of seagrass beds are mainly caused by human impacts such as sedimentation from coastal construction, fishery and illegal fishing. Seasonal changes caused by monsoons occurred in some areas. Antrophogenic causes such as push-net fishing and siltation from coastal development are believed to be responsible for degraded seagrass beds (Adulyanukosol and Poovachiranon, 2006). A summary of the status of seagrass and its coverage in Thailand is shown in Table 11.

Table 11. The status and coverage of seagrass in Thailand. (Poovachiranon, 2006, na = not available)

Province	Coverage (ha)	Status	Causes of degradation
Gulf of Thailand			
Trat	644	Fair	Monsoon
Chanthaburi	2,704	Good	Fishery, shrimp farm, increasing of coastal community
Rayong	6,048	Fair	Fishery, waste from houses, sediment, cruising of tourist boat, seasonal change
Chonburi	96	Degraded	Construction of a retaining wall, pier and house in Sattahip Bay
Petchaburi	28.8	In reservoir	NA
Prachuap Khiri Khan	3.2	Natural	NA
Chumphon	172.8	Degraded	Sediment and water waste from aquaculture, crude oil survey
Surat Thani	1,708.8	Fair	Sediment from shrimp farm, aquaculture and coastal development
Nakhon Si Thammarat	7.2	Natural	Seasonal change
Phatthalung	73.6	Natural	NA
Songkhla	54.88	Natural	NA
Pattani	83.2	Degraded	Coastal development, industry along the river, waste from industry, fisheries (push net and trawl)
Narathiwat	12.2	Natural	NA
Total	5,489		
Andaman sea			
Ranong	150.4	Degraded & natural	High sediment from river mouth
Phangnha	2,536	Good	Seasonal change, fisheries (trawl, push net), tsunami
Phuket	612.8	Fair & degraded	Sediment from land, fisheries (trawl, push net), water waste from shrimp farm, tsunami
Krabi	2,507.2	Fair	Seasonal change, sediment from land, push net
Trang	3,366.4	Fair	Push nets, beach encircle net, sediment from land, tsunami
Satun	275.2	Fair	NA
Total	9,448		
Grand Total	14,937		

3.6.2 Extreme weather condition and seagrass

There are few studies reporting climate phenomena and extreme weather condition in Thailand. The most important piece of work has been done by Chinvanno et al. (2009) in projecting a climate change for Thailand and surrounding countries based on a simulation by PRECIS (Providing Regional Climates for Impacts Studies) regional climate model and used Global Circulation Model (GCM) ECHAM4 dataset. Result from the simulation provides future climate projection for Thailand and surrounding countries up to the end of the century. The final result of future climate projection shows a small trend of increasing temperature throughout Thailand, especially in the central plain of Chao Phraya river basin and lower part of north-eastern region. However, hot period over the year will be longer in the future up to 2-3 months by the end of century. Total annual precipitation may fluctuate in the early part of the century but the projection shows clear trend of increasing precipitation from middle of the century onward, especially in the area near Mekong River as well as the southern region, except the western border where future precipitation may remain almost unchanged. Change in wind speed and wind direction can be detected in the coastal zone, where south-west wind speed may increase by 3-5% in the future. Another good piece of work in coastal area is reported by Sangmanee et al. (2011). This study evaluated an impact of climate change on future water resources of Klong Krabi Yai catchment using SWAT model. Future climate data, precipitation and temperature data from 5 Global Circulation Models, over the period of 2045-2064 showed that annual rainfall will increase in range of 3% to 20% and mean annual maximum temperature will increase in range of 1.6-3.8 Degree Celsius while increasing of minimum temperature will be higher than maximum temperature.

A struck of tsunami on the Andaman Sea coast of Thailand on 26 December 2005 is considered the worst extreme natural disaster ever facing by Thailand coast. A few study had been evaluate impacts of tsunami on marine ecosystem including seagrass beds. Study on rapid assessments on marine ecosystems was conducted in the beginning of January 2006 by Department of Marine and Coastal Resources (2005). It was found that seagrass beds received little damage from the tsunami. About 72% (57.6 km^2) of the total seagrass area along the Andaman Sea coast was inspected post tsunami, of this only 5% had been affected. A dugong and a hump-backed dolphin have been saved and released back to the wild.

Another study by Masahiro et al. (2006) evaluated abundance and biomass of seagrass and its associated animal community along the Andaman Sea coast of Thailand, an area that was hit by a tsunami on Dec. 26, 2004. A comparative analysis of seagrass species diversity and abundance based on pre-/post-disturbance data at several seagrass beds at Kuraburi, northern Phang-nga (most-affected region) and Trang (less-affected region) were assessed. It was found that species diversity, coverage and biomass of seagrass declined greatly after the tsunami at one seagrass bed (Thung Nang Dam) in Kuraburi. The effect of the tsunami was less obvious at two other beds a few kilometers away from Thung Nang Dam, and at the seagrass beds in Haad Chao Mai National Park in Trang, where temporal change before and after the tsunami was the least obvious. A steady decline in biomass was observed in the three seagrass beds that had not been severely affected by the tsunami, possibly associated with other types of disturbance such as river discharge. Analyses revealed that the effect of the tsunami on seagrass ecosystems was highly variable even on small spatial scales, and that other factors causing disturbance to the seagrass beds are important factors of the observed temporal variation.

3.6.3 Fish and seagrass

Seagrass habitats support diverse fish assemblages and serve as nurseries for juvenile fishes, including some commercially important species (Connolly, 1994). They also offer protection from larger predators to juvenile and small fish and larval shrimps, recycle nutrients, stabilize sediments and produce and export detritus (Saenger et al., 2013). In Thailand, Satumanatpan (2011) reported high abundance of benthic fauna in the seagrass ecosystem in Kung Krabaen Bay even though the bay's coast had many intensive shrimp farms. *Halodule pinifolia* and *Enhalus acoroides* were two species of seagrasses distributed widely in the bay. Additionally, 27 families of polychaetes, 10 species of gastropods and 18 species of bivalves were predominantly distributed in the seagrass beds. The abundance of gastropods, bivalves and polychaetes were significantly correlated with the biomass of *H. pinifolia* (65%, 39% and 27%, respectively); whereas only bivalves correlated significantly with the biomass of *E. acoroides* (36%).

3.6.4 Type of boat and fishing gear

There are 5.8±2.0 persons in the fishing household with the biggest family member in Pattani bay (6.1±2.0) and lowest in Koh libong island (4.8±1.7). Most of fishermen used long-tailed boat for their fishing (68%) followed by small-centered engine boat (18%). However, there was some fisherman not using boat for their fishing activities. About 38% of them used shrimp net for fishing, followed by crab net, fish net and shell collector in seagrass beds (Figs. 36 and 37). With this boat and gear, they generally catch about 11.3±14.4 kg of fishes, estimated to be 979±745 Baht/trip. The average cost per fishing trip was 323.7±261.9 Baht.

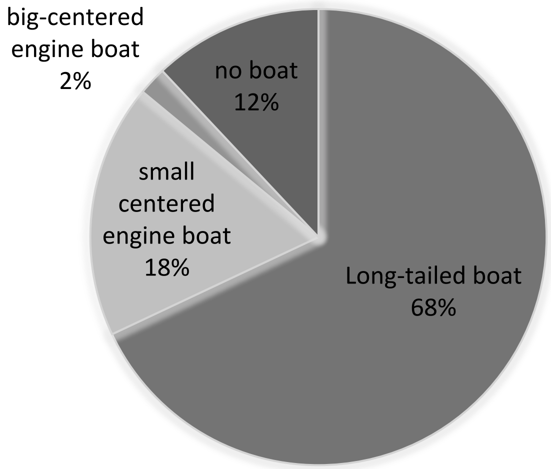


Fig. 36: Type of boat used by fishermen in the study area

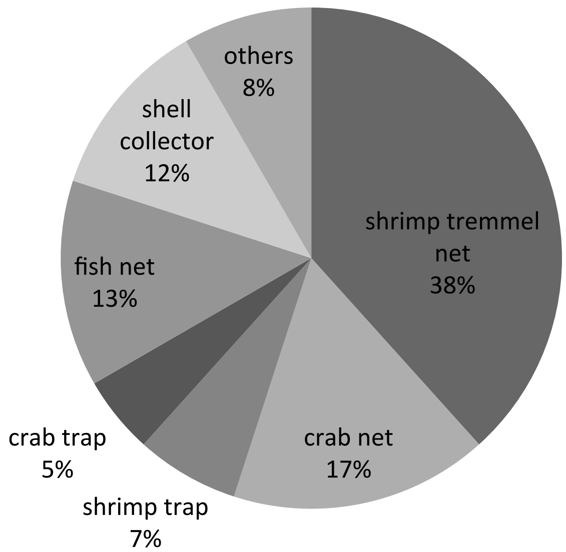


Fig. 37: Type of fishing gear used by fishermen in the study area

3.6.5 Income and expenditure

Economically, fishermen earned 13,612 Baht/month (Figure 38). Of these, 9,888 Baht/month was from fishing activity, 3,616 Baht/month from secondary occupation and 184 Baht/month from tertiary occupation. They spent 12,032 Baht/month with the balance left about 1,580 Baht/month. Fishermen in Koh Tha rai island had the largest total income (25,350 Baht/month) and the lowest in Pattani bay (9,293 Baht/month).

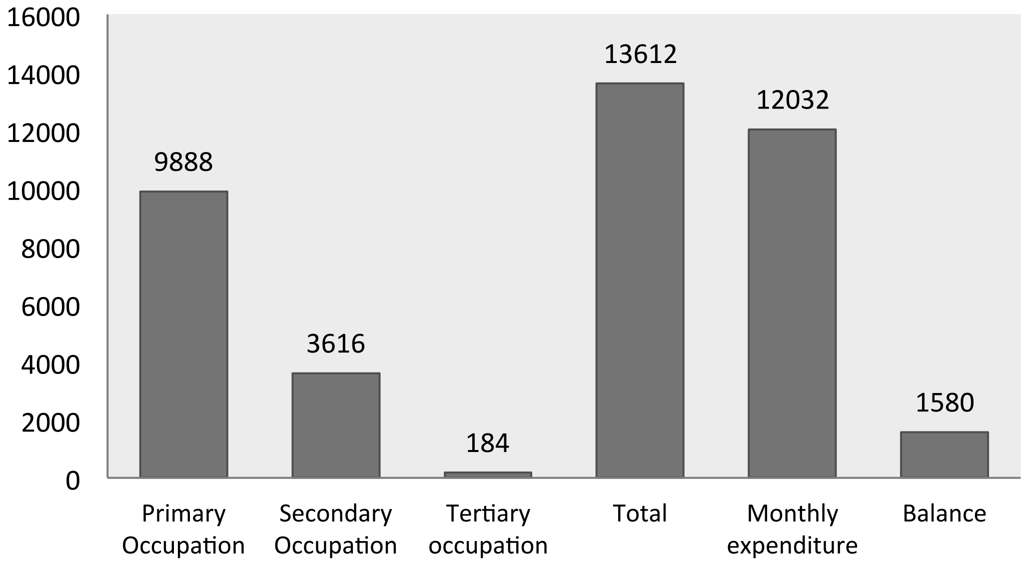


Fig. 38: Sources of income, monthly expenditure and balance (Baht/month) for fishing households in the study area.

3.6.6 Change of seagrass in the past 20 years

Overall, 62% of fishermen observed decreasing of the quantity of seagrass in the study area with environment and pollution were the most important factor (68%). However, 100% of respondent indicated that there was a decrease of seagrass quantity in the area (Table 12).

Table 12: Change of the quantity of seagrass and causes of change in the past 20 years.

Changes	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Increasing	0.0	30.0	60.0	18.0
Decreasing	100.0	10.0	0.0	62.0
Causes of changes				
Environment and pollution	83.3	30.0	60.0	68.0
Grazing	3.3	0	0	2.0
Reclamation	10.0	0	0	6.0
Local interruption	10.0	0	0	6.0
Shallow water and sediment	23.3	0	0	14.0
Freshwater	16.7	0	0	0.0
Trawler and push net	16.7	0	0	0.0
Not relevant	-	70	60	

3.6.7 Occurrence of climate extreme

Fishermen in all the three areas highly indicated an occurrence of climate extreme in their areas (Table 13). They also believed that the number of tropical storm increased due to climate change in their area. About 66% believed that there is a relationship between water temperature and tropical storm.

Table 13: Occurrence of climate extreme.

Occurrence of climate extreme	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	96.7	60.0	90.0	88.0
No	0.0	30.0	10.0	8.0
Undecided	3.3	10.0	0.0	4.0
Number of tropical storm				
Yes	93.3	50.0	70.0	80.0
No	6.7	10.0	20.0	10.0
Undecided	0.0	40.0	10.0	10.0
Relationship between temperature and storm				
Yes	80.0	50.0	40.0	66.0
No	6.7	40.0	30.0	18.0
Undecided	13.3	10.0	30.0	16.0

3.6.8 Climate change and fishing

About 78% of fishermen changed their seasons of caching fishes nowadays due to climate change and most of them (82%) thought that total catches of fish is lowered due to climate change compared to the past (Table 14). In general, a decreasing of catch up to 14.6% was reported due to climate change as compared to the last 20 years.

Table 14: Climate change and fishing activities in seagrass bed of Thailand.

Changes in the season of catching fish due to climate change	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	86.7	50.0	80.0	78.0
No	10.0	10.0	20.0	12.0
Undecided	3.3	40.0	0.0	10.0
Total catchment of fish is lowered due to climate change				
Yes	93.3	50.0	80.0	82.0
No	6.7	30.0	20.0	14.0
Undecided	0.0	20.0	0.0	4.0

3.6.9 Weather news and forecast

Almost all of the fishermen (82%) thought that it is necessary to listen to weather news before going fishing and 92% of them practiced listening to weather news any time before going out fishing except a low rate of listening in Koh libong island (Table 15). For those who followed the weather news, 98% of them followed warning from that forecast. This is because 84% of them believed that precaution from the forecast is reliable.

Table 15: Weather news and forecast.

Listen to weather news before going catching fish	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	90.0	90.0	100.0	92.0
No	10.0	0.0	0.0	6.0
Undecided	0.0	10.0	0.0	2.0
Necessary to listen to weather news before going to fishing				
yes	86.7	80.0	60.0	82.0
no	13.3	10.0	40.0	18.0
Follow warning from weather forecast				
Yes	96.7	100.0	100.0	98.0
No	3.3	0.0	0.0	2.0
Undecided	0.0	0.0	0.0	0.0
Weather forecasting and/or depression precaution is exact				
Yes	80.0	80.0	100.0	84.0
No	0.0	0.0	0.0	0.0
Undecided	20.0	10.0	0.0	14.0

3.6.9 Impact of storm on fishing

Most of the fishermen (80%) indicated that the number of day for going fishing is lowered especially in Pattani bay due to extreme and unexpected weather condition. However, it was found that fishing days of fishermen in the past 10-15 years was 289.7 days compared to 231.1 days in the present day. They also felt that tropical storm is more severe than in the past 10-15 years (Table 16).

Fifty-eight percents of fishermen experienced that increasing rate of depression in their area affected the operation cost for fishing. Most of them (88%) felt that climate extreme had an impact on their livelihood. However, there are only some of fishermen, about 20%, having chance to involve in other jobs apart from fishing.

Table 16: Impacts of storm on fishing.

Number of days going to fishing lowered due to storm	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	96.7	50.0	60.0	80.0
No	0.0	50.0	40.0	18.0
Undecided	3.3	0.0	0.0	2.0
Storms are more severe than the previous time				
Yes	83.3	50.0	50.0	70.0
No	6.7	20.0	10.0	10.0
Undecided	10.0	30.0	40.0	20.0
Operation cost of fishing increased due to extreme weather condition				
Yes	76.7	20.0	40.0	58.0
No	3.3	10.0	30.0	10.0
Undecided	20.0	70.0	30.0	32.0
Impacts of climatic extremes in livelihoods				
Yes	100.0	50.0	90.0	88.0
No	0.0	30.0	0.0	6.0
Undecided	0.0	20.0	10.0	6.0
Opportunity to involve in other work				
Yes	23.3	10.0	20.0	20.0
No	73.3	80.0	80.0	76.0
Undecided	3.3	10.0	0.0	4.0

3.6.10 Assistant aids during crisis

They normally did not get loan or finance assistance from any agency during the crisis from climate extreme such as tropical storm. There was a different response on relationship between household debt and extreme weather condition (Table 17). Only those in Pattani Bay showed that their debt was increased due to climate change, but not in Koh Libong island and Koh Tha rai island. However, 74% felt that climate change had a negative impact on fishing activities. It is clearly reflected that most of the fishermen in Pattani bay responded that there was a trend in their village where villagers migrate to other places for the sake of alternative sources of income.

Table 17: Assistance during crisis.

Get loan/financial assistance in crisis period	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	23.3	40.0	60.0	34.0
No	76.7	60.0	40.0	66.0
Undecided	0.0	0.0	0.0	0.0
Indebt of household is increased				
Yes	83.3	0.0	30.0	56.0
No	3.3	90.0	70.0	34.0
Undecided	13.3	10.0	0.0	10.0
Climate change has negative impact on fishing activity				
Yes	93.3	30.0	60.0	74.0
No	3.3	30.0	30.0	14.0
Undecided	3.3	40.0	10.0	12.0
Trend of migration for alternative source income				
Yes	83.3	0.0	10.0	52.0
No	10.0	100.0	90.0	44.0
Undecided	6.7	0.0	0.0	4.0

3.6.11 Seagrass and fishing activities

About 80% of fishermen thought that seagrass is important in their everyday life of fishing, especially in Koh Libong island (Table 18). They also believed that the main challenge for fishing in seagrass beds is climate change, especially for those in Pattani bay.

Table 18: Seagrass and fishing activities.

Seagrass is important in everyday life of fishing	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Yes	83.3	50.0	100.0	80.0
No	10.0	30.0	0.0	12.0
Undecided	6.7	20.0	0.0	8.0
The biggest problem facing in fishing in seagrass bed				
Climate change	83.3	30.0	30.0	62.0
Others	13.3	10.0	50.0	20.0

3.6.12 Status of seagrass resources

There was a different view of fishermen on the status of seagrass resources in their areas in the last 10-15 years (Table 19). For those in Koh Tha Rai island and Koh Libong island responded that seagrass has increased, which is in opposite of those in Pattani bay. However, many of them (58%) felt that seagrass will be decreased due to climate change in the next 5-10 years. Only some of them, 26%, attended skill training related to climate change and fisheries or seagrass.

Table 19: Status of seagrass resources in Thailand.

Status of resources in the last 10-15 years	Pattani Bay	Koh Tha Rai island	Koh Libong island	All
Increasing	33.3	100.0	70.0	54.0
Decreasing	66.7	0.0	0.0	40.0
Not sure/equal	0.0	0.0	30.0	6.0
The impact due to climate change in next 5-10 years in seagrass				
Increasing	0.0	0.0	0.0	0.0
Decreasing	83.3	0.0	40.0	58.0
Not sure/equal	16.7	100.0	60.0	42.0
Attend skils training related to climate change and fisheries or seagrass				
Yes	13.3	10.0	80.0	26.0
No	86.7	90.0	20.0	74.0
Undecided	0.0	0.0	0.0	0.0

3.7 Seagrass in Vietnam: Status and Conservation Issue

3.7.1 Distribution of seagrass

Seagrass species composition in North Vietnam (from Quang Ninh to Hue) consists of 9 species of 3 families Hydrocharitaceae, Zosteraceae and Cymodoceaceae, whereas the Southern part (from Da Nang to Ca Mau) is home to more species (14 species) (Tien et al., 2002).

3.7.2 Coastal and island areas

In the coastal areas large-size species are found: *E. acoroides, T. hemprichi, C. serulata, C. rotundata*, whose populations together with those of other species form vast seagrass carpets. In the coastal areas with no mountain shields, with big waves, stable salinity and sand and coral seabed frequently found species are *E. acoroides, T. hemprichii, C. rotundata, C. serulata, H. ovalis and H. uninervis* (Tien et al., 2002).

The sea around the islands is the home of *Zostera japonica, Halophila ovalis, H. decipiens, H.beccarii, H. minor, Halodule pinifolia, H. univervis, Thalassia hemprichii, Syringodium isoetifolium, Cymodoceace serrulata, C. rotundata. Thalassodendron ciliatum* (Tien et al., 2002;Table 20).

Table 20: Distribution of seagrass in the sea around some sea islands in Vietnam.

No	Species	Tran island	Cat Ba island	Hon Nom island	Phu Quy island	Con Dao island	Trsa
1	*Zostera japonica*	+	+				
2	*Halophila ovalis*	+	+	+	+		+
3	*H. decipiens*		+				
4	*H. beccarii*		+				
5	*H. minor*				+		
6	*Halodule pinifolia*			+		+	
7	*H. uninervis*				+		+
8	*Thalassia hemprichii*				+	+	+
9	*Syringodium isoetifolium*				+	+	
10	*Cymodoceace serrulata*					+	+
11	*C. rotundata*				+		+
12	*Thalassodendron ciliatum*						+

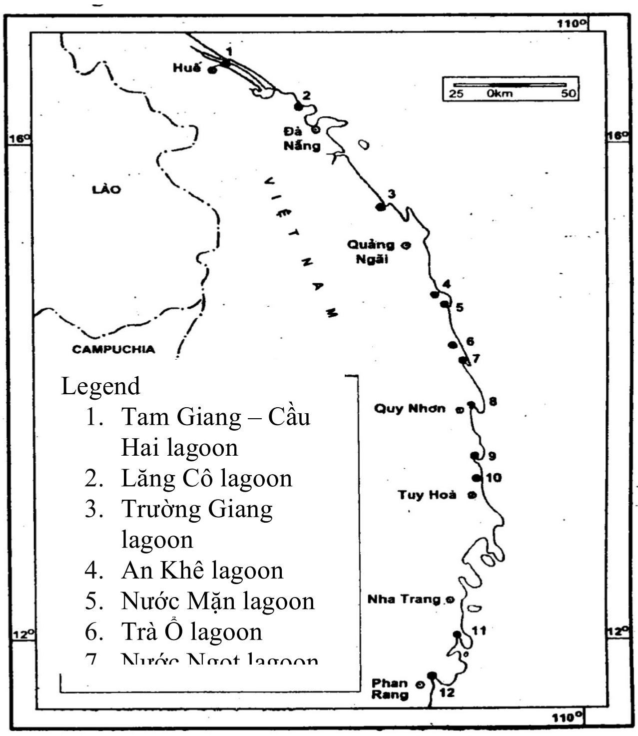
3.7.3 Lagoon areas

The lagoon is coastal water not completely closed, separated from the sea by sand bars and connected to the sea through outlets and receiving fresh water from the inland. The lagoon, thus, is a brackish water environment. In Vietnam there are several lagoons concentrated in the central coastal area from Hue to Khanh Hoa [Fig. 39].

Most lagoons in the form of sealed bottom is mud, mud and sand, so the depth is not great here the majority of seagrass are present develop into large populations. The lagoon here is classified into two groups:

Most of the lagoons are nearly closed with mud or mud-sand bottom. They are all not very deep, therefore nearly all the representatives of seagrass can develop into great populations. These lagoons are of two types:

Fig. 39: Vietnam's coastal lagoons.



Lagoons with low salinity of less than 30 ‰, typical of this type are such lagoon as Tam Giang - Cau Hai, O Loan, Thi Nai. Sea grasses frequently found in them are: *Halodule pinifolia, Zostera marina, Halophila ovalis, Halophila beccarii, Halodule uninervis, Rupia maritima* [Table 21].

Lagoons with high salinity including those with wide mouths, low inflow of fresh water resulting in high salinity of 30 ‰ on the average. Typical of this group are lagoons Lang Co, Cu Mong, and Xuan Dai. The species composition of seagrasses includes *H. ovalis, Enhalus acoroides, Thalassia hemprichii. Cymodocea rotundata*.

Table 21: Distribution of sea grasses in some major lagoons of Vietnam.

Species	Lagoons				
	Tam Giang	**Lăng Cô**	**Ô Loan**	**Cù Mông**	**Xuân Đài**
Halodule pinifolia,	+	+	+	+	
Zostera marina	+	+			
Halophila ovalis,	+		+	+	+
Halopila beccarii	+			+	
Halodule uninervis	+		+	+	+
Rupia maritima	+		+		
Enhalus acoroides		+		+	+
T. hemprichii		+		+	+
C. rotundata				+	+
C. serulata				+	+

3.7.4 Productivity, density, biomass and growth of seagrass

The development of seagrass is apparently seasonal with the best growth recorded from November to June the next year. In the sea around the islands seagrass grows well all year round, especially during the rainy season, when the salinity drops from 30‰ to 25-27‰. In the central coastal region of seagrass develops well from March to September each year (Tien et al., 2002).

In an investigation at My Giang, Khánh Hòa province (12^o 29’ 00’’N and 109^o 17’30’’-109^o 18’ 00’’ E Nguyễn Hữu Đại (Nai, 2011) recorded that My Giang water had high transparency and stable salinity, fluctuating around 32-34‰, resulting in high biomass and high growth rate during months 9,11, 3 and 4. Đông Ba Thìn Lagoon (12^o 01’00’’-12^{o}01’30’’N and 109^{o}12’00’’-109^{o}12’30’’E, is an unusual site where seagrass disappears during rainy seasons due to too low salinity and can restore only when dry season comes bringing a higher salinity.

In the central and southern provinces *Enhalus acoroides* has a leaf growth rate of 1.8 cm/day; *Cymodocea* sp., *Thalassia hemprichii.* - 0.6 cm. As a result, it takes an estimated period of 20-30 days to form a complete leave. Reproduction is primarily asexual, sexual reproduction is not common. Of the species inhabiting the lagoons only *Ruppia maritima* and *Enhalus acoroides* bear flowers. According to Dai [3], the survey at My Giang showed that there was only 8-30% of the seagrass bearing flowers. Tien et al. (2002) also noted *Enhalus acoroides* bore the most flowers and fruit in July (30%). *Zostera Japonica* bore flowers during March and April. The average number of flower buds/m^2 was 209 ±52. Biomass and shoot density changes over months, high in the dry season and low in the rainy season. *Zostera marina* (with a 30-90% coverage) had a biomass of 1400 g-4000 g (fresh leaves)/m^2.

The seagrass size in Gia Luan was 0.06 cm, lower than that of Tam Giang lagoon - greater than 19.36 cm. The grass area from Da Nang to Quang Ninh has an average of 69.2% coverage. Standing body weight ranged from 16 to 600 g/m^2. Stolon and rhizome weight ranged from 48 to 2000g/m^2, with an average of 970.3 g/m^2 (Tien et al., 2002).

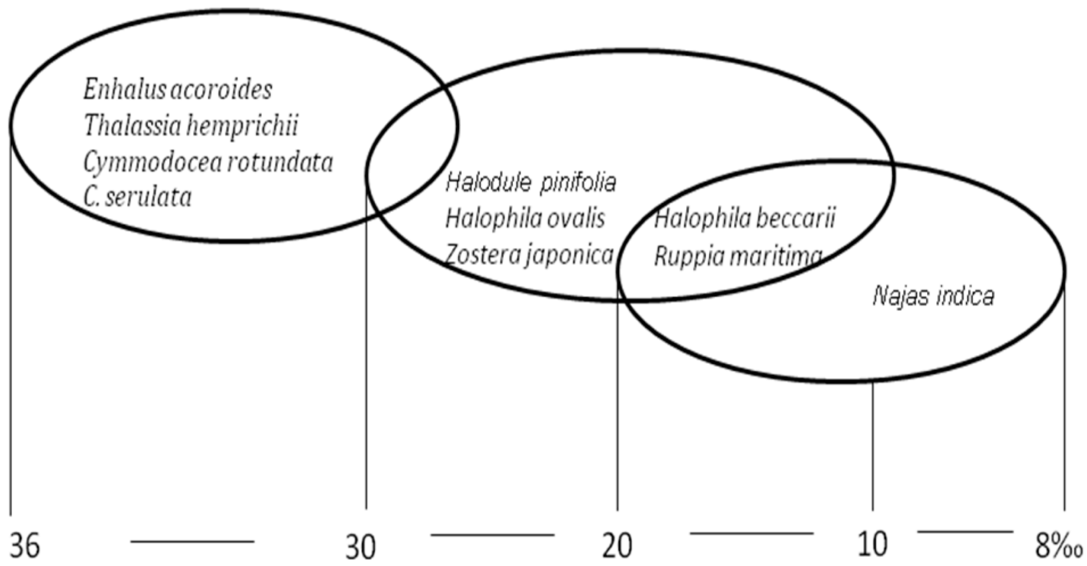
3.7.5 Relations between seagrass distribution and bottom sediment, salinity and depth

Seagrass lives on different types of sediment: mud, muddy sand, sand, gravel, sand and dead coral. In a transect of seagrass distribution with depth, Tien et al (2002) noted that 6 species of seagrass concentrated in areas with depths from 0 - 3m: *H. ovalis, H. uninervis, E. acoroides, T. hemprichii, Cymodocea serrulata, C. rotundata.* At depths 3 – 5 m, 3 species were recorded: *Cymodocea serrulata, H. ovalis, H. uninervis.* At depths 8 - 15m only *H. ovalis* was found. In some areas around the islands *Halophila decipiens and C. serrulata* are recorded at a depth of 10 – 20 m.

As for salinity, sea grass can be divided into 2 groups depending on the adaptability to salinity: i) Species found in areas with high salinity of 25 %o or more: *Halophila decipiens, H.ovalis, Halodule pinifolia, H. uninervis, E.acoroides, Th. hemprichii, Cymmodocea serutalata, C. rotundata and C. serulata. Zostera japonica* ii) Species found in areas with the salinity of 20%o or less: *R. maritima, H. beccarii* [4].

In the lagoon environment, the following seagrass groups are categorized depending on their adaptability to salinity as follows [Fig. 40].

Fig. 40: Distribution of seagrass according to salinity in lagoons.



3.7.6 Seagrass resources and current exploitation

One-species meadows are often formed by these species: *Z. japonica*, *H. ovalis R. maritima*, *H. beccarii, Enhalus acoroides, Thalassia hemprichii, Cymodocea serrulata, Halodule uninervis;* multi-species meadows are often formed by *Zostera japonica - H. ovalis - Halodule decipiens - Halophila beccarii; T. hemprichii- Zostera japonica-Halodule pinifolia- H.ovalis; E. acoroides- H. uninervis- H. ovalis- Halophila minor; T. hemprichii-Cymodocea serrulata-C. rotundata-S. isoetifolium* (Tien et al., 2002).

It is the formation of these seagrass meadows that created large seagrass areas in the intertidal zones, coastal islands and lagoons. The meadows are feeding sites of many animals and their habitats and nursing places for their early days. Đai and Tiến (Nai, 2011; Tien et al., 2002) have recorded many seagrass meadows and listed macro zoobenthos including the group Mollusca, Crustacean and Echinodermata and larvae of many fish species.

In terms of practical use, seagrass in Vietnam has merely been considered as a source of green manure to fertilize on-land crops such as tobacco, sweet potatoes, peppers and some fruit trees. The exploited species are: *Halodule pinifolia, Zostera japonica and Ruppia maritima.*

3.7.7 Seagrass depletion and conservation

Currently many of degraded seagrass beds have been recorded. Due to heavy coastal fisheries activities and especially destructive fishing methods by means of explosives and harmful fishing gears, seagrass beds are being threatened. To make it worse, the building of aquaculture ponds are considered a serious cause of destruction of seagrass. For example, the depletion of *Zostera japonica* meadow in Quang Ninh, *Ruppia maritima* in Liên Vị, and *Halophola beccarii* in Nam Dinh are only a few to mention (Tien et al., 2002).

In addition, the exploitation of upstream forests are leading an increase in sediment carried away into the sea in large amounts, which is the cause of the degradation of seagrass. Nguyen Van Tien discovered the dwindling of *Halophila ovalis* in Tuan Chau, Dai Yen under this influence (Tien et al., 2002).

To address this problem with an aim to recover and protect seagrass in some places such as Nui Thanh, Quang Nam province, *Zostera japonica* has been grown (1 ha in Nui Thanh) (Nai, 2011). In Dau Go of Ha Long Bay, Quang Ninh two species of *Zostera japonica* and *Halophila ovalis* was planted in a pilot project. With 30kg of grass seedling planted on an area of 2.500m^2, the survival rate was recorded at 60 %. *Halophila ovalis* had a similar survival rate of upto 70 %. Especially, *Thalassia hemprichii* collected in Thua Thien Hue and grown in completely submerged environments in Cat Ba Island had a survival rate of 100 %. *Halophila ovalis* and *Zostera japonica* after two years of trials has developed into an area of seagrass meadow, though not so large; but according to Tien et al (2002) this promising progress will result in new way to use planted seagrass for restoration in other areas in Vietnam*.* *Thalassia hemprichii*, which grows well in Cat Ba, can be cultivated in other waters of North Vietnam.

In the Tam Giang - Cau Hai, one of the biggest lagoons in Southeast Asia, seaweed thrives and forms large meadows on its beds. Local government has developed on 12 seagrass protection zones. [Fig. 41; Table 22]. The zones are managed under the community-based mechanism, meaning that groups of fishers are assigned the task of manage these seagrass protection zones. According to the fishermen community, despite losing part of fishing grounds (347.7 ha) but the aquatic grass protection zones help increase resources. Hopefully, the achievements brought by the building of seagrass protection zones in Tam Giang Lagoon will pave the way for the construction of the protected areas of seagrass in the lagoon central Vietnam in the coming time.

Fig. 41: Seagrass protection areas of in the lagoon of Tam Giang-Cầu Hai.

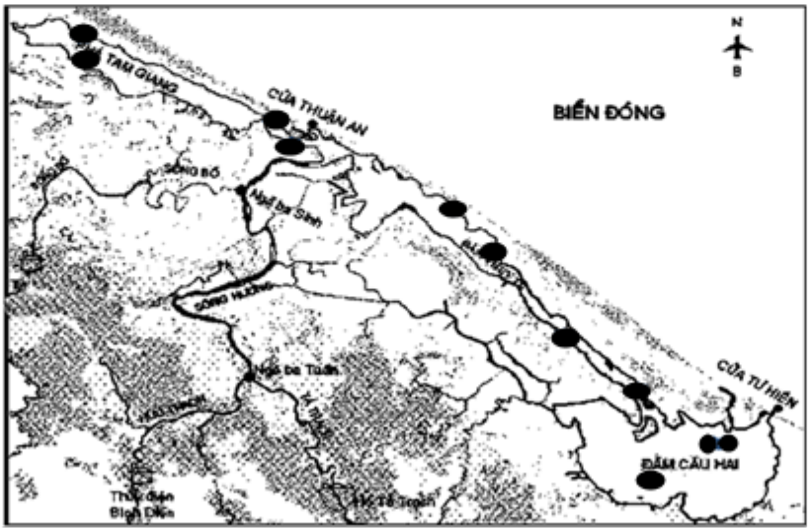


Table 22: Name of seagrass protection area in Tam Giang-Cau Hai lagoon.

No	Name of protection zone	Location	Area (ha)	Date of establishment
1	Cồn Chìm	Village Nghĩa Lập, Commune Vinh Phú	**23.6**	5/11/2009
2	Cồn Cát	Village 8, Commune Điền Hải	**17.7**	9/3/2010
3	Doi Chỏi	Village Thanh Mỹ, Commune Phú Diên	**30.4**	22/9/2010
4	Đập Tây-Chùa Ma	Village Giang Xuân, Commune Vinh Giang	**35.0**	17/11/2010
5	Vũng Mệ	Village Hà Công, Commune Quảng Lợi	**40.0**	19/5/2011
6	Hòn Núi Quện	Village Mai Diêm Phường, Commune Lộc Bình	**40.0**	19/5/2011
7	Khe Đập Làng	Village Hòa An, Commune Lộc Bình	**36.0**	25/6/2012
8	Mai Doi Bống	Commune Vinh Xuân	**30.0**	19/12/2012
9	Cồn Sầy	Village Vân Quất Đông	**30.0**	24/01/2013
10	Hà Nã	Commune Vinh Hiền	**25.0**	18/03/2013
11	Cồn Giá	Commune Vinh Hà	**40.0**	17/01/2014
	Total		**347.7**	

3.7.8 Effects of climate change on seagrass

A rapid appraisal on the impact of climate change on fisheries activities and seagrass was conducted in the Tam Giang-Cau Hai Lagoon of Thua Thien Hue province. Results obtained from interviews of 259 fishermen show that up to 93.44% respondents say in the recent years phenomena of extreme climate/weather have appeared more often than before. Concerning the general climate picture of Thua Thien Hue in the past year, 68.73% of lagoon fishermen say that climate change has increased the number of tornadoes, storms and typhoons every year. Storms have appeared and threatened life and production of fishing communities in particular and coastal inhabitants in general. However, in Thua Thien Hue floods have been less often in the past year. With an exception for floods, hurricanes and tornadoes have occurred more frequently than ever before. According to local people, this is worrying because natural disasters are usually difficult to predict by relying only on experience. Yet, what concerns us is that 20.08% of interviewees are ignorant of the concept of climate change.

3.7.9 Access to information on weather and climate and its applications to fishing activities

Most fishermen and coastal inhabitants of the lagoon stay informed of the weather to serve their occupational activities through TV and radio. 92.28% fishermen said they listen to weather forecast regularly and 92.66% respondents said that information given by weather forecast is accurate.

Fishermen rely on this information to plan their fishing activities. Their fishing is stopped only under the threat of a big storm offshore. If they are caught in a storm when they are at sea, they can rely on the guidelines given by the local government to either return ashore as quickly as possible or escape the storm by moving away from it.

3.7.10 Impact of climate change on fishermen livelihoods

Fishermen (52.90%) said that storms have become much more powerful, their progress complex and difficult to accurately predict and with greater impacts. Especially, thunderstorms, tornadoes are becoming more common and unusual and more devastating than in the past. About 74.13% fishermen said that increase in tornadoes and hurricanes are more threatening to people's lives and properties. Fishing equipment and gears and facilities for aquaculture are frequently under the threat of a storm with severe damage.

Regarding the impact of climate change on production, 76.06% fishers think that climate change has reduced their fishing catches and fishing season time. However, their explanation about this incident was related not to the impacts of climate change but to the impact of random fishing activities with destructive fishing gear, and to an increase in people involved in fishing as well as polluted environment. 64.86% of the fishermen interviewed (259 people) said that in recent years weather and climate changes, prolonged hurricanes and other natural disasters have reduced their time-spent fishing. Fishermen also said that only 10 to 15 years ago, fishing could be done almost all year round except during the time of a storm. As for lagoons, rains, storms have caused brackish water fresher and fish species of marine origin find their way to the sea. Fishermen spend more time repairing fishing gears. 80.69% of the surveyed population is engaged in fishing but only about 19.31% of them have extra jobs as fish traders, selling groceries.

Fishermen admit seagrass and mangrove have a very important role in their daily life. 78.38% said that seagrass meadows are the shelter and breeding places of aquatic life, "no seagrass no shrimp nor fish". It is also a source of food for poultry, cattle and for some types of wild fish and cultured fish. Despite these benefits, seagrass may do harm to fishery practicing. With excessive amounts, seagrass may cause difficulties and obstruction to fishermen's fishing activities (damage to fishing net). In the survey, 42.08% said there was no disappearance of seagrass or mangrove due to climate change, but they only change by season in the same fashion yearly, depending on the salinity of water (during the time fresh water dominates brackish water disappear, but freshwater seagrass thrives and vice versa). The dwindling biomass of seagrass compared with that of the previous time is negligible.

Also, according to local people changes of seagrass in the lagoon is due to the impact of the river dam, which affect the fresh water amount flowing into the lagoon, which may cause the degradation of seagrass. And this is owing to some other causes including exploitation of seagrass as food for fish, and destructive fishing activities, construction of aquaculture ponds and waste discharged from ponds, and erosion.

4.0 Conclusions

It is stated earlier that the project undertakes the research on the impacts of climate change on the seagrass and salt march habitats in some of the Asian coasts namely Bangladesh, Indian, Japan, Malaysia, Philippines, Thailand and Vietnam. It is clear that the climate change events increase the risks of livelihoods of fishermen as well as seagrass ecosystems and functions. Based on the present findings, seagrass and salt marsh habitats in Asian coasts are expected to be vulnerable by both the catastrophic and manmade activities. Compared to the climate changes extremes and its affects, the manmade processes were believed to have more sensitive to the seagrass beds and salt marsh habitats in the Asian coasts. Besides, climate change events accelerating this degradation process. For example, in Thailand, climate change has impact on seagrass habitats where fresh water and sediments are perceived as key component for seagrass loss. Some findings showed that seagrass are reducing in one place and regenerating in other place whenever the environment is favorable. In Philippines, seagrass are found to be death due to the temperature variables and sometime regenerates from rhizome, while human activities could hinder the growth.

The results implicated that a good seagrass beds and salt marsh habitats pledge the fishing community receives diversified benefits both the direct (tangible) and indirect (intangible) forms as well as in drawing seagrass and salt marsh dependent fishery species to improve productivity and livelihoods.

Evaluation of multiple ecosystem services from seagrass beds and salt marsh habitats are worthwhile to link the natural science and socio-economic research, and would be utilized to plan conservation and adaptive management of coastal ecosystems by providing quantitative criteria to stakeholders for decision-making. At the current stage, attempts for the evaluation are confined to some limited aspects of ecosystem services such as seafood production and carbon segregation. Future challenges in this field include more comprehensive analyses on the value of multiple ecosystem services, especially that of cultural services, through collaboration by specialists on marine ecology and socio-economy.

Precious ecosystem services given by seagrass, salt marsh and other coastal ecosystems could change drastically with ongoing global climate changes. However, our knowledge on the effects of climate changes on coastal ecosystems is still insufficient. Concurrent monitoring of these habitats, experimental analyses manipulating responsible factors, and integrated long-term, broad-scale modeling are necessary to deepen our understandings about processes how climate change affects coastal ecosystems in Asian coasts. Then, by adding more comprehensive evaluation on multiple ecosystem services, we can provide more science-based management plans for conservation and sustainable use of coastal ecosystems in a changing world.

Awareness activities within the fishermen on climate change impacts on the seagrass and salt marsh ecosystems may improve the knowledge on the issues, while strengthening the resilience toward climate change processes. Since seagrass and salt marsh beds are intricately linked to resilience of ecosystems, adaptation strategies linked to their conservation would safeguard livelihoods of communities depending on the same.

Based on our findings, three different directions of questions for mitigation on seagrass and salt marsh habitats and fishermen can be handled (Table 23).

1. How to sustain seagrass and salt marsh ecosystems from extreme weather/climate condition?
2. How to sustain life of fishermen affecting by extreme weather condition?
3. How to sustain livelihoods of fishermen relied mainly on goods and services from seagrass and salt marsh ecosystems?

Table 23: Specific objectives and mitigation measures relevant to seagrass and salt marsh habitats and fishermen.

Specific objectives	**Mitigation measures**
To sustain seagrass and salt marsh ecosystems from extreme weather/climate condition	Monitoring, restoration and etc.
To sustain life of fishermen affecting by extreme weather condition	Warning system, protective system and etc.
To sustain livelihoods of fishermen relied mainly on goods and services from seagrass and salt marsh ecosystems	Alternative livelihoods, rehabilitate habitat and etc.

5.0 Future Directions

With this collaboration of research project of APN, we have been developed a network of scientists those are interested to work in collaboration in future like Vietnam, Bangladesh and India. We have consulted with our Japanese partner to develop a research and collaborative initiative (through JSPS funding) with Vietnam partner on seagrass ecosystems. Bangladesh and Indian partner are keenly interested to work on salt marsh ecosystems, which is badly needed, as works on these resources are less in that region. A regional out look on seagrass and salt marsh ecosystems, lives and livelihoods in view of climate change impacts will be published in a Book form by June 2015. It is very much important that the findings of this research project should needed to be share with the large groups like policy makers, science officers, academia, students, local leader and community to develop a meaningful dialogue and adaptation policy on seagrass and salt marsh ecosystems in Asian coasts.

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Appendix

List of Participant at APN Workshop on
"Climate Change Impact on Seagrass and Salt marsh Ecosystems in South and South East Asia in Coasts"
(3rd April- 4th April 2014, UPMKB)

Sl. No.	Name and Contact Details	Signature
1	Dr. Abu Hena M K Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: abuhena@upm.edu.my	
2	Prof. Migule D Fortes Coastal Ecologist, Biodiversity and Integrated Coastal Area Management Specialist University of the Philippines, Marine Science Institute CS, Diliman, Q C 1101, Philippines Email: migueldfortes@gmail.com	
3	Dr. Phap T T Hue College of Sciences, Hue University, Vietnam Email: cmdhus@gmail.com	
4	Prof. Dr. Nakaoka M Akkeshi Marine Station, Hokkaido University, Sapporo, Japan Email: nakaoka@fsc.hokudai.ac.jp	
5	Dr. Aysha Akhtar Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh Email: aysha_imsfcu@yahoo.com	
6	Dr. Muta Harah Z Department of Aquaculture, Faculty of Aquaculture, University Putra Malaysia, 43400 Serdang, Selangor D E, Malaysia Email: muta@upm.edu.my	
7	Dr. Sukree H Faculty of Science and Technology Prince of Songkla University, Pattani Campus, Thailand Email: hsukree@bunga.pn.psu.ac.th	
8	Dr. Md Hanafi Idris Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: mhanafi@upm.edu.my	
9	Prof. Dr. Japar Sidik Bujang Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: japar@upm.edu.my	
10	Dr. Manoranjan Mishra Centre for Environment and Economic Development, New Delhi, India Email: geo_manu05@googlemail.com	
11	Mr. Masum Billah Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: masum_imsf07@yahoo.com	Young Scientist

12	Mrs. Hasmidah Md Isa Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: asmidar_unic@yahoo.com	Young Scientist
13	Ms. Nettey Toney Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: nettelytonie@gmail.com	Young Scientist
14	Mr. A S M Saifullah Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: saifullahasm@yahoo.com	Young Scientist
15	Mr. Md Muzammel Hoque Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: hoque_doe@yahoo.com	Young Scientist
16	Mr. Kaleem Shah Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: kaleemkhattak@yahoo.com	Young Scientist
17	Mr. Sawkat Hossain Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: sawkat@gmail.com	Young Scientist
18	Mr. Md Hafizbilla Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: hafiz_nawai@yahoo.com	Young Scientist
19	Ms. Azima Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia	Young Scientist
20	Mr Hadi B Hasim Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia Email: hadih@yahoo.com	Young Scientist

Workshop Banner

Workshop Bunting

Workshop on Climate Change Impacts on Salt Marsh and Seagrass Ecosystems in South and Southeast Asian Coasts

3-4 April 2014
Bintulu, Sarawak, Malaysia
Workshop Venue: Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB)

PROGRAMME

PRE-WORKSHOP: WEDNESDAY, 2 APRIL 2014

Whole day	Arrival of Participants - Participants collect welcome packs
19:30	Dinner hosted by UPMKB at Park City Hotel

DAY 1: THURSDAY, 3 APRIL 2014

06:30-8.30	Breakfast at Park City Hotel
08:45	Travel to UPMKB
09:30	Arrival at UPMKB
	Welcome speech by the Dean, Faculty of Agriculture and Food Sciences Briefing on the Status of APN Project by Project Coordinator, Dr. Abu Hena Mustafa Kamal and Workshop activity
11:00	Country Paper Presentation and Discussion Country paper, Bangladesh by Mrs. Aysha Akhtar Country paper, India by Dr. Mishra Manoranjan
12:30	Lunch
14:00	Country Paper Presentation and Discussion Country paper, Japan by Prof. Dr. Masahiro Nakaoka Country paper, Malaysia by Dr. Abu Hena Mustafa Kamal/Dr. Muta Harah Zakaria/ Dr. Japar Sidik Bujang Country paper, Philippines by Prof. Dr. Miguel D. Fortes
15:30	Break
16:00	Country Paper Presentation and Discussion Country paper, Thailand by Dr. Sukree Hajisamae Country paper, Vietnam by Dr. Ton That Phap Country paper, South Korea by Prof. Dr. Kun Seop Lee
18:00	End of Day
20:00	Dinner: A taste of local food

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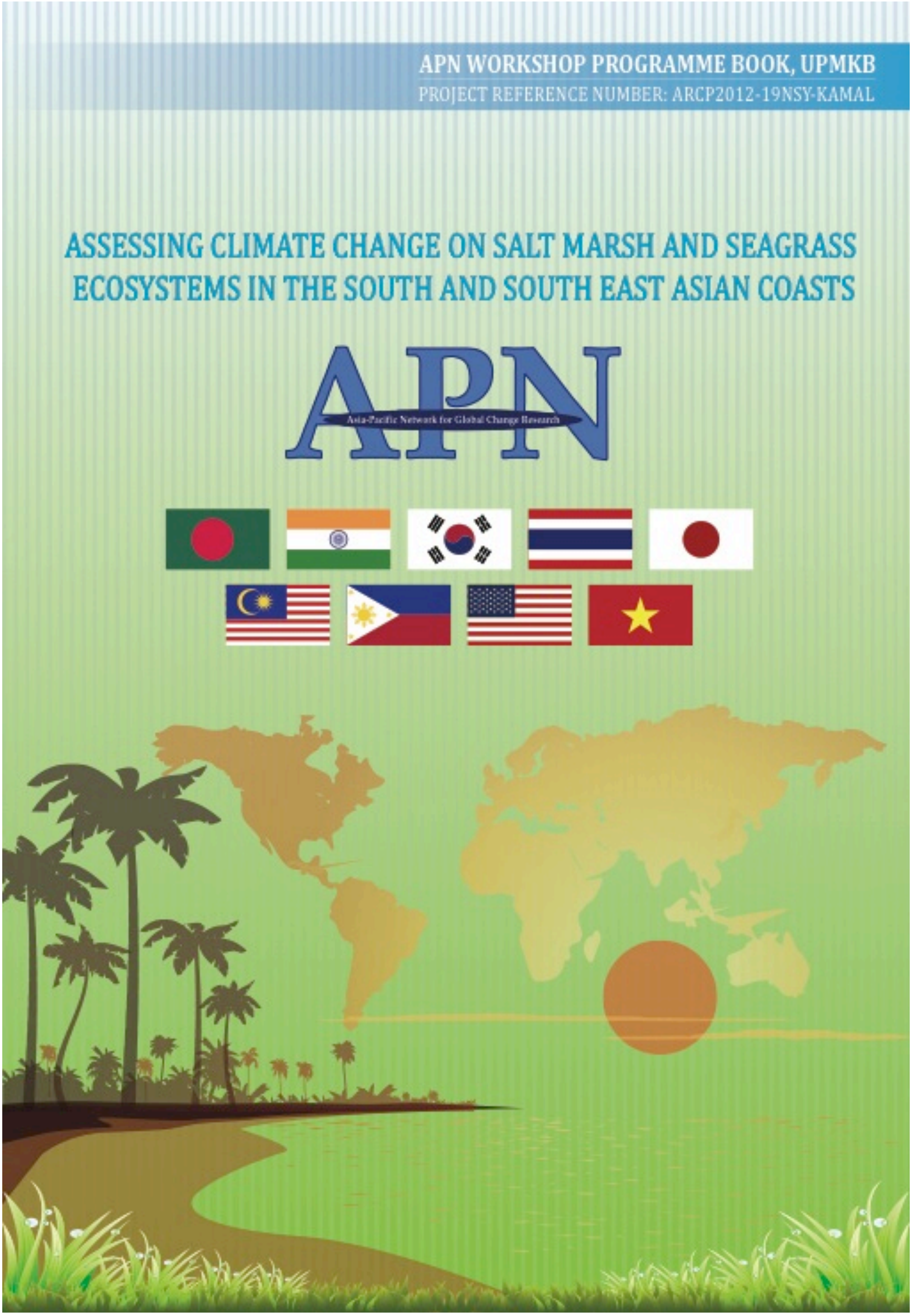
PROGRAMME

DAY 2:	**FRIDAY, 4 APRIL 2014**
06:30-8:00	Breakfast at Park City Hotel
08:45	Travel to UPMKB
09:30	**Overview and Discussion on the APN Project** Output, Report and Publication
11:30	Lunch Break Back to Park City Hotel
15:30	Excursion to Local Souvenir Shop/ Campus Tours
18:00	End of Day
20:00 -	
DAY 3:	**SATURDAY, 5 APRIL**
06:30-8.30	Breakfast at Park City Hotel or a taste of local breakfast
Whole day	Departure of Participants


APN WORKSHOP PROGRAMME BOOK, UPMKB
PROJECT REFERENCE NUMBER: ARCP2012-19NSY-KAMAL
ASSESSING CLIMATE CHANGE ON SALT MARSH AND SEAGRASS ECOSYSTEMS IN THE SOUTH AND SOUTH EAST ASIAN COASTS
APN
Asia-Pacific Network for Global Change Research

BANGLADESH

Fishers' Perception of Climate Change on Salt Marsh and Seagrass Ecosystems in the Southeastern Coast of Bangladesh

Aysha A[1], Billah M M[1,3], Zamal H[1], Hoque M M[2] and Abu Hena M K[3]

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[2]Community-Based Adaptation to Climate Change through Coastal Afforestation Project, United Nations Development Programme (UNDP), Bangladesh

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Abstract

Southeastern coast of Bangladesh is bestowed with salt marsh and seagrass ecosystems. Coastal people of this region are being benefitted directly or indirectly from the fisheries, fodder and other resources of these ecosystems. Nevertheless, these ecosystems are vulnerable due to climate change induced impacts like-cyclone, flood, saline water intrusion, water logging, and also due to sea level rise. This study was conducted to determine the fishers' perceptions in regards to potential effect of climate change upon goods and services of salt marsh and seagrass ecosystems in the southeastern coast of Bangladesh. Two hundred households were surveyed by using semi-structured questionnaire in two coastal areas of southeastern coast namely, Salimpur, Chittagong and Sadar Upazilla, Cox's Bazar from December, 2012 to May, 2013. In both study areas, 70% respondents reported that tropical cyclone was the major climatic hazard followed by flood and saline water intrusion. Fishermen are helpless to face the effects of climate change due to their poverty especially less income (50% opined in both areas) and food deficiency (10% opined in both areas). Besides, local fishermen used salt marsh for fodder (60% opined in both areas), fuel (12% opined) and also for thatching materials (10% opined in both areas), respectively. In Salimpur, Chittagong 17% respondents preferred bait fishing, whereas, it was not cited by the respondents of Cox's Bazar. In Salimpur, Chittagong, establishment of coastal infrastructure especially ship breaking industry (50% respondents opined) and over harvesting (28% opined), whereas in Cox's Bazar, overharvesting (60% respondents opined), were the major reasons for the degradation of these valuable ecosystems. In addition to that in both study areas, major proportion of respondents opined that climatic hazard has medium effects on these ecosystems. However, in both study areas, this degradation was accelerated due to lack of proper conservation and management practices. Our findings suggest that fishers' oriented awareness programme in regards to climate change, sustainable use of these resources, development of conservation management plan (CMP) and its implementation with the active participation of community people may be the best option for its sustainable conservation, restoration and management of these productive but degraded ecosystems.

INDIA

Climate Change Induced Impact on Salt Marsh Ecosystems: Understanding Public Perception, Values and Policy in Coastal Odisha, India

Mishra M, Meher M K and Padhi B K

Centre for Environment and Economic Development, New Delhi, India

Abstract

The thematic review and annotated bibliography explored that coastal plant ecosystem especially salt marsh are declining globally and threatened by multitude of anthropogenic and climatic factors. These coastal ecosystems not only store large amount of carbon dioxide but also generate key ecological services like nutrient transformation, sediment stabilization, filtering runoff water, flood protection, biodiversity conservation and self adaptation to sea level changes. However, there is a gap between scientific consciousness and public perception on climate change impact on salt marsh ecosystems. There is a critical need to understand the public perception, value and policy to protect, monitor, manage and restore these high value marine ecosystems. This study found that the local communities in Odisha coast are conscious about the signals of climate change and also declining trend in salt marshes area in the region. Majority of respondents perceived that coastal ecology are changing over years due to sea level and shoreline changes besides, human interference such as deforestations, farmland extension, salt work and aquaculture activities. Further, majority of them also professed that climate induced natural disasters like cyclone, flood, drought and heat waves have increased both in frequency and intensity in past few decades. Unexpectedly, erratic rain, short winter and warmer wind force the local communities to struggle with different adaptation strategies leading degradation of coastal ecosystems. This paper provides the policy relevant insight for formulating sustainable adaptation strategies for coastal communities in developing countries in averting the ongoing and future climate crisis and also restoring salt marshes in the region.

JAPAN

Evaluation of Biodiversity, Ecosystem Functions and Services of Temperate Seagrass Beds in Japan

Nakaoka M, Watanabe K, Shoji J, Hamaoka H and Hori M

Akkeshi Marine Station, Hokkaido University, Sapporo, Japan

Abstract

Asian coastal areas are characterized by high marine biodiversity including some foundation species like seagrass, mangrove and corals which provide habitats for other associated organisms. The coastal ecosystems created by such marine biota have high ecosystem functions and exert various types of ecosystems services to human, such as providing seafood and regulating water quality. However, ongoing human activities such as overexploitation, eutrophication, coastal developments and climate changes, threaten these ecosystems. Understanding of biodiversity and ecosystem functions, as well as their relationships with environmental factors, is the first step toward the effective conservation and sustainable use of these precious habitats. In this paper, we review the status and variability of biodiversity, ecosystem functions and services provided by temperate seagrass beds along Japanese Archipelago based on data by past studies. Seagrass beds in temperate Japan mainly consist of several species of *Zostera* spp. with species composition varies along the latitude and depth gradients. The preliminary analyses revealed that the seagrass species richness, abundance and temporal stability of seagrass beds vary with latitude and depth. Biodiversity and abundance of associated fauna including epiphytic invertebrates and fish also vary greatly among sites with different environmental conditions. We are also conducting evaluation of various ecosystem services such as carbon absorption rates, and productivity of commercially important species from eelgrass beds. We found that the regulating services are high in dense seagrass vegetation, whereas provisioning services are high in sparse vegetation near the periphery. The result highlights that the combinational conservation of different types of vegetation is important to maximize multiple ecosystem services by seagrass beds. Based on the obtained information, we are creating maps showing value of ecosystem services by eelgrass beds in Japan, which would be useful for establishing plans for conservation and adaptive programs toward global climate changes.

MALAYSIA

Seagrass Ecosystems at Johore Straits, Malaysia: Climate Change Impacts and Fishermen Outlook

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Abstract

Seagrass beds in coastal and marine environments are one of the most productive ecosystems worldwide. They are the source of livelihoods of a third of the region's population. The ecosystems and functions of seagrass are an effective line of defense against the impacts due to climate change variables. This study aimed to investigates (1) the present existence and utilization of seagrass beds and its resources, (2) fishermen outlook and climate change impacts in seagrass ecosystems and (3) vulnerability and adaptation measures to be taken in the seagrass beds at Johore Straits, Malaysia. Studies found that the majority of them are small-scale fishermen, with an average income of 1228 RM (~400 US$)/month. Most of the fishermen are well known about the presence of seagrass beds in their fishing areas and had pointed the reduction of beds due to the environmental cues from both the catastrophic (71%) and manmade (71%). Based on the fishermen, about 70-80% of seagrass beds are reduced at present than the previous. Decreasing of seagrass beds in this area were also noticed due to the development of port and uses of coastal land reclamation. Besides, they have encountered that climate change variables are probably be accelerating these decreasing processes. Majority of the fishermen realized the unpredicted and untimely monsoonal changes (i.e., heavy rain, storm, current and drought of extreme climate), which probably reduced the fish diversity and species composition in this fishing ground. On the other hand, it was found that the combination of both the manmade (i.e., pollution, port activities and coastal development) and climate change disturbances probably could have impacts in the reduction of fish number, which lowering up to 28% of catches. The fishing activities were also decreased from 21 days/month to 14 days/month, lowering about 67%, and affecting on their fishing profession, while leaning fishermen to migrate to other area for job. Fishermen communities in this area are not well known about the adaption and mitigation measures of climate change impacts. In addition to that, majority of the fishermen believed that seagrass beds and its ecosystems could have significance roles in their livelihoods and marine ranching in this area; nevertheless this ecosystem would not be subsisted in next a decade due to environmental changes. Thus there is an urgent need to conserve and manage this important ecosystem in this tropical coastal water.

PHILIPPINES

Seagrass Ecosystem Services and Their Economic Valuation in SE Asia: A Preliminary Assessment

Miguel D. Fortes

Coastal Ecologist, Biodiversity and Integrated Coastal Area Management Specialist
University of the Philippines, Marine Science Institute CS, Diliman, Q C 1101, Philippines

Background

From 7 countries bordering the South China Sea, some ecosystem services provided by seagrass beds have been categorized into 5 types (Table 1). The value of total annual production of goods and services of seagrass habitats demonstrate sun equivocally, although yet incomplete, the importance of seagrasses in the region, with a total annual value of production exceeding US$86 million. In comparison with coral and mangroves, this is exceedingly low, the primary reason is the almost complete lack of data and, where these exist, they are 'outrageously' unreliable. In the Philippines, the value of the total annual production of the goods and services of seagrass from the few study sites (with a total area of 23,245 ha) was worth only US$809,766 (UNEP (2007a). This is because only data from capture fisheries were considered reliable, so that seagrass goods had a total value of only US$34.84. On the other hand, seagrass services had no value, since none of the data submitted were considered and reliable. Interestingly, Fortes et al. (2007), in connection with the total valuation of damages due to the grounding of the coal Barge APOL in Bolinao in 2007, submitted to the insurance company a valuation of the lost benefits from a 35 ha seagrass beds (and a small portion of an unproductive reef) with 6 years recovery allowing for some spread of the rubble costing US$60,000. These data emphasizes the need for a more thorough accounting of the services from the habitats.

Evaluation Status

Economic valuation of the goods and, much less of services, from seagrass habitats in the Philippines has been done but only for a few sites and the reliability of much of the data on services is highly questionable. The ease or rapidity of seagrass services accounting depends highly upon the nature of the service and the state of the effort in the country. In Table 1, items under L1 for the most part have been, or are being, undertaken albeit in a few locations in the country and region, and these are more or less straightforward, in terms of 'tag' or market prices. These are where ecosystem accounting can be made more rapidly. However, at the rate local seagrass ecosystems are being degraded and lost, and how this loss impacts the coast, accounting of L2 services should also be undertaken together with some of the L3 services *as a matter of policy*. But prioritization should be based on site-specific criteria like, among others, urgency, probability of success, and overall positive benefits to the coastal community concerned. Ecosystem services all cater to aspects of human well-being. While the need for accounting of L3 services may not yet be the focus of this project, these aspects are virtually 'untouched' largely because of paucity of information and relative difficulty in their determination. For the most part, a more subjective approach may be used to complement the more qualitative approaches in the valuation process of the latter two sets of services. It should be noted that ecosystem services overlap significantly when they address aspects of human well-being. This overlapping function is one major factor for the inherent difficulty in the accounting of seagrass ecosystem services. In addition, the connectivity function of seagrass with other nearby ecosystems, one of the most important functions of the ecosystem in the tropics, is yet almost completely unstudied. It is the coastal ecosystems connectivity function that largely sustains the stability and integrity of coasts in the tropical world.

THAILAND

Fishers' Perception of Climate Change on Salt Marsh and Seagrass Ecosystems in the Southeastern Coast of Bangladesh

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Abstract

This paper is aimed at (1) providing a review of status, coverage and causes of degradation of seagrass in Thailand, (2) reporting changes in seagrass ecosystems and the livelihoods of fishing communities depending on these habitats and (3) proposing mitigation measures for long term and sustainable management of these resources. Available data and information on status, coverage, causes of degradation and some evident of impacts of climate change on seagrass ecosystem in Thailand were reviewed. Different fishing communities in the vicinity of seagrass habitat were selected from three provinces to represent both South China Sea and Andaman Sea. Koh Libong Island in Trang Province was for the Andaman Sea, while Pattani Bay, Pattani Province and Tha rai Island, Nakorn Sritammarat Province for the South China Sea. Fifty randomly selected fishermen were interviewed. Most of them were small-scale fishermen using mainly long-tailed boat with some experience in fishing operation. Various fishing gears were used by fishermen from different study areas. However, shrimp trammel net and crab net were the most popular gears used by fishermen living in the vicinity of seagrass habitat. The perception and response of fishermen on the changes of seagrass within the past 10-20years, both quantity and number of species, were different between provinces. Increasing of seagrass was found in Tha Rai Island and Libong Island, but severe decreasing of seagrass habitat was in Pattani Bay. Environmental changes, shallow water and sedimentation were likely the main causes for the decreasing of seagrass in Pattani Bay. Most of the fishermen currently felt that there was an increasing of extreme weather condition. They believed that it was an impact of climate change. Moreover, they found that it also affected their fishing activities especially reducing their annual number of day for fishing from 290 to 231 days, lowering about 45.1% of catches, and affecting their fishing season. Most of them followed and believed daily news on climate and weather reports before they went fishing. Some mitigation measures are also proposed in this paper.

VIETNAM

Seagrasses in Vietnam: Status and Conservation Issues

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Abstract

In Vietnam, before 1959, the studies of seagrasses are mostly done by foreigner scientists. Seagrasses in Vietnam really have been paid attention to study by Vietnamese researchers in recent years. So far 15 species of seagrasses are identified from Vietnam marine waters. They are found along the coast, islands, bays, estuaries and lagoons. The relationship between seagrass distribution and some environmental factors along with the biological characteristics are presented. Most of the listed seagrass species formed meadows which cover a large area in the littoral and especially in lagoons. These seagrass meadows are considered as important feeding grounds and nursery ground for aquatic animal, especially for fish and shrimps at the juvenile stage. This presentation also mentions the degradation of the seagrasses and some pilot transplanting as well as the establishing protected area of seagrasses. Especially, results achieved from a rapid appraisal the impact of climate change on the seagrasses and in the Tam Giang lagoon is also discussed.

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Equipment Rental	Universiti Putra Malaysia	1000	
Vehicles Rental	Universiti Putra Malaysia	1000	
Over Head Projectors	Universiti Putra Malaysia	500	
Computer	Universiti Putra Malaysia	200	
Personnel support including Project Lead	Universiti Putra Malaysia	1000	
Total		**5700**	**00**

Workshop Photos and Activities


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