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CLIMATE CHANGE IMPACT ON COASTAL FISHERIES AND AQUACULTURE IN INDIA

SAARC COUNTRY MEETING

ICAR - Central Marine Fisheries Research Institute
Kochi, Kerala, India

CONTEXT

- **Production from marine capture fishery (3.59 million t in 2014) - close to estimated potential (4.4 million t).**
- **Growth rate of consumption 3.5% per annum.**
- **By 2050 - Estimated domestic demand – 20.23 million t [10.12 million t (50%) to be met from marine sector] plus Increase in export demand.**
- **Livelihoods - Sector sustains more than 4 million fisher folk inhabiting 3288 fishing villages - 1.6 million active fishers. Expected to increase around 10%.**
- **Limited scope for increase in production from present grounds.**
- **Mariculture technology – meet demand supply gap – 50% to be met from mariculture.**
- **Management – Transition from open access to regulated fishery – policy for mariculture.**

CHALLENGES

Emerging

General

- Rising SST
- Changes in rainfall patterns
- Greater frequency of extreme weather events
- Rising sea levels
- Infrastructural damage

Specific

- Ocean acidification
- Coral bleaching
- Habitat loss
- Resource vulnerability
- Employment loss
- Phenological changes

Future

General

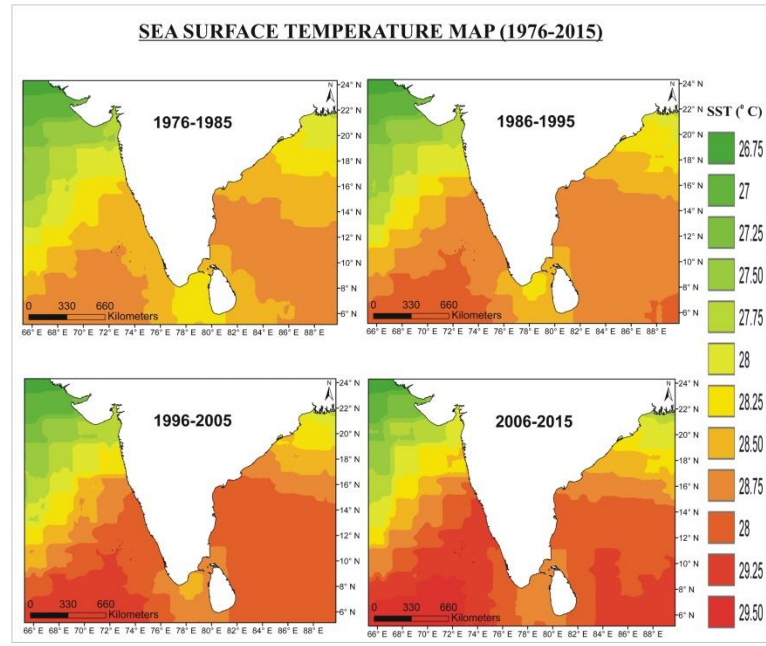
- Environmental degradation
- Diversified use of ecosystems
- Biodiversity losses
- Flip in marine community structure
- Sharing of transboundary stocks
- Emergence of diseases in mariculture systems

Specific

- Green fishing polices/mariculture technologies
- Marine habitat restoration
- Regional co-operation for management of transboundary stocks

RISE IN SEA SURFACE TEMPERATURE VISIBLE IN INDIAN WATERS

- The variation of Sea surface Temperature (SST) along Indian Seas during the 40 years from 1976 to 2015 revealed that (SST) increased by
  1. 0.819 °C along southwest India
  2. 0.690 °C along southeast India
  3. 0.602 °C along northeast India
  4. 0.597 °C along northwest India
- The rate of change in SST was ranked as:
  1. Northwest India (0.0156/annum)
  2. Southwest India (0.0132/annum),
  3. Southeast India (0.005/annum)
  4. Northeast India (0.001/annum)
- Rate of change in SST over Indian Seas revealed that west coast has more impact than in the east coast of India.



Distribution of Indian mackerel has undergone significant change with increase in SST

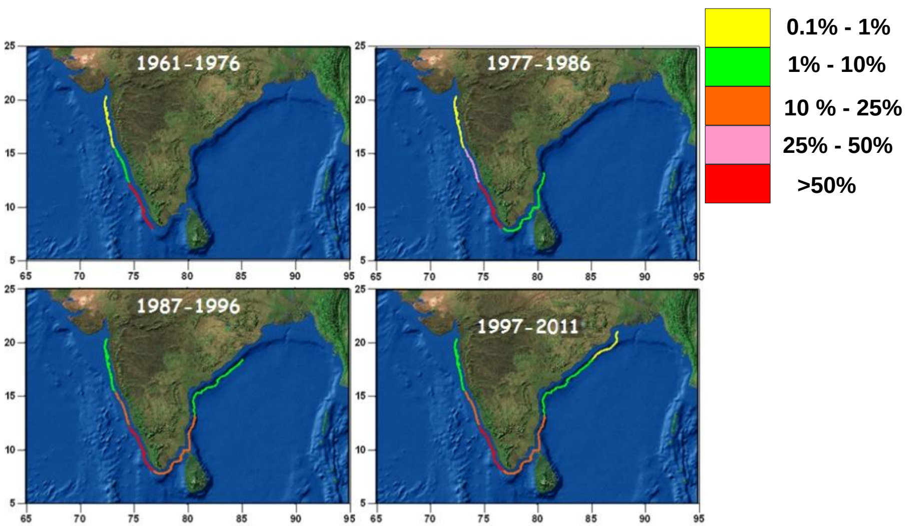
Descent to deeper waters

- Indian mackerel generally occupies surface and subsurface waters. conventionally caught by surface drift gillnets by artisanal fishermen.
- In recent years, the fish is increasingly getting caught in bottom trawlnets operated by large mechanised boats at about 50 m depth.

CHANGES IN DISTRIBUTION, ABUNDANCE AND PHENOLOGY OF MARINE FISHES

Extension of Distributional Boundaries

- Warming of surface waters is enabling the oil sardine and mackerel to extend their distributional range north of 14ºN.

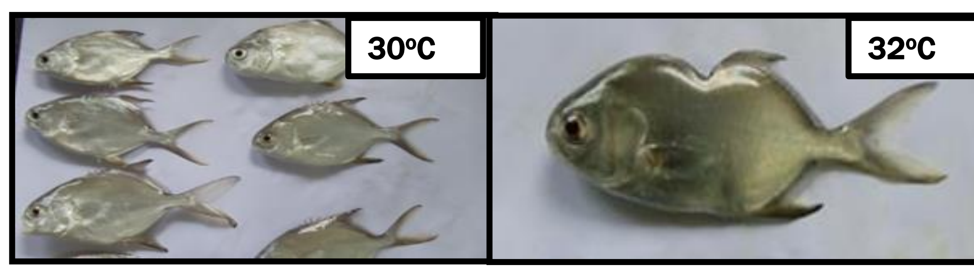


With increase in SST, evidences is now available for

- Increase in dispersal and abundance of small pelagics (oil sardine and mackerel).
- Reduction in mean size in the fishery (Indian mackerel, *Nemipterus*)
- Reduction in length at first maturity (mackerel, coastal prawns).
- Reduction in fecundity (mackerel, coastal prawns).
- Change in spawning season (*Nemipterus* sp)
- Change in diet composition (oil sardine).

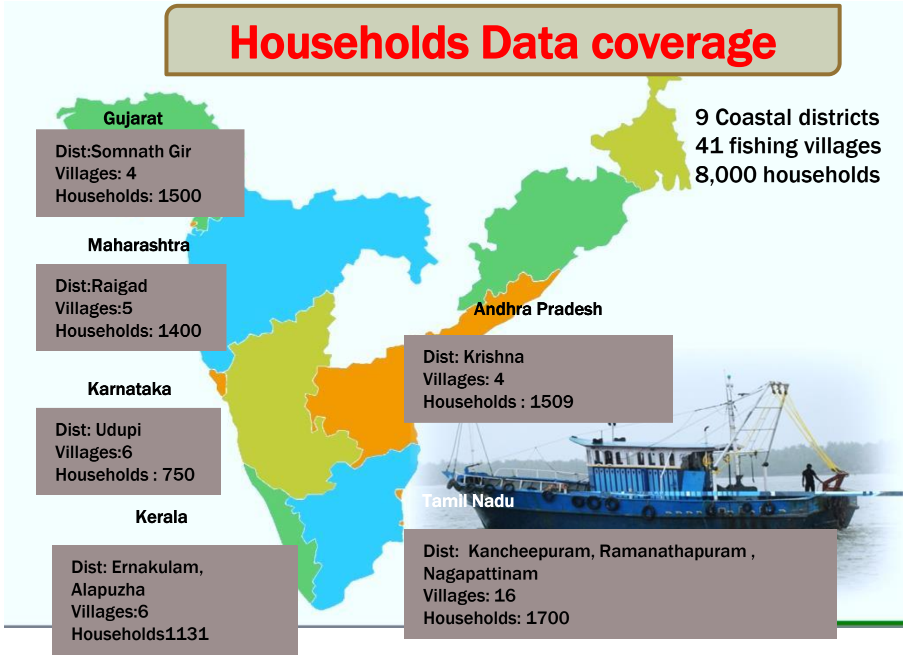
Effects of Elevated Temperature on Pompano fingerlings

- Pompano fingerlings grown at 30ºC and 32ºC show the effects of elevated temperature on early stages of growth.

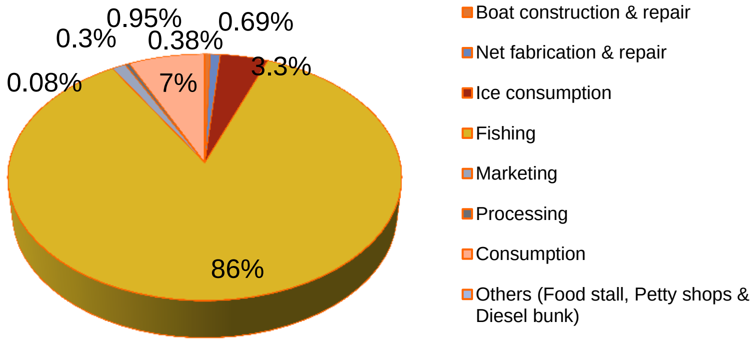


INTEGRATED DISTRICT LEVEL ADAPTATION AND MITIGATION

- **Survey results (8000 households)**
  - The level of knowledge on climate change is inadequate (64.7%).
  - The major means of information comes through media (67%), friends and relatives (11%), and State government organizations (21.5%).
  - Alternate avocations are minimal with marketing of fish, agriculture, livestock, dairy and coir industry.
  - The level of governmental support is not adequate (72%) in fishers' perception.



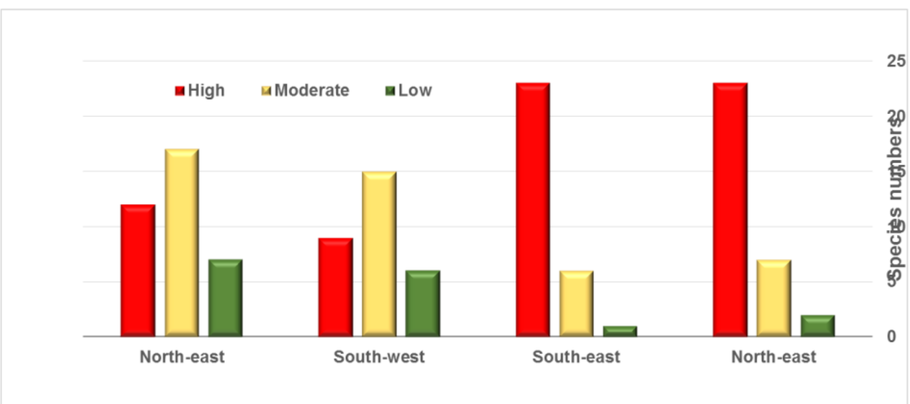
Carbon footprint by marine fishing in Chennai during 2014



- Carbon footprint in life cycle of marine fisheries was assessed from Mangalore, Tuticorin, Veraval and Visakhapatanam.
- Highest emissions were recorded in harvest phase in all cases

VULNERABILITY OF MARINE FISH STOCK ASSESSED

- Scientific criteria was developed to enable assessment of the vulnerability of fish stock.
- As a result of this assessment, resilient strategies for mitigating damage to highly vulnerable species have been identified.



Zone-wise dispersion of species based on vulnerability assessment

	Zones	No of zones	Major influencing factor	Major gear
M. monoceros	SW, SE, NE	3	Life history and fishing pressure	Trawl
P. niger	NW, SW, SE	3	Fishing pressure (juvenile)	Trawl
P. tenuispinis	SW, SE, NE	3	Life history and fishing pressure	Trawl
C. limbatus	SW, SE	2	Life history	Trawl
D. russelli	NW,SE	2	Fishing pressure	Trawl
F. indicus	SW,NE	2	Life history and fishing pressure	Trawl
K. pelamis	SE,NE	2	Life history and fishing pressure	
N. japonicus	SE,NE	2	Fishing pressure	Trawl
P. monodon	SE,NE	2	Life history and fishing pressure	Trawl
S. gibbosa	SE,NE	2	Fishing pressure and lack of upwelling	
S. tumbil	SE,NE	2	Fishing pressure	Trawl
S. undosquamis	SE,NE	2	Fishing pressure	Trawl
S. commerson	SE,NE	2	Fishing pressure	
S. jello	SE,NE	2	Fishing pressure	Trawl
T. albacares	SE,NE	2	Life history and fishing pressure	
T. lepturus	SE,NE	2	Fishing pressure	Trawl

RESILIENCE OPTIONS FOR HIGHLY VULNERABLE MARINE SPECIES/FISHING

Vulnerability in marine fisheries due to CC	Possible measures for resilience	Indicators of measurement of resilience
Highly vulnerable fish stocks	Regulation of fishing (fleet size, mesh size, spatiotemporal closure/habitat restoration (mangroves)	1. Increase in CPUE 2. Increase in mean length in the catch 3. Increase in fecundity 4. Increase in size at maturity 5. Reduction in fleet size 6. Spatio-temporal closure for 7. Regulatory measures such as MLS/regulation of mesh size
Reduction in fecundity/size at maturity in wild stocks	Implementation of MLS to increase mean size in the catch	1. Increase in size at maturity 2. Increase in fecundity 3. Implementation of MLS regulations
Extension of distributional boundaries of small pelagics due to increase in SST	Better exploitation and utilisation of small pelagics in all the maritime zones	1. Increase in the landings of pelagic extended species 2. Increase in CPUE of small pelagics
Increased carbon footprint of mechanised fishing operations	Use of PFZs to reduce scouting time, Use of wind/ solar energy in fishing vessels (Green fishing), Geo-referencing of fishing grounds	1. Whether PFZ advisory available for the region 2. Number of vessels utilise PFZ advisories 3. Number of vessels use low energy alternatives for fishing 4. Availability of spatio-temporal map/information on fishing grounds

RESILIENCE INDICATORS FOR COASTAL FISHERMEN COMMUNITY

Vulnerability in marine fisheries due to CC	Possible measures for resilience	Indicators of measurement of resilience
Reduction in livelihood options of coastal fishermen due to reduced catches	Low -cost cage farming (Both estuarine and mariculture) Pond culture silver pompano (Seed Bank) Empowerment of fishermen through CBA Integration of fish farming with saline tolerant pokkali paddy farming in the fields	1. Number of fishermen adopted the alternative options of livelihood 2. Area under cage farming/pond culture of silver pompano/ CBA 3. Increased income to fishermen/farmer 4. Increase in farming days/fishing days 5. Increased production from coastal area 6. Institutional support for alternative farming technologies 7. Tolerant varieties used by farmers (Saline tolerant silver pompano) 8. Seed availability 9. Feed availability 10. Availability of Institutional credit and advisories
Coastal village vulnerability	Development of Participatory Attitude on Preparedness, Adaptation and Mitigation (APAM) framework	1. Number of villages with such framework developed 2. Degree of awareness about CC among coastal villagers 3. Increase in infrastructure developed 4. Number of mitigation measures applied in the village 5. Adoption of alternate livelihood options suggested
Loss of livelihood due to natural hazards	Establishment of early warning systems. Installation of Automatic weather stations under NICRA, weather/catch forecast	1. Availability of early warning systems 2. Availability of weather forecast 3. Availability of PFZ advisories 4. Availability of community gathering centres 5. Awareness among fishermen about history of natural hazards
Reduced income to fishermen community	Multivendor E-commerce facility for fishermen SHGs for community empowerment and	1. Increase in the share of fishermen in consumer rupee 2. Number of SHGs benefited 3. Increase in profit for fisheries stake holders 4. Number of such facility established

ADAPTATION OPTIONS FOR MARINE FISHERIES

Carbon sequestration through seaweed cultivation

- Studies were conducted on the carbon sequestration potential of the seaweed *Kappaphycus alvarezii.*
- Specific rate of sequestration of CO_2 by the seaweed was estimated at 0.0187g/day.

Kappaphycus alvarezii grown in carbon sequestration experiments

Low cost cage construction

- Cages were developed using locally available materials like GI pipe and floated on fibre barrels.
- The low cost cage developed by CMFRI was demonstrated by making twelve low cost cages.
- This technology makes cage culture affordable to the common fishermen.
- The no of cages have increased from 12 to 700 now with the production expected to increase to 4 lakh tonnes from cage farming.

Low cost cages employed in cage culture moored off Karwar

Integrated Multi-Trophic Aquaculture (IMTA)

- Seaweed was farmed concurrently with cobia in cages.
- The demonstration yielded nearly double the amount that would be obtained from a similarly sized system used purely to cultivate seaweed.

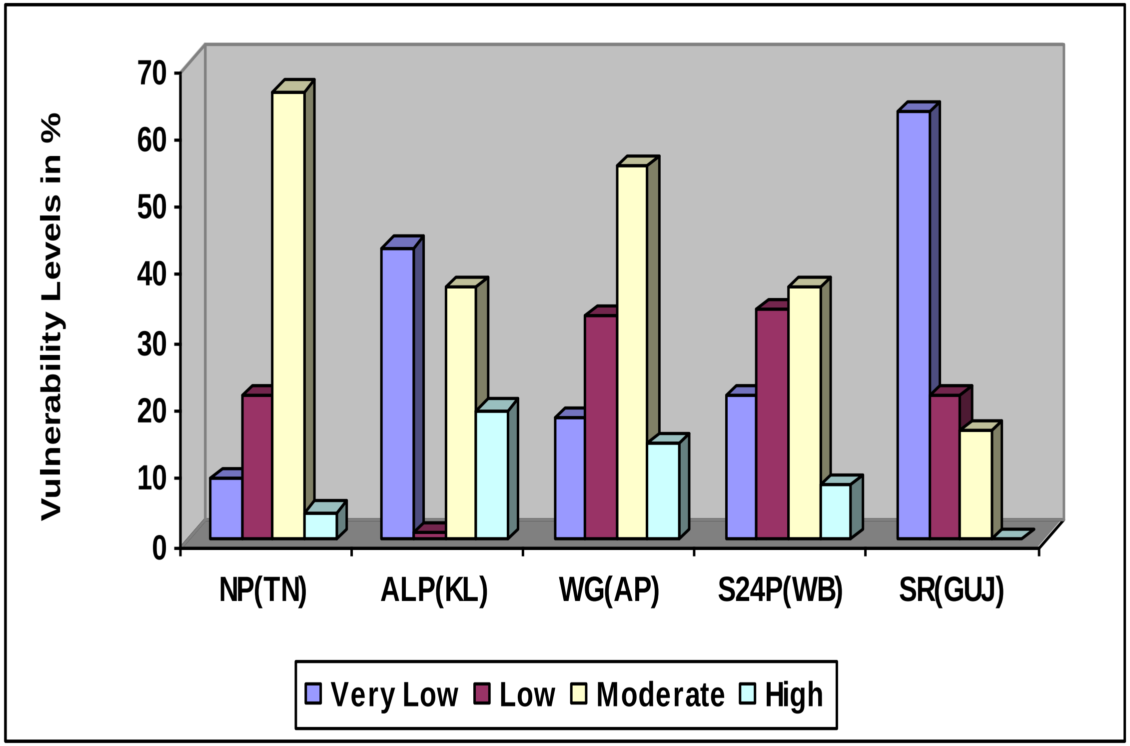
Handing over of the harvest of cobia and *Kappaphycus alvarezii*

Vulnerability of aquaculture to climate change

Based on data analysis of extensive farmer's survey (n= minimum of 120) and exposure, sensitivity and adaptive capacity indicators → Vulnerability of aquaculture to climate change was assessed.

Vulnerability Levels	Vulnerability Score (Normalised)
Very Low Vulnerable	(0 – 1.0)
Low Vulnerable	(1.1 -2.0)
Moderately Vulnerable	(2.1-3.0)
Highly Vulnerable	(3.1- 4.0)
Very High Vulnerability	(4.1-5.0)

Aqua farmers vulnerability (%) in coastal states

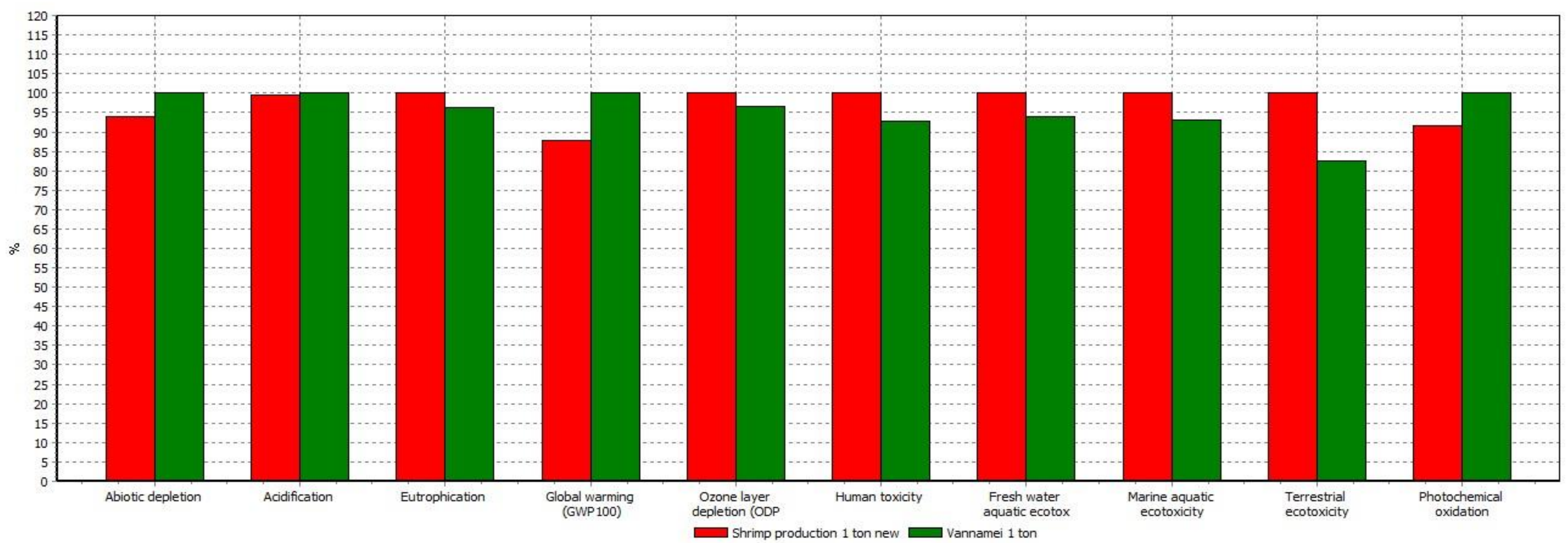


- **4 to 19%, 37 to 66%, 1 to 34% and 9 to 43% of the aqua farmers in all the four states were under high, moderate, low and very low categories of vulnerability, respectively except Gujarat, where 64% were under very low category.**

Comparison of *P.monodon* and *L.vannamei* farming systems (1 ton production) for their contribution to environmental burden (Characterisation)

Impact category	Unit	P.monodon production 1 ton	L.Vannamei 1 ton
Abiotic depletion	kg Sb eq	9.55	10.18
Acidification	kg SO2 eq	14.29	14.36
Eutrophication	kg PO4— eq	79.00	76.15
Global warming (GWP100)	kg CO2 eq	1817.83	2068.22
Ozone layer depletion (ODP)	kg CFC-11 eq	0.001	0.001
Human toxicity	kg 1,4-DB eq	259.58	240.82
Fresh water aquatic ecotox.	kg 1,4-DB eq	40.39	37.93
Marine aquatic ecotoxicity	kg 1,4-DB eq	139911.81	130345.26
Terrestrial ecotoxicity	kg 1,4-DB eq	2.28	1.88
Photochemical oxidation	kg C2H4	0.41	0.44

- **Among the two production systems, *L.vannamei* contributed more towards GWP.**
- **Global warming potential (GWP) was high in *L.vannamei* system compared to *P.monodon* and it is contributed mainly by use of aerators and production of feed in feed mill i.e., mainly by use of energy.**



Comparing 1 p 'Shrimp production 1 ton new' with 1 p 'Vannamei 1 ton'; Method: CML 2 baseline 2000 V2.04 / World, 1990 / characterisation

EMPOWERMENT OF WOMEN

- Strong relationship between hunger and gender inequality
- Equalising women status with men in S. Asia and SS Africa estimated to reduce malnourished children by 13.4 and 1.3 million respectively
- Women mostly involved in processing and marketing
- Excellent opportunities for involvement of women in farming of food and non-food aquatic organisms
- Many success stories – increase in household incomes, better

  nutrition and health for family

POLICIES AND ENABLING ATMOSPHERE

- Commitment of governments to implement coping strategies
- R & D initiatives
- Ecosystem approach
- Development of saline tolerant species
- Building institutional and legal frameworks
- Access to micro-credit
- Training in livelihood initiatives and provision of subsidies as needed
- Market access

RECOMMENDATIONS

- Identification of vulnerable fishery/coastal resources

- Vulnerable resources should be made resilient following adaptation strategies. Such adaptation strategies may be extended to fishermen and their communities who are largely dependent on vulnerable resources.

- Low cost fish farming technologies countering climate variability, alternate energy and fuel based on marine resources, farming of potential carbon sequestering species such as seaweeds may be developed.

RECOMMENDATIONS

- Identifying and grading critical as well as ecologically sensitive habitats such as mangroves, corals, wetlands and others for developing restoration strategies.
- Creating awareness campaigns for reduction of GHG emissions and empowering vulnerable communities through capacity building programmes.
- Strategies on utilizing e-commerce ventures and Information Communication Technology methods for social and livelihood security of fisher folks and fish farmers.

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