Coastal vulnerability assessment, adaptation and mitigation opportunities in climate hotspots in Kerala, India

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The fastest warming ocean regions and the overlap with national EEZs

Project focus on countries adjacent to several of these regions in the Southern hemisphere
A holistic approach has been developed and applied to five southern hemisphere hotspot regions: Brazil, India, the Mozambique Channel, Southern Benguela (South Africa) and South East Australia. The project is to deliver a comprehensive set of options to reduce coastal vulnerability and position vulnerable coastal communities for an improved future.

**GOAL**
This project contributes to improving community adaptation efforts by characterizing, assessing and predicting the future of coastal-marine food resources through the provision and sharing of knowledge across regional "hotspots".
Objectives

- Assessing the coastal vulnerability of identified climate change hotspots.

- Identifying the livelihood dependency of coastal community on fisheries and their Alternative Livelihood Options (ALOs).

- Deliver alternative options in terms of adaptation and transformation within coastal communities.

- Engaging the different stakeholder towards a climate resilient fisheries management practices and fisher livelihoods.
Vulnerability Model (modified from IPCC)
Identified Hotspot area

- South West India hotspot - Kerala (Trivandrum, Kollam, Alappuzha and Ernakulam Districts)

- South East India hotspot - Tamil Nadu (Tuticorin and Ramanathapuram districts - encompassing Gulf of Mannar and Palk bay)
Trophic modeling of South Kerala ecosystem

- South Kerala hotspot identified: **Zone K1-K6** (Thiruvananthapuram, Kollam, Alappuzha and Ernakulam)
  - Habitat Area Calculated for South Kerala Hotspot: **18,059 Km²**

- Data Collection for trophic modeling
  a) 26 groups identified
  b) Collected and processed “Catch” data for the years 2010-14
  c) Components - production biomass ratio, consumption biomass ratio, biomass, diet composition

- Model mass balanced
- Ecosim simulations - Different SST scenarios
The total system throughout: 18,799.779 t/km²/year (represents the size of the entire system in terms of flow)

Gross efficiency of the fishery: 0.00236 (close to that of the Berring ecosystem)

The ecosystem system omnivory index of 0.431 indicates the complex feeding interactions in the ecosystem.
Species Sensitivity Assessment to climate change

- Evaluated the relative sensitivity of key 36 commercial fisheries species to climate change impacts.

Attributes and criteria to estimate sensitivity

- **Abundance**
  - Fecundity
  - Recruitment Period
  - Age at maturity
  - Feeding habit

- **Distribution**
  - Larval duration
  - Juvenile movement
  - Spatial availability

- **Phenology**
  - Environment as cue for spawning
  - Environment as cue for metamorphosis
  - Spawning periodicity
  - Migration (Juvenile/adult movement)

- Based on literature collections
- Expert judgements
- Data quality scoring guidelines (3-Adequate Data, 2-Limited Data, 1-Expert Judgment, 0-No Data)
<table>
<thead>
<tr>
<th>Sl No</th>
<th>Species</th>
<th>Abundance</th>
<th>Distribution</th>
<th>Phenology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fecundity</td>
<td>Capacity</td>
<td>Capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– egg production</td>
<td>larval dispersal</td>
<td>adult/juvenile movement</td>
</tr>
<tr>
<td>1.</td>
<td>Auxis rochei</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Carcharhinus limbatus</td>
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<tr>
<td>3.</td>
<td>C. macrostoma</td>
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<td>1</td>
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<tr>
<td>4.</td>
<td>Decapterus ruselli</td>
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<tr>
<td>5.</td>
<td>Dussumieria acuta</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>6.</td>
<td>E. affinis</td>
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<tr>
<td>7.</td>
<td>Epinephelus diacanthus</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>8.</td>
<td>johnieopsis sina</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>9.</td>
<td>Lactarius lactarius</td>
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<tr>
<td>10.</td>
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<td>1</td>
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<tr>
<td>11.</td>
<td>loligo duvacei</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>M. dobsoni</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>Megalaspis cordyla</td>
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<td>1</td>
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</tr>
<tr>
<td>14.</td>
<td>Nemipterus randali</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15.</td>
<td>Otolithes ruber</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Sensitivity scores plotted from highest to lowest for each of the three attributes. 3 = most sensitive/high risk, 1 = least sensitive/low risk.
## Sensitivity scores of major species based on Ranks

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Abundance</th>
<th>Distribution</th>
<th>Phenology</th>
<th>Total</th>
<th>Rank</th>
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<td>1.</td>
<td><em>M. dobsoni</em></td>
<td>1.2</td>
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<td>1.75</td>
<td>5.20</td>
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<tr>
<td>2.</td>
<td><em>Johnieopsis sina</em></td>
<td>1.4</td>
<td>2.5</td>
<td>1.33</td>
<td>5.23</td>
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<tr>
<td>3.</td>
<td><em>Epinephelus diacanthus</em></td>
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<td>2.5</td>
<td>1.5</td>
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<tr>
<td>4.</td>
<td><em>P. stylifera</em></td>
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<td>2.25</td>
<td>1.75</td>
<td>5.25</td>
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<tr>
<td>5.</td>
<td><em>S. devsi</em></td>
<td>1.4</td>
<td>2.25</td>
<td>1.75</td>
<td>5.4</td>
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<td>6.</td>
<td><em>Priacanthus hamur</em></td>
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<td>2.5</td>
<td>1.67</td>
<td>5.42</td>
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<tr>
<td>7.</td>
<td><em>Lactarius lactarius</em></td>
<td>1.2</td>
<td>2.5</td>
<td>1.75</td>
<td>5.45</td>
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<tr>
<td>8.</td>
<td><em>Otolithes ruber</em></td>
<td>1.2</td>
<td>2.25</td>
<td>2</td>
<td>5.45</td>
<td>6</td>
</tr>
<tr>
<td>9.</td>
<td><em>Rastrilleger kanagurta</em></td>
<td>1.2</td>
<td>2.25</td>
<td>2</td>
<td>5.45</td>
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<tr>
<td>10.</td>
<td><em>Sardinella longiceps</em></td>
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<td>2.25</td>
<td>2</td>
<td>5.45</td>
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<tr>
<td>11.</td>
<td><em>Scomberomorus commerson</em></td>
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<td>12.</td>
<td><em>Dussumieria acuta</em></td>
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<td>13.</td>
<td><em>Penaeus indicus</em></td>
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<td>1.75</td>
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<td>14.</td>
<td><em>Portunus sanguinolentus</em></td>
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<td>1.67</td>
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<td>15.</td>
<td><em>Charybdis feriatus</em></td>
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<td>2.5</td>
<td>1.6</td>
<td>5.6</td>
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</table>
### Garrette analysis - Impact of climate change on resources

<table>
<thead>
<tr>
<th>Parameters</th>
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<th>Rank</th>
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<tbody>
<tr>
<td>Catch reduction</td>
<td>73.04</td>
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<tr>
<td>Increased efforts in fishing</td>
<td>65.66</td>
<td>II</td>
</tr>
<tr>
<td>Migration of fishes</td>
<td>47.73</td>
<td>V</td>
</tr>
<tr>
<td>Varied Catch composition</td>
<td>57.70</td>
<td>III</td>
</tr>
<tr>
<td>Shift in spawning seasons</td>
<td>42.24</td>
<td>VIII</td>
</tr>
<tr>
<td>Temporal shift in the species availability</td>
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<td>IV</td>
</tr>
<tr>
<td>Loss in craft and gear</td>
<td>46.62</td>
<td>VI</td>
</tr>
<tr>
<td>Occurrence of invasive species</td>
<td>46.30</td>
<td>VII</td>
</tr>
<tr>
<td>Alterations in fishing seasons</td>
<td>41.26</td>
<td>IX</td>
</tr>
<tr>
<td>Depletion of farm and inventories</td>
<td>35.60</td>
<td>XI</td>
</tr>
<tr>
<td>Non availability of regular species</td>
<td>35.96</td>
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</tbody>
</table>
**Socio Economic Vulnerability assessment**

**Vulnerability**: The degree to which a system is susceptible to, or unable to cope with, adverse effect of climate change, including climate variability and extremes.

- **Exposure (E)**: The nature and degree to which fisheries production systems are exposed to climate change.

- **Sensitivity (S)**: Degree to which national economies are dependent on fisheries and therefore sensitive to any change in the sector.

- **Potential impact (PI)**: All impacts that may occur without taking into account planned adaptation.

- **Adaptive capacity (AC)**: Ability or capacity of a system to modify or change to cope with changes in actual or expected climate stress.

\[ V = f(PI, AC) \]
Coastal vulnerability assessment under GULLS

- Coastal villages selected as hotspots for study: (600 samples each)
  **South-west**: Elankunnapuzha, Beemapally and Poonthura (Kerala)
  **South East**: Ramanathapuram (Tamil Nadu) – (Analysis under process)

A composite vulnerability index was prepared

**Vulnerability (V) = Exposure (E) + Sensitivity (S) - Adaptive Capacity (AC)**

- A total of 198 indicators were identified
  (E-36, S-37, and AC-126)
- Mapped using Open domain Quantum GIS (QGIS).
• The vulnerability indices were computed for the normalized data set (0 and 1) using the Patnaik and Narain method (2005)

\[ x_{ij} = \frac{X_{ij} - \min_i \{X_{ij}\}}{\max_i \{X_{ij}\} - \min_i \{X_{ij}\}} \]

if \( \uparrow \) relationship with vulnerability

\[ y_{ij} = \frac{\max_i \{X_{ij}\} - X_{ij}}{\max_i \{X_{ij}\} - \min_i \{X_{ij}\}} \]

if \( \downarrow \) relationship with vulnerability

• The data analysis was done using the common scoring framework and analysis method (1-4 scale) given by GULLS international team.

• Poonthura is more vulnerable than Elamkunnappuzha.
Conceptual framework for assessing coastal community vulnerability

**Ecological vulnerability**

- **Exposure**
  - Environmental change
  - Personal exposure to:
    - Storms
    - Floods
    - Drought
    - Shoreline changes

- **Sensitivity**
  - Household dependence on marine resource
    - Social dependence
    - Economic dependence
    - Historical & Cultural dependence

- **Adaptive Capacity**
  - Flexibility
    - Personal
    - Occupational
    - Institutional
  - Social capital
  - Human capital
  - Financial capital
  - Physical capital
  - Natural capital

**Potential Impact**

**Socio-ecological vulnerability**

**Adaptation options**
Category of the integrated framework with Exposure, Sensitivity and Adaptive Capacity with different components and its indicators

**Category**
- Exposure
- Sensitivity
- Adaptive Capacity

**Components**
- Environmental
- Personal exposure
- Storms
- Flood
- Drought
- Shoreline change

**Sub-components**
- Social dependence
  - Attachment to place
  - Attachment to
- Economic dependence
  - On fishing
  - Competition for fish
- Historical & cultural dependence
  - Historical
  - Social mobility

**Indicators**
- Age of fishery
- Ancestral involvement
- Fishing family identity
- Age of fishery
- Ancestral involvement
- Options for different job
- Employability
- Alternative employment
- Biggest risk
- Markets
- Resource management
- Community cohesion
- Gender equity
- Financial assistance
- Women leadership role
- Local knowledge
- Health
- Education
- Skills
- Knowledge
- Labour
- Savings
- Debt
- Credit
- Insurance
- Age of building
- Boat details
- Source of drinking water
- Sources
- Disposal techniques
- Changing resource base
- Livelihood
- Climate change
- Adaptations
Overall Vulnerability
Potential Impact - Exposure

Spatial distribution of Exposure of Elamkunnapuzha Village

Spatial distribution of Exposure of Poonthura village
Potential Impact - Sensitivity
Adaptive Capacity
Assessing Alternative Livelihood Options

- Data select: Primary sources and secondary sources.
- Pre tested survey schedules
- Focus group discussions were held in select coastal villages
- A total sample of 1259 respondents was selected from the coastal villages of Poonthura and Elamkunnapuzha
- Data collected on socio economic demographic view of the respondents, level of awareness of fisher folk about climate change, fisher’s perception on the impacts of climate change on resources etc.
- The primary data was collected during the period between May – July 2017.
<table>
<thead>
<tr>
<th>Measures</th>
<th>Poonthura</th>
<th>Elamkunnappuzha</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Rank</td>
<td>Score</td>
<td>Rank</td>
</tr>
<tr>
<td>Organic Farming</td>
<td>50.32</td>
<td>IV</td>
<td>45.62</td>
<td>V</td>
</tr>
<tr>
<td>Increase Energy Efficiency</td>
<td>61.45</td>
<td>III</td>
<td>62.35</td>
<td>II</td>
</tr>
<tr>
<td>Reduce Food Waste</td>
<td>66.13</td>
<td>II</td>
<td>60.52</td>
<td>III</td>
</tr>
<tr>
<td>Rain Water Harvesting</td>
<td>27.1</td>
<td>VIII</td>
<td>50.12</td>
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<tr>
<td>Transportation Alternatives</td>
<td>49.16</td>
<td>V</td>
<td>37.33</td>
<td>VI</td>
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<tr>
<td>Avoid Products with Lot of Packaging</td>
<td>73.39</td>
<td>I</td>
<td>70.56</td>
<td>I</td>
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<tr>
<td>Use Paper Judiciously</td>
<td>37.58</td>
<td>VI</td>
<td>30.56</td>
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<tr>
<td>Limit The Use of Fossil Fuels</td>
<td>18.65</td>
<td>IX</td>
<td>19.54</td>
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<td>Pricing Carbon</td>
<td>30.81</td>
<td>VII</td>
<td>27.23</td>
<td>VIII</td>
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<tr>
<td>Others</td>
<td>17.42</td>
<td>X</td>
<td>16.52</td>
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</tbody>
</table>
Alternate Livelihood Options

• **30.47 %** (32 % from Elamkunnappuzha and 19 % from Poonthura) have alternative livelihood options

• Whereas **69.52%** (61 % from Elamkunnappuzha and 67 % from Poonthura) have no alternative livelihood options other than fishing

• **75.955 %** are willing to participate in adaptation and mitigation programmes

• **61%** are willing to take part in individual climate change activities followed by household and social roles.

• The top five ALO’ prefered by fishermen-
  – Daily wage labour,
  – SHG, Small scale industry,
  – Service Industry
  – Masonry/carpentry
Fisher’s - Awareness, preparedness and mitigation level

- The level of knowledge on climate change is inadequate with 24.7% respondents aware and 75.1% heard about climate change.
- The major sources of information are media (44%), friends and relatives (41%), and state government organizations (21.5%).
- The existing indigenous technology knowledge is based on wind, colour and nature of sea (37%).
- Community involvement and mobilization exists among fishermen in terms of coordinating activities in response to natural hazards/events (16%).
- The level of governmental support is not adequate (72%) in fishers’ perception.
Climate change agents

- Section of the society with better education, experience and multiple avocations
- Various programs were conducted to identify and develop **climate change agents** from different age and gender groups
- Influence and inspire general community in the entire process
- Ensure the involvement of maximum people in the process.
• ClimEd - an instructional material has been developed as a part of the study.

• ClimEd is published in different series; so far five ClimEd series each in Hindi, Malayalam, English and Tamil (20 nos) have been developed.

• Each series focus on different aspects of climate change they are:
  ClimEd Series –I "Know Your Warming Planet"
  ClimEd Series- II “Learning & Coping Climate Change”
  ClimEd Series- III “Societal role in curbing climate change”
  ClimEd Series IV “Climate Change and Policy”
  ClimEd Series V – Households in combating climate change
ClimEd Series - English

ClimEd Series I - Know Your Warming Planet

ClimEd Series II - Learning & Coping Climate Change

ClimEd Series III - Societal role in curbing climate change

ClimEd Series IV - Climate Change and Policy

ClimEd Series V - Households in combating climate change

The world is changing... Are we?? Shouldn't we??

"If we contributed, then we need to fix it"
• Fast approaching a scenario of biodegradable plastic waste destroys the ecosystem of the aquatic organisms which results in harmful effects to marine life, due to consumption of degraded microplastics was explained through the Fish Cemetery installation

• Participated in the Biennale

https://www.youtube.com/watch?v=CWVD9Z4DY
CreVAMP Framework

Elements
- Awareness
- Preparedness
- Adaptation
- Mitigation

Approaches
- Attitude
- Mobilisation
- Livelihoods
- Technology
- Avocations
- Tradeoffs / Offsets
- Forecasting
- Linkages

Outcome
- Village Climate information system
- Climate communities
- Green fishing
- Adaptation and Mitigation Plan

Change Agents
- Government
- Society
- Individuals

Climate Change Informed Fisheries /Fishers
Achievements

• Climate change as a science has been transferred to fishers
• Climate change have been incorporated into Panchayath planning
• Were able to identify climate change champions
• Build linkages with national and international climate change agencies
• Perpetuated into tropical fisheries sector

South West India: At a Glance

- **Hotspot size:** 590 km (coastline)
- **Depth regime/continental shelf:**
  - The continental shelf area is 39,139 sq km, the area within the 18m depth range accounts for 5,032 sq km, the area between 18-73m is approximately 25,000 sq km and 73-182m is the balance of the area.

**South West India**

**Summary**

The state of Kerala, located at the extreme southern narrow strip of the Indian sub-continent is wedged between the Arabian Sea to the west and the Western Ghats to the east. It is lying between 8°10', 12° 48' North latitudes and 74° 52', 77° 22' East longitudes. Kerala's coastline of 590 km with 187 landing centres spreading over nine coastal districts and the Exclusive Economic Zone (EEZ) extends up to 200 nautical miles far beyond the continental shelf, which covers an area of 218,636 sq km provide opportunities in traditional fishing in inshore waters from ages.

The hotspot area of south west India comprises of four coastal districts (South Zone: Thiruvananthapuram & Kollam and Central zone: Ernakulam and Alappuzha), and the rationale behind the section of this particular location is i) it falls within the upwelling ecosystem of the south-west coast of India, ii) this region has rich diversity and supports substantial marine and estuarine fisheries iii) identified as major spawning gyre of many pelagic species based on fish and larval surveys iv) has extensive system of backwaters.

**Oceanographical context**

The Indian subcontinent divides the northern Indian Ocean into two basins - the Arabian Sea and Bay of Bengal. The Arabian Sea is known for the intense annually reversing monsoon winds and high evaporation. Even though the Elman transport is less during northeast monsoon than during southwest monsoon, especially south of 10°N, the heat transport south of the Arabian Sea keeps similar amplitude as that of south-west monsoon. Among the western boundary currents Somali Current of Arabian Sea is unique due to its strength and the reversal during monsoon season. The studies indicated a presence of two-gyre circulation system in the western Arabian Sea during south west monsoon. Another notable feature is the upwelling of cool subsurface waters in the Arabian Sea during the summer monsoon.
Challenges

• Difficult to impart the concept of climate change as a science to the fishers
• Climate change cannot be delineated out of the many factors affecting fishermen livelihood
• Cost to ex-chequer
• Find alternate livelihood options
• Strengthening value chain
• Resistance to move from their present ambience